S3-D-7

F- Planning
F- Bramhall St. (ME Med.)

Helicopter Pad ~~Noise +~~
~~Sound Studies~~
Various Studies

ACKNOWLEDGMENTS

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MAINE MEDICAL CENTER
PROPOSED HELICOPTER PAD

EXECUTIVE SUMMARY

Maine Medical Center (MMC) proposes to construct a helicopter pad as part of its Phase I site expansion at its existing hospital in Portland, Maine. Other key elements of the Phase I expansion include a multi-story birthing center and nursery, a utility plant, and an additional seven-story parking garage.

The helicopter landing and takeoff pad (helipad) will be constructed on the top level of an existing parking garage structure bordering MMC and Congress Street. The proposed helipad will improve emergency services by providing medically supervised helicopter flights directly to and from Maine Medical Center for critical patient transfers. The function of the proposed helipad is to provide quick access for the increasing numbers of trauma, cardiac, and other patients. Based on current operations in Maine, helicopter flights to MMC average approximately four flights per week with a possible increase to five or six flights per week once the helipad becomes operational. Experience statewide has shown that about one-third of flights occur between 3:00 pm and 7:00 pm; and just 13% of flights occur between midnight and 8:00 am.

Resource Systems Engineering (RSE) completed an evaluation of sound levels likely to occur in the vicinity of the proposed helipad. RSE measured sound levels of helicopter test flights carried out by LifeFlight of Maine and compiled topographic and design information for the proposed Phase I expansion. RSE also monitored community sound levels at residences nearby MMC to evaluate noise impact from the proposed helipad. A separate report *Community and LifeFlight Helicopter Sound Level Study* dated April 15, 2004 provides a comparison of flight test and community sound levels. LifeFlight of Maine is a full partner in operational noise mitigation and follows noise abatement procedures as set forth in the *Fly Neighborly Guide* published by the Helicopter Association International. These procedures are consistent with advisory circular AC 91-66, Noise Abatement for Helicopters, developed by the Federal Aviation Administration (FAA). The Helicopter Association International enhanced the FAA noise reduction guidelines as part of its *Fly Neighborly Guide.*

The primary objectives of the Noise Mitigation Study were to assist Maine Medical Center in selecting a site for the proposed helipad that would limit noise impact and to investigate additional noise control options to ensure that all practical noise mitigation was being incorporated into helipad design and operations. From test flight results and project data, RSE developed a noise prediction model to calculate sound levels likely to occur from future use of the proposed helipad. The helipad site and associated flight paths were carefully selected based on sound level estimates and community monitoring results to limit noise impact. The noise model confirmed that locating the helipad on the existing parking garage would enable existing and proposed buildings to block sound propagation to noise sensitive areas to the west and south.

Sound level estimates were developed for the helipad site with various construction and mitigation options. Many model cases were run to investigate a myriad of possible mitigation options. Refinement and analysis of noise model estimates showed that the best mitigation option is to face the helicopter toward the north whenever possible during operation on or in close-range to the helipad. Due to prevailing winds the helicopter will typically land facing to the north.

FAA design criteria were found to significantly restrict opportunities for additional mitigation using noise barriers. Through development and analysis of mitigation options, RSE found that an effective noise barrier, serving all areas not mitigated by new structures at MMC, would be too large to be practical for construction. Smaller noise barriers were found to provide no significant additional noise reduction to areas not mitigated by new construction or by facing the helicopter northerly while on or in close range to the helipad.

During the Noise Mitigation Study, RSE also found that FAA design criteria were inherently aligned to the optimum location of the helipad on the existing garage for noise reduction from existing and proposed structures. Further, due to area topography and the barrier effect of the existing garage, there was no significant sound level reduction from absorptive versus reflective surfaces of MMC buildings.

The proposed flight paths and helipad on the existing parking garage will be located in areas where existing community sound levels near MMC are the highest. Because of site topography, the noise model showed that locating the helipad on the existing parking garage would limit the number of residential properties affected by helipad sound levels.

MAINE MEDICAL CENTER
PROPOSED HELICOPTER PAD
NOISE MITIGATION

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LIST OF ACRONYMS

ANSI	American National Standards Institute
ASA	Acoustic Society of America
B&K	Bruel & Kjaer
CFR	Code of Federal Regulations
dB	Decibel (Unit of Sound Pressure Level)
dBA	Decibel A-weighted
DEP	Department of Environmental Protection
F	Fahrenheit
FAA	Federal Aviation Administration
ISO	International Organization for Standardization
HP	Horsepower
Hz	Hertz (cycles per second)
L1	Sound Level Exceeded 1% of a Measurement Period
L10	Sound Level Exceeded 10% of a Measurement Period
L50	Sound Level Exceeded 50% of a Measurement Period
L90	Sound Level Exceeded 90% of a Measurement Period
Ldn	Day-Night Sound Level
L_{Aeq}	Equivalent Sound Level Measured on the A-Scale
L_{Aeqday}	Daytime L_{Aeq}
$L_{Aeqnight}$	Nighttime L_{Aeq}
MMC	Maine Medical Center
Mph	Miles per hour
MRSA	Maine Revised Statutes Annotated
RSE	Resource Systems Engineering

MAINE MEDICAL CENTER
PROPOSED HELICOPTER PAD

NOISE MITIGATION

1.0 INTRODUCTION

Maine Medical Center (MMC) proposes to construct a helicopter pad as part of its Phase I expansion at its existing hospital in Portland, Maine. Other key elements of Maine Medical Center's Phase I expansion include multi-story birthing center and nursery, a utility plant, and an additional seven-story parking garage.

Resource Systems Engineering (RSE) completed an evaluation of sound levels likely to occur in the vicinity of the proposed helipad. RSE measured sound levels of helicopter test flights carried out by LifeFlight of Maine and compiled topographic and design information for the proposed Phase I expansion. From test flight results and project data, RSE developed a noise prediction model to calculate sound levels likely to occur from future use of the proposed helipad.

RSE also monitored community sound levels at residences nearby MMC to evaluate noise impact from the proposed helipad. A separate report *Community and LifeFlight Helicopter Sound Level Study* dated April 15, 2004 provides a comparison of flight test and community sound levels. The following report provides noise model predictions of future sound levels reflecting construction of the Phase I projects and evaluation of noise mitigation options for the proposed helipad.

2.0 SITE DESCRIPTION

The primary hospital site is located between Congress Street and Bramhall Street approximately one-half mile east of Interstate 295 and two miles northeast of the Portland International Jetport. The vicinity of Maine Medical Center is mostly developed land including a mixture of uses. In addition to the hospital and related parking and medical facilities, development along Congress Street is predominantly commercial. Between Congress Street and Park Avenue, there are a considerable number of residential buildings. To the west, St. John Street is predominantly commercial with residential and commercial/medical buildings located between St. John Street and MMC. Areas south and east of MMC are primarily residential with the City's Western Promenade Park and occasional commercial uses as well.

The helicopter landing and takeoff pad (helipad) will be constructed on the top level of an existing parking garage structure bordering MMC and Congress Street. The proposed helipad will improve emergency services by providing medically supervised helicopter flights directly to and from Maine Medical Center for critical patient transfers. The function of the proposed helipad is to provide quick access for the increasing numbers of trauma, cardiac, and other patients. This project is part of a larger Phase I expansion that includes:

- A birthing center to be built at the site of the former New England Rehabilitation Hospital bounded by Ellsworth, Crescent, Wescott and Charles streets. The plan calls for closing Charles Street and connecting the new building to the medical center.

- Expansion and renovation for the Emergency Department to be built in the adjoining basement level space of the new Charles Street building.
- A seven-story parking garage next to the existing garage on Congress Street, featuring enclosed pedestrian skywalks to the medical center. Two homes on Crescent Street purchased by Maine Medical Center will have to be razed.
- A new utility plant between MMC and Gilman Street to the west to provide more efficient heating and cooling for new and existing buildings.

This report addresses sound that will be generated from operation of the proposed helipad. Sound from other portions of the Phase I expansion are not addressed, however, the helipad sound level analysis takes into account the barrier, shielding and reflection effects provided by other parts of the proposed expansion.

3.0 HELIPAD OPERATION

LifeFlight of Maine will provide most of the helicopter flights to the proposed MMC helipad. Since its creation in 1998, LifeFlight has provided emergency medical helicopter services in Maine. LifeFlight operates two Agusta 109C helicopters in Maine: one based at Eastern Maine Medical Center in Bangor and one at Central Maine Medical Center in Lewiston. The Agusta 109C is expected to be the primary helicopter using the proposed helipad at MMC.

LifeFlight is a statewide medical helicopter service that is available 24 hours per day, seven days per week. Helicopter transport is restricted to the most acutely ill or injured patients and a physician must prescribe its use. In addition to the aircraft stationed in Bangor and Lewiston, there are backup aircraft available in the event that one or more of the aircraft are not available.

Based on current operations in Maine, helicopter flights to MMC average approximately four flights per week with a possible increase to five or six flights per week once the helipad is operational. No more than 30% of helicopter flights are expected to occur between the hours of 10:00 pm and 7:00 am. Experience statewide has shown that about one-third of flights occur between 3:00 pm and 7:00 pm; and just 13% of flights occur between midnight and 8:00 am.

For the proposed helipad, the period of helicopter operation on or in close-range to the helipad is expected to be approximately nine minutes per flight. This consists of four minutes for approach, landing, and spool down, and approximately five minutes from the beginning of cold startup through liftoff and close-range departure flight.

The test flights at MMC, addressed in RSE's report of April 15, 2004, involved approach, hovering above the proposed helipad site, and departure consisting of approximately one minute of close-range operation per flight test. The test flights did not include landing and takeoff of the aircraft, or the quieter spool down and startup/warm-up cycles of an actual medical flight.

4.0 SITE SELECTION

MMC evaluated several sites for possible location of a medical helipad. RSE prepared a noise model to estimate sound levels from each possible helipad location. For purposes of site selection, the sound level analysis evaluated helicopter sound levels while operating on the helipad. MMC and others evaluated other considerations such as emergency room access, flight path access, and structural limitations. Possible helipad sites evaluated included the Bean Tower, the existing parking garage, the proposed new parking garage, and the proposed new Charles Street Building.

In conjunction with the helipad noise model, RSE monitored existing community sound levels to determine noise sensitive areas in the vicinity of Maine Medical Center. Existing community sound levels were compared to noise model results to determine the relative noise impact of possible helipad sites. The noise model was developed to represent the Phase I expansion including the Charles Street building and new parking garage. Site profiles showed that the top of the existing parking garage is at a lower elevation than both existing and proposed hospital buildings. Consequently, the noise model confirmed that locating the helipad on the existing parking garage would enable existing hospital buildings and the new Charles Street building to block sound propagation to noise sensitive areas to the west and south. Because of site topography, the noise model showed that locating the helipad on the existing parking garage would limit the number of residential properties affected by helipad sound levels.

Further analysis was conducted to determine if sound would reflect off existing and proposed structures and increase noise impact on residential properties. The nearest residential properties to the parking garage are across Congress Street and at much lower elevation than the top level of the parking garage. Consequently, helipad sound that reflects off the hospital buildings would be blocked by the existing parking garage and therefore will not increase noise impact of the helipad at nearby residential properties.

Another criteria for reducing noise impact is to locate the helipad in an area where community sounds are relatively high. The results of community sound level monitoring shown in Table 1 (see also Flight Test Report 4/15/04) show that the highest daytime and nighttime community sound levels occurred at position CP-2 across Congress Street from the existing parking garage. Therefore, the existing parking garage would put the helipad where the highest existing community sound levels occur. The primary source of existing sound levels at CP-2 is traffic on Congress Street. A vicinity site plan showing Maine Medical Center and the community monitoring positions is shown as Figure 1.

TABLE 1

Existing Daytime and Nighttime Sound Levels

	Maine DEP Average Hourly L_{Aeq}		**City of Portland Average Hourly L_{Aeq}**		
Monitoring Position	**Daytime 7 am to 7 pm**	**Nighttime 7 pm to 7 am**	**Daytime 7 am to 9 pm**	**Nighttime 9 pm to 7 am**	**FAA Day-Night Sound Level (L_{dn})**
CP-1: Gilman & A Street	60	57	59	57	64
CP-2: Congress & Weymouth Street	61	57	61	57	65
CP-3: Wescott & Crescent Street	57	54	56	54	61
CP-4: Ellsworth & Charles Street Ext.	57	55	56	55	62
CP-5: Bowdoin & Chadwick Street	52	48	51	48	56
CP-6: West Promenade & West Street	57	55	56	56	63

Maine DEP Average Hourly L_{Aeq} – Arithmetic average of hourly equivalent sound levels (Hourly L_{Aeq}) for daytime (7 am to 7 pm) and nighttime (7 pm to 7 am).

City of Portland Average Hourly L_{Aeq} – Same as Maine DEP Average Hourly L_{Aeq} except for different daytime (7 am to 9 pm) and nighttime (9 pm to 7 am) periods.

FAA Day-Night Sound Level – The 24-hour equivalent sound level calculated by adding 10 dBA to hourly equivalent sound levels between 10 pm and 7 am.

Other site selection criteria evaluated by Maine Medical Center include availability of flight paths over transportation, industrial and commercial corridors, and access to helipad approaches to maximize safe operation in prevailing wind conditions; noise and exhaust impact on hospital facilities, internal access to emergency/operating facilities, compliance with FAA siting and safety criteria, construction schedule, cost and aesthetics.

5.0 NOISE MITIGATION

As described in Section 4.0, MMC has made efforts to locate the helipad and establish flight paths to minimize noise impact on residential areas. The following describes additional noise mitigation measures that have been evaluated by RSE.

5.1 Aircraft Certification & Flight Procedures

LifeFlight of Maine is a full partner in operational noise mitigation and follows noise abatement procedures as set forth in the *Fly Neighborly Guide* published by the Helicopter Association International. These procedures are consistent with advisory circular AC 91-66, Noise Abatement for Helicopters, developed by the Federal Aviation Administration (FAA), which provides guidelines for noise reduction when operating helicopters. The Helicopter Association International enhanced these guidelines as part of its *Fly Neighborly Guide*.

Specific provisions require pilots to maintain as high an altitude as possible on approach and as directed by air traffic control at the Portland Jetport. Final approach to the helipad is at a steep 12-15 degree angle to shorten the approach and flight time near the ground to lessen helicopter noise. Once on the helipad, pilots will generally spool down the aircraft (cooling the turbines for two minutes), or slow the rotors down, to either pick up or deliver the medical crew and patient. Helicopter sound levels decrease during the spool-down cycle and will drop by 10 dBA within 30 seconds after landing on the helipad. When departing, pilots use the best rate of climb (four to eight degree angle) from the helipad and follow approved flight paths until attaining a minimum altitude of 500 feet.

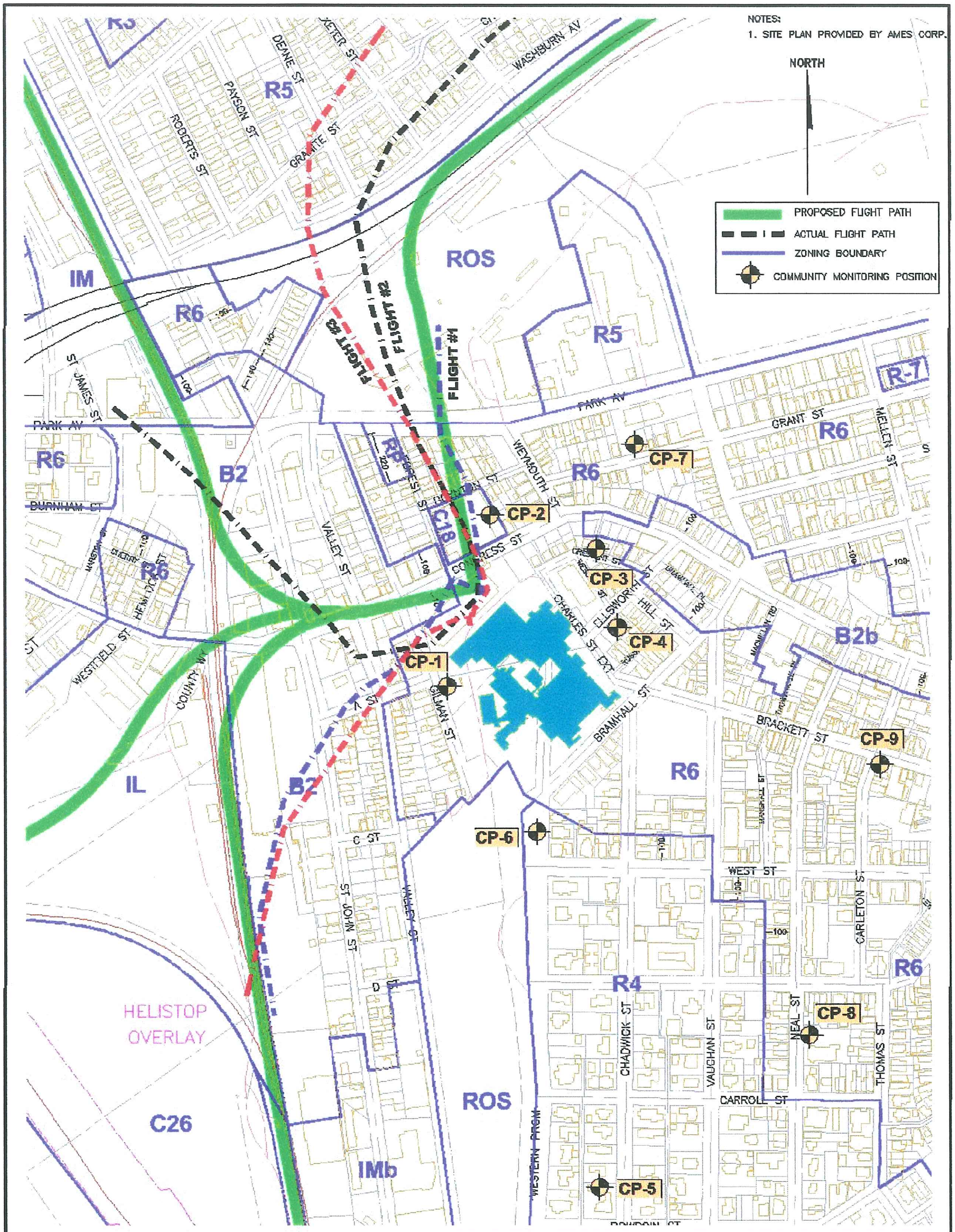
The FAA prescribes noise standards for certification of aircraft, including helicopters, in 14 CFR Part 36 (Noise Standards: Aircraft Type and Airworthiness). In order to receive certification, the aircraft manufacturer must demonstrate compliance with applicable takeoff, flyover, and approach noise levels of Part 36. More stringent noise limits apply to aircraft certifications after March 1986. Helicopters that demonstrate compliance with established noise limits meet the criteria for Stage 2 helicopters.

The specific aircraft currently used by LifeFlight of Maine are 1991 Agusta A-109C helicopters, which have a maximum takeoff weight of 5,997 pounds. RSE understands that the Agusta A-109C has been measured and certified in accordance with 14 CFR 36 and is a Stage 2 helicopter. The aircraft also complies with limits set by the International Civil Air Organization (ICAO), which are substantially equivalent to the applicable sections of 14 CFR 36. Sound levels measured for the Agusta A-109C are 2 to 5 dB below the ICAO limit.

5.2 Flight Testing

LifeFlight of Maine conducted flight testing in order to measure helicopter sound levels likely to be generated during medical flights. LifeFlight conducted flight testing at Maine Medical Center on September 13, 2003. The primary objectives in Portland were to simulate helipad flight operations for

FIGURE 1 VICINITY SITE PLAN



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MAINE MEDICAL CENTER
VICINITY SITE PLAN
PORTLAND, MAINE

DWG NO.: VSP-01
PROJECT: 010120
DRWN: RHM
CHECK: RSB

SHEET: 1 OF 1
REV: 1
DATE: 4-14-04
APP'D:

observation by local residents and to monitor resulting community and hospital sound levels. Monitoring results of the flight tests help to quantify sound levels as observed by the residents. Further, the results provide a basis for validating the noise prediction model at various receiver sites. Monitoring procedures, instrumentation and results from flight testing at Maine Medical Center can be found in *Community And LifeFlight Helicopter Sound Level Study* by RSE dated April 15, 2004.

Flight testing at Eastern Maine Medical Center was conducted in 1998 at the former helicopter landing site in an open parking lot to quantify helicopter noise during takeoff and landing procedures. In addition, measurements of sound level directivity were taken of the helicopter while hovering above the landing site.

RSE worked with LifeFlight personnel to establish the timing and sequence of takeoff and approach procedures when most of the noise associated with helipad operations will occur. Test flights were conducted to simulate the takeoff and approach of a typical medical flight from the proposed helipad. One objective of the flight testing was to monitor sound levels likely to be generated during future operation of the proposed helipad. Pilots followed standard operating procedures for noise avoidance and reduction as established by LifeFlight in accordance with the *Fly Neighborly Guide*.

The duration of *takeoff* (from cold startup to fly away) was approximately five minutes (5:00) resulting in an L_{Aeq} of 86.1 dBA at approximately 200 feet from the landing site and flight path. The time from startup to liftoff was 3:45 (mm:ss), or 75% of the time required to complete the takeoff sequence. The approach and landing sequence took approximately four minutes (4:00) resulting in an L_{Aeq} of 85.5 dBA. The period from touchdown to shutdown was 2:00, or 50% of the time required to complete the approach and landing sequence. The overall L_{Aeq} for the takeoff and approach for a round trip flight was 85.8 dBA for a period of nine minutes (9:00). Of these nine minutes, the amount of time spent on the helipad was 5:45, or 64% of the total time that the helicopter operated on or in very close proximity to the helipad.

Octave band and directional sound levels were measured with the helicopter hovering above the ground-level landing site. While hovering, the helicopter rotated its position so that sound level readings could be taken at eight compass points. The L_{Aeq}s at various angles ranged from 88 to 95 dBA. Octave band sound levels were measured at 200 feet from the left side of the hovering aircraft.

Sound instrumentation used for flight testing at Eastern Maine Medical Center consisted of a Larson Davis 812 Integrating Sound Level meter equipped with a Bruel & Kjaer 4155 microphone, and a B&K 2231 Precision Sound Level Meter equipped with a B&K 4155 microphone. A Bruel & Kjaer 1625 Octave Band Filter was used to record octave band sound levels from the helicopter.

5.3 Noise Model

RSE completed a study of future sound levels associated with operation of the proposed helipad at MMC. This analysis consisted of monitoring helicopter test flights, developing a sound level prediction model for MMC, and evaluating various noise mitigation options.

In order to estimate future sound levels at surrounding land uses, RSE developed a sound level prediction (noise) model for Maine Medical Center. The noise model was developed using the Computer Aided Noise Abatement (CADNA) software program by DataKustik to map terrain and existing structures in three-dimensions, locate the helipad and other components of the proposed Phase I expansion, define helicopter sound levels, and calculate outdoor sound propagation to surrounding land uses. Distances and elevations for use in the model were imported from topographic site plans prepared by The Ritchie Organization and Sebago Technics.

The CADNA model calculates sound propagation and attenuation according to standardized procedures as set forth in International Organization for Standardization ISO 9613 *Acoustics – Attenuation of Sound During Propagation Outdoors.* Attenuation components consist of distance, atmospheric absorption, barrier insertion loss, and shielding. Second order reflection was used to account for reflection of sound from nearby structures.

The octave band sound levels from flight testing at EMMC were used in the noise model with broadband adjustments to reflect takeoff and approach sequences. Octave band measurements were taken during flight testing at MMC, however, the aircraft flown was a BK 117, which is a backup helicopter to the Agusta 109C. Available noise performance data for the BK 117 and Agusta 109C indicates that the BK 117 is slightly louder by 0.6 dBA. Monitoring results and field observations provided data concerning the amount of on-pad and flight time associated with a typical flight mission.

5.4 Additional Noise Mitigation Options

Sound level estimates were developed for the helipad site with various construction and mitigation options. Many model cases were run to investigate a myriad of possible mitigation options. These included relocating the helipad on the top of the existing parking garage, the orientation of the helicopter while on the pad, and construction of sound barriers to block the sound path to nearby residential properties to the north.

5.4.1 Constraints

Constraints related to helipad access and safety were a limiting factor to the placement of potential sound barriers. These constraints were described in a Heliport Criteria - Working Document issued by TRO on June 26, 2003. The working document provides a list of criteria taken directly from FAA Advisory Circular No. 150/539-2 Heliport Design. Summaries of the constraints are as follows:

a. Final Approach and Takeoff Area (FATO) – Objects and structures should be outside the FATO to permit a clear approach/takeoff path aligned with prevailing winds. The size of the FATO is 1.5 times the overall length of the largest aircraft that may use the helipad. For the proposed helipad, the FATO is a circle with a diameter of 97.5 feet.

b. Safety Area – An 18-foot extension of the FATO and should be clear of objects and structures (e.g. parked autos and elevator towers). The overall diameter of the FATO and safety area is 133.5 feet.

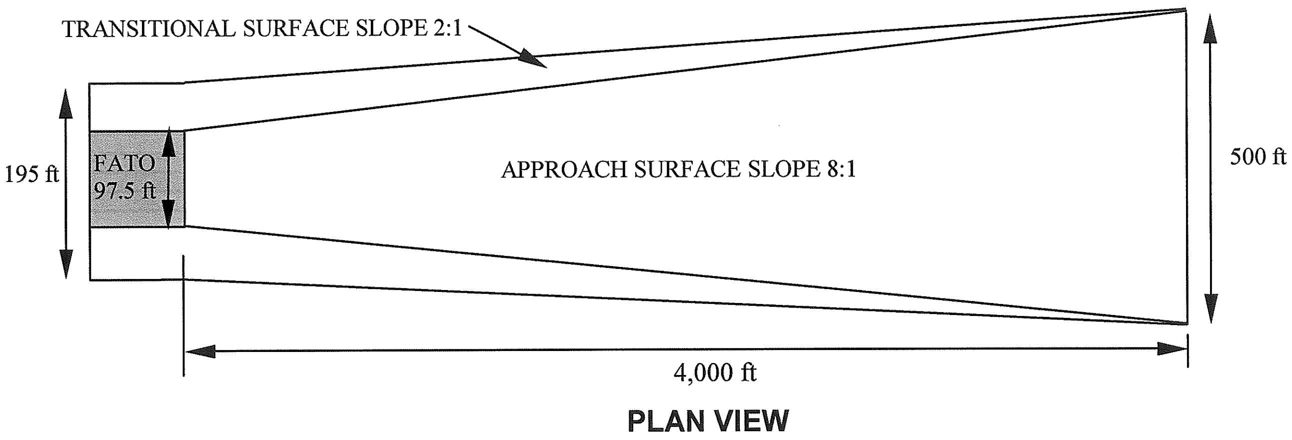
c. Touchdown and Lift-Off Area (TLOF) – This defines the size of the helicopter landing pad to accommodate the largest planned aircraft. The TLOF has a slip resistant surface and can support 1.5 times the weight of the design helicopter. The TLOF for the proposed helipad is 60 by 60 foot square. Adding a gutter system and safety net, results in a total pad size of nearly 72 by 72 feet.

d. Approach Surface – Two flight paths (approaches) are planned for the proposed helipad. Approach A is from the north and Approach B is from the west. For each approach, the "approach surface" is established that extends 4,000 feet from the edge of the FATO at a slope of 8 to 1 (horizontal to vertical). The starting width of the approach surface matches the FATO, which is 97.5 feet for the proposed helipad. The ending width of the approach surface, 4,000 feet from the FATO, is 500 feet. No structures, such as noise barriers or elevator towers are permitted above the approach surface.

e. Transitional Surface – the transitional surface borders the FATO plus the 4,000-foot length of each approach surface. The width of the transitional surface begins at 48.75 feet (half the FATO) and converges at the 500-foot width point of the approach surface. The slope of the transitional surface is 2 to 1.

The following diagram (Figure 2) shows a layout of the FATO, Safety Area, Approach Surface, and Transitional Surface for one approach path of the proposed helipad.

FIGURE 2 – Helipad Safety and Approach Zones



The second approach from the west is nearly perpendicular to the approach from the north, which provides additional restrictions from those shown in Figure 2. The helipad safety and approach zones restrict the location of potential structures near the helipad and consequently limit opportunities for additional noise mitigation. The FAA restrictions moved the helipad further west of the new elevator tower resulting in additional noise reduction due to existing and proposed structures.

5.4.2 Barrier Options

Placing effective noise barriers on the existing garage within these constraints would require a combination of horizontal, sloped and vertical barriers. Barrier analysis began with some “oversized” structures that would not be practical to construct but would provide noise reduction. Next, the barriers were optimized to reduce their size as much as possible yet still achieve meaningful noise reduction from helipad operations.

Various barrier design and mitigation options were compared with sound levels expected from the helipad design that was the outcome of the site selection process. For each case, the noise source was located at the north edge of the pad (helicopter facing MMC) and the noise source located at the center of the helipad (helicopter facing both north and south). Noise barriers were modeled as sound absorbing and the helipad surface as reflective.

When considering noise mitigation options, surrounding buildings were modeled as reflective surfaces and then compared to buildings with absorptive surfaces. This comparison showed no significant change in community sound levels due to reflection of sound waves from MMC buildings.

The following model cases were selected to represent the extensive options modeled as part of the mitigation analysis:

Case 001 Existing Site Conditions Plus the Proposed Helipad and New Elevator

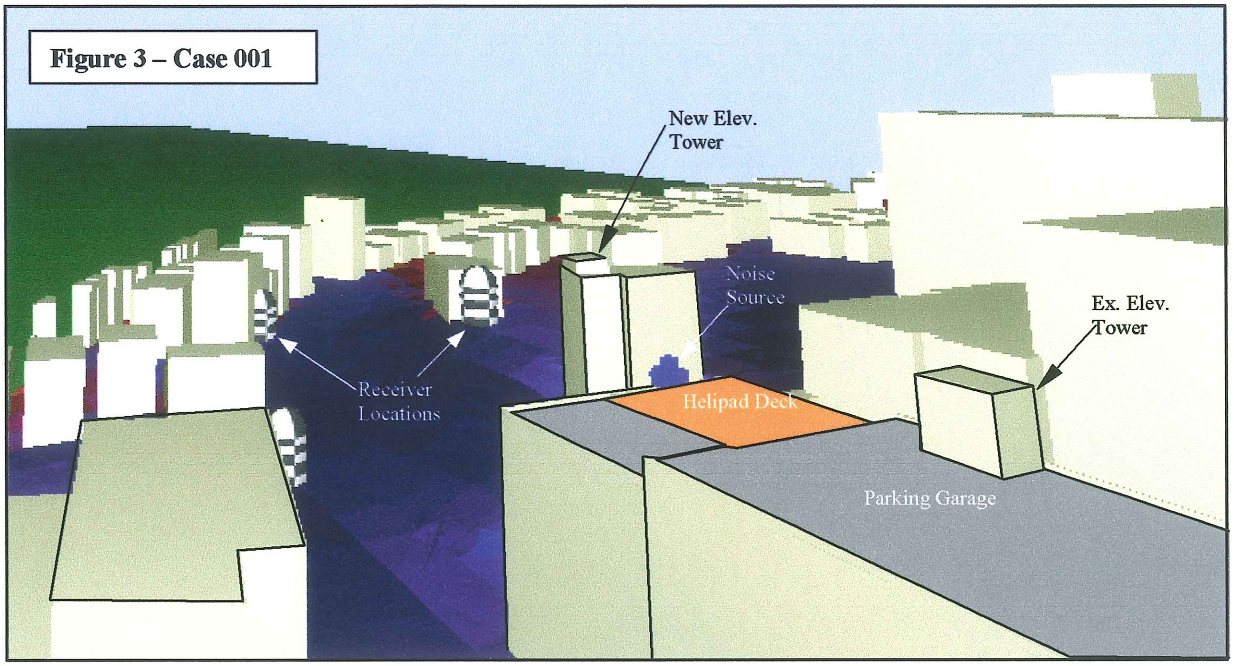


Figure 3 – Case 001

Case 002 Helipad with Construction of the Phase I Expansion

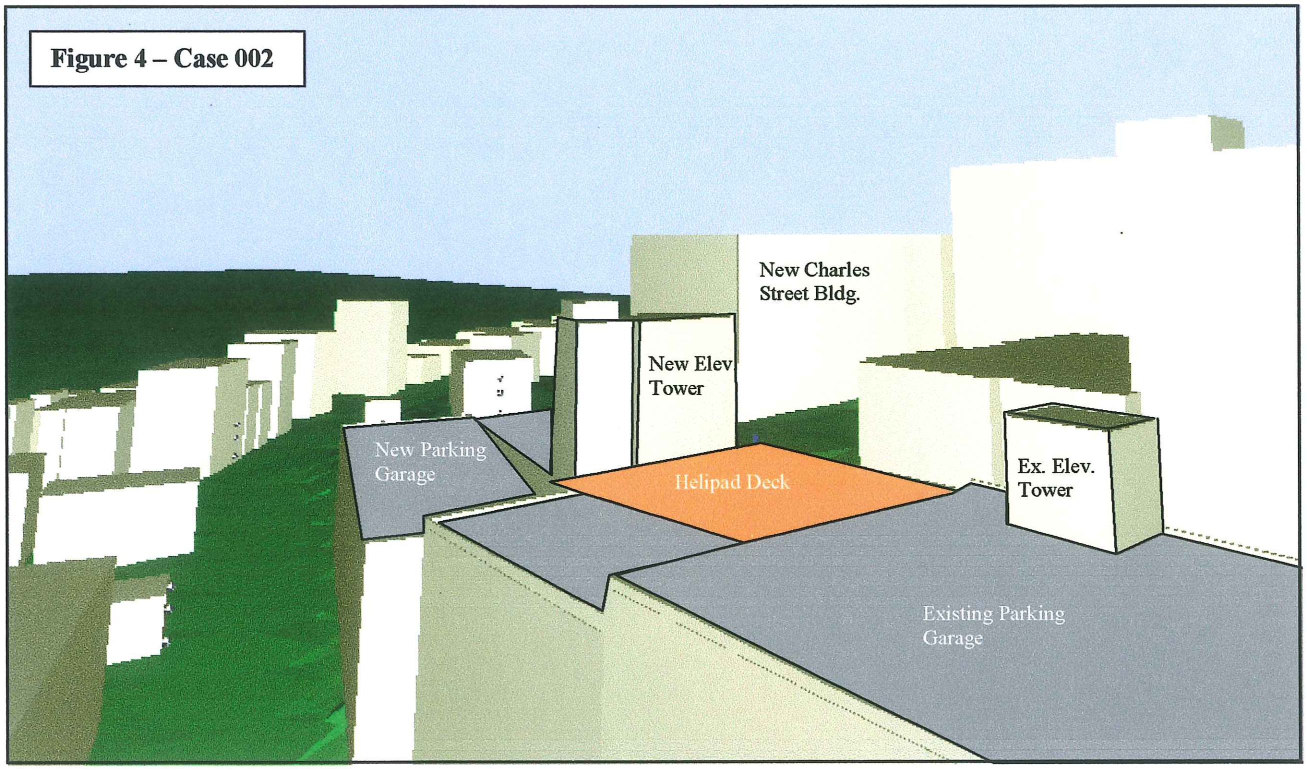


Figure 4 – Case 002

Case 003 Helipad with Phase I Expansion (Case 002) plus Sloped and Vertical Barriers

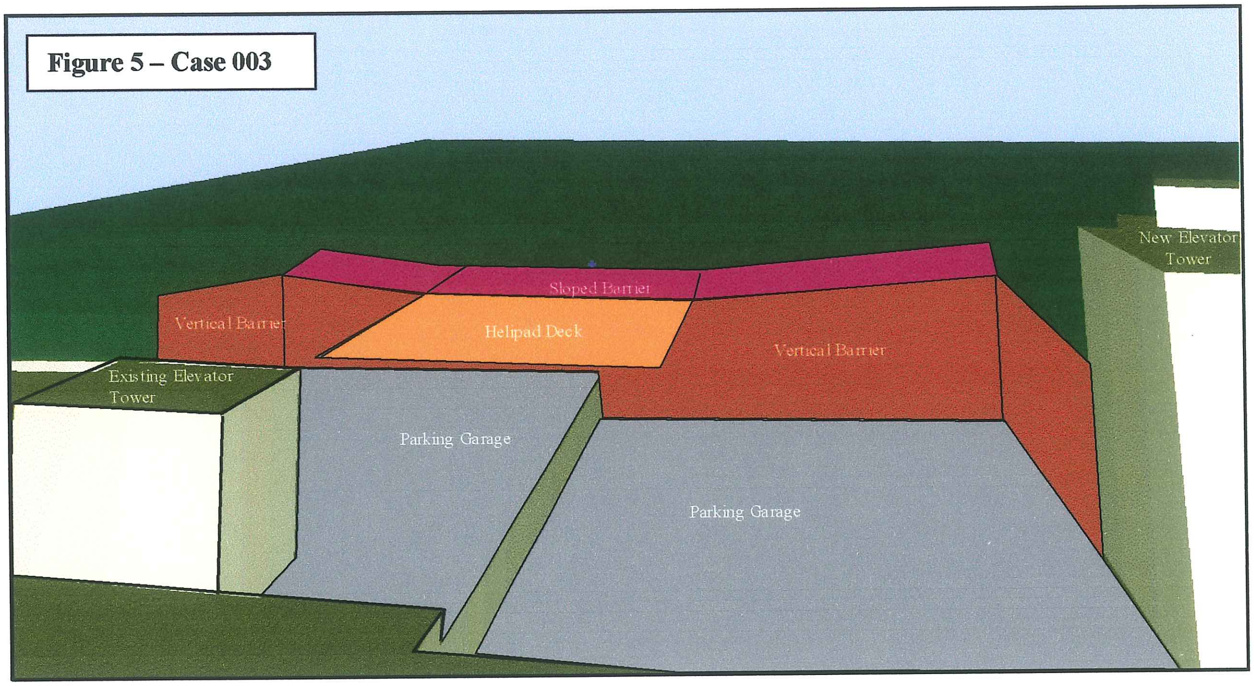


Figure 5 – Case 003

Case 004 Helipad with Phase I Expansion (Case 002) plus Sloped Noise Barriers

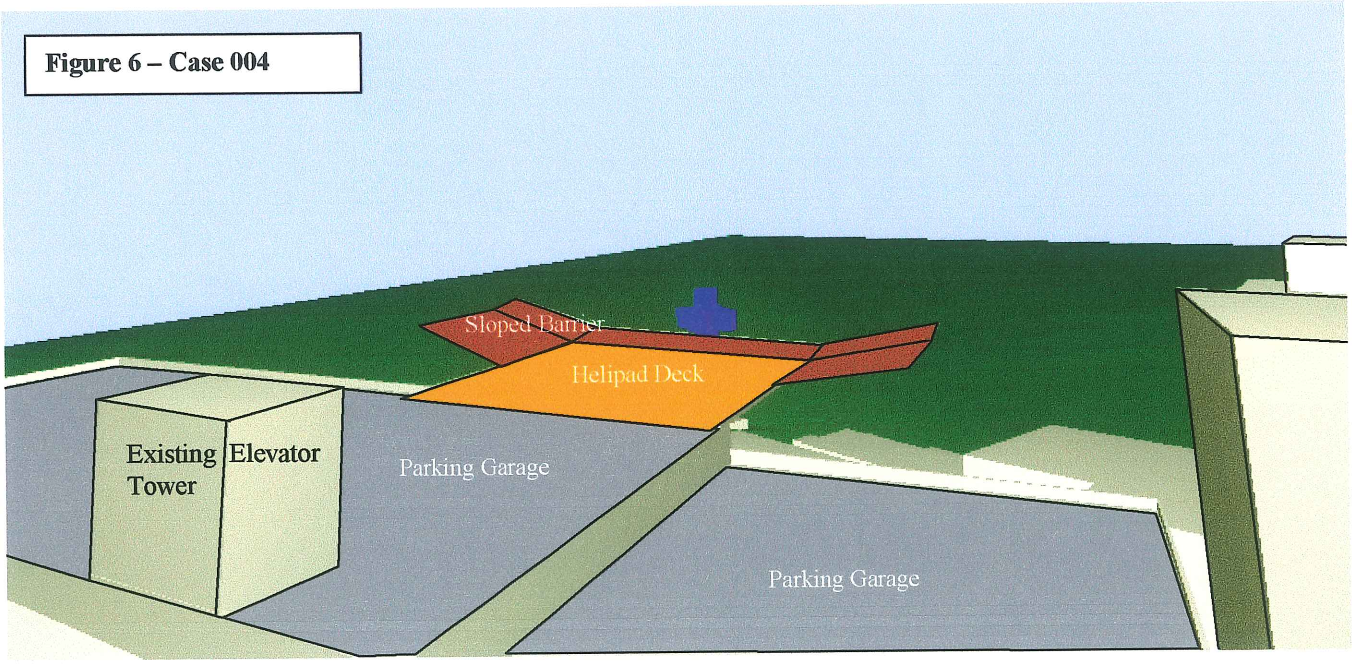


Figure 6 – Case 004

5.5 Mitigation Sound Level Estimates

Comparing Cases 001 and 002 shows the change in sound levels at the community monitoring positions that result from construction of the Charles Street Building. The following Table 2 provides this comparison:

Table 2
Helipad Sound Levels (dBA)
Case 001 vs Case 002

Receiver Position	Ht. Above Ground	Case 001 Center	Case 002 Center	dBA Change
CP-1	5	71	71	0
CP-2	5	71	71	0
CP-3	5	67	67	0
CP-4	5	75	56	-19
CP-6	5	54	54	0
CP-7	5	59	59	0

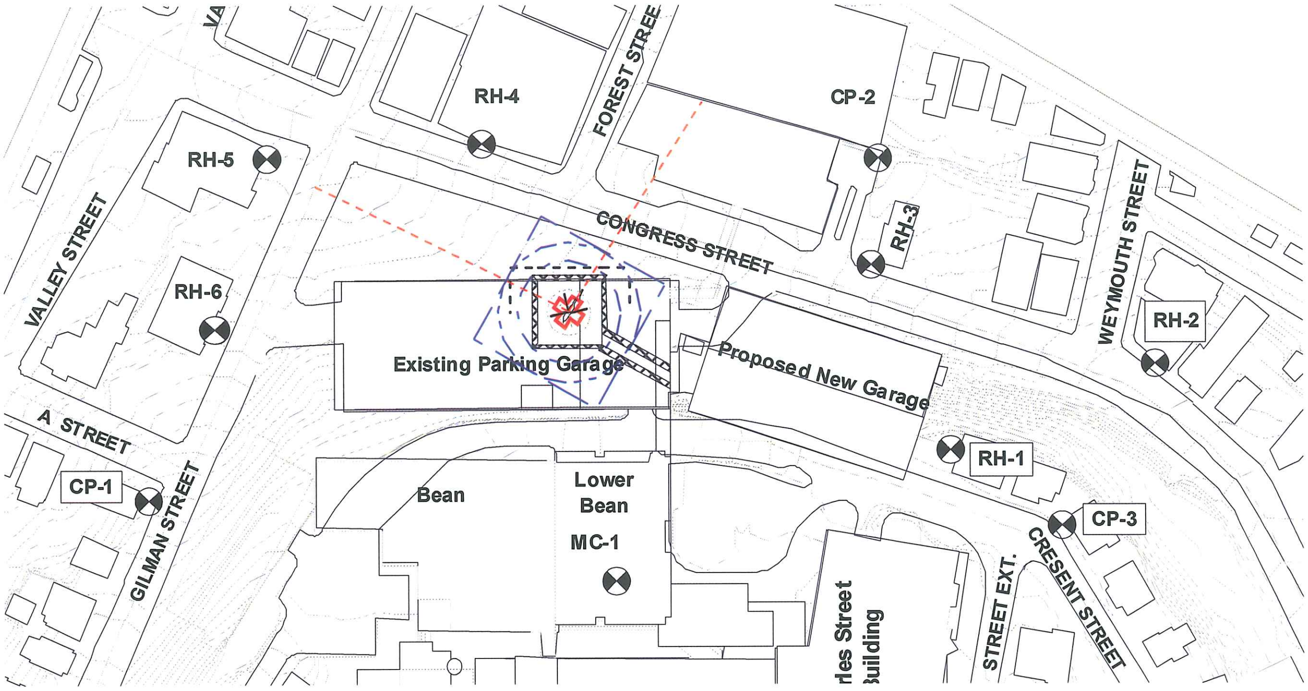
As expected, construction of the Charles Street Building significantly reduces sound levels in the vicinity of Position CP-4, Ellsworth Street and generally in a southeasterly direction.

The following Table 3 provides a comparison of Case 002 sound levels with the helicopter facing south toward MMC and with the helicopter facing north toward across Congress Street. The receiver positions presented in Table 3 represent the nearest residential properties to the existing parking garage and are shown on Figure 7.

Table 3
Helipad Sound Levels (dBA)
Case 002 North vs Case 002 South

Receiver Position	Ht. Above Ground (ft)	Case 002 Facing South	Case 002 Facing North	dBA Change
RH-1	5	79	73	-6
	16	79	73	-6
	24	79	73	-6
RH-2	5	78	78	0
	16	81	77	-4
	24	81	80	-1
RH-3	5	84	76	-8
	16	83	80	-3
	24	84	82	-2
RH-4	5	87	76	-11
	16	89	77	-12
	24	86	78	-8
RH-5	5	82	79	-3
	16	83	80	-3
	24	84	80	-4
RH-6	5	69	68	-1
	16	69	69	0
	24	70	70	0

FIGURE 7 - Noise Model Receiver Positions



Model estimates show sound level reductions up to 12 dBA with the helicopter operating on the pad facing north and the tail toward the hospital. This landing configuration allows the helipad and parking garage to block noise in the direction of residential land uses to the north. Further, the largest reductions occur at receivers where the highest helipad sound levels were predicted. This is a significant reduction considering that the helicopter spends most of its time operating on the pad when in close proximity to the hospital. Based on prevailing winds, RSE understands that the helicopter will normally land facing north with its tail rotor toward the hospital. With the tail toward the hospital the increase in sound levels at the hospital is negligible (less than 0.5 dBA).

The following comparison shows the additional noise reduction that could be achieved with implementation of the noise mitigation measures evaluated as model Case 003. In addition to construction of the Phase I expansion, Case 003 adds large vertical and sloped barriers to the helipad and the top of the existing garage (See Figure 5). The vertical barriers wrap around three sides of the helipad and range in height from 19 feet west of the helipad to 26 feet east of the helipad. The sloped barriers extend 20 feet north from the edge of the helipad at a slope of 8 to 1, following the approach surface. Table 4 compares helipad sound levels from Case 002 (Phase I expansion) and Case 003 (Phase I expansion plus vertical and sloped barriers).

Table 4
Helipad Sound Levels (dBA)
Case 002 (Phase I Expansion) vs Case 003 (Phase I Expansion Plus Vertical and Sloped Barriers)

Receiver Position	Ht. Above Ground (ft)	Case 002 Facing South	Case 003 Facing South	dBA Change	Case 002 Facing North	Case 003 Facing North	dBA Change
RH-1	5	79	68	-11	73	69	-4
	16	79	68	-11	73	69	-4
	24	79	68	-11	73	69	-4
RH-2	5	78	73	-5	78	72	-6
	16	81	74	-7	77	73	-4
	24	81	74	-7	80	74	-6
RH-3	5	84	74	-10	76	71	-5
	16	83	75	-8	80	71	-9
	24	84	75	-9	82	72	-11
RH-4	5	87	78	-9	76	72	-4
	16	89	79	-10	77	73	-4
	24	86	80	-6	78	73	-5
RH-5	5	82	76	-6	79	69	-10
	16	83	77	-6	80	70	-10
	24	84	77	-7	80	70	-10
RH-6	5	69	67	-2	68	68	0
	16	69	67	-2	69	69	0
	24	70	68	-2	70	69	-1

Table 4 shows that reductions of up to 11 dBA could be achieved with large barrier structures modeled as Case 003. Although such a barrier system may be viable for a ground-based helipad, RSE understands that the structural requirements alone would present a major obstacle to construction of this type of barrier system on the top of the existing garage. Further, the noise reductions for Case 003 with the helicopter facing south would provide no more attenuation than facing the aircraft to the north.

The final mitigation comparison shows the noise reduction that could be achieved with a more practical noise barrier system modeled as Case 004 (Helipad with Phase I Expansion plus Sloped Noise Barriers to the North, East and West) shown as Figure 6. The sloped barriers extend along the approach surface approximately 20 feet from the edge of the helipad toward the north and 26 feet along the approach surface to the east and west sides of the helipad. Table 5 provides a comparison of this case with Case 002 (Phase I Expansion).

This comparison shows noise reduction for Case 004 of up to 7 dBA with the helicopter facing south and up to 8 dBA while facing north. Again the noise model shows that rotating the aircraft to face north will result in greater noise reduction than implementing the Case 004 barrier (with the helicopter facing south). The additional reduction provided by the Case 004 barrier with the helicopter facing north will provide the most attenuation (8 dB) to receiver RH-5. Noise reduction at other receivers is less and overall sound levels are not significantly less than Case 002 facing north.

Table 5
Helipad Sound Levels (dBA)
Case 002 (Phase I Expansion) vs Case 004 (Phase I Expansion Plus Sloped Barriers)

Receiver Position	Ht. Above Ground (ft)	Case 002 Facing South	Case 004 Facing South	dB Change	Case 002 Facing North	Case 004 Facing North	dB Change
RH-1	5	79	79	0	73	73	0
	16	79	79	0	73	73	0
	24	79	79	0	73	73	0
RH-2	5	78	75	-3	78	78	0
	16	81	77	-4	77	77	0
	24	81	76	-5	80	80	0
RH-3	5	84	76	-8	76	73	-3
	16	83	77	-6	80	74	-6
	24	84	78	-6	82	81	-1
RH-4	5	87	80	-7	76	73	-3
	16	89	82	-7	77	74	-3
	24	86	84	-2	78	74	-4
RH-5	5	82	78	-4	79	71	-8
	16	83	79	-4	80	72	-8
	24	84	79	-5	80	72	-8
RH-6	5	69	67	-2	68	68	0
	16	69	67	-2	69	69	0
	24	70	68	-2	70	69	-1

Sound level contour maps of each model case can be found in Appendix I.

6.0 SUMMARY AND CONCLUSIONS

The primary objectives of the Noise Mitigation Study were to assist Maine Medical Center in selecting a site for the proposed helipad that would limit noise impact and to investigate additional noise control options to ensure that all practical noise mitigation was being incorporated into helipad design and operations. The helipad site and associated flight paths were carefully selected based on sound level estimates and community monitoring results to limit noise impact. Further refinement and analysis of the noise model estimates showed that the best mitigation option is to face the helicopter toward the north whenever possible during operation on or in close-range to the helipad. Due to prevailing winds the helicopter will typically land facing north.

Further, FAA design criteria were found to significantly restrict opportunities for additional mitigation using noise barriers. Through development and analysis of mitigation options, RSE found that an effective noise barrier, serving all areas not mitigated by new structures at MMC, would be too large to be practical for construction. Smaller noise barriers, such as Case 004, would provide no significant additional noise reduction to all areas not mitigated by new construction or by facing the helicopter northerly while on or in close range to the helipad.

During the Noise Mitigation Study, RSE also found that:

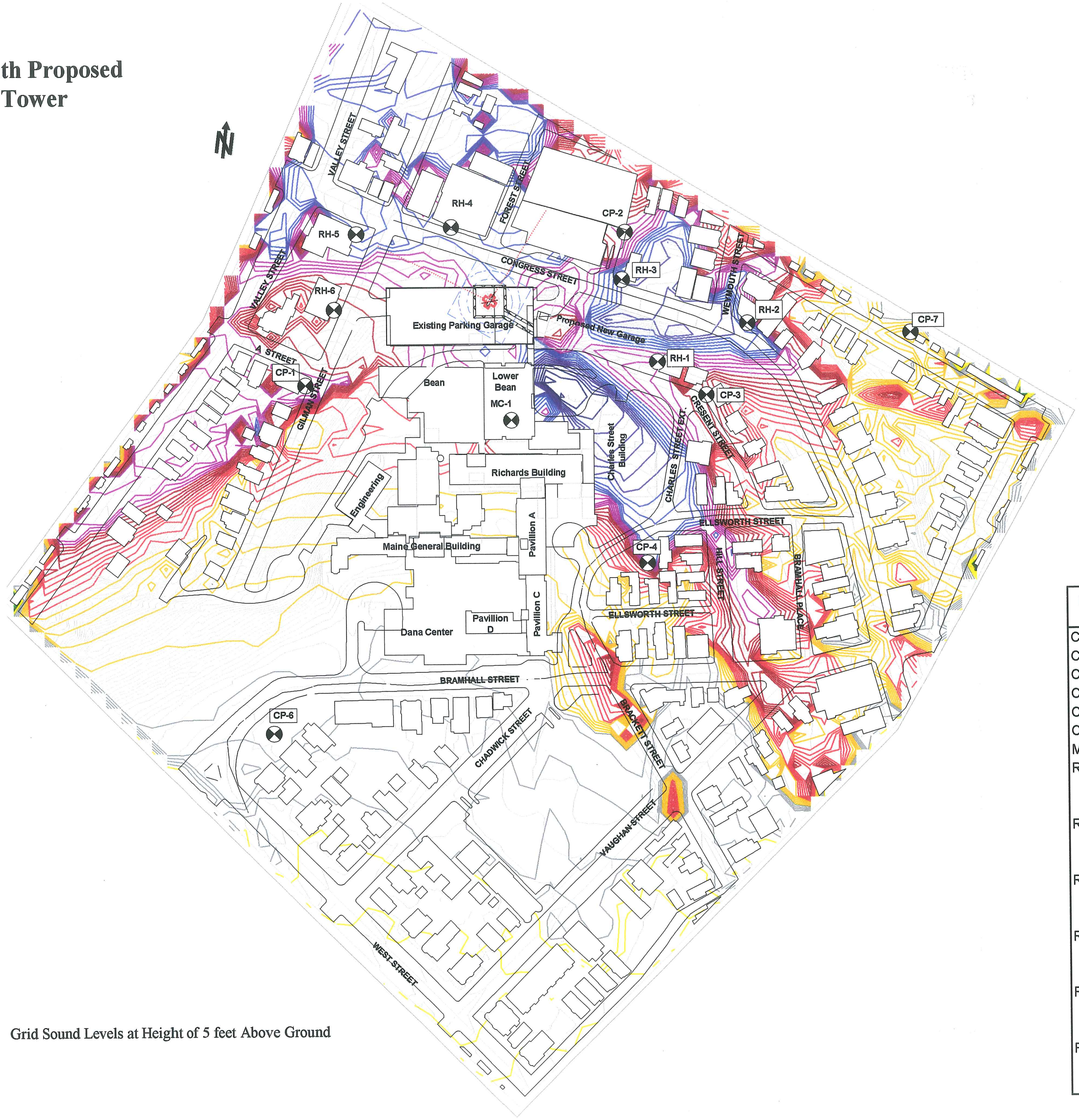
1. FAA design criteria were inherently aligned to the optimum location of the helipad on the existing garage for noise reduction from existing and proposed structures.

2. Because of area topography and the barrier effect of the existing garage, there was no significant sound level reduction from absorptive versus reflective surfaces of MMC buildings.

APPENDIX I
SOUND LEVEL CONTOUR MAPS

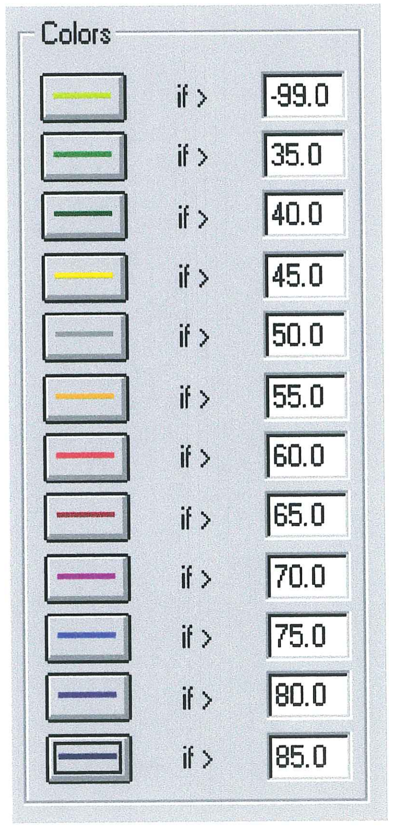
MMC Case 001

Existing Site Conditions with Proposed Helipad and New Elevator Tower



Grid Sound Levels at Height of 5 feet Above Ground

Sound Level Key (dBA)



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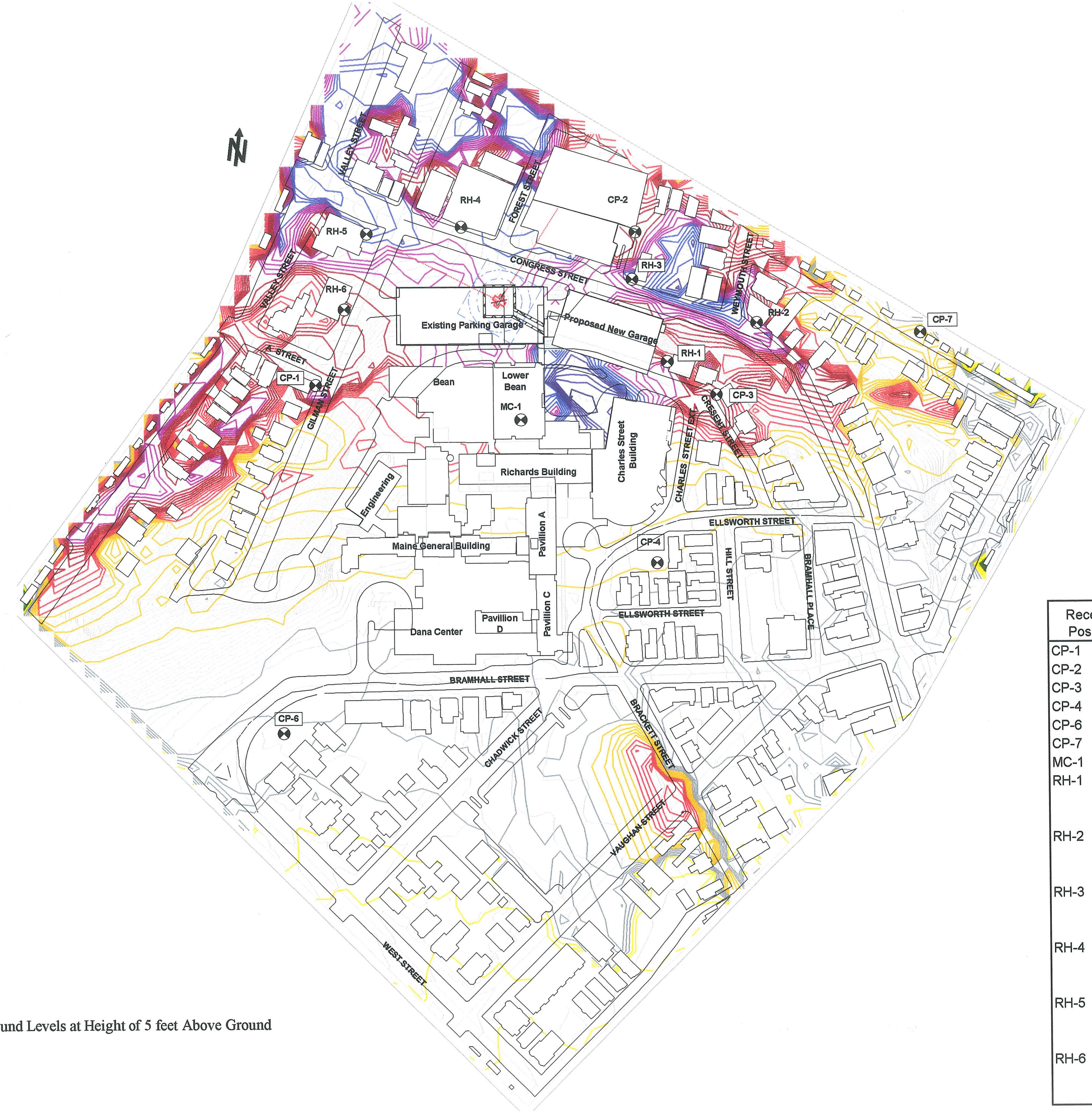
Receiver Position	Ht. Above Ground (ft)	Case 001 Facing North
CP-1	5	71
CP-2	18	71
CP-3	5	67
CP-4	5	75
CP-6	5	54
CP-7	5	59
MC-1	31	86
RH-1	5	73
	16	73
	24	73
RH-2	5	80
	16	81
	24	81
RH-3	5	78
	16	81
	24	82
RH-4	5	76
	16	77
	24	78
RH-5	5	79
	16	80
	24	80
RH-6	5	68
	16	69
	24	70

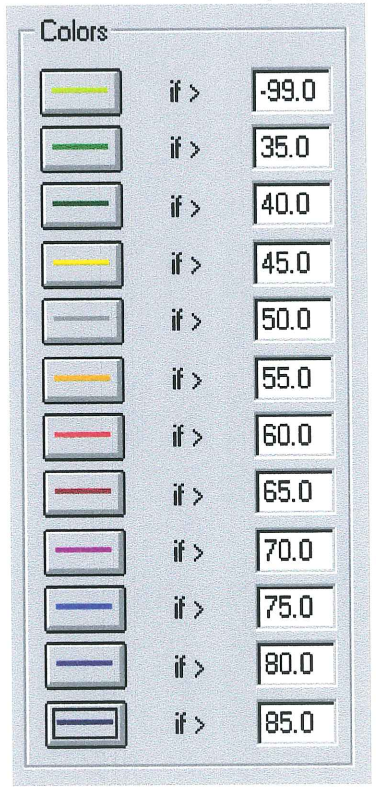
MMC Case 002

Proposed Helipad with Full Construction of Phase I Expansion



Grid Sound Levels at Height of 5 feet Above Ground

Sound Level Key (dBA)



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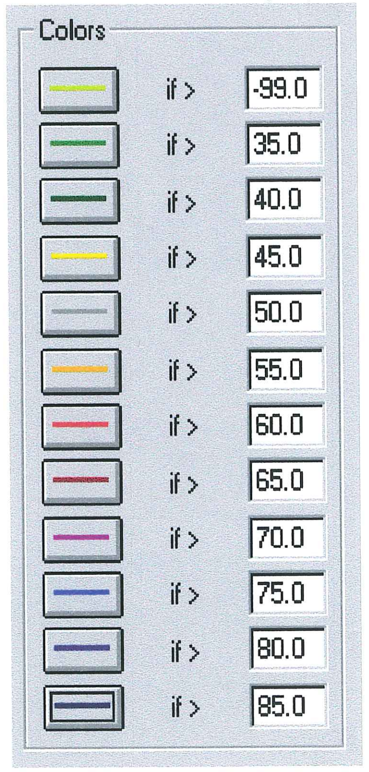
Receiver Position	Ht. Above Ground (ft)	Case 002 Facing North
CP-1	5	71
CP-2	18	71
CP-3	5	67
CP-4	5	56
CP-6	5	54
CP-7	5	59
MC-1	31	86
RH-1	5	73
	16	73
	24	73
RH-2	5	78
	16	77
	24	80
RH-3	5	76
	16	80
	24	82
RH-4	5	76
	16	77
	24	78
RH-5	5	79
	16	80
	24	80
RH-6	5	68
	16	69
	24	70

MMC Case 003

Helipad with Phase I Expansion plus Sloped and Vertical Barriers

Grid Sound Levels at Height of 5 feet Above Ground

Sound Level Key (dBA)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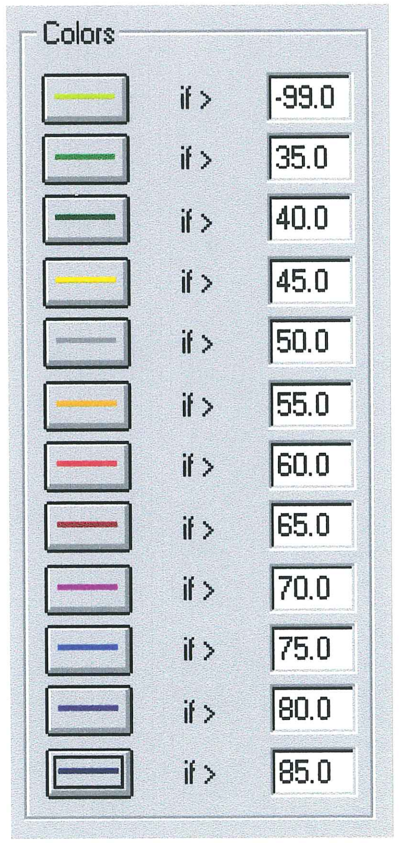
Receiver Position	Ht. Above Ground (ft)	Case 003 Facing North
CP-1	5	70
CP-2	18	64
CP-3	5	67
CP-4	5	56
CP-6	5	54
CP-7	5	58
MC-1	31	86
RH-1	5	69
	16	69
	24	69
RH-2	5	72
	16	73
	24	74
RH-3	5	71
	16	71
	24	72
RH-4	5	73
	16	74
	24	74
RH-5	5	70
	16	70
	24	71
RH-6	5	68
	16	69
	24	69

MMC Case 004

Helipad with Phase I Expansion Plus Sloped Noise Barriers

Grid Sound Levels at Height of 5 feet Above Ground

Sound Level Key (dBA)



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🟥	if >	65.0
🟪	if >	70.0
🟦	if >	75.0
🟦	if >	80.0
🟦	if >	85.0

Receiver Position	Ht. Above Ground (ft)	Case 004 Facing North
CP-1	5	70
CP-2	18	68
CP-3	5	67
CP-4	5	56
CP-6	5	54
CP-7	5	59
MC-1	31	86
RH-1	5	73
	16	73
	24	73
RH-2	5	78
	16	77
	24	80
RH-3	5	73
	16	74
	24	81
RH-4	5	73
	16	74
	24	74
RH-5	5	71
	16	72
	24	72
RH-6	5	68
	16	69
	24	69

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MAINE MEDICAL CENTER
PORTLAND, MAINE

COMMUNITY AND LIFEFLIGHT HELICOPTER SOUND LEVEL STUDY

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Project No. 010120

APRIL 15, 2004

Resource
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Brunswick, Maine

Resource
Systems
Engineering

April 15, 2004
File 010120/2.5.5.2

Maine Medical Center
22 Bramhall Street
Portland, Maine

ATTENTION: Hank Dunn, P.E.

REFERENCE: Proposed Helipad

SUBJECT: Community and LifeFlight Helicopter Sound Level Study – Final Report

Dear Mr. Dunn:

The enclosed final report provides a summary of community and hospital sound levels measured under existing ambient conditions and during helicopter flight tests. The final report incorporates revisions to the draft report dated October 30, 2003 and compares ambient and flight test conditions on a five-second and one-minute basis. The objective of the comparisons in the report is to show the effect of helicopter flights as short-term events. This is in contrast to state and federal regulations that employ sound level metrics for longer time periods.

The Maine Department of Environmental Protection (DEP) applies an hourly equivalent sound level (L_{Aeq}) as the primary basis for compliance. The Federal Aviation Administration (FAA) utilizes a yearly 24-hour day-night sound level (L_{dn}). These sound metrics spread the sound energy of flight events over longer time periods in order to quantify changes in community sound levels.

The test flights involved hovering over the proposed helipad site and did not include the quieter spool down and startup/warm-up cycles of an actual medical flight. Actual medical flights will differ from the test flights monitored on September 13, 2003, which each lasted approximately one minute at the proposed helipad site. For flight test events, the final report presents short-term sound level measurements but does not calculate the hourly equivalent sound level of the Maine DEP or the 24-hour day-night sound level of the FAA. To supplement the final report, the following provides calculations of hourly L_{Aeq} and L_{dn} sound levels based on the flight test results.

RSE understands that the proposed helipad at Maine Medical Center will average approximately one flight per day on an annual basis. The period of helicopter operation for each flight is expected to be approximately four minutes for approach, landing, and spool down, and approximately five minutes from the beginning of cold startup through liftoff and close-range flight. Combining approach and departure times of one medical flight, this gives a total of nine minutes of close-range helicopter operation per flight. One-minute L_{Aeq} data from the flight tests are higher than sound levels expected to occur during the spool down and startup/warmup sequences of proposed helipad operations. Calculation of hourly L_{Aeq} sound levels is based on eight minutes of helicopter operating time occurring over one hour. Similarly, calculation of 24-hour L_{dn} sound levels is based on eight minutes of helicopter operating time occurring over 24 hours.

The following tables present hourly and day-night sound levels calculated based on measurements from the flight tests.

Comparison of Maine DEP Hourly Ambient and Flight Test Sound Levels (L_{Aeq})

	Average Ambient Hourly L_{Aeq}		Flight Test Sound Levels[a]		Difference in Hourly L_{Aeq}	
Position	**Day**	**Night**	**1-Min L_{Aeq}**	**Hourly L_{Aeq}**	**Day**	**Night**
CP-1	60	57	75	66	+6	+9
CP-2	61	57	82	73	+12	+16
CP-3	57	54	75	66	+9	+12
CP-4	57	55	73	64	+7	+9
CP-5	52	48	60	51	-1	+3
CP-6	57	55	66	57	0	+2
CP-7[c]	58	55	66	57	-1	+2
CP-8[c]	52	49	57	48	-4	-1
CP-9[c]	58	55	59	50	-8	-3

Comparison of FAA Day-Night Ambient and Flight Test Sound Levels (L_{dn})

		Flight Test Sound Levels[b]		
Position	**FAA Day-Night Sound Level (L_{dn})**	**1-Min L_{Aeq}**	**Annual L_{dn}- 30% Night Flights**	**Difference in Annual L_{dn}**
CP-1	64	75	54	-10
CP-2	65	82	61	-4
CP-3	61	75	54	-7
CP-4	62	73	52	-10
CP-5	56	60	39	-17
CP-6	63	66	45	-18
CP-7[c]	62	66	45	-18
CP-8[c]	56	57	36	-20
CP-9[c]	62	59	38	-24

[a] *The 1-Min L_{Aeq} is the average of four flight test events and the hourly L_{Aeq} is based on an eight minute flight during 1 hour.*

[b] *The 1-Min L_{Aeq} is the average of four flight test events and the hourly L_{dn} is based on an eight minute flight during 24 hours.*

[c] *Ambient sound levels for positions CP-7 through CP-9 based on ambient monitoring before and after flight testing.*

The tables show that when a helicopter flight occurs during daytime hours and without any new buildings, the hourly sound level from the helicopter will differ from the average ambient sound level by –8 to +12 dBA. When a helicopter flight occurs during nighttime hours, the hourly sound level from the helicopter will differ from the average ambient by –3 to +16 dBA. However, when calculated as set forth by the FAA, the annual Ldn from helicopter operations will differ from the existing Ldn by –24 to –4 dBA. The annual Ldn for helicopter operations assumes that 30% of the medical flights will occur between the hours of 10 pm and 7 am.

Future helicopter sound levels will be lower in some areas due to blocking of the sound path from the proposed expansion. RSE's noise model will be used to determine the expected noise reductions from full build-out of the proposed expansion.

Sincerely,
Resource Systems Engineering

Charles F. Wallace, Jr., P.E.
President

R. Scott Bodwell, P.E.
Project Engineer

Enclosure

ACKNOWLEDGMENTS

Resource Systems Engineering wishes to thank personnel at Maine Medical Center and LifeFlight of Maine for their assistance and cooperation during conduct of the helicopter flight testing.

Resource Systems Engineering personnel responsible for this investigation and report are Charles F. Wallace, Jr., P.E., R. Scott Bodwell, P.E., Ann M. Vedock, Environmental/Acoustical Specialist and Ronald H. Mattson, CAD Technician/Acoustical Specialist.

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MAINE MEDICAL CENTER
COMMUNITY AND LIFEFLIGHT HELICOPTER
SOUND LEVEL STUDY

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5.0 Helicopter Flight Test Sound Levels 4
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7.0 Conclusions 9

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3 Comparison of Ambient Community and Flight Test Sound Levels One-Minute L_{Aeq}
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Set 3 MMC Monitoring Positions: 5-Second Results
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Glossary of Terms and Acronyms
Appendix I Summary of Federal, State and Local Noise Standards
Appendix II Community Monitoring Results December 18-19, 2002

MAINE MEDICAL CENTER
COMMUNITY AND LIFEFLIGHT HELICOPTER
SOUND LEVEL STUDY

1.0 INTRODUCTION

On Saturday, September 13, 2003, helicopter flights were conducted at Maine Medical Center to simulate future operation of the proposed helipad operation. The helicopter was flown by LifeFlight of Maine, who currently provides emergency medical helicopter transport to Eastern Maine Medical Center in Bangor and Central Maine Medical Center in Lewiston.

The objective of the flight testing was to compare helicopter sound levels with existing community and hospital sound levels. Previously, RSE had monitored community sound levels in the vicinity of the hospital for a 24-hour period covering December 18-19, 2002. During this period, monitoring was conducted at six community positions (CP-1 through CP-6). Three more community positions and four hospital positions were added for monitoring during the helicopter flight test. Sound levels at all hospital and community positions were measured before, during and after the helicopter flight test.

LifeFlight operates two Agusta 109C helicopters in Maine: one based in Bangor and one based in Lewiston. The Agusta 109C is expected to be the primary helicopter using the proposed helipad at MMC. Flight testing with an Agusta 109C was planned for the simulation; however, the helicopter was called to an emergency and was not available. In order to maintain the community schedule, a BK 117 backup helicopter was flown instead.

This report compares sound levels measured during flight tests with ambient community sound levels without the helicopter. The objective of this report is to compare measurement results of the helicopter flight test with existing ambient sound levels. The report does not include noise model predictions of future sound levels reflecting full build-out conditions or provide a comparison to local, state and federal noise standards.

2.0 MONITORING POSITIONS

During the flight test, monitoring was conducted at nine community positions and four hospital positions. Community monitoring positions were selected based on the results of area mapping, ownership and accessibility, and potential noise impacts from the helipad. Community mapping included identification of land uses and zoning in the vicinity of the Maine Medical Center.

The resulting vicinity site plan (Figure 1) provides a noise study map that delineates community monitoring positions in relation to structures and property boundaries of Maine Medical Center, structures and lot lines of property in the vicinity of MMC, existing land use and zoning designations, and the location of the proposed helipad and approach/departure routes.

The nine community monitoring positions are as follows:

CP-1	Gilman and A Street - West of MMC
CP-2	Congress and Weymouth Street - North of MMC
CP-3	Crescent and Wescott Street - Northeast of MMC
CP-4	Ellsworth and Charles Street Ext - East of MMC
CP-5	Bowdoin and Chadwick Street – South of MMC
CP-6	West Prom and West Street – South of MMC
CP-7	Grant Street (Parkside) – Northeast of MMC
CP-8	Neal Street – Southeast of MMC
CP-9	Brackett and Carleton Street – East of MMC

Hospital positions include three inside the hospital and one outside on a nearby rooftop. The interior positions were selected in conjunction with Maine Medical Center to represent areas of the hospital known to be sensitive to noise intrusion. The exterior position was selected for purposes of determining the transmission loss across the exterior walls of the hospital. The hospital positions are as follows:

MC-3E	Outside on the rooftop of the Lower Bean Building
MC-3I	Inside the NICU (Bean Building)
MC-5I	Inside the Newborn Nursery (Richards Tower)
MC-6I	Inside the Teen Room (Barbara Bush Hospital)

The hospital locations are shown on Figure 2 along with some of the closest community monitoring positions.

During the flight test monitoring, RSE personnel were stationed at community positions CP-3 (Crescent) and CP-6 (West Prom), and hospital positions MC-3I (NICU) and MC-5I (Nursery). RSE personnel recorded observations prior to, during, and after the flight testing.

3.0 NOISE STANDARDS

A review of federal, state and local noise standards indicates there is no specific noise standard that Maine Medical Center is required to meet during operation of the proposed helipad. The pertinent federal regulation is a voluntary guideline, the Maine DEP regulation exempts aircraft operation, and the Portland Code does not appear to regulate noise from uses in the R-6 zone. A brief summary of local, state and federal noise standards and their potential applicability to the proposed helipad can be found in Appendix I.

4.0 EXISTING COMMUNITY SOUND LEVELS

On December 18 and 19, 2002, sound levels in the vicinity of the proposed helipad were monitored for a 24-hour period to determine existing ambient sound levels. RSE monitored ambient sound levels at six monitoring positions CP-1 through CP-6 as shown on Figure 1, Vicinity Site Plan.

Instrumentation consisted of Larson-Davis Model 812 Integrating Sound Level Meters, which were programmed to continuously measure sound levels and calculate statistics at both hourly and one-second intervals. One Larson-Davis Model 824 Sound Level Meter and Real Time Analyzer was used to measure sound levels at position CP-3. It was programmed to continuously measure sound levels, including one-third octave band readings, and calculate statistics at both hourly and five-second intervals.

The sound level meters meet Type 1 (precision) performance requirements of American National Standard Institute Specification for Sound Level Meters, ANSI S1.4-1983. The microphones were fitted with standard windscreens and mounted on tripods at a height of four to five feet above the ground. The sound level meters were calibrated before and after the twenty-four hour monitoring period using a Bruel & Kjaer 4231 Sound Level Calibrator. Additionally, a certified laboratory performs a calibration within 12 months of the measurements. Calibration certificates are available upon request.

During monitoring on December 18-19, 2002, temperatures ranged from 19 to 42 degrees F; winds were generally from the northwest ranging from 3 to 8 mph during the day and 0 to 3 mph at night. Skies were clear.

Hourly sound level readings, including L_{Aeq}, L_{AFmax}, L_{Amin}, L_{A1}, L_{A10}, L_{A50} and L_{A90} values, are presented in Appendix II as Tables II-1 through II-6 and Figures II-1 through II-6. The L_{Aeq} represents the average energy level of all sounds present during the measurement period. The one-hour or hourly L_{Aeq} is the parameter specified for use by the Maine DEP and FAA for establishing pre-development ambient sound levels. The L_{AFmax} is the maximum A-weighted sound level, using fast time weighting, and L_{Amin} is the minimum A-weighted sound level during the hour. L_{A1} is the sound level exceeded 1% of time. Likewise, L_{A10}, L_{A50} and L_{A90} are the sound levels exceeded 10%, 50% and 90% of the time during the hour.

At CP-1, during Maine DEP daytime hours (7 am to 7 pm), hourly L_{Aeq} readings ranged from 58 to 63 dBA with an average of 60 dBA. During Maine DEP nighttime hours (7 pm to 7 am), hourly L_{Aeq} readings ranged from 54 to 62 dBA with an average of 57 dBA.

At CP-2, during Maine DEP daytime hours, hourly L_{Aeq} readings ranged from 59 to 65 dBA with an average of 61 dBA. During nighttime hours, hourly L_{Aeq} readings ranged from 55 to 61 dBA with an average of 57 dBA.

At CP-3, hourly L_{Aeq} readings during Maine DEP daytime hours ranged from 53 to 59 dBA with an average of 57 dBA. Hourly L_{Aeq} readings during nighttime hours ranged from 51 to 58 dBA with an average of 54 dBA.

At CP-4, hourly L_{Aeq} readings during Maine DEP daytime hours ranged from 55 to 59 dBA with an average of 57 dBA. Hourly L_{Aeq} readings during nighttime hours ranged from 53 to 59 dBA with an average of 55 dBA.

The primary noise sources at CP-1 through CP-4 during daytime and nighttime hours were local traffic and traffic on Interstate 295. Additional sources included aircraft traveling to and from the Portland International Jetport, HVAC equipment at MMC, and residential activity.

At CP-5, during Maine DEP daytime hours (7 am to 7 pm), hourly L_{Aeq} readings ranged from 46 to 58 dBA with an average of 52 dBA. During nighttime hours (7 pm to 7 am), hourly L_{Aeq} readings ranged from 43 to 57 dBA with an average of 48 dBA. Between 7 am and 3 pm, propane heaters operated on the property of CP-5 raising sound levels above typical levels for these hours. The average daytime hourly L_{Aeq} without the heaters operating was 47 dBA from 3 pm to 7 pm. Other noise sources at CP-5 included local and distant traffic, Jetport aircraft, train station, hospital and residential activity.

At CP-6, during Maine DEP daytime hours (7 am to 7 pm), hourly L_{Aeq} readings ranged from 53 to 60 dBA with an average of 57 dBA. During nighttime hours, hourly L_{Aeq} readings ranged from 51 to 65 dBA with an average of 55 dBA. The primary noise sources at CP-6 were local traffic on West Promenade Street and traffic on I-295 to the west. Other noise sources included Jetport aircraft, park/pedestrian and residential activity.

Other calculated values in Tables II-1 through II-6 (Appendix II) are the FAA daytime L_{Aeq} (7 am to 10 pm), nighttime L_{Aeq} (10 pm to 7 am), and day-night (24-hour) sound level (L_{dn}). The L_{dn} values ranged from 56 to 65 dBA. When calculating the L_{dn}, 10 dBA is added to nighttime hourly sound levels. A summary of existing daytime and nighttime sound levels is presented in Table 1. This includes daytime and nighttime sound levels as defined by the Maine DEP and City of Portland, and FAA L_{dn} sound levels.

TABLE 1

Existing Daytime and Nighttime Sound Levels

	Maine DEP Average L_{Aeq}		City of Portland Average L_{Aeq}		
Monitoring Position	**Daytime 7 am to 7 pm**	**Nighttime 7 pm to 7 am**	**Daytime 7 am to 9 pm**	**Nighttime 9 pm to 7 am**	**FAA Day-Night Sound Level (L_{dn})**
CP-1: Gilman & A Street	60	57	59	57	64
CP-2: Congress & Weymouth Street	61	57	61	57	65
CP-3: Wescott & Crescent Street	57	54	56	54	61
CP-4: Ellsworth & Charles Street Ext.	57	55	56	55	62
CP-5: Bowdoin & Chadwick Street	52	48	51	48	56
CP-6: West Promenade & West Street	57	55	56	56	63

5.0 HELICOPTER FLIGHT TEST SOUND LEVELS

The flight test and associated sound level testing in the community and at the hospital was successfully completed as a result of extensive planning and coordination between Maine Medical Center, LifeFlight of Maine, and RSE. Flight testing consisted of four separate approach, hover, and departure sequences to simulate planned flight operations associated with the new helipad. The flight path, angle of descent, hover, and departure route flown during each simulation were intended to follow the proposed flight paths to and from the helipad.

Original plans were to fly an Agusta 109C during the flight test. LifeFlight currently stations an Agusta 109C at both Central Maine Medical Center in Lewiston and Eastern Maine Medical Center in Bangor. RSE understands that the Agusta 109C will be used for over 90% of the flights involving Maine Medical Center. During the scheduled flight testing, one of the Agusta helicopters was grounded for scheduled maintenance and the other was called to a medical emergency in Caribou. The backup aircraft is a BK 117, which was substituted for the Agusta 109C for the flight test. RSE understands that the BK 117 is a heavier helicopter with larger engines. Available noise performance data for the BK 117 and Agusta 109C indicates that the BK 117 is slightly louder by 0.6 dBA.

The position of the helicopter was tracked using a portable GPS with time-based horizontal and vertical tracking. Of the four flight test simulations, GPS data was tracked on the first three. Other than coordinates announced by the crew, there was no GPS data tracking during the fourth flight test. Slight variations in the flight path could lead to significant sound level differences at certain positions.

Instrumentation consisted of Larson-Davis Model 812 Integrating Sound Level Meters, which were programmed to continuously measure sound levels and calculate statistics at both hourly and one-second intervals. Two Larson-Davis Model 824 Sound Level Meters/Real Time Analyzers were used to measure sound levels at position CP-3 and MC-3E. These were programmed to continuously measure sound levels, including one-third octave-band readings, and calculate statistics at both one-second and hourly intervals. In addition, a CEL 593 Sound Level Analyzer was used to measure sound levels at position MC-3I to measure one-third octave band sound levels at five-second intervals.

The sound level meters meet Type 1 (precision) performance requirements of ANSI S1.4-1983, Specification for Sound Level Meters. The microphones were fitted with standard windscreens and mounted on tripods at a height of four to five feet above the ground. The sound level meters were calibrated before and after flight test monitoring using a Bruel & Kjaer 4231 Sound Level Calibrator. Calibration certificates are available upon request.

During flight testing, RSE stationed observers inside the hospital in the NICU and the newborn nursery. Community observers were stationed at CP-3 (Crescent Street) and CP-6 (West Prom). The observer at CP-6 had to move to new position CP-7 (Parkside) due to someone tampering with the instrumentation.

Meteorological data, including wind speed and direction, temperature, and relative humidity, was recorded on the Upper Bean Rooftop. During monitoring on September 13, 2003, temperatures ranged from 63 to 69 degrees F and relative humidity ranged from 63 to 83%. Skies were partly cloudy and winds were approximately 5 to 8 mph from 15:00 to 18:00, calming to 3 to 6 mph during the 18:00 hour. Wind direction was primarily from the south and south-southwest.

Monitoring results of the flight tests have been graphed at intervals of five seconds and one minute in order to compare helicopter and existing sound levels at community and hospital positions.

These graphs are presented as Figure Sets 1 through 4 as follows:

Figure Set 1	Community Monitoring Positions: 5-Second Results	Graphs comparing flight test and community sound levels on a 5-second L_{Aeq} basis. Community sound level readings are from 2003 and 2002.
Figure Set 2	Community Monitoring Positions: One-Minute Results	Same as Figure Set 1 but comparing sound levels on a one-minute L_{Aeq} basis.
Figure Set 3	MMC Monitoring Positions: 5-Second Results	Graphs comparing flight test and hospital sound levels on a 5-second L_{Aeq} basis. Hospital sound levels are from 2003 at both indoor and outdoor positions.
Figure Set 4	MMC Monitoring Positions: One-Minute Results	Same as Figure Set 3 but comparing flight test and hospital sound levels on a one-minute L_{Aeq} basis.

Summary result tables were prepared based on review of sound level readings from these Figure Sets. Many comparisons could be made to quantify the differences between ambient (non-helicopter) sound levels and sound levels measured during the flight testing. Considering that each of the four flight tests was a distinct and relatively short-term event, RSE chose to compare the four flight test events with the four loudest non-helicopter community events on both a five-second and one-minute basis. This same approach was used to compare hospital sound levels both outside on the Lower Bean Roof and indoor positions. The following Tables 2 through 5 provide the sound level range and average at each position during ambient (non-helicopter) and helicopter flight test events.

Table 2

Comparison of Ambient Community and Flight Test Sound Levels

5-Second L_{Aeq} (4 Loudest Events)

Position	Ambient Range (2003)	Ambient Average (2003)	Flight Test Range	Flight Test Average	Sound Level Change between Averages
CP-1	76 to 83	79	78 to 89	82	+3
CP-2	71 to 85	79	76 to 93	88	+8
CP-3	69 to 73	71	79 to 82	80	+9
CP-4	66 to 72	69	73 to 82	79	+10
CP-5	77 to 88	83	61 to 70	66	-17
CP-6	73 to 79	75	68 to 76	71	-4
CP-7	66 to 69	68	66 to 75	71	+3
CP-8	74 to 81	78	60 to 65	63	-15
CP-9	73 to 76	74	60 to 68	65	-11

Table 3

Comparison of Ambient Community and Flight Test Sound Levels

One-Minute L_{Aeq} (4 Loudest Events)

Position	Ambient Range (2003)	Ambient Average (2003)	Flight Test Range	Flight Test Average	Sound Level Change between Averages
CP-1	69 to 71	70	72 to 82	75	+5
CP-2	64 to 76	70	73 to 86	82	+12
CP-3	62 to 66	64	75 to 76	75	+11
CP-4	60 to 65	63	67 to 76	73	+10
CP-5	68 to 79	74	55 to 63	60	-14
CP-6	66 to 71	68	62 to 70	66	-2
CP-7	59 to 62	60	62 to 69	66	+6
CP-8	65 to 74	70	54 to 59	57	-13
CP-9	63 to 67	65	57 to 60	59	-6

Table 4

Comparison of Ambient Hospital and Flight Test Sound Levels

5-Second L_{Aeq} (4 Loudest Events)

Position	Ambient Range	Ambient Average	Flight Test Range	Flight Test Average	Sound Level Change between Averages
MC-3E	63 to 66	65	86 to 91	89	+24
MC-3I	64 to 68	66	53 to 64	60	-6
MC-5I	72 to 75	74	63 to 68	66	-8
MC-6I	53 to 57	54	61 to 64	62	+8

Table 5

Comparison of Ambient Hospital and Flight Test Sound Levels

One-Minute L_{Aeq} (4 Loudest Events)

Position	Ambient Range	Ambient Average	Flight Test Range	Flight Test Average	Sound Level Change between Averages
MC-3E	62 to 63	62	81 to 86	85	+23
MC-3I	61 to 64	62	51 to 62	57	-5
MC-5I	65 to 67	66	60 to 64	63	-3
MC-6I	46 to 50	49	56 to 60	58	+9

The results and comparisons show that the impact on community sound levels varies significantly by location. Locations close to the hospital with a direct line-of-sight to the top of the existing parking garage showed the highest increases in short-term sound levels ranging from 8 to 12 dBA at positions CP-2 through CP-4 for both five-second and one-minute L_{Aeq} readings. Conversely, community locations further away and in the flight path of the Portland Jetport showed significantly higher sound levels during ambient events (jet aircraft) than hospital flight tests. Ambient events at CP-5 and CP-8 ranged from 13 to 17 dBA higher than helicopter flight tests.

6.0 FUTURE SOUND LEVELS

The maximum sound levels that will be generated during use of the proposed helipad are not expected to exceed sound levels measured during the test flights. However, the period of sound exposure associated with a medical helicopter flight is expected to be longer than the test flights, which were approximately one-minute events at the proposed helipad.

Based on testing at Eastern Maine Medical Center in Bangor, once the helicopter lands on the helipad it will operate for approximately two minutes to spool down prior to total shutdown. Helicopter sound levels decline during the spool down sequence. Depending upon how long the helicopter spends on the pad waiting for or loading a patient, it is likely that the time period from start to liftoff will approach or exceed three and a half minutes. Helicopter sound levels increase gradually from startup to liftoff. When a patient is delivered to the hospital, the amount of time on the helipad may be shorter depending upon whether the helicopter will shutdown completely or drop off the patient and depart immediately.

Future sound levels will also be affected by proposed changes to hospital and community buildings that will result from the proposed expansion. Modifications and additions, such as a new helipad and associated elevator tower, will be made to the existing parking garage to construct the helipad facility. A second parking garage will be built adjacent to the existing parking garage and the new Charles Street Building will be built northeast of the Maine Medical Center complex adjacent to Richards Tower. These site changes will act to block helicopter noise south and east of the hospital, but will also reflect a portion of helicopter noise to the north and west.

A helipad noise model of MMC was developed utilizing topographic survey data and helicopter flight testing at Eastern Maine Medical Center. Estimates from this noise model were used to compare sound levels and assist helipad siting on the existing MMC parking garage. The results of the flight test will be used to refine the computer noise model to predict future sound levels in the vicinity of the hospital under full build-out conditions of the expansion. Incorporating flight test data into the noise model will provide estimates of future sound levels for comparison to relevant local, state and federal standards.

7.0 CONCLUSIONS

From monitoring results in the vicinity of Maine Medical Center, flight test sound levels can be compared directly with ambient community sound levels. Both flight test and community sound levels were measured under existing site conditions and, therefore, do not include construction of the Charles Street Building, helipad, elevator tower, and new parking garage.

The results show areas where helicopter sound levels exceeded daytime community sound levels by 8 to 12 dBA, based on five-second and one-minute L_{Aeq} readings. The results also showed areas near the hospital where helicopter sound levels were at or below existing daytime community sound levels.

The overall impact of helicopter sound levels depends on the type and number of daytime and nighttime flights that will occur and the building configuration at the time of the flights. Incorporating this information into the analysis would provide a basis for comparison to relevant local, state and federal noise standards.

FIGURE 1. VICINITY SITE PLAN AND HELICOPTER FLIGHT PATHS

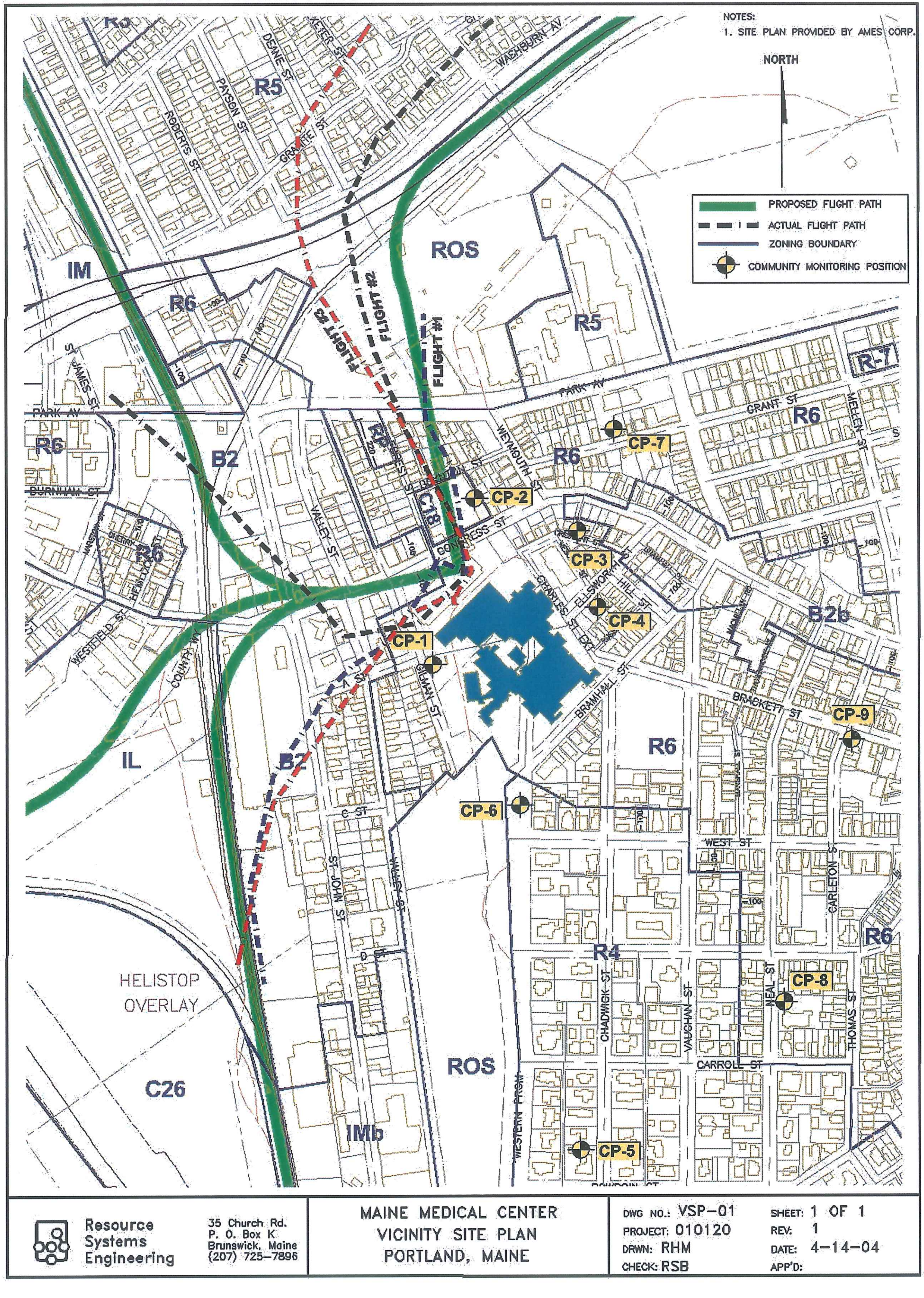
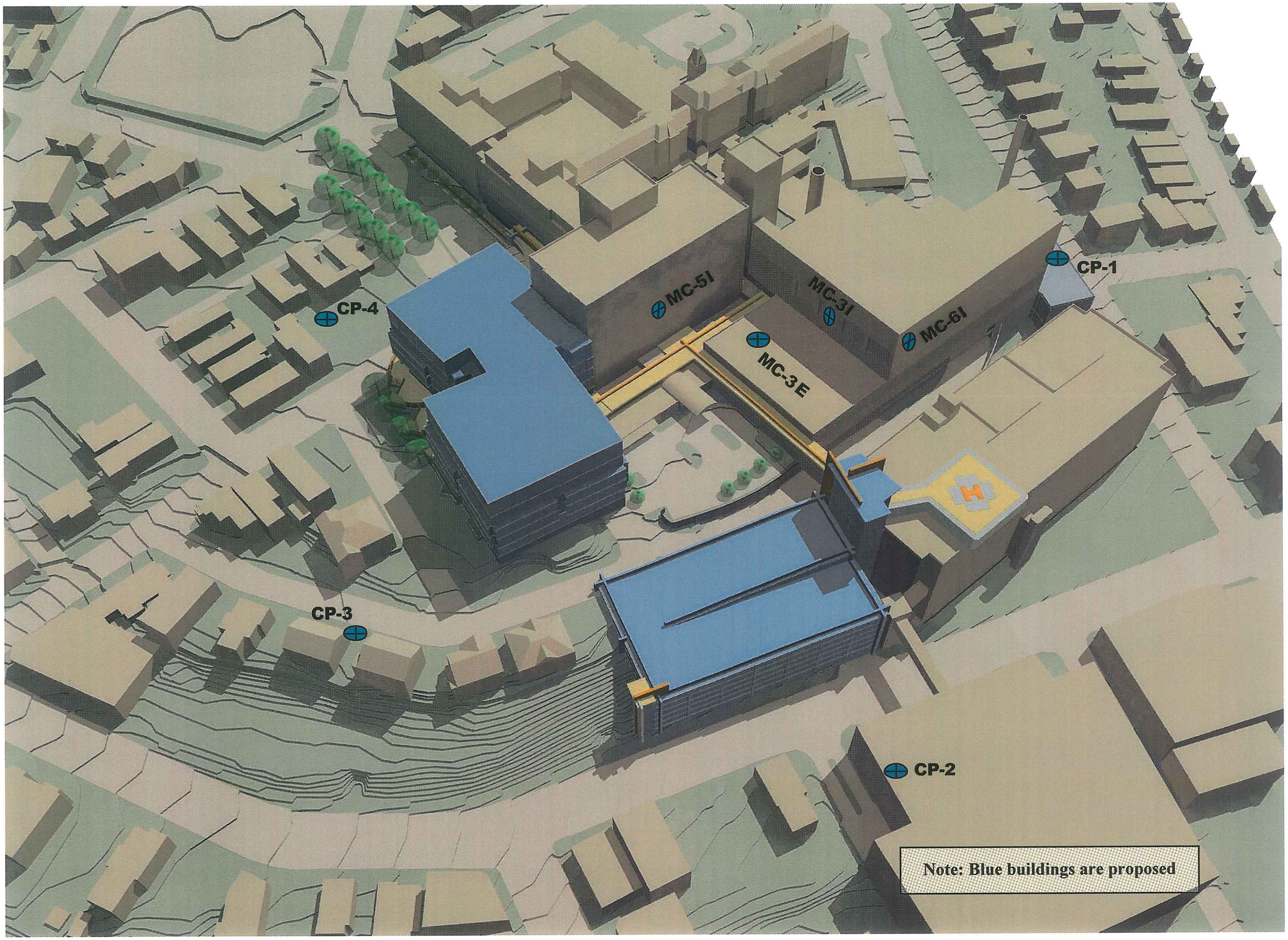
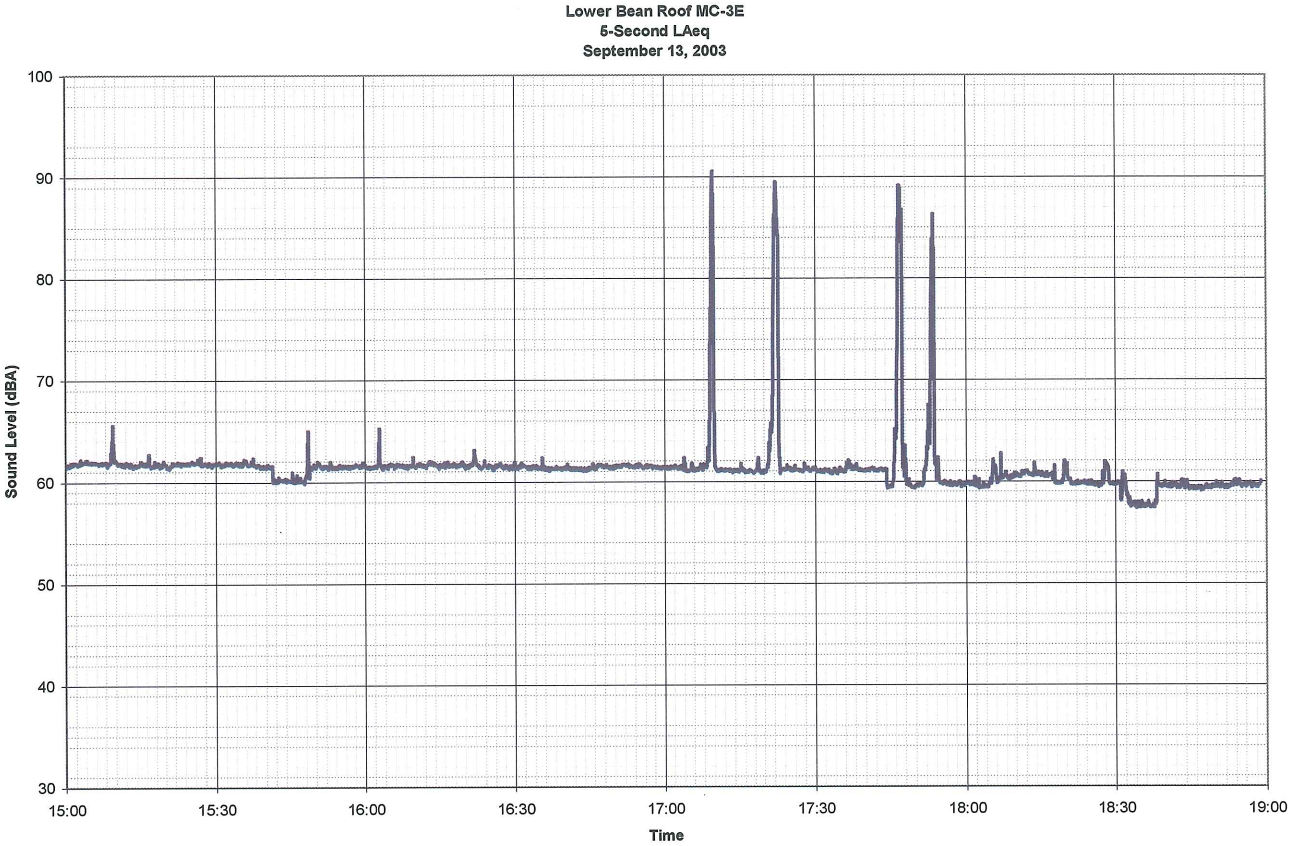


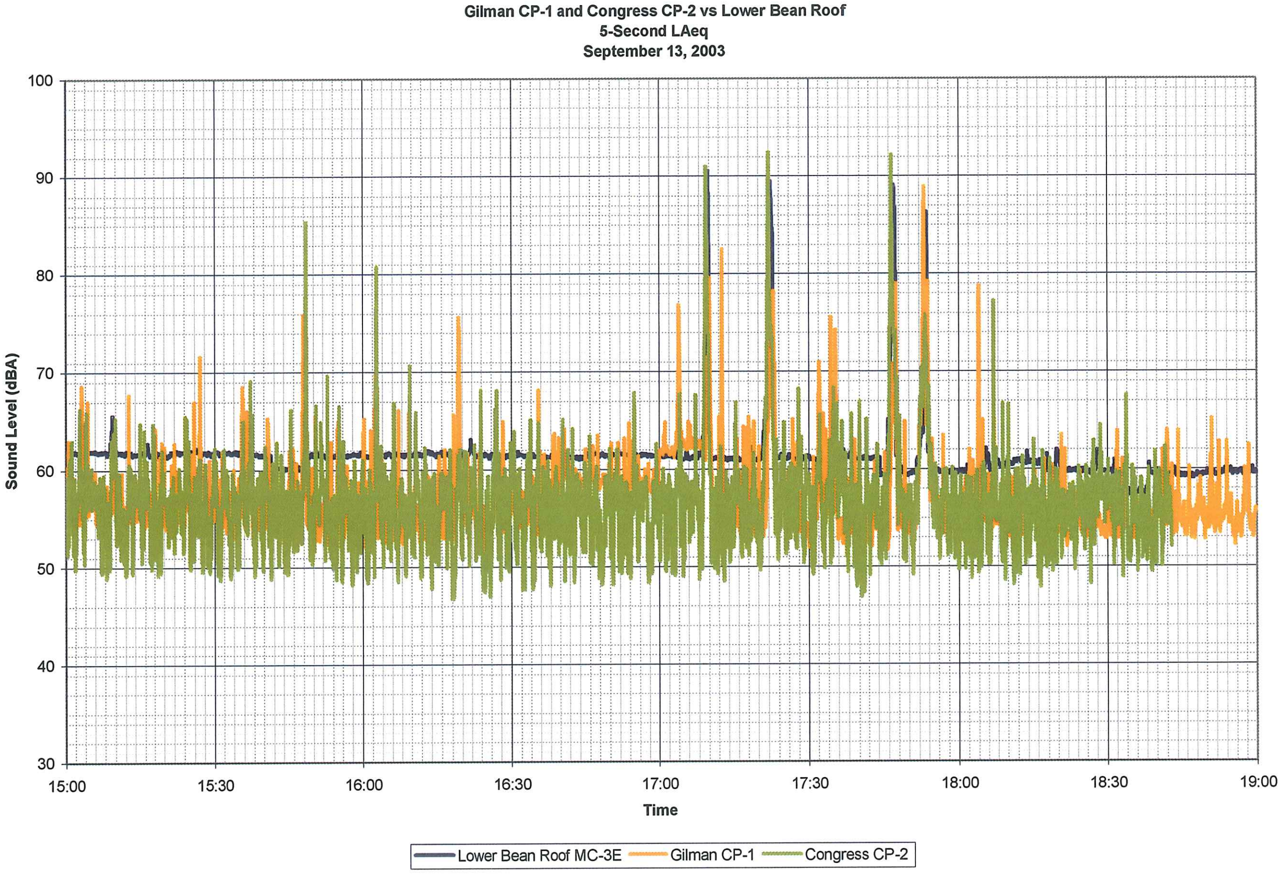
FIGURE 2. MAINE MEDICAL CENTER SOUND MONITORING POSITIONS AND HELIPAD LOCATION

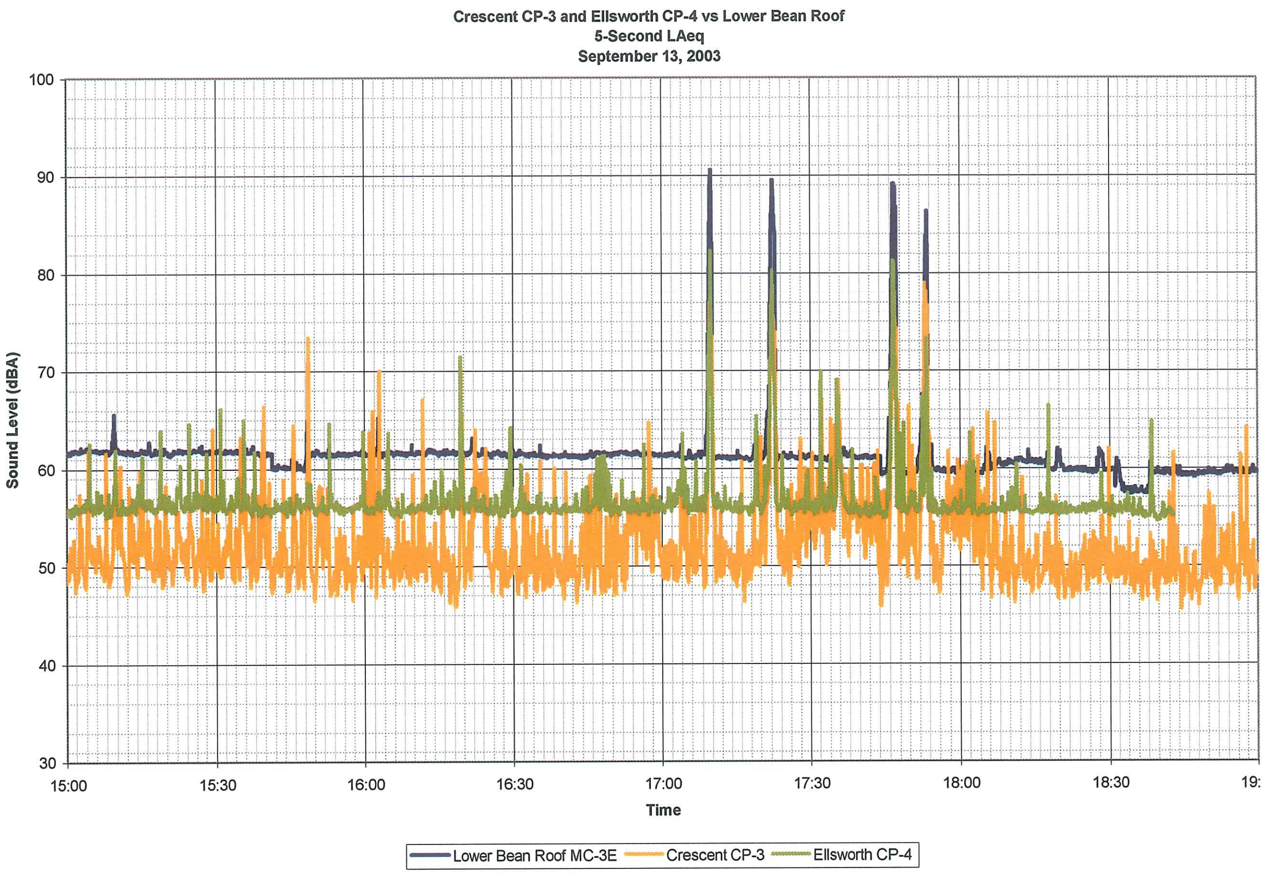


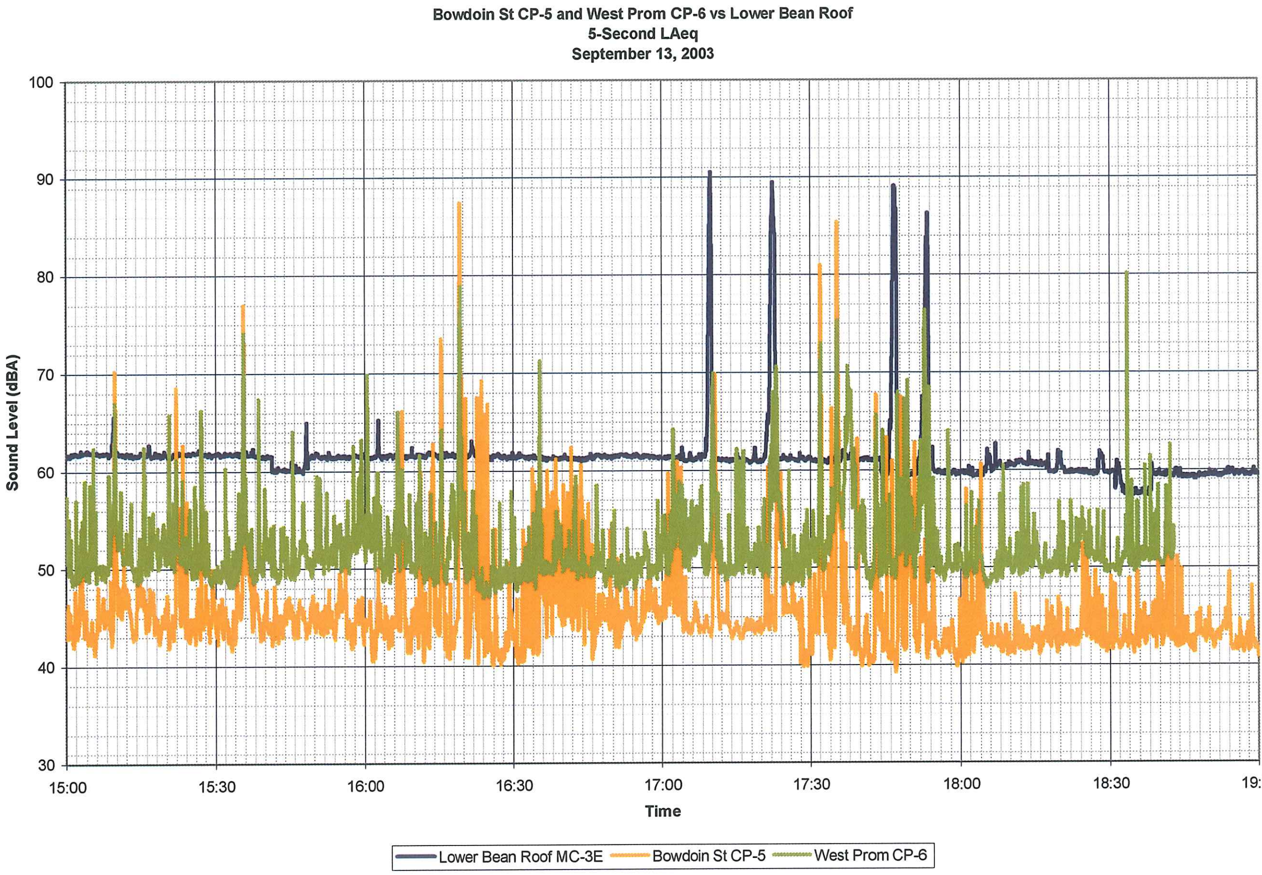
Note: Blue buildings are proposed

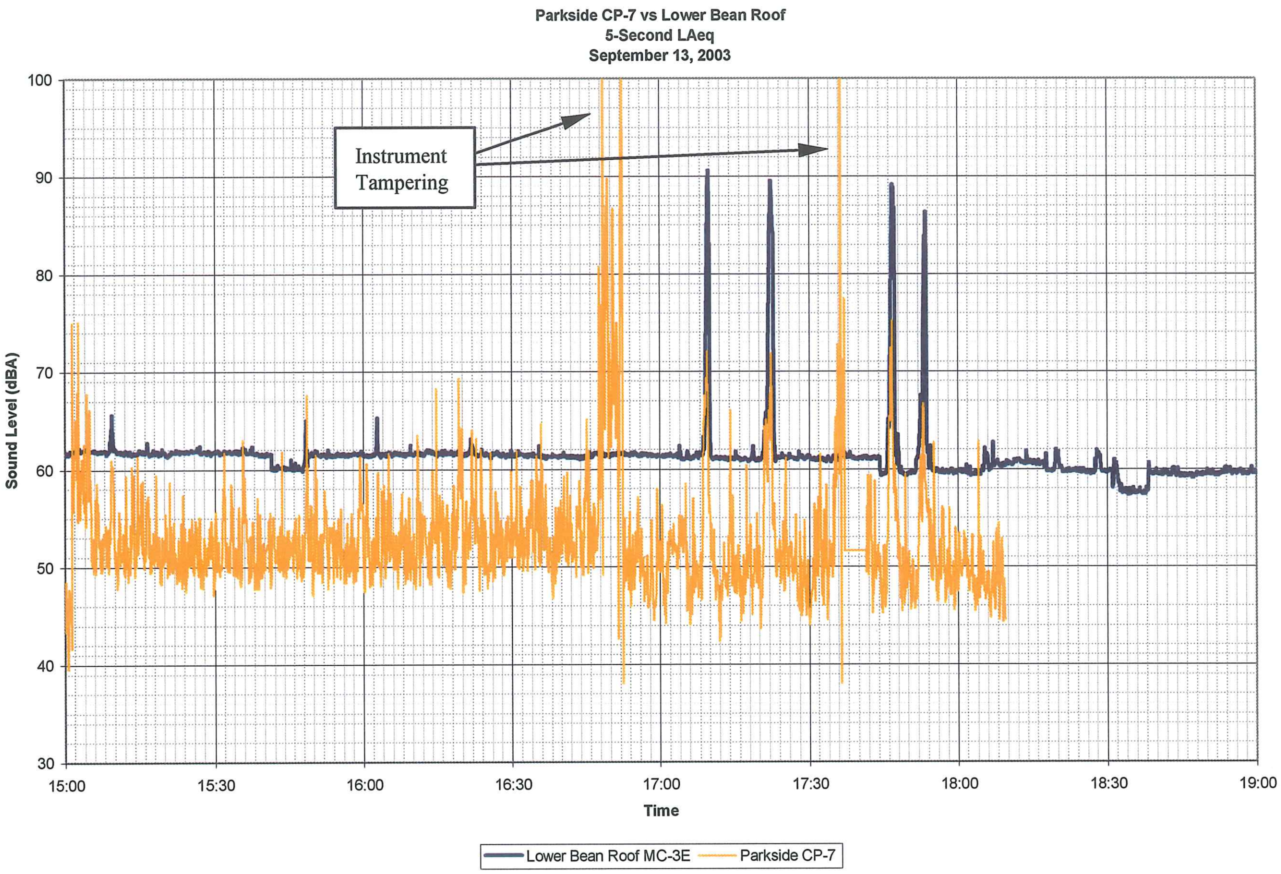
FIGURE SET 1. COMMUNITY MONITORING POSITIONS AND MMC ROOFTOP POINT 5-SECOND RESULTS



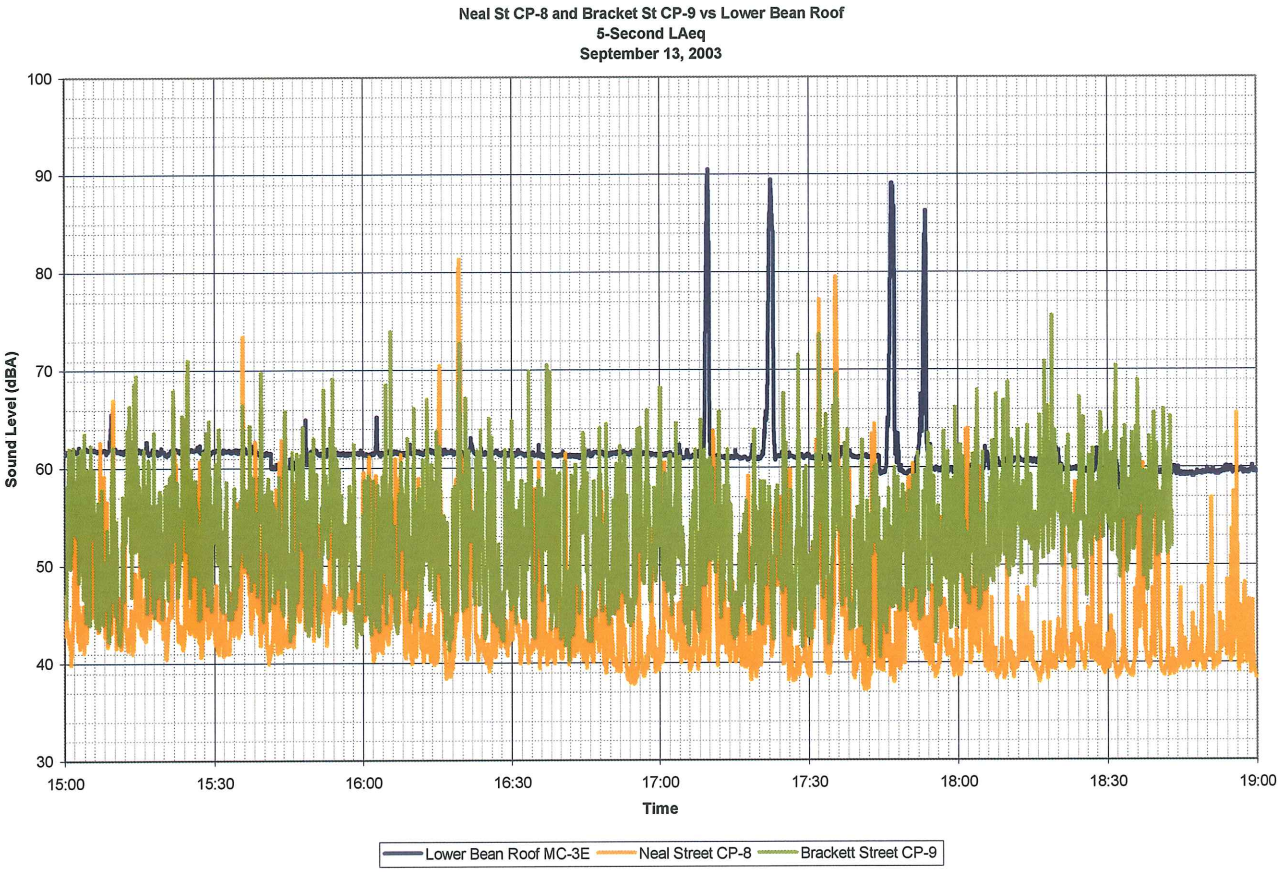



Crescent CP-3 and Ellsworth CP-4 vs Lower Bean Roof
5-Second LAeq
September 13, 2003
Sound Level (dBA)
100
90
80
70
60
50
40
30
15:00
15:30
16:00
16:30
17:00
17:30
18:00
18:30
19:00
Time
Lower Bean Roof MC-3E
Crescent CP-3
Ellsworth CP-4

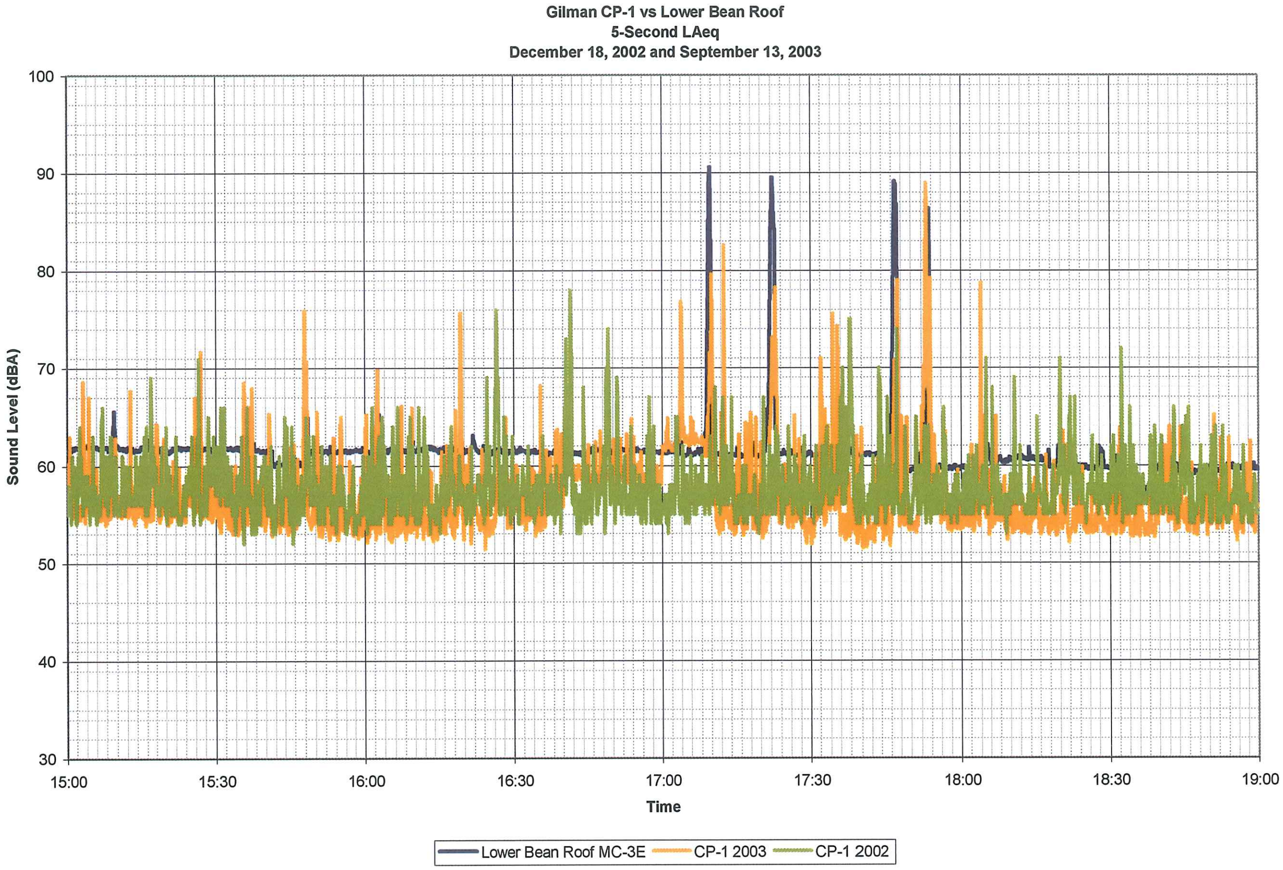

Bowdoin St CP-5 and West Prom CP-6 vs Lower Bean Roof
5-Second LAeq
September 13, 2003
Sound Level (dBA)
100
90
80
70
60
50
40
30
15:00
15:30
16:00
16:30
17:00
17:30
18:00
18:30
19:00
Time
Lower Bean Roof MC-3E
Bowdoin St CP-5
West Prom CP-6

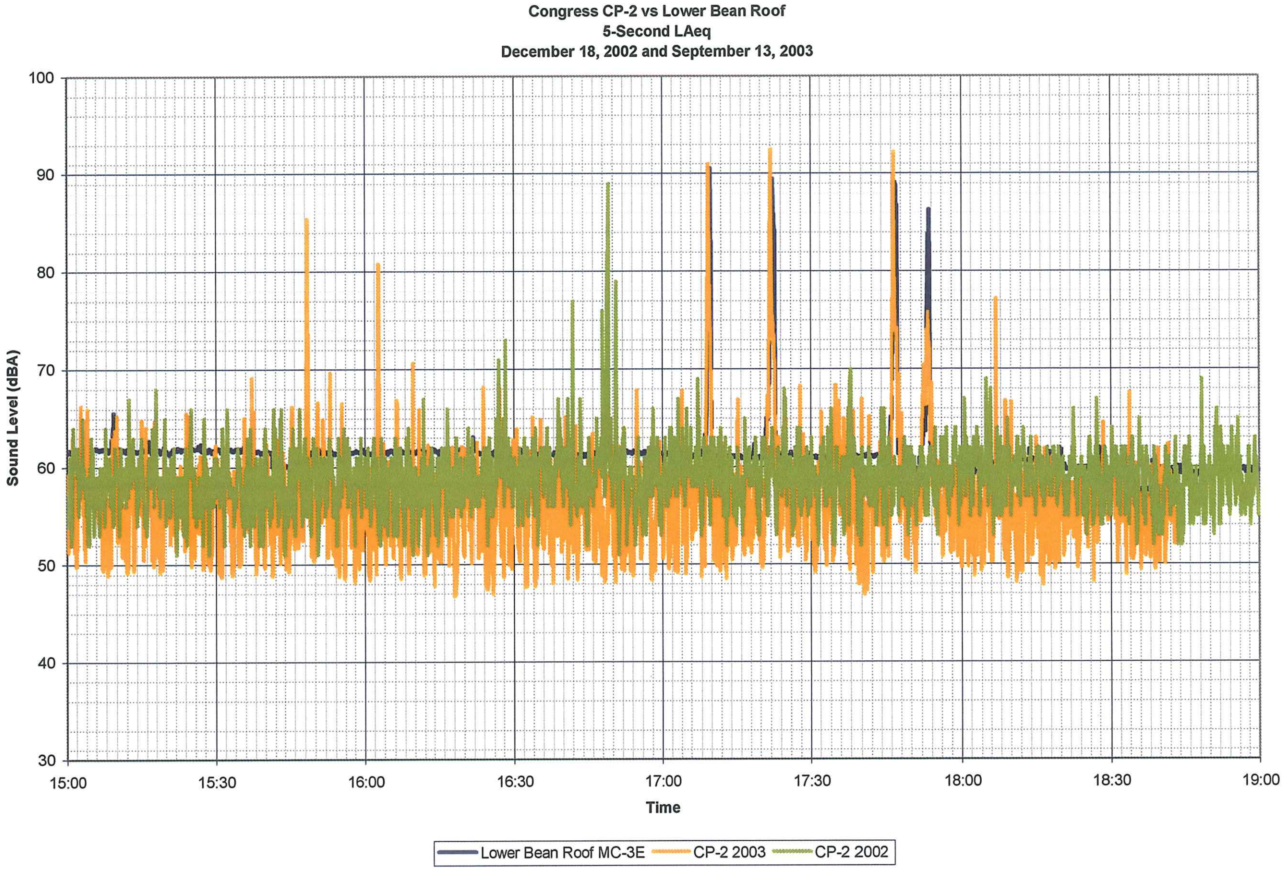


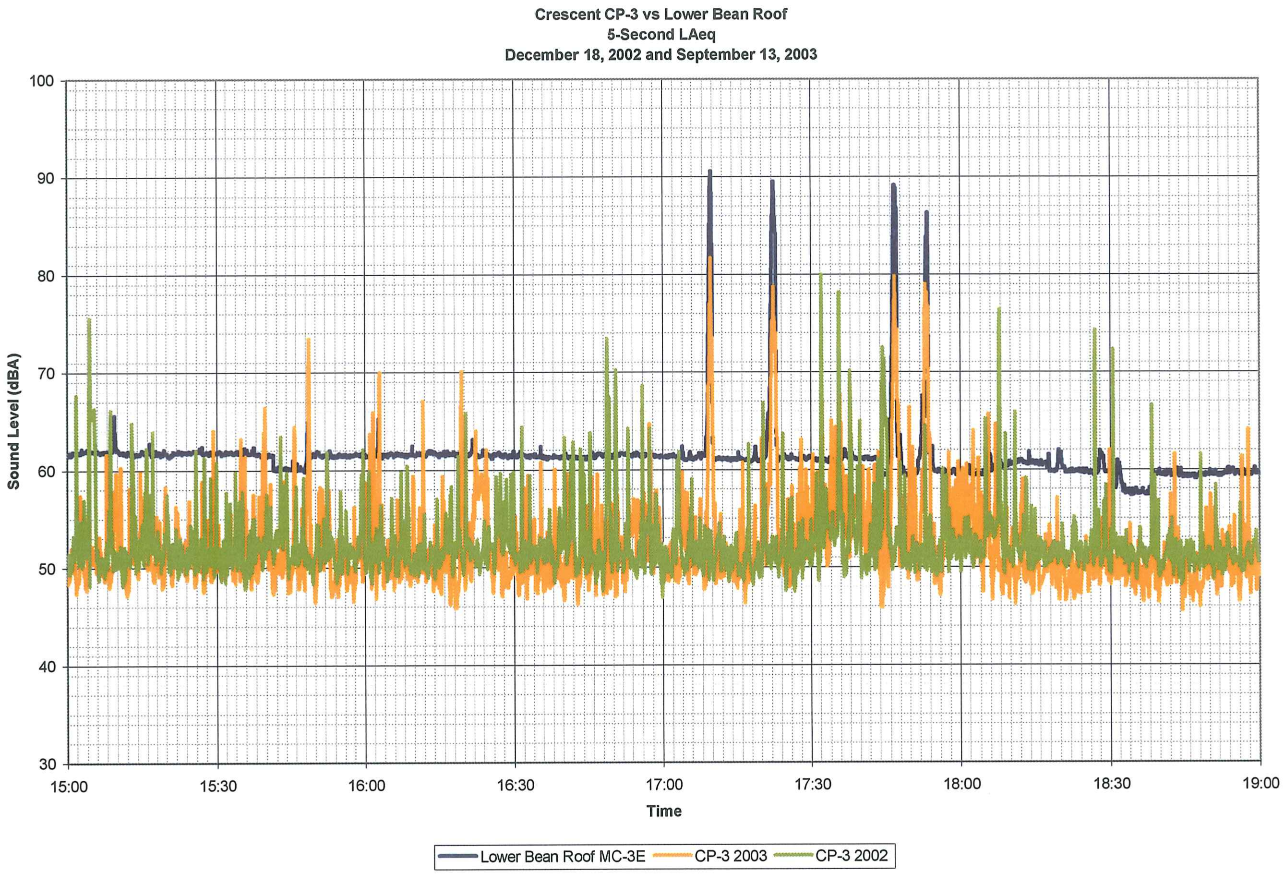
Parkside CP-7 vs Lower Bean Roof
5-Second LAeq
September 13, 2003

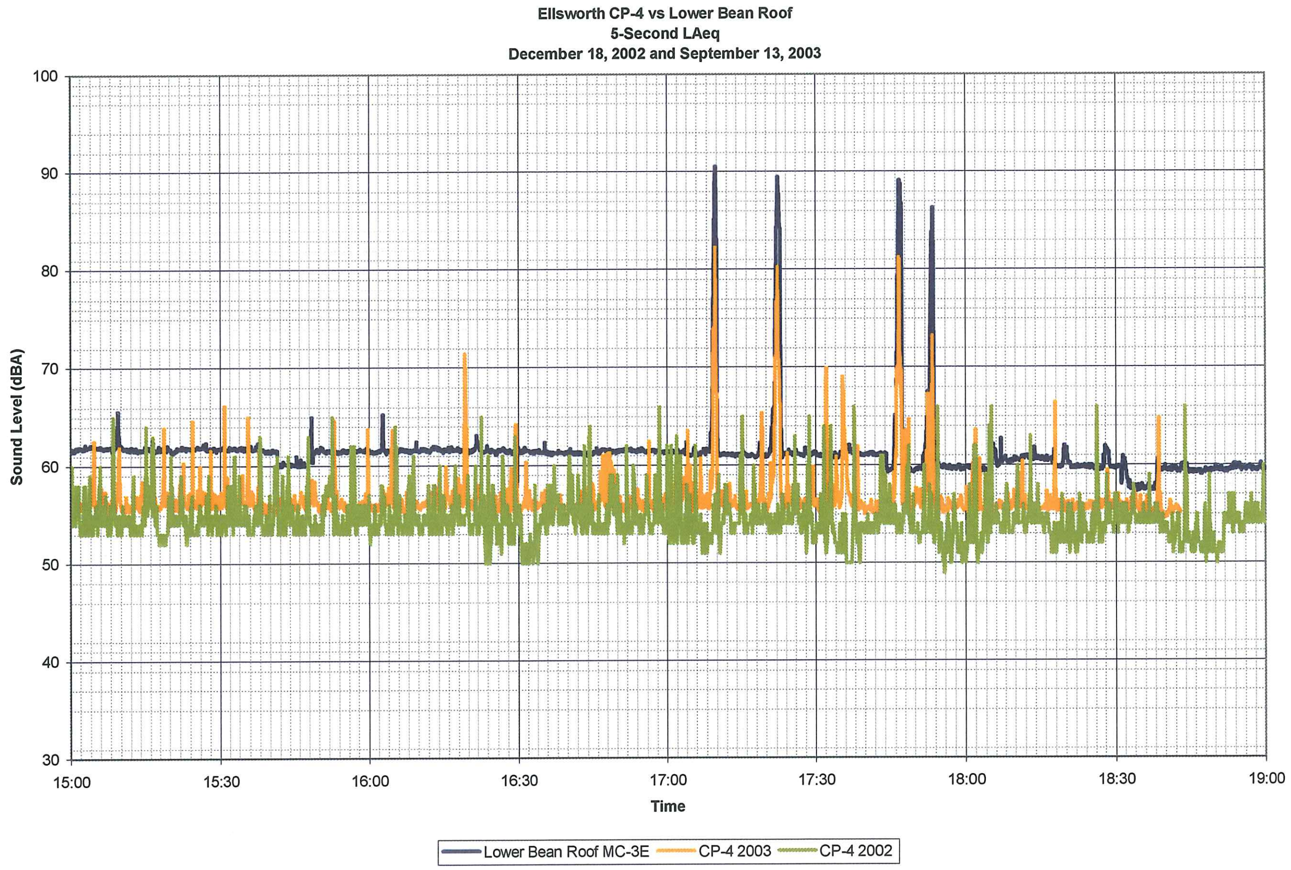


Neal St CP-8 and Bracket St CP-9 vs Lower Bean Roof
5-Second LAeq
September 13, 2003


Gilman CP-1 vs Lower Bean Roof
5-Second LAeq
December 18, 2002 and September 13, 2003
100
90
80
70
60
50
40
30
Sound Level (dBA)
15:00
15:30
16:00
16:30
17:00
17:30
18:00
18:30
19:00
Time
Lower Bean Roof MC-3E
CP-1 2003
CP-1 2002


Congress CP-2 vs Lower Bean Roof
5-Second LAeq
December 18, 2002 and September 13, 2003
100
90
80
70
60
50
40
30
Sound Level (dBA)
15:00
15:30
16:00
16:30
17:00
17:30
18:00
18:30
19:00
Time
Lower Bean Roof MC-3E
CP-2 2003
CP-2 2002


Crescent CP-3 vs Lower Bean Roof
5-Second LAeq
December 18, 2002 and September 13, 2003


Ellsworth CP-4 vs Lower Bean Roof
5-Second LAeq
December 18, 2002 and September 13, 2003


Bowdoin St CP-5 vs Lower Bean Roof
5-Second LAeq
December 18, 2002 and September 13, 2003

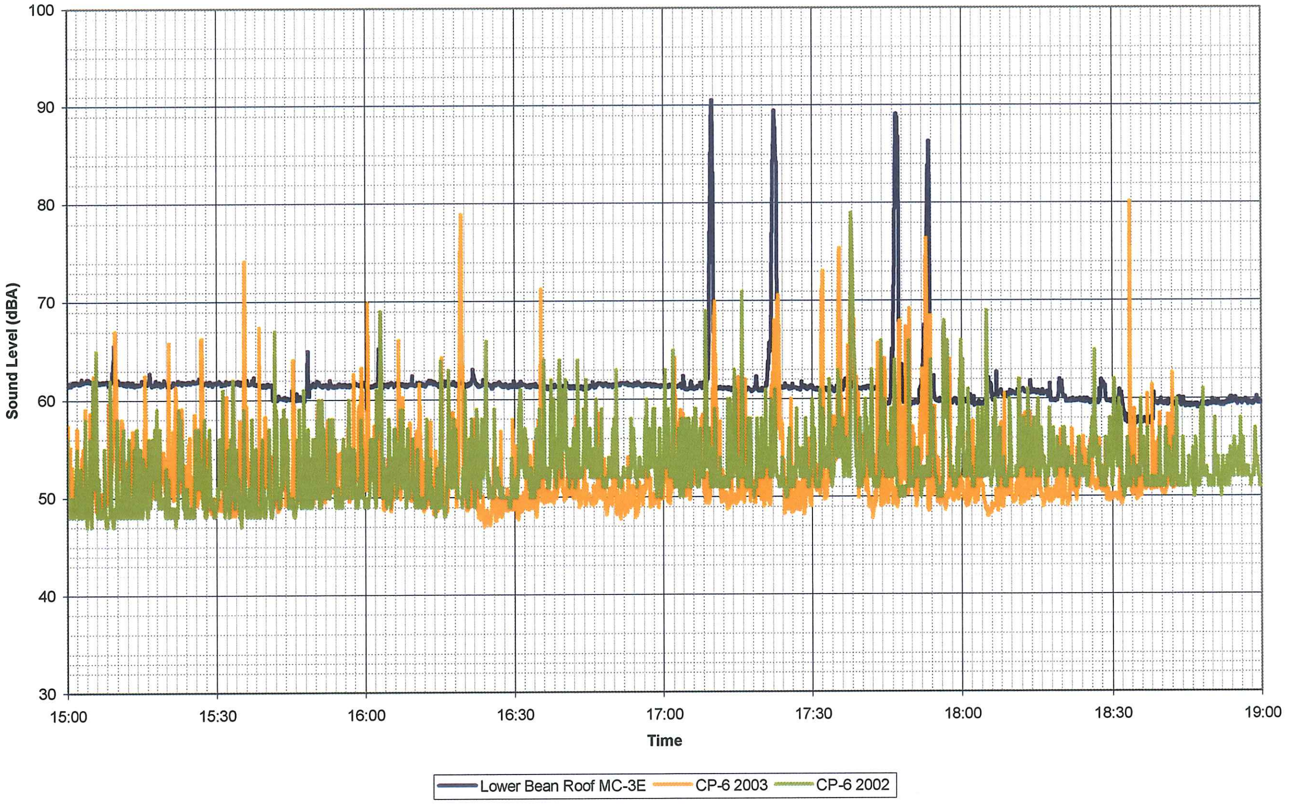
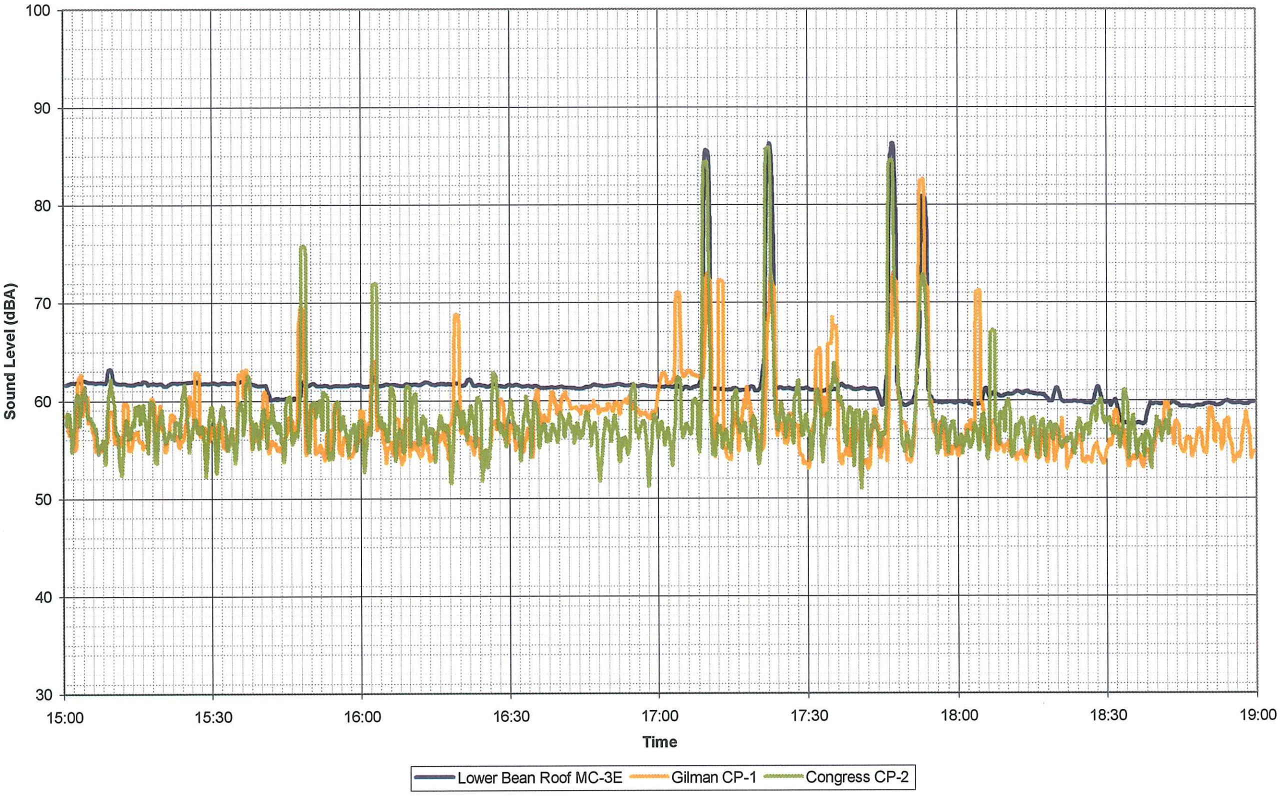
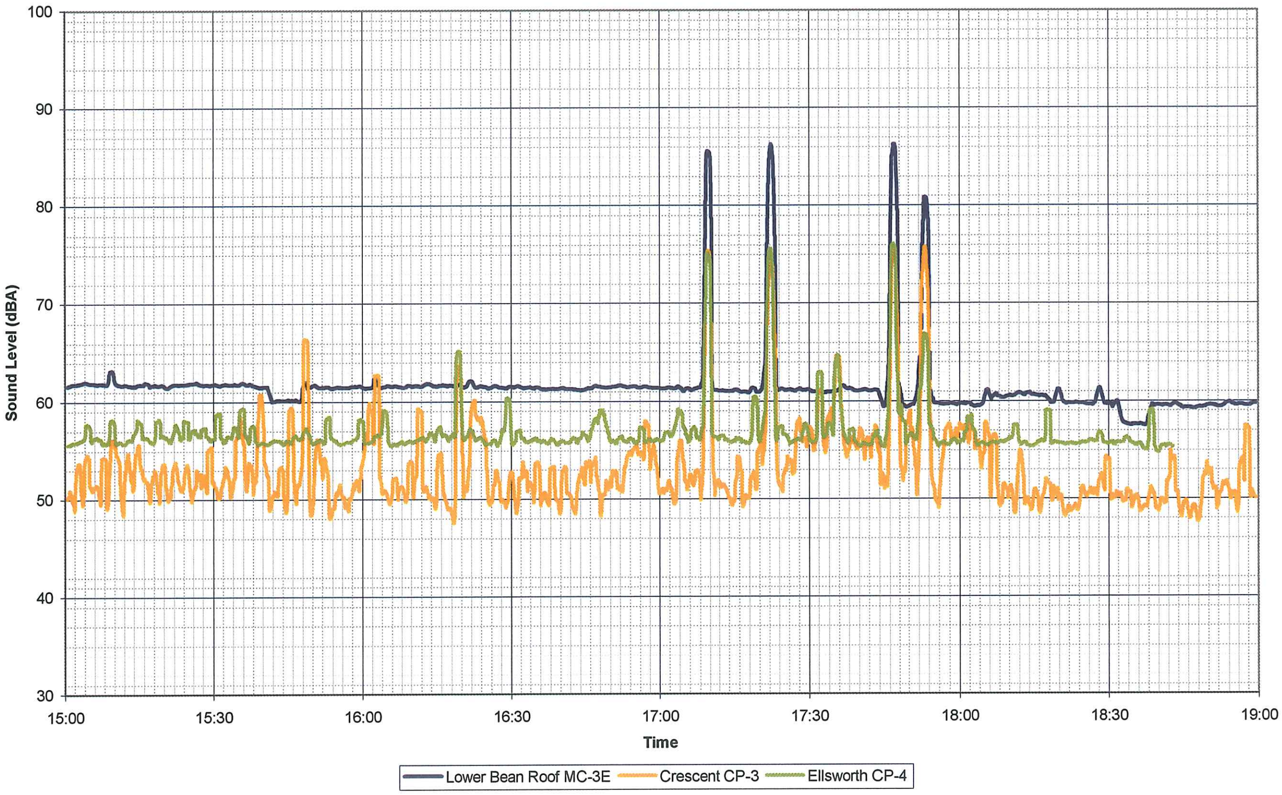

West Prom CP-6 vs Lower Bean Roof
5-Second LAeq
December 18, 2002 and September 13, 2003

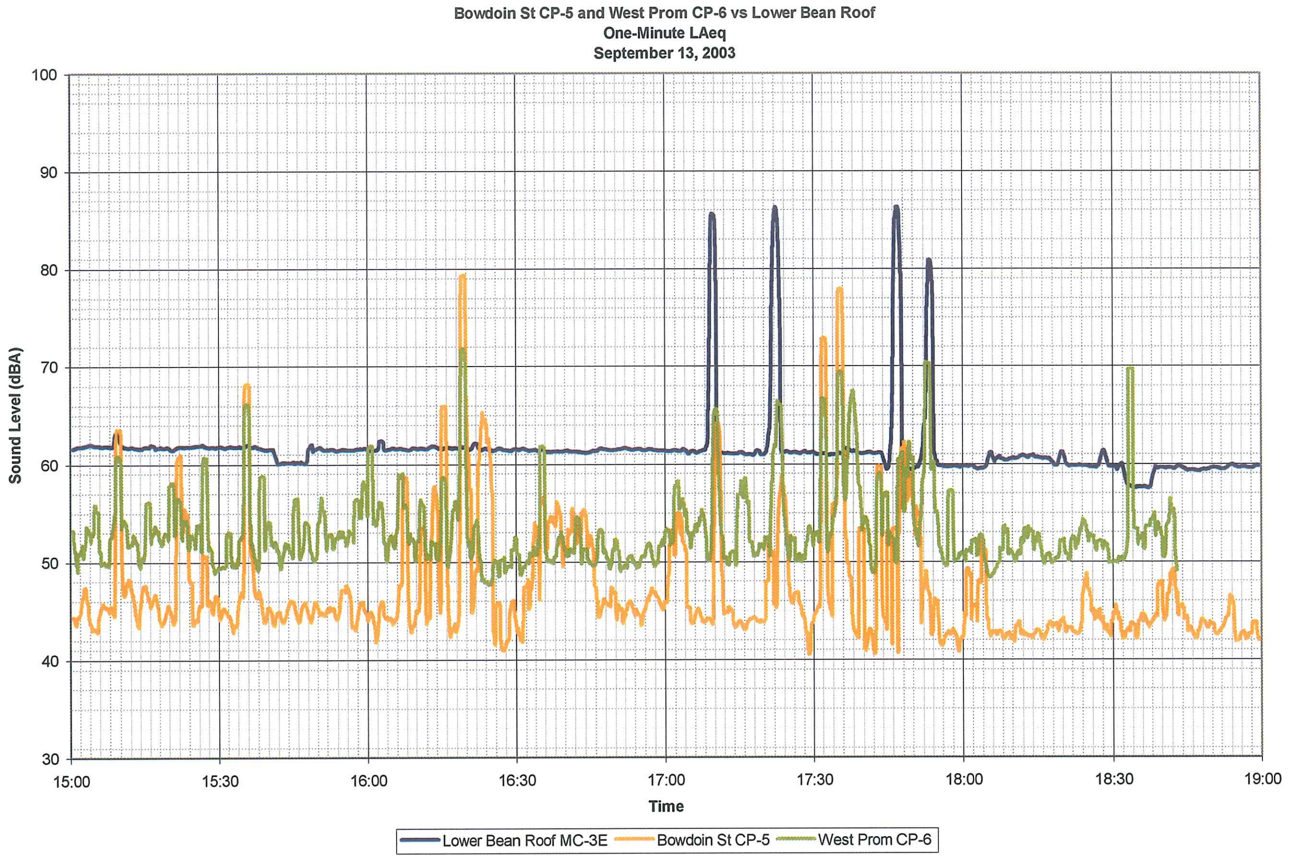
FIGURE SET 2. COMMUNITY MONITORING POSITIONS AND MMC ROOFTOP POINT ONE-MINUTE RESULTS

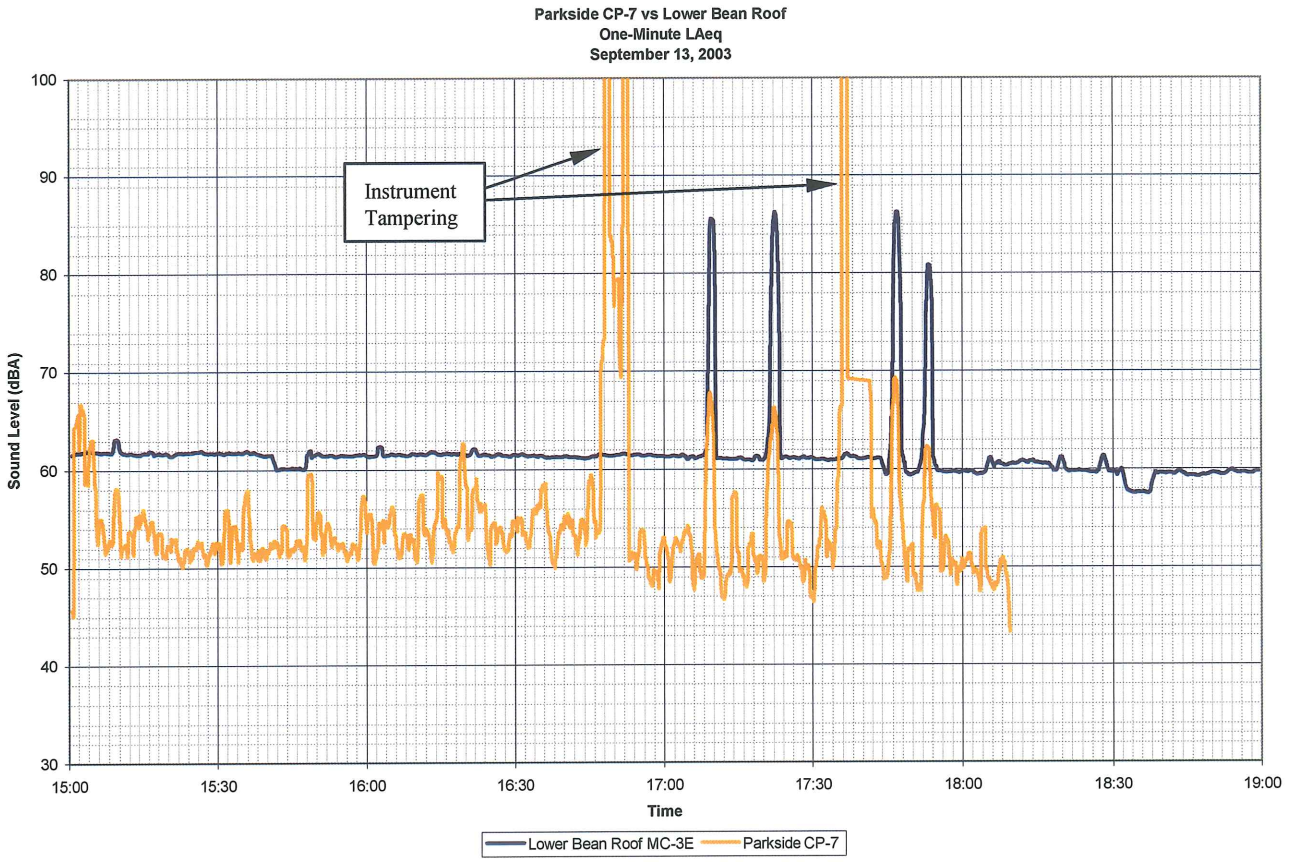
Gilman CP-1 and Congress CP-2 vs Lower Bean Roof
One-Minute LAeq
September 13, 2003



Crescent CP-3 and Ellsworth CP-4 vs Lower Bean Roof
One-Minute LAeq
September 13, 2003




Bowdoin St CP-5 and West Prom CP-6 vs Lower Bean Roof
One-Minute LAeq
September 13, 2003


Parkside CP-7 vs Lower Bean Roof
One-Minute LAeq
September 13, 2003

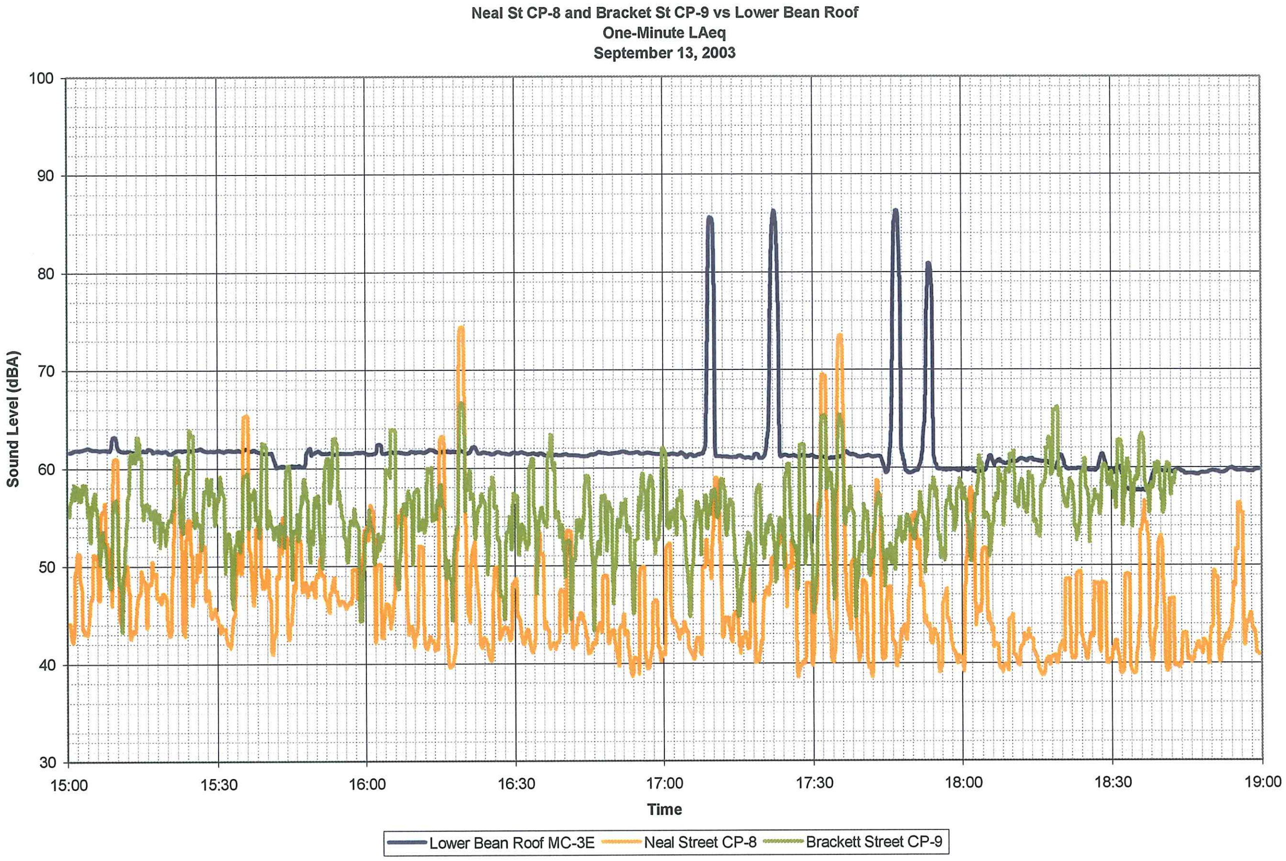
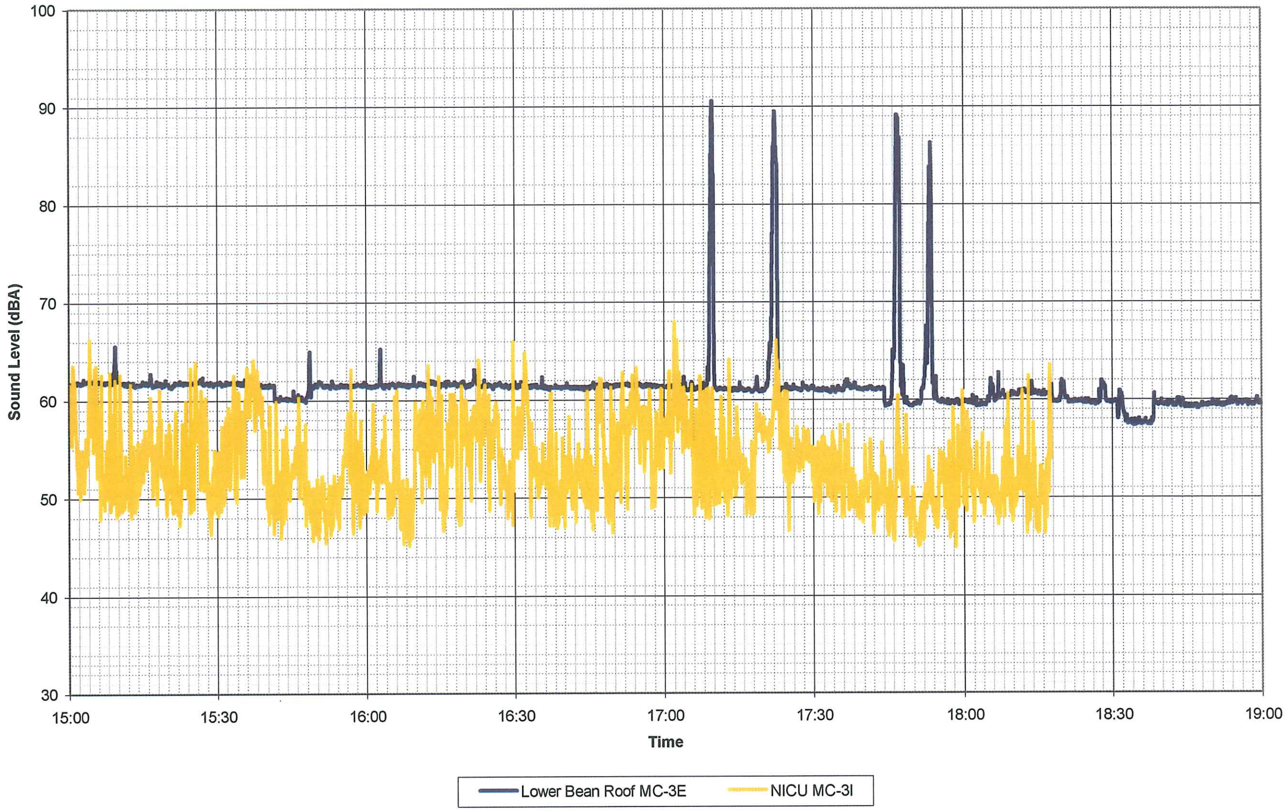

Neal St CP-8 and Bracket St CP-9 vs Lower Bean Roof
One-Minute LAeq
September 13, 2003
Sound Level (dBA)
100
90
80
70
60
50
40
30
15:00
15:30
16:00
16:30
17:00
17:30
18:00
18:30
19:00
Time
Lower Bean Roof MC-3E
Neal Street CP-8
Brackett Street CP-9

FIGURE SET 3. MMC MONITORING POSITIONS: 5-SECOND RESULTS

NICU (Indoors) vs Lower Bean Roof
5-Second LAeq
September 13, 2003



Nursery and Teen Room (Indoors) vs Lower Bean Roof
5-Second LAeq
September 13, 2003

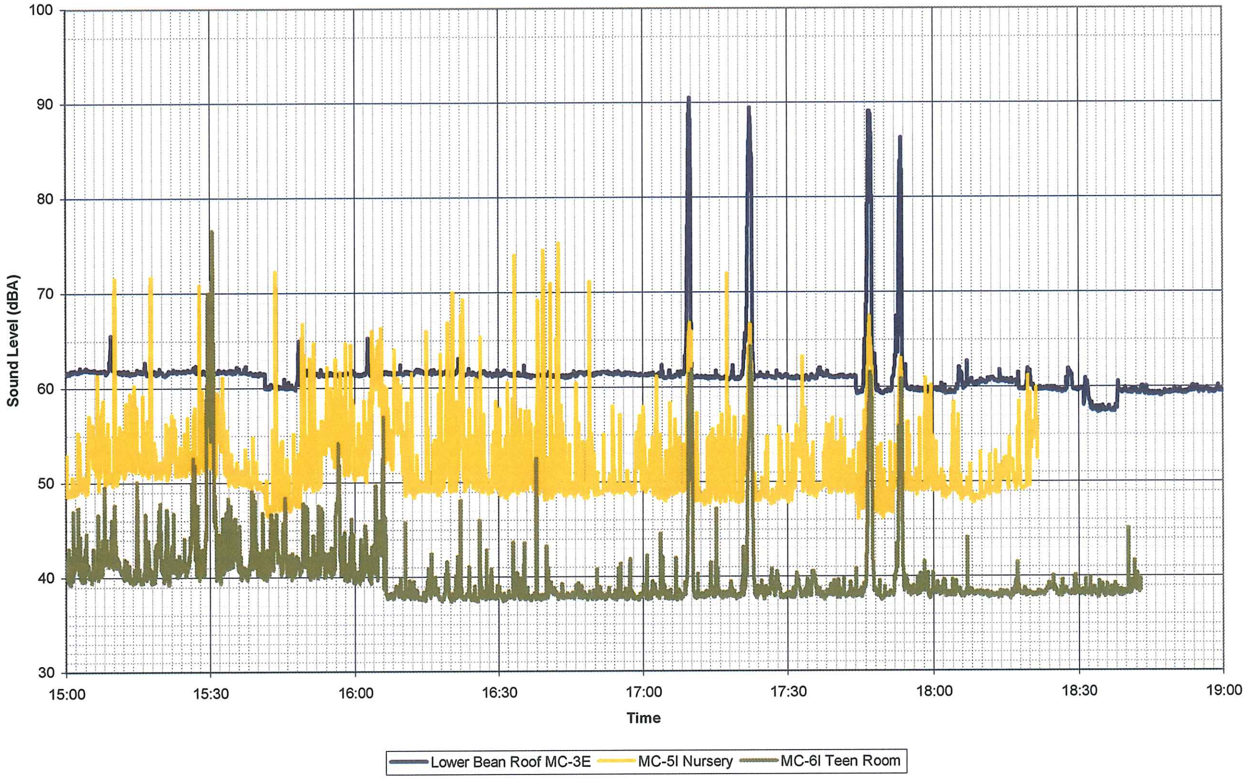
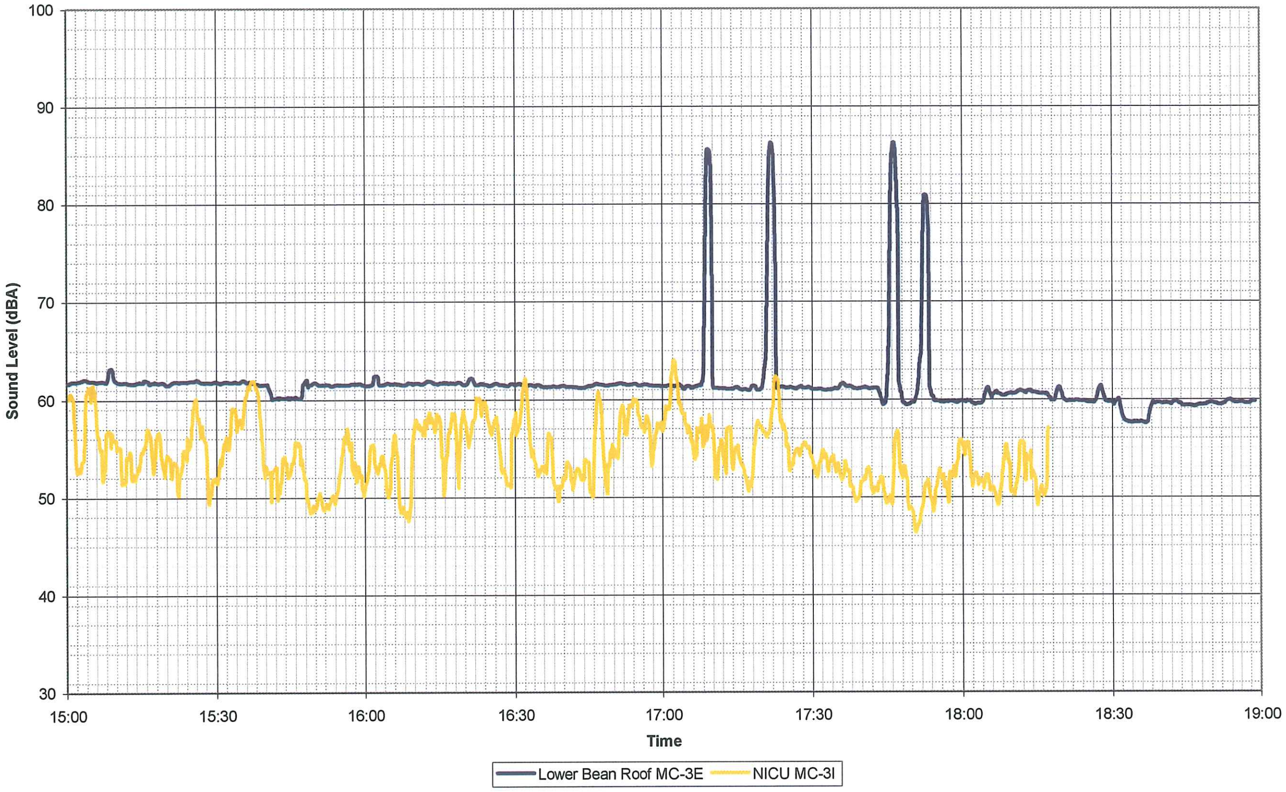
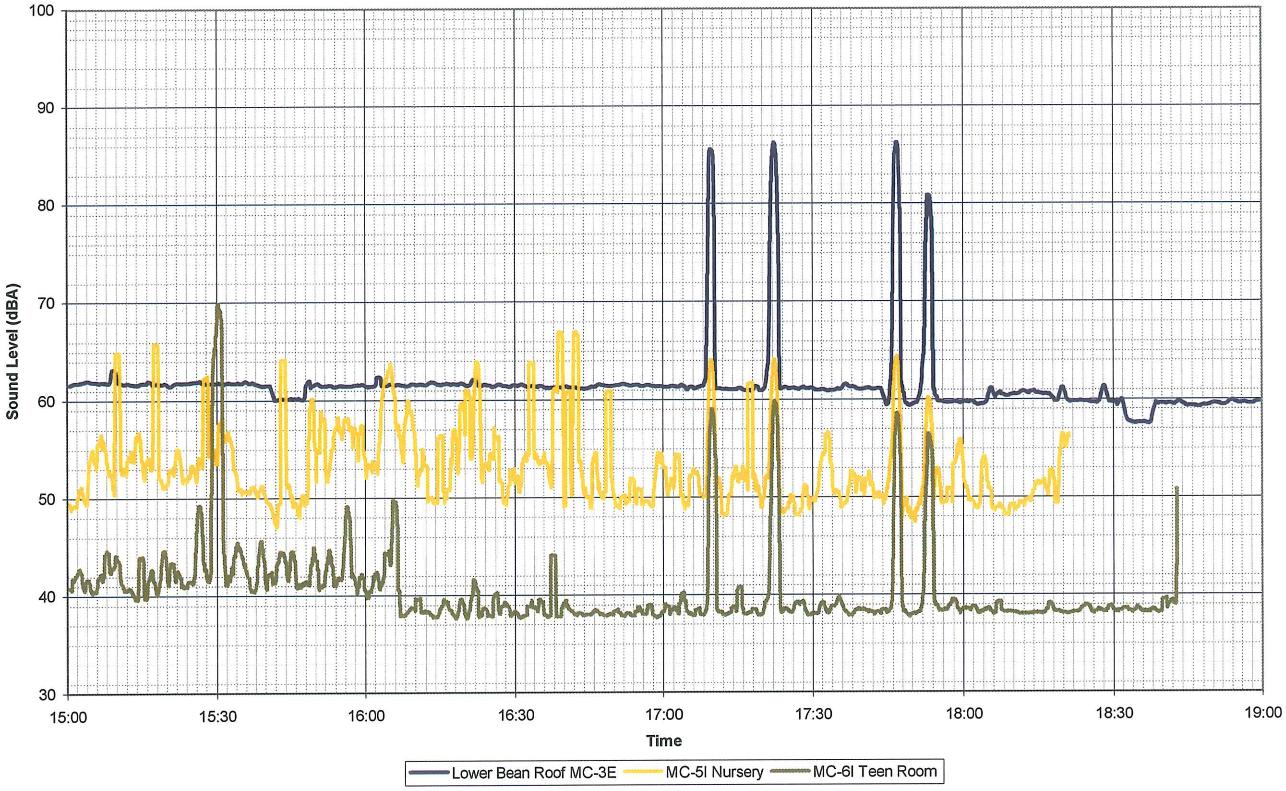


FIGURE SET 4. MMC MONITORING POSITIONS: ONE-MINUTE RESULTS

NICU (Indoors) vs Lower Bean Roof (Outdoors)
One-Minute LAeq
September 13, 2003



Nursery and Teen Center (Indoors) vs Lower Bean Roof (Outdoors)
One-Minute LAeq
September 13, 2003



Glossary of Terms and Acronyms

A-Weighted Sound Level – *A measure of sound pressure level designed to reflect the acuity of the human ear, which does not respond equally to all frequencies.*

Decibel (dB) – *Unit of level when the base of the logarithm is the tenth root of ten, and the quantities concerned are proportional to power. Unit symbol, dB.*

dBA – *Unit of sound level. The weighted sound pressure level by the use of the A metering characteristic and weighting specified in ANSI Specifications for Sound Level Meter.*

Equivalent Sound Pressure Level (L_{Aeq}) – *The level of the mean-square A-weighted sound pressure during a stated time period, or equivalently the level of the sound exposure during a stated time period divided by the duration of the period.*

Far Field – *The region where the sound pressure level decreases 6 dB for each doubling of distance. The distance from a sound source is greater than an acoustic wavelength. In the far field, the effect of the type of sound source is negligible.*

Free Field – *Field in a homogeneous, isotropic medium free from boundaries. In practice, the effects of boundaries on a free field are negligible over the region of interest.*

Frequency – *For a function periodic in time, the reciprocal of the period. Unit, hertz (Hz).*

Hertz (Hz) – *Unit of measure of frequency, numerically equal to cycles per second.*

L_{A1} – *Sound level is exceeded 1% of the time during the measurement period*

L_{A10} – *Sound level is exceeded 10% of the time during the measurement period*

L_{A50} – *Sound level is exceeded 50% of the time during the measurement period*

L_{A90}- *Sound level is exceeded 90% of the time during the measurement period.*

L_{AFmax} – *Maximum fast-weighted sound pressure level during the measurement period.*

L_{Amin} – *Minimum sound pressure level during the measurement period.*

Maine Revised Statutes Annotated - *MRSA*

APPENDIX I
SUMMARY OF FEDERAL, STATE AND LOCAL NOISE STANDARDS

Federal Aviation Administration (FAA)

FAA advisory circular AC 150/5020-1, *Noise Control and Compatibility Planning For Airports,* identifies land use compatibility with various levels of aircraft noise. The threshold noise exposure for residential land uses is a day-night sound level (Ldn) of 65 dBA.

An FAA advisory circular for siting Heliports (AC No. 150/5020-2) provides technical guidance for calculating the acoustic environment near new heliports. The FAA discontinued this circular in the early 1990s.

FAA advisory circular AC 91-66, *Noise Abatement for Helicopters,* presents guidelines for noise reduction when operating helicopters. The Helicopter Association International has enhanced these guidelines and produced a *Fly Neighborly Guide.* RSE understand that flight operations at Maine Medical Center will follow this guide.

FAA regulation 14 CFR Part 36, *Noise Standards: Aircraft Type and Airworthiness,* prescribes noise standards for certification of aircraft, including helicopters. For certification, the aircraft manufacturer must show compliance with specified takeoff, flyover, and approach noise levels. RSE understands the primary aircraft to be used at Maine Medical Center is a 1991 Agusta A-109C, which has been certified in accordance with 14 CFR 36 Appendix H.

Maine Site Law and Regulations

Section 484 (3) of the Site Location of Development Law (Site Law) requires a developer to make adequate provision for fitting a development harmoniously into the existing natural environment and to demonstrate that the development will not unreasonably adversely affect existing uses and the natural environment. Site Law Regulation, Chapter 375.10, *Control of Noise*, establishes sound level limits at property boundaries of a development and at nearby *protected locations*. Protected locations include residences, schools, state parks, and designated wilderness areas. Limits vary depending upon local zoning and pre-development sound levels.

Maine DEP noise standards specifically exempt aircraft operations that are subject to federal regulation (ref. Chapter 375.10.C.5.b.). During review of the Eastern Maine Medical Center helipad, the Maine DEP found that helicopters are considered aircraft subject to FAA noise regulations. Consequently, the Maine DEP did not review the project for noise impact. There was an argument by opponents of the project that the FAA does not regulate ground operations. This argument may have led to EMMC's election to apply the FAA guidelines and install a noise barrier.

City of Portland

The City of Portland has enacted a Land Use Code, which specifies noise limits by zoning designation. Preliminary site maps indicated that Maine Medical Center was located within the R6 residential zone. Nearby zoning designations included B2 and B2b Community Business Zones.

According to City Code Section 14-187, uses in the B-2 and B-2b zones are subject to sound level limits of 60 dBA between 7:00 a.m. and 9:00 p.m., and 55 dBA between 9:00 p.m. and 7:00 a.m.

No sound level limits are specified for uses within the R-6 zone. The limits for zones B-2 and B-2b appear to apply only to uses within these zones and, therefore, may not apply to Maine Medical Center in the R-6 zone.

Portland established a Helistop Overlay Zone allowing "helicopters serving medical needs to land in certain areas, while protecting surrounding areas from any negative effects associated with such a use" (Section 14-325). As of February 2001, the Helistop Overlay Zone did not appear on the zoning map in the area of Maine Medical Center and helistop standards (Section 14-327) did not address sound levels.

If these preliminary findings are correct, there may not be any specific noise standard that Maine Medical Center is required to meet during operation of the proposed helipad. The pertinent federal regulation is a voluntary guideline, the Maine DEP regulation exempts aircraft operation, and the Portland Code does not appear to regulate noise from uses in the R-6 zone and the Helistop Overlay Zone does not address sound levels.

APPENDIX II
COMMUNITY MONITORING RESULTS
DECEMBER 18-19, 2002

Table II-1
Pre-Development Hourly Sound Level Readings
Position CP-1 (Gilman & A Street)

Date	Start Time	Measured Sound Levels (dBA)						
		L_{Aeq}	L_{Amax}	L_{Amin}	L_{A1}	L_{A10}	L_{A50}	L_{A90}
18-Dec-02	10:00	60	90	53	68	61	56	54
18-Dec-02	11:00	58	79	52	66	59	56	54
18-Dec-02	12:00	59	80	52	69	61	56	55
18-Dec-02	13:00	59	85	52	69	60	56	54
18-Dec-02	14:00	57	72	52	65	60	56	54
18-Dec-02	15:00	58	76	51	66	61	57	54
18-Dec-02	16:00	61	82	51	72	62	57	54
18-Dec-02	17:00	60	80	53	70	61	57	55
18-Dec-02	18:00	59	78	52	68	61	57	55
18-Dec-02	19:00	57	73	52	65	59	56	54
18-Dec-02	20:00	57	73	51	64	59	56	54
18-Dec-02	21:00	62	81	52	75	60	56	54
18-Dec-02	22:00	59	79	50	69	60	56	54
18-Dec-02	23:00	57	73	50	64	60	56	53
19-Dec-02	0:00	55	78	48	64	57	53	51
19-Dec-02	1:00	54	71	49	61	57	53	51
19-Dec-02	2:00	57	76	49	70	59	53	51
19-Dec-02	3:00	56	69	48	64	59	54	52
19-Dec-02	4:00	55	73	49	60	58	54	52
19-Dec-02	5:00	58	74	51	66	60	57	55
19-Dec-02	6:00	62	79	56	68	63	61	58
19-Dec-02	7:00	63	85	57	76	63	60	58
19-Dec-02	8:00	60	77	55	67	62	59	58
19-Dec-02	9:00	61	80	54	72	61	58	56
19-Dec-02	10:00	60	77	54	70	61	58	56
19-Dec-02	11:00	60	79	53	71	62	58	55
19-Dec-02	12:00	60	81	54	69	61	58	55
19-Dec-02	13:00	59	79	52	69	60	56	54
Maine DEP Daytime (7 am to 7 pm) Avg		**60**	**80**	**53**	**69**	**61**	**57**	**55**
Maine DEP Nighttime (7 pm to 7 am) Avg		**57**	**75**	**50**	**66**	**59**	**55**	**53**
Portland Daytime Average (7 am to 9 pm)		**59**	**79**	**53**	**68**	**61**	**57**	**55**
Portland Nighttime Average (9 pm to 7 am)		**57**	**75**	**50**	**66**	**59**	**55**	**53**
FAA Daytime LEQ (7 am to 10 pm)		**60**						
FAA Nighttime LEQ (10 pm to 7 am)		**58**						
24-Hour LEQ		**59**						
FAA Day-Night Sound Level (Ldn)		**64**						

Table II-2
Pre-Development Hourly Sound Level Readings
Position CP-2 (Congress & Weymouth Street)

	Start	Measured Sound Levels (dBA)						
Date	Time	L_{Aeq}	L_{Amax}	L_{Amin}	L_{A1}	L_{A10}	L_{A50}	L_{A90}
18-Dec-02	10:00							
18-Dec-02	11:00	59	79	48	67	62	58	53
18-Dec-02	12:00	61	85	49	69	63	59	55
18-Dec-02	13:00	60	76	50	67	62	58	54
18-Dec-02	14:00	59	77	49	67	62	58	53
18-Dec-02	15:00	59	74	49	66	62	58	54
18-Dec-02	16:00	65	94	50	71	62	59	54
18-Dec-02	17:00	60	76	51	68	62	59	55
18-Dec-02	18:00	60	74	51	66	62	59	55
18-Dec-02	19:00	59	73	51	65	62	58	55
18-Dec-02	20:00	58	75	50	65	61	57	53
18-Dec-02	21:00	61	79	50	73	62	56	53
18-Dec-02	22:00	59	78	49	68	61	56	53
18-Dec-02	23:00	57	85	48	64	60	55	51
19-Dec-02	0:00	55	79	46	63	58	53	49
19-Dec-02	1:00	55	73	46	63	58	53	49
19-Dec-02	2:00	55	69	46	62	58	52	49
19-Dec-02	3:00	57	75	47	66	60	54	50
19-Dec-02	4:00	56	76	49	63	58	54	51
19-Dec-02	5:00	58	73	48	66	61	56	52
19-Dec-02	6:00	61	74	54	68	63	59	57
19-Dec-02	7:00	62	78	54	71	64	60	57
19-Dec-02	8:00	63	78	56	68	65	62	60
19-Dec-02	9:00	63	78	52	71	65	61	58
19-Dec-02	10:00	63	89	54	71	64	61	58
19-Dec-02	11:00	63	86	51	69	65	61	58
19-Dec-02	12:00	60	78	50	67	63	59	54
19-Dec-02	13:00	62	89	49	70	63	58	54
Maine DEP Daytime (7 am to 7 pm) Avg		**61**	**81**	**51**	**69**	**63**	**59**	**55**
Maine DEP Nighttime (7 pm to 7 am) Avg		**57**	**76**	**49**	**65**	**60**	**55**	**52**
Portland Daytime Average (7 am to 9 pm)		**61**	**80**	**51**	**68**	**63**	**59**	**55**
Portland Nighttime Average (9 pm to 7 am)		**57**	**76**	**48**	**66**	**60**	**55**	**52**
FAA Daytime LEQ (7 am to 10 pm)		**61**						
FAA Nighttime LEQ (10 pm to 7 am)		**57**						
24-Hour LEQ		**60**						
FAA Day-Night Sound Level (Ldn)		**65**						

Table II-3
Pre-Development Hourly Sound Level Readings
Position CP-3 (Wescott & Crescent Street)

Date	Start Time	Measured Sound Levels (dBA)						
		L_{Aeq}	L_{Amax}	L_{Amin}	L_{A1}	L_{A10}	L_{A50}	L_{A90}
18-Dec-02	10:00							
18-Dec-02	11:00							
18-Dec-02	12:00	57	79	47	66	58	53	50
18-Dec-02	13:00	58	85	46	70	56	51	49
18-Dec-02	14:00	53	71	47	61	54	51	49
18-Dec-02	15:00	55	84	47	66	55	51	49
18-Dec-02	16:00	55	83	47	66	55	51	49
18-Dec-02	17:00	59	86	47	67	56	51	49
18-Dec-02	18:00	56	85	48	64	54	51	50
18-Dec-02	19:00	54	75	48	60	55	52	50
18-Dec-02	20:00	54	74	48	62	54	52	50
18-Dec-02	21:00	56	76	47	70	55	51	49
18-Dec-02	22:00	54	76	46	65	54	51	49
18-Dec-02	23:00	54	83	46	62	55	51	49
19-Dec-02	0:00	54	82	44	60	52	49	47
19-Dec-02	1:00	51	67	44	58	54	50	47
19-Dec-02	2:00	51	67	45	59	54	49	47
19-Dec-02	3:00	53	70	45	62	55	51	48
19-Dec-02	4:00	53	68	46	58	55	51	49
19-Dec-02	5:00	54	68	47	60	57	53	50
19-Dec-02	6:00	58	75	52	63	60	57	55
19-Dec-02	7:00	59	79	53	69	59	56	55
19-Dec-02	8:00	56	74	50	62	57	55	53
19-Dec-02	9:00	59	83	49	69	58	53	51
19-Dec-02	10:00	58	87	48	70	57	53	51
19-Dec-02	11:00	57	88	47	66	56	52	50
19-Dec-02	12:00	54	85	47	63	55	51	49
19-Dec-02	13:00							
Maine DEP Daytime (7 am to 7 pm) Avg		**57**	**83**	**48**	**66**	**56**	**52**	**50**
Maine DEP Nighttime (7 pm to 7 am) Avg		**54**	**73**	**46**	**62**	**55**	**52**	**49**
Portland Daytime Average (7 am to 9 pm)		**56**	**81**	**48**	**66**	**56**	**52**	**50**
Portland Nighttime Average (9 pm to 7 am)		**54**	**73**	**46**	**62**	**55**	**51**	**49**
FAA Daytime LEQ (7 am to 10 pm)		**56**						
FAA Nighttime LEQ (10 pm to 7 am)		**54**						
24-Hour LEQ		**55**						
FAA Day-Night Sound Level (Ldn)		**61**						

Table II-4
Pre-Development Hourly Sound Level Readings
Position CP-4 (Ellsworth & Charles Street Ext.)

Date	Start Time	Measured Sound Levels (dBA)						
		L_{Aeq}	L_{Amax}	L_{Amin}	L_{A1}	L_{A10}	L_{A50}	L_{A90}
18-Dec-02	10:00							
18-Dec-02	11:00							
18-Dec-02	12:00							
18-Dec-02	13:00	56	72	50	63	58	54	52
18-Dec-02	14:00	56	70	52	63	57	54	53
18-Dec-02	15:00	56	68	52	63	57	54	53
18-Dec-02	16:00	55	75	49	63	57	54	52
18-Dec-02	17:00	55	70	48	65	57	54	51
18-Dec-02	18:00	55	72	49	62	56	54	51
18-Dec-02	19:00	55	71	49	60	56	54	52
18-Dec-02	20:00	54	66	49	61	56	54	51
18-Dec-02	21:00	54	74	49	63	56	53	51
18-Dec-02	22:00	54	69	49	60	56	53	51
18-Dec-02	23:00	54	70	50	60	56	54	51
19-Dec-02	0:00	55	75	49	66	56	52	50
19-Dec-02	1:00	53	67	48	59	55	52	50
19-Dec-02	2:00	53	65	49	59	55	53	50
19-Dec-02	3:00	55	71	49	63	57	54	51
19-Dec-02	4:00	55	69	49	60	57	54	51
19-Dec-02	5:00	57	71	50	65	59	56	52
19-Dec-02	6:00	59	73	52	66	61	59	56
19-Dec-02	7:00	59	72	56	67	61	59	57
19-Dec-02	8:00	58	73	52	66	59	57	54
19-Dec-02	9:00	57	74	50	67	58	54	52
19-Dec-02	10:00	59	84	49	69	60	54	51
19-Dec-02	11:00	57	79	50	67	60	54	52
19-Dec-02	12:00	57	79	50	65	58	54	52
19-Dec-02	13:00	56	74	50	64	58	54	53
Maine DEP Daytime (7 am to 7 pm) Avg		**57**	**74**	**50**	**65**	**58**	**55**	**53**
Maine DEP Nighttime (7 pm to 7 am) Avg		**55**	**70**	**49**	**62**	**57**	**54**	**51**
Portland Daytime Average (7 am to 9 pm)		**56**	**73**	**50**	**64**	**58**	**55**	**52**
Portland Nighttime Average (9 pm to 7 am)		**55**	**70**	**49**	**62**	**57**	**54**	**51**
FAA Daytime LEQ (7 am to 10 pm)		**56**						
FAA Nighttime LEQ (10 pm to 7 am)		**56**						
24-Hour LEQ		**56**						
FAA Day-Night Sound Level (Ldn)		**62**						

Table II-5
Pre-Development Hourly Sound Level Readings
Position CP-5 (Bowdoin & Chadwick Street)

	Start	Measured Sound Levels (dBA)						
Date	Time	L_{Aeq}	L_{Amax}	L_{Amin}	L_{A1}	L_{A10}	L_{A50}	L_{A90}
18-Dec-02	10:00							
18-Dec-02	11:00							
18-Dec-02	12:00							
18-Dec-02	13:00	52	70	46	60	58	48	47
18-Dec-02	14:00	53	73	36	65	54	43	39
18-Dec-02	15:00	46	67	37	58	48	41	39
18-Dec-02	16:00	47	67	38	58	48	44	41
18-Dec-02	17:00	50	74	41	61	50	44	42
18-Dec-02	18:00	46	66	41	56	48	44	42
18-Dec-02	19:00	46	70	41	54	48	45	43
18-Dec-02	20:00	48	70	43	57	49	46	45
18-Dec-02	21:00	57	80	43	70	51	47	46
18-Dec-02	22:00	51	75	41	62	49	45	43
18-Dec-02	23:00	45	63	40	54	47	44	42
19-Dec-02	0:00	43	54	38	48	45	43	40
19-Dec-02	1:00	44	65	39	49	46	43	42
19-Dec-02	2:00	45	54	41	50	47	45	43
19-Dec-02	3:00	48	63	41	58	49	45	43
19-Dec-02	4:00	45	62	41	49	47	45	43
19-Dec-02	5:00	48	69	43	56	49	46	45
19-Dec-02	6:00	51	69	46	59	52	50	49
19-Dec-02	7:00	57	73	49	66	60	55	52
19-Dec-02	8:00	55	73	52	59	56	55	53
19-Dec-02	9:00	55	71	47	64	59	51	48
19-Dec-02	10:00	58	88	46	64	52	49	47
19-Dec-02	11:00	49	70	40	57	51	48	43
19-Dec-02	12:00	51	71	40	63	51	44	42
19-Dec-02	13:00							
Maine DEP Daytime (7 am to 7 pm) Avg		**52**	**72**	**43**	**61**	**53**	**47**	**45**
Maine DEP Nighttime (7 pm to 7 am) Avg		**48**	**66**	**41**	**56**	**48**	**45**	**44**
Portland Daytime Average (7 am to 9 pm)		**51**	**72**	**42**	**60**	**52**	**47**	**45**
Portland Nighttime Average (9 pm to 7 am)		**48**	**65**	**41**	**56**	**48**	**45**	**43**
FAA Daytime LEQ (7 am to 10 pm)		**53**						
FAA Nighttime LEQ (10 pm to 7 am)		**48**						
24-Hour LEQ		**52**						
FAA Day-Night Sound Level (Ldn)		**56**						

FIGURE II-1
Pre-Development Hourly Equivalent Sound Levels (LAeq)
December 18-19, 2002

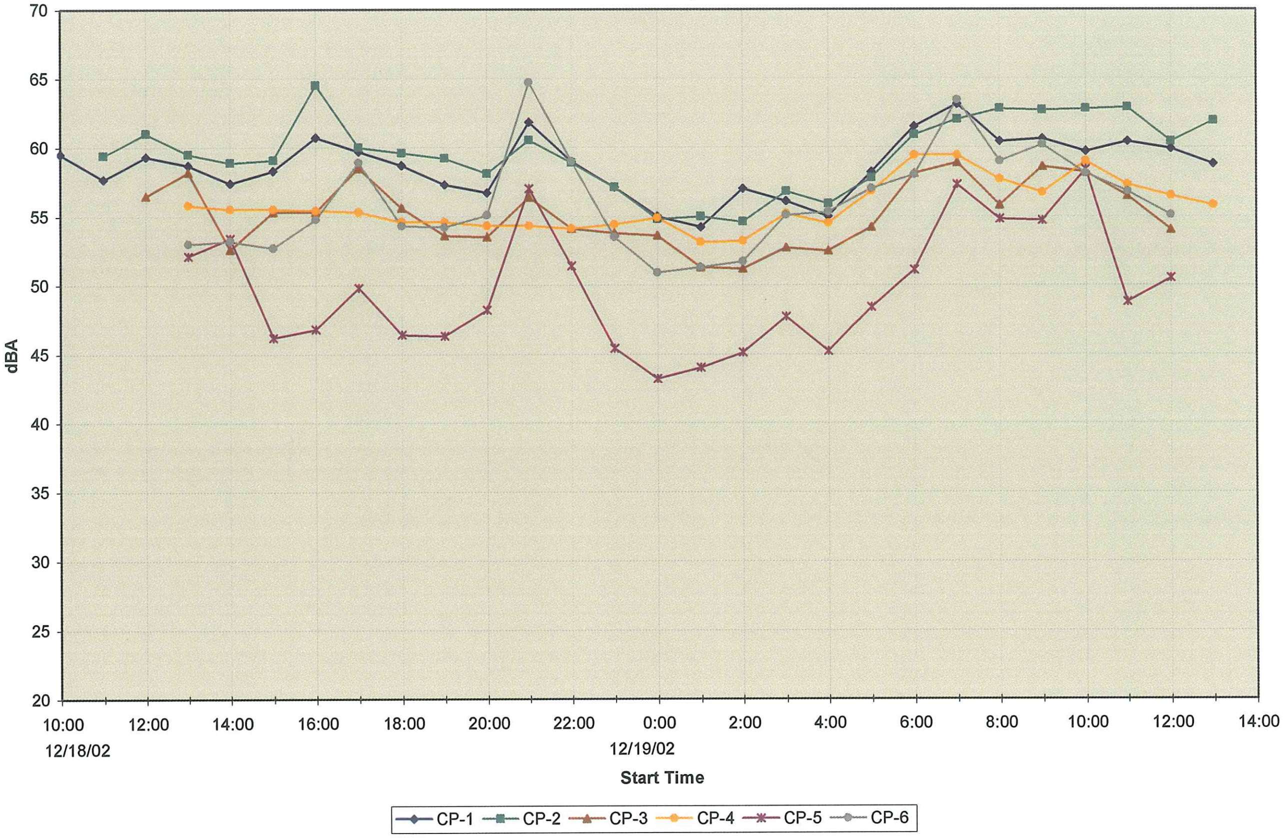


FIGURE II-2
Pre-Development Hourly Equivalent Sound Levels (LA1)
December 18-19, 2002

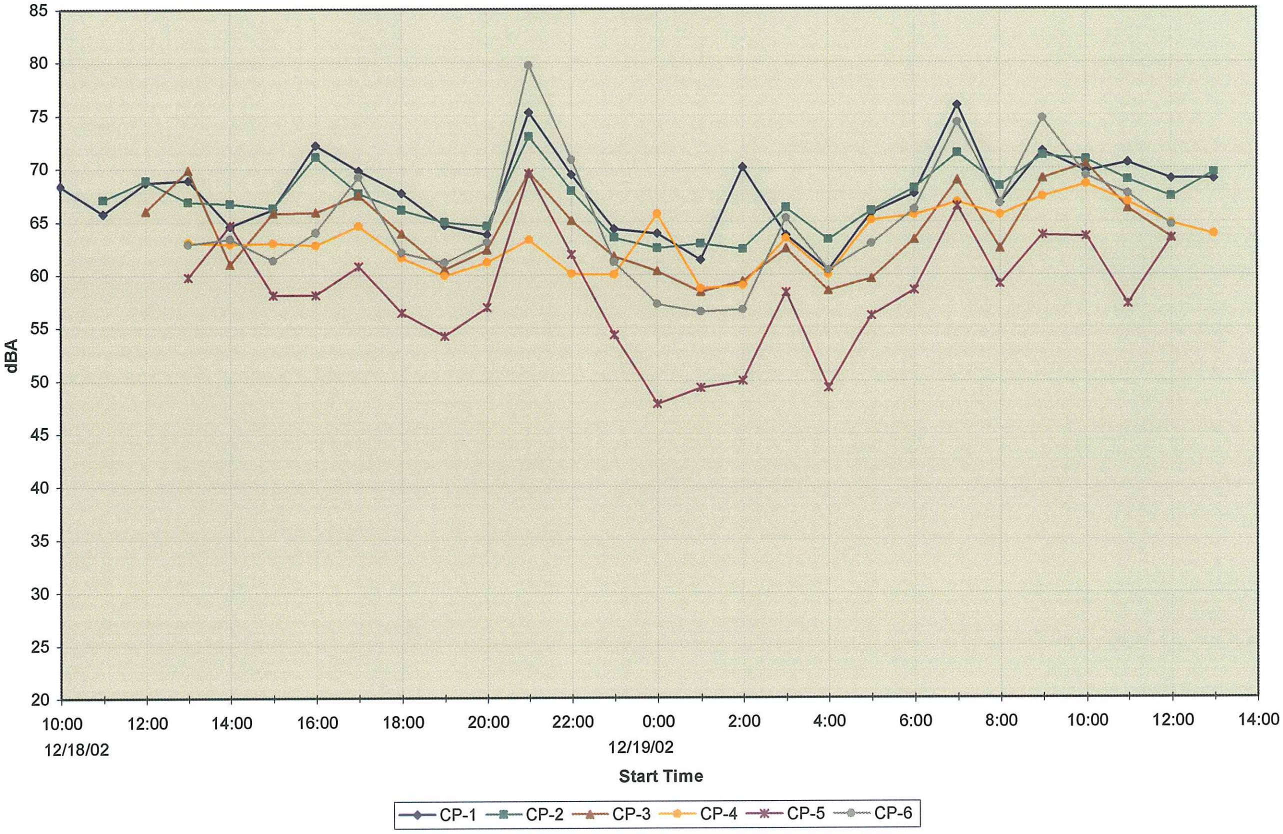


FIGURE II-3
Pre-Development Hourly Equivalent Sound Levels (LA10)
December 18-19, 2002

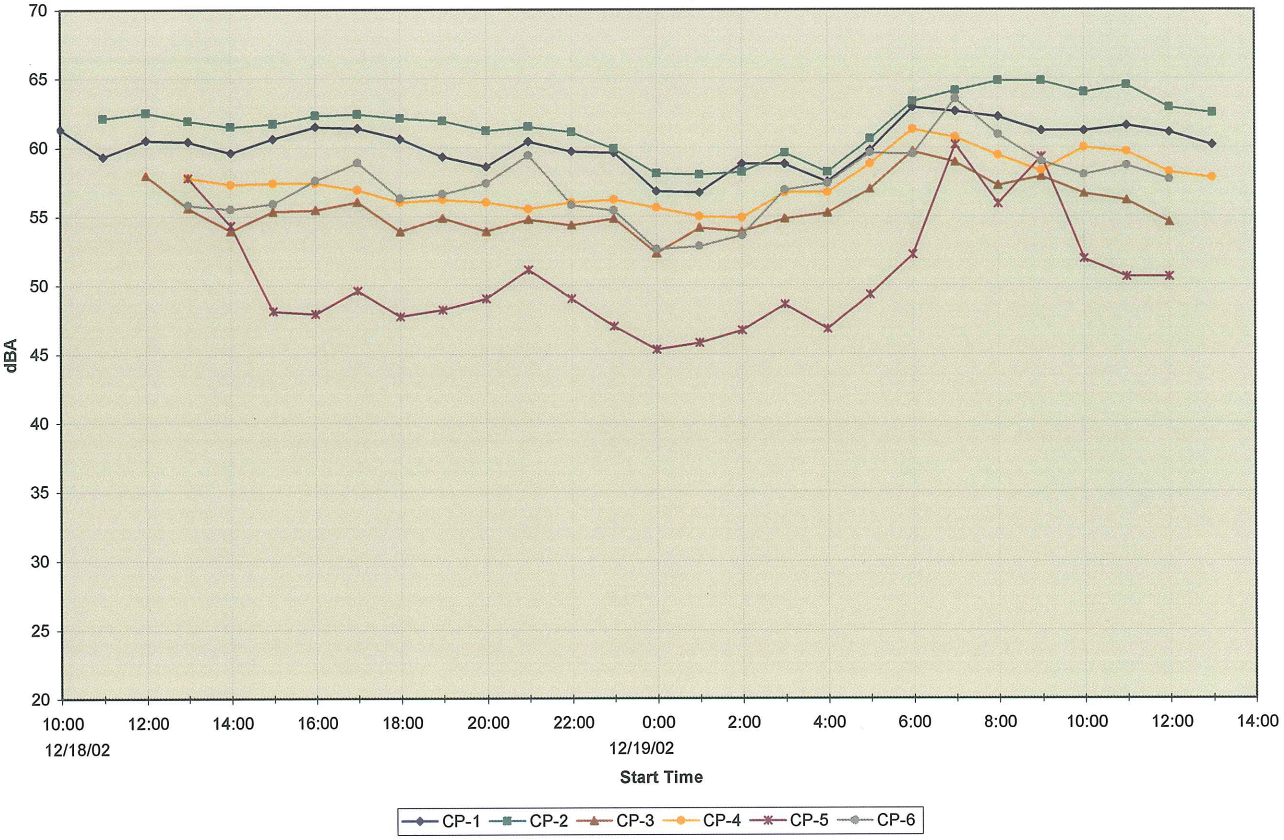


FIGURE II-4
Pre-Development Hourly Equivalent Sound Levels (LA50)
December 18-19, 2002

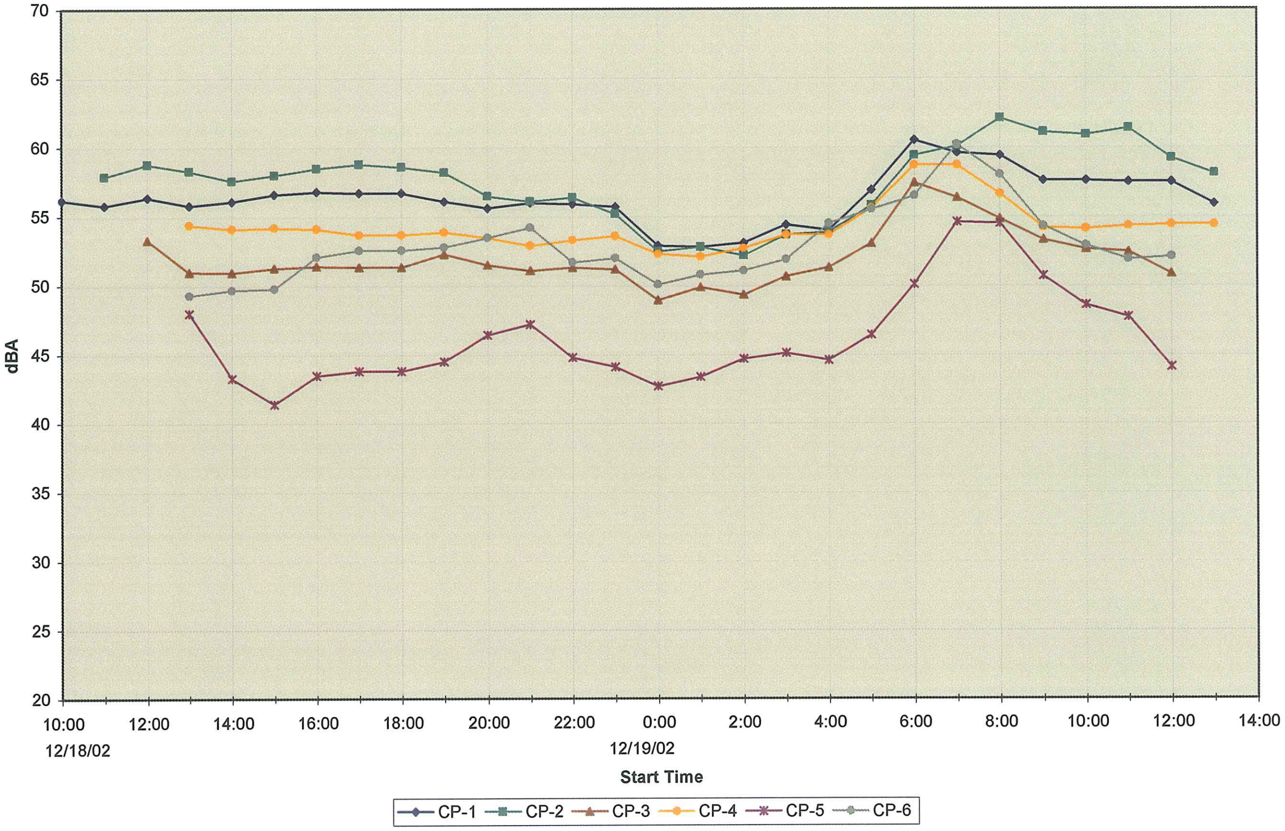


FIGURE II-5

Pre-Development Hourly Equivalent Sound Levels (LA90)
December 18-19, 2002

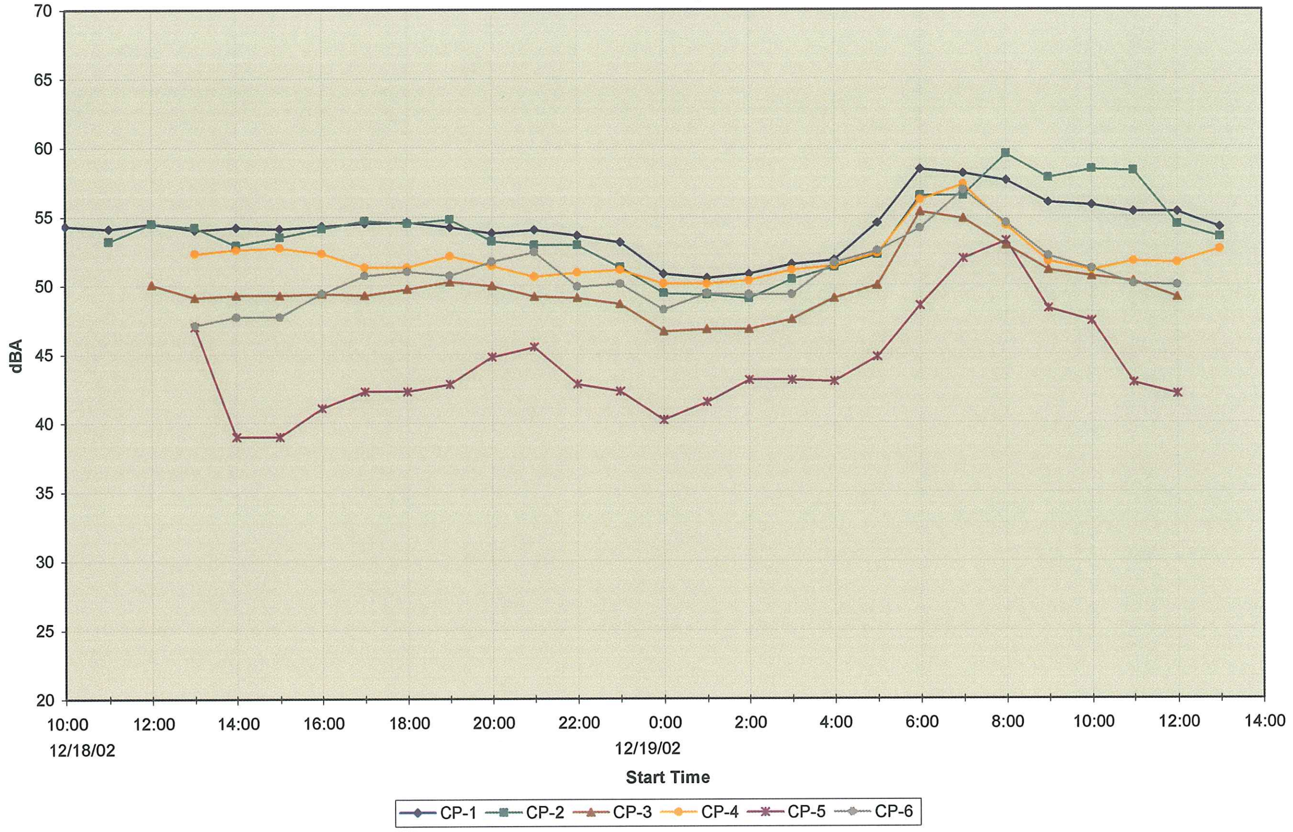
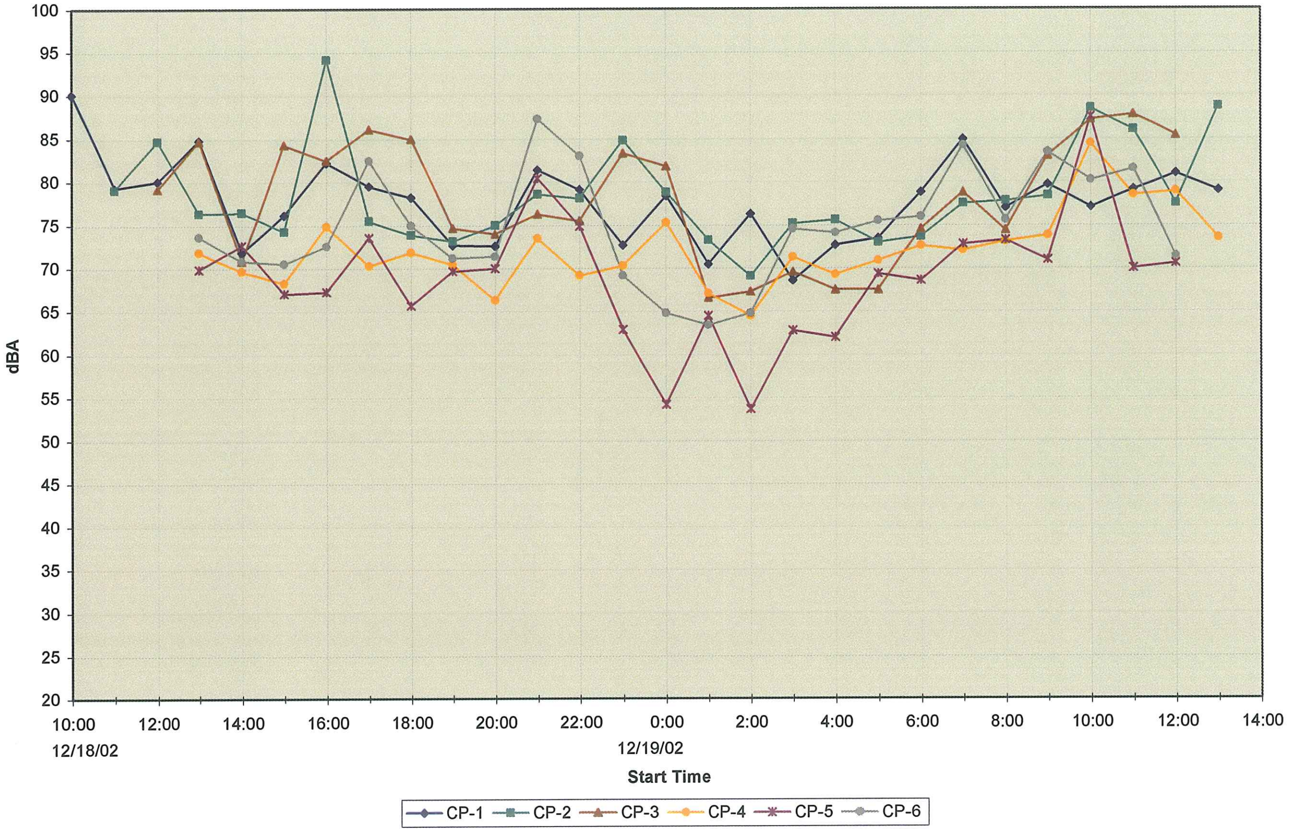


FIGURE II-6

Pre-Development Hourly Equivalent Sound Levels (LAmax)
December 18-19, 2002



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Planning & Development Department
Lee D. Urban, Director

Housing & Neighborhood Services Division
Aaron Shapiro, Director

MEMORANDUM

TO: Alex Jaegerman
FROM: Aaron Shapiro
DATE: February 1, 2005

RE: Noise Mitigation Project – Maine Medical Center Helipad

Staff of the Division of Housing & Neighborhood Services are available and capable of assisting in the implementation of noise mitigation measures in conjunction with the development of Maine Medical Center's helipad facility.

It is my understanding that five of the most severely effected residential properties are slated for mitigation measures. These measures most likely will include the installation of acoustically -designed replacement windows and some form of air-conditioning system. The five properties are multi-family buildings located along Congress Street.

At this time we are gathering information concerning acoustically-designed windows and cost information. Hank Dunn of MMC told me that the properties contain approximately 90 windows. I've not been told how many apartment units are involved, though some of the properties have commercial business activity on their first floor.

Dwight Gailey and Roger Hutchins, the Division's Housing Rehabilitation Specialists will be assigned to the project. They will perform project management services on the projects: inspections, specification development, oversight, requisition review, etc., similar to their typical duties. While administrative fees for our services have been mentioned, and will certainly be required, no actual cost amount has been determined.

From: "Elizabeth Begin" <ewb_52@hotmail.com>
To: <aqj@portlandmaine.gov>
Date: 02/01/2005 4:36 PM
Subject: Maine Medical Center

Alex, I am unable to attend tonight's Planning Board meeting and would like to submit the following comments for the record. Would you please forward to the appropriate person? Many thanks, Elizabeth

My name is Elizabeth Begin and I live at 5 Orchard St. Portland. I have been following the development of the MMC project since it was first developed, and I would like to share some thoughts.

Projects which are the size and scope of the one being presented by Maine Medical Center remind me how much easier it is when nothing changes. Or we perceive that nothing changes. But of course things do change, every day, and the impact of those changes varies depending on how we are affected by them.
There is no question that the MMC plan is a big plan. It is complicated. It weaves pressures that result from growth and expansion, advances in technology, aging infrastructure and public demand. And the result is a well thought out and elegantly designed proposal.
The new building for women and children puts together services that make sense. The parking garage further reduces the stress on neighborhood streets while enhancing the arrival and departure experience for patients and visitors. The helipad will bring the critically ill to where they should be.
And I am incredibly proud to live in the neighborhood where all this is taking place. I have attended a number of meetings where MMC has answered questions, listened to ideas, reformulated earlier suggestions and made changes. They have run 2 helicopter tests. There has been an enormous effort to allow the public to participate. I have not seen another project in Portland that has even come close to involving the neighbors and the public as openly and with the integrity that has been demonstrated by MMC.
I support the MMC plan with enthusiasm. I am convinced that the future growth of Portland goes hand in hand with the excellence of her medical facilities. And I urge the Planning Board to give the project its support.
Thank you.

From: "Rick Seeley" <rseeley@gpcog.org>
To: "Alex Jaegerman (E-mail)" <AQJ@portlandmaine.gov>
Date: 02/01/2005 9:41 AM
Subject: FW: Maine Medical Center Parking Garage
CC: "Sarah Hopkins (E-mail)" <SH@portlandmaine.gov>

-----Original Message-----
From: Steve Linnell
Sent: Monday, January 31, 2005 1:35 PM
To: Rick Seeley
Cc: Eric Ortman; Erik West; Caroline Allam
Subject: FW: Maine Medical Center Parking Garage

-----Original Message-----
From: Kevin Donoghue [mailto:kjdonoghue@yahoo.com]
Sent: Friday, January 28, 2005 11:41 AM
To: editor@theforecaster.net; cbusby@theforecaster.net
Cc: aqj@portlandmaine.gov; jduson@portlandmaine.gov; kgeraghty@portlandmaine.gov; phefler@gpmetrobus.com; pcavanaugh@gpmetrobus.com; scsmedia@cs.com; Ed King; Stephen Spring; etrice2@hotmail.com; Steve Linnell
Subject: Maine Medical Center Parking Garage

To the Editor:

Thanks to Chris Busby and the Forecaster for covering the planned expansion and proposed contract zone by Maine Medical Center and the required neighborhood meeting Janauary 24. Indeed, it was quite encouraging to read that those able to attend the meeting voiced the most concern over the proposed parking garage, an aspect over which I, too, must voice concern.
Superficially, my opposition is aesthetic, but more seriously, that aesthetic is significant, first, to our neighborhood sidewalks and, second, to our regional transportation planning priorities.

The proposed 500-car garage is to be built alongside the current 700-car garage on Congress Street, a street which is remarkable for its pedestrian orientation and its vibrant mix of uses. The hospital campus already presents the greatest of institutional dead spaces on Congress Street, dead spaces of the sort that have earlier sapped the vitality from parts of both Spring Street and Cumberland Avenue. Congress Street can, however, still salvage another future.

Fairweather pedestrians can be forgiven for believing that downtown ends at Longfellow Square; after all, crossing westward over the square demands a certain level of militancy and the row of suburban-style kwik-e-marts thereafter tend not to inspire a wish-you-were-here postcard. However, moving westward, we can welcome urban-style housing developments like Walker Terrace, pedestrian-oriented neighborhood businesses like the Bike Cycle and Youngo's Cafe at Bramhall Square, and still more vestiges of the urban environment down below the hospital: Pizza Villa, the Inn at St. John, the Dogfish Cafe, and a transit station we can *actually walk* to. Preserving and enhancing this pedestrian connectivity should be a priority for this walking city, but as the hospital has resisted and no planner has insisted, there will be no mixed-uses here.

What, then, are our priorities? Parking, it would seem. Parking structures may well make efficient use of veritical space, but it is of linear space, of the roads, we should be thinking. Increasing the supply of parking accelerates the demand for roadway and eventual congestion.
Maine Medical Center may well have compelling reasons for its own parking supply increases, but what is the hospital or, moreover, the city doing to curb the demand for it? Not much yet. We can start doing something about this by asking questions and by seeking new solutions:

Must the garage be built at all, or are there other solutions? If current reliance on automobiles is held constant, then it is of no surprise that more hospital capacity demand more parking. If, however, we invest in housing development and mass transit, we may very well be suprised. We may also find that such monuments to automobile dependency can help such investment, either by making annual contributing to public transportation or using their visibilty to market it.

If the garage must be built, must it be built on Congress Street? If the garage were located, say, near the county jail, perhaps, then, there would result suffient pedestrian demand to create humane passage over St. John Street and Valley Street *and* to Union Station Plaza.

If the garage must be built on Congress Street, can it not accomodate mixed uses? If the garage, planned to have no setback whatever, included retail on the ground floor, it might, if done well, actually *enhance* pedestrian connectivity along this eminantly walkable street.

Without asking such questions, we are unlikely to find many satisfactory answers and without reforming our transportation priorities, our sidewalks and roadways may lead nowhere quickly.

Kevin Donoghue
Portland

From: "Paul Gray" <GRAYP@mmc.org>
To: <rseeley@gpcog.org>
Date: 02/01/2005 10:57:22 AM
Subject: Re: FW: MMC construction

Rick
Thanks for the e-mail
Paul

>>> "Rick Seeley" <rseeley@gpcog.org> 02/01/05 10:46AM >>>
Paul,

FYI - I just received the message below and have forwarded it to the Planning Division for distribution to the Planning Board at the hearing today.

Rick

-----Original Message-----
From: Jo Coyne [mailto:jocoyne@gwi.net]
Sent: Tuesday, February 01, 2005 10:38 AM
To: Rick Seeley
Cc: Chris Hirsch; Molly Fitzpatrick; Chip Martin; Jo Coyne
Subject: MMC construction [html]

Dear Mr. Seeley,

I will be unable to attend the Planning Board's public hearing tonight on the expansion proposed by Maine Medical Center. I would like to request via this e-mail that ongoing monitoring of MMC activity levels, complaints, etc., be assigned to neighborhood groups in general rather than to specific organizations.

Unfortunately, the recently-formed West End Neighborhood Association was not able to join the Western Promenade Association and the Parkside Neighborhood Association in working with MMC on their construction plans. We would, however, like to be included as the plans move forward. If there are other neighborhood groups in the same situation, we feel that they should be included as well.

Yours truly,

Jo Coyne, President
West End Neighborhood Association
36 Salem St., Portland 04102
207-775-3902
jocoyne@gwi.net

CC: <AQJ@portlandmaine.gov>, <pl@portlandmaine.gov>, <SH@portlandmaine.gov>

Alex Jaegerman - MMC conditional zone agreement

From: "Chris Vaniotis" <cvaniotis@bssn.com>
To: "Alex Jaegerman (E-mail)" <AQJ@portlandmaine.gov>
Date: 02/01/2005 11:07 AM
Subject: MMC conditional zone agreement
CC: "Paul Gray (E-mail)" <GRAYP@mmc.org>, "Penny Littell (E-mail)" <pl@portlandmaine.gov>, "Sarah Hopkins (E-mail)" <SH@portlandmaine.gov>, "Rick Seeley (E-mail)" <rseeley@gpcog.org>

Alex,

Paul Gray and I have reviewed John Anton's propopsed language for paragraph 16 in the conditional zone agreement and we are fine with it.

Chris

Noise Mitigation for Proposed MMC Helipad

At the January 11, 2005 Planning Board Workshop a question was asked about the feasibility of reducing helicopter noise in the neighborhood close to the proposed MMC helipad by mounting sound absorbing material on the Bean, Richards, and potentially, Charles Street buildings. This was a topic that MMC's noise consultants (RSE) explored thoroughly in their modeling as reported in their report of July 1, 2004, "Proposed Helicopter Pad Noise Mitigation". On page 3 of this report in Section 4.0, Site Selection, the consultant pointed out that the location of the helipad atop the existing parking garage but at an elevation lower than that of both the existing and proposed hospital buildings, effectively shields residential areas to the west and south from helicopter noise. RSE further stated:

> "Further analysis was conducted to determine if sound would reflect off existing and proposed structures and increase noise impact on residential properties. The nearest residential properties to the parking garage are across Congress Street and at a much lower elevation than the top level of the parking garage. Consequently, helipad sound that reflects off the hospital buildings would be blocked by the existing parking garage and therefore will not increase noise impact of the helipad at nearby residential property."

On page 8 of the July 1, 2004 report, in Section 5.4.2, Barrier Options, the consultant explains the methodology used to evaluate barrier options in the sound model:

> "Various barrier design and mitigation options were compared with sound levels expected from the helipad design that was the outcome of the site selection process. For each case the noise source was located at the north edge of the pad (helicopter facing MMC) and the noise source located at the center of the helipad (helicopter facing both north and south). Noise barriers were modeled as sound absorbing and the helipad surface as sound reflective."
>
> "When considering noise mitigation options, surrounding buildings were modeled as reflective surfaces and then compared to buildings with absorptive surfaces. This comparison showed no significant change in community sound levels due to reflection of sound waves from MMC buildings". [emphasis added]

In the summary on page 14 of the July 1, 2004 report, RSC found

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MAINE MEDICAL CENTER
PORTLAND, MAINE

COMMUNITY AND LIFEFLIGHT HELICOPTER SOUND LEVEL STUDY

DRAFT

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Project No. 010120

OCTOBER 30, 2003

ACKNOWLEDGMENTS

Resource Systems Engineering wishes to thank personnel at Maine Medical Center and LifeFlight of Maine for their assistance and cooperation during conduct of the helicopter flight testing.

Resource Systems Engineering personnel responsible for this investigation and report are Charles F. Wallace, Jr., P.E., R. Scott Bodwell, P.E., Ann M. Vedock, Environmental/Acoustical Specialist and Ronald H. Mattson, CAD Technician/Acoustical Specialist.

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PORTLAND, MAINE
SOUND LEVEL STUDY

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MAINE MEDICAL CENTER
PORTLAND, MAINE
SOUND LEVEL STUDY

1.0 INTRODUCTION

On Saturday, September 13, 2003, helicopter flights were conducted at Maine Medical Center to simulate future operation of the proposed helipad operation. The helicopter was flown by LifeFlight of Maine, who currently provides emergency medical helicopter transport to Eastern Maine Medical Center in Bangor and Central Maine Medical Center in Lewiston.

The objective of the flight testing was to compare helicopter sound levels with existing community and hospital sound levels. Previously, RSE had monitored community sound levels in the vicinity of the hospital for a 24-hour period covering December 18-19, 2002. During this period, monitoring was conducted at six community positions (CP-1 through CP-6). Three more community positions and four hospital positions were added for monitoring during the helicopter flight test. Sound levels at all hospital and community positions were measured before, during and after the helicopter test.

LifeFlight operates two Agusta 109C helicopters in Maine: one based in Bangor and one based in Lewiston. The Agusta 109C is expected to be the primary helicopter using the proposed helipad at MMC. Flight testing with an Agusta 109C was planned for the simulation; however, the helicopter was called to an emergency and was not available. In order to maintain the community schedule, a BK 117 backup helicopter was flown instead.

This report compares sound levels measured during flight tests with ambient community sound levels without the helicopter. Helicopter sound levels will vary from the results of the measurements as described in Section 7.0. The objective of this report is to compare the measurement results of helicopter flight test with existing ambient sound levels. The report does not include noise model predictions of future sound levels reflecting full build-out conditions or provide a comparison to local, state and federal noise standards.

2.0 MONITORING POSITIONS

During the flight test, monitoring was conducted at nine community positions and four hospital positions. Community monitoring positions were selected based on the results of area mapping, ownership and accessibility, and potential noise impacts from the helipad. Community mapping included identification of land uses and zoning in the vicinity of the Maine Medical Center. The resulting vicinity site plan (Figure 1) provides a noise study map that delineates community monitoring positions in relation to structures and property boundaries of Maine Medical Center, structures and lot lines of property in the vicinity of MMC, existing land use and zoning designations, and the location of the proposed helipad and approach/departure routes. The nine community monitoring positions are as follows:

CP-1	Gilman and A Street - West of MMC
CP-2	Congress and Weymouth Street - North of MMC
CP-3	Crescent and Wescott Street - Northeast of MMC
CP-4	Ellsworth and Charles Street Ext East of MMC
CP-5	Bowdoin and Chadwick Street – South of MMC
CP-6	West Prom and West Street – South of MMC
CP-7	Grant Street (Parkside) – Northeast of MMC
CP-8	Neal Street – Southeast of MMC
CP-9	Brackett and Carleton Street – East of MMC

Hospital positions include three inside the hospital and one outside on a nearby rooftop. The interior positions were selected in conjunction with Maine Medical Center to monitor areas of the hospital that have been found to be sensitive to noise intrusion. The exterior position was selected for purposes of determining the transmission loss across the exterior walls of the hospital. The hospital positions are as follows:

MC-3E	Outside on the rooftop of the Lower Bean Building
MC-3I	Inside the NICU (Bean Building)
MC-5I	Inside the Newborn Nursery (Richards Tower)
MC-6I	Inside the Teen Room (Barbara Bush Hospital)

The hospital locations are shown of Figure 2 along with some of the closest community monitoring positions.

During the flight test monitoring, RSE personnel was were stationed at community positions CP-3 (Crescent) and CP-6 (West Prom), and hospital positions MC-3I (NICU) and MC-5I (Nursery). RSE personnel recorded observations prior to, during, and after the flight testing.

3.0 NOISE STANDARDS

A review of federal, state and local noise standards indicates there is no specific noise standard that Maine Medical Center is required to meet during operation of the proposed helipad. The pertinent federal regulation is a voluntary guideline, the Maine DEP regulation exempts aircraft operation, and the Portland Code does not appear to regulate noise from uses in the R-6 zone. A brief summary of local, state and federal noise standards and their potential applicability to the proposed helipad can be found in Appendix I.

4.0 EXISTING COMMUNITY SOUND LEVELS

On December 18 and 19, 2002, sound levels in the vicinity of the proposed helipad were monitored for a 24-hour period to determine existing ambient sound levels. RSE monitored ambient sound levels at six monitoring positions as shown on Figure 1, Vicinity Site Plan.

Instrumentation consisted of Larson-Davis Model 812 Integrating Sound Level Meters, which were programmed to continuously measure sound levels and calculate statistics at both hourly and ten-second intervals. One Larson-Davis Model 824 Sound Level Meter and Real Time

Analyzer was used to measure sound levels at position CP-3. It was programmed to continuously measure sound levels, including one-third octave band readings, and calculate statistics at both hourly and five-second intervals.

The sound level meters meet Type 1 (precision) performance requirements of American National Standard Specification for Sound Level Meters, ANSI S1.4-1983. The microphones were fitted with standard windscreens and mounted on tripods at a height of four to five feet above the ground. The sound level meters were calibrated before and after each twenty-four hour monitoring period using a Bruel & Kjaer 4231 Sound Level Calibrator. Additionally, a certified laboratory performs a calibration within the 12 months of the measurements. Calibration certificates are available upon request.

During monitoring on December 18-19, 2002, temperatures ranged from 19 to 42 degrees F; winds were generally from the northwest ranging 3 to 8 mph during the day and 0 to 3 mph at night. Skies were clear.

Hourly sound level readings, including L_{Aeq}, L_{Amax}, L_{Amin}, L_{A1}, L_{A10}, L_{A50} and L_{A90} values, are presented in Appendix II as Tables II-1 to II-6 and Figures II-1 through II-6. The L_{Aeq} represents the average energy level of all sounds present during the measurement period. The one-hour L_{Aeq} is the parameter specified for use by the Maine DEP and FAA for establishing pre-development ambient sound levels. The L_{Amax} is the maximum A-weighted sound level during the hour and the L_{Amin} is the minimum A-weighted sound level during the hour. L_{A1} is the sound level exceeded 1% of time during the hour. Likewise, L_{A10}, L_{A50} and L_{A90} are the sound levels exceeded 10%, 50% and 90% of the time during the hour.

At CP-1, during Maine DEP daytime hours (7 am to 7 pm), L_{Aeq} readings ranged from 58 to 63 dBA with an average of 60 dBA. During Maine DEP nighttime hours (7 pm to 7 am), L_{Aeq} readings ranged from 54 to 62 dBA with an average of 57 dBA. At CP-2, during Maine DEP daytime hours, L_{Aeq} readings ranged from 59 to 65 dBA with an average of 61 dBA. During nighttime hours, L_{Aeq} readings ranged from 55 to 61 dBA with an average of 57 dBA.

At CP-3, L_{Aeq} readings during Maine DEP daytime hours ranged from 53 to 59 dBA with an average of 57 dBA. L_{Aeq} readings during nighttime hours ranged from 51 to 58 dBA with an average of 54 dBA. At CP-4, L_{Aeq} readings during Maine DEP daytime hours ranged from 55 to 59 dBA with an average of 57 dBA. L_{Aeq} readings during nighttime hours ranged from 53 to 59 dBA with an average of 55 dBA.

The primary noise source at CP-1 through CP-4 during daytime and nighttime hours was local traffic and traffic on Interstate 295. Additional sources included aircraft traveling to and from the Portland Jetport, HVAC equipment at MMC and residential activity.

At CP-5, during Maine DEP daytime hours (7 am to 7 pm), L_{Aeq} readings ranged from 46 to 58 dBA with an average of 52 dBA. During nighttime hours (7 pm to 7 am), L_{Aeq} readings ranged from 43 to 57 dBA with an average of 48 dBA. Between the hours of 7 am and 3 pm, propane heaters operated on the property of CP-5 raising sound levels above typical levels for these hours. The average daytime L_{Aeq} without the heaters operating was 47 dBA from 3 pm to 7 pm. Other noise sources at CP-5 included local and distant traffic, Jetport aircraft, train station, hospital and residential activity.

At CP-6, during Maine DEP daytime hours (7 am to 7 pm), L_{Aeq} readings ranged from 53 to 60 dBA with an average of 57 dBA. During nighttime hours, L_{Aeq} readings ranged from 51 to 65 dBA with an average of 55 dBA. The primary noise sources at CP-6 were local traffic on West Promenade Street and traffic on I-295 to the west. Other noise sources included Jetport aircraft, park/pedestrian and residential activity.

Other calculated values in Tables II-1 to II-6 (Appendix II) are the FAA daytime L_{Aeq} (7 am to 10 pm), nighttime L_{Aeq} (10 pm to 7 am), and day-night (24-hour) sound level (L_{dn}). The L_{dn} values ranged from 56 to 65 dBA. A summary of existing daytime and nighttime sound levels is presented in Table 1. This includes daytime and nighttime sound levels as defined by the Maine DEP and City of Portland, and FAA L_{dn} sound levels.

TABLE 1

Existing Daytime and Nighttime Sound Levels

	Maine DEP Average L_{Aeq}		City of Portland Average L_{Aeq}		
Monitoring Position	**Daytime 7 am to 7 pm**	**Nighttime 7 pm to 7 am**	**Daytime 7 am to 9 pm**	**Nighttime 9 pm to 7 am**	**FAA Day-Night Sound Level (L_{dn})**
CP-1: Gilman & A Street	60	57	59	57	64
CP-2: Congress & Weymouth Street	61	57	61	57	65
CP-3: Wescott & Crescent Street	57	54	56	54	61
CP-4: Ellsworth & Charles Street Ext.	57	55	56	55	62
CP-5: Bowdoin & Chadwick Street	52	48	51	48	56
CP-6: West Promenade & West Street	57	55	56	56	63

5.0 HELICOPTER FLIGHT TEST SOUND LEVELS

The flight test and associated sound level testing in the community and at the hospital was successfully completed as a result of extensive planning and coordination between Maine Medical Center, LifeFlight of Maine, and RSE. The flight simulations consisted of four separate approach, hover, and departure sequences to simulate planned flight operations associated with the helipad. The flight path, angle of descent, hover, and departure route flown during each simulation was intended to follow the proposed flight paths to and from the helipad.

Original plans were to fly an Agusta 109C during the flight test. LifeFlight currently stations an Agusta 109 at both Central Maine Medical Center in Lewiston and Eastern Maine Medical Center in Bangor. RSE understands that the Agusta 109 will be used for over 90% of the flights involving Maine Medical Center. During the scheduled flight testing, one of the Agusta helicopters was grounded for scheduled maintenance and the other was called to a medical emergency in Caribou. The backup aircraft is a BK 117, which was substituted for the Agusta 109 for the flight test. RSE understands that the BK 117 is a heavier helicopter with larger engines. Available noise performance data for the BK 117 and Agusta 109 indicates that the BK 117 is slightly louder by 0.6 dBA.

The position of the helicopter was tracked using a GPS with time-based horizontal and vertical tracking. Of the four flight test simulations, GPS data was tracked on the first three. Other than coordinates announced by the crew there was no GPS data tracking during the fourth flight test. Slight variations in the flight path could lead to significant sound level discrepancies.

Instrumentation consisted of Larson-Davis Model 812 Integrating Sound Level Meters, which were programmed to continuously measure sound levels and calculate statistics at both hourly and ten-second intervals. Two Larson-Davis Model 824 Sound Level Meter and Real Time Analyzer were used to measure sound levels at position CP-3 and MC-3E. It was programmed to continuously measure sound levels, including one-third octave band readings, and calculate statistics at both hourly and five-second intervals. In addition, a CEL 593 Sound Level Analyzer was used to measure sound levels at position MC-3I to measure one-third octave band sound levels at 5-second intervals.

The sound level meters meet Type 1 (precision) performance requirements of American National Standard Specification for Sound Level Meters, ANSI S1.4-1983. The microphones were fitted with standard windscreens and mounted on tripods at a height of four to five feet above the ground. The sound level meters were calibrated before and after the flight test monitoring period using a Bruel & Kjaer 4231 Sound Level Calibrator. Calibration certificates are available upon request.

During flight testing, RSE stationed observers inside the hospital in the NICU and the newborn nursery. Community observers were stationed at CP-3 (Crescent Street) and CP-6 (West Prom). The observer at CP-6 had to move to new position CP-7 (Parkside) due to someone tampering with the instrumentation.

Meteorological data, including wind speed and direction, temperature, and relative humidity, was recorded on the Upper Bean Rooftop. During monitoring on September 13, 2003 temperatures ranged from 63 to 69 degrees Fahrenheit and relative humidity ranged from 63 to 83%. Skies were partly cloudy and winds were approximately 5 to 8 mph from 15:00 to 18:00, calming to 3 to 6 mph during the 18:00 hour. Wind direction was primarily from the south and south-southwest.

Monitoring results of the flight tests have been graphed at intervals of five seconds and one minute in order to compare helicopter and existing sound levels at community and hospital positions. These graphs and a summary table are presented as Figure Sets 1 through 4 and are described as follows:

Figure Set 1	Community Monitoring Positions: 5-Second Results	A series of eight graphs comparing 5-second L_{Aeq} sound levels from 2003 at community positions CP-1 through CP-9 and six graphs comparing readings from 2002 and 2003 at CP-1 through CP-6.

Figure Set 2	Community Monitoring Positions: One-Minute Results	The same as Figure Set 1 but comparing one-minute L_{Aeq} readings at community positions.
Figure Set 3	MMC Monitoring Positions: 5-Second Results	A series of four graphs comparing 5-second L_{Aeq} sound levels from 2003 at hospital monitoring positions (MC-3E, MC-3I, MC-5I, MC-6I).
Figure Set 4	MMC Monitoring Positions: One-Minute Results	The same as Figure Set 3 but comparing one-minute L_{Aeq} readings at hospital positions.

Summary tables of results were prepared based on review of sound level readings from the Figure Sets. There are many comparisons that could be made to quantify the differences between ambient (non-helicopter) sound levels and sound levels measured during the flight testing. Considering that each of the four flight tests was a distinct and relatively short-term event, we chose to compare the four flight test events with the four loudest non-helicopter community events based on a 5-second basis first and then one a one-minute basis. The same approach was used to compare hospital sound levels both outside on the Lower Bean Roof and inside positions. The following summary tables provide both range and average of sound levels during ambient (non-helicopter) and helicopter flight test events.

Table 2
Comparison of Ambient Community and Flight Test Sound Levels
5-Second LAeq (4 Loudest Events)

Position	Ambient Range (2003)	Ambient Average (2003)	Flight Test Range	Flight Test Average	Sound Level Change of Averages
CP-1	76 to 83	79	78 to 89	82	+3
CP-2	71 to 85	79	76 to 93	88	+8
CP-3	69 to 73	71	79 to 82	80	+9
CP-4	66 to 72	69	73 to 82	79	+10
CP-5	77 to 88	83	61 to 70	66	-17
CP-6	73 to 79	75	68 to 76	71	-4
CP-7	66 to 69	68	66 to 75	71	+3
CP-8	74 to 81	78	60 to 65	63	-15
CP-9	73 to 76	74	60 to 68	65	-11

Table 3
Comparison of Ambient Community and Flight Test Sound Levels
One-Minute LAeq (4 Loudest Events)

Position	Ambient Range (2003)	Ambient Average (2003)	Flight Test Range	Flight Test Average	Sound Level Change of Averages
CP-1	69 to 71	70	72 to 82	75	+5
CP-2	64 to 76	70	73 to 86	82	+12
CP-3	62 to 66	64	75 to 76	75	+11
CP-4	60 to 65	63	67 to 76	73	+10
CP-5	68 to 79	74	55 to 63	60	-14
CP-6	66 to 71	68	62 to 70	66	-2
CP-7	59 to 62	60	62 to 69	66	+6
CP-8	65 to 74	70	54 to 59	57	-13
CP-9	63 to 67	65	57 to 60	59	-6

Table 4
Comparison of Ambient Hospital and Flight Test Sound Levels
5-Second LAeq (4 Loudest Events)

Position	Ambient Range	Ambient Average	Flight Test Range	Flight Test Average	Sound Level Change of Averages
MC-3E	63 to 66	65	86 to 91	89	+24
MC-3I	64 to 68	66	53 to 64	60	-6
MC-5I	72 to 75	74	63 to 68	66	-8
MC-6I	53 to 57	54	61 to 64	62	+8

Table 5
Comparison of Ambient Hospital and Flight Test Sound Levels
One-Minute LAeq (4 Loudest Events)

Position	Ambient Range	Ambient Average	Flight Test Range	Flight Test Average	Sound Level Change of Averages
MC-3E	62 to 63	62	81 to 86	85	+23
MC-3I	61 to 64	62	51 to 62	57	-5
MC-5I	65 to 67	66	60 to 64	63	-3
MC-6I	46 to 50	49	56 to 60	58	+9

The results and comparisons show that the impact on community sound levels varies significantly by location. Locations close to the hospital with a direct line-of-sight to the top of the existing parking garage showed the highest increases in sound levels ranging from +8 to +12 at positions CP-2 through CP-4 for both 5-second and one-minute LAeq readings. In contrast, community locations further away and in the flight path of the Portland Jetport showed significantly higher sound levels during ambient events (jet aircraft) than hospital flight test events. This data shows that ambient events at CP-5 and CP-8 range from 13 to 17 dBA higher than helicopter test flights.

6.0 FUTURE SOUND LEVELS

The maximum sound levels that will be generated during use of the proposed helipad are not expected to significantly exceed the sound levels measured during the test flights, however, the period of sound exposure associated with a single helicopter flight is expected to be longer. During an actual flight, the amount of time the helicopter spends operating in close proximity to the proposed helipad will be considerably longer than occurred during the test flights. For example, when picking up a patient for transport to another hospital, we expect that the helicopter will need to be on the helipad, and perhaps shutdown, prior to moving the patient to the helipad for loading into the helicopter.

Based on testing at EMMC, once the helicopter lands on the helipad it will operate for approximately two minutes to spool down prior to total shutdown. Depending upon how long the helicopter spends on the pad waiting for or loading a patient, it is likely that the time period from start to liftoff will approach or exceed three and a half minutes. Other flights where a patient is dropped off, the amount of time on the pad may be shorter depending upon whether the helicopter will shutdown completely or drop off the patient and depart right away.

Secondly, future sound levels will be affected by proposed changes to hospital and community buildings that will result from the proposed expansion. Modifications will be made to the existing parking garage to construct the helipad. A second parking garage will be built adjacent to the existing parking garage and the new Charles Street Building will be built northeast of the Maine Medical Center complex adjacent to Richards Tower. These site changes will act to block helicopter noise from many areas east of the hospital, but will also reflect a portion of helicopter noise toward north and west.

The existing helipad noise model utilizes topographic survey data of MMC and vicinity, and the results of earlier helicopter flight testing at Eastern Maine Medical Center in Bangor, Maine. Estimates from this noise model were used to compare sound levels and assist helipad siting on the existing MMC parking garage. The results of the flight test can be used to refine the computer noise model to predict future sound levels in the vicinity of the hospital under full build-out conditions. Incorporating flight test data into the noise model would provide estimates of future sound levels for comparison to relevant local, state and federal standards. Based on comparison of the flight test results and noise model estimates, RSE would make adjustments, as necessary, to the noise source spectral and directivity data in order to calibrate the noise model.

7.0 CONCLUSIONS

The flight test monitoring provides sound level data for direct comparison to ambient community sound levels. The results show areas near the hospital where helicopter sound levels will increase daytime community sound levels by 8 to 12 dBA based on 5-second and one-minute LAeq readings. Also, the results show areas in the vicinity of the hospital where helicopter events will generate sound levels that will be lower than existing daytime community sound levels.

The overall impact of helicopter sound levels depends on the type and number of daytime and nighttime flights that will occur. Incorporating this information into the analysis will provide a basis for comparison to relevant local, state and federal noise standards.

FIGURE 1. VICINITY SITE PLAN AND HELICOPTER FLIGHT PATHS

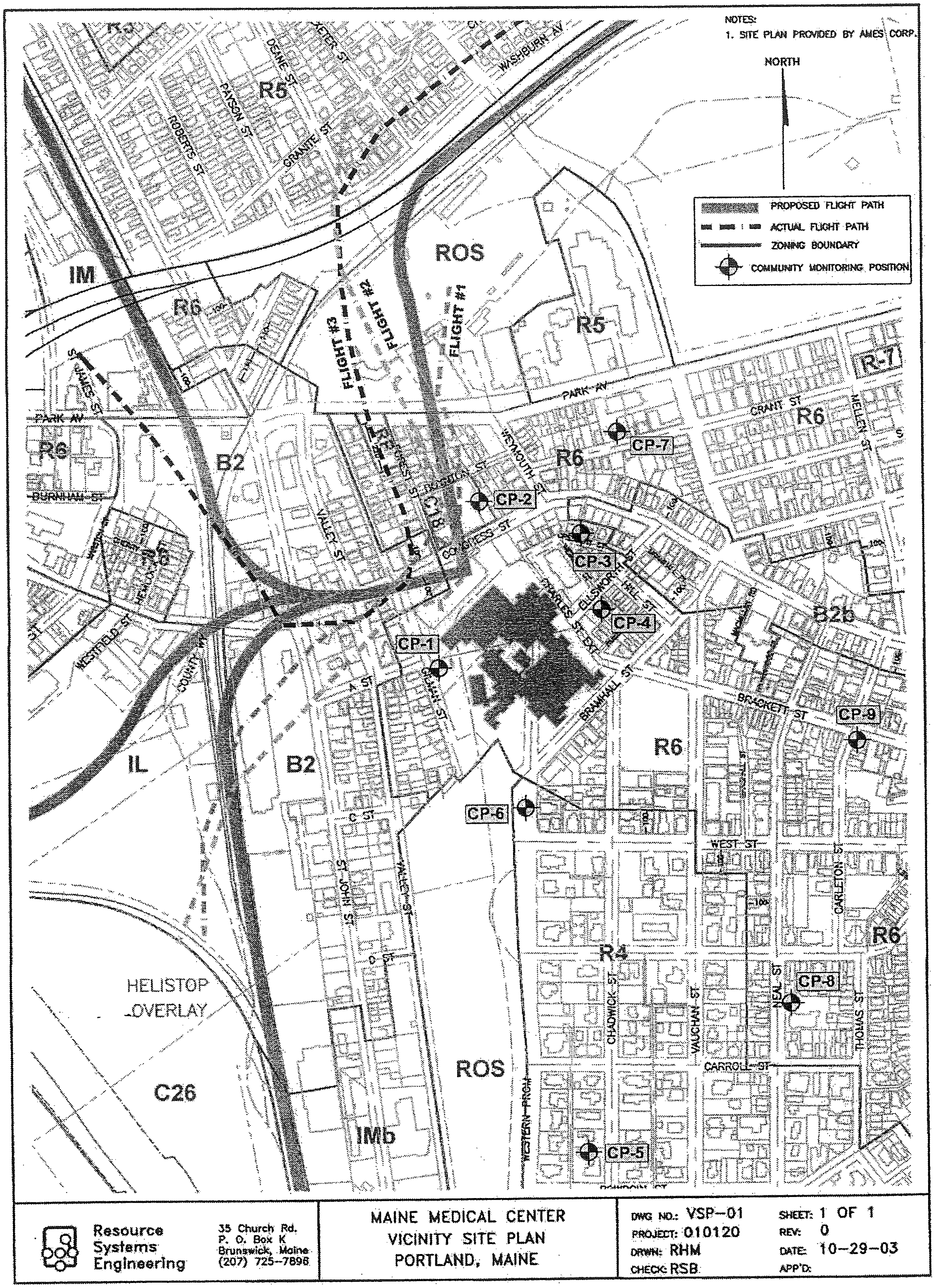
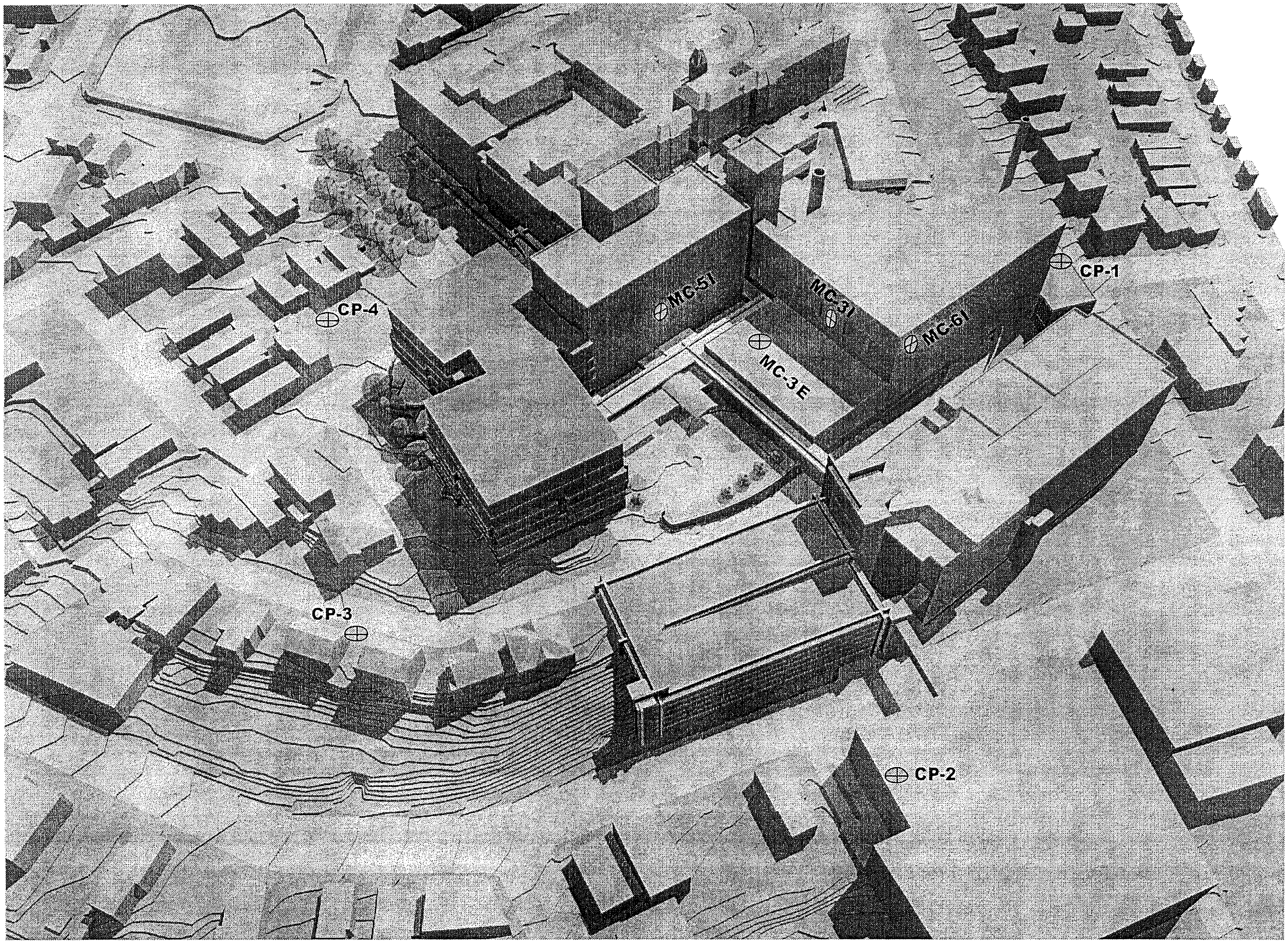


FIGURE 2. MAINE MEDICAL CENTER SOUND MONITORING POSITIONS AND HELIPAD LOCATION



The Greater Portland Council of Governments
68 Marginal Way, 4th Floor
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GPCOG

Fax

To: Bob Miller **From:** Rick Seeley

Fax: 781 · 229 · 7939 **Pages:** 5 incl. cover

Phone: 781 · 229 · 0707 **Date:** 7/13/04

Re: MMC Contract Zone Agr. **CC:**

☐ **Urgent** ☐ **For Review** ☐ **Please Comment** ☐ **Please Reply** ☐ **Please Recycle**

Notes/Comments:

purpose of constructing any of the future expansions described in section 5(b) of this Agreement and within the height limits specified in section 5(b) may be approved by the Planning Board under Chapter 14, Article V, without the need for amendment of this Agreement or further approval by the City Council. Minor revisions to the Site Plan in the nature of field adjustments may be approved by the Planning Authority, without the need for amendment of this Agreement or further approval by the City Council.

3. No building permits shall be issued unless and until **MMC** receives conditional use approval pursuant to section 14-474 (Expansion of Institutional Use) and section 14-483 (Housing Replacement), and site plan approval pursuant to section 14-483(e) of the City Code. No occupancy of the newly constructed buildings shall be permitted unless and until all site plan conditions of approval have been satisfied and the City Council has taken final action on the street discontinuances and street acceptances required for the realignment of certain streets, as shown on the Site Plan (Exhibit A).

4. **MMC** shall provide to the **CITY** a performance guarantee covering all required site improvements under section 14-525(j) of the City Code and the two replacement dwelling units provided under paragraph 5(d) of this Agreement.

5. The **PROPERTY** shall be governed by the regulations applicable in the zoning districts underlying the Conditional Zone created by this Agreement, as such districts were depicted on the Zoning Map of the City of Portland immediately prior to the effective date of this Conditional Zone Agreement, as the same may be amended from time to time, except as follows:

(a) Height Limits – Initial Construction. The maximum structure height (measured according to the definition of "building, height of" in section 14-47) shall be:

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- 70 feet for the New Parking Garage, as depicted on the Site Plan
- 45 feet for the Central Utility Plant, as depicted on the Site Plan
- 111 feet for the L. L. Bean Wing, as already constructed.

(b) Height Limits – Future Expansions. After initial construction described in subparagraph (a) above, the maximum structure height (measured according to the definition of "building, height of" in section 14-47) for any expansion of those buildings described in subparagraph (a) shall be:

- 130 feet for the Charles Street Addition
- 95 feet for the New Parking Garage
- 70 feet for the Central Utility Plant

- 145 feet for the L. L. Bean Wing

provided application for any such expansion is made no earlier than three years and no later than ten years from the effective date of this Agreement, and that the expansion is approved by the Planning Board under the site plan review provisions of Chapter 14, Article V and complies with all other applicable ordinance provisions.

(c) Setbacks.

- The setback of the New Parking Garage shall be zero (0) feet from the right of way line of Congress Street.
- The setback of the southeast corner of the Charles Street Addition shall be five (5) feet from the right of way line of Ellsworth Street, which will be realigned pursuant to the Site Plan.

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6. The Helicopter Landing Pad shall be governed by the provisions of the Helistop Overlay Zone, except as follows:

(a) Setbacks. Because it is to be located on the roof of an existing structure, the landing pad shall not be required to meet the setback requirements of Section 14-327(3) or the fencing requirements of Section 14-327(4).

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(c) <u>Fly Neighborly</u>. In negotiating any contract or agreement with any provider of emergency medical transport by helicopter, **MMC** will utilize its best efforts to require the provider to operate in compliance with the "Fly Neighborly Guide" revised February 1993, prepared by the Helicopter Association International Fly Neighborly Committee and published by the Helicopter Association International. **MMC** shall establish a complaint number and a protocol for handling complaints, which shall be publicized within the neighborhood.

(d) <u>Helipad operating guidelines</u>. The following standard practices will be incorporated as general policy for operations in and out of the Maine Medical Center Helipad. At all times, the Pilot in Command (PIC) will determine safety of operations as a first consideration. Under normal operating circumstances, take-offs, landings and standing-by on the Helicopter Landing Pad shall be conducted according to the Operating Guidelines, attached hereto as Exhibit C, subject at all times to the judgment of the helicopter pilot concerning safety and to the judgment of the emergency medical personnel concerning the health of the patient.

(e) <u>Equipment</u>. In negotiating any contract or agreement with any provider of emergency medical transport by helicopter, **MMC** will utilize its best efforts to require that helicopters utilizing the Helicopter Landing Pad (with the exception of U.S. military or government aircraft) are relatively new turbine powered aircraft meeting requirements under ICAO Annex 16 Chapter 8 for in-flight noise levels and complying with FAA airworthiness standards, 14 CFR part 36.11 and 14 CFR 21 Sub-part D, or any amended or successor requirements or standards.

7. Signage shall comply with the requirements of sections 14-336 through 14-372.5 of the City Code, except as otherwise specifically depicted on the Site Plan (Exhibit A). **NEED TO REVIEW TO ENSURE WE ARE COMFORTABLE WITH SIGNS AS DEPICTED SINCE WE ARE ESSENTIALLY APPROVING**

8. For the purpose of keeping surrounding residential areas apprised of its future development plans, and to address any neighborhood issues related to the operations of the **MMC** campus (including but not limited to complaints or operating issues with respect to the helipad and future planning and development programs associated with **MMC**), **MMC** shall, no less than quarterly, invite representatives of the Maine Medical Center Neighborhood Council to meet with designated representatives of **MMC**. For purposes of this requirement, the Maine Medical Center Neighborhood Council shall consist of two representatives of the Parkside neighborhood, two representatives of the West End neighborhood and two representatives of the Gilman/Valley Streets neighborhood. In the event of any disagreement as to the persons to constitute the representatives of those neighborhoods, the City Manager may designate the persons who shall serve on the Maine Medical Center Neighborhood Council.

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11. **MMC** shall provide landscaping of the area surrounding its Vaughn Street parking lot as shown on the landscaping plan attached hereto as Exhibit D and shall construct, maintain and continue to own the "pocket park" located at Ellsworth and Charles Streets as shown on the Site Plan (Exhibit A).

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TRANSACTION REPORT

2004/JUL/14/WED 17:04

FAX(TX)

#	DATE	START T.	RECEIVER	COM.TIME	PAGE	TYPE/NOTE	FILE
01	JUL/14	16:58	7812297939			NO RESPONSE	5937

THE FOLLOWING DATA COULD NOT BE SENT.
PLEASE GIVE THIS TRANSACTION REPORT TO SENDER.

The Greater Portland Council of Governments
68 Marginal Way, 4th Floor
Portland, ME 04101
Phone: 774-9891
Fax: 774-7149

GPCOG

Fax

To:	Bob Miller	**From:**	Rick Seeley
Fax:	781-229-7939	**Pages:**	5 incl. cover
Phone:	781-229-0707	**Date:**	7/13/04
Re:	MMC Contract Zone Agr.	**CC:**	

☐ **Urgent** ☐ **For Review** ☐ **Please Comment** ☐ **Please Reply** ☐ **Please Recycle**

Notes/Comments:

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Notes/Comments:

purpose of constructing any of the future expansions described in section 5(b) of this Agreement and within the height limits specified in section 5(b) may be approved by the Planning Board under Chapter 14, Article V, without the need for amendment of this Agreement or further approval by the City Council. Minor revisions to the Site Plan in the nature of field adjustments may be approved by the Planning Authority, without the need for amendment of this Agreement or further approval by the City Council.

3. No building permits shall be issued unless and until **MMC** receives conditional use approval pursuant to section 14-474 (Expansion of Institutional Use) and section 14-483 (Housing Replacement), and site plan approval pursuant to section 14-483(e) of the City Code. No occupancy of the newly constructed buildings shall be permitted unless and until all site plan conditions of approval have been satisfied and the City Council has taken final action on the street discontinuances and street acceptances required for the realignment of certain streets, as shown on the Site Plan (Exhibit A).

4. **MMC** shall provide to the **CITY** a performance guarantee covering all required site improvements under section 14-525(j) of the City Code and the two replacement dwelling units provided under paragraph 5(d) of this Agreement.

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Fax

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From: Rick Seeley
Fax: 781-229-7939
Pages: 11 including cover
Phone:
Date: 7/12/04
Re: MMedical Center Helipad
CC:

☐ Urgent ☐ For Review ☐ Please Comment ☐ Please Reply ☐ Please Recycle

Notes/Comments:

Bob - Here's what we spoke of today except for:

- Contract Zone Provisions (still looking for most recent)
- emails on scope of your work (still checking)

I will get the remaining materials to you tomorrow most likely by email.

Rick Seeley

Maine Medical Center
Helipad

City of Portland Planning Board requested documents

I. May 4, 2004 Planning Board Workshop Presentation

Topics covered included clinical need for helipad at MMC, sound studies, Lifeflight of Maine medical policy and quality program, Lifeflight of Maine safety program, Lifeflight of Maine helicopter operations and flight paths, proposed ongoing role for Neighborhood Council in relation to noise monitoring. The attached Powerpoint slides were used in this presentation.

II. Noise Study

Maine Medical Center commissioned Resource Systems Engineering (RSE), a Maine firm with over 25 years of experience with Federal, State and local noise standards, to conduct noise studies in relation to the proposed helipad. The initial step was for RSE to develop a model that predicted sound levels from alternative helipad locations based on the measured sound profile of Lifeflight of Maine aircraft and the known site topography and structures in the vicinity of the MMC's Bramhall campus. To secure a baseline picture of noise levels in the adjacent community RSE also conducted a 24-hour measure of ambient noise levels at six community sensor locations in December 2002.

Subsequently, on September 13, 2003, Lifeflight of Maine conducted four trial flights during one hour to simulate the approach, descent and departure of a Lifeflight of Maine helicopter at the proposed pad location. A late afternoon sample time was chosen as it is the time when most medical helicopter demand occurs, historically. This trial is reported in detail in the April 15, 2004 final report by RSE, which was distributed May 4, 2004, to members of the Planning Board. Some of this data is included in the attached PowerPoint presentation and the graphs displaying indicated decibel levels at nine community sensor locations are displayed. Color versions of these same graphs are included in the April 15, 2004 RSE final report.

In general, the flight tests on September 13, 2003 demonstrated that sound levels associated with helicopter approaches to the pad location would be most pronounced at locations immediately adjacent to the MMC Bramhall campus at Gilman Street and Congress Street sensor locations. Sound levels measured at other community sensor locations in Parkside and the Western Prom neighborhood showed moderate to no increase in sound levels above background levels. Details are included in the April 15, 2004 RSE report and are summarized in the May 4, 2004 presentation.

Significant sound mitigation has been achieved by siting the helipad optimally on the top of the garage and locating flight paths to reduce sound levels at most residential areas. RSE is evaluating additional mitigation options including baffling and addition of sound absorbing materials. Initial assessment of these options indicates that attempts to add such mitigation conflicts with helipad design constraints restricting the erection of barriers above the flight path within specified distances. RSE has found that options which significantly reduce sound levels would not be practical to build due their size or configuration.

Initial noise modeling was done with the helicopter facing south toward the hospital/tail rotor pointing north. Recent modeling shows that rotating the helicopter 180 degrees so that the tail rotor points south significantly reduces noise (12-14 dBA) at areas where the highest sound levels were predicted. LoM reports that most flights will involve the tail-south configuration, due to prevailing wind conditions.

Rotating the helicopter provided more noise reduction than other mitigation options due to shielding from the helipad and parking garage. Although no viable options have been found to date, RSE had not completely ruled out further mitigation approaches.

LifeFlight of Maine has developed a plan for replacement of its aircraft that would allow acquisition of modern, quieter operating helicopters. However, it does not yet have funding for a complete replacement plan.

III. Flight Paths

Proposed flight paths were developed with Lifeflight of Maine, based on suitable approach paths over commercial and industrial areas, prevailing wind patterns, and ground structures. Intended flight paths were included in the May 4, 2004 Planning Board workshop presentation. Also included in the presentation were GPS derived tracking of three of the four test flights. The 4th test flight was inadvertently not tracked by GPS, but it was made at 180 degrees from the direction of the previous flights with departure in the direction from which the three previous flights had approached. Review of the measured sound levels from the 4th flight indicated a lower sound impact from certain central locations close by the pad location. The 4th flight approached from the south and departed to the north and east.

The duration of actual flights will differ from the flight simulations as follows: the simulated flights used the intended flight paths and descent and approach angles then hovered at the intended pad location for approximately 30 seconds before departing along the previously described departure paths, ascent and departure angles and speed. Each simulated approach lasted about 4 - 5 minutes from beginning of descent to return to an altitude where the perceived sound level on the ground was negligible. An actual flight will involve a descent and approach at the same angle and speed ending with engine shutdown while the patient is prepared to move to the Emergency Department. Engines will be restarted for a period of approximately two minutes to get up to speed and a departure and descent will require about two minutes, thereafter.

IV. Fly Neighborly Guide

Lifeflight of Maine subscribes to and supports the principles and guidelines included in the "Fly Neighborly Guide" (copy enclosed) published by the Helicopter Association International. This document includes recommended guidelines for pilot training, noise abatement and operation of helicopters to minimize noise impact during helicopter operation. Flight guidelines include selection of routes and air speed, appropriate approach and landing descent angles and techniques and appropriate departure maneuvers.

V. Safety

Unlike an earlier attempted air-medical service in Maine, Lifeflight of Maine has been constructed on the fundamental principles of meeting the highest possible safety standards while providing air-medical transport only for those patients for whom it is clinically indicated. The question of safe operations was raised at the September 24, 2003 public meeting conducted by Maine Medical Center and Tom Judge, Executive Director of Lifeflight of Maine, responded with a comprehensive review of the issue of safety and the current scientific data surrounding medical helicopter use. His response letter of October 19, 2003 is attached and provides excellent background for this topic.

Mr. Judge's commitment to safe medical helicopter operations is evidenced by his having served as the national Chair of the Association of Air Medical Services Safety Committee which also last year awarded him and Lifeflight of Maine its national safety award. In addition, Keystone helicopters, the helicopter operator for Lifeflight of Maine, was recently awarded the platinum safety award from the Helicopter Association of Aviation Operators.

In summary, Mr. Judge's letter and its attached documents report that in recent years critical care helicopter transports have approximated 250,000 per year in the U.S., increasing by 5 - 7% per year. During recent years an average of 4 – 6 flights per year have involved accidents resulting in injuries. Only one accident involved injury to someone other than helicopter passengers or crew. Most importantly, efforts to reduce such incidents are stabilizing and successfully reducing the accident rate for air medical transport flights, year by year.

It should be pointed out that in the City of Boston helicopters have been landing in the city and on top of hospital buildings for 17 years with no accidents and Lifeflight of Maine has not had an accident reported during its five-year tenure in the State of Maine.

Enclosures
10/19/03 letter from T. Judge; attached
Safety Review and Risk Assessment of Air Medical Transport prepared by

the Air Medical Physician Association, November 2002
Association of Air Medical Services Position paper in response to Slack article

VI. Ongoing Noise Monitoring Plan

Perceived sound levels associated with use of the helipad will depend upon actual flight paths and approach and departure procedures. Lifeflight of Maine and Maine Medical Center will participate in an ongoing program of monitoring, which will include:

1. LOM's commitment to the guidelines included in the "Fly Neighborly" guide.
2. MMC will publish a telephone contact number and encourage all neighbors who perceive unusual sound levels associated with use of MMC's helipad to report such events to the hospital.
3. Patterns of concern will be relayed on a monthly basis by MMC to Lifeflight of Maine for consideration of alternate flight paths.
4. Reports will be summarized for quarterly review by the Neighborhood Council.
5. Any unusual conditions requiring unusual flight paths will be reported as they occur by Lifeflight to MMC.
6. Lifeflight of Maine will endeavor to minimize sound impact through modification of flight paths and approach and departure techniques.

VII. Helipad Elevations

An elevation view of the helipad is included in the project drawings. The surface of the pad is approximately 14 feet above the highest parking deck directly below it. This height will ensure that cars will be able to park beneath it so that no parking spaces will be lost from the existing parking garage.

VII. Flight Volume Prediction Model

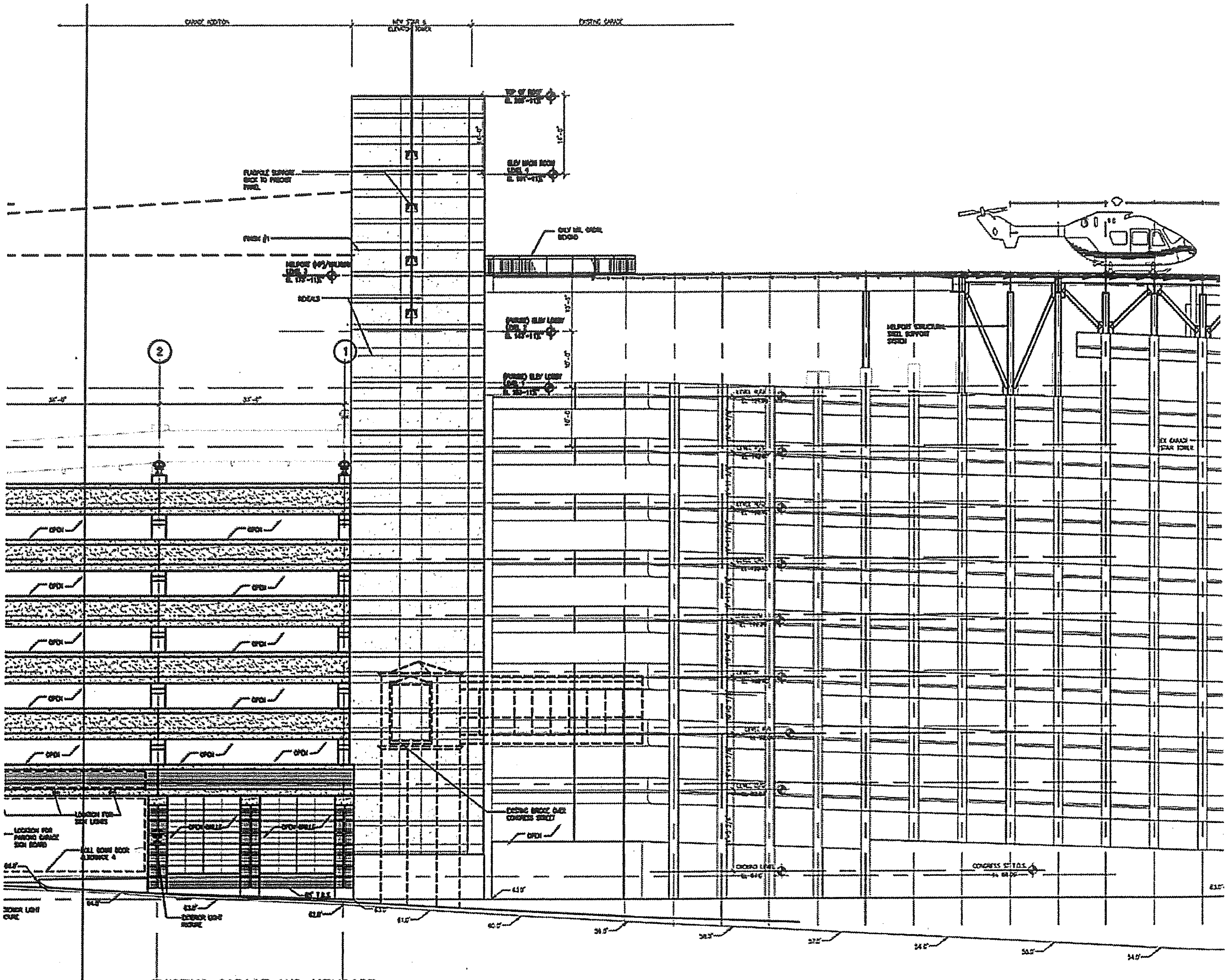
A well recognized article in Annals of Emergency Medicine (16:4 April 1987 391-398) authored by Macione and Wilcox from the University of Massachusetts Medical Center postulated a flight volume model for medical helicopter use that has since been proven an accurate predictor of flight volumes for a mature medical helicopter program. This model predicts that the most accurate modeling of flight volumes is a function of <u>rural square miles</u> in a program's service area.

Current flight volume in Maine is in the range of 850 flights per year. Presently, the northern counties of the state are served out of Bangor and are seeing about 300 flights per year. Western and central counties served out of Lewiston account for another 225 flights per year and 200 flights are now going to the Portland jetport bound for MMC. The predominant destination for the remaining volume are hospitals in Boston or mutual aid calls to Dartmouth-Hitchcock hospital in New Hampshire.

Use of the Macione-Wilcox model in Maine predicts a mature program ceiling volume of about 1,100 flights per year for the entire state with continued flight volume growth state-wide. The construction of a pad at MMC will increase direct scene to trauma center flight volume slightly in western York and Cumberland Counties, southern Kennebec, and Lincoln counties. There will also be a small increase in flight volume of inter-hospital transport of critically unstable patients from these same areas to MMC in addition to patients from other areas of Maine requiring the unique capabilities of specialist physicians at MMC. It is impossible to completely predict how many of the volume of growth in flights might end up at MMC's pad but assuming two-thirds did, MMC's volume of flights could grow to an average total of about one per day.

1,100 + 365 = 1,465

5/14/04

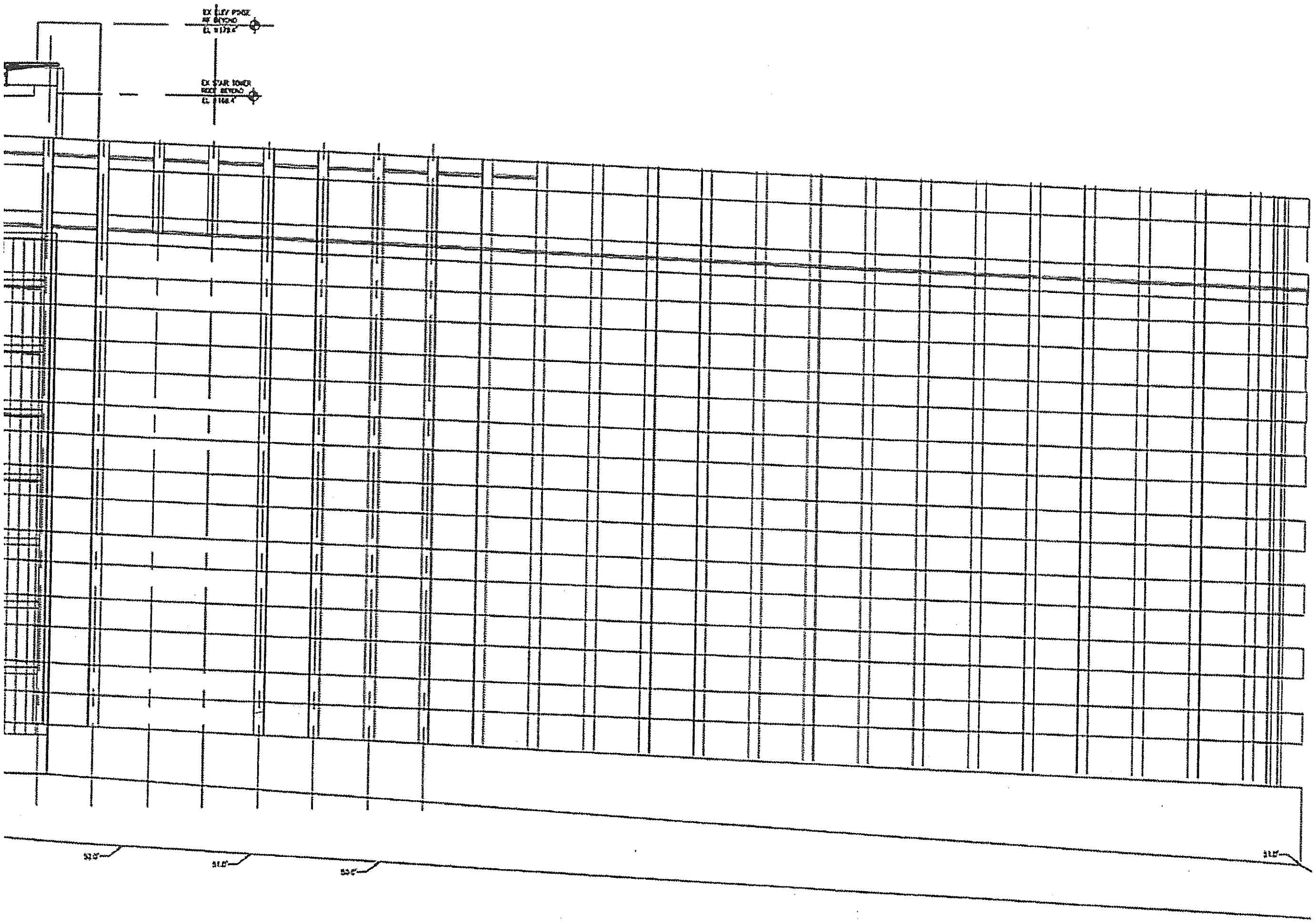


EXISTING GARAGE AND HELIPORT NORTH ELEVATIONS

A5

SCALE: 3/32" = 1'-0"

Heliport Elevations



Form approved OMB No. 2120-0036

U.S. Department of Transportation
Federal Aviation Administration

NOTICE OF LANDING AREA PROPOSAL

DRAFT

Name of Proponent, Individual, or Organization Maine Medical Center ☐ Check if the property owner's name and address are different than above, and list property owner's name and address on the reverse.	Address of Proponent, Individual, or Organization *(No., Street, City, State, Zip Code)* 22 Bramhall Street Portland, ME 04102

☒ Establishment or Activation ☐ Deactivation or abandonment
☐ Alteration ☐ Change of Status
OF
☐ Airport ☒ Heliport ☐ Ultraflight Flightpark ☐ Seaplane Base ☐ Vertiport ☐ Other (Specify)

A. Location of Landing Area

1. Associated City/State Portland	2. County/State *(Physical Location of Airport)* Cumberland Maine		3. Distance and Direction From Associated City or Town	
4. Name of Landing Area Maine Medical Center	5. Latitude 43 ° 39' 14"	6. Longitude 70 ° 16' 37"	7. Elevation 174.00 (NGVD)	Miles: In City Direction: N/A

B. Purpose

Type Use ☐ Public ☒ ~~Private~~ ☐ Private Use of Public Land/Waters	If Change of Status or Alteration, Describe Change N/A	☐ Establishment or change to traffic pattern (Describe on reverse)	Construction Dates To Begin/Began 11/04/04	Est. Completion 8/02/05

C. Other Landing Areas	Ref. A5 above: Direction From Landing Area	Distance From Landing Area
Portland Jetport	SW	1.2 miles

D. Landing Area Data

	Existing (if any) Rwy #1	Rwy #2	Rwy #3	Proposed Rwy	Rwy	Rwy
1. Airport, Seaplane Base, or Flightpark						
Magnetic Bearing of Runway(s) or Sealane						
Length of Runway(s) or Sealane(s) in Feet						
Width of Runway(s) or Sealane(s) in Feet						
Type of Runway Surface *(Concrete, Asphalt, Turf, Etc.)*						

2. Heliport	Existing	Proposed
Dimensions of Final Approach and Takeoff Area (FATO) in Feet		49' Radius
Dimensions of Touchdown and Lift-Off Area (TLOF) in Feet		60'X60'
Magnetic Direction of Ingress/Egress Routes		N06° 33' 12" E N86° 31' 17" W
Type of Surface *(Turf, concrete, rooftop, etc.)*		Aluminum Slat Heliport

3. All Landing Areas	Description of Lighting *(If any)*	Direction of Prevailing Wind
	Surface, Perimeter, Obstruction	NW

E. Obstructions

Type	Height Above Landing Area	Direction From Landing Area	Distance From Landing Area
1. Elevator Tower	5 ft	SE	40 ft
2. LL Bean Building	87 ft	SE	105 ft
3. Richards Building	117 ft	SE	225 ft

F. Operational Data

1. Estimated or Actual Number Based Aircraft

Airport, Flightpark, Seaplane base	Present *(If est. indicate by letter "E")*	Anticipated 5 Years Hence	Heliport	Present *(If est. indicate by letter "E")*	Anticipated 5 Years Hence
Multi-engine			Under 3500 lbs. MGW NONE		
Single-engine			Over 3500 lbs. MGW ALL	0	30
Glider					

2. Average Number Monthly Landings

	Present *(If est. indicate by letter "E")*	Anticipated 5 Years Hence		Present *(If est. indicate by letter "E")*	Anticipated 5 Years Hence
Jet			Helicopter	0	30
Turboprop			Ultralight		
Prop			Glider		

3. Are IFR Procedures For The Airport Anticipated
☒ No ☐ Yes Within _____ Years Type Navaid:

G. Other Considerations

Identification	Direction From Landing Area	Distance From Landing Area
To be determined by FAA Site visit	___	___

H. Application for Airport Licensing

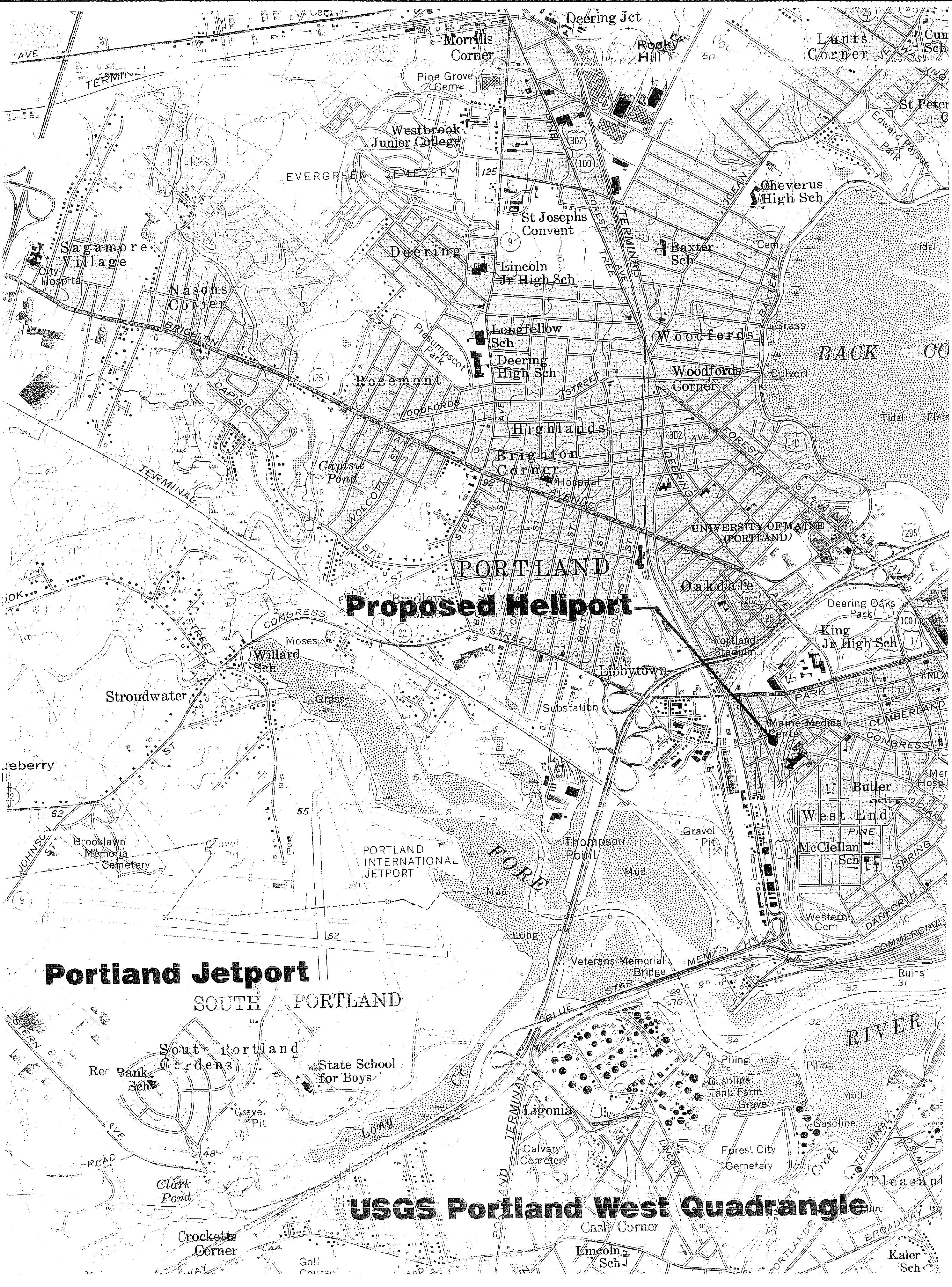
☐ Has Been Made ☒ Not Required ☐ County
☐ Will Be Made ☐ State ☐ Municipal Authority

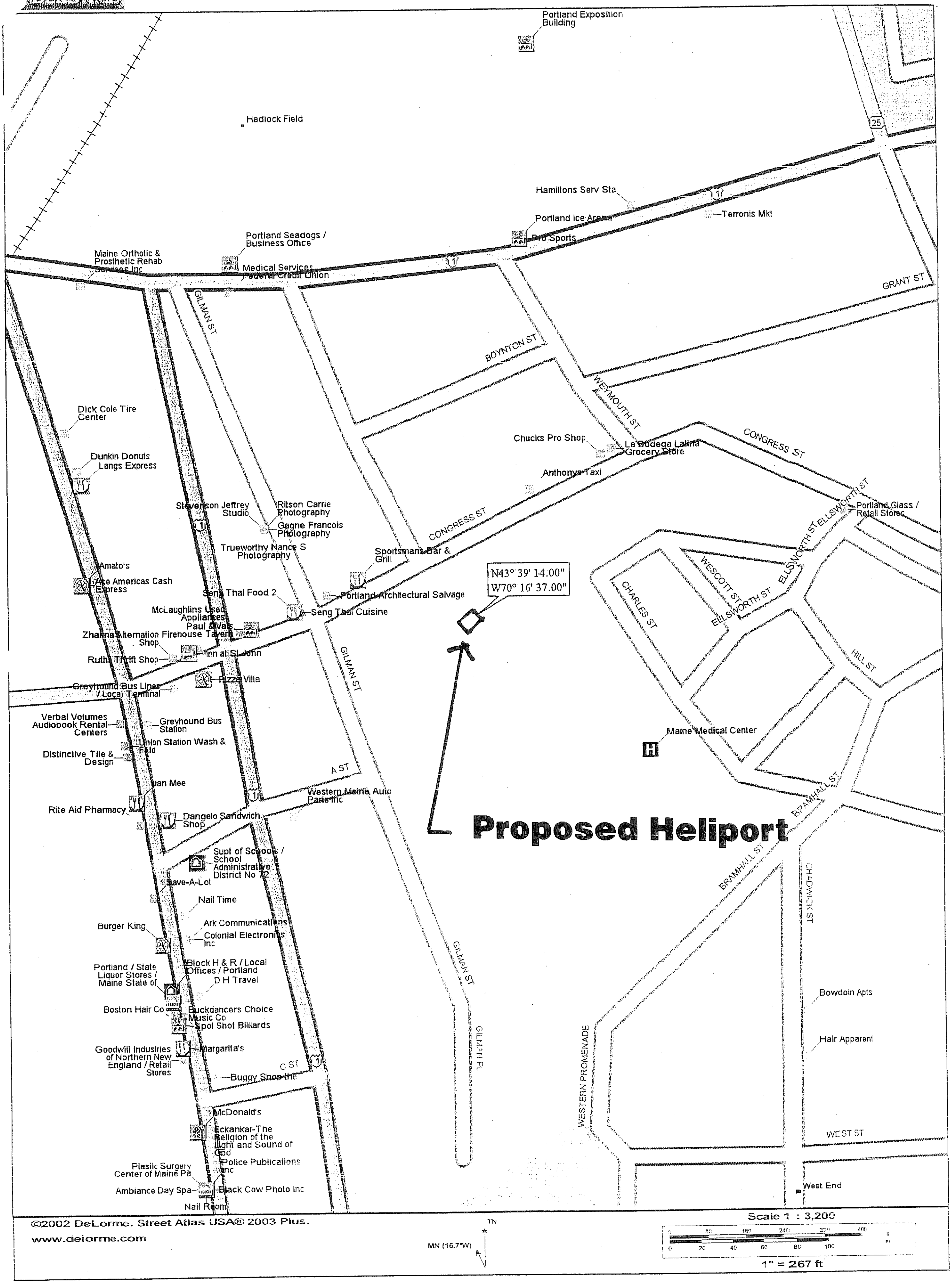
I. CERTIFICATION: *I hereby certify that all of the above statements made by me are true and complete to the best of my knowledge.*

Name, title *(and address if different than above)* of person filing this notice–type or print William T. Conway, VP Sebago Technics, Inc. P.O. Box 1339 Westbrook, Maine 04098-1339	Signature *(in ink)* William T. Conway
Date of Signature	Telephone No. (Precede with area code) (20[illegible]) 856-0277

FAA Form 7480-1 (1-93) Supersedes Previous Edition

Central Region Electronic Revision per ACE-625 (March, 2000)


Proposed Heliport
Portland Jetport
USGS Portland West Quadrangle
Deering Jct
Morrills Corner
Rocky Hill
Lunts Corner
Pine Grove Cem
Westbrook Junior College
EVERGREEN CEMETERY
St Josephs Convent
Cheverus High Sch
Baxter Sch
Sagamore Village
City Hospital
Nasons Corner
Deering
Lincoln Jr High Sch
Longfellow Sch
Deering High Sch
Woodfords
Woodfords Corner
BACK CO
Presumpscot Park
Rosemont
Highlands
Brighton Corner
Hospital
Capisic Pond
UNIVERSITY OF MAINE (PORTLAND)
PORTLAND
Oakdale
Deering Oaks Park
King Jr High Sch
Portland Stadium
Libbytown
Moses
Willard Sch
Stroudwater
Substation
Maine Medical Center
Butler Sch
West End
McClellan Sch
Western Cem
Thompson Point
Gravel Pit
Mud
FORE
PORTLAND INTERNATIONAL JETPORT
Brooklawn Memorial Cemetery
Long
Veterans Memorial Bridge
RIVER
SOUTH PORTLAND
South Portland Gardens
State School for Boys
Red Bank Sch
Ligonia
Calvary Cemetery
Forest City Cemetery
Gasoline Tank Farm
Piling
Clark Pond
Crocketts Corner
Cash Corner
Lincoln Sch
Kaler Sch
Golf Course
Pleasant



N43° 39' 14.00"
W70° 16' 37.00"

Proposed Heliport

PORTLAND MAINE
Strengthening a Remarkable City, Building a Community for Life • *www.portlandmaine.gov*

Planning and Development Department
Lee D. Urban, Director

December 22, 2004

VIA GENERAL COURIER

TO: Vince Conti
Paul Gray
Joe Gray
Councilor Karen Geraghty
Peter Murray
Patrick Murphy
Anne Pringle
George Silverman

RE: *Report to the City of Portland: Helicopter transport into Maine Medical Center,* dated December 17, 2004 and prepared for the City by Stephen H. Thomas, MD, MPH

Dear All:

Enclosed is the above-captioned Report.

Sincerely,

Lee
Lee D. Urban
Planning and Development Director

Enclosure

cc: Alex Jaegerman
Sarah Hopkins
Rick Seeley

389 Congress Street • Portland, Maine 04101 • Ph (207) 874-8683 • Fx 756-8217 • TTY 874-8936

Report to the City of Portland:
Helicopter transport into Maine Medical Center

Stephen H. Thomas MD MPH

17 December 2004

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Executive summary

The consultant was charged with assisting the helipad debate by means of assessment and commentary upon the following major points:

1) helicopter triage guidelines currently used to determine who needs air transport by Life Flight of Maine (LFOM) to Maine Medical Center (MMC);
2) clinical and logistic circumstances associated with the current "bifurcated" system (of LFOM transport into Portland Jetport, followed by ground transport to MMC);
3) consideration, based upon review of a series of LFOM-MMC transports, of relative merits of replacing bifurcated transport with transport to an on-site MMC helipad;
4) determination, based upon review of a sample of LFOM transports to MMC, as to the proportion of LFOM patients who could be safely triaged *away* from landing at any on-site MMC helipad, instead using the bifurcated transport model

There were other charges to the consultant. Comment was to be provided on subjects such as mechanisms of benefit associated with use of helicopter Emergency Medical Services (HEMS), clinical and logistical courses of patients in the pre-transport time frame (*i.e.* at trauma scenes or referring hospitals), and helicopter safety concerns. These issues are addressed in the body of the consultant's report, but are excluded from this summary page.

The consultant's work commenced with identification of a study sample of 100 consecutive LFOM-MMC transports. Clinical and logistics information relevant to these patients was obtained by reviewing records at both LFOM and MMC. Data gathering continued with review of LFOM policies and procedures. As needed, the consultant contacted other individuals in the field in order to benefit from their expertise in areas pertinent to bifurcated transport and HEMS safety.

Given the broad scope of the work assigned to the consultant, and the importance of providing supporting evidence for the consultant's statements, this report's conclusions are not easily encapsulated. With the *caveat* that some important details are excluded in a short summary, the consultant's major conclusions comprise the remainder of this one-page abstract.

Most importantly, the consultant concludes that LFOM patients coming into MMC are of notably high acuity, in large part because the currently used triage rules in are reasonable and consistent with national guidelines. There is no reason to suspect there will be major changes in the HEMS triage guidelines, on either the local or national fronts, in the foreseeable future.

The high LFOM acuity contributed heavily to the consultant's opinion that risks associated with Jetport-to-MMC bifurcated transport were concerning. It is left to the City of Portland to adjudicate "acceptable risk." But the consultant's considered decision is that it is highly unlikely there is a prospectively identifiable (*i.e.* at transport time) patient subset of any significant size, in which bifurcated transport could comfortably replace use of an available on-site MMC pad.

Overview of scope of report

As dictated by the City of Portland, with advice from parties interested in the issue at hand, this report addresses multiple facets of the question of helicopter EMS (HEMS) transports into MMC. The main discussions in this report cover:

1) Assessment of the criteria used to determine air vs. ground triage for transports into MMC, with concentration on the questions:
    - Is there consistency between the "local" guidelines (*i.e.*, those dictating HEMS triage for flights into MMC) and generally accepted national guidelines?
    - What is the likelihood that national (and/or local) guidelines will change in such fashion as to lower the threshold for HEMS transports into MMC?
    - Is there currently in place at LFOM, an internal review mechanism for provision of utilization review for helicopter use appropriateness?
2) Review of a consecutive series of HEMS transports into MMC, to:
    - Determine whether air transport triage is being conducted in a manner consistent with the local guidelines;
    - Assess, in a set of actual patient transports, the timing and other process variables associated with the current system of landing at the Jetport and utilizing a ground transport vehicle to MMC; and
    - Adjudicate whether any clinical deterioration (or significant risk thereof) occurred in association with the ground transport leg (from Jetport-to-MMC).
3) Description of consultant-performed "mock run" ground vehicle transports to MMC, as executed from the Jetport and also from the new Mercy Hospital site to the MMC
4) Consideration of safety issues pertinent to the possible on-site location of the MMC pad

The report is divided into sections. The first section following this overview is an introduction to the subject of HEMS and its possible benefits, to both patients and EMS systems.

Introduction and background: HEMS benefits to patients and regions

Air medical transport, as provided by HEMS, has been used in the civilian medical setting since the 1970s. Currently, expert sources estimate that there are 400-450 helicopters providing up to 250,000 transports annually in the U.S.[1] While this report does not intend to focus on the evidence supporting use of helicopter transport in this country, some background information on HEMS and its salutary effects provides a useful framework for the discussion as to the proposed Maine Medical Center (MMC) on-site helipad.

The growth of HEMS has been accompanied by increasing scrutiny as to potential benefits accrued by this resource-intensive intervention. General reviews of the HEMS literature[2-4] have concluded that the weight of evidence supports contentions of outcomes benefits from use of air medical transport. Perhaps more relevant to the situation in Maine and the City of Portland, studies have identified significant mortality reduction associated with HEMS use in nearby urban New England (Boston)[5] and in more distant areas (notably Georgia and Oregon) with more rural demography that approximates the Maine situation.[6,7] Notably, the papers dealing with HEMS and outcomes benefits do not deal solely with trauma. In one study with geographical parallel to the southern Maine setting, HEMS dispatch to non-trauma "stroke scenes" was used in the Florida/Georgia border region to improve patient access to timely provision of advanced stroke care.[8]

When considering whether, and for which patients, HEMS should utilize an on-site hospital helipad, a brief overview of HEMS benefits is helpful. It is important to consider not only benefits to individual patients, but also benefits accrued to the regions served by HEMS.

HEMS benefits to patients

Mortality seems like the most obvious potential patient benefit upon which to focus, and in fact survival improvement has been the main endpoint of most of the major HEMS studies. This is probably because mortality is relatively easy to address in the types of large, retrospective study designs comprising most of the HEMS outcomes literature. Due to the relatively low number of patients for whom HEMS can *definitively* be shown to save lives, studies lacking large numbers tend to have insufficient statistical power to demonstrate a HEMS outcome effect.

Morbidity improvement (*e.g.* better neurological outcome) as a clinical study endpoint has the attraction of being easier to test, since fewer patients must be enrolled to find this more frequent outcome (as compared with mortality). By definition, however, nonmortality HEMS-associated benefits which have been demonstrated – improved pain care,[9] better pediatric[10] and adult[11] endotracheal intubation and airway management, more streamlined access to time-critical cardiac[11] or neurologic[8,13] care – are somewhat less compelling than "saved lives." On the other hand, nonmortality endpoints such as better airway management can provide clues to mechanisms by which HEMS use results in outcomes improvement.

HEMS and regional benefits

Some of the above-mentioned HEMS mortality/morbidity advantages (*e.g.* faster transport of patients with cardiac or trauma to definitive care) have clear relevance to the question of on-site helipad landing at MMC. Also, any intervention that helps individual patients, should also be considered on the positive side of the EMS regional ledger. More specifically to regional issues, there are additional HEMS-associated advantages with particular applicability in areas of Maine-like population density.

As an example of a HEMS advantage with high relevance to southern Maine, HEMS may be the best means for getting advanced-level prehospital care (ALS) to patients in relatively remote regions. On first impression, getting ALS care to patients in remote areas seems to have very little relevance to MMC's helipad, since the issue deals with getting the helicopter and crew to the patient, not getting the patient to the hospital. Upon further consideration, however, there *are* aspects of this regional HEMS benefit with applicability to the MMC helipad question. To wit, patients could incur ALS access delay and outcome detriment, if LFOM is called for initial ALS response and helicopter liftoff is delayed due to getting flight crews back to the Portland Jetport from MMC. Theoretically, LFOM could be delayed in responding, in a manner that would not occur if LFOM were using an on-site MMC helipad, due to crew nonavailability related to their being occupied on the ground leg between the Jetport and MMC. How likely is occurrence of such a scenario? An idea of the relative scarcity – but not absence – of LFOM response delay due to the aircraft/crew being already occupied, can be gleaned from reviewing a set of LFOM transports. For this and for other reasons mentioned elsewhere in this report, a review of records was performed by the consultant. The review entailed detailed reading of both the LFOM and MMC medical records of a consecutive set of 100 LFOM-MMC air transports during a period from 12/2003 through 7/2004.

Based upon the review of records, HEMS delays due to helicopter nonavailability appear to be uncommon in Maine. Nevertheless, when delays have occurred they can be potentially critical. For example, one cardiac patient was to be transported from a community hospital to the MMC cardiac cath lab for emergency coronary care. There was a 37-minute lag between the initial LFOM call and subsequent helicopter dispatch, which was due to the LFOM aircraft being occupied with other transports.

HEMS nonavailability due to having the aircraft and crew busy on other worthy transports can hardly be criticized. Less defensible would be a HEMS response delay due to time lost from having flight crews' needing to make ground transit legs between the MMC and the Portland Jetport. While the scenario of delayed LFOM response, attributable to the ground transport leg and preventable with use of an on-site MMC pad, would not be expected to occur commonly, the example is telling. Importantly, the concepts of regional HEMS benefits, and regional "risks" of HEMS nonavailability for rapid response, illustrate that some risks incurred with the bifurcated transport model are not obvious, and that regional EMS systems considerations should weight in the decision as to whether an on-site MMC helipad is used. Use of a bifurcated transport model not only places the current patient undergoing transport at potential risk, as outlined in some other sections of this report, but there is the additional consideration that the extra transport time can cause risk to *other* patients in the region, who may have urgent need for a helicopter.

Given the time-criticality of many HEMS missions for scene trauma, a ground transport-associated HEMS response delay of even half-hour can have significant effects. As a specific clinical example, airway management serves well. Intubation (placement of a breathing tube in the trachea for ventilatory support) in the field by *ground* ambulance providers has been correlated with *increased* patient mortality, but the same data have demonstrated that airway management by *HEMS* crews – who have higher success rates than ground EMS providers[22] – *decreases* mortality.[23,24] Delays in LFOM response to a trauma scene associated with the air medical crew being "tied up" on Jetport-MMC ground transport, could range from as little as a few minutes to over a half-hour (as might be the case if LFOM is called for a scene transport just after commencing a ground transport leg into MMC). If these delays are of sufficient magnitude that airway management must be deferred for a longer period, or perhaps performed by less well-equipped and less proficient ground EMS providers, there is potential for significant impact due to need for a Jetport-MMC ground transport leg.

There is another system-related benefit to HEMS, which has applicability to the MMC helipad debate. Regionalization of specialty care has improved trauma outcomes, and there is growing confirmation that it improves outcomes in other patients (e.g. cardiac, neurologic).[8,12,13] One of the tenets upon which regionalization rests is rapid transport of patients for interventions such as trauma surgery, cardiac catheterization, or stroke treatment. All of these interventions are necessarily time-critical. It follows that a central goal of any medical center striving to provide regionally unique, time-sensitive care, is to streamline the access to that care. It is important to emphasize that this issue is being addressed *not* from any type of marketing perspective (*i.e.* for MMC), but rather from the distinct clinical perspective of having an excellent institution optimize ability to serve its patient population with maximum efficiency and efficacy.

In summing the association between HEMS and individual patient as well as regional care, it is important to keep in mind, that HEMS is intended to transport the most critically ill and injured patients. For others who need MMC care, ground transport will remain the best mechanism for getting to tertiary care. For patients with time-critical need to get to the "referral center," for either diagnostic or therapeutic (or both) reasons, the individual case – and the EMS system and region as a whole – is more likely than not to benefit from elimination of an extra transport leg. The potential advantage of eliminating the Jetport-to-MMC leg is multifold, as will be discussed in subsequent sections of this report.

Subsequent sections of this report address HEMS benefit mechanisms and cover logistics of the MMC bifurcated transport system. The goal is to keep in focus the fact that the best solution to this and other healthcare discussions, is the one that optimizes chances for favorable patient outcome – and by extension improves healthcare for the region as a whole.

HEMS transport speed and out-of-hospital time

When advantages of helicopter transport are considered, one of the first points to arise is the concept of speed. The speed of the helicopter allows the advanced life support crew to arrive at the patient quicker, provides a region with rapid-response advanced care coverage using a limited number of vehicles, and may get the patient to definitive care faster. These are all important advantages that may be accrued with use of HEMS. However, there is more to the "speed" story.

Some of air transport's time-associated benefits, which are due to minimizing out-of-hospital time, are gained even in the absence of HEMS getting the patient to tertiary care faster than ground transport. This aspect of the HEMS advantage to patients has no small relevance to the MMC situation.

In some patients – especially those who are in tenuous condition or who may require difficult interventions in the event of clinical deterioration – the minimization of time spent in the relatively uncontrolled out-of-hospital transport environment is an admirable goal. Expert commentators have long stated that "interhospital transport is not without risk."[28] This section of the report will address some facets of transport risk, and develop the idea that transport should minimize the time spent in the out-of-hospital setting.

It is well known, and consistent with common sense, that a myriad of interventions from airway management[14,15] to advanced life support tasks[16] to chest compressions for CPR,[17,18] are simply more difficult to perform in the out-of-hospital (air or ground) transport vehicle than they are in the controlled setting of the hospital. While transport equipment is of admirable quality, even optimally-functioning prehospital equipment may fail to detect abnormalities (*e.g.* cardiac dysrhythmias) easily found in the hospital environment.[19] Furthermore, equipment malfunctions seem to occur more frequently in the transport setting; such problems are also more difficult to "fix" outside of the hospital.[19]

To move to specific clinical scenarios, one easily understood situation in which out-of-hospital time is best minimized is the case of a pregnant patient. Given the complicated pregnancies characterizing interhospital transports, and the resultant desire to minimize chances of an out-of-hospital delivery, a rapid helicopter flight is quite preferable to use of a ground vehicle. Since some referring hospitals may have ready access to ground transport vehicles, it is possible that ground transport could be *started* (if not completed) faster than would be achieved with a helicopter. For example, if the helicopter is 20 minutes away, and a ground unit is ready to embark on short notice, it is possible that despite the helicopter's greater speed, the ground transport option would get the patient to the receiving center in a similar time frame. In such cases, helicopter transport could still be preferable; the out-of-hospital time can be relevant even when the overall "transport time" is similar between ground and air transport options.

There were many cases identified in the LFOM-MMC review, in which the minimization of out-of-hospital time was important. A few illustrative examples are informative. One patient, who had respiratory disease, was receiving a certain mode of advanced ventilatory support at the referring hospital. She had to be taken off of this advanced ventilation mode during transport, due to inability to provide the intervention in the out-of-hospital setting; in such a case the absolute minimization of out-of-hospital time was of obvious import.

In another case demonstrating the importance of minimizing out-of-hospital times, a patient had a severe electrolyte abnormality. The patient had the cardiac conduction delays which can be seen with such an problems, and had a pacemaker in place during transport. The transport pacemaker was external transcutaneous device – a type which often fails to capture and control the heartbeat in patients such as the one in question. Failure of the external device to capture requires placement of an internal (transvenous) pacemaker. While a relatively easy job in the hospital setting, internal pacer placement is simply not an option in the field. Thus, it is important to minimize the out-of-hospital time for patients like this one, in whom pacemaker capture failure can translate to the need for CPR.

The intent of this section's discussion is to demonstrate that speed issues are relevant in more ways than the obvious. Even if a patient gets to the hospital in the same amount of time via ground or air transport (*i.e.* if ground transport is able to leave the referring hospital much sooner than HEMS would), in some instances the need for HEMS is driven by the desire to minimize time spent in the less-safe transport setting. Depending on the clinical scenario at hand, the out-of-hospital time issue can have direct relevance to determinations of whether patients should be flown to an on-site helipad at MMC. In trying to ascertain the clinical impact of prolonging out-of-hospital time with a Jetport-to-MMC ground leg, the next step for this report is to characterize the timing of this extra transport leg.

Characterizing the ground transport leg from Jetport to MMC

This section will provide statistical summary of the time incurred by LFOM using the bifurcated system of transport to MMC. For the series of 100 LFOM-MMC transports reviewed, reliable data on the time for the ground leg were available for 36 cases. The mean (average) time was 16.9 minutes (standard deviation, 4.9). The statistical 95% confidence interval for the mean was 15.2 to 18.5 minutes. The median ground leg transport time was 16 minutes (interquartile range, 12.5 to 20.0 minutes); 99% of the ground legs were achieved within the range of 10-30 minutes.

Though there was a lot of missing data, careful review of the applicable information renders highly unlikely any association between presence of transport time data and significantly shorter (or longer) length of ground leg time. In other words, there seems to be no "selection bias" in terms of which ground transport runs had the times recorded. The consultant believes that the time estimate of 15-16 minutes accurately reflects the time required to offload patients at the Jetport and get them to MMC.

Patient transfers during HEMS transport

Apart from the time issues associated with bifurcated transport, another component of risk that must be considered is that which is incurred by the extra physical movement of the patient (*i.e.*, jostling while moving from stretchers to ambulances, and during the ambulance ride). To quantify as much as possible the extent of this potential for patient shifting and movement, the consultant performed a "dry run" from the Jetport to MMC. It was found that the Jetport-to-MMC transit involves a number of steps and two extra patient movements. Considering the high acuity of the LFOM patients comprising the study sample of 100 patients, general use of on-site MMC landings would, in the consultant's opinion, be significantly advantageous as compared to a bifurcated transport model.

The patient transfer issue, taken in consideration with the acuity of the LFOM-MMC cohort, is core to the consultant's judgment that nearly all patients undergoing HEMS transport into MMC would stand to benefit from on-site landing. Development of this theme is the focus of the rest of this section of the report.

A large proportion of patients transported by LFOM have been intubated; that is, they have breathing tube and are undergoing artificial ventilation. In the sample of 100 cases reviewed, 18% of patients were intubated (95% statistical confidence interval: 11% to 26.9%). Intubated patients tend to be of sufficient acuity that they benefit most from expedited transport; for that reason alone these patients should be transported directly to the Level I center (without an extra transport leg) if possible. However, even apart from time considerations, the act of moving intubated patients incurs risk. One complication reported due to moving intubated patients is development of ventilator-associated pneumonia, which appears to be caused by jarring and displacement of ventilator tubes.[27] Furthermore, the fact that patients must often be manually ventilated (*i.e.* "bagged") during transfers entails risk of over- or underventilation and attendant complications. Consistent ventilation synchrony (*i.e.* matching of assisted breaths with patients' spontaneous breathing efforts) is very difficult to maintain during manual ventilation; asynchrony markedly increases the patient's work of breathing.[20] Other problems with manual ventilation include inconsistent positive pressure and potential for worsening blood oxygenation for a given percentage of inspired oxygen.[20] Attendant changes in blood oxygenation are often sufficiently severe to incur substantial risk of low blood pressure, cardiac dysrhythmia, or both.[21]

Other issues may also arise related to ground transport and patient transfers. These risks have been well-delineated in the realm of both intra- and interhospital transport; either setting serves to demonstrate the advantage in minimizing patient transfers. Risks identified in previous clinical studies[29-31] include, but are not limited to: inadvertent discontinuation of blood pressure support drug infusions (with resultant hypotension), loss or infiltration of intravenous lines, repositioning-associated changes in patient comfort (with associated pain-caused physiologic sequelae), accidental dislodgment of endotracheal tubes, displacement of fractures with associated pain and bleeding, movement of surgical drains, and disconnection of cardiac monitoring leads. Furthermore, even in the absence of any dislodgments or equipment-specific issues, it is known that positional changes tend to effect changes in cardiac output and respiratory mechanics.[32] These movement-associated adverse events, clinically significant in terms of both morbidity and mortality,[29] have been shown to occur even when trained personnel are accompanying, and paying close heed to, the patient being transported.[30]

Relevant to the MMC helipad question – which should not be distracted by consideration of rarely occurring risks – are findings that mishaps have been found to occur in as many as a *third* of transports of critically ill patients, and that problems tend to occur during patient movement from one stretcher over to another.[30] Thus, there are clinically important risks associated with even a single unnecessary patient transfer – such as would occur with any ground transport leg after LFOM landing in Portland.

In addition to intubated patients, another population both comprised a large proportion of the LFOM-MMC sample and is also at particular risk from transfers. Pediatric patients, which constituted a fourth of the LFOM-MMC study set of 100 transports, are known to be particularly vulnerable to problems occurring during transfer. This makes common sense to anyone involved with pediatric trauma or critical care, but there is also evidence basis for concerns. Problems with oxygenation and ventilation, as well as inadequate fracture immobilization and resultant displacement and pain, have been noteworthy in studies of pediatric patients.[31]

By this point, the reader could be forgiven for wondering if the risks associated with patient transfer are being a exaggerated for effect. In fact, out-of-hospital care is indeed a potentially dangerous business – especially when the patients undergoing transport are of the acuity found in the LFOM-MMC group. Unfortunately, the risks of moving patients are imperfectly understood even by most healthcare providers. Physicians and others who do not actively participate in day-to-day care of critically ill and injured patients tend to be undereducated as to level of risk associated with patient transfer, even when the transfers" occur within the hospital environment. The sobering truth is that, as one expert reviewer has concluded, at major hospitals about one patient per month suffers cardiac arrest or death from transport-related complications.[33] Thus, patient transport should not be taken lightly, as there are potential risks in just about all who undergo this activity. Selected cases will illustrate the applicability of patient transfer concerns in those individuals being flown into Portland.

There were at least three patients with spine injuries (among other problems). In patients such as these, transport time is a critical parameter of interest for this report. Just as critical, though, is the need for minimization of patient movements, since the "conversion" of spine injuries from incomplete (or even asymptomatic) to devastating is a real risk. The importance of minimizing jostling is also illustrated in the case of a patient who had a rather severe spine injury. The LFOM crew documented their special precautions to prevent further displacement and neurological injury during their transfers of this patient; the success of those precautions does not negate the desirability, in future cases, of minimizing transfers in such patients.

Other instances where the actual movement of patients poses high risk are easy to find in the LFOM-MMC transport series. In patients who have suffered certain types of trauma, the extra two transfers associated with the Jetport-to-MMC ground leg clearly incur nontrivial risk (*i.e.* for further injury, such as the risk associated with transfer of at least one trauma patient in the series of reviewed transports). In another example, a patient who had undergone a temporizing surgical procedure was at risk, due to the potential for complications associated with moving patients who have had such procedures. In these cases, it was important to minimize both out-of-hospital time and also transfers.

Inadvertent traction on both medical and nonmedical instruments and objects is an obvious area of patient transfer risk. There are other instances, less easily explained but nonetheless familiar to prehospital and in-hospital providers, where patient deterioration is associated with the simple act of movement. As an example, one patient suffered a precipitous blood oxygenation drop (pulse oximetry falling to 80% instead of normal >97%) concomitant with movement from the referring hospital stretcher to the LFOM stretcher. No deterioration occurred during the subsequent movements of transferring this patient, but seasoned clinicians would not discount as coincidence the temporal association of transfer and deterioration.

This section of the consultant's report has attempted to portray the only-too-real risks which are incurred by moving critically ill and injured patients from one place to another. Clearly, the transport of such patients to regional facilities such as MMC is, on balance, in the best interests of patient outcome. However, the transport-associated risks outlined in this section should make a case that a plan for getting patients to tertiary care centers, should best incorporate all possible mechanisms to render their movement between facilities as safe as possible. Since the patient sample reviewed for LFOM flights into MMC is of high acuity, this population is a good target for efforts at elimination of unnecessary movements and transfers.

Clinical deteriorations occurring in the 100-transport sample of Jetport-MMC ground legs

Much of the previous sections' discussion has focused on risks, rather than actual untoward clinical events, associated with the Jetport-to-MMC ground transport leg. To some degree, a considered judgment about appropriateness of bifurcated transport should focus on those risks, rather than actual untoward events. This is because the risks, as previously discussed, are based upon clinical knowledge and research; risks and probabilities are more generalizable to future operations than are single occurrences which may never be repeated. Assessment of risks in a large group also avoids some of the subjectivity inherent to retrospective assignment of adverse outcomes. It is not easy to know which patients who did poorly, had suboptimal outcomes due to the extra time or jostling of the ground transport leg. Conversely, no one can, with absolute certainty, aver that any patients who did poorly, did so only because of ground transport.

With the above *caveat*, if analysis of a reasonably large set of LFOM-MMC transports fails to identify any clinical consequences occurring during, or associated with, ground transport, then the likelihood of frequent adverse events from ground transport would seem to be less than that implied by previous sections' discussion. Thus, this section of the consultant's report will address instances in which adverse clinical events – ranging from vomiting to cardiac arrest – happened during the ground transport leg of patient transports between the Jetport and MMC.

One patient had been stable, both neurologically and by vital signs, since before LFOM was called to the referring hospital, where this patient had a neurologic diagnosis. There were no problems during the air transport leg, but during the 20-minute ground transport leg (from 1922 to 1942) the patient suffered significant deterioration (disorientation, speech problems, and lethargy). Upon arriving at MMC, the patient underwent emergency ventriculostomy (to relieve brain pressure) after a computed tomography (CAT) scan.

Another trauma patient, was diagnosed at a community hospital as having both neurologic and spine injuries. He was stable during the air transport leg, but during the ground transport from the Jetport he began yelling and became very agitated (with concomitant increases in intracranial pressure, in addition to potential disruption of his spine injury). Similarly, another trauma patient became very drowsy during the ground transport leg (indicating neurological deterioration, likely from increased intracranial pressure). Increases in intracranial pressure, which are well known to have adverse outcomes in the head-injured patient, also occurred with near-certainty in another trauma patient, who did fine during the air transport leg but who was "bucking the ventilator" (*i.e.* fighting mechanical ventilation) during ground transport.

One trauma patient was noted to have neck vein distension, decreasing breath sounds, and increasing respiratory rate (from 18 to 38 breaths per minute) during the ground transport from the Jetport. These findings strongly suggest collapsed lung. Due to the proximity to MMC when the patient worsened (the ground leg took 12 minutes from 1328 to 1340), no interventions were performed during the ground transport. However, it is clear that had the ground leg been longer, or the LFOM crew more aggressive, the lack of definitive diagnostic interventions – such as X-ray – in the ambulance would have resulted in the patient undergoing temporizing treatment for a collapsed lung (needle thoracostomy). The needle thoracostomy, which involves placement of a needle catheter in the chest to release air from a collapsed lung, would have been painful to the patient and would have necessitated (as do any and all needle thoracostomies) placement of a chest tube. Since this patient was quickly found on chest X-ray at MMC to *not* have the collapsed lung that his clinical signs so strongly suggested, he avoided these procedures. In this case, needle thoracostomy performed during the ground transport *would have been appropriate*, given the clinical circumstances, but it would have translated into a surgical procedure (chest tube placement), significant pain, and many days in the hospital that would have been avoided by having LFOM land on-site at MMC.

In another case, a patient with bleeding did not appear to have significant instability at the referring hospital, but the patient developed low blood pressures during the LFOM air transport leg. The blood pressures stabilized during the air transport leg (there were normotensive blood pressures during final 24 minutes of flight). During the 11-minute interval between the Jetport landing (2159) and loading onto the ground ambulance at 2210 (by which time the patient would likely would have been in or near the operating room given an on-site landing at MMC), the patient rebled and significantly deteriorated such that by 2221 the patient was receiving medications for slow heart rate.

In another case, a patient suffered two logistics-type complications associated with the ground transport leg. First, the battery on the mechanical ventilator became depleted – a complication known to incur substantial clinical risk[19] – and the patient subsequently required manual ventilation. Manual ventilation is less desirable for a number of reasons that are well characterized in the critical care transport literature; these problems have clear applicability to this patient, given her history of severe pulmonary hypertension.[20,21] The second logistics problem in this patient was a delay in the commencement of the ground transport leg. This was due to the need to remix more of the patient's infusion therapy; a remixture which would have been obviated if LFOM had landed on-site at MMC.

The mechanical ventilator battery problem arose again, during the ground transport leg in another patient, resulting in the need for LFOM crew to perform manual (bag-valve) ventilation, with its less effective and more problematic profile (as compared to mechanical ventilation). As an even more concerning problem, the switchover to manual ventilation in this patient – who had suspected sepsis – resulted in unnecessary exposure of the crew to the infectious agent with which this patient ultimately was diagnosed.

In an example of severe, yet unexpected, deterioration occurring during ground transport, a patient who was stable at a referring institution, and had no instability by either complaints or vital signs during air transport. Approximately 11 minutes into a 16-minute ground transport from the Jetport to MMC, the patient's respirations suddenly decreased and the patient became near-comatose; the patient required assisted ventilations during the final minutes of the ground transport and required emergency intubation at MMC. This patient provides evidence of the real-life difficulty of any system which attempts to "triage" patients away from an on-site helipad to bifurcated transport.

As another sample case, a patient had vomiting at the end of the air transport leg. The patient vomited again during the ground transport, with the latest episode of vomiting being bloody. This complication has relevance to bleeding risk during the emergency cardiac cath lab procedure this patient underwent at MMC (since catheterization lab drugs include large doses of potent anti-clotting medication).

Another patient had a decrease in blood pressure just after landing at the Jetport. This patient improved with medications given just after the aircraft landed, but deteriorated after being loaded into the ground ambulance. (If the patient had been landed at an on-site helipad at MMC, the patient would have been in the MMC operating room by the time his condition deteriorated.) This patient's systolic blood pressure dropped to 40 (normal: 120), and by the time the 16-minute ground transport to MMC was completed the patient was in full arrest. This patient's chances of survival were significantly and adversely impacted by the bifurcated transport.

Another patient with a bleeding problem, was receiving a blood transfusion to help balance ongoing hemorrhage. The blood transfusion was completed soon after LFOM landed at the Jetport. During the ground transport leg, which began at 2031, the patient's blood pressure dropped first to 98 (at 2035) and then to a near-arrest level of 55 (at 2040). This patient's vital organ perfusion was clearly compromised at a time when the patient would have been in the operating room if the aircraft had landed at an on-site MMC pad.

Another patient had vomiting during the ground transport leg of the patient's interfacility transfer to MMC's cath lab. This patient had had no nausea or vomiting during air transport. Vomiting is very uncomfortable for the patient, causes anxiety and sympathetic nervous system outflow (not good for patients in the throes of a heart attack), and is associated with the risk of aspiration of gastric contents into the lung. It would appear that avoidance of vomiting may be insufficient reason for triage away from bifurcated transport, but it is not easy to decide in which patients nausea and vomiting risk is "acceptable" if they are of the acuity seen in the reviewed

LFOM-MMC sample.

Another case involved a trauma patient with an unusual piece of equipment in place for transport. There were no problems during the air transport, but a potentially life-threatening problem developed during ground transport. The patient had to undergo a "rescue" procedure in the ambulance during a 13-minute Jetport-to-MMC leg.

In short, this section has outlined clinically significant complications in 14 cases, or 14% of the transports (statistical 95% confidence interval, 8-22%). Importantly, this calculation does *not* include patients with acute illness (*e.g.* heart attack) or injury (*e.g.* brain trauma) for whom prolonged transport associated with the ground leg posed additional risks due to time-criticality of disease (see next section).

Time criticality in the sample set of Jetport-MMC ground transports

Previous sections of this report have addressed overt patient deteriorations occurring during the ground transport leg, and it is the opinion of the consultant that the types of deteriorations that were identified are in the range of "expected" sequelae from bifurcated transport. There is another part of the "deterioration" issue that deserves emphasis, however: patients who are of high illness and acuity simply have better chances at good outcome, if they get to the receiving center more expeditiously. Irrespective of the ability to objectively measure the precise impact of an added 15-20 minutes on patient outcome, the fact is that patients of the nature of those reviewed in the LFOM-MMC cohort are precisely those in whom an extra few minutes can be lifesaving or otherwise critical.

Clinicians have long known that, for trauma, there is an initial period of about an hour (Dr. R. Adams Cowley's so-called "golden hour") during which evaluation and interventions tend to be particularly critical to outcome. Equally certain is the clinical basis for the adage, as applied to patients having heart attacks, that "time is myocardium" (heart muscle). Neurologists providing cutting-edge stroke care have modified the statement to "time is brain." Patients with a variety of other medical conditions, ranging from sepsis to toxicology and overdose situations, stand to benefit from streamlined delivery to tertiary care.

While there can be little argument that patients with acute trauma, heart attacks, strokes, and other obviously time-critical diagnoses should benefit from rapid transport, it is not easy to ascertain any specific adverse events associated with delays incurred by employing a Jetport-to-MMC ground transport leg. There are, to be sure, some instances – which were *not* included in the above sections' outlining of ground transport deterioration events – where ground transport and the attendant delays more likely than not had adverse effects. For example, one patient had worsening of chest pain (due to an acute heart attack) during the final 10 minutes of air transport. Worsening pain directly correlates with dying and "at-risk" (ischemic) heart muscle, so it is obvious that what this patient needed was immediate heart catheterization – which he indeed received, after a delay of 20 minutes incurred for ground transport.

There is no way to know how much more heart muscle was lost due to ground transport time in any given patient, such as any of those urgent cardiac cases (9 in all) involving transport directly to the MMC cardiac catheterization suite. However, as every physician involved with cardiac care knows, a 20-minute delay in getting a patient to the cath lab can have profound impact upon survival and also on non-mortality endpoints (*e.g.* amount of heart muscle lost).

The imprecision of measuring transport- and time-related adverse effects does not mitigate the undesirability of prolonging transport in cases such as that of cardiac patients. Similarly, neither the consultant nor anyone else can say with absolute certainty what extra minutes' ground transport time meant to ICU lengths-of-stay, organ damage complications, neurologic outcomes, or a host of other outcomes endpoints in patients in the LFOM-MMC transport group. However, there is at least one mechanism of focusing the question, and that is to assess patients who received time-critical interventions upon arriving at MMC.

Medical and surgical interventions were often provided immediately upon patient arrival at MMC. Some illustrative cases will clarify the point of time-criticality. One patient had a persistent heart rate above 200 beats per minute, despite about a dozen drug administrations; this patient was successfully converted to a normal heart rhythm by a cardiologist within minutes of MMC arrival. Another patient suffered complete respiratory collapse at the time of arrival at MMC; this patient was immediately intubated for ventilatory support. Another patient underwent an emergency neurosurgical procedure upon MMC arrival. In another case, a patient with a bleeding problem and alteration in the ability to form blood clots (coagulopathy) underwent immediate MMC interventions that included urgent correction of the blood clotting abnormality.

This section has attempted to show that, even in the absence of overt deterioration, patients in the LFOM-MMC cohort tended to have clinical situations in which time was critical. In such patients, lack of deterioration doesn't imply that the patients in question would not have benefited significantly from elimination of the ground transport leg from the Jetport to the MMC facility. The main basis for this opinion of the consultant, and the primary foundation for the consultant's consistent judgment that patients in the LFOM-MMC sample would have been better served by an on-site helipad, lies in patient acuity. The next section of this report addresses the acuity of LFOM transports, with focus on how patients are "selected" for helicopter transport, and on the processes designed to insure appropriateness of helicopter use (utilization review).

Patient acuity, triage, and utilization review at LFOM

One of the charges for the consultant was to assess the HEMS-transported patients for overall acuity, with the goal of determining whether LFOM helicopter triage guidelines were consistent with national guidelines. Additionally, the consultant was asked to comment on the likelihood that there would be national (or local) guidelines changes resulting in significant alterations in air transport utilization. In other words, a question was: How likely is that air medical transports into MMC will increase due to major changes in nationally utilized helicopter use guidelines? This section addresses those issues, and also touches upon the question of whether frequency of HEMS use is likely to increase if an on-site pad is constructed at MMC.

The "national helicopter triage guidelines" used were the most recent, and most evidence-based (*i.e.* founded on the available clinical and scientific research) air transport guidelines available. Published in 2003,[25] these guidelines (which are reproduced in Appendix II of this report) have been endorsed by the National Association of EMS Physicians (NAEMSP), the Air Medical Physician Association (AMPA), and the Association of Air Medical Services (AAMS). The national guidelines were promulgated by the NAEMSP Air Medical Services Committee, and the process of developing and writing the guidelines took the better part of three years. There has been no new evidence widening the scope of air medical transport in the time period since 2003, when the NAEMSP guidelines were published. The consultant can state, to a reasonable degree of certainty, that it is highly unlikely any major changes in the guidelines will occur in the next few years. Major changes after that time period are also unlikely – the literature supporting the first set of guidelines was 20+ years in the making – but any modifications will of course be driven by scientific evidence from clinical studies.

Notably, the consultant was not able, at the time of this report, to collect transport numbers data from a similar area (to Portland) which transitioned from bifurcated transport, to an on-site helipad. One area of potential similarity (Albany Medical Center in New York) was identified, as having transitioned from an off-site to on-site helipad years ago, but that program was not able to provide exact numbers on transport volume. The program's director did indicate that their HEMS service's gradual and modest increase in transport volume did not appear to be affected by the transition from off-site to on-site helipad.[45] In short, the consultant does not believe, based upon his experience with either the triage guidelines or with other programs that utilize on-site pads, that construction of an on-site MMC pad is likely to result in burgeoning numbers of HEMS transports.

The aim of the national triage guidelines is to provide an overview of circumstances in which helicopter use, as compared with ground transportation, is the most appropriate mechanism for getting patients to high-level care. In the case of MMC, ground critical care transport is readily available. The presence of the alternative transport mode means that patients who need to get to MMC, but in whom illness or injury isn't time-critical, can use the ground transport vehicle. The main goal of such ground vehicle utilization is to reserve helicopter assets in order to maximize their availability for truly needy patients. In terms of relevance to the MMC situation, the ground critical care capabilities mean that the average patient who *does* come into MMC by air, is of relatively high acuity.

Contributing to the high relative acuity of air transported patients into MMC is the fact that regional hospitals (*e.g.* Central Maine Medical Center, Eastern Maine Medical Center) serve to "filter out" less critical patients, transferring to MMC (often by air) those patients whose needs outstrip the capabilities of the regional hospitals. As an example of the exception proving the rule, one patient was transported to MMC from a scene after a skiing incident. The patient was initially scheduled to go to another hospital by air, but operating room unavailability at that hospital prompted aircraft diversion to MMC. The point with relevance to the MMC on-site helipad issue, is that patients from further distances (from MMC), whose acuity places them at lower relative risk from birfurcated transport, aren't transported to MMC. Rather, these patients go through a filtering process whereby initial evaluation at referring hospitals receiving the initial air transports (*e.g.* CMMC, EMMC) selects out only the most acute illnesses and injuries for flight into Portland. The end result of this process is that patients transported by air into MMC tend to be, even when compared with other air transports, on the higher end of the acuity scale.

In reviewing the LFOM transports in the set of 100 LFOM-MMC patients, it was clear that LFOM was indeed adhering to its stated triage guidelines, which are represented in Appendix I of this report. Furthermore, the review of details of the LFOM guidelines reveals that they are consistent with the helicopter utilization guidelines promulgated by national authorities.[25] There was no evidence that the LFOM helicopter utilization guidelines were either more or less stringent, than the general accepted parameters for use of helicopter transport.

Reasonable guidelines for LFOM helicopter utilization do not necessarily translate into 100% "appropriate" use. As can be seen, the guidelines are fairly complicated, and it is important to remember that in the state of Maine, helicopter dispatch can be activated by a wide variety of nonmedical personnel (*e.g.* ski area workers, remote woodland corporate entities) that would be expected to be more likely than trained paramedics to "overutilize" the resource. Thus, it is vital that an *a posteriori* "utilization review" occur on an ongoing basis, to insure that the use of the helicopter resource is occurring in a manner consistent with the local (LFOM) and national guidelines.

Upon reviewing LFOM policies and procedures, the consultant has found that there is indeed an ongoing utilization review process. In fact, each flight is reviewed by a physician director and there are feedback loops which help inform and educate referring agencies as appropriate. While an on-site review of LFOM documents was sufficient to convince the consultant of the fact that LFOM post-flight appropriateness review processes were up to national standards, it is more important to note that pertinent LFOM policies have been approved by the national Committee on Accreditation of Medical Transport Systems (CAMTS).

CAMTS accreditation is the highest goal for U.S. air medical transport services, and cannot be achieved unless a given program demonstrates proficiency and efficiency in a wide variety of medical, procedural, and safety parameters; not least among these is the requirement for ongoing utilization review and feedback.[37] As a CAMTS-certified program, LFOM is required to demonstrate that the program follows both the letter and spirit of the rule requiring ongoing utilization review. Specifically, LFOM must perform "a structured, periodic review of transports (to determine transport appropriateness or that the mode of transport enhances medical outcome, safety, or cost-effectiveness over other modes of transport) performed at least semi-annually and resulting in a written report."[37]

During the charges to the consultant, one question that arose was: "Should there be some independent ongoing utilization review of LFOM flights into MMC?" The consultant believes that, *objectively* speaking, the LFOM processes currently in place are sufficient. (This assumes there is ongoing updating and maintenance of LFOM standards to match national guidelines; such would be evidenced by LFOM maintaining its CAMTS accreditation.)

Despite the consultant's belief that adding an additional layer of "independent" utilization review is administratively and medically unnecessary, the Portland helipad debate seems sufficiently vigorous that – in the event an on-site MMC helipad is constructed – some period of ongoing review may be helpful. A truly independent reviewer (assuming one could be easily found and agreed upon) could help assuage fears of inappropriate use of an MMC helipad facility. The arguments *against* institution of such additional review hinge upon both the costs (in time and other resources) of redundant review, and the low likelihood that such a system would identify problems missed by the extant process. The decision is of course left to the City of Portland, but the salient points seem to be: 1) LFOM triage protocols are consistent with national guidelines, 2) LFOM transports as reviewed by the consultant are executed in line with LFOM triage protocols, and 3) there is an appropriate and national-standard quality assurance and utilization review mechanism already in place.

This section has addressed some of the putative explanations for LFOM's high patient acuity, and additionally has made a case that changes in the currently used triage guidelines are likely to be minor in the foreseeable future. Furthermore, it appears unlikely to the consultant that construction of an on-site MMC helipad would add significantly to the current transport volume profile of LFOM into MMC. The next sections address what actually appears to happen, during a "mock transport" from various locations to the MMC.

Mock transports

The mock transports were executed so that the consultant could get a first-hand sense of what was entailed in the various possibilities for getting air-transported patients into MMC. They are necessarily subjective, with some estimates of time that may not be precise, but the general information obtained was of substantial value to the consultant, and may be illuminating to the reader of this report.

Mock transport from Jetport to MMC

To familiarize the consultant with the current logistics of the ground transport leg, a "mock run" from the Portland Jetport to the MMC was executed at approximately 1500 on a weekday (11/18). This time was selected because it correlated with the time that appeared to correlate with the highest volume of LFOM-MMC transports.

Upon landing at the Jetport, the helicopter waits 2-3 minutes for the engines to "spool down." LFOM does not engage in hot-offloading, which is the practice of removing the patient to a ground ambulance while the rotor blades are still turning. Hot-offloading of patients is uncommonly indicated, and incurs a greater risk to ground personnel than does the alternative of "cold-offloading" (after the rotors have stopped turning). Conversations with LFOM personnel indicate that hot-offloading is "not an option" with Jetport transports, due to its being disallowed by the personnel (Medcu) providing ground transport. For the vast majority of cases, landing of LFOM at an on-site MMC pad will not save the few minutes required by the practice of cold-offloading; however, it is conceivable that with appropriate training the use of an on-site MMC pad can offer the *potential* to utilize hot-offloading in highly time-critical cases.

Subsequent to patient unloading from the helicopter, the patient is placed onto a transport stretcher, rolled to the ambulance, and loaded into the ground vehicle. In combination with the subsequent need for post-ground leg transfer to the hospital stretcher, the current ground transport system thus entails *two* patient transfers: one to the ground ambulance, and another to the hospital stretcher at MMC. (This compares unfavorably to the on-site MMC pad system's single transfer onto a hospital stretcher from the rooftop pad.)

After the patient is loaded into the ground transfer ambulance, the ground vehicle must leave the security-controlled area of the airport. This step, which requires an attendant to open a locked gate, usually takes negligible time. However, LFOM crew indicate that on occasion, there is a wait to get the gate opened. For example, in one patient with severe bleeding, there was an 8-minute time lapse between Jetport landing and commencement of ground transport vehicle will turn right and continue on to MMC.

The mock run from the proposed Mercy site entailed five 90-degree turns. Two traffic lights were in the pathway. Having been calculated in a run in which the traffic lights were green, the consultant's estimated "new Mercy"-to-MMC transit of about 3 minutes probably approximates fairly closely, the "real-life" transport time between those two sites. To this three minutes should be added the expected time for engine spool-down and patient transfer to the ambulance, to achieve an expected total time (from helicopter landing to patient arrival at MMC) of about 8-9 minutes.

Mock transport from proposed rooftop helipad

The aircraft will land on the rooftop of a parking garage. Subsequent to patient unloading from the helicopter (see discussion above, covering hot- vs. cold-offloads), the patient is placed onto a rolling hospital stretcher (important: a single patient transfer rather than two). An elevator (dedicated to LFOM use when the aircraft arrives) will take the patient down about 20 feet (2 levels of the parking garage), after which time the patient must traverse a distance of about 100 feet (over a street). This is achieved in a closed and air-conditioned/heated hallway, after which a right turn brings the patient to the operating suite, or a left turn brings the patient into the Emergency Department. There is a dedicated CT scanner in the ED (which has relevance to certain types of emergent cases such as strokes).

Since the helipad and related structures are not built, times estimated for this transport system are estimated. Assuming a cold-offload and a ready elevator, it would appear that the total time elapsed between landing and patient arrival in the E.D. (or OR), would tend toward 4-5 minutes. Perhaps more importantly, at least for the sake of comparison against logistics setups involving ground ambulance legs, elapsed times could be assessed as the interval commencing with patient loading onto the first stretcher (transport stretcher for ground ambulances, hospital stretcher for on-site MMC transports) after helicopter landing. By this adjudication, the patient could be in the MMC ED/OR within 1-2 minutes after being offloaded from the aircraft.

Use of an acuity or time-of-day dependent helipad triage system

The crux of the issue confronting the City of Portland appears *not* to be whether an on-site MMC pad would be good for some patients, but instead whether such a landing area would be necessary for *all* patients. The current system uses a bifurcated approach, in which patients land at the Portland Jetport and subsequently undergo an additional trip in a ground vehicle. The issue of risks (from transfers and from time costs) associated with this extra transport leg have been outlined elsewhere in this report. It is not the intent of this section to reiterate arguments and impressions noted elsewhere. Rather, this section assumes that direct-to-MMC (on-site pad) transport *is* available and agreed-upon to be preferable for many HEMS patients; the section's goal is to consider whether bifurcated transport (*i.e.* as occurs now) should be maintained as an option for *some* patients (as defined by acuity or time-of-day).

One point to make is the that construction of an on-site MMC helipad would not, irregardless of any triage rules, completely eliminate the possibility of Jetport-MMC bifurcated transport. This is because weather considerations could occur, which would exclude flight into MMC but which would allow transport into the Jetport due to the latter's navigational advantages as an airport. This situation is not anticipated to occur commonly, but it is worth mentioning in any discussion about whether bifurcated transport should be "discontinued." The rarity of weather-dictated bifurcated transport is well-predicted, based upon the experience of other HEMS programs in New England: the fact of the matter is that when the weather is truly bad, no HEMS operations will occur (to the Jetport or to MMC).

If the system of bifurcated transport works now, and if it must be available for the rare case where weather allows helicopter operations but closes the MMC helipad, then why not have an approach whereby pre-flight screening determines the appropriate landing area? Such a triage system would, for example, come into play for nighttime operations where noise would be a particular consideration. For cases of lesser acuity, where there is lesser risk from patient transfers and time delays, it seems quite fair to pose the question as to why on-site MMC landing is really necessary.

If there is a helipad on-site at MMC, there would be only two reasons to triage patients away from landing at MMC and incur the extra resource expenditure and patient risks associated with use of the ground transport leg. These two reasons are safety and noise.

The issue of noise is addressed by another consultant's report. The issue of safety is covered in another section of this report, but some safety notes may be relevant here. If the weather is particularly bad, it may be safer to land aircraft at the Jetport, as noted above. Pilots routinely make this type of decision, and the certification of LFOM (which provides nearly all helicopter transports to MMC) by the Committee on Accreditation of Medical Transport Systems (CAMTS) demonstrates that program's demonstrated excellence in, and commitment to, safety issues which include pilot qualifications and training. Thus, for instances in which bifurcated transport is necessitated by weather/safety considerations, it is reasonable to believe that HEMS programs and pilots will exercise appropriate judgment. Other, closely related, safety-related information is found separately in this report in a subsequent section.

The critical reader may have noted the phrase, used on the previous page, "If the system of bifurcated transport works now." A rational philosophical objection to construction of a new helipad is: "If all patients currently go into the Jetport, do we *really* need to re-triage *all* patients to an on-site helipad?" In other words, where are all of the adverse medical outcomes ascribed to the ground transport leg?

As outlined in another section of this report, there *are* many adverse medical outcomes that have been associated with the ground transport leg. Rather than repeating clinical information previously iterated, the consultant will refer the reader to this report's sections discussing risks and deteriorations associated with the ground transport leg. The point is, the system "works" now, but it could clearly work better, for nearly all patients. The mere fact that a certain approach may be the best *current* solution does not translate to any certainty that there is not room for significant improvement.

Given the critical reminder that the opinion is based upon the consultant's review of LFOM-MMC transports revealing a clear pattern of high acuity, it is the consultant's judgment that transition to an on-site MMC helipad will effect substantial improvements to a system which is already good. As the major trauma center for Maine, MMC would do well to improve system care by offering the same expedited helicopter access as that which is now available at many other state facilities such as Eastern Maine Medical Center and Central Maine Medical Center. Given the high acuity of the trauma patients in the 100-patient sample, the consultant believes that transporting a trauma patient to the Jetport, if an on-site MMC pad were available, would not meet the standard of trauma care. Similarly, in virtually all cases of "scene" transport, trauma or otherwise, landing at an on-site MMC pad would be dictated both for considerations of trauma care, and due to the inevitable uncertainty underlying clinical knowledge about patients who haven't yet been evaluated by a physician.

If the idea of triaging trauma and scene patients away from an on-site pad isn't viable, the next step is to consider directing other (no trauma) patients away from rooftop. In this case also, the strong argument to maximize use of the on-site pad is based upon the imperfections of triage – imperfections that are not likely to go away any time soon. While a *retrospective* review can identify cases in which no adverse events occurred during ground transport, it is virtually impossible to predict, in a patient sample of the marked acuity of the LFOM-MMC cohort, which patients will be the unlucky ones. In some cases – trauma patients, those with ongoing chest pain from heart attacks – it is theoretically easy for a bifurcated system to triage the patient to the on-site hospital landing pad. Complications arise when it comes time to draw the line, and to determine which patients are "well enough" to *not* be at risk from the ground transport. (This doesn't even begin to consider the fact that provision of an infrequently utilized intervention – in this case ground transport – is associated with deterioration of the skills and expertise required to optimally perform that intervention.)

At the heart of the matter is the fact that for patients who aren't in obvious need of an on-site helipad, there is no triage mechanism possessing sufficient safety margin, that can be used to allow confident direction of the patient to the option of prolonged ground transport. The triage officer must have accurate information upon which to base a decision. However, any clinician who works in a tertiary hospital, and who has accepted patients in transfer, knows that – despite the best interests of community hospital providers – the patient that arrives at the Level I center may not bear much resemblance to the one described in the transfer conversation. This is not meant as an indictment on providers at referring hospitals, since patient situations change and diagnosis is still an inexact science. However, the relevance to the MMC helipad debate remains: regardless of the underlying explanation, any information given to a triage officer who is trying to figure which patients can go to the Jetport, should be viewed with healthy skepticism. For example, in a patient for whom LFOM transport was requested due to suspicion of a problem in the (noncerebral) vasculature, MMC specialists quickly realized the vascular problem had nothing to do the patient's problems; instead the patient was determined to have a stroke.

There is more to the triage difficulty argument than anecdotal stories (such as that of any of the previously mentioned LFOM-MMC patients) and the consultant's extensive experiences of patients arriving at tertiary care in quite different shape than that billed by transporting facilities. Clinical research demonstrates that patients undergoing interfacility transfer are inherently hard to characterize, and that they often are "sicker" than commonly used objective scores can measure.[35] The relevance to the MMC situation is: patients who appear to be "well enough" for bifurcated transfer may in fact have some of the other, more difficult to assess, characteristics associated with higher risk during transport. In a patient population in whom the acuity levels are low- or mid-range, the risks of triaging away from an on-site MMC pad are likely at a comfortable level. For the patients in the LFOM-MMC cohort, however, illness and injury acuity are sufficiently high that a reasonable and objective triage officer would rarely choose to incur the risks attendant to ground transport, when an on-site landing area is readily available. For example, to recall a previously noted case: patients can be stable in the ICU without any kind of deterioration occurring during air transport, but then, during the Jetport-to-MMC leg, they can suddenly become near-comatose with severe respiratory depression. This was a stable patient at another institution, who had passed the "test of time," for whom a "triage officer" could quite reasonably – and wrongly – denied access to an on-site MMC pad.

Since a system whereby triage to bifurcated transport is based upon injury acuity or other factors (such as time of day) appears less desirable than direct-to-hospital helicopter routing, the question arises as to whether such systems currently exist. The consultant being unaware of any such systems in the U.S., others with expertise were asked about whether they were familiar with a logistical model of the triage-to-bifurcated transport type.

HEMS services in the U.S. tend to be run by vendors that supply pilots and equipment to hospitals and other agencies running the HEMS service; the vendors bring aviation expertise to the partnership whereas the hospital personnel bring medical and transport expertise. The consultant contacted representatives from HEMS vendors, asking whether they were aware of any system whereby patients are triaged away from on-site helipads depending on clinical acuity or time of day.

The Director of Operations at one of the largest and oldest vendors, Keystone Flight Services which operates 35 helicopters flying from 28 locations in the U.S. Northeast, responded: "There are no Keystone contracts that I am aware of who have night restrictions on hospitals. This includes the receiving hospital helipads as well as the hospital helipads they take patients from."[38] The Vice President and General Manager of Keystone's Flight Services added: "To my knowledge we do not operate from any hospital heliports that are restricted from use at night."[39] Another vendor widely used in the U.S. is CJ Systems Aviation Group, which manages air medical services of 105 helicopters at 77 base sites. Their Director of Operations reported that: "I have not seen such a restriction in any of the programs we support."[40] Additionally, the Executive Director of the Association of Air Medical Services, to which organization nearly all American HEMS operators belong, answered: "I have not heard of any heliports operating under this kind of split/differentiated schedule."[41]

The consultant has been involved, to some degree, in situations at two locations in which the issue of bifurcated transport may be applicable. In the City of San Francisco, a helipad serving San Francisco General Hospital has been and remains the subject of intense debate, which involves a variety of issues including environmental impact, noise, safety, and even impact on overcrowded hospitals in the San Francisco area. (The consultant was involved in the process, to the extent of being asked to comment on medical importance of having an on-site helipad for a Level I Trauma Center.) While there are neighbors involved in the helipad process, with final hearings still pending, the Department of Public Health EMS authorities in San Francisco have "never considered a 'bifurcated' approach to landings." [44]

In another major city, much closer to Portland, a sort of bifurcated transport does exist, but the situation in New York City (specifically, Manhattan) offers few parallels to a plan for acuity- or time-of-day based triage of MMC patients away from an on-site helipad. First, and maybe most importantly, the issue in NYC is that helicopters – of *all* types, EMS and other – are not allowed to land on pads in Manhattan. This decision, which appears to be the result of a 1997 crash into the East River, of a Colgate-Palmolive corporate helicopter, is not likely to be modified given the occurrences of 9/11/01. The consultant, having served two visiting professorships in NYC, is familiar with some of the relevant issues. Of significance is the fact that in NYC, the helicopter "ban" applies only in Manhattan; a plentitude of Level I trauma centers in surrounding boroughs (and in New Jersey) translates into a rare need for HEMS transport directly into Manhattan island. Furthermore, there are no systems in place – to the knowledge of the consultant, or to others with experience with HEMS transport in New England and New York City,[42] – for differential triage to bifurcated versus on-site transport in NYC; indeed, the experts with whom the consultant spoke were of the impression that outside of rare/emergency contingency plans for landing in Central Park, there was *no* provision for HEMS to land at hospital sites in Manhattan.

Helipad sharing

The consultant was to report on any issues related to a system of helipad sharing, between MMC and Mercy Hospital. There is a new building site to which Mercy Hospital is relocating, and it is the consultant's understanding that Mercy has approval to construct an on-site helipad at their new location. The question which has been posed by participants in the MMC helipad debate is: Do we really need two helipads so close together?

If the patients comprising the LFOM-MMC transports were of lower acuity, then there could perhaps be reasonable argument in favor of a "shared helipad" system whereby MMC-bound patients land at Mercy and then undergo a relatively quick ground transport leg to MMC. With the acuity characterizing the LFOM study sample, however, the patient transfer issues mentioned elsewhere in this report come into play, even over a short-distance ground leg.

Given the axiom that *processes* (e.g. patient transfers) inherent to performance of a ground transport leg can represent as much of a threat to patients as do time delays, the consultant's judgment is that a shared Mercy helipad is not a good answer to get patients to MMC. Speaking from the perspective of medical appropriateness, it seems clear to the consultant that the overwhelming preponderance of patients, including all adult and pediatric trauma patients, would be using the shared helipad as a means to get to MMC – not Mercy. Considering the transport-associated risks as outlined elsewhere in this report, medical needs and risk assessments render untenable a "solution" in which the Jetport landing plan is exchanged for a plan to land in-town, at a non-trauma center hospital which by any calculation would receive a distinct minority of air medical transports. The consultant has not performed any clinical reviews of patients going to Mercy (though the facility seems to not receive HEMS transports on any regular basis), so the possibility of a shared helipad *at MMC*, with occasional transports of patients down the hill to Mercy, may indeed be feasible.

Safety considerations

As mentioned earlier in this report, safety is one of the theoretical foundations upon which to base concerns about an on-site MMC helipad. As noted, the particular safety profile of *current* HEMS operations in Maine (with LFOM expected to provide nearly all air transports into MMC's pad) is such that in the consultant's opinion, it is fair to assume that any HEMS helicopter landing at MMC's on-site pad, is maintained and piloted at the top of industry standards.

Before discussing just what the industry standards mean, it is worthwhile to digress and discuss what happens when a program operates *outside* the standards. Unfortunately, the people of Maine are only too aware of the risks. From the National Transportation Safety Board (NTSB) report BFO94FA013[36]:

> "On November 19, 1993, at 2039 Eastern Standard Time, a Bell 206-L-1, N911ME, landed hard during a forced landing touchdown in the Atlantic Ocean seven miles east of Portland International Jetport, Portland, Maine. The helicopter was owned by Airmed Skycare Inc of Portland, and operated by Echo Helicopter Inc. of Portland, Maine. Instrument meteorological conditions prevailed at the accident site. The certificated commercial pilot received serious injuries, while two of the three passengers were fatally injured. The third passenger has not been recovered and is presumed to be fatally injured. The helicopter was submerged in 85 feet of water and was destroyed. The flight was conducted under part 14 CFR 135. The medical evacuation flight originated in Ellsworth, Maine."

The NTSB report narrative continues on, to outline tragic consequences of a series of errors. From establishing a situation in which medical transport was profit-motivated, to having a pilot accept – and subsequently fail to abort – a mission for which he and his aircraft were unsuitable, the Casco Bay crash represents the worst of helicopter EMS operations. The inevitable question for the current debate is: Could it happen again in Maine? Most pertinent to the issue of MMC landing versus Jetport landing, the question is "Could the helicopter crash near its landing site and place nearby individuals at risk?

Despite having been involved in HEMS since 1990, the consultant is unaware of any instances of bystander (*i.e.* not crew or ground personnel) fatality incurred from a helicopter crashing at or near a hospital-based helipad. However, in an effort to maximize the chances of identifying such an instance, the consultant contacted the single individual whose name is most identified with HEMS safety: Dr. Ira Blumen of Chicago, the author of a comprehensive 70-page report addressing HEMS safety.[34]

The question directed to Dr. Blumen was: How likely is it that the helicopter could crash at or near the hospital's helipad, injuring or killing neighbors? Of course, Blumen's response was that we are dealing with probabilities, not absolutes, but the good news is that the probabilities are – while nonzero – extraordinarily low. In fact, despite decades' experience in HEMS, including research for preparation of his safety report published in 2002,[34] Dr. Blumen did not recall *any* instance in which a person not involved with the helicopter transport was killed in a crash. In his reply to the consultant, he indicated[26]:

> "I know of only one accident that killed "someone on the ground." On 1/22/2001 (Air Evac, based out of Quincy, IL) a security guard who was supposed to be securing the helipad during take-off walked into the tail rotor and was killed. There have been numerous helipad accidents (rooftop and ground), but I do not know of any others that injured/killed non-crewmembers or the patient."

No one's memory is perfect, and there may indeed have been some instances that are not recalled by the consultant or safety experts. However, it is difficult to dispute the contention that a HEMS aircraft crash killing someone on the ground is an extremely rare event. Furthermore, it is obvious that such a crash could occur at any time during flight (not necessarily at or near the helipad), so the theoretical protection offered by vectoring the helicopter away from an on-site MMC landing pad is outweighed (by at least an order of magnitude) by the patient benefits expected to be accrued from use of an on-site pad. When considering the low, but nonzero, likelihood of a helipad-related crash, it may be worth considering another event, also of low but nonzero risk: a Portland citizen has a prolonged wait for an ambulance, due to delayed EMS response attributable to resource occupation on a Jetport-MMC ground transport.

In summary, the consultant has informed the City of Portland that his expertise lies outside the realm of safety. However, using the best available resources, the consultant has attempted to illuminate the understandably resonant safety issue and paint a rational picture of extremely low – even difficult to quantify – risk levels. One program, LFOM, will be the near-exclusive user of the pad; their pilots will be familiar with the helipad and will be available to train any other pilots as they assume positions rendering them likely to land at MMC. (This sort of cross-training occurs quite commonly in HEMS in general, and in New England in particular; the Boston hospitals' rooftop helipads are used by six HEMS services.) Furthermore, accident-related issues such as mechanical and fire hazards will apply minimally, since no HEMS maintenance or even refueling will occur on-site at MMC. In short, safety considerations do not appear to be a rational basis for avoiding construction of an on-site helipad. As the San Francisco Department of Public Health report on their own helipad issue concluded, "There is little evidence to support any danger to surrounding neighborhoods, even though some of these neighborhoods would be subject to helicopter overflight."[43]

Conclusion

The consultant entered this process with a goal of assessing what HEMS transports into MMC *currently* look like, in order to provide commentary on what the best model for the future may be. If the HEMS resource would have been found to provide "convenience" transports, or even transports for purely logistical reasons (*e.g.* off of a mountaintop), the consultant was more than prepared to identify the transports as being of noncritical nature. However, for reasons outlined elsewhere in this report, the current system of helicopter triage in the state of Maine is such that LFOM is used appropriately, and in fact the patient acuity for LFOM transports rivals that of any program with which the consultant is familiar – from rural or urban areas.

There are clearly described risks associated with adding extra time and patient transfers onto the out-of-hospital transport of either scene or interfacility runs. Equally clear are the benefits associated with expedited transport into tertiary care centers, for a wide variety of medical and surgical patients. Unfortunately, while in retrospect (and with limitations inherent to attempts to adjudicate clinical cause and effect) some patients "would have been fine" with the additional ground transport leg, the consultant believes the LFOM-MMC transport sample evidence supports a conclusion that any acuity or time-of-day based system of triage *away* from an on-site helipad, to the Jetport for bifurcated transport, is undesirable when viewed from the standpoint of the patient being transported, and indeed the EMS system as a whole.

Having an on-site MMC helipad is reasonably certain to translate into better-quality care, in terms of maximizing chances for benefit and minimizing chances of risk, to the people of Maine who undergo air medical transport. The current system of bifurcated transport has not been a disservice to the population served by MMC, but the available data very clearly support an upgrading of the hospital's capability to expedite transport into its critical care areas. In just about every clinical system, including the one by which LFOM and MMC operate to get patients into MMC, there is room for improvement. Construction and regular use of an on-site helipad at MMC appears to exemplify such an improvement for the hospital, for LFOM, and for the patients.

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Appendix I: LFOM triage guidelines

LIFEFLIGHT OF MAINE
GUIDELINES FOR HELICOPTER TRANSPORT

GENERAL GUIDELINES

Many patients who require transport to centers with specialized or tertiary level resources are appropriate for transport by ground ambulance. A select group of patients may benefit from the advantages that helicopter transport can offer. These advantages include:

Decreased response time and length of transport
Availability of highly trained medical crews and specialized equipment
Increased access to tertiary and definitive care facilities when the patient requires specific or timely treatment which is not available at the referring hospital or facility

Even though the guidelines below are useful, they are not necessarily all-inclusive and should not replace decisions about transport based on sound medical judgement. It is likely that patients appropriate for helicopter transport would have medical conditions that fulfill one or more of the general criteria listed below, and would as well include one or more of the specific criteria, which follow. Some general criteria include:

- The patient requires critical care life support (monitoring, personnel, medications, or specific equipment) during transport that is not available from the local ground ambulance service.
- The patient's clinical condition requires that the time spent out of the hospital environment (in transport mode) be as short as possible.
- The potential for delays which may be associated with ground transport is likely to worsen the patient's clinical status.
- The patient is located in an area which is inaccessible to regular ground traffic.
- The use of local ground transport team would leave the local area without adequate EMS coverage.

SPECIFIC GUIDELINES

TRAUMA – Patient at Scene: Maine EMS Prehospital Trauma Triage Protocol

TRAUMA – Patient at Hospital:

Central Nervous System

Spinal cord injury or major vertebral injury
Head injury with one or more of the following:
Lateralizing signs
Penetrating injury or open fracture (with or without CSF leak)
Depressed skull fracture
Glasgow Coma Scale < 12 or deterioration GCS
For Scene Responses

Chest

Major chest wall injury
Wide mediastinum or other signs suggesting great vessel injury

Cardiac injury
Patients who may require prolonged ventilation
Pelvis
Unstable pelvic ring disruption
Open pelvic fracture
Unstable pelvic fracture with shock or other evidence of continuing hemorrhage
Major extremity injuries
Fracture/dislocation with loss of distal pulses
Open long-bone fractures
Extremity ischemia
Multiple system injury
Head injury combined with face, chest, abdominal or pelvic injury
Burns
with associated injuries
greater than 20% total body surface area
involving the respiratory system
involving face, head, feet, hands, or genitalia
electrical burns
Multiple long-bone fractures
Injury to more than two body regions
Secondary deterioration (late sequelae of trauma)
Respiratory failure with mechanical ventilation required
Sepsis
Single or multiple organ system failure (deterioration in central nervous, cardiac, pulmonary, hepatic, renal, or coagulation systems)
Major tissue necrosis
Comorbid Factors
Age <5 or >55 years
Known cardiorespiratory or metabolic disease
Pregnancy
Immunosuppression
Evidence of high energy impact
Death of occupant in same car

ADULT MEDICAL SURGICAL

Cardiac
Patients with cardiogenic shock (or requiring IABP)
Patients with acute MI & contraindications to lytic therapy who are candidates for emergent PTCA
High risk patients with failed thrombolytic therapy (large AMI, previous MI, previous CABG, severe ongoing ischemia) who are candidates for rescue PTCA
Life threatening medically refractory arrhythmias
Patients with medically refractory, unstable or post-infarct angina
Patients with suspected acute ventricular septal defects
Patients with rapidly decompensating valvular heart disease
Selected patients with cardiac tamponade and hemodynamic compromise
Patients with symptoms or signs of aortic dissection
Patients with the following conditions: acute pulmonary edema, cardiomyopathy, infectious

endocarditis, severe pulonary hypertension, hypertensive crisis, congenital heart disease or need for specialized pacemaker therapy

Patients requiring acute intervention (i.e., IV nitroglycerin, antidysrhythmics, thrombolytics, anticoagulants, PTCA, emergent cardiac catheterization, CABG, emergency cardiac surgery, or pericardiocentesis) unavailable at referring institution.

Other Medical/Surgical or Critical Care

Status post cardiopulmonary arrest with need for definitive management capabilities

Patients requiring continuous intravenous vasoactive medications or mechanical ventricular assist to maintain a stable cardiac output

Patients who may require mechanical ventilator support or are at risk of having an unstable airway

Acute pulmonary failure requiring sophisticated pulmonary intensive care

Acute ischemic event (extremities, intestinal) which requires urgent diagnostic procedures/treatment not available at referring facility

Dissecting, leaking, or ruptured thoracic/abdominal aneurysm

Acute cerebrovascular accident in evolution requiring therapy or diagnostic procedures not available at the referring institution

Gastrointestinal hemorrhage leading to hypoperfusion or requiring blood transfusion, angiography or other procedures not available at the referring institution

Unstable patient with renal failure requiring acute hemodialysis unavailable at the referring institution

Severe poisonings or overdoses requiring intensive care

Severe hypothermia or hyperthermia requiring immediate active therapy

Uncontrollable seizure activity

Decompression illness or carbon monoxide poisoning requiring hyperbaric oxygen therapy

Significant acidosis not responsive to initial therapy

Patients requiring emergency cardiothoracic, vascular or neurosurgical diagnostic or operative procedures unavailable at the referring institution

Complications of cancer and chemotherapy; opportunistic infections with unstable vital signs

Patients who have met the criteria for brain death and whose families have consented for organ donation when urgent transport is required for organ salvage

Patients receiving organ transplantation, when time frame of donor organ viability is extremely limited (i.e., heart, lung)

Transfer of time-sensitive transplant organ from procurement hospital to site of transplant

HIGH RISK OBSTETRICS

The majority of obstetrical patients are appropriately transported by ground ambulance; there are some, however, in whom timeliness of transport is especially important. LifeFlight of Maine is dedicated to the rapid and safe transport of high risk obstetric patients. Before consideration of air transport, there should be a very high probability that delivery will not occur during transport. If delivery is imminent or likely to occur during transport, alternate care plans should be considered.

General complications

Medical care immediately available to the patient is not optimal for the patient's actual or predicted obstetrical, medical or surgical complications

There is reasonable expectation that the birth of one or more infants may require obstetric or neonatal intensive care beyond the capabilities of the referring institution

The patient's obstetrical, medical or surgical problems require continuous attendance by trained personnel not available at the referring institution

Obstetrical complications

Active premature labor with or without rupture of membranes at less than 34 weeks, or fetal weight is estimated at less than 2,000 grams
Severe pre-eclampsia or eclampsia
Abruptio placentae or placenta previa
Third trimester bleeding
Fetal hydrop

Medical Complications

Infections which may cause premature birth
Severe organic heart disease
Renal disease with deteriorating function or increasing hypertension
Drug overdose
Collagen vascular disease, metabolic disease (e.g. hyperthyroidism), or any disease considered to exceed the resources of the referring institution
Miscellaneous unusual or severe illnesses

Surgical complications

Trauma requiring intensive care or surgical correction beyond the capabilities of local institutions, or trauma requiring procedures that may cause premature labor
Acute abdominal emergencies at less than 34 weeks gestation or with a baby whose estimated weight is less than 2,000 grams
Thoracic emergencies requiring intensive care or surgical correction
Neurosurgical emergencies such as intracranial hemorrhage, expanding pituitary tumor, or brain tumor
In general the following patients who are in labor should **NOT** be considered for air transport

multiparous patients:

cervix dilated 3-4 cm or more with active labor and a substantially effaced cervix
contractions less than 5 minutes apart
history of rapidly progressing labor

primiparous patients:

cervix dilated 4-5 cm or more with active labor
contractions less than 5 minutes apart

PEDIATRICS

Patient experiencing or has a high risk of developing cardiac dysrhythmias or cardiac pump failure that requires interventions not available at the referring institution.
Patient experiencing or has a high risk of developing acute respiratory failure or respiratory arrest and is not responsive to initial therapy
Patient requires invasive airway procedures (including endotracheal or nasotracheal intubation, tracheotomy or cricothyroidotomy) and assisted ventilation.
Patient with any of the following vital signs:
respiratory rate <10 or >60 breaths per minute
systolic blood pressure <60mm Hg in a neonate
systolic blood pressure <65mm Hg in an infant <2 years of age
systolic blood pressure <70mm Hg in a child 2-5 years of age or systolic blood pressure <80mm Hg in a child 6-12 years of age
Patient with any of the following clinical conditions:
near-drowning with signs of hypoxia or altered mental status
status epilepticus
acute bacterial meningitis
acute renal failure

poisonings and overdoses with hemodynamic or neurologic instability
Reye's syndrome
Hypothermia
Multiple trauma
GCS <12 or deterioration
Intensive care to intensive care transfer when ground transport time is >30 minutes
Vasoactive drip required to maintain BP
Arterial pH <7.2
Patients within 48 hours of respiratory/cardiac arrest
Non-trauma patient requiring cardiothoracic, neuro or pediatric surgeon for emergent care unavailable at referring institution

NEONATAL

Infant requiring mechanical ventilation or CPAP
Premature infant with gestational age <30 weeks and complications
Body weight <1500 grams and complications
Supplemental oxygen >60%
Neonate with extra-pulmonary air leak, interstitial emphysema, or pneumothorax
Need for transfer to Neonatal unit when ground transport time is >30 minutes
Cardiac or respiratory arrest within 24 hours
Temperature instability
Neonate requiring vasopressor drip medications or repeated volume challenges to maintain BP
Neonates with seizure activity, congestive heart failure, or disseminated intravascular coagulation
Surgical emergencies including diaphragmatic hernias, necrotizing enterocolitis, abdominal wall defect, intussusception, suspected volvulus, congenital heart defects

GENERAL EXCLUSIONS TO HELICOPTER TRANSPORT

Terminally ill patients, unless they have an acute correctable problem of an emergent nature
Patients in full arrest at the referring institution who cannot be stabilized to a perfusing circulation
Incessant VF or VT with severe hemodynamic compromise
Advance directives precluding aggressive life prolonging measures
Anoxic encephalopathy/coma

Appendix II: National HEMS utilization guidelines

POSITION PAPER
NATIONAL ASSOCIATION OF EMS PHYSICIANS

GUIDELINES FOR AIR MEDICAL DISPATCH

David P. Thomson, MD, MS, Stephen H. Thomas, MD, MPH, for the 2002–2003 Air Medical Services Committee of the National Association of EMS Physicians

INTRODUCTION

Air medical transport has become a well-established part of the emergency medical services (EMS) system. Through the use of aircraft, patients are moved swiftly and safely throughout the world. However, for a number of reasons, the use of air medical transport remains somewhat controversial. One reason for this controversy is that debate continues to surround appropriate utilization of air medical transport. Since the topics of triage to air transport were last addressed by the National Association of EMS Physicians' (NAEMSP's) Air Medical Task Force (hereafter abbreviated as "the Task Force"), there has been significant evolution of thought concerning appropriateness of air medical dispatch. Therefore, the goal of this position paper is to outline current recommendations guiding utilization of air medical transport.

This position statement builds on earlier work by the Task Force and replaces two previous position statements.[1,2] The first NAEMSP position statement on the subject was published in *Prehospital and Disaster Medicine* in January-March 1992 as a contribution of the 1992 Task Force.[1] The 1994 Task Force published a follow-up paper addressing non-trauma and pediatric considerations.[2] The current Task Force members gratefully acknowledge the work of the previous documents' authors: Drs. Nicholas Benson, Catherine Carruba, Dan Hankins, Richard Hunt, and David Wilcox. The current authors have also drawn upon the work of other organizations, including the Association of Air Medical Services (AAMS)[3] and the American Academy of Pediatrics (AAP),[4] which have produced similar documents.

This position statement has also been endorsed by the Air Medical Physician Association (AMPA), by approval of its Board of Directors.

DISCUSSION

Air medical transport has grown to the point where we commonly speak of people being "life-flighted." As of this writing, the AAMS, which represents the vast majority of U.S. air medical providers, reports 271 air medical program members, 193 of which have a helicopter EMS component.[5] The growth of air medical transport is, at least in part, due to a perception that provision of such a service results in benefits to the patients and/or regions where air transport exists. In some cases, the benefit results from the increased level of care provided by the air medical crew; these individuals are generally trained to a higher level of care than available ground EMS providers. In other cases, the putative explanation for improved outcome is the increment in speed afforded by the air transport vehicle. However, there is continued debate surrounding use of air transport.

One source of debate is cost. Economic analyses have suggested that helicopters are cost-effective,[6] and that utilization of helicopters is no more expensive than deployment of similarly configured ground ambulances with comparable staffing levels and response times.[7] However, acceptance of these premises is far from universal, and acquisition and maintenance of aircraft undoubtedly represent a significant expense in an era of limited health care dollars. Within this economic envelope, payers for health care including commercial insurance, managed care organizations, and public payers, including Medicare and Medicaid in the United States and government sup-

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Table 1. Questions That Can Assist in Determining Appropriate Transport Mode

- Does the patient's clinical condition require minimization of time spent out of the hospital environment during the transport?
- Does the patient require specific or time-sensitive evaluation or treatment that is not available at the referring facility?
- Is the patient located in an area that is inaccessible to ground transport?
- What are the current and predicted weather situations along the transport route?
- Is the weight of the patient (plus the weight of required equipment and transport personnel) within allowable ranges for air transport?
- For interhospital transports, is there a helipad and/or airport near the referring hospital?
- Does the patient require critical care life support (e.g., monitoring personnel, specific medications, specific equipment) during transport, which is not available with ground transport options?
- Would use of local ground transport leave the local area without adequate emergency medical services coverage?
- If local ground transport is not an option, can the needs of the patient (and the system) be met by an available regional ground critical care transport service (i.e., specialized surface transport systems operated by hospitals and/or air medical programs)?

ported programs in the world, recognize the medical utility of air transport for selected patients.

Safety is also a consideration in the debate about utilization of air medical transport. Air ambulance crashes, although infrequent, are well publicized, and air transport programs must allocate both time and dollars in a continuing effort to maximize safety.

Another source of debate is the relatively limited literature directly addressing outcomes benefit associated with air transport. At the time the original NAEMSP and AAMS documents were produced, there was very little research available on which the committees could base their recommendations. Although this situation has improved somewhat during the last decade, research regarding the appropriate deployment of complex medical care systems remains in its infancy. This document represents what we believe to be the current state of the art, based upon a sometimes subjective interpretation of the best available evidence.

Some caveats must be considered prior to outlining the Task Force's guidelines. These caveats, at least as important as are the actual guidelines, address some limitations inherent to the process of creating this position statement.

First, and foremost, the specific criteria and diagnoses listed in the guidelines are *not* intended to be a comprehensive listing, but rather an indication of the types of entities for which air medical response may be appropriate. As a related note, the guidelines are intended to assist prehospital provider decision making, rather than override judgment of those at the patient's side. In fact, many EMS systems have their own criteria for air medical dispatch. Such criteria (e.g., specific mechanism-of-injury triage tools) inevitably differ between regions based on demographic, geographic, and health care resource considerations. Furthermore, air medical dispatch rules continue to evolve with increasing regionalization of nontrauma care (e.g., for patients with acute coronary or neurological syndromes). The growing number of specialized ground critical care vehicles has also impacted indications for air medical dispatch, as some patient populations traditionally transported by air are good candidates for high-level-of-care ground transport. It is also reasonable to assume that the nationwide issue of emergency eepartment ground ambulance "diversion" could affect helicopter utilization patterns. In short, no group of practitioners or researchers can foresee every circumstance; good medical care requires that scientific principles be individualized for each patient and situation. As an aid to guiding individual patient triage decision making, the questions as outlined in Table 1 may be helpful.

Just as appropriateness of air medical dispatch can be judged only in light of a given patient's situation, regional and logistic considerations are also necessary. For example, a patient with an amputation of a dominant thumb may require helicopter or fixed-wing evacuation from an offshore island or remote wilderness area; conversely, a patient with severe vehicular trauma occurring within or near city limits may be best served by ground transport.[6]

Due to the fact that most literature addresses helicopter (rotor-wing) rather than airplane (fixed-wing) aircraft, this position statement concentrates on the former transport mode. However, general guidelines for fixed-wing transport are also provided. Additionally, as specialized (i.e., "critical care") ground transport continues to evolve, this modality will likely be used for some patients historically undergoing air transport.

It should be noted that, as applied to helicopter transport, these guidelines are for *response*, not necessarily *transport*. (In cases where fixed-wing transport is activated patients, will nearly always be transported unless there is a change in clinical status.) Even in the most conservative EMS system, there will be an occasional case where air transport is activated appropriately, but upon availability of further information it becomes clear that completion of the transport by air is not indicated. Examples of such cases include situations where patients at a trauma scene are re-evaluated and found to be either obviously uninjured or to have unsurvivable injuries (in these cases the air transport crew may best serve the patient by assisting ground EMS during surface transport to the nearest facility or by following local protocols for patient death).

Ground EMS services, air medical services, hospitals, and third-party payers should understand that in order to make the air transport resource available to those who need it, a certain level of overtriage is unavoidable. Also, decision making about patient transport should take into account the capabilities of local and regional EMS and hospitals. Given the inherent uncertainty surrounding prehospital diagnosis and triage, an EMS system with zero air transport overtriage is almost certainly underutilizing its helicopter resource. On the other hand, while this position statement is intended to address air medical dispatch (as considered prospectively), it must be emphasized that an ongoing process of utilization review is critical to optimizing utilization of the air transport resource. Such utilization review can be focused upon both triage characteristics (e.g., mechanism of injury) and retrospective review of patient course at the receiving hospital (e.g., early discharge without diagnostic or therapeutic intervention).

Just as it is important to appropriately incorporate air transport into the scene *and* interfacility transport needs of a region, utilization review should be aimed at both mission types. As for interfacility transports, the historical prerogative of referring hospital treating physicians to determine transport mode is subject to increasing scrutiny. Because of understandable concerns about Consolidated Omnibus Reconciliation Act/ Emergency Medical Treatment and Labor Act (COBRA/EMTALA)-related liability for intratransport deterioration, referring physicians may occasionally overtriage patients to helicopter transport. It is hoped that these guidelines may help frame the transport decision-making process in such fashion as to optimize transport mode appropriateness, maximize resource utilization, and serve as a foundation to support case-by-case triage decisions made by referring physicians.

The increasing complexity of transport decision making has emphasized the importance of air transport services' medical directors being available for real-time consultation as to transport mode. Research has shown that regions may benefit from detailed assessment of their specific geographic/ logistical situations, with generation of maps serving as guides to assist in air vs. ground triage.[8]

Prior to creating this position paper, the literature concerning the transport of trauma and nontrauma patients was reviewed and summarized by a subcommittee of the NAEMSP Air Medical Services Task Force. The reader is referred to these annotated bibliographies, published previously in *Prehospital Emergency Care*,[9,10] for an overview of studies addressing air transport and patient outcomes. The literature reviews are not comprehensive, and the literature has continued to grow even in the short interval between researching of the bibliographies and publication of the reviews. For example, recent studies have reinforced arguments in favor of helicopter transport of blunt trauma patients[11,12] and strongly suggested outcomes benefit for interfacility air transport for a subset of patients with acute myocardial infarction.[13] Additionally, the Task Force recognizes that air transport modalities should play a cooperative role in systemwide responses to disasters and mass casualty incidents; the potential contributions of air transport services in these situations are not discussed in this paper since they have been outlined in *Prehospital Emergency Care.*[14]

In summary, the guidelines that follow are offered as a noncomprehensive overview of clinical and logistical situations in which air medical dispatch may be appropriate. The Task Force offers these guidelines as an aid to EMS systems' operational planning, with the earlier mentioned caveats—most importantly, that no set of guidelines should be interpreted as dogma and that the judgment of those at the patient's side should always count foremost in decision making.

GUIDELINES

1. General
   a. Patients requiring critical interventions should be provided those interventions in the most expeditious manner possible.
   b. Patients who are stable should be transported in a manner that best addresses the needs of the patient and the system.
   c. Patients with critical injuries or illnesses resulting in unstable vital signs require transport by the fastest available modality, and with a transport team that has the appropriate level of care capabilities, to a center capable of providing definitive care.
   d. Patients with critical injuries or illnesses should be transported by a team that can provide intratransport critical care services.
   e. Patients who require high-level care during transport, but do not have time-critical illness or injury, may be candidates for ground critical care transport (i.e., by a specialized ground critical care transport vehicle with level of care exceeding that of local EMS) if such service is available and logistically feasible.
2. Comparative considerations for air transport modes
   a. Rotor-wing
      i. Advantages
         (a) In general, decreased response time to the patient (up to approximately 100 miles distance depending on logistics such as duration of ground transfer leg)
         (b) Decreased out-of-hospital transport time
         (c) Availability of highly trained medical crews and specialized equipment

- ii. Disadvantages
  - (a) Weather considerations (e.g., icing conditions, weather minimums)
  - (b) Limited availability as compared with ground EMS
- b. Fixed-wing
  - i. Advantages
    - (a) In comparison with rotor-wing, decreased response time to patients when transport distances exceed approximately 100 miles
    - (b) In comparison with ground transport, decreased out-of-hospital transport time
    - (c) Availability of highly trained medical crews and specialized equipment
    - (d) In comparison with rotor-wing, less susceptibility to weather constraints
  - ii. Disadvantages
    - (a) Requires landing at airport, with two extra transport legs between airports and the patient origin and destination
    - (b) In comparison with ground transport, more subject to weather-related unavailability (e.g., icing, snow)
    - (c) Overall, less desirable as a transport mode for severely ill or injured patients (though extenuating circumstances may modify this relative contraindication to fixed-wing use)

3. Logistical issues that may prompt the need for air medical transport
   - a. Access and time/distance factors
     - i. Patients who are in topographically hard-to-reach areas may be best served by air transport.
       - (a) In some cases patients may be in terrain (e.g., mountainside) not easily accessible to surface transport.
       - (b) Other cases may involve the need for transfer of patients from island environs, for whom surface water transport is not appropriate.
     - ii. Patients in some areas (e.g., in the western United States) may be accessible to ground vehicles, but transport distances are sufficiently long that air transport (by rotor-wing or fixed-wing) is preferable.
   - b. Systems considerations
     - i. In some EMS regions, the air medical crew is the only rapidly available asset that can bring a high level of training to critically ill/injured patients. In these systems, there may be a lower threshold for air medical dispatch.
     - ii. Systems in which there is widespread advanced life support (ALS) coverage, but such coverage is sparse, may see an area left "uncovered" for extended periods if its sole ALS unit is occupied providing an extended transport. Air medical dispatch may be the best means to provide patient care and simultaneously avoid deprivation of a geographic region of timely ALS emergency response.
     - iii. Disaster and mass casualty incidents offer important opportunities for air medical participation. These roles, too complex for detailed discussion here, are outlined elsewhere.[11]

4. Clinical situations for **scene** triage to air transport (also known as "primary" air transport) are outlined below. In some cases (e.g., flail chest), the diagnosis can be clearly established in the prehospital setting; in other cases (e.g., cardiac injury suggested by mechanism of injury and/or cardiac monitoring findings), prehospital care providers must use judgment and act on suspicion. Absent unusual logistical considerations as an overriding factor, scene air response involves rotor-wing vehicles rather than airplanes. As a general rule, air transport scene response should be considered more likely to be indicated when use of this modality, as compared with ground transport, results in more rapid arrival of the patient to an appropriate receiving center or when helicopter crews provide rapid access to advanced level of care (e.g., when a ground basic life support team encounters a multiple trauma patient requiring airway intervention).
   - a. **Trauma**: Scene response to injured patients probably represents the mode of helicopter utilization with the best supporting evidence.
     - i. General and mechanism considerations
       - (a) Trauma Score <12
       - (b) Unstable vital signs (e.g., hypotension or tachypnea)
       - (c) Significant trauma in patients <12 years old, >55 years old, or pregnant patients
       - (d) Multisystem injuries (e.g., long-bone fractures in different extremities; injury to more than two body regions)
       - (e) Ejection from vehicle
       - (f) Pedestrian or cyclist struck by motor vehicle
       - (g) Death in same passenger compartment as patient
       - (h) Ground provider perception of significant damage to patient's passenger compartment
       - (i) Penetrating trauma to the abdomen, pelvis, chest, neck, or head
       - (j) Crush injury to the abdomen, chest, or head
       - (k) Fall from significant height
     - ii. Neurologic considerations
       - (a) Glasgow Coma Scale score <10
       - (b) Deteriorating mental status
       - (c) Skull fracture
       - (d) Neurologic presentation suggestive of spinal cord injury
     - iii. Thoracic considerations
       - (a) Major chest wall injury (e.g., flail chest)
       - (b) Pneumothorax/hemothorax
       - (c) Suspected cardiac injury
     - iv. Abdominal/pelvic considerations
       - (a) Significant abdominal pain after blunt trauma
       - (b) Presence of a "seatbelt" sign or other abdominal wall contusion

        (c) Obvious rib fracture below the nipple line
        (d) Major pelvic fracture (e.g., unstable pelvic ring disruption, open pelvic fracture, or pelvic fracture with hypotension)
    v. Orthopedic/extremity considerations
        (a) Partial or total amputation of a limb (exclusive of digits)
        (b) Finger/thumb amputation when emergent surgical evaluation (i.e., for replantation consideration) is indicated and rapid surface transport is not available
        (c) Fracture or dislocation with vascular compromise
        (d) Extremity ischemia
        (e) Open long-bone fractures
        (f) Two or more long-bone fractures
    vi. Major burns
        (a) >20% body surface area
        (b) Involvement of face, head, hands, feet, or genitalia
        (c) Inhalational injury
        (d) Electrical or chemical burns
        (e) Burns with associated injuries
    vii. Patients with near drowning injuries
  b. **Nontrauma:** At this time the literature support for primary air transport of noninjured patients is limited to logistical considerations. It is conceivable that clinical indications for scene air response may be identified in the future. However, at this time prehospital providers should incorporate logistical considerations, clinical judgment, and medical oversight in determining whether primary air transport is appropriate for patients with nontrauma diagnoses.

5. Clinical situations for air transport in **interfacility** transfers are best summarized as being present when: 1) patients have diagnostic and/or therapeutic needs which cannot be met at the referring hospital, and 2) factors such as time, distance, and/or intratransport level of care requirements render ground transport nonfeasible.
  a. **Trauma:** Injured patients constitute the diagnostic group for which there is best evidence to support outcome improvements from air transport.
    i. Depending on local hospital capabilities and regional practices, any diagnostic consideration (suspected, or confirmed as with referring hospital radiography) listed above under "scene" guidelines may be sufficient indication for air transport from a community hospital to a regional trauma center.
    ii. Additionally, air transport (short- or long-distance) may be appropriate when initial evaluation at the community hospital reveals injuries (e.g., intra-abdominal hemorrhage on abdominal computed tomography) or potential injuries (e.g., aortic trauma suggested by widened mediastinum on chest x-ray; spinal column injury with potential for spinal cord involvement) requiring further evaluation and management beyond the capabilities of the referring hospital.
  b. **Cardiac:** Due to regionalization of cardiac care and the time-criticality of the disease process, patients with cardiac diagnoses often undergo interfacility air transport. Patients with the following cardiac conditions may be candidates for air transport:
    i. Acute coronary syndromes with time-critical need for urgent interventional therapy (e.g., cardiac catheterization, intra-aortic balloon pump placement, emergent cardiac surgery) unavailable at the referring center
    ii. Cardiogenic shock (especially in presence of, or need for, ventricular assist devices or intra-aortic balloon pumps)
    iii. Cardiac tamponade with impending hemodynamic compromise
    iv. Mechanical cardiac disease (e.g., acute cardiac rupture, decompensating valvular heart disease)
  c. **Critically ill medical or surgical patients:** These patients generally require a high level of care during transport, may benefit from minimization of out-of-hospital transport time, and may also have time-critical need for diagnostic or therapeutic intervention at the receiving facility. Ground critical care transport is frequently a viable transfer option for these patients, but air transport may be considered in circumstances such as the following examples:
    i. Pretransport cardiac/respiratory arrest
    ii. Requirement for continuous intravenous vasoactive medications or mechanical ventricular assist to maintain stable cardiac output
    iii. Risk for airway deterioration (e.g., angioedema, epiglottitis)
    iv. Acute pulmonary failure and/or requirement for sophisticated pulmonary intensive care (e.g., inverse-ratio ventilation) during transport
    v. Severe poisoning or overdose requiring specialized toxicology services
    vi. Urgent need for hyperbaric oxygen therapy (e.g., vascular gas embolism, necrotizing infectious process, carbon monoxide toxicity)
    vii. Requirement for emergent dialysis
    viii. Gastrointestinal hemorrhages with hemodynamic compromise
    ix. Surgical emergencies such as fasciitis, aortic dissection or aneurysm, or extremity ischemia
    x. Pediatric patients for whom referring facilities cannot provide required evaluation and/or therapy
  d. **Obstetric:** In gravid patients, air transport's advantage of minimized out-of-hospital time must be balanced against the risks inherent to intratransport delivery. If transport is necessary in a patient in whom delivery is thought to be imminent, then a ground vehicle is usually appropriate, although in some cases

the combination of clinical status and logistics (*e.g.* long driving times) may favor use of an air ambulance. Air transport may be considered if ground transport is logistically not feasible and/or there are circumstances, such as the following:

  i. Reasonable expectation that delivery of infant(s) may require obstetric or neonatal care beyond the capabilities of the referring hospital
  ii. Active premature labor when estimated gestational age is <34 weeks or estimated fetal weight <2,000 grams
  iii. Severe pre-eclampsia or eclampsia
  iv. Third-trimester hemorrhage
  v. Fetal hydrops
  vi. Maternal medical conditions (e.g., heart disease, drug overdose, metabolic disturbances) exist that may cause premature birth
  vii. Severe predicted fetal heart disease
  viii. Acute abdominal emergencies (i.e., likely to require surgery) when estimated gestational age is <34 weeks or estimated fetal weight <2,000 grams

e. **Neurological:** In addition to those with need for specialized neurosurgical services, this category is being expanded to include patients requiring transfer to specialized stroke centers. Examples of neurological conditions where air transport may be appropriate include:
  i. Central nervous system hemorrhage
  ii. Spinal cord compression by mass lesion
  iii. Evolving ischemic stroke (i.e., potential candidate for lytic therapy)
  iv. Status epilepticus

f. **Neonatal:** Regionalization of neonatal intensive care has prompted the development of specialized (air and/or ground) services focusing on transport for this population. Given the fact that, in neonates, rapid transport is often less of a priority than (time-consuming) stabilization at referring institutions, some systems have found that the best means for incorporating air vehicles into neonatal transport is to use them to rapidly get a stabilization/transport team to the patient; the actual patient transport is then performed by a ground vehicle. In some systems, patients are transported (usually with a specialized neonatal team) by air when the ground transport out-of-hospital time exceeds 30 minutes. Examples of instances where air medical dispatch may be appropriate for neonates include:
  i. Gestational age <30 weeks, body weight <2,000 grams, or complicated neonatal course (e.g., perinatal cardiac/respiratory arrest, hemo-dyamic instability, sepsis, meningitis, metabolic derange-ment, temperature instability)
  ii. Requirement for supplemental oxygen exceeding 60%, continuous positive airway pressure (CPAP), or mechanical ventilation
  iii. Extrapulmonary air leak, interstitial emphysema, or pneumothorax
  iv. Medical emergencies such as seizure activity, congestive heart failure, or disseminated intravascular coagulation
  v. Surgical emergencies such as diaphragmatic hernia, necrotizing enterocolitis, abdominal wall defects, intussusception, suspected volvulus, or congenital heart defects

g. **Other:** Air medical dispatch may also be appropriate in miscellaneous situations such as the following:
  i. Transplant
    (a) Patient has met criteria for brain death and air transport is necessary for organ salvage
    (b) Organ and/or organ recipient requires air transport to the transplant center in order to maintain viability of time-critical transplant
  ii. Search-and-rescue operations are generally outside the purview of air medical transport services, but in some instances helicopter EMS may participate in such operations. Since most search-and-rescue services have limited medical care capabilities, and since most air medical programs have similarly limited search-and-rescue training, cooperative effort is necessary for optimizing patient location, extrication, stabilization, and transport.
  iii. Patients known to be in cardiac arrest are rarely candidates for air medical transport.
    (a) A previous NAEMSP position paper[15] has addressed situations in which resuscitation efforts should be ceased in the field for adult nontraumatic cardiac arrest victims. In such cases air transport should not be considered an alternative to discontinuing (futile) efforts at resuscitation.
    (b) In situations where patients are in cardiac arrest and do not meet local criteria for cessation of resuscitative efforts, or in jurisdictions in which prehospital providers cannot cease such efforts, air transport is an option only in very rare cases (e.g., pediatric cold-water drowning where helicopter transport to a cardiac-bypass center is considered).

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Appendix III: Normal chain of events during various transport situations

One of the jobs assigned to the consultant was to prepare descriptions reflecting the logistics of "typical" transports. Indeed, an overview of the transport continuum, starting with the onset of illness or injury and carrying through to MMC arrival, may be useful. Other sections of the consultant's report deal in detail with the occurrences after LFOM is called; this Appendix is intended to give information relevant to the "pre-LFOM" course and chain of events.

Transports are categorized as either primary ("scene runs," usually for trauma but sometimes for other conditions) or secondary ("interfacility runs" – from referring hospital to receiving center). This section will outline a typical chain of events occurring for each transport type. Additionally, example cases from the LFOM-MMC review cohort will be used to give an idea of the timing and other parameters associated with some illustrative situations.

Overview of transport logistics for scene runs

A scene run entails helicopter response directly to the patient. In Maine, the aircraft is called, by any of a variety of personnel including, but not limited to: police, emergency medical technicians, fire/rescue workers, or in some cases others (*e.g.* forestry personnel) who are physically present at the accident or illness scene and who are enabled to make a determination of necessity for HEMS use. This determination is made based upon the triage criteria of the Maine EMS system. The Maine EMS protocols are in line with those used in other regions of the country.

For scene runs, until helicopter arrival the patient is provided whatever aid is available (for instance, basic life support from a fire/rescue service, or advanced life support from a paramedic). Depending on the scene's layout and topography, the helicopter may either land in close proximity to the patient, or – as a less desirable but safety-compelled option – at a more distant site necessitating ground ambulance transport to get the crew to the patient.

Upon arriving at the patient, HEMS crews on a scene run usually assume responsibility for the medical decision-making. Patients are stabilized for HEMS transport, and are then transferred to the helicopter. If not done previously, radio contact is established with the receiving hospital to make them aware of the impending arrival of the scene patient, to enable execution of appropriate preparations (*e.g.* assembly of a trauma team). Upon landing at the Jetport, the helicopter crew offloads the patient for a ground transport to MMC. From the Jetport, patient transfer logistics to MMC are as outlined elsewhere in this report.

Overview of transport logistics for interfacility runs

An interfacility transport occurs after a physician caring for the patient at a referring hospital makes a determination that the patient's clinical needs (for either diagnosis or therapy) outstrip those available at the local facility. Additionally, for HEMS transport the referring physician makes a determination that the air, as opposed to ground, transport mode is most fitting in the given situation (*e.g.* for acuity and time-criticality reasons). Just as is the case for scene transports, there are guidelines to assist the attending physician in making the determination as to optimal transport mode.

Concurrent to the request for HEMS, the referring physician discusses the case with receiving physicians at the tertiary center. The helicopter lands at the referring hospital's helipad – given the small size of most referring hospitals, only in uncommon cases is there bifurcated transport of any significant distance – and the crew enters the referring hospital to begin the transport process.

Unlike the case as occurs with scene response, the HEMS crew arriving at the patient for interfacility transport doesn't usually assume primary responsibility for medical decision-making; a physician is usually present and the HEMS crew discusses the patient's case with the referring medical staff.

Subsequent to an appropriate exchange of clinical information, the patient is loaded onto the aircraft – in some cases after a ground vehicle ride of a minute or two – and transported to the receiving center. As was noted for scene runs, radio report is given to the receiving facility while the aircraft is *en route*, and the final ground transport leg from the Jetport to MMC occurs as outlined elsewhere in this report.

Review of cases illustrating "pre-LFOM" scene & interfacility logistics

Recounting of some actual patients in the set of 100 LFOM-MMC transports can help illustrate the events and times associated with HEMS mission types. Applicable times for the onset of illness or injury, or time parameters for the "pre-LFOM" course, were often unavailable, but some representative cases serve to paint a picture of logistics in scene and interfacility transports of varying nature.

A sample case of a fairly "standard" scene run is given by the following vignette. A child was involved in vehicular trauma, and is seen by prehospital providers who called for HEMS at 0947. LFOM was dispatched at 0948, lifted off at 0957 (a longer delay than usual), and arrived at the patient's side at 1014. A few minutes were required to stabilize the patient, and LFOM departed the scene at 1020, with a Jetport arrival time of 1030.

Sometimes LFOM is called and requested to be on "standby" in cases where those at the scene suspect, but are not certain, that HEMS will be necessary. This occurred in the instance of a patient with penetrating trauma. The patient was initially evaluated by local ground EMS at 1315; those calling the ground ambulance had also notified LFOM to be on "standby" in a 1301 contact. Upon arriving at the patient, ground EMS requested LFOM dispatch and the helicopter arrived at the patient at 1339. After an expedited patient evaluation the patient was taken to Portland, with a 1416 landing at the Jetport.

Occasionally, LFOM is called initially for scene response, with subsequent change to request for an interfacility mission. In the instance of one trauma patient, LFOM was called at 1243. Before LFOM arrived at the scene (and presumably due to high patient acuity), it was decided by ground EMS to take the patient to the local hospital. At 1258, LFOM was asked to re-task the transport as an interfacility mission. The helicopter arrived at the referring hospital at 1327, and the crew was at the patient's bedside at 1334. The aircraft left the referring hospital at 1407, landing at the Jetport at 1438. After a 5-minute transfer into the ground ambulance for the Jetport-to-MMC leg, the patient arrived at the MMC intensive care unit at 1450.

Following is a typical example of an interfacility LFOM transport of an injured patient for whom pre-hospital times are documented. A trauma patient was at the scene, to which location a local advanced life support ground unit was dispatched at 1548. The responding ground EMS unit arrived at the patient at 1600, and spent 7 minutes stabilizing him for transport, leaving the trauma scene for the local hospital at 1607. The patient arrived at the local hospital at 1618, and LFOM was called at 1709. The helicopter landed at the local hospital at 1735, with the crew arriving at the patient's bedside ten minutes later (1745). Stabilization of the patient for transport, and transfer to the helicopter, required a half-hour; LFOM left the referring hospital at 1815 and landed at the Portland Jetport at 1831.

Following is an example of time course in an interfacility cardiac transport. This patient had chest pain upon awakening at home at 0530. An ambulance was called, and arrived at the patient's home at 0540. The patient was in the local hospital at 0558; his initial physician evaluation there was timed 0605. In this case, the patient's cardiac syndrome proved refractory to standard therapy, and LFOM was called (and the crew was dispatched) at 0640. The helicopter landed at the referring facility at 0733, and the crew was at the patient at 0738. After patient stabilization for transport, LFOM departed the local hospital at 0806. The aircraft landed at the Jetport at 0832, and the patient underwent ground transport to the MMC. He arrived at MMC at 0843 and was taken directly to the cardiac cath lab.

A final example illustrates what happens when a patient presents to a hospital at which HEMS is based. This case, of an interfacility transport of a patient who presented by private vehicle, involved a patient with breathing problems. After transport by private vehicle to an outlying ED, to which facility the patient arrived at 0547, LFOM was called at 0659. The LFOM crew was dispatched ("paged out") at 0700 and arrived at the patient at 0716. Stabilization for transport occupied the time span to 0752, at which time the patient left the referring facility, arriving at Portland's Jetport at 0804.

It is hoped that this appendix illustrates some of logistics and times associated with the "pre-LFOM" time frame. The vignettes demonstrate that different types of patients can have markedly different logistics needs, and that there are many steps in the time course from onset of illness (or injury) through arrival at MMC.

"DRAFT, DRAFT, DRAFT" 12/10/04

Introduction and background

Air medical transport, as provided by helicopter Emergency Medical Services (HEMS), has been used in the civilian medical setting since the 1970s. Currently, reliable sources estimate that there are 400-450 helicopters providing up to 250,000 transports annually in the U.S.[1] While this report does not intend to focus on the evidence supporting use of helicopter transport in this country, some background information on HEMS and its salutary effects should provide a useful framework for the discussion as to the proposed Maine Medical Center (MMC) on-site helipad.

The growth of HEMS has been accompanied by increasing scrutiny as to potential benefits accrued by this resource-intensive intervention. General reviews of the HEMS literature[2-4] have concluded that the weight of evidence supports contentions of outcomes benefits from use of air medical transport. Perhaps more relevant to the situation in Maine and the City of Portland, studies have identified significant mortality reduction associated with HEMS use in urban (Boston) New England[5] and in non-New England states (Georgia, Oregon) with more-rural demography that approximates the Maine situation.[6,7] Notably, the papers dealing with HEMS and outcomes benefits do not deal solely with trauma. For instance, in one study with geographical parallel to southern Maine, HEMS dispatch to non-trauma "scenes" was used in the Florida/Georgia border region, to improve stroke care by extending the ability of the tertiary center to evaluate patients within the critical time frame of the treatment window.[8]

HEMS benefits to patients

When considering whether, and for which patients, HEMS should utilize an on-site hospital helipad, a brief overview of HEMS benefits is helpful. It is important to consider not only benefits to individual patients, but also benefits accrued to the regions served by HEMS.

Mortality seems like the most obvious potential benefit upon which to focus, and in fact survival improvement has been the main endpoint of most of the major HEMS studies. This is likely because mortality is relatively easy to address in the types of large, retrospective study designs that comprise most of the HEMS outcomes literature. Due to the relative infrequency with which HEMS can *definitively* be shown to save lives, studies lacking large numbers tend toward having insufficient statistical power to demonstrate significant HEMS outcome effect.

Morbidity improvement as an endpoint has the attraction of being easier to test, since fewer patients must be enrolled. By definition, however, nonmortality HEMS-associated benefits which have been demonstrated – whether improved pain care,[9] better pediatric[10] and adult[11] airway management, or more streamlined access to time-critical cardiac[11] or neurologic[8,13] care – are somewheat less compelling than "saved lives." On the other hand, nonmortality endpoints such as "better airway management" can provide clues to mechanisms by which HEMS use results in outcomes improvement.

HEMS and regional advanced life support coverage

Some of the above-mentioned HEMS mortality/morbidity advantages have clear relevance to the question of on-site helipad landing at MMC. There are additional advantages associated with HEMS use, that have particular applicability in areas with population densely such as that of Maine. For example, HEMS may be the best means for getting advanced-level prehospital care (ALS) to patients in remote regions; this seems to have little relevance to MMC's helipad, but in fact there *are* indirectly applicable issues. Patients could incur ALS access delay and outcome detriment, if Life Flight of Maine (LFOM) is called for initial ALS response and helicopter liftoff is delayed due to getting flight crews back to the Portland Jetport from MMC.

Based upon a review of 100 consecutive LFOM-MMC air transports 12/2003-7/2004, HEMS delays due to helicopter nonavailability appear to be uncommon in Maine. Nevertheless, when delays have occurred they can be potentially critical. For example, patient #10 in the review of LFOM transports (see Appendix I) had had a cardiac arrest and was to be transported from a community hospital to the MMC cardiac catheterization lab for emergency coronary care. There was a 37-minute lag between LFOM call and helicopter dispatch, which was due to LFOM aircraft being occupied with other transports. HEMS nonavailability in such instances can hardly be criticized. Less defensible would be a HEMS response delay due to time lost from having flight crews' needing to make ground transit legs between the Portland Jetport and MMC. While this scenario would not be expected to occur commonly, the example is telling because it illustrates that not all "risks" associated with bifurcated transport (*i.e.* landing at Jetport, with ground leg to MMC) are predictable or even related to the actual patient undergoing bifurcated transport.

HEMS and transport speed

When advantages of helicopter transport are considered, one of the first aspects to arise is the concept of speed. Helicopters are of course much faster than ground vehicles, and it is true that helicopter transport tends to get patients to receiving hospitals more quickly than ground ambulances. However, air transport may offer important benefits, specifically related to time and transport speed, even *without* getting patients to tertiary care any faster than alternate transport modes. The nature of this important HEMS advantage lies in minimizing out-of-hospital time. In some patients – especially those who are in tenuous condition or who may require difficult interventions in the event of deterioration – the minimization of time spent in the relatively uncontrolled out-of-hospital transport environment is an admirable goal. It is well known, and consistent with common sense, that a myriad of interventions from airway management[14,15] to advanced life support tasks[16] to even CPR,[17,18] are simply more difficult to perform in the out-of-hospital (air or ground) transport vehicle than they are in the well-controlled hospital setting.

An easily understood scenario in which out-of-hospital time would be best minimized, is the case of a pregnant patient undergoing interfacility transport. Given the types of pregnancies which tend to result in need for interhospital transport, a rapid helicopter transport is obviously preferable to use of a ground vehicle, even if there is no time advantage in getting the patient to the receiving center (which could be the case if the ground vehicle is immediately available and there is a delay in getting the helicopter to the referring hospital). There were many cases in the LFOM/MMC review, in which the minimization of out-of-hospital time was important. Patient #36, a young girl with severe asthma who was receiving advanced ventilatory support (bilevel positive airway pressure) at the referring hospital, had to be taken off the advanced ventilation mode during transport due to inability to provide the intervention in the out-of-hospital setting; in such a case the absolute minimization of out-of-hospital time was of obvious import.

In another case where minimization of out-of-hospital time would be desirable, patient #73 had severe high potassium and associated cardiac conduction delays. The pacemaker which was in place during the transport was an external transcutaneous device – a type which often fails to capture and control heart beats in patients such as #73. Failure of the external device to capture requires placement of an internal (transvenous) pacemaker – a relatively easy job in the hospital setting but not possible in the field.

Characterizing the ground transport leg from Jetport to MMC

Incurring a ground transport leg from the Portland Jetport takes time. For the 100 transports reviewed, reliable data on the time interval required for the ground leg were available for 36 cases. The mean (average) time was 16.9 minutes (standard deviation, 4.9). The statistical 95% confidence interval for the mean was 15.2 to 18.5 minutes. The median and interquartile range for the ground leg transport time was 16 (12.5-20.0 minutes); 99% of the ground legs were achieved within the range of 10-30 minutes. Though there was a lot of missing data, careful review of the applicable information renders highly unlikely any association between presence of timing data and significantly shorter (or longer) length of ground leg time; there seems to be no "selection bias" in terms of which runs had the times recorded. In other words, the consultant believes that the time estimate of 15-16 minutes accurately reflects the time required to offload patients at the Jetport and get them to MMC.

Patient transfers during HEMS transport

In addition to the time issues associated with bifurcated transport, another component that must be considered is the physical addition of another transport leg. Such an addition, based upon the consultant's "dry run" from the Jetport to MMC, involves a number of steps and two extra patient movements. Indeed, the latter can be as important as any time costs associated with the ground transport leg. For example, patient #8 had a high-cervical spine fracture (as well as a traumatic brain hemorrhage); time is critical to patients like this one (and in patients #75 and #93, who had similarly unstable spine injury), but so is the absolute need for minimization of moving the patient – the "conversion" of spine injuries from incomplete (or even asymptomatic) to devastating is a real risk. This was a consideration in patient #39, who had a spine fracture with bone fragments in the spinal canal. The LFOM crew documented their special precautions to prevent further displacement and neurological injury during patient transfers; the success of those precautions does not mean the need for them should be minimized.

Other instances where the actual movement of patients poses high risk are easy to find in the LFOM/MMC transport series. Patient #22, a young girl with an impaled object in her flank, was "stable" during her LFOM transport, but the extra two transfers associated with the Jetport-MMC ground transport leg clearly incurred nontrivial risk (*i.e.* for dislodgment or further impalement) which would best be avoided. Patient #67, with an emergency surgical airway in place, is another example of a case where out-of-hospital time (in case of loss of airway) and patient transfers is best minimized.

The inadvertant traction on an impaled foreign body is an obvious risk of patient transfers. There are other, less obviously explainable but no less familiar (to both prehospital and in-hospital providers), instances where patient deterioration is associated with the simple act of transferring the patient. For example, patient #29 suffered a dangerous drop in blood oxygenation (pulse oximetry down to 80%) concomitant with movement from the referring hospital stretcher to the LFOM stretcher. No deterioration occurred during the subsequent movements of transferring this patient (who had an intracranial bleed), but seasoned clinicians would not likely discount as coincidence, the temporal association of transfer and deterioration.

Clinical deteriorations occurring in the 100-transport sample of Jetport-MMC ground legs

Much of the previous discussion has focused on risks, rather than actual untoward clinical events, associated with the Jetport-MMC ground transport leg. To some degree, a considered judgment about the appropriateness of bifurcated transport should focus on those risks, as they are more likely generalizable to future operations than are single happenings – which may never recur. That said, if analysis of 100 patient transports fails to identify any instances of *real* clinical consequences occurring during, or associated with, ground transport, then the likelihood of frequent occurrences of such events would be low. Thus, the next section of this report will address instances in which adverse clinical events – ranging from mild occurrences such as vomiting, to severe ones such as cardiac arrest – happened during the ground transport leg of patient transports between the Jetport and MMC.

Patient #7 had been stable, both neurologically and by vital signs, since before LFOM was called to the referring hospital, where this 72-year-old female had a diagnosis of head bleed. There were no problems during the air transport leg, but during the 20-minute ground transport leg (from 1922 to 1942) she suffered significant neurological deterioration (disorientation, speech problems, lethargy). At MMC, she had emergency ventriculostomy (to relieve brain pressure) after a repeat CT scan.

Patient #8, a 29-year-old male who had been in a snowmobile crash, was diagnosed as having a brain bleed and a high cervical-spine injury. He was stable during the air transport leg, but during the ground transport from the Jetport he began yelling and was very agitated (with concomitant increases in intracranial pressure, in addition to potential disruption of his C-spine injury). Similarly, patient #27 was a 9-year-old male transported from a North Yarmouth trauma scene with severe facial and head injuries, who was neurologically stable during the air transport leg but who became more drowsy during the ground transport leg. Increases in intracranial pressure also occurred with near-certainty in patient #44, a 26 year-old male with head bleed after a fall, who did fine during the air transport leg but was "bucking the ventilator" during ground transport.

Patient #9, a 4-year-old male with a gunshot wound to the chest, was noted to have neck vein distension, decreasing breath sounds, and increasing respiratory rate (from 18 to 38/minute) during the ground transport leg from the Jetport. Due apparently to the proximity to MMC when the patient worsened (the ground leg took 12 minutes from 1328 to 1340), no interventions were necessary during the ground leg. (However, it is clear that had the ground leg been longer, or the LFOM crew more aggressive, the lack of definitive diagnostic interventions in the ambulance would have resulted in the patient undergoing needle thoracostomy which would have been painful, would have resulted in need for a chest tube, and would have been unnecessary based upon the patient's ultimate actual course.)

Patient #12, a 72-year-old female with gastrointestinal bleeding (from abnormal connection between her aorta and her bowel), did not appear to have significant instability at the referring hospital, but she developed low blood pressures during the LFOM air transport leg. Her blood pressures stabilized during the air transport leg (normal blood pressures during final 24 minutes of flight). During the 11 minute interval between the Jetport landing (2159) and loading onto the ground ambulance at 2210 (by which time she likely would have been in or near the operating room if she had landed at an on-site MMC pad), she had a large bloody stool and sustained gradual decrease in neurological and hemodynamic status during the ground transport leg. By 2221 she was receiving medications for slow heart rate, and she lost her pulse as she arrived at MMC. Resuscitation efforts were in vain. Her chances of survival were significantly diminished by the time incurred by the ground transport leg.

Patient #31, a 55 year-old female who had had a cardiac arrest, suffered two logistics-type complications associated with the ground transport leg. First, the battery on the mechanical ventilator became depleted – a complication known to incur significant clinical risk[19] – and the patient had to be ventilated with manual ventilation which is less desirable for a number of reasons well characterized in the critical care transport literature, and particularly applicable in this patient who had a history of severe pulmonary hypertension.[20,21] The second logistics complication was a delay in the commencement of the ground transport leg, associated with the need to remix more of the patient's infusion therapy (though the resultant ground transport leg was only 17 minutes in duration).

Add patient #

The mechanical ventilator battery problem arose during the initial ground transport leg in another patient, resulting in the need for the LFOM crew to perform bag-valve-mask ventilatory support with its less effective and more problematic profile than mechanical ventilation. As an even more concerning problem, the switchover to manual ventilation in this patient – who had suspected sepsis – resulted in exposure of the crew to the infectious agent (*N. meningitidis*) causing meningitis (which was what the patient ultimately had).

Patient #45 is an example of severe, yet unexpected, deterioration occurring during ground transport. She was stable in the ICU at a referring institution, where the diagnosis was high blood sugar and cardiac syndrome. There was no instability during air transport, during which time the patient had no chest pain or vital signs instability. Approximately 11 minutes into a 16-minute ground transport from the Jetport to MMC, the patient's respirations suddenly decreased and she became near-comatose; she required assisted ventilations during the final phase of the ground transport and required emergency intubation at MMC.

Pateint #60, a 58 year-old male with ongoing chest pain from a heart attack, had vomiting at the end of the air transport leg. He vomited again during the ground transport, with the latest episode of vomiting being bloody (which has relevance to bleeding risk during the cath lab procedure he was to undergo emergently at MMC).

Patient #82, a 65 year-old male with aortic aneurysm, had a decrease in blood pressure upon landing at the Jetport. He improved with medications given just after landing, but deteriorated after being loaded into the ground ambulance (by which time he would have been in or near the operating room if he had landed on-site at MMC). His blood pressure dropped to 40, and by the time the 16-minute ground transport got him to MMC he was in full arrest, from which he was not resuscitated. This patient's chances of survival were significantly and adversely impacted by the bifurcated transport.

Another patient with aortic aneurysm, Patient #85, had an acutely bleeding aorta and was receiving a blood transfusion which was completed soon after LFOM landed at the Jetport. During the ground transport, which began at 2031, the patient's blood pressure dropped down to 98 (at 2035) and then to a near-arrest level of 55 (at 2040). This patient survived, but his vital organ perfusion was clearly compromised at a time when he would have been in the operating room if he had landed at an on-site MMC pad.

Patient #88 had vomiting during the ground transport leg of his interfacility transfer from PBMC to MMC's cath lab. He had had no nausea or vomiting during air transport.

Patient #96, a 7 year-old male with a motorcross-related crash and head injury, was being ventilated with a laryngeal mask airway with problems until a leak developed (probably due to ongoing secretions) during ground transport. The patient was reintubated in the ambulance, during a 13-minute Jetport/MMC leg.

Time criticality in the sample set of Jetport-MMC ground transports

A final category of patients are those who, even given the "sick" nature of the cohort of patients assessed for this study, stand out as being particularly in need of urgent services at MMC – services which had their provision delayed due to necessity of the ground transport leg. For example, patient #19 had worsening of chest pain (due to an acute heart attack) during the final 10 minutes of the air transport leg, and instead of being at the cath lab upon LFOM landing in Portland at 0630, had to undergo a 20-minute ground transport leg.

HEMS benefits to systems

It goes without saying that if HEMS is associated with mortality (or significant morbidity) improvement, then it benefits a regional EMS system to have access to such a service. Separate from such patient-centered benefits, however, are benefits to regions/EMS systems accrued by having HEMS capabilities. While patient-centered thinking should be paramount, some of these logistical and economical considerations represent very important potential utilities for HEMS services.

The principle of HEMS being used to cover a region with ALS has been mentioned above, in terms of the risk to a given patient, of needing a helicopter and having the crew's response delayed due to time taken during ground transport to and from MMC. This issue is also applied in the systems paradigm for an EMS region: the system's overall HEMS and ALS coverage is potentially compromised when the crew must take an extra 30-35 minutes for round-trip ground transport legs. Given the time-criticality of many HEMS missions for scene trauma, this delay of less than an hour can have significant deleterious effects. For example, airway management in the field by *ground* EMS providers has been strongly correlated with *increased* mortality, but the same studies have demonstrated that airway management by *HEMS* crews – who are known to have much higher success rates than ground EMS providers[22] – *decreases* mortality.[23,24] Delays in LFOM response to a trauma scene associated with the air medical crew being "tied up" on ground transport, could range from as little as 15 minutes (as would occur if LFOM is at MMC, having just dropping off a patient) to over a half-hour (as might be the case if LFOM is called for a scene transport just after commencing a ground transport leg into MMC). If these delays are of sufficient magnitude that airway management must be attempted by less experienced, less well-equipped, and less facile ground EMS providers, there is potentially significant impact from the need for a Jetport-MMC ground transport leg.

Another system-related benefit to HEMS, regionalization of specialty care, also has relevance to the MMC heliport issue. It is known that such regionalization has improved trauma outcomes, and there is growing confirmation that care regionalization improves outcomes in other patient types (*e.g.* cardiac, neurologic).[8,12,13] One of the main tenets upon which care regionalization for these diagnoses rests is the rapid transport of patients for emergency trauma surgery, urgent cardiac catheterization, or expedited intracerebral stroke imaging and administration of lytic therapy. All of these interventions are necesssarily time-critical. It follows that a central goal of any medical center striving to provide regionally unique, time-sensitive care, is to streamline the access to that care. It is important to emphasize that this issue is being addressed here *not* from any marketing perspective (*i.e.* for MMC), but rather from the distinct clinical perspective of having an institution exercise its role to serve its patient population with the greatest possible efficiency and efficacy.

Mock transport from Jetport to MMC

To familiarize the consultant with the current logistics of the ground transport leg, a "mock run" from the Portland Jetport to the MMC was executed at approximately 1500 on a weekday (11/18). This time was selected because it correlated with the time that appeared to correlate with the highest volume of LFOM-MMC transports.

Upon landing at the Jetport, the helicopter waits 2-3 minutes for the engines to "spool down." LFOM does not engage in hot-offloading, which is the practice of removing the patient to a ground ambulance while the rotor blades are still turning. Hot-offloading of patients is uncommonly indicated, and incurs a greater risk to ground personnel than does the alternative of "cold-offloading" (after the rotors have stopped turning). Conversations with LFOM personnel indicate that hot-offloading is "not an option" with Jetport transports, due to its being disallowed by the personnel (Medcu) providing ground transport. For the vast majority of cases, landing of LFOM at an on-site MMC pad will *not* save the few minutes required by the practice of cold-offloading; however, it is conceivable that with appropriate training the use of an on-site MMC pad can offer the *potential* to utilize hot-offloading in highly time-critical cases.

Subsequent to patient unloading from the helicopter, the patient is placed onto a transport stretcher, rolled to the ambulance, and loaded into the ambulance. In combination with the ultimate need for post-ground leg transfer to the hospital stretcher, the current ground transport system thus entails *two* patient transfers (as compared with one transfer onto a hospital stretcher from the rooftop pad): one to the ground ambulance, and another to the hospital stretcher at MMC.

After the patient is loaded into the ground transfer ambulance, the ground vehicle must leave the security-controlled area of the airport. This step, which requires an attendant to open a locked gate, usually takes negligible time. However, LFOM crew indicate that on occasion, there is a wait to get the gate opened. For example, in patient #13, a 73 year-old male with gastrointestinal bleeding from the esophagus, there was an 8-minute time lapse between landing at the Jetport and commencement of ground transport to MMC. The LFOM record notes that 6 minutes were required to get the patient into the ground ambulance, and a 2-minute delay was incurred to "get going" (which was later translated by LFOM personnel as indicating problems getting through the gate).

After the ground ambulance clears the security zone of the Jetport, there is a turn onto the road towards MMC. This turn, by the consultant's count, is the first of *nine* 90-degree turns that the ground ambulance makes during its journey to MMC. Depending on the clinical situation, these turns and the associated patient movement risk can pose as much, or even more, patient safety concern as the actual time required for the ground transport leg. The drive to MMC also involves passage through traffic lights (12) and a stop sign. Even if these do not force stoppage of the ambulance, there is an expected change in smoothness of transport vehicle's transit which can pose additional issues ranging from nausea to vehicle motion-related technical problems.

During the consultant's "dry run," the time elapsed between departing the Jetport and arriving at MMC was 15 minutes. Since this 15 minutes was driving time only, and didn't take into account the time (usually about 3-5 minutes) required for patient offloading from the helicopter and loading into the ambulance, this time is shorter than that calculated from the available records from LFOM/MMC (see section on ground transport times). Given the fact that the time "lost" by transferring the patient is "gained" by Medcu running with lights and sirens to MMC, the consultant's time of 15 minutes is consistent with what would be predicted based upon the available information.

Mock transport from Mercy (new site)

To familiarize the consultant with the potential logistics of a ground transport leg from the new Mercy Hospital site (on the river), a "mock run" from the site to the MMC was executed at approximately 1300 on a weekday (11/20). Upon landing at the Mercy site, the helicopter waits 2-3 minutes for the engines to "spool down." It is not anticipated that the option of "hot-offloading" would be a possibility at a non-MMC facility, but this cannot be ascertained without doubt. Subsequent to patient unloading from the helicopter, the patient is placed onto a transport stretcher, rolled to the ambulance, and loaded into the ambulance. Notably, the use of the ground ambulance, instead of a (MMC) hospital stretcher, to receive the patient from the helicopter, results in the same two-transfer need that the Jetport system entails.

After the patient is loaded into the ground transfer ambulance, the ground vehicle departs for MMC (without any potential delays due to airport-related security gates). After the ground ambulance turns left (during the consultant's mock run, from a driveway near Redlon & Johnson company, onto St. John street), there is a short drive to Congress street. At Congress, the ground vehicle will turn right and continue on to MMC.

The mock run from the proposed Mercy site entailed 5 90-degree turns. Two traffic lights were in the pathway. Having been calculated in a run in which the traffic lights were green, the consultant's estimated "new Mercy"-to-MMC" transit time of 3 minutes probably approximates fairly closely, the actual transit time between those two sites. To this three minutes should be added the expected time for engine spool-down and patient transfer to the ambulance, to achieve an expected total time (from helicopter landing to patient arrival at MMC) of about 8-9 minutes.

Mock transport from proposed rooftop helipad

The aircraft will land on the rooftop of a parking garage. Subsequent to patient unloading from the helicopter (see discussion above, covering hot- vs. cold-offloads), the patient is placed directly onto a hospital stretcher (important: a single patient transfer rather than two). An elevator (dedicated to LFOM use when the aircraft arrives) will take the patient down about 20 feet (2 levels of the parking garage), after which time the patient must traverse a distance of about 100 feet over a street. This is achieved by crossing the street in a closed and air-conditioned/heated hallway, after which a right turn brings the patient to the operating suite, or a left turn brings the patient into the ED. There is a dedicated CT scanner in the ED (this has relevance to certain types of emergent cases such as strokes).

Since the helipad and related structures were not built, times estimated for this transport system must be estimated. Assuming a cold-offload and a ready elevator, it would appear that the total time elapsed, between helicopter landing and patient arrival in the MMC ED (or OR), would tend toward 4-5 minutes. Perhaps more importantly, at least for the sake of comparison against logistics setups involving ground ambulance legs, elapsed times could be assessed as the interval commencing with patient loading onto the first stretcher (transport stretcher for ground ambulances, hospital stretcher for on-site MMC transports) after helicopter landing. By this adjudication, the patient could be in the MMC ED or OR within a minute or two after being offloaded from the aircraft onto a stretcher.

Patient acuity in the LFOM-MMC sample reviewed

Ground critical care transport is available to MMC. 150 neonatal transports per year; 400 total?

Dangers of the transport environment

Problems with ventilation during transport are major issues. "Even the most experienced practitioner, however, is unlikely to maintain consistent ventilation synchrony with spontaneously breathing patients." The asynchrony increases work of breathing for the patient. Other problems with manual ventilation during transport include inconsistent PEEP The authors found that the P_aO_2/F_iO_2 declined in some patients receiving intratransport manual ventilation, but not in any case where patients received mechanical ventilation. (2)

Hypotension or dysrhythmia occurred in 7 of 19 patients who had ABG deterioration (P_aCO_2 change of at least 10 torr, or pH increase of at least .05) during transport. Overzealous manual ventilation and associated hypocarbia (and respiratory alkalosis), and/or underventilation (respiratory acidosis), occurred in most patients receiving manual ventilation. (3)

Monitors in the ICU setting may detect abnormalities (*e.g.* dysrhythmias) harder to detect on transport equipment. Equipment problems or misuse occurred in 11% of patients. Battery failure and disconnection from mechanical ventilator were the two problems encountered in this study, and could have had serious clinical effects. (4)

Interhospital transport is not without risk, but seems to be a good thing for patients with a variety of diagnoses. (This study concentrated on patients with respiratory failure.) (5)

The act of moving intubated patients around seems to increase the chances of a variety of complications, such as pneumonia – this seems to come about as a result of the jarring and movement of the ventilator tubing. (6)

Explanations for problems occurring during transport aren't always clear. The problem may be interruption of infusions during patient movement, leading to brief but important periods of hypotension. Another explanation may be changes in oxygenation with patient repositioning, or repositioning-associated changes in pain with resultant physiologic effects. The changes due to patient transfer/transport were clinically significant, associated with both morbidity and mortality. (7)

Examples of concerning mishaps include accidental extubation, ECG lead disconnections, inetrruption of vasoactive drug infusions, and intravenous line disconnection or infiltration. There was no association between mishaps occurrences and presence of RNs, presence of RTs, or total number of escorts. A third of patient transfers out of the ICU were associated with mishaps. ECG and IV disconnections can be as life-threatening as other complications. Many problems occurred during CT scanning, where movement of the patient from the stretcher to scanner and back was a part of the risk. (8)

Children are particularly vulnerable to problems occurring during transfer. Adverse events included plugging of ETTs, problems with oxygen supply, inadequate immobilization of fractures. (9)

Complications occurring during transfer include fracture site reduction loss, bleeding at fracture sites, increased pain, and dislodgment of ETTs, vascular lines, or surgical drains. Positional changes can influence cardiac output or respiratory mechanics. (10)

About 1 patient per month, at a major center, suffers cardiac arrest and/or death associated with transport-related complications. (11)

Use of a time-of-day dependent helipad triage system

Personal communication, Ira J Blumen, 11/8/2004: "It is disappointing that a major trauma center would even consider delaying the arrival of trauma patients by requiring ground transfer from the airport."

Accepting transfer patients results in marked effects on institutions' tracking of survival; this occurs even when there is adjustment for measures of acuity (*e.g.* using APACHE scoring). Thus, patients who undergo interhospital transfer appear to be inherently "sicker" – even in ways that are not easily quantifiable – than patients in the same MICU who were admitted primarily at the study institution. The relevance to the MMC situation is: patients who appear to be "well enough" for bifurcated transfer may in fact have some of the other, more difficult to assess, characteristics associated with higher risk during transport. (1) The authors' phrasing is "transfer to another ICU is often associated with some unmeasured aspect related to severity of illness." (OldRef1)

Personal communication, John W. Hustwit (Director of Operations, Keystone Flight Services, a nationwide company which operates 35 helicopters flying from 28 locations in the U.S. Northeast), 11/2/2004: "There are no Keystone contracts that I am aware of who have night restrictions on hospitals. This includes the receiving hospital helipads as well as the hospital helipads they take patients from."

Personal communication, Larry Adams (Vice President and General Manager of Flight Services Division, Keystone), 11/1/2004: "To my knowledge we do not operate from any hospital heliports that are restricted from use at night."

Personal communication, Dawn Mancuso (Executive Director, Association of Air Medical Services), 11/1/2004: "I have not heard of any heliports operating under this kind of split/differentiated schedule."

Personal communication, Ken Javorski (Director of Operations, CJ Systems Aviation Group, which manages air medical services of 105 helicopters at 77 base site facilities), 11/2/2004: "I have not seen such a restriction in any of the programs we support."

Safety considerations

Ira's safety report: (12)

NTSB report of Casco Bay crash: (13)

Personal communication, Ira J. Blumen, 11/8/2004: "I know of only one accident that killsed "someone on the ground." On 1/22/2001 (Air Evac, based out of Quincy, IL) a security guard who was supposed to be securing the helipad during take-off walked into the tail rotor and was killed. There have been numerous helipad accidents (rooftop and ground), but I do not know of any others that injured/killed non-crewmembers or the patient."

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Appendix I: Abstracts of 100 LFOM/MMC patient transports

#1
10 F intubated (at CMMC ICU) with pneumonia and status asthmaticus (severe asthma, refractory to treatment); there was difficulty getting patient onto LFOM ventilator (patient required chemical paralysis); early interventions upon arrival at MMC PICU included medication infusions (steroids, terbutaline) and reintubation with a larger endotracheal tube

#2
54 F in ED with complex medical history (Waldenstrom's macroglobulinemia and hypertension); MRI at RFGH indicating new nonhemorrhagic strokes and suspected venous sinus thrombosis; upon arrival at MMC medical floor had urgent neurology/neurosurgery evaluation and repeat MRI

#3 (pre-referring hospital time information)
8 F with dehydration, pH 6.97 (serum bicarbonate 9) and increasing work of breathing at CMMC ED; by arrival at MMC ED (where dx new-onset DM with DKA was made) patient with respiratory rate up to 27-29; early MMC interventions included emergency endocrinology consultation with adjustment of insulin, electrolyte, and fluid therapy; time course – patient arrived CMMC by private vehicle 0547, LFOM called 0659 (dispatched 0700), LFOM arrived CMMC 0716 and at patient 0716, LFOM departed CMMC 0752 and arrived Portland 0804

#4
51 M at Rumford ED with head bleed on CT; early MMC ED interventions included institution of antihypertensives, neurosurgery consultation and repeat imaging which identified 6 aneurysms (one of which had ruptured); patient subsequently deteriorated, had extremely difficult intubation by MMC anesthesia (and died in the MMC ICU due to brain swelling)

#5
71 M in ICU at Androscoggin Valley with pneumonia and respiratory failure (intubated), receiving plasma for bleeding, transported to MMC ICU where respiratory support was provided until family made him "DNR"; upon landing at Jetport patient began biting the breathing tube and had to receive chemical paralytics

#6 (example of unreliability of pre-transport diagnosis)
74 F at Franklin Memorial ED with CT finding of dissecting aortic aneurysm; in ED at MMC patient underwent emergency cardiothoracic surgical evaluation with subsequent neurology consultation and ultimate diagnosis of stable aorta with new stroke

#7 (clinically significant deterioration during ground transport leg)
72 F ED patient at Franklin Memorial where CT revealed head bleed which was confirmed upon early CT at MMC; early MMC interventions included emergency ventriculostomy which effected improvement in neurologic status; patient had been stable since before LFOM call with Glasgow Coma Score 13 (on scale of 15) and stable vital signs but during 20-minute transfer to MMC patient became more confused (loss of time/place orientation), speech worsened, and lethargy increased; time course – LFOM called for transport at 1804, LFOM landed with patient at Jetport 1922, arrived MMC ED 1942

#8 (pre-referring hospital time course; potential clinical problem during ground transport leg)
29 M involved in snowmobile crash, at Frisbee ED found to have traumatic subarachnoid hemorrhage with shoulder injury; LFOM to MMC ED where he underwent expedited trauma/subspecialty evaluation with diagnoses of subarachnoid hemorrhage, brain contusion and C1 cervical spine fracture; patient course/times – ALS was dispatched to the snowmobile crash scene 1548, ALS on scene 1600, ALS left scene 1607, ALS arrived Frisbee 1618; Frisbee called LFOM 1709, LFOM arrived Frisbee helipad 1735, LFOM at patient 1745, LFOM departed Frisbee 1815 and at Jetport 1831; patient agitated and yelling during ground transport to MMC (dangerous given his C1 fracture and head injury)

#9 (clinical deterioration during ground transport leg)
4 M sustained pellet-gunshot wound to chest and had shortness of breath; during ground transport patient had decreasing breath sounds as well as jugular venous distension (suggestive of collapsed lung) with respiratory rate increasing from 18 (during ground transport leg) to 38 by the time of MMC ED arrival; early MMC evaluation included chest X-ray and trauma assessment; time course – arrived Jetport 1328, arrived MMC 1340

#10
84 M with heart attack (had cardiac arrest) at FMH ED, transported directly to the cath lab at MMC for immediate cardiac care

#11
9-month M long-distance transport (238 miles) from TAMC; septic from infected central line which was removed upon arrival to the Pedi ward at MMC

#12 (potentially preventable death occurred during ground transport)
72 F diagnosed at Memorial Hospital ED with abdominal pain and GI bleeding from suspected aorto-duodenal fistula (connection between aorta and bowel); was not significantly unstable at referring hospital but developed low blood pressures during LFOM air transport (62 at 2130, 77 at 2135); blood pressures stabilized (125 to 175) for remaining 24 minutes of flight time; landed Jetport 2159 with completion of loading into ground unit 2210; just after transfer to ground unit stretcher, patient "felt it running out of me" and had large bloody stool which was followed by unresponsiveness and decreases in heart rate, blood pressure, and respirations; further patient deterioration prompted intubation and bradycardia despite atropine (administered at 2221); just after MMC ED arrival patient became pulseless and resuscitation efforts failed

#13 (timing of transferring to ground unit and ground unit departing for MMC)
73 M at Bridgton ED vomiting blood from esophageal varices; transported to MMC ED where he had early gastroenterology consultation and urgent reversal of his Coumadin anticoagulation; time course – arrived Jetport 0023, ground ambulance departing for MMC 0031, arrived MMC 0041; LFOM chart notes 6 minutes between landing and transferring to ground unit and 2 minute delay to “get going” on ground transport leg (documentation not specific as to reason; subsequent conversations with LFOM crew denote delays can be due to getting gate opened)

#14
6 F with persistent heart rate exceeding 200/minute despite at least 8 administrations of adenosine at Houlton Regional ED; LFOM to MMC PICU where immediate conversion to sinus rhythm was achieved by pediatric cardiology

#15
25 F in motor vehicle crash, 1-hour extrication, deep coma at scene; EMMC evaluation determined need for MMC transport for Plastics for extensive facial trauma

#16
54 M with history of coronary stenting and recurrent/refractory chest pain in ED at Memorial Hospital; transported by LFOM (pain-free during transport) directly into MMC cath lab

#17 (clinical intervention – chemical paralysis – required for ground transport leg)
46 M in ED at Huggins Hospital after high-speed motor vehicle crash; multiple rib fractures and collapsed lung with blood in chest and ongoing hemorrhage; intubated for transport and had need for chemical paralysis due to “movement” just prior to transport into ground unit for MMC leg; time course – arrived Jetport 2057, in Medcu 2101, at MMC ED 2115

#18 (time course from referring hospital arrival to MMC arrival)
26 M at Calais Regional ED with grinder injury to face (laceration down to bone) and hand; transfer to MMC for trauma/plastics evaluation; time course – patient arrival Calais Regional 1310, LFOM called/dispatched 1451, LFOM to patient 1601, Jetport 1805, MMC arrival 1825

#19 (time information from onset of symptoms to MMC arrival; clinical worsening during final 10 minutes of air transport leg)
61 M at RFGH ED with heart attack, transported directly to MMC cath lab with worsening of pain during the final 10 minutes of air transport leg; time course – patient awakened by CP 0030, presents to RFGH 0150, LFOM dispatched 0424, LFOM arrives at patient 0520, LFOM departs RFGH 0554, Jetport 0630, MMC cath lab 0650

#20
58 M at PBMC ED with heart attack, noted to be “not perfusing well”; transported directly to MMC cath lab

#21 (time course from pre-referring hospital through to MMC arrival; mild clinical deterioration during ground transport leg)
48 M at RFGH with heart attack and ongoing chest pain unresponsive/refractory to medications, transported directly into MMC cath lab; time course – initial ambulance call to transport patient to RFGH 0530, EMS arrival at patient 0540, patient arrival (via EMS) RFGH 0558 with initial RFGH evaluation timed 0605, LFOM called/dispatched 0640, LFOM at RFGH 0733 (0738 at patient), LFOM departed RFGH 0806, arrived Jetport 0832, MMC cath lab 0843

#22 (time course from injury to Jetport arrival; suggestion of clinical deterioration during ground transport leg)
10 F impaled sharp object in flank at West Port Island; throat pain began during ground transport to MMC ED; time course – EMS arrival at patient 1315, LFOM called 1301 and told to standby before being dispatched 1315, LFOM arrived at patient 1339, Jetport arrival 1416

#23
46 M in EMMC ED with orbital/facial injuries and pelvic fracture after snowmobile injury, 3 units blood transfusion at EMMC; LFOM to MMC for trauma/subspecialty evaluation

#24 (prehospital through MMC times for initially planned scene run converted to interfacility transport)
7 M had clothing ignite from propane heater, sustained burns including to his airway; LFOM transported to MMC burn unit; time course – LFOM initially called for scene transport 1243, changed to interfacility run 1258, LFOM arrived RFGH pad 1327 and at patient 1334, LFOM depart RFGH 1407, Jetport 1438, in Medcu 1443, in MMC ICU 1450

#25
20 F unconscious and intubated at PBMC after cardiac arrest and seizures; continued unresponsiveness and complex past medical history prompted LFOM for MMC ED transport

#26
77 M in Stephen's Memorial ED with multisystem trauma and increasing agitation (from head bleed) required intubation by LFOM for transport to MMC ED

#27 (time course for prehospital events to Jetport arrival; mild clinical deterioration during ground transport leg)
9 M in North Yarmouth after head-on MVC; LFOM called to scene due to obvious head injury (depressed skull fracture) and facial/eye injuries; slightly more drowsy during ground leg; time course – LFOM called 0947, dispatched 0948, lifted off 0957, LFOM arrived at patient 1014, LFOM departed scene 1020, arrived Jetport 1030

#28
5 M at CMMC after sustained head injury in car crash for transport to MMC; time course – LFOM arrive Jetport 1209 and arrive MMC ED 1220

#29 (illustrative case of decompensation during patient movement)
72 M at RFGH on Coumadin, life-threatening head bleed after falling, dangerously low oxygenation (S_pO_2 80%) upon being moved from RFGH stretcher to LFOM stretcher

#30
42 M hemophiliac with severe anemia, gastrointestinal bleeding, and hypoperfusion; no blood available at Bridgton Hospital ED; arrived Jetport 1526, MMC ED 1540

#31 (delay involved with ground transport leg; clinically significant complication associated with ground transport leg)
55 F at Inland Hospital after cardiac arrest requiring multiple injections of epinephrine and infusion of same to maintain blood pressure; history of pulmonary hypertension with her own pump for continuous outpatient infusion therapy with epoprostenol (discontinuation of which, even momentarily, can be rapidly life-threatening); due to battery depletion in mechanical ventilator had to be transitioned to manual ventilation ("bagging" – much less preferable for many patients and especially one with these medical issues); ground transport leg also noted for delay due to need to remix epinephrine infusion; time course – arrived Jetport 2233, MMC ED 2250

#32
33 F in ED at PBMC after sustaining injuries to head, face, spine and ribs in motor vehicle crash, transported to MMC ED for trauma/subspecialty evaluation

#33
36 F with facial and neck burns, intubated in ED at CMMC and for transfer to MMC ED for burn care

#34
38 M gunshot wound to head comatose in PBMC ED; borderline blood pressure; organ donation was a consideration in transferring to MMC ED

#35
50 F with possible heart attack at Memorial Hospital, transported to MMC cardiac ICU with ongoing severe chest pain; time course – arrived Jetport 1335, arrived MMC 1347

#36 (prolonged out-of-hospital time placed patient at potential risk due to ventilatory support withdrawal for transport)
9 F severe asthma/respiratory distress; assisted ventilation (BiPAP – two-level positive pressure assistance – had to be discontinued for transport) from Rumford to MMC PICU; time course – arrived Jetport 2256, MMC 2320

#37
18 M fell, sustaining spinal cord and head injuries; agitated and labs positive (at Huggins Hospital ED) for cocaine and alcohol intoxication; time course – arrived Jetport 0046, to MMC ED 0110

#38 (time interval between arrival at MMC and arrival at patient unit)
44 M after snowmobile crash with spleen laceration and subsequent pulmonary embolism in Memorial Hospital ICU; time course – arrived Jetport 1145, at MMC 1200, report to ICU at 1210

#39 (incurred increased potential risk from multiple transfers between stretchers)
16 F at Lakes Region ICU after falling and sustaining multiple extremity and spine fractures (with bone fragments into spinal canal), emergency neurosurgical intervention/fixation within a few hours of arriving at MMC; LFOM noted “no neuro deterioration occurring with transfer” between stretchers

#40
48 F sustained pelvic and extremity fx in snowmobile crash; in ED at Millinocket Regional and transferred to MMC ED for trauma/subspecialty evaluation

#41
11 M multisystem trauma in car crash, intubated at Memorial Hospital ED; splenic injury, collapsed lung, and suspected aortic rupture; to MMC ED for trauma evaluation

#42
75 M at Rumford ED; coagulopathy (Coumadin) and gastrointestinal bleed requiring plasma transfusion; shortness of breath; low blood pressure; slow heart rate; to MMC ICU

#43
69 M in ED at PVH with ruptured abdominal aortic aneurysm; transported to ED at MMC where emergency surgical evaluation led to subsequent stent placement

#44 (potential clinical deterioration – intracranial pressure complication – during ground transport leg)
26 M intubated/comatose at Stephen's Memorial; head trauma after fall; subdural hematoma, skull fx; resisting vent during ground transport leg (with associated increases in intracranial pressure); early MMC ED interventions included head and neck CT

#45 (significant, and unexpected, deterioration during ground transport leg)
39 F in FMH ICU with high blood sugar and heart attack; also with history of asthma; during air transport patient had no chest pain or vital signs instability; patient deteriorated rapidly during ground transport leg, 5 minutes out from MMC ED; respirations became sonorous and slow (respiratory rate 8) and patient responded (with moans) only to painful

stimulus; a nasal airway was inserted and the patient had assisted ventilations (not intubated due to proximity to MMC); very difficult intubation at MMC; time course – arrived Jetport 2354, arrived MMC 0010

#46
4 M sustaining facial, head, and abdominal injuries in car crash (unconscious at scene); transported from Huggins Hospital to ED at MMC for trauma/subspecialist evaluation

#47
64 F with respiratory distress, cardiogenic shock, acute insufficiency of heart valves, on mechanical ventilator in FMH ICU, transferred to MMC for ICU care

#48
34 M with heart attack, failed thrombolytic therapy (with continuing chest pain) at PBMC ED; transported directly to cath lab at MMC for emergency cardiac intervention

#49
89 F with anemia (being transfused), abdominal pain (with history of abdominal aortic aneurysm), and shortness of breath from congestive heart failure at Millinocket Regional ED; transferred to MMC ED for emergency evaluation by both cardiology (with performance of emergency echocardiogram) and vascular surgery (assessed patient for possible aortic leak)

#50
74 F with pulmonary embolism and bradycardia in ED at SVH; transferred to ICU at MMC for emergency intensive care services including urgent imaging of lower extremity veins

#51
22 M transported from scene of car crash in York; severe back pain and pain on breathing; transported to MMC ED for trauma evaluation

#52
54 F with pancreatitis, sepsis, and low blood pressure in ICU at PBMC; transported to MMC ICU where she was urgently intubated for respiratory collapse

#53
6 M with near-drowning and respiratory arrest at Turner scene; intubated by LFOM at scene and transported to MMC ICU; time course – arrived Jetport 2111, arrived MMC 2130

#54
10 F injured snow-tubing; Rumford ED findings of forehead hematoma, facial trauma, altered mental status; to MMC ED; time course – arrived Jetport 1506, arrived MMC 1520

#55
1 F in CMMC ED, intubated on mechanical ventilation, with respiratory failure, wheezing, and fever; to MMC pediatric ICU; time course – arrived Jetport 0534, arrived MMC 0546

#56
11 F fell, sustained head injury with seizures; transported from Gardner trauma scene to MMC ED

#57
83 F in ED at RFGH after motor vehicle crash, with liver laceration, rib fractures, falling hematocrit, and hypotension; transferred to MMC ED for trauma evaluation

#58
72 F heart attack, cardiac conduction abnl; EMMC ED to MMC ICU; hypoxemia and nausea during air transport; time course – arrived Jetport 1504, arrived MMC 1530

#59
48 F in Exeter Hospital ED after motor vehicle crash with injuries including liver laceration; transport to MMC ED for trauma evaluation

#60 (possible clinical issue – repeat vomiting – after ground transport leg)
58 M in Memorial Hospital ED with heart attack; ongoing chest pain requiring uptitration of pain medications and transport directly into MMC cath lab; vomited on final approach to Jetport and had repeat vomiting (this time bloody) upon arrival to MMC; time course – arrived Jetport 1918, arrived MMC 1930

#61
20 F with multiple skiing-related injuries (liver/kidney/hip) at Bethel scene; LFOM was diverted to MMC ED due to OR nonavailability at closer hospital

#62
27 M near-amputation of wrist after saw injury, evaluated Miles Memorial ED and transported to MMC ED; time course – arrived Jetport 1705, arrived MMC 1721

#63
58 M with subarachnoid (brain) hemorrhage intubated in Bridgton ICU; transported to ICU at MMC where early ventriculostomy was performed

#64
67 M in ED at Memorial Hospital with intracranial bleed (subdural hematoma) as well as suspected heart attack; transported to MMC ED where urgent interventions included correction of coagulopathy, neurosurgical consultation, and CT scanning

#65
44 M in PBMC ICU (intubated) with pancreatitis and ARDS with deteriorating pulmonary status, for transport to MMC ICU; time course – arrived Jetport 1850, arrived MMC 1900

#66
64 M with acute heart attack and continuing EKG abnormalities for transport directly to MMC cath lab from FMH ED; time course – arrived Jetport 2136, arrived MMC 2152

#67 (potentially unstable airway)
35 M in high-speed car crash; Huggins ED diagnoses included multiple fractures and respiratory distress requiring emergency surgical airway; time course – arrived Jetport 0437, arrived ED at MMC 0455

#68
40 F at Lakes Region ED with ongoing hemorrhage from pelvic fracture; transported to MMC ED

#69 (complication occurred during ground transport leg – potential risk to both patient and providers)
49 M in Goodall Hospital with sepsis, coma, hypotension, and low platelet count (suspected meningitis) for transfer to MMC ICU; upon arrival at Jetport the ventilator battery went dead so patient (who had ultimate diagnosis of meningococcal meningitis) was bagged for entire ground leg; time course – arrived Jetport 0640, arrived MMC 0655

#70
53 F at Rumford ED with acute heart attack and ongoing chest pain, transported to MMC ICU where early interventions included urgent cardiology evaluation (patient worked into cath lab schedule for urgent procedure)

#71
5 M in ATV crash, evaluated in ED at CMMC with abdominal injuries (suspected trauma to spleen and renal artery); transported to MMC ED for trauma evaluation

#72
32 F at Whitefield scene with seizure, respiratory distress, ongoing gastrointestinal bleeding; LFOM transport to MMC ED; time course – arrived Jetport 0734, arrived MMC 0745

#73
61 M in FMH ED with severe hyperkalemia (requiring external pacing pads) due to renal failure; transport to MMC ED; time course – arrived Jetport 0713, arrived MMC 0730

#74
6-mth M sustained forehead laceration and suspected head injury by Rumford ED, after reportedly run over by a car (later turned out to have been dropped); transported to MMC ED; time course – arrived Jetport 1617, arrived MMC 1637

#75 (potential for deterioration due to transfers associated with extra transport leg)
59 M at CMMC ED, for transport to MMC ED, with unstable cervical spine and spinal cord injury (had neurological deficit); time course – arrived Jetport 1812, arrived MMC 1826

#76
9 M with abdominal injury after dirt bike crash, at FMH ED with suspected splenic injury; transported to MMC ED

#77
85 F with partial and full thickness burns to head and torso (30% body surface area); intubated by LFOM at Ellsworth scene and transported to MMC ED

#78
67 M with acute heart attack and cardiac dysrhythmia in ED at Memorial, for transport to MMC cardiac ICU; time course – arrived Jetport 2047, arrived MMC 2110

#79
65 M in PBMC ED after fall; spinal cord injury, fluctuating neuro findings; transported to MMC ED for urgent neurosurgery eval; time course – arrived Jetport 1254, MMC 1310

#80
12 M at Rochester ED with rigid abdomen and chest pain (abdominal and chest "seat belt signs") after entrapped in car crash; to MMC ED

#81
2 M with spina bifida and infected post-operative site in sacrum at NMMC ED; transported to MMC Pedi; early MMC interventions included Neurosurgery and Infectious Disease consults; time course – arrived Jetport 2116, arrived MMC 2131

#82 (clinical deterioration – arrest – occurring during ground transport leg)
65 M in ED at CMMC with symptomatic adominal aortic aneurysm (severe abdominal pain, mottled and pulseless lower extremities); transported to MMC ED where he arrived in arrest after having suffered decrease in blood pressure and decreasing level of consciousness upon landing at Jetport; he had improvement with medications (atropine) after landing at Jetport but deteriorated after being loaded into ambulance for ground transport leg with drop in blood pressure to 40 and then in full arrest by the time of arrival at MMC ED; immediate MMC intubation performed but there was no return of cardiac activity; time course – arrived Jetport 1314, arrived MMC 1330

#83
79 M in FMH ED intubated and comatose after a fall; acute heart attack with high-grade cardiac conduction abnormality (complete heart block), requiring vasopressors to support blood pressure; urgent MMC interventions in cardiac ICU included cardiac care as well as repeat cranial CT scan

#84
63 M with head bleed, intubated in Bridgton ED, for transport to MCC ICU where early interventions were limited to neurosurgical assessment (bleed was nonsurvivable)

#85 (clinical deterioration – near arrest – occurring during ground transport leg)
77 M with acutely hemorrhaging aorta; transfused at FMH ED and during air transport leg; transfusion finished just at time of landing at Jetport; during ground transport leg blood pressure dropped to 55 and heart rate dropped to 50s, responding only briefly to wide-open normal saline infusion (with pressure bags); patient required assisted ventilation with bag-valve-mask and nasal airway placement during ground transport; transported directly to OR at MMC; time course – landed Jetport 2031, blood pressure initially dropped to 98 at 2035 to 98 then down to 55 by 2040

#86
22 M in Bridgton ED with multisystem trauma including head bleed (subdural hematoma and brain contusion) after being struck by car; early interventions in MMC ED included placement of intracranial pressure monitor by neurosurgery

#87
15 M with toxic shock syndrome at RFGH ED; transported to ICU at MMC

#88 (clinical issue – nausea/vomiting – during ground transport leg)
64 F in ED at PBMC with acute heart attack and cardiac arrest; for transport to MMC cardiac ICU; had nausea and vomiting during ground transport leg (had had none during the air transport leg); upon arrival at MMC immediately taken to cath lab and had balloon angioplasty in addition to stenting

#89
77 M (same patient as transport #85) at FMH ED with pulmonary embolism and respiratory distress; also possible acute heart attack; transported to MMC ED

#90
41 M involved in propane explosion, in Rumford ED with burns and near-amputated extremity; LFOM intubated patient and transported to MMC, releasing an extremity tourniquet during the transport without hemorrhagic complication; time course – arrived Jetport 1943, arrived MMC 1955

#91
31 M with deep laceration ("near-amputation") to left arm, no pulses distal to the injury; transported from PBMC ED to MMC ED for replantation/repair

#92
79 M with hemorrhagic stroke, intubated in ED at RFGH, transported by LFOM to MMC ED where he received urgent neurosurgical evaluation and ventriculostomy

#93
41 M in ED at Huggins Hospital after recreational vehicle crash (no pulse at scene), intubated and comatose with severe cervical spine injury; transported to MMC ED where urgent Trauma evaluation was performed and patient diagnosed as having brain death (organs were harvested)

#94
37 M diagnosed with bleeding cerebral aneurysm at EMMC ED; urgent interventions upon MMC ED arrival included neurosurgical evaluation, angiography, and aneurysm clipping

#95
80 M with acute heart attack, cardiac conduction defect (complete heart block), and ongoing chest pain; transported directly from RFGH ED to MMC cath lab

#96 (potentially significant clinical deterioration during ground transport leg)
7 M at scene in Minot with head injury (periods of being comatose) after a crash on a motocross jump; intubated by LFOM but subsequent vomiting dislodged the endotracheal tube; the laryngeal mask airway which was then placed, was noted to have a leak (due to increase in secretions) during Medcu ambulance ground transport leg, so patient

reintubated in ambulance; time course – arrived Jetport 1245, arrived MMC 1258

#97
38 F at CMMC ED with lawnmower injury to dominant hand (multiple digital amputations/near-amputations), transported to MMC ED for replantation evaluation

#98 (example of LFOM transporting patient *out* of MMC)
38 F (same patient as #97) at MMC ED with lawnmower injury to dominant hand (digital amputations/near-amputations), transported to MGH ED for replantation evaluation

#99
50 M at EMMC ED with cirrhosis of the liver, abdominal pain, and gastrointestinal bleeding (on octreotide infusion), transported by LFOM to MMC ICU

#100
58 M at Memorial Hospital ED with acute heart attack, symptomatic cardiac dysrhythmia (bradycardia), altered mental status; transported directly to MMC cath labkm

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orig to Lee

Rick Seeley

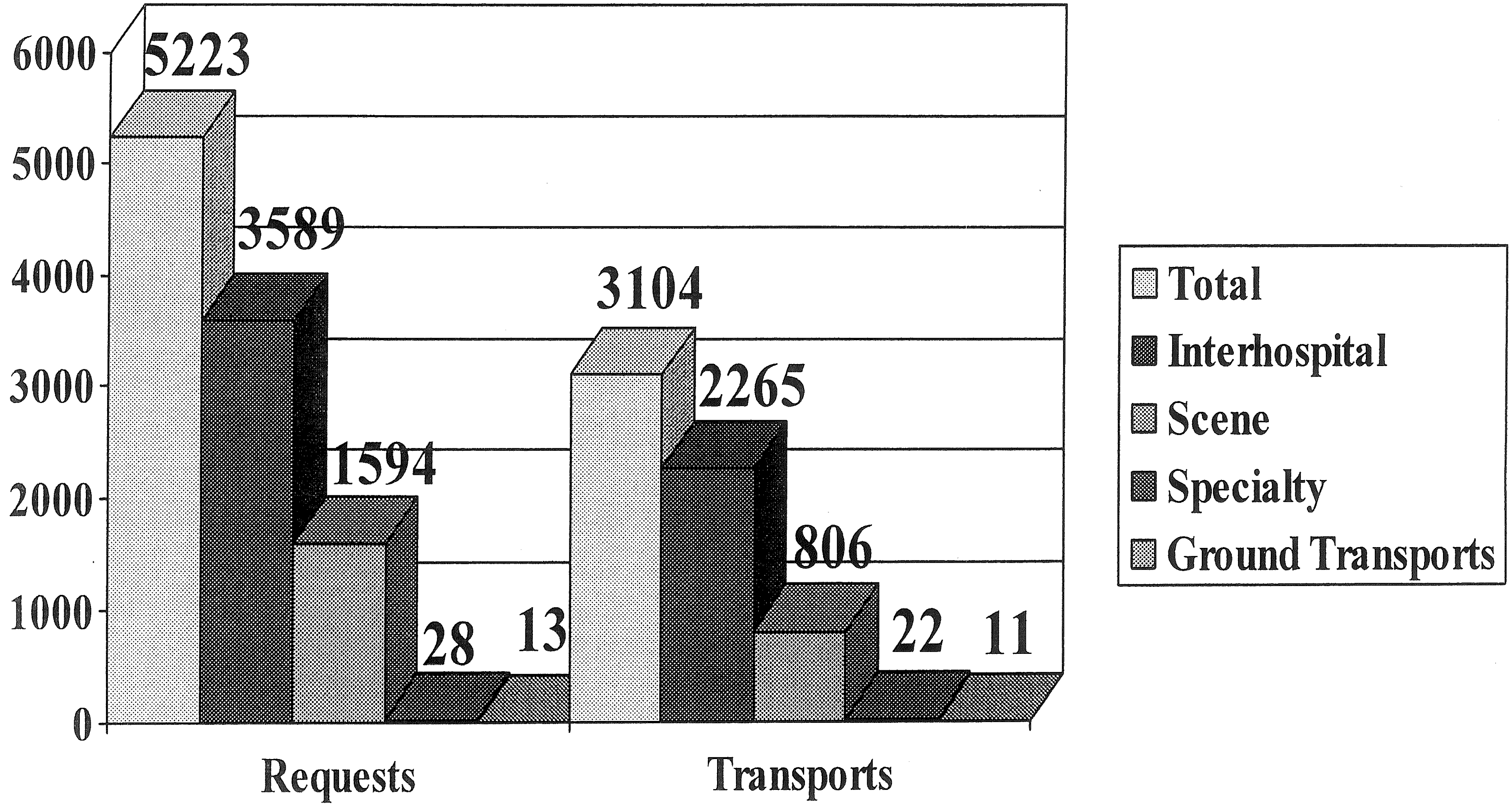
EMS Run Report System
Ambulance Arrivals at MMC

	2001	LOM	2002	LOM	2003	LOM	Jan-Feb 2004	LOM
Arrivals at MMC by Type of Run								
Emergency Transport	13712	4	14369	4	14681	4	2484	2
Routine Transfer	4213		4238		4058		639	
Emergency Transfer	2313	126	2692	194	2828	160	474	32
Total Arrivals	**20238**	**130**	**21299**	**198**	**21567**	**164**	**3597**	**34**
Note LOM arrivals are included in MHIC data								
Code 3 Arrivals at MMC	**2926**		**3748**		**3894**		**599**	
Note: > 90% LOM arrivals Code 3 (lights / sirens)								
Emergency Arrivals at MMC by Time of Day								
0001-0400	1467		1616		1537	**12**	264	
0401-0800	1200		1308		1367	**12**	253	
0801-1200	3292		3332		3627	**11**	652	
1201-1600	3709		4023		4176	**40**	700	
1601-2000	3379		3568		3748	**50**	592	
2001-0000	2568		2826		2713	**25**	438	
unknown	410		388		341	**14**	59	
Total Emergency Arrivals	**16025**		**17061**		**17509**	**164**	**2958**	
(note partial data for 2003 arrival times-LOM)								

LOM arrivals are less than 1% of total emergency arrivals at MMC

Maine Health Information Center - 07/20/2004

LifeFlight: activity



LifeFlight: Missions Not Flown
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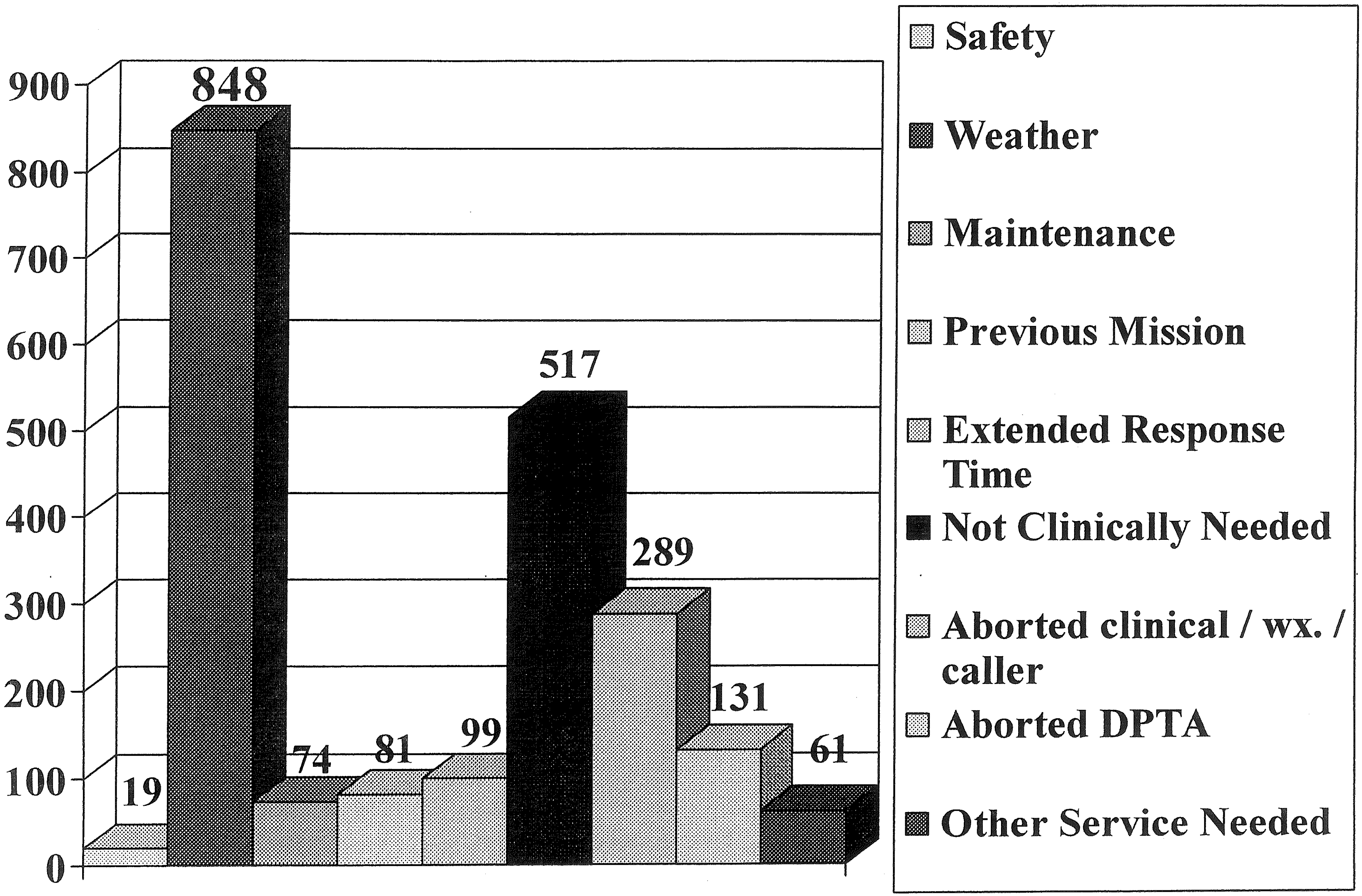

MMC Transports
January 2002 - Present

Origin of call	Age	Chief Complaint	Destination
Millinocket Regional	19 mos	Stridor, respiratory distress	
Gardner (scene)	36	3rd degree burns	
Frisbee Memorial	25	MVA; 3rd trimester	
Blue Hill Memorial	2	Pneumonia	
Huggins	35	Vaginal bleeding. 14 weeks pregnant; seizures	
CMMC	52	Chest pain	
EMMC	13	overdose	
PBMC	8	hydrocephalus	
MMC	18	amputation - fingers	Mass. General
SVH	1	Possible meningitis; sepsis, seizing	
Cliff Island (scene)	87	Chest pain	
C.A. Dean	35	Femur fracture	
Mayo Regional	15	Tib-Fib fracture	
FMH	1	RSV & seizures	
Memorial Hospital	80	Respiratory failure	
Memorial Hospital	81	cardiac arrest	
PBMC	65	Chest pain	
Bridgton	57	myocardial infarction	
Memorial Hospital	25	head injury	
Memorial Hospital	66	Respiratory distress	
MG Waterville	46	liver laceration, tension pneumothorax ® side	
CMMC	1	Respiratory failure	
CMMC	58	myocardial infarction	
MCMH	46	3rd degree burns	
Mayo Regional		Respiratory distress	
EMMC	2	lethargy	
Calais Regional	3	Bowel disease,fever	
EMMC	0	male, 3.8 kilos, bronchiolitis	
Wentworth Douglas Ho	53	GSW to neck	
FMH	54	pelvic fx - skiing accident	
CMMC	27	3rd degree burns	
Calais Regional	3 mos.	RSV	
Frisbee Memorial	2 mos.	Respiratory distress	
FMH	72	AAA	
Frisbee Memorial	33	head injury	
Stephen's Memorial	11	Abdominal pain	
Frisbee Memorial	79	Dyspnea	
Stephen's Memorial	31	head injury; epidural bleed, skull fx	
MG Augusta	7 mos.	cardiac arrest	
Memorial Hospital	66	AAA	
RFGH	5 weeks	epiglottis	
St. Joseph's	4	ingestion, toxic substance	
Memorial Hospital	52	GI Bleed	
PBMC	70	Acute renal failure post liver transplant	
Rumford	60	MI	
Rumford	58	Chest pain	
Frisbee Memorial	14	unconscious	
Rumford	66	Chest pain	
Frisbee Memorial	2	ingestion, toxic syndrome	
Frisbee Memorial	42	head injury	

MMC Transports
January 2002 - Present

Origin of call	Age	Chief Complaint	Destination
PBMC	80	Aneurysm	
Memorial Hospital	74	Chest pain	
Frisbee Memorial	2	head injury	
Rumford	58	Chest pain	
DECH	80	Thrombosis, femoral	
Brunswick (scene)	5	neck injury (ATV)	
DECH	22	pulmonary embolism	
TAMC	22	Tib-Fib fracture	
TAMC	9	liver injury	
RFGH	83	abdominal pain; leaking aneurysm	
Rumford	68	Chest pain	
PBMC	35	intracerebral hemmorhage	
FMH	4	respiratory distress	
FMH	12	unconscious; overdose	
NMMC	2	25% burns	
Memorial Hospital	90	GI Bleed	
Memorial Hospital	67	Chest pain	
Calais Regional	15	pelvic sepsis	
FMH	53	cryptogenic cirrhosis	
PBMC	73	occipital parietal bleed	
Memorial Hospital	82	head injury	
Bridgton	3	leg injury	
EMMC	40	pelvic fx	
Frisbee Memorial	16	femur fx, fempopbypass ® leg	
Bowdown (scene)	5	head injury	
West Bath (scene)	20	MVA; abdominal pain	
Houlton Regional	58	tumor, abdominal pain	
Rumford	67	Chest pain	
Memorial Hospital	75	Chest pain	
Rumford	30	facial contusions	
Vinalhaven Clinic	77	Subdural hematoma	
York Hospital	43	head injury	
EMMC	11	facial injury	
CMMC	45	3rd degree burns	
Memorial Hospital	81	cardiac arrest	
PBMC	46	cardiac arrest	
PBMC	66	abdominal pain	
CMMC	75	myocardial infarction	
CMMC	8 mos.	seizure, active	
PBMC	69	pneumothorax	
PBMC	56	cardiac arrest	
Port Clyde (scene)	4	head injury	
Palermo (scene)	8	MYA; head injury	
FMH	47	Chest pain	
Frisbee Memorial Hosp	25	head injury	
Rumford	44	Lower GI bleed	
Bridgton	49	Chest pain	
Bridgton	3	head injury & abdominal	
FMH	6 mos.	head injury	
EMMC	68	interarterial TPA, CVA	

MMC Transports
January 2002 - Present

Origin of call	Age	Chief Complaint	Destination
CMMC	55	MI Chest pain	
PBMC	74	interparenchemal bleed parietal lobe	
Memorial Hosp.	55	Shock, throat & mouth cancer	
CMMC	45	Myocardial infarction	
Rumford	76	Chest pain	
Vinalhaven (scene)	76	Chest pain	
Standish (scene)	30	Back pain	
Memorial Hosp.	45	Spinal cord injury	
PBMC	44	MI; TNK	
FMH	10	Seizure disorder	
CMMC	64	Pulmonary Edema	
Bridgton	42	Chest pain	
Bridgton	73	Subarachnoid Blee	
EMMC	11	skull fx; pulmonaryu contusion	
CMMC	3	epileptic seizures	
Rumford	8	Right ankle fx, pain shoulders, chest, neck	
CMMC	1	Seizures, epiliepsy	
CMMC	72	Spinal cord injury	
MMC	52	liver failure	Lahey Clinic
Rumford	46	Chest pain; unstable angina	
FMH	62	liver failure	
CMMC	53	Acute MI	
Rumford	42	chest pain	
Memorial Hosp.	7 mos.	Congenital heart defect w/respiratory distress	
Memorial Hosp.	67	Myocardial infarction	
Memorial Hosp.	9	Miotonic dystrophy	
Memorial Hosp.	43	Abdominal pain	
Memorial Hosp.	57	chest pain	
Memorial Hosp.	5	skull fracture	
Miles Memorial		pulmonary fibrosis	
Bridgton	20	Fx spleen, elbow	
Memorial Hosp.	78	Abdominal pain	
PBMC	64	MI	
Frisbee Memorial Hosp	34	Head injury	
PBMC	86	Chest pain	
MMC	52	1st, 2nd & 3rd finger amputation	Brigham & Women's
FMH	70	MI	
PBMC	30	Back injury	
Memorial Hosp.	41	Cerebral hemmorhage	
CMMC	32	Spinal cord injury	
Androscoggin Valley Ho	43	Respiratory distress	
Rumford	75	cardiac	
Rumford	47	MI	
PBMC	55	chest pain	
Speare Memorial	48	thrombolitic leg	
Frisbee Memorial Hosp	69	Head injury	
St. Joseph's Hosp.	0	Abdominal pain	
Rumford	69	Respiratory distress	
NMMC	58	Hemoptysis	
Miles Memorial	17	head injury	

MMC Transports
January 2002 - Present

Origin of call	Age	Chief Complaint	Destination
Androscoggin Valley Ho	80	Pelvic fracture	
Miles Memorial	16	head injury	
WCGH	34	Cirrhosis of liver	
MCMH	24	Atrial flutter	
PBMC	52	chest pain	
Memorial Hosp.	72	Myocardial infarction	
Rangely (scene)	60	Scalding facial burns	
TAMC	47	burns	
Huggins	39	Facial injuries	
Frisbee Memorial Hosp	21	head injury	
Memorial Hosp.	53	Seizures	
Memorial Hosp.	76	chest pain	
MMC	50	2nd & 3rd degree burns head to thighs	Brigham & Women's
MMC	15	pinky amputation	Boston Children's Hosp.
Rumford	78	Aneurysm	
PBMC	73	hypotension	
MMC	43	thumb amputation	Brigham & Women's
CMMC	39	3rd degree burns	
NMMC	79	Fever	
Parsonfield (scene)	35	3rd degree burns	
MMC	35	3rd degree burns	Mass. General
Memorial Hosp.	57	CP	
FMH	41	GSW - right hand	
CMMC	9	head injury	
Memorial Hosp.	37	overdose	
CMMC	70	cardiac	
Huggins	5	MVA	
CMMC	40	MT	
FMH	69	Left anterior lateral MI	
Huggins	21	overdose	
PBMC	62	Subarachnoid & subdural hematoma	
Rumford	47	cardiac	
No. Haven Clinic	85	Chest pain	
Memorial Hosp.	33	neck	
CMMC	70	cardiac	
CMMC	59	Myocardial infarction	
PBMC	57	Myocardial infarction	
Pittston (scene)	14	Femur fracture	
Frisbee Memorial Hosp	52	AAA	
MG-Waterville	62	Obstructed aorta	
Frisbee Memorial Hosp	21	cut throat	
CMMC	55	cardiac	
Androscoggin Valley Ho	35	Acute abdomen	
Androscoggin Valley Ho	34	MT	
CMMC		MI	
Memorial Hosp.	76	Intracerebral hemorrhage	
Otisfield (scene)	21	OB	

Dept. of Planning & Development
Planning Division

Alexander Jaegerman
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CITY OF PORTLAND

Lee, Sarah, Rick Seeley -

The copy previously distributed was missing a portion of the executive summary. Please add this to your copy.

Alex

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A SAFETY REVIEW AND RISK ASSESSMENT IN AIR MEDICAL TRANSPORT

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Charles L. Maddow, MD
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EXECUTIVE SUMMARY

INTRODUCTION

In 1998, helicopter EMS (HEMS) saw the beginning of an alarming accident trend. That year there were eight accidents, followed by ten in 1999, and twelve in 2000. That was a significant increase considering there had been only one accident in 1996 and in 1997 there were a total of three. Questions were raised—and the industry, as well as individual programs, began to look for answers. Is HEMS unsafe? Are HEMS crewmembers at a significantly higher risk for injury or death? Is the information available to answer these questions?

In general, the lack of readily available data made it difficult, if not impossible, to answer these questions adequately. This prompted the University of Chicago Aeromedical Network (UCAN) Safety Committee to begin its own investigation and research in the fall of 2000.

There are many ways to review the safety of air medical transport and to assess the relative risk to its crewmembers. For more than a decade, when our industry or industry observers (e.g., FAA, media, general public) looked at HEMS accident information, the only available information was the number of accidents and fatalities—commonly referred to as the raw data. No one was able to determine if the increase in accidents was simply related to an increase in the number of hours flown, or whether HEMS had indeed become more dangerous.

Our primary investigation began with an extensive review of accident and incident data specific to the HEMS industry. Based on this review, a comprehensive research model was developed to estimate and project exposure data that the air medical industry has stated "does not exist". Without this exposure data (number of transports and/or the number of hours flown by HEMS), it would be impossible to calculate annual HEMS accident rates and fatality rates or to draw any meaningful conclusions or comparisons.

The study focus next shifted to a comparison of HEMS accident rates and fatality rates to other forms of air travel. Finally, a comparison of air medical transport to other occupations or "routine" risks is made to contrast the fatality rates and the odds of death. To accomplish this, the "population at risk" in HEMS would need to be determined if we were to attempt to make these unique comparisons. This data has never been tracked or even estimated in the HEMS literature.

Upon analyzing HEMS-related risks and assessing the risks faced by air medical crewmembers, this report also identified ways to enhance program (and industry) safety with the hope of reducing our level of accident exposure. Every occupation has inherent risks. Medical professionals and transportation professionals are no different and are exposed to various risks every day.

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Being safe does not eliminate risk—it reduces it. This paper provides valuable information regarding risk that will hopefully help each and every air medical program and air medical professional better understand their day-to-day risk. More importantly, they will have information that should help guide the coordination, implementation and evolution of a safety and risk management program, thereby reducing the number of accidents and enhancing survivability.

HEMS DATABASE

This investigation began with a comprehensive analysis of various databases to identify individual HEMS accidents and their corresponding fatalities and injuries. Our research model then enabled us to estimate flight hours, patients flown, and other variables for evaluation. Since 1972, HEMS has flown an estimated 3.0 million hours while transporting approximately 2.75 million patients. In 31 years (through September 2002) there have been 162 accidents involving dedicated medical helicopters and four accidents involving dual-purpose helicopters in the United States. There have been 67 fatal accidents with 183 fatalities, including 144 crewmembers. Since 1998, there have been a total of 50 accidents—nearly 31% of all the accidents we have experienced over three decades.

In the early and mid-1980s, during the HEMS industry's most rapid growth, we experienced an alarming number of accidents. From 1980-1987, there were 54 accidents, averaging 7.7 accidents per year. The late 1980s to mid-1990s showed considerable improvement. From 1987-1997, dedicated HEMS averaged 4.9 accidents each year. From 1998-2001, however, we have seen that average more than double to 10.75 accidents per year. Not since the four-year period of 1983 to 1986 have we seen such a large number of accidents.

The data is not uniformly grim, however. Of the 44 accidents from 1998 to 2001, 15 (34%) resulted in at least one fatality. For the 1980s, our accident database revealed 39% of all accidents resulted in at least one fatal injury, while from 1990-1997, that rate had increased to 47%. Despite the increase in accidents over the past four years, the percentage of fatal accidents has declined by nearly 30% compared to the early 1980s. In addition, the last four years have seen the lowest consecutive 4-year fatality rate in HEMS history since the early 1980s. The percentage of fatal injuries has also decreased in the 1998-2001 accidents and we see a higher percentage of crewmembers and passengers who sustained no injuries. The fact remains, nonetheless, that since 1990, there has been an average of 2.5 fatal accidents annually, taking the lives of 5 to 6 crewmembers each year.

RECURRENT FACTORS IN HEMS ACCIDENTS

This report summarizes several notable publications, investigations and presentations that analyze and identify key factors related to HEMS accidents. Included in these studies were evaluations regarding incident, operational, and human factor variables. The analyses included the severity of injury, when HEMS accidents occur, condition of light, phase of flight, purpose of flight, the cause of HEMS accidents, pilot experience, aircraft damage and occurrence of post-impact fires. Two studies were also included that analyzed the chain-of-events and problems that led to past accidents. These reports propose interventions intended to prevent future accidents.

A disproportionate number of HEMS accidents occurred during night operations. While an estimated 38% of all HEMS flights were at night, 49% of the accidents over 20 years (1978-1998) occurred during night operations. It was also found that more accidents occurred during cruise (36%) than any other phase of flight.

Scene transports also accounted for a disproportionate number of HEMS accidents. Since 1988, the percentage of scene response flights has averaged 31%, while a total of 42% of the accidents during patient-related missions occurred on scene flights. If all missions had equal risk, then 31% of the accidents should have been on scene missions.

Pilot error was attributed as the direct or indirect cause of HEMS accidents nearly three times more often than mechanical failure. The studies we analyzed have associated human factors with 65-76% of the HEMS accidents studied. Of the fatal accidents studied, human error was associated with 84%. Human error was a factor in more than two-thirds of the en-route accidents, more than 80% of the accidents during takeoff, and approximately 90% of the accidents during approach and landing.

In 1988, the NTSB concluded that poor weather poses the greatest single hazard to EMS helicopter operations. Subsequent publications found that in the 1980s, 22% of the accidents were determined to be weather-related. In the early to mid-1990s, 32% were related to weather. Tragically, while the total number of accidents went down, the percentage of weather-related accidents had increased by 10%. Since 1998, however, it appears that this trend has dropped significantly to less than 15%. In addition, 88% of the weather-related HEMS accidents occurred at night. Approximately 75% of all weather-related HEMS accidents resulted in fatalities and nearly two-thirds had no survivors.

In-flight collision with an object (CWO) has occurred with 25 HEMS accidents and there has been a dramatic increase in the number of CWO accidents and incidents over the past few years.

More than 25% of the accidents involving CWOs resulted in fatalities. Sixteen (64%) of these CWO accidents occurred during scene response missions. Once again, if all missions had equal risk, 31% of the CWO accidents should have been on scene missions. Instead that percentage rate has more than doubled. It was also identified that more than 40% of all the approach and landing accidents and 50% of all takeoff accidents were CWOs. Unexpectedly, weather has not been identified as a factor in CWO accidents.

Also unexpectedly, pilot fatigue and total hours of flight time do not appear to be significant factors in HEMS accidents. Analysis of HEMS incidents suggests that an IFR rating and currency may be protective in overcoming situations and avoiding accidents. In addition, communications problems, time pressures, and distractions are frequently identified as

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contributing risk factors in HEMS accidents and incidents.

The magnitude of injuries and aircraft damage is significant in HEMS accidents. HEMS accidents are more likely to result in fatalities or serious injuries than other helicopter accidents. One study found that main cabin occupants in EMS helicopters have nearly 4.5 times the risk of serious injury (especially back injuries and head injuries) or death in survivable crashes when compared to a comparable population of occupants in the main cabin of non-EMS air taxi helicopters. For front seat occupants, there was no significant difference in injury risk between the two groups. This seemed to support the author's premise that EMS aircraft modifications, which are generally limited to the main cabin, were directly associated with the risk of injury and may contribute to occupant injury and death in otherwise survivable crashes.

Different studies reported the incidence of post-impact fires between 2-15%. Nearly half of the accidents resulted in the destruction of the helicopter. No conclusions, however, can be made regarding single- vs. twin-engine aircraft.

HEMS ACCIDENT AND FATAL ACCIDENT RATES

An important aspect of this study was the determination of HEMS accident and fatal accident rates for the defined study period (1980-2001). Calculations are based upon estimated exposure data, which has been determined through several industry-wide surveys, various calculations and several assumptions, which are stated.

An extensive review of the air medical literature was conducted to determine what data was available. Total flight hours and total patients transported were unavailable for more than 50% of the years reviewed. For various years, published data included: average flight hours per program, total patients transported, average patients transported per program, loaded miles, and average flight hours per patient transport. Unfortunately, there was no data regarding the number of HEMS programs or dedicated helicopters in operation since 1992.

Considering the available vs. unavailable information, it was concluded that if the number of programs and helicopters in operation could be determined, then the total flight hours and patients transported could be estimated for the year. Furthermore, an assumption was made that the growth in the HEMS industry has been fairly constant since 1992. It would then be possible to estimate the number of programs and helicopters for the years lacking data.

To determine a fairly accurate number of dedicated HEMS programs and helicopters, several steps were performed. First, a state-by-state survey was posted on the *Flightweb* listserve. The resulting information was supplemented by the AAMS Membership Directory and the "Directory of Air Medical Programs" published in *AirMed*. To further supplement these results, information was obtained from the helicopter manufacturers and a survey of five of the largest HEMS operators was conducted.

It was also determined that our research model should include *total* flight hours in this evaluation. In HEMS, a considerable number of accidents occurred on non-patient missions—including public relations (PR) flights, refueling, maintenance, training, and so on. Personal correspondence with several HEMS programs and operators suggests that non-patient flight time may range from 5 to 15%. PR flights made up approximately half of this for many programs. In an effort to more accurately determine the average number of total flight hours per program, additional information was obtained from the surveyed HEMS operators.

The survey results identified 231 dedicated HEMS programs, operating a total of 377 helicopters (excluding back-up aircraft). Subsequent discussion with several industry leaders and evaluation of information from the aircraft manufacturers suggests that, if anything, these numbers may be slightly underestimated. The helicopter manufacturers estimated that there were 462 medical helicopters (dedicated and backup) in the United States, not including dual-purpose helicopters. With an average of one backup for every 7.1 dedicated helicopters in the combined operators fleets, there are an estimated 53 backup aircraft yielding a total of 430 helicopters. This represents a variation of approximately 7% fewer aircraft compared to the number of helicopters from the manufacturers' survey. This may also indicate a slight discrepancy in the number of HEMS programs resulting from th Internet survey. In using the lower state-by-state survey results of 377 dedicated helicopters and 231 programs for our calculations, it is realized that the proposed exposure data (flight hours and number of patients transported) may be underestimated. As a result, the calculated accident and fatality rates could be overstated by an estimated 7-10%. This difference, however, does not impact the overall trends identified in HEMS accidents nor the comparison with other aviation operations.

The calculated results show a dramatic decrease in the HEMS accident rate since the mid-'80s. As the raw data would predict, the accident rate since 1998 has steadily increased. However, despite this increase, the rate remains roughly one-third of what was experienced in the early to mid-1980s due to the overall increase in flight hours.

Looking at an average accident rate for 1992-2001, (3.78 accidents per 100,000 flight hours), the average HEMS progra flying 911 hours per year, would have on accident over 29.1 years of flight time. If a program flies less, the number of years would presumably increase, and if a program flies more, the time frame would decrease. Another way to propose the likelihood of an accident would be to compare the number of accidents to the number of programs (or helicopters). Again, using the most recent ten years, there has been an average of 7 accidents each year. With 231 dedicated HEMS programs, and assuming all things being equal, we would find a similar prediction of one accident per program every 33 years. If you base this comparison on the number of dedicated helicopters estimated for 2001 (400) rather than programs, the margin now goes up to nearly 57.1 years. Looking at the average number of HEMS accidents (9) for the past five years, we would expect one accident per helicopter every 44.4 years.

The second comparison looks at the fatal accident rate per 100,000 flight hours. Here too, a dramatic improvement is identified since the early and mid-1980s. Our current rate, despite having gone up slightly over the past few years, is approximately 75% less than our worst years. Once again if we take an average flight program and an average fatal accident rate for the past ten years (1.38 fatal accidents per 100,000 flight hours), we would predict one fatal accident while flying for over 79.3 years. When we focus on the average fatal accident rate for 1997-2001 (1.69) this figure drops to 64.8 years.

The final normalized comparison evaluates the accident rate per 100,000 patients transported.

With a 10-year (1992-2001) average accident rate of 3.89 accidents per 100,000 patients transported and the typical HEMS program flying 882 patients in a year, a program would have one accident while transporting an estimated 25,700 patients over 29.2 years. Calculations for 1998-2001 (4.79 accidents per 100,000 patient transports) resulted in an estimate of one accident while transporting nearly 21,000 patients over a 23.74 year period.

A final annual comparison of HEMS accidents considers the percentage of HEMS programs and helicopters that have sustained an accident. These calculations do not take into account the possibility that an individual program may have suffered more than one accident—which has occurred. Overall, the 22-year average annual percentage calculates to 5.8% of the programs having had accidents between 1980 through 2001. If one considers only the past five years, an average of 4.1% of the programs have had an accident each year. In 1982, an estimated 16.3% of the HEMS programs (8 accidents, 49 programs) were involved in accidents. The safest year was in 1996, when an estimated 0.5 % of the programs had an accident (1 accident, 207 programs).

Calculating the percentage of helicopters that were involved in HEMS accidents each year finds a high of 12.9% of the HEMS aircraft in 1982 (8 accidents, 62 helicopters). In 1996, there was 1 HEMS accident during a year when an estimated 309 dedicated medical helicopters were in operation, for a total of 0.3%. The average percentage over 21 years calculates to 4.4% of the HEMS fleet. Over the past 5 years, this percentage has averaged 2.5% for each year.

HEMS COMPARED TO OTHER AVIATION OPERATIONS

Raw data and normalized statistics are available from the FAA/NTSB for the different types of aviation operations. With the estimated accident and fatality rates per 100,000 flight hours for HEMS, it is now possible to compare various types of aviation in a more meaningful way.

The accident rate for HEMS was dramatically higher than for all other aviation operations during the early and mid-1980s. Beginning in 1987, we see a sharp decline in the HEMS accident rate, which has remained consistently below the accident rates for both general aviation and all helicopter aviation. In addition, from 1987 through 1997, the HEMS accident rate was lower than the overall accident rate for all Part 135 non-scheduled flights 6 of the 10 years. Since 1998, however, the HEMS accident rate has surpassed that of the non-scheduled Part 135 operations each year

Comparing the average accident rates for the past 20 years (1982–1999), 10 years, and 5 years for the five types of aviation operations, helicopters, and HEMS yield some interesting findings. Even with the high accident rates of the 1980s, the 20-year average for HEMS is below all helicopter operations and general aviation. For the 10-year average, the HEMS accident rate is less than 50% the rate of helicopters and general aviation. For the past 5 years, the average accident rate for HEMS has gone up, but remains significantly lower than all helicopter operations and general aviation.

Initially, the fatality rate for air medical helicopters was equal to or dramatically higher than all other aviation operations. In 1990, however, there were no fatal HEMS accidents. From 1992 to 1997, HEMS was consistently below both general aviation and all helicopter operations in fatal accidents. Since 1998, the HEMS fatality rate has been consistently higher. Looking at the average fatal accident rate for the past 20 years, 10 years, and 5 years for the various aviation operations, HEMS has a higher fatal accident rate than all other aviation during the 20-year period. However, over the past 10 years HEMS has averaged a lower fatality rate than helicopters and general aviation (Part 91). For the past 5 years, however, the average HEMS fatality rate once again exceeded all other aviation operations.

A COMPARISON OF RISK

In order to assess and compare risk, the relevant figure needed must be in the form of a ratio, fraction, or percentage. To arrive at these figures normalization of the data had to occur and we needed to know two primary numbers. The numerator of the fraction tells us how many individuals doing a particular activity were either injured or killed over a given period of time. The denominator represents how many people were engaged in that activity—the population at risk. By reducing all risks into ratios by utilizing this format we can begin to compare different types of activities and the relative risks.

If one were to try to compare air medical transport to other occupations or "routine" risks to determine either the odds of death in one year or the fatality rate per 100,000 (the most common comparison) we would need to know two things. The first is the number of HEMS crew fatalities per year. The second would be the number of people engaged in HEMS transport (i.e., the number of HEMS pilots and medical crewmembers) for each year. The number of fatalities is known, but the number of crewmembers in HEMS has never been tracked.

For the purpose of this study, the average number of crewmembers per helicopter is estimated to be 22 persons (4 pilots, 6-8 nurses as the primary caregivers, and 10-12 second medical crewmembers). In 2001 there were an estimated 400 dedicated medical helicopters, producing an estimated population at risk of approximately 8,792. Having estimated the number of helicopters for each year in this study, the number of crewmembers can be approximated for each year.

It is important to realize that in estimating exposure in this method, it does so for the *average* crewmember and the *average* flight program. When the raw data is normalized, it does not take into account the *amount* of exposure for an individual during the year. For this por-

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tion of the study, calculations are based on the average program, which in 2001 transported approximately 882 patients, flying an estimated 957 hours over the course of the full year, and all crewmembers (pilots and medical crewmembers) flying an equal amount of time.

Fatality and Death Rates

Fatality statistics for HEMS personnel are presented in several different formats. In each case, the number of crew fatalities was determined for each year. To be consistent with statistics from the National Safety Council (NSC), the data was normalized to produce a death rate per 100,000 population at risk for each given year. Over the 21 years reviewed for this portion of the study (1981-2001), the HEMS population has grown from approximately 858 to 8,792. While this growth seems impressive, this is still a very small sampling to translate to a ratio per 100,000. With such a small population base, each fatality has a significant impact on the fatality rate. In this design, the range for the HEMS crewmembers fatality rate is from 0 to 699 per 100,000. With such a wide range, a 22-year average was calculated and used in the various comparisons. The average annual death rate over the 22 years is 196 per 100,000 crewmembers.

Another relationship used to compare the annual number of HEMS crew fatalities is in terms of "odds." For example, in 2001there were only two crew deaths out of an estimated crew population of 8,792. Looking solely at the numbers, the odds to an individual crewmember suffering a fatal accident that year would be considered to be 1 in 4,396. Contrasting this with what could be considered our riskiest year (1980), there were 6 crew fatalities out of an estimated 858 crewmembers industry-wide. This would correspond to fatality odds of 1 in 143. Excluding 1990 when there were no fatalities, the average odds per year over the 22-year period are 1 in 1,158.

To further illustrate the risk related to HEMS transport, we can compare and contrast the above numbers with other activities, other types of accidents, and other causes of death. Taking into consideration the wide range of fatality rates and odds that we have estimated for each year in HEMS, the calculated averages are used in subsequent comparisons.

In 1998, the death rate per 100,000 for all accidental deaths was 36.2. Motor vehicle accidents were the highest in this category with 16.1 deaths per 100,000 individuals. When one considers the average annual death rate (192) for HEMS crewmembers over the 22 years reviewed, HEMS is surpassed only by heart disease (268.2 deaths per 100,000) and cancer (200.4 deaths per 100,000) when the data is normalized. The average one–year odds of 1 in 1,158 for HEMS crewmembers is also higher than the one-year odds for all deaths due to injury (1 in 1,796) and all accidental deaths (1 in 2,762).

A final comparison looks at the estimated exposure that will produce a 1 in 1,000 risk of death.

In the 22-year HEMS study period an estimated 3,002,176 total hours have been flown. Adding together the estimated number of crewmembers each year yields a total of 105,922. This corresponds to an average exposure of 28.3 hours of flight time producing the estimated odds of 1 in 1,158. Adjusting the ratio to 1 in 1,000, we get an average exposure of 32.9 hours.

HEMS: The Risk to the Patient

There is some level of risk related to all aspects of healthcare. The results of two comprehensive studies have suggested that between 44,000 and 98,000 Americans die in hospitals each year as a result of medical errors. Normalizing these numbers produces a death rate between 131 and 292 per 100,000 patients due to medical errors. The NSC, however, provides statistics on "complications of surgery/medical care" that is based upon the reported number of deaths compared to the entire U.S. population. Their finding of 1.2 deaths per 100,000 individuals is dramatically different.

While air medical *transport* is not a medical *treatment* and aviation accidents would not be considered a medical error, some could argue that these accidents represent an adverse event in the healthcare environment. In our 22-year study, we estimate a total of 2,745,207 patients have been flown by HEMS. Over this same time period, 21 patients have lost their lives in HEMS accidents. This corresponds to a death rate of 0.76 per 100,000 patients flown. Based upon these figures, it would appear that there is a far greater risk to the patient of dying from an adverse event while hospitalized than from an accident aboard a medical helicopter.

Occupational Risks: Deaths and Injuries in the Workplace

The NSC reports an average death rate across all industries at 3.8 per 100,000 workers, with mining (21.2) and agriculture (22.5) having the highest rates. With a death rate of 192 per 100,000, the HEMS death rate is approximately nine times greater than the riskiest industries. However, it must be pointed out that this comparison is greatly distorted when you consider the small HEMS "population." Even in 2001, with our largest estimated number of crewmembers, 2 fatalities resulted in a death rate of 23 per 100,000.

RISK MANAGEMENT IN HEMS

A HEMS accident is not caused by a single event, but by a chain of events. In most accidents, numerous risk factors can be identified. Acting on any of these risks and breaking the chain at any point may prevent an accident from occurring. Safety of flight requires the right attitude and active participation. Every pilot, mechanic, medical crewmember, communication specialist, and administrator must be fully knowledgeable of their role and responsibilities. Each must be committed to a safe operation and to ongoing risk management. Nothing takes the place of comprehensive training, proficiency, and sound judgment.

An important training component should be Air Medical Resource Management. The goal of AMRM is to improve crew communications and interactions by addressing teamwork, communication skills, decision making, workload management, situational awareness, preparation and planning, cockpit distractions, and stress management.

The risks in HEMS should not be underestimated. The cumulative effects of multiple risk factors must be considered when making decisions on each and every transport. Risk management is a major component of the decision-making process. It relies on situational awareness, problem recognition, and exercising good judgment to reduce risks associated with each flight.

Accident prevention must be the objective. But there will be "a next accident." The air medical community and each program must be certain that the proper aircraft, systems, training, and equipment are in place to enhance the survivability of an accident. A study that evaluated the use of helmets in survivable military crashes found that main cabin occupants with no helmet were at 5 times the risk for a serious head injury and 7.5 times the risk for a fatal head injury than their helmeted counterparts. Another series of U.S. Army studies found that shoulder harnesses were an important factor in reducing the incidence and severity of serious back injuries. Yet, not every crewmember wears a helmet, not every aircraft is equipped with shoulder harnesses and not every person buckles their seat belt prior to takeoff.

CONCLUSION

Throughout all types of industry, there is generally a 20/80 ratio when it comes to accidents: 20% of all accidents are caused by machine-related problems and 80% of the accidents are caused by human error. This seems to be accurate for HEMS as well. The NTSB commonly identifies "pilot error" as the probable cause in the majority of HEMS accidents. But is it truly *pilot* error? Or have we all failed in some way?

There is no logical reason for the increase in the number of accidents over the past several years. We have regulations, we have safety committees, we have standards, we have safety summits, we have AMRM, we have surveys and we have reports. We have better aircraft, we have newer technology and we have accreditation. And we have 30 years of experience. What we also ***still*** have are unnecessary pressures, unnecessary risks, unnecessary distractions, poor communications, complacency—and the same old human errors. What we do ***not*** have is an excuse!

This report provides a comprehensive review of past studies and offers considerable new information regarding accident rates and risks related to HEMS. This report does not provide the solution to a safer industry. Only you can do that—at your program, on your next flight, on every flight. By providing new information and increasing awareness, we hope to decrease future accidents, and to better educate flight program personnel of the potential risks at hand each and every time the phone rings and the aircraft lifts off.

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LIFEFLIGHT OF MAINE

19 October 2003

Mike Ryan, Vice President Operations
Maine Medical Center
22 Bramhall St.
Portland, ME 04

RE: Follow up neighborhood meeting Sept. 24th.

Dear Mike,

Apologies for the delay in getting this information requested by Karen Geraghty and Ann Pringle. We have just completed national accreditation and we have had two comprehensive site surveys in the last several weeks. We were very pleased that in both surveys the three highest sections of the standards commended were for our physician oversight, quality management, and safety program and practices. From my meeting notes there were two areas of requests for further information from Karen and Ann. The first is the potential noise impact which the final study results by RSE will answer. The second issue is safety. As Maine's experience with air medicine previous to LifeFlight ended in tragedy, this is a fair and timely question. From the outset, in designing LifeFlight, we paid close attention to all of the incentives and disincentives to ensure the highest regards to safety in all operations.

I have attached two articles regarding safety. The first is a major compilation of various air medical safety studies over the past 10-15 years by Dr. Ira Blumen and colleagues at the University of Chicago. This study was published by the Air Medical Physicians Association and resulted from a risk analysis for staff, particularly their flight physicians by UCAN.

The second is a paper that I wrote last year for Aviation International News in response to a paper written by a plantiff's attorney who specializes in representing victims of aviation accidents. Essentially this is a review of the risk and benefits question.

In a discussion on safety and risk, it is extremely important to have a contextual base for what the studies indicate. As air medicine, especially the use of helicopters, is the exception rather than the rule for transporting patients and the stakes are always high, there is high media interest and tremendous emotion as a backdrop for everything we do. Consequently, accidents are always high profile.

Without question there is some element of risk in what we do in LifeFlight. This is no different than for our colleagues in fire, EMS, and law enforcement. Similar to our public safety colleagues, the risk is primarily to the medical crews and pilots. The challenge is to recognize, identify, acknowledge, and manage the risks in a manner that reduces risk to the minimum and ensuring that the expected benefits always outweigh the risks incurred.

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It is important to also note that there is risk in all of medicine. Physicians manage the risk and benefits of therapy on behalf of patients every hour of every day—in medication regimens, surgery, and even the choice not to intervene. Every time an aircraft is tasked and a patient is put into an aircraft is the result of a direct physician order for a time and care critical medical intervention. This is why it is essential that physicians oversee every component of operations in LifeFlight.

In addition to our medical director, Dr. Norm Dinerman, MD, FACEP, Chief of Emergency Medicine at EMMC, and our Associate Medical Directors, Dr. Kevin Kendall, MD, FACEP, Emergency Medicine CMMC, and Dr. Mike Baumann, MD, FACEP, Medical Director Emergency Medicine, MMC, LifeFlight's medical teams, protocols, and quality assessment and management are overseen by 14 additional emergency medicine and specialist physicians from across the state.

Specifically, in response to the question of data as regards safety, to date in 2003, nationally there have been nine accidents producing major structural damage to an aircraft, injury, or fatalities in medical aircraft. These have occurred during all operations—maintenance, ferry flights, pilot and ground crew training, and patient transport. Patient transport operations are approximately 60% of total operations flight time.

Four of these accidents have resulted in injuries or fatalities. Three of the four accidents resulted in one or more fatalities. No patient fatalities have occurred this year. Of the three fatal accidents this year, one occurred on the grounds of a major airport in fog conditions (Salt Lake City), the second occurred while the aircraft was enroute back to base from a refuel at the local airport (Northern Illinois), and the third accident occurred after a rescue hoist operation in which the aircraft was returning to base after dropping off the hoisted patient to a waiting ground ambulance (Utah).

In 2002 there were 11 total accidents in which five accidents resulted in one or more fatalities. The three year period 2001-2002 averaged 13 accidents per year with 6 on average resulting in serious injury or fatalities, primarily to pilots or medical crew as risk is nearly completely tied to exposure. There has been one accident since 2000 in which someone on the ground not associated with the flight was injured or fatally injured. (Hospital security guard tail rotor strike in 2001)

As in all areas of medicine there must be constant effort to reduce the error rate to zero, however, risk also needs to be put into a context of use. There are two distinct equations which help provide background context to the overall safety question.

The first is overall risk compared to transport volume. Dr. Blumen used admittedly conservative statistics in calculating risk exposure. Nationally, there are approximately 500 air medical provider agencies operating around 450 medical helicopters being used for primary medical (HEMS) or combination medical-rescue missions. Most of these provider agencies, similar to LifeFlight, are hospital based or affiliated with fully dedicated critical care air medical helicopters. These services now provide an estimated 250,000+ HEMS critical care patient transports per annum in the US with an average annual increase of 5-7% in transport volume primarily due to the continued loss of fixed healthcare services—hospitals, specialist physicians, and emergency departments, in rural areas.

From a standpoint of volume the accident rate is stable or declining with an three year average of one accident for every 19,000 plus patient transport flights and an injury or fatal accident rate of one per 41,500 patient transport flights. NASA, the NTSB, the FAA, insurance carriers, the Helicopter Association (HAI) aviation operators and Association of Air Medical Services (AAMS) are all extremely involved in safety initiatives to reduce the accident rate. LifeFlight is very involved with these efforts with leading membership roles on the AAMS / CORE Industry Safety Committee and the Air Medical Safety Advisory Council as well as working regionally with the Northeast Air Alliance. In addition to the national safety award LifeFlight that will be presented to LifeFlight next month, Keystone Helicopters just won a Platinum Safety Award from HAI.

The second equation of risk has to do with balancing risk and benefit. Based on published studies, the most conservative projections are that between 2 and 12% of all HEMS patients are considered "unexpected survivors." This group would not have survived their illness or injury without access to a medical helicopter. The trade off for taking on some risk and potential for life lost in an air medical operation is the tremendous patient benefit gain of a minimum of 5,000-30,000 lives saved per year in the US.

The HEMS effect on survival is most pronounced in rural areas with estimates in excess of 30% for unexpected survivors. A recent study in Academic Emergency Medicine from Oregon Health Sciences looked at inter-hospital transports in two rural regions each comprised of four rural hospitals. One region lost HEMS service due to an accident and subsequent withdrawal of available helicopter transport. The comparator region had and maintained HEMS service. After a one year adjustment period (to allow for the ground EMS system to stabilize) in the rural area without HEMS service the researchers found a four fold increase in mortality rates secondary to trauma.

A recent multi-hospital study from Boston (non-rural area) published in the Journal of Trauma indicated that 24% of blunt trauma patients are unexpected survivors. Blunt torso and head trauma / traumatic brain injury are the primary constellation of injury for LifeFlight patients. Based on the Boston study alone there are in excess of 230 patients in Maine who owe their survival to LifeFlight's ability to provide critical care on-scene with rapid transport to trauma surgeons in Maine's tertiary hospitals.

The other risk equation specific to the helipad at MMC is a combination of the exposure rate in volume of transports and the risk to patients and the public in landing at the airport with secondary ground transfer.

Helicopters are used for the exceptional patient needing both critical care skills and equipment not available in ground ambulances and time critical transportation. As an example, there are approximately 200,000 ground ambulance transports in Maine alone each year of which in excess of 100,000 are 911 generated emergency transports. We estimate that MMC will receive approximately 200-250 patients per annum via LifeFlight. Currently, most of these patients require a lights and siren response across the city with associated risks to other vehicles and pedestrians.

The more important issue is the risk to critically ill or injured patients is successive transfers, each adding both a time delay and additional handling that can lead to loss of breathing tubes, intravenous fluid and medication lines, and invasive monitoring lines. This is the typical profile for an air medical transported patient.

Entering the hospital via a helipad versus secondary ground ambulance transport from the airport or off site landing area not only saves precious minutes for patients but reduces additional patient handling. Our experience is that even short—1-2 minute driving time events add upwards of 8-10 minutes for transfer of patients due to the loading and unloading of the ground ambulance. The typical ground transfer via the Portland Jetport can add up to 20 minutes or more to total transfer time.

Helipads are considered the state of care for tertiary and trauma centers throughout the country. Rooftop helipads are the norm in most urban centers due not only to available land area and flight paths immediately surrounding the hospital but rooftop locations decrease noise impact and increase safety as the pads have controlled "person" access.

Hospital helipads increase the safety of patient care in both time savings and reduction of clinical risk. While time savings may not seem an intuitive patient safety issue, decreasing access time to specialist physicians is the best and safest care we can provide unstable patients.

As Maine's largest hospital with specialized services for critically ill and injured patients it is extremely important for all of Maine's citizens and visitors to have this gateway to care when needed. While the number of patients that will arrive at MMC using this new "door" is very small—hundreds of air transports annually versus the several thousands of annual emergency ground ambulance transports arriving at the ED—these patients are the most clinically vulnerable of Maine's citizens, all experiencing a time critical emergency.

Please let me know if I can provide any further information.

Sincerely,

Thomas Judge, CCT-P
Executive Director

Attachment II

AAMS

Thank you for the opportunity to comment on Mr. Slack's monograph, "*Air Ambulance Operations: Enhancing Public Safety or Causing Unnecessary Tragedy?*" Mr. Slack is to be commended for his interest and promotion of the safety agenda, one which is shared by everyone in aviation medicine. He is also to be commended for acknowledging the idea of best practice through the promotion of the CAMTS accreditation standards.

The author, a plaintiff attorney representing families of passengers or air crew lost to accidents, raises a number of provocative issues in his paper, all of which ultimately focus on the risks and benefits of air medical transport. Unfortunately, much of the author's potential contribution is lost in his rhetoric describing "...HEMS programs are both expensive and dangerous..." This is followed by a remarkable and evidence free conclusion that "the risks of being transported by helicopter may exceed the mortality risks associated with the original injury or illness."

There are five fundamental problems in Mr. Slack's approach and analysis of the issues that we examine in turn:
- the risks and benefits of medicine;
- the measurement of safety in air medical flight operations;
- the problems with extrapolation of one accident into a generalized assessment of air medicine
- the problems with using limited research and erroneous analysis of the evidence that does exist regarding benefits, costs, and overuse; and
- subsequent recommendations and conclusions that are not based on the evidence.

The alarmist tone of the monograph may seem an exciting story and good editorial copy, and may even enhance the author's cases in court. Unfortunately it is misleading and extremely corrosive to the public's trust in medicine. With extreme bias as a starting premise it is impossible for the author to evaluate any evidence on the essential role of air medicine within the healthcare system. We, active practitioners in the field of air medicine, and members of a community that grieves at the loss of the crew of AirCare 1 and other colleagues that have lost lives in the line of duty offer an opposing view of the evidence and what it means.

1. The overarching issue raised by the author is the question of risks and benefits in medicine as a whole. From this overarching issue comes the first fundamental problem with the Mr. Slack's analysis of the safety and necessity of air medical operations. There are risks in all ambulance transport, whether by ground or air, but in allocating air medical response through direct order or protocol, physicians weigh the risks of intervention delays against the hazards of transportation. Without this critical judgement by physicians there would be no air medical transport—at heart, the use of a medical helicopter is a medical therapy in and of itself.

Stated another way, the real question is: can we eliminate the medical risk in any given therapy and at what cost to benefit? Without question, any potential for incident or accident that might produce injury or death in any medical endeavor is a cause for concern. This test of first, do no harm, is faced by medicine and physicians every day in every emergency department, operating room, and in every intensive care unit. In every arena, there is constant balancing of the benefits for individual patients and society as a whole against the known risk of any therapy.

A clear example of this balancing act are patients suffering acute myocardial infarctions, or in lay terms, heart attacks, caused by a blockage in one of the major arteries feeding blood to the heart muscle. Left untreated, patients are at high risk for lethal rhythm disturbances or become debilitated with poor cardiac function due to the loss of active heart muscle. The goal of therapy is to re-perfuse the heart muscle. Each successive minute of delay in breaking the blockage increases the immediate risk of death and long term disability to the patient. Emergency treatment, in simplest terms, is a trial of clot disrupting medications (lytic therapy), the passage of a catheter to undo the blockage in a blood vessel (angioplasty), or a combination of both therapies.

The latter treatment, angioplasty, [1] [2] has been proven the most beneficial therapy, but is only available in specialty heart centers. For a patient experiencing this emergency, time is of the essence and the attending physician must make rapid decisions about the course and location of treatment. For the unstable cardiac patient in a community or rural hospital the physician is required to evaluate the risks of delays in intervention with the risks of transport. Evidence shows that the risks of intervention delays outweigh the risks of specialty team transportation and that for a patient distant from a heart center the best method of achieving early intervention is through air medical transport. [3]

While virtually all patients benefit from these cardiac therapy strategies, a small number will have poor results—the risk side of the therapy itself. Each and every medical therapy has inherent risks. On an hourly basis, emergency, trauma and cardiac surgeons meet this dilemma head-on, balancing risks and benefits, patient by patient. More mundane examples of these tests are clinical trials for new medicines, new therapies for cancer, new surgical procedures, and the endless list of medical advances over time. Each advance comes with benefits and risks. In every arena of medicine, there is constant effort not only to improve care and health outcomes, but also to improve patient safety at every juncture. In fact, much of the current work in improving safety in medicine is looking to the field of aviation for lessons learned in reducing risk.

2. The second problem we identify in the author's analysis is what the author terms a "storm" of accidents. The question is whether there has been a potentially alarming increase in the accident rates of medical helicopters over the past three years. On the surface, the question is answered in the affirmative, but only from the metric of the absolute number of accidents. There are a number of difficulties, however, with such a limited approach. The author, using data from the NTSB, correctly cites a number of accidents producing injury or fatalities in air medical operations since 1998, concluding that earlier lessons about safety have somehow been unlearned. The problem here is the author's surface analysis. While one can cite the absolute numbers, these need to be placed into context of exposure to fully understand the issue.

While the author notes an increase in the number of accidents from 1998 to 2000, as compared with the early to mid 1990's, he provides no corresponding data to understand these accidents in relationship to exposure. Following from annual surveys published in the Air Medical Journal, recent work by Dr. Ira Blumen and colleagues at the University of Chicago [4] presented nationally in the last year and soon to be published, has given context to the accident rate problem. As an example, the major EMS helicopter operators in the US reported a 12% increase in flight hours between 1998 and 1999 alone. Thus, the absolute accident rate must be tied to the exposure rate to make any definitive conclusion about safety of flight operations. The data, normalized over time, indicates that medical helicopter accident rates per 100,000 flight hours are *less* than those of all helicopter operations, general aviation, and scheduled Part 135 operations. This is in spite of the increased hazards of emergency medical unscheduled operations, often at night, using scene-landing zones.

Averaged over the past five years, medical helicopter accident rates of 3.45/100,000 flight hours are significantly less than the mid-1980's rates (13.42/100,000 flight hours) cited by the author. This is not to suggest there is an acceptable rate of accidents. The goal is and must be a zero accident rate. Without question, more needs to be done to ensure safety of air medical operations but clearly lessons have been learned. This is the heart of quality improvement. The fact is air medical operations are safer today than in the early to mid-80's and we argue are evidence of the constant ongoing efforts to improve safety.

3. The wide extrapolation of the benefits argument is the third major problem we identify in Mr. Slack's work. In analyzing the tragic accident with AirCare 1, the author notes a number of distinct human error and aeronautical weather decision-making issues that are of great concern. We share the author's concern regarding how to improve flight decisions and what must be done, which we will discuss later in the paper. Unfortunately, this tragic accident cannot be extrapolated into the author's much wider assertions regarding, "questionable HEMS necessity" or that medical helicopters are "expensive and dangerous" and of "limited benefit to the vast majority of patients transported." Nor does the evidence cited support the author's wide criticism of the costs, benefits, and efficacy of medical helicopter operations citing both outcomes and the problem of over-triage.

The question of outcome benefit associated with air medical response and transport is quite complex and requires a separate paper in and of itself. It is not enough to locate and quote various studies, it is also necessary to evaluate the studies for methodology and accuracy of conclusions. We believe the evidence relates a very different picture. In reverse order from the author, we examine the questions of benefit, costs, and overuse and believe the evidence in each support the case for air medical response.

The question of benefit. In rebutting the assertions of limited benefit, there are two frames of reference for measuring benefit. The first is societal. Does the deployment of specialty medical teams in helicopters save lives?

Having earlier described the problem with the author's analysis of accident rates as compared to exposure it is also possible to quantify the overall risk of death from accident versus the benefit of access to specialty care afforded by the use of medical helicopters. While the impact of a single accident on the individual patient or medical crewmember is profound and cannot be overstated, the benefits of medical helicopter deployment across the population are also profound and should not be understated.

The integration of air medical transport with sophisticated trauma care systems in the United States has dramatically decreased the morbidity and mortality of the critically injured.[5] Numerous studies have shown that trauma center care is effective in improving outcomes, but without an effective means of delivering the patient to the trauma center, mortality increases.[6] Air medical transport is not a goal in itself, but a tool to rapidly deliver advanced medical care to the patient and decrease out-of-hospital time. A major tenet of the emergency care system is that the time from injury to advanced treatment is a crucial determinant in clinical outcomes[7].

Trauma care has improved dramatically over the past several decades. One of the earliest studies of the impact of air medical transport on reducing trauma mortality was by Baxt and Moody in San Diego. In that 1983 study, the mortality of 150 consecutive trauma patients treated at the scene and transported to a trauma center by traditional prehospital EMS was compared with that of 150 consecutive trauma patients treated at the scene and transported to the same trauma center by an air ambulance. A statistical analysis designed to predict mortality based on injury severity revealed that the mortality of the EMS group was statistically no different from that of a large trauma patient population treated at a major trauma center. There was however, a 52% reduction in predicted mortality of the air medical group. This reduction in mortality was attributed to the ability of a helicopter to deliver a highly skilled medical crew to the patient and communicate effectively with the hospital. [8]

Research notes a 2 to 12% increase in unexpected survivors—patients whose lives are saved through the utilization of helicopter medical teams for critical patients. [9] [10] [11] A more recent study reports the reduction in mortality to be as high as 24%. [12] In addition to significantly reduced mortality, the use of medical helicopters also reduces the extent of injury or illness, morbidity. Currently there are approximately 300,000 medical flights per year in the United States, of which just under 200,000 a year are emergency transports by medical helicopter. Using the more conservative unexpected survival rates demonstrated in Gearhart's study noted above, a calculation over the same time period cited by the author (1998-2000) yields an unexpected survivor rate of 11,000-65,000 individuals among the approximately 550,000 patients flown in medical helicopters. This benefit is most evident in the rural landscape where time and distance from a specialty trauma center are as much a problem as the patients specific injuries. In fact, <u>appropriate</u> utilization of air medical operations is directly related to the rural square mile area covered by the helicopter[13] and is generally the predominant decision in determining location, coverage areas, and response protocols for medical helicopters.[14]

The additional frame of reference is the much larger group of patients who may immediately survive their injuries. Does medical transport favorably impact these patients as well? Studies indicate measurable benefits for a wide group of trauma patients including blunt trauma patients, the predominant injury constellation in motor vehicle accidents. Further, they indicate not only are the most severely injured patients benefited through the use of medical helicopters but that moderately injured patients, classified through injury severity and revised trauma scores, also benefit and that on review use was judged to be appropriate.[15] [16] [17] [18] [19]

Additionally, contrary to the author's assertions, the use of air medical scene response, despite inherent hazards, has been shown to decrease time to tertiary care and is correlated with increased survival. [20] [21] In fact, a recent study from Utah compared two rural areas both of which had air medical programs with one area losing the access to air medical service. In comparing the two areas, mortality was noted to increase four times in the area that had lost air medical service as compared to the area with continued service.[22] Clearly we would argue the evidence illustrates a substantial and compelling case for both patient and societal benefit in the unique integration of medical and aviation technology.

In addition to the positive impact on potentially life-taking trauma, increasingly medical helicopters are being recognized as a valuable tool to link community hospitals with needed specialty care. The use of medical helicopters is a tool to increase equity and access to healthcare for rural populations. [23]Outcome and cost effectiveness benefits have been noted in care for stroke patients, [24] [25] cardiac patients, [26] [27] [28] [29] [30]obstetrical patients, [31] [32]neo-nates,[33] and in surgical emergencies [34]as they increase the size of referral to specialty centers due to timesavings. Increasingly, medical helicopters are becoming the access system to critical care in rural areas for critically ill and injured patients. The use of air medical transport is an effective adjunct medical therapy for a wide group of selected patients needing transfer to specialty care centers.

The question of costs. Once again the evidence is not with the author. It is always tempting, but often inaccurate, to equate lower costs with cost effectiveness and higher costs with cost 'prohibitiveness.'

Despite the substantial acquisition and running costs of a dedicated medical helicopter, studies provide a favorable comparison between the costs of using medical helicopters and the costs of other medical interventions when measuring costs per life year saved, and these costs compare favorably with ground EMS transport and other medical interventions. At an average discounted cost per life year saved of $2,454, [35]medical helicopter utilization compares favorably with the average costs of 310 emergency medical interventions at $19,000 measured by Teng and colleagues. [36] Significantly, Teng and colleagues include in their analysis paramedic EMS systems at $8,886 per cost of life year saved and tPA lytic therapy for heart attack victims at $32,678 per cost of life year saved, common community level medical emergency medical strategies, with the latter noted earlier in this paper.

Not only is the measured impact of medical helicopters on a patient level cost effective, but helicopter systems have also been shown to be a cost effective medical transportation strategy with 'true' system costs per air patient transported of $2,811 estimated to be 31% less expensive than ground ($4,475) ambulance systems [37] for comparable specialty team critical care transport response.

The question of overuse. Again, the author uses material out of context to argue there is a problem in establishing appropriate air medical triage guidelines. The overwhelming emergency response and transport of ill and injured patients is by ground ambulance. Air medical transport is the exception rather than the rule and, contrary to the author's assertions, consensus triage guidelines for the wide range of critically ill and injured patients do exist. Triage guidelines developed by the Association of Air Medical Services (AAMS) and the National Association of Emergency Medical Physicians (NAEMSP) are widely used by air medical programs.

These guidelines effectively address the problem highlighted by the author of transport of futile resuscitations. We will note that NAEMSP is about to publish new guidelines for air medical utilization that have been endorsed by AAMS and the Association of Air Medical Physicians (AMPA). Most importantly, and again contrary to the author's assertions, these triage guidelines have been shown to be effective [38] [39] in identifying the appropriate use of air medical resources. The guidelines are used by insurance companies and federal and state regulators and public payors such as Medicare and Medicaid to determine medical necessity of air medical transport. Recent studies in Boston and Calgary looked at the frequency and characteristics of patients discharged within 24 hours of air transport. [40] [41]. These studies demonstrate that air ambulance patients have longer hospital stays and are more seriously injured, indicative of appropriate triage mechanisms. Emergency air medical response is supported through policy and research and widely recognized as an essential component of effective EMS and trauma systems. [42] [43] [44]

4. Unfortunately, the evidence not only contradicts the author's wide extrapolation into the benefits argument but the author's analysis of the data he does cite is fundamentally flawed. The author uses a total of seven studies and one survey article to justify his negative review of the benefits of air medicine. Of these one regarding costs (Sheehey) is quoted out of context. The author notes that two support the use of helicopter retrieval for children. Thus all of the author's negative conclusions are based on a total of four studies each of which is cited multiple times. (Cunningham, Nicholl, Cameron, Owen) This is the fourth problem we identify in Mr. Slack's monograph. The author's question of "...under what circumstances, if any, is HEMS a medically superior means to transport patients" cannot possibly be answered from his extremely limited analysis of the evidence.

Not only has the author used limited research but his analysis of the research is fundamentally flawed. An example, is the use of non-contextual data to back up his assertions and his erroneous interpretation that the use of medical helicopters produces limited benefits. Comparing operations in England (Nicholl)[45] with Texas to illustrate rural ground versus air times is problematic at the least. England, one of the most densely populated countries on earth covers less than a quarter of the surface area of Texas. Major hospitals are estimated to be within 45 minutes drive time of the entire population. Nicholl's study of the system in Cornwall does not say that medical helicopter response is without benefit, but rather notes that outcomes were not improved using the system as practiced currently in England. He calls for tighter medical control and utilization criteria. It is important to also note that the paramedic staffed helicopters in England do not have the same skill mix or advanced protocols used in the US. Further, medical oversight and control, medical crew, and protocols for air medical deployment are completely different than in air medical operations in the US or for that matter, Europe or Australasia. (Australia, New Zealand, and the far east). Nor are guidelines in England based on consensus physician led guidelines as in the USA.

More troubling is the author's use of the evidence. While the author notes findings of "no statistically significant difference" between ground versus air transported patients in the Brooke Army Medical Center study, the study actually finds that "HEMS patients were of significantly higher acuity"[46] and that HEMS evacuation of the more severely injured patients farthest from the trauma center resulted in mortality rates that met national standards. This is a case *for* rather than against use of medical helicopters for critically injured patients.

The author also has problems with the evidence he cites by Cunningham and Cameron in which he acknowledges mixed results. The Cunningham study from North Carolina [47] finds benefit for moderate to severely injured patients as designated by trauma scores, precisely the cohort of patients that are targeted by medical helicopter response guidelines. The Cameron study from Australia[48] looked at severely injured patients attended by a single paramedic medical crew with limited intervention skills. Intubation rates, the placement of essential breathing tubes for critical patients were only approximately 60% of comparable experience in the US which results in the study's negative experience not being easily translatable to the United States. [49] This problem is also a contextual problem similar to the author's use of Nichol's study from England.

The selective use of data, used out of context, to broadly make conclusions about benefits of any therapy is extremely problematic. We believe the author has started from a premise and then looked for data to support the premise rather than objectively looking at the broad range of evidence available regarding costs, benefits, use, and outcomes. Again, this might benefit the author's assertions in other arenas but at the potential detriment to the thousands of patients who owe their lives to this blending of technology and medicine. Even a cursory search and review of the available evidence widely refutes the author's assertions. As noted before, outcomes research is complex and it is always tempting, but inaccurate, to look for the easy conclusion one has already pre-determined. We believe the author has used an extremely limited and erroneous approach to evidence and consequently his conclusions cannot be trusted.

5. Finally, and perhaps the most troubling problem we identify is a combination of the author's recommendations coupled with the assertion that not enough is being done to address safety concerns. Air operators through the Air Medical Safety Advisory Council are already implementing an updated crew resource management program, which targets aeronautical decision making. The FAA and the Helicopter Association International (HAI) have also developed resource tools for air medical programs supporting crew resource management. While the author correctly notes problems encountered, when inclement weather is coupled with poor aeronautical decision-making, his global set of proscriptions does little to increase patient or air medical crew safety. This coupled with his alarmist conclusions that hospitals should discontinue air medical operations until his recommendations are implemented does not help vulnerable critically ill and injured patients. As examples, a single, national set of weather minimums, like all universal rules may be too restrictive for some geographies while simultaneously too undemanding for other geographies. Many of the recommendations, such as increasing pilot total hour experience requirements are not supported by evidence and in fact CAMTS has recently reduced hours-based standards in favor of specific quality management driven training standards.

The author's assertion that little is being done to enhance patient and air medical crew safety is completely inaccurate. Faced with the increased numbers of incidents/accidents in the late 1990's cited by the author, the FAA, NASA, and the air medical community have come together with a renewed focus and emphasis on enhancing safety. There are numerous safety-related initiatives in constant process at the program, air operator, and national levels. Many of these initiatives relate to the general recommendations of the author in supporting better weather reporting and forecasting systems and improving training for pilots and medical crew.

Most significant was the Safety Summit, led by the FAA and the Association of Air Medical Services (AAMS), held in the author's home state of Texas in April 2000. Representatives from all of the major Part 135 Operators, the Helicopter Association International, (HAI) the FAA, NASA, AAMS, and the professional air medical associations representing pilots, (National Association of EMS Pilots NEMSPA) nurses, (Air & Surface Transport Nurses Association ASTNA), paramedics, (National Flight Paramedics Association (NFPA), physicians, (Air Medical Physicians Association AMPA) and communication specialists (National Association of Air Communication Specialists (NAACS) developed a national consensus paper with six priorities for immediate and longer term initiatives, including:

- developing a specific air medical crew resource management program;

- developing a forum for the Part 135 Operators to exchange information similar to the Helicopter Safety Advisory Committee for the Gulf petroleum support operations;

- filling in the data gaps through better information exchange including working with the NASA ASRS program

- developing a forum for the leaders of the Part 135 Operators to share and exchange safety initiatives;
- to develop new aircraft standards and technologies; and

- improving access to weather reporting systems.

Concurrent with these Safety Summit initiatives in 2000, the AAMS CORE Industry Safety Committee, comprised of program directors and representatives of ASNTA, NAEMSP, NFPA, and NAACS, published a new consensus document of safety position statements. Following from these initiatives, the (NEMSPA) and HAI undertook national surveys of pilots and line maintenance staff looking at all aspects of safety practices in air medical operations, the results of which were published and presented at the national Air Medical Transport Conference in 2001.

All of the initiatives from the Safety Summit are well in motion as well as other safety initiatives. Specifically:

- The Air Medical Safety Advisory Council (AMSAC) with representatives from all of the major Part 135 Operators, the FAA, and NASA, has developed a national Air Medical Crew Resource Management Course and has already run two "train-the-trainer" programs with a commitment to hosting ten additional programs over the next few years and to developing a wide cadre of instructors.

- The AMSAC published the first recommend practice guideline this summer dealing with launch times.
- A workgroup lead by HAI and NEMSPA undertook and published a "Root Cause Analysis" of many if not all of the accidents from NTSB reports cited by the author, to look for opportunities for evidenced-based rapid improvement to air medical operations.

- The AAMS Safety Committee has developed a draft position statement on maintenance following from the line technician survey.

- CAMTS has adopted the significant elements of the AAMS Safety Position Statements in the most current standards and has recently published a new and updated version of standards.

- NAEMSP is publishing new air medical guidelines endorsed by AAMS and AMPA.

Contrary to the author's assertions air medicine is not in crisis. The use of medical helicopters to provide specialized care teams and transport to critically ill and injured patients is a daily and medically necessary event in the United States and indeed all over the world. The numbers of air medically transported patients are very small in comparison with ground EMS transported patients. The use of air medical resources is always the exception, not the rule. Patients correctly rely on physicians and medical providers to make good decisions and safe decisions on their behalf. Providers take this responsibility and sacred trust seriously for each and every patient.

The goal of air medical transport is to improve clinical outcomes for patients. This is accomplished by providing highly skilled medical teams to the patient's side in the least amount of time followed by rapid transport while performing or maintaining life saving interventions. The importance of doing what is best for the patient is the overarching message.

More can be and is being done on a daily basis to enhance patient and medical crew safety. Every air medical crewmember is a precious resource to their families and loved ones, to their co-workers, and to their patients. We, in the air medical community, are engaged on a daily basis in identifying, reducing, avoiding, managing, and preventing risk. As noted earlier the goal is a zero accident rate. At the end of the day, we live and work in a human endeavor while we work to improve our systems. The author is to be commended for his interest and his promotion of the safety message and the challenge to continually test and measure the use of medical resources. There is significant common ground on the important role of raising the bar through accreditation based standards. A wider, evidenced-based view, however, is necessary.

Respectively Submitted,

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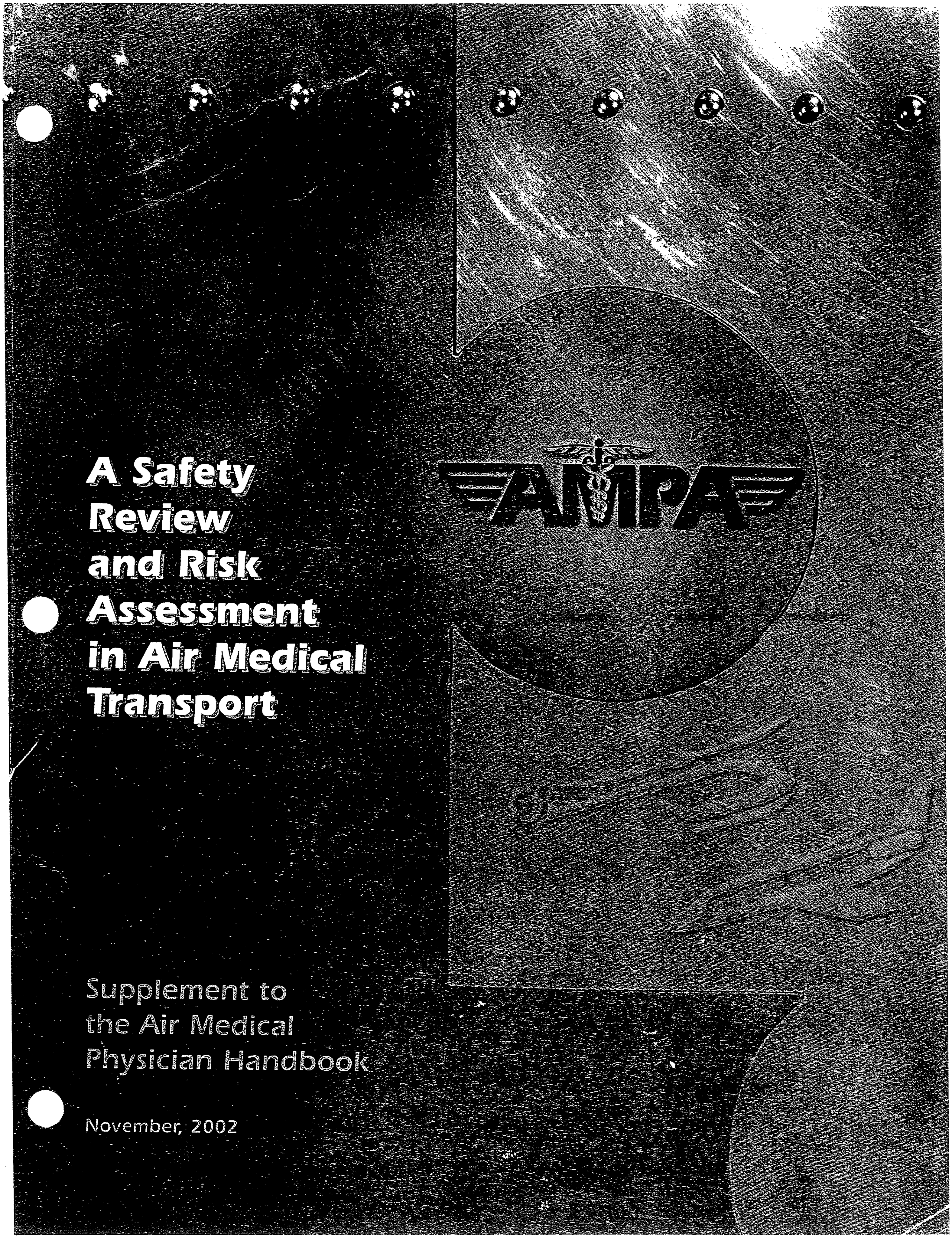

A Safety Review and Risk Assessment in Air Medical Transport

Supplement to the Air Medical Physician Handbook

November, 2002

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November, 2002

To the Air Medical Community,

Safety is a primary concern for all medical transport professionals. Regardless of whether transporting in helicopters, ground ambulances, or fixed-wing aircraft, or if transporting from scenes to hospitals, between hospitals or within a hospital, the movement of patients raises both the risk of medical complications and the risk of transportation accidents and incidents. A great deal of attention has been focused on helicopter incidents and accidents. While improvements in equipment, protocols, training, and operations have occurred, air medical helicopter transport is not as safe as we would like.

In the attached safety report, Dr. Ira Blumen and his team from UCAN provide a fresh perspective on medical helicopter safety statistics and an assessment of risk. They look at the existing data from a variety of viewpoints and have undertaken a unique research project to fill in many of the statistical gaps that previously existed. They compare Helicopter EMS with other aviation data, other routine risks, and provide a basis for future work.

The authors are to be commended for this significant effort. AMPA is proud to make this report available to everyone in the air medical community, and the AMPA Board thanks the many contributors who made this possible.

All of us associated with air medical care should read this report, discuss it with their peers, friends and family, and then read it again. Then they should go to work motivated to improve safety even further. When the second edition of this report is produced, wouldn't it be wonderful to demonstrate lasting improvements in safety, for our community and our patients?

Sincerely,

Kenneth A. Williams, MD, FACEP President, AMPA 2000-2002	Harry E. Sibold, MD, FACEP President, AMPA 2002-2004

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Si Handbook

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A SAFETY REVIEW AND RISK ASSESSMENT IN AIR MEDICAL TRANSPORT

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EXECUTIVE SUMMARY

INTRODUCTION

In 1998, helicopter EMS (HEMS) saw the beginning of an alarming accident trend. That year there were eight accidents, followed by ten in 1999, and twelve in 2000. That was a significant increase considering there had been only one accident in 1996 and in 1997 there were a total of three. Questions were raised—and the industry, as well as individual programs, began to look for answers. Is HEMS unsafe? Are HEMS crewmembers at a significantly higher risk for injury or death? Is the information available to answer these questions?

In general, the lack of readily available data made it difficult, if not impossible, to answer these questions adequately. This prompted the University of Chicago Aeromedical Network (UCAN) Safety Committee to begin its own investigation and research in the fall of 2000.

There are many ways to review the safety of air medical transport and to assess the relative risk to its crewmembers. For more than a decade, when our industry or industry observers (e.g., FAA, media, general public) looked at HEMS accident information, the only available information was the number of accidents and fatalities—commonly referred to as the raw data. No one was able to determine if the increase in accidents was simply related to an increase in the number of hours flown, or whether HEMS had indeed become more dangerous.

Our primary investigation began with an extensive review of accident and incident data specific to the HEMS industry. Based on this review, a comprehensive research model was developed to estimate and project exposure data that the air medical industry has stated "does not exist". Without this exposure data (number of transports and/or the number of hours flown by HEMS), it would be impossible to calculate annual HEMS accident rates and fatality rates or to draw any meaningful conclusions or comparisons.

The study focus next shifted to a comparison of HEMS accident rates and fatality rates to other forms of air travel. Finally, a comparison of air medical transport to other occupations or "routine" risks is made to contrast the fatality rates and the odds of death. To accomplish this, the "population at risk" in HEMS would need to be determined if we were to attempt to make these unique comparisons. This data has never been tracked or even estimated in the HEMS literature.

Upon analyzing HEMS-related risks and assessing the risks faced by air medical crewmembers, this report also identified ways to enhance program (and industry) safety with the hope of reducing our level of accident exposure. Every occupation has inherent risks. Medical professionals and transportation professionals are no different and are exposed to various risks every day.

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A SAFETY REVIEW AND RISK ASSESSMENT IN AIR MEDICAL TRANSPORT

INTRODUCTION

For nearly thirty years, safety has been a focus of committees, articles, lectures, position statements, standards and recommendations within the helicopter EMS (HEMS) industry. Despite the safety programs and safety initiatives industry-wide and program-specific, helicopter EMS accidents continue to occur. HEMS has been credited with saving the lives of tens of thousands of critically ill or injured persons. Tragically, however, there have also been over 150 lives lost due to helicopter accidents in the pursuit of these life-saving missions.

Does the fact that HEMS accidents occur every year suggest that air medical transport is unsafe? Are HEMS crewmembers at a significantly higher risk for injury or death? This report will try to answer these questions by reviewing accident data and trends, identifying potential causes of helicopter accidents and incidents, and reviewing accident and injury rates.

Nothing we do is completely safe. In a 1972 U.S. Supreme Court decision, the court concluded that "safe is not the equivalent of risk free." There are risks, often potentially serious ones, associated with every occupation, every mile traveled, every food eaten, every hobby, every investment – basically with every action we take. Clearly, some actions are riskier than others and the only way to eliminate risk from any activity would be to avoid participating in it completely.

As health care providers, we are constantly faced with risk. We make patient care decisions based upon the related risks and benefits of any given treatment or transfer. The Emergency Medical Treatment and Active Labor Act (EMTALA) requires that we "inform the individual (or a person acting on the individual's behalf) of the risks and benefits..." and document that the benefits of transfer outweigh the increased risks to the individual.

In air medical transport safety must be the top priority. We must also consider the risk related to air medical transport—not just to satisfy EMTALA—but to assure that procedures are in place to avoid *unnecessary* risk and that proactive steps are taken to control risk.

This report reviews and summarizes some of the most important publications, presentations, and studies that address various aspects of helicopter EMS accidents. In addition, we describe an extensive research project and our results that enable us to better understand the risks related to air medical transport.

This research was supported in part through a grant from the Foundation for Air Medical Research and by the University of Chicago Aeromedical Network (UCAN).

AIR MEDICAL PHYSICIAN HANDBOOK

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tractions, and stress management.

The risks in HEMS should not be underestimated. The cumulative effects of multiple risk factors must be considered when making decisions on each and every transport. Risk management is a major component of the decision-making process. It relies on situational awareness, problem recognition, and exercising good judgment to reduce risks associated with each flight.

Accident prevention must be the objective. But there will be "a next accident." The air medical community and each program must be certain that the proper aircraft, systems, training, and equipment are in place to enhance the survivability of an accident. A study that evaluated the use of helmets in survivable military crashes found that main cabin occupants with no helmet were at 5 times the risk for a serious head injury and 7.5 times the risk for a fatal head injury than their helmeted counterparts. Another series of U.S. Army studies found that shoulder harnesses were an important factor in reducing the incidence and severity of serious back injuries. Yet, not every crewmember wears a helmet, not every aircraft is equipped with shoulder harnesses and not every person buckles their seat belt prior to takeoff.

CONCLUSION

Throughout all types of industry, there is generally a 20/80 ratio when it comes to accidents: 20% of all accidents are caused by machine-related problems and 80% of the accidents are caused by human error. This seems to be accurate for HEMS as well. The NTSB commonly identifies "pilot error" as the probable cause in the majority of HEMS accidents. But is it truly *pilot* error? Or have we all failed in some way?

There is no logical reason for the increase in the number of accidents over the past several years. We have regulations, we have safety committees, we have standards, we have safety summits, we have AMRM, we have surveys and we have reports. We have better aircraft, we have newer technology and we have accreditation. And we have 30 years of experience. What we also ***still*** have are unnecessary pressures, unnecessary risks, unnecessary distractions, poor communications, complacency—and the same old human errors. What we do ***not*** have is an excuse!

This report provides a comprehensive review of past studies and offers considerable new information regarding accident rates and risks related to HEMS. This report does not provide the solution to a safer industry. Only you can do that—at your program, on your next flight, on every flight. By providing new information and increasing awareness, we hope to decrease future accidents, and to better educate flight program personnel of the potential risks at hand each and every time the phone rings and the aircraft lifts off.

REVIEWING THE DATA

There are many ways to review the safety of air medical transport and to ssess the relative risk to its crewmembers. One can look at the safety record and practices of an individual program or look at the industry as a whole. Section 1 of this report looks at the accident and incident data that is specific to the HEMS industry. Another approach is to compare the accident data with that of other forms of air travel and other modes of transportation. This approach is taken in Section 2. Finally, Section 3 compares the identified risks for HEMS to other occupations, high-risk activities, and various routine daily activities.

When looking at accident data, it is common to talk about raw numbers (number of accidents), percentages, or accident rates. But what does that really mean? How can we look at the data, compare statistics, and arrive at conclusions? The Office of System Safety within the Federal Aviation Administration (FAA) has stated that research has shown the importance of comparing like groups when comparing accident data or safety performance. For example, a comparison of one year's HEMS accident statistics with another year's HEMS accident statistics is more likely to be accurate and meaningful than a comparison of general aviation accident data to HEMS data. It may also be helpful at times to look at different categories of aviation to try to draw comparisons and conclusions.

There is no consensus among researchers and participants in the aviation industry as to what constitutes "safety data." In addition, when interpreting comparisons, equivalent types of data are more likely to be accurate than comparisons of different types of data. Therefore, we must first level the playing field in terms of exposure to risk. It is essential that accident and incident data be "normalized." Raw data on accidents and incidents must be converted to accident or incident rates before it can be used for drawing conclusions about safety over time, or to compare different types of aviation, airplanes, pilots, types of operations, and so on.

Comparisons based strictly upon the number of events that occur may not tell the real story. To be meaningful, comparisons must be based upon equal exposure to risk. The longer we are exposed to a particular risk, or the more times we undertake an activity involving risk, the greater the overall risk. However, this alone does not determine total risk. Reduction factors such as experience, proficiency, equipment, and flight conditions can have a significant positive impact on safety.

The FAA and other organizations track aviation data in a number of different ways. The most common method is with respect to flight hours and departures. The data is then normalized in terms of accidents (or fatalities) per 100,000 flight hours or accidents (or fatalities) per 100,000 departures (i.e., takeoffs). In most aviation, unlike HEMS, takeoff and landings are the higher risk periods. Therefore, short and multiple stop flights are riskier mile-for-mile than long nonstop flights. Airlines generally prefer to focus on accident rates per mile, which makes air travel seem very safe.

The FAA estimates the total flight hours for general aviation based on a survey of a sample of aircraft owners and operators. Scheduled air carriers, on the other hand, must report flight hours, departures, and passengers carried, so their accident statistics may be compared using either departures or flight hours. In the early 1980s when data was kept for HEMS, it was tracked in terms of flight hours and patients transported (which is different than departures). Unfortunately, the air medical transport industry has been unable to develop a consistent method to track its own data – a problem that has recently drawn a great deal of attention. However, numerous calculations are outlined later in this report to make some appropriate comparisons with HEMS.

In much the same way that the FAA normalizes its data, similar strategies must be used to compare the risk of injury or death. To assess the magnitude of risk, we must again normalize the data in some fashion. In this case, the relevant figure is in terms of a ratio, fraction, or percentage. By reducing all risks to a common format, we can begin to compare different types of activities and the relative risks. The larger the percentage, the riskier the activity.

SECTION 1: AIR MEDICAL ACCIDENTS AND INCIDENTS

This section presents an overview of HEMS accidents and reviews several notable investigations. The first, from a series of articles written by Rick Frazer and published in *AirMed*, presents a 20-year review of air medical accidents and specific types of accidents. Second is a 1988 report of 59 HEMS accidents (1978-1986) by the National Transportation Safety Board (NTSB). The next study by Patrick Veillette is from the Flight Safety Foundation (April 2001) and reviews 87 accidents from 1987 through 2000. A 1994 study by the NASA-Ames Research Center is then summarized which evaluates air medical incidents, rather than accidents. The final report in this section is the "Air Medical Accident Analysis" which analyzed past accidents and identified interventions to prevent future accidents. This section concludes with a review of the 1998-2001 HEMS accidents and finally with a comparison of HEMS accident rates, which are based upon available data, research, several necessary assumptions, and various calculations.

BACKGROUND

Air medical transport began in the military, which laid the groundwork for the air transport of critically ill and injured patients. The first civilian air medical operations were established in the late 1960s in the form of dual-purpose programs, which combined the function of public safety agencies with EMS missions. In 1972, the first fatal EMS-related accident occurred within one of these dual-purpose programs. That same year, St. Anthony's Hospital in Denver established the first dedicated hospital-based HEMS program.

In the 1970s and '80s, various publications and organizations tracked the growth of the dedicated helicopter EMS industry. The number of dedicated programs grew slowly in the '70s, but gathered significant momentum in the early 1980s. In 1981 there were 45 programs and by 1986 the industry had almost tripled to 129 programs. Unfortunately, this was accompanied by an increase in the number of air medical accidents.

In the late 1980s new trends were seen. More programs added a second helicopter to their operation, while other programs closed down. In many areas competition was fierce. By 1990 there were 174 programs operating 231 helicopters.

In the '90s, air medical programs and industry-wide statistics became increasingly difficult to track. While new programs started and helicopters were added to many established programs, others merged operations and still more closed. Fixed-wing (airplane) air medical transport continued to grow and became an integrated component of the industry. During this time, the industry did not maintain an accurate census. In addition, industry-wide data was not kept as to the total number of patients transported or the total number of hours flown. The importance of this data will become evident later in this report.

AN OVERVIEW OF HEMS ACCIDENTS: 1972 TO 2002

This research study, developed by members of the UCAN Safety Committee, began with a comprehensive review of numerous databases to identify HEMS accidents and their corresponding fatalities and injuries. Since the introduction of civilian HEMS in 1972, the United States has experienced 162 accidents involving dedicated medical helicopters and four additional accidents involving dual-purpose aircraft. Of these accidents, 67 have resulted in at least one fatality. Figure 1–1 shows the total number of HEMS accidents and fatal accidents (an accident where at least one occupant died) broken down for each year since 1980. As the lines in gray show, until the last few years, the highest number of accidents occurred in the mid-1980s—the same time that the industry experienced its most rapid growth. The early and mid-1990s showed an improvement, but unfortunately, 1998–2001 showed a steady increase in accidents. Fortunately, the number of fatal accidents did not rise at the same rate.

The NTSB defines an aircraft accident as "an occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight and all such persons have disembarked, and in which any person suffers death or serious injury, or in which the aircraft receives substantial damage." An incident means "an occurrence other than an accident, associated with the operation of an aircraft, which affects or could affect the safety of operations." The NTSB also classifies the severity of various injuries that may occur from an accident as fatal ("any injury which results in death within 30 days of the accident"), serious, minor, or none.

When reviewing any accident database or report, it is essential to know the inclusion and exclusion criteria for the data that is used. There are many agencies, organizations, and individuals who maintain and track data regarding HEMS accidents and incidents. There is not always agreement on what should be included in a report or study. Some studies look at only patient missions. Others will look at non-patient missions as well. Some reports include fixed-wing (FW) as well as rotor-wing (RW) and some databases include incidents as well as accidents. An accident database may include only dedicated air medical services, while others might include dual-purpose (e.g., police, fire) aircraft. There is no right or wrong way, but it is essential to know what is included in each statistical review.

The accidents listed in Figure 1–1 are the end product of a detailed review of various personal databases, publications, and Internet websites. In numerous cases, available information was insufficient to determine inclusion vs. exclusion into our own database. To clarify the accident information, direct communication by telephone or email was also employed. Included in this table are dedicated medical helicopter accidents that occurred on either patient or non-patient missions. Also included are known accidents involving dual-purpose helicopters (a total of four accidents and nine fatalities) that crashed during medical missions. Fixed-wing air medical accidents, military accidents and international accidents have not been included in our database or statistical analysis.

Our review found 162 HEMS accidents in which we identified a total of 183 fatal injuries. Accidents have taken the lives of pilots, nurses, physicians, paramedics, respiratory therapists, patients, police officers, fire fighters, and observers. There were also 60 individuals who suffered serious injuries and 73 with minor injuries. A total of 195 people were not injured. Figure 1–2 shows a breakdown for injuries and fatalities for each year in our study. We have also included year-to-date information for 2002.

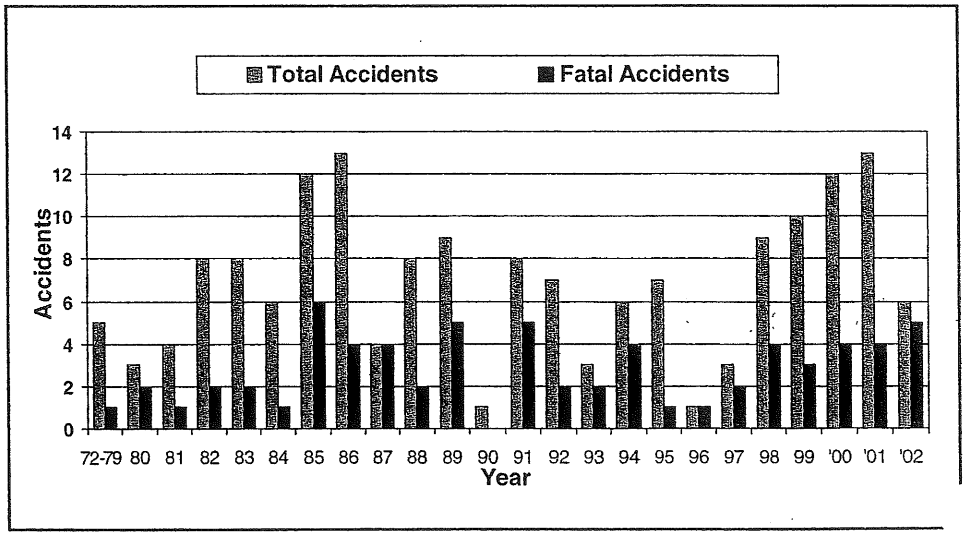
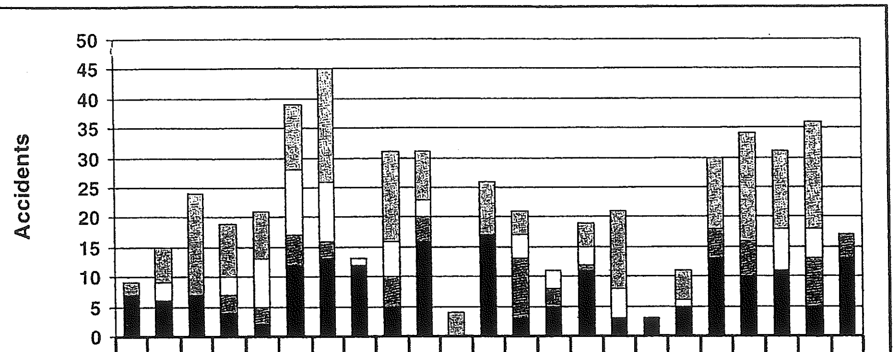


Figure 1–1: HEMS Accidents and Fatal Accidents, 1972–2002*
(*through 9/30/02)



	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	'00	'01	'02
▨ None	2	6	17	9	8	11	19	0	15	8	4	9	4	0	4	13	0	5	12	18	13	18	0
☐ Minor	0	3	0	3	8	11	10	1	6	3	0	0	4	3	3	5	0	1	0	0	7	5	0
▩ Serious	0	0	0	3	3	5	3	0	5	4	0	0	10	3	1	0	0	0	5	6	0	8	4
■ Fatal	7	6	7	4	2	12	13	12	5	16	0	17	3	5	11	3	3	5	13	10	11	5	13

Figure 1–2: Fatalities and Injuries, 1980–2002* (*as of September 30, 2002)

AIR MEDICAL ACCIDENTS: A 20-YEAR REVIEW

Perhaps the most complete analysis of air medical accidents is represented in a series of *AirMed* articles by Rick Frazer. The first of the series was published in the September/October 1999 issue. The article "Air Medical Accidents—A 20 Year Search for Information" presents a review 104 rotor-wing, 15 fixed-wing, and three public EMS accidents for a total of 122 accidents between 1978 and 1998. Included were only accidents that occurred to dedicated medical transport services, not to private or public aircraft that may also perform an occasional medical transport.

This study included only accidents as defined by the NTSB. In follow-up to this article, Frazer looked at specific types of accidents—those related to weather, collisions with objects, and maintenance.

Accidents and Fatal Accidents

While the number of HEMS accidents is a critical consideration, even more important is the high number of fatal accidents seen in HEMS. In the 1980s, 42% of all accidents resulted in at least one fatal injury. Between 1990 and 1998, this percentage rose to 56%. Figure 1–3 compares the number of accidents to fatal accidents for 1978 through 1998—the years included in Frazer's report. It is important to note that these numbers do not necessarily correspond to the number of accidents previously presented since this study also included over a dozen fixed-wing accidents and several accidents that did not meet our inclusion criteria.

Severity of Injury

Frazer reported that 406 individuals were involved in HEMS accidents. There were 168 fatalities, 50 serious injuries, and 61 minor injuries. There were 127 who sustained no injury. Figure 1–4 shows the trend over the years with regard to fatalities and Figure 1–5 summarizes the severity of injuries for all the reported accidents.

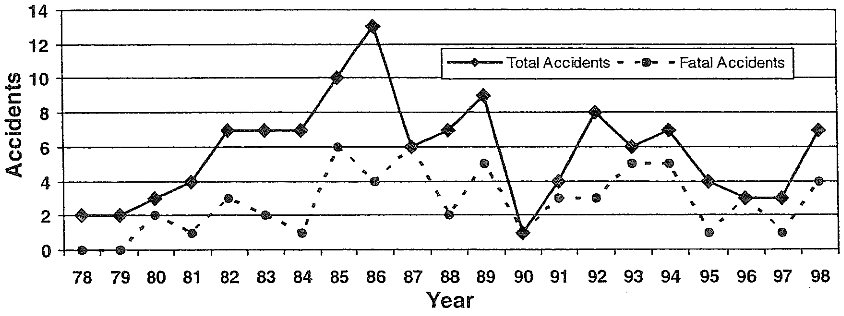


Figure 1–3: Accidents and Fatal Accidents, 1978—1998

Adapted from: Frazer, AirMed, Sept/Oct 1999

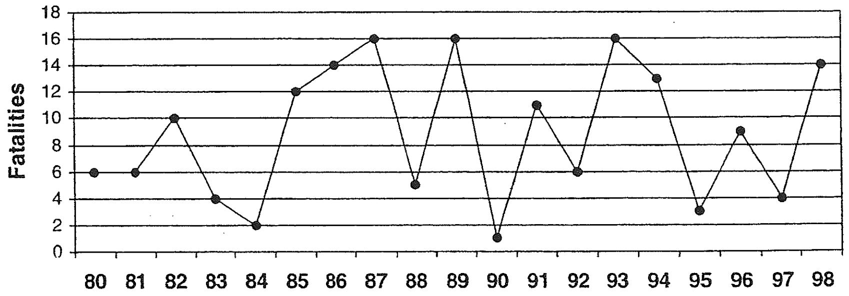


Figure 1–4: Fatalities per Year

Adapted from: Frazer, AirMed, Sept/Oct 1999

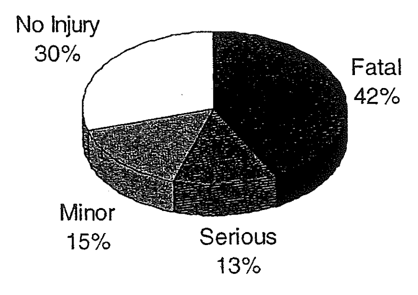


Figure 1–5: Severity of Injuries — Air Medical Accidents, 1980—1998 (n=397)

Adapted from: Frazer, AirMed, Sept/Oct 1999

When Do HEMS Accidents Occur?

When an accident occurs is an important consideration when looking at the safety of flight and may provide insight to the severity of injuries and the high number of fatalities. The time of day (i.e., day vs. night), type of mission (i.e., the purpose of the HEMS flight), and the phase of flight are all-important factors to evaluate.

Condition of Light

It would appear in Figure 1–6 that EMS accidents showed no significant preference for day vs. night operations. However, the 1999 *AirMed* Transport Survey indicates that only 38% of all HEMS flights were at night. Since 1988, the range has been between 35 to 42%, with an average of 38%. In contrast, 49% of the HEMS accidents over 20 years occurred during night operations. Of interest, Frazer's report identifies three noticeable peak accident times: noon to 1pm, 6–7pm, and 10–11pm.

Phase of Flight

The phase of flight that the aircraft was in at the time of the accident is reported in the NTSB reports. This includes takeoff, landing, cruise, hovering, maneuvering, or taxiing. Data for both helicopter and fixed-wing accidents are provided in Figure 1–7.

As previously mentioned, in most aviation operations, aircraft are more prone to incidents or accidents during takeoffs and landings. This was not found to be the case with HEMS accidents. More accidents occurred during cruise (36%) than any other phase of flight. Accident reports frequently identify entry into inadvertent instrument meteorological conditions (IMC) as a contributing factor for many of the accidents (i.e., flying into poor weather conditions).

Purpose of Flight

The purpose of flight for HEMS accidents was tracked by Frazer in his article. He divided flights into two major categories: patient-related and non-patient related. He further divided the patient flights into scene vs. interhospital; and finally determined if the aircraft was enroute to the patient, had a patient on board, or if the aircraft was returning from a patient flight (i.e., the third "leg" of a transport). Evaluating these components of HEMS transports might indicate a particular interval when more accidents seemed to occur. Figure 1–8 depicts the various purposes of flight and the different legs of patient transport.

Trying to determine the most dangerous flight or leg of a patient transport from Figure 1–8 may be difficult. More accidents occur on the transport to the patient than on either remaining leg. However, if the helicopter was transporting the patient back to its base facility, there would be no third leg of a transport. The pie charts in Figures 1–9 to 1–12 look at the percentage of accidents that occurred on the various types of missions and then each leg of the transport.

In general, it appears that approximately 50% of all accidents occur enroute to the patient and 50% on the way back. Of note is the fact that 85 of the 104 HEMS accidents that occurred were on patient-related missions, of which 36 were scene responses. This corresponds to 42% of the accidents during patient-related missions. Referring again to the "2000 Annual Transport Statistics," scene missions accounted for only 28% of all patient transports. Since 1988, the percentage of scene response flights has ranged from 25% to 36%, with an average of 31%. If all missions had equal risk, then 31% of the accidents should have been on scene missions. Scene missions have always been perceived as the most difficult and potentially the most dangerous in HEMS and this data would seem to confirm this. However, the fact that a higher percentage of the accidents occur after the patient has been picked up rather than enroute to the scene (56% to 44%) further confounds this theory.

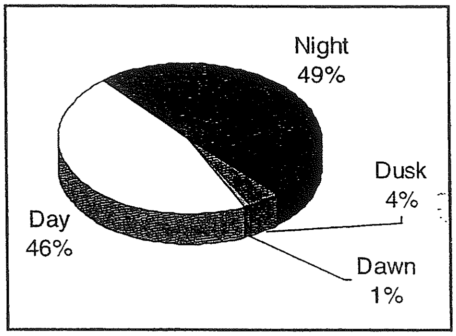


Figure 1–6: Day vs. Night HEMS Accidents, 1978–1998 (n=107)
Adapted from: Frazer, AirMed, Sept/Oct 1999

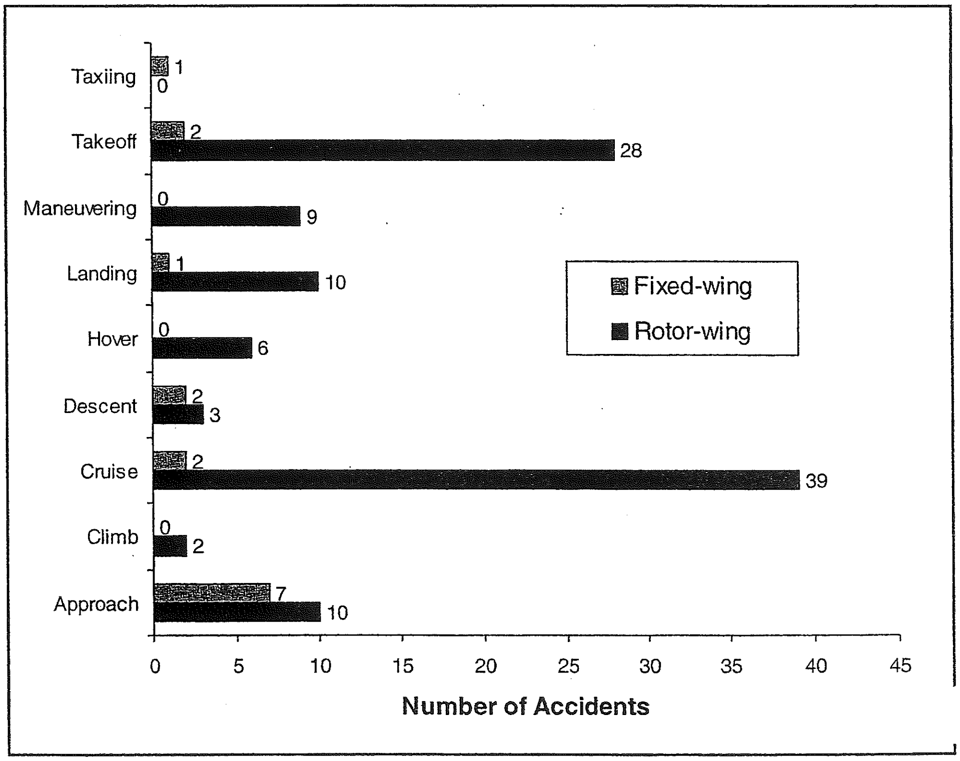


Figure 1–7: Phase of Flight
Adapted from: Frazer, AirMed, Sept/Oct 1999

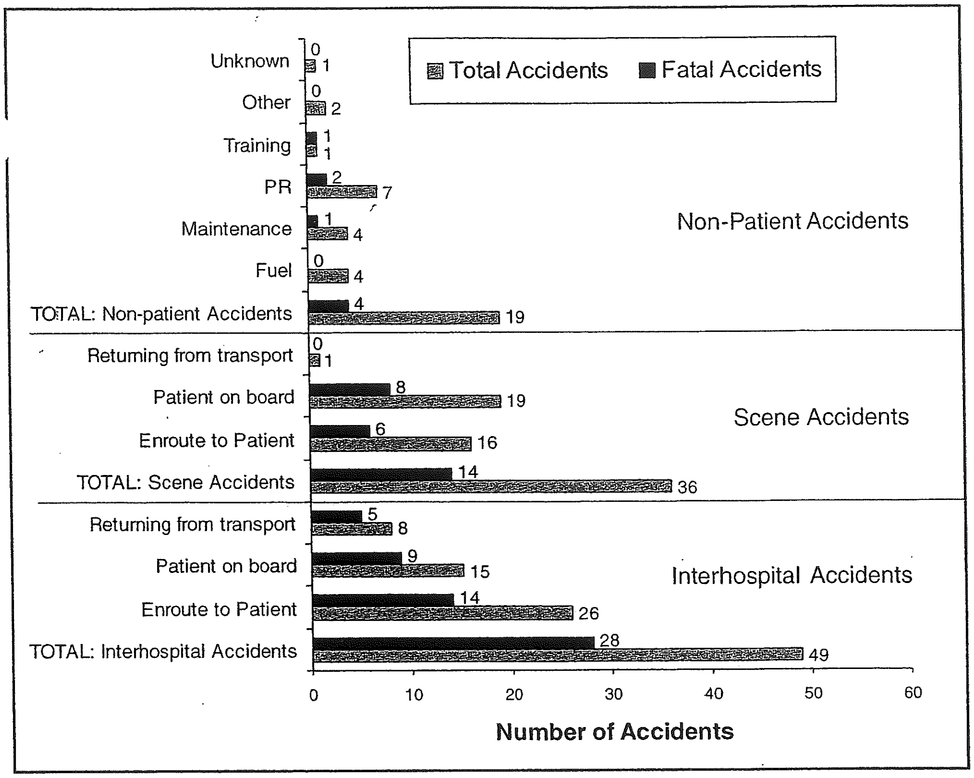


Figure 1–8: Phase and Purpose of Flight *Adapted from: Frazer, AirMed, Sept/Oct 1999*

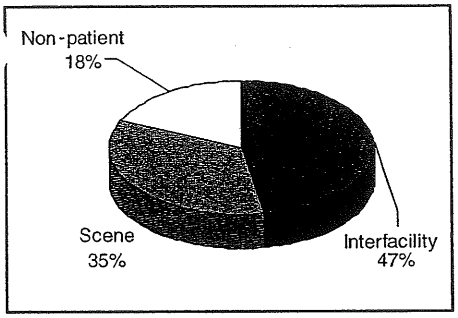


Figure 1–9: All HEMS Accidents (n=104)
Adapted from: Frazer, AirMed, Sept/Oct 1999

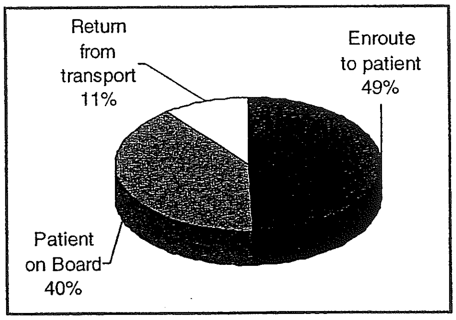


Figure 1–10: Accidents During All Patient Transports (n=85)
Adapted from: Frazer, AirMed, Sept/Oct 1999

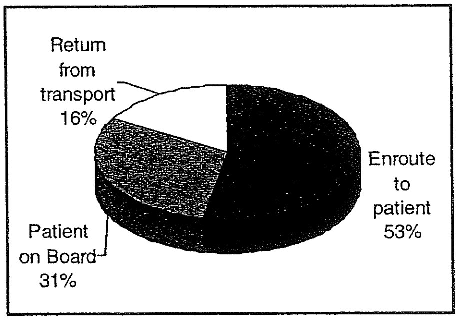


Figure 1-11: Accidents During Interhospital Transports (n=49)
Adapted from: Frazer, AirMed, Sept/Oct 1999

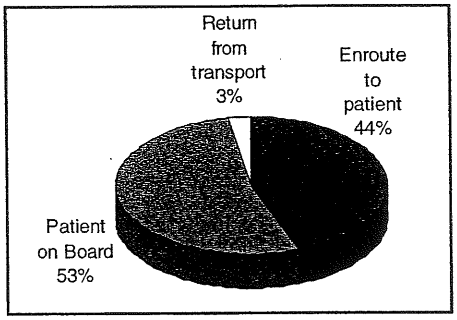


Figure 1–12: Accidents During Scene Transports (n=36)
Adapted from: Frazer, AirMed, Sept/Oct 1999

The Cause of HEMS Accidents

It is rare that a single isolated event causes an accident. Instead, it is generally agreed that a set of contributing factors and circumstances usually lead to a final event that results in the accident. The NTSB investigations, however, usually conclude that an accident occurred as a result of one of two probable causes—either pilot error or mechanical problem. The NTSB may also list the case as "Unknown" or "To be Determined." At times, the NTSB may list more than one cause for a particular accident.

Identifying and specifying the cause of an accident may not be easy, even after a thorough and detailed investigation. In one HEMS accident, after an engine problem developed, the pilot shut down the wrong engine. The result was a fatal accident. Should this accident be attributed to pilot error or a mechanical failure?

The two main categories—pilot error and mechanical failure—are divided into more specific causes as determined in the final report of the NTSB. In his report, Frazer listed the causes of 104 helicopter accidents. A total of 68 (65%) were pilot error and 26 (25%) were mechanical failure. The remaining accidents were unknown (3) or still to be determined (9). Figure 1–13 lists the identified causes of the rotor-wing accidents.

Weather-related Accidents

Weather-related accidents remain an all too familiar theme in HEMS. Frazer's 1999 report listed 23 such accidents, of which 17 were fatal. In the May/June 2000 issue of *AirMed*, Frazer's article "Weather Accidents and the Air Medical Industry" updated his weather-related accident data. With this article, Frazer's accident database has increased from 122 to 136 helicopter and fixed-wing accidents, with 121 final reports available. There are now 31 weather-related accidents in his database, equal to 26% of the accidents with final reports. Of these 31 accidents, 25 were rotor-wing and 6 were fixed-wing.

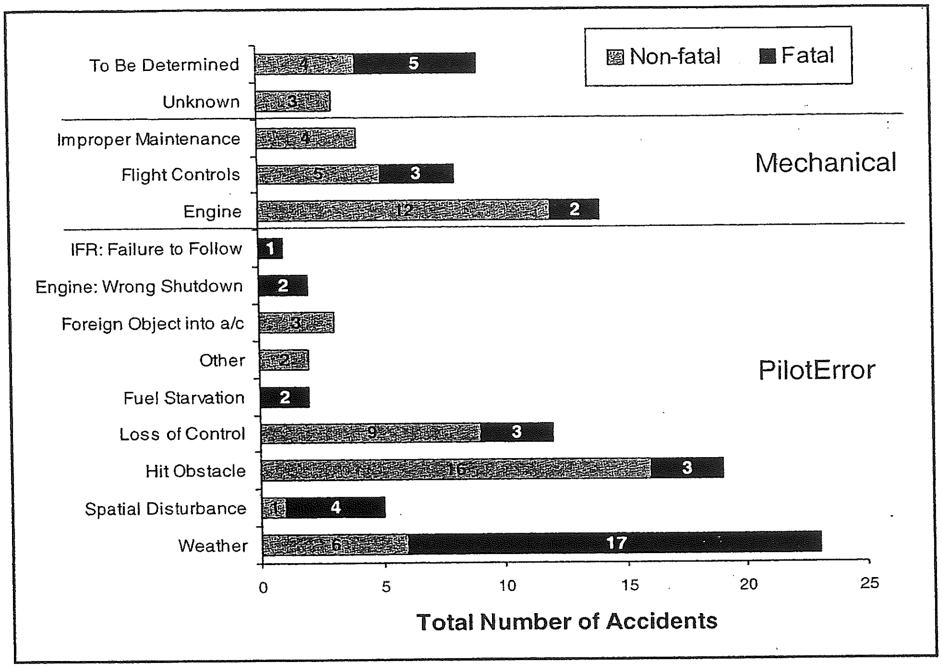


Figure 1–13: HEMS Accidents by Cause *Adapted from: Frazer, AirMed, Sept/Oct 1999*

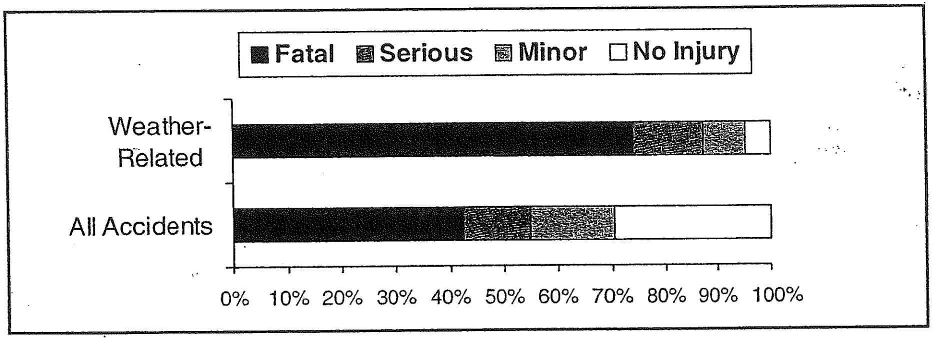


Figure 1–14: Severity of Injuries–All Accidents vs. Weather-related, 1982–1998

(All accidents: n=397; Weather-related accidents: n=103)

Adapted from: Frazer, AirMed, Sept/Oct 1999 and Frazer, AirMed, May/June 2000

In the 1980s, there were a total of 73 accidents, of which 16 (22%) were determined to be weather-related. In the 1990s the number of accidents (with final reports) had decreased to 44, with 14 (32%) related to weather. Tragically, while the total number of accidents went down, the percentage of weather-related accidents increased by 10%.

Looking at when these weather-related accidents occur is also of importance. Previously it was noted that nearly half of all HEMS accidents occurred at night (53 of 107). In comparison, Frazer's article in 2000 found that 22 of 25 (88%) weather-related HEMS accidents occurred at night. Fixed-wing weather-related accidents remained at 50%, even at night.

Of the 25 weather-related helicopter accidents, 17 (68%) of the accidents were interhospital and 8 (32%) were scene missions. This correlates well to the overall percentage of scene missions for HEMS program, which was previously noted at 31%. Of interest, there is a noted decrease in the percentage of scene accidents when comparing weather-related accidents (32%) to all patient-related mission accidents (42%).

The outcome of weather-related accidents is also very dramatic. Nineteen of the 25 HEMS accidents (76%) had fatalities and 64% had no survivors. Compared to all accidents in Frazer's 1999 study, only 45% (55 of 122) of all accidents resulted in at least one fatality. In addition, 76 of 103 (74%) of the souls on board sustained fatal injuries, 14 had serious injuries, 8 suffered only minor injuries, and 5 had no injury. Figure 1–14 shows the relative comparison (percentage) of the severity of injuries in the weather-related accidents reported in 2000 to the total accidents reported by Frazer in 1999.

In general, the cause of the weather-related accidents does not appear to be a pilot's disregard for established weather minimums at takeoff. Instead, it is the pilot's encounter with instrument meteorological conditions (IMC) en route. In the narratives of the 25 helicopter accidents, Frazer noted that 10 pilots were turning around, one was circling, six continued into IMC and one was on an IFR flight plan. The pilots' actions were unknown in 7 cases.

Background Information: Weather Limitations

Subpart D of the FAA Part 135 regulations (sections 135.201 to 135.205) outlines the FAA's operating limitations and weather requirements, including minimum altitudes and visibility for "air taxis." In addition, the Federal Aviation Regulations (FARs) under Part 135 require that Air Taxi Operators set their own weather minimums in Chapter 4 of their Operations Manual. The weather minimums describe the minimum ceiling (lowest cloud height above the ground that covers 5/8 or more of the sky) and the minimum visibility the pilot must have to accept a flight.

The ceiling and visibility requirements generally vary for day vs. night flight and for local vs. cross-country flights. The definition of "Local" may also vary from 50 to 100 miles or more. Many state regulatory agencies and organizations may also set minimums for ceiling and visibility. The Commission on Accreditation of Medical Transport Systems' weather guidelines are:

Condition	Area	Ceiling	Visibility
Day	Local	500'	1 mile
Day	Cross Country	1000'	1 mile
Night	Local	800'	2 miles
Night	Cross Country	1000'	3 miles

There are three types of weather-related accidents:

- ***Controlled Flight Into Terrain*** (CFIT) refers to an event that normally occurs in IFR conditions or at night. Loss of situational awareness is apparent in all CFIT accidents.
- ***Loss of Aircraft Control*** corresponds to an event in IFR conditions when the pilot is unable to maintain control of the aircraft by reference to the flight instruments. Spatial disorientation is the primary cause and is often the result of continued VFR flight into IFR conditions.
- ***In-flight Collision with an Obstacle*** is an event that normally occurs in conditions of restricted visibility when the pilot is unable to see an obstacle or the terrain in time to avoid a collision. This is the most common weather-related accident for helicopters.

Collision with Objects

An in-flight collision with an object (CWO) may occur in various conditions and settings. Frazer's 1999 study identified 9 HEMS accidents that resulted from a CWO. In his 2001 report "Air Medical Accidents Involving Collisions with Objects," the database increased from 122 to 150 fixed-wing and rotor-wing accidents, 27 of which involved a CWO. This represented a dramatic increase in the number of CWO accidents, as there had been a total of 8 such accidents during the 9-year period from 1990 to 1998, while in 1999 and 2000 alone, there were 7 CWO accidents. Frazer also identified 21 CWO incidents over the past 5 years.

Twenty-five of the CWO accidents in Frazer's report involved rotor-wing aircraft. Frazer observed that weather was not considered to be a factor in any of these. Sixteen (64%) of the accidents occurred during scene response missions—all occurring at or near the landing zone. Eight (32%) were during some phase of flight during interhospital transports, four of these at or on the hospital helipad. The remaining CWO was during a maintenance flight. Of the 24 patient missions, 12 occurred on the way to pick up the patient, 9 occurred with the patient on board, and 3 were returning after a patient flight. As previously presented, scene response flights account for an average of 31% of all patient transports. If all missions had equal risk, 31% of the CWO accidents should have been on scene missions. Instead that percentage more than doubles.

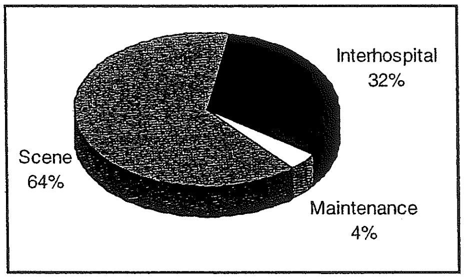


Figure 1–15: Type of Mission—CWO Accidents (n=25)
Adapted from: Frazer, AirMed, May/June 2001

Wires are the most common objects with which helicopters collide. Of the 25 CWO accidents, 9 were wire strikes. Frazer classified four of the CWO accidents as "other," which included the ground, rocks, and in one incident, a barge. There were three CWOs with trees, three with ground obstacles (lamp posts, fencing, etc.), two with support cables to towers and one each with a building, hangar, hospital helipad, and tower.

As expected, collisions with objects occur most commonly on takeoff and landing. The time of day also varies, but yielded some interesting results as seen in Figure 1–16.

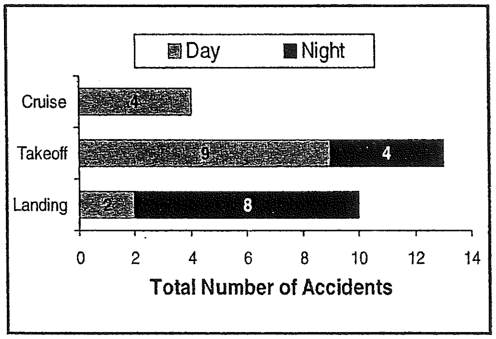


Figure 1–16: Phase of Flight and Lighting Conditions
Adapted from: Frazer, AirMed, May/June 2001

Since most of the CWO accidents occur during takeoff and landing, it follows that the aircraft are at a lower altitude and slower speed.

Accordingly, only 7 of the 25 (28%) RW accidents resulted in a fatality. Of the 4 cruise accidents, 3 were fatal. All the cruise CWO accidents identified by Frazer were RW, all were during the day in clear weather, and 3 were on the return flight home.

Frazer concludes his 2001 study with recommendations for comprehensive training and procedures for flight personnel to enhance safety and reduce the likelihood of CWO accidents. "Medical personnel should be taught how to spot obstacles, and detailed procedures should be in place on how to communicate—down to the exact words the crew uses—an immediate threat versus an obstacle in the distance." In addition, Frazer suggested the disassociation of Landing Zone (LZ) and safety training from marketing and emphasize the importance of ongoing safety education as a separate, budgeted activity.

Maintenance-related Accidents

The data presented in Figure 1–13 represent Frazer's 1999 study, which showed 26 maintenance-related accidents (MRAs) out of 122 total accidents. In the May/June 2002 *AirMed*, Frazer examined the "Air Medical Accidents Attributed to Maintenance." A total of 34 such accidents were identified in the 2002 report which now includes 143 rotor-wing and 18 fixed-wing MRAs. Thirty of the MRAs were rotor-wing and four were fixed-wing. Excluding 11 accidents that lacked NTSB final reports, Frazer concluded that 23% of all accidents were maintenance-related.

Frazer separated the probable cause of the MRAs into five different categories. Over the 24-year period, there were a total of 17 engine-related accidents, 15 of which involved rotor-wing aircraft. Twelve involved single-engine aircraft and three involved twin-engine aircraft. Even though the engine-related accidents represent half of all MRAs, Frazer observed that engine-related *incidents* happen much more frequently. Fortunately, due to the skills of the EMS pilots, the vast majority of these incidents do not result in accidents.

In 11 of the final NTSB reports, Frazer found "inadequate or improper maintenance" as a factor in the accident. In addition, there were five reports that identified "manufacturer design" or "inadequate aircraft component product/design" as a factor.

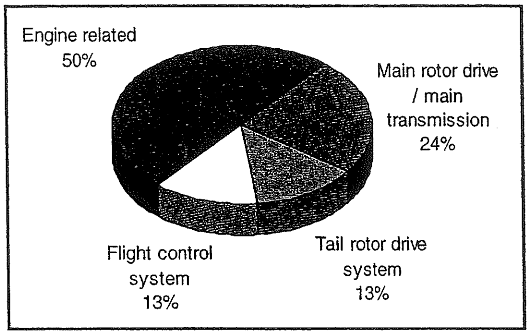


Figure 1– 17: Probable Cause of Maintenance-related HEMS Accidents (n=30)
Adapted from: Frazer, AirMed, May/June 2002

As Figure 1–18 shows, nearly 50% (16 of 34) of all rotor-wing and fixed-wing MRAs occurred during cruise. Interhospital transport accounted for nearly two-thirds of the accidents.

Pilot Experience

Experienced pilots don't make mistakes or have accidents. Or do they? Unfortunately, flying with "high-time" pilots does not necessarily guarantee that an accident won't happen. Much of the HEMS industry requires a minimum of 2,000 hours of flight time before assuming command of a medical helicopter. In addition, most operators, organizations, and even some states dictate a specific number of flight hours in type-specific aircraft before a pilot can fly medical missions.

Figure 1–19 shows the flight experience of the pilots involved in HEMS accidents. Unfortunately, there is no data available regarding the average number of flight hours for *all* HEMS pilots or the percentage of all HEMS pilots that would fall into each category listed in Figure 1–19. Of the pilots involved in HEMS accidents, the lowest total hours were 1,432, while the highest was 14,000. More importantly perhaps, in 27 of the 122 accidents (22%), the pilot had fewer than 200 hours of flight time in the make and model of the aircraft they were flying at the time of the accident. Eighteen (15%) had fewer than 100 hours and one had only three hours.

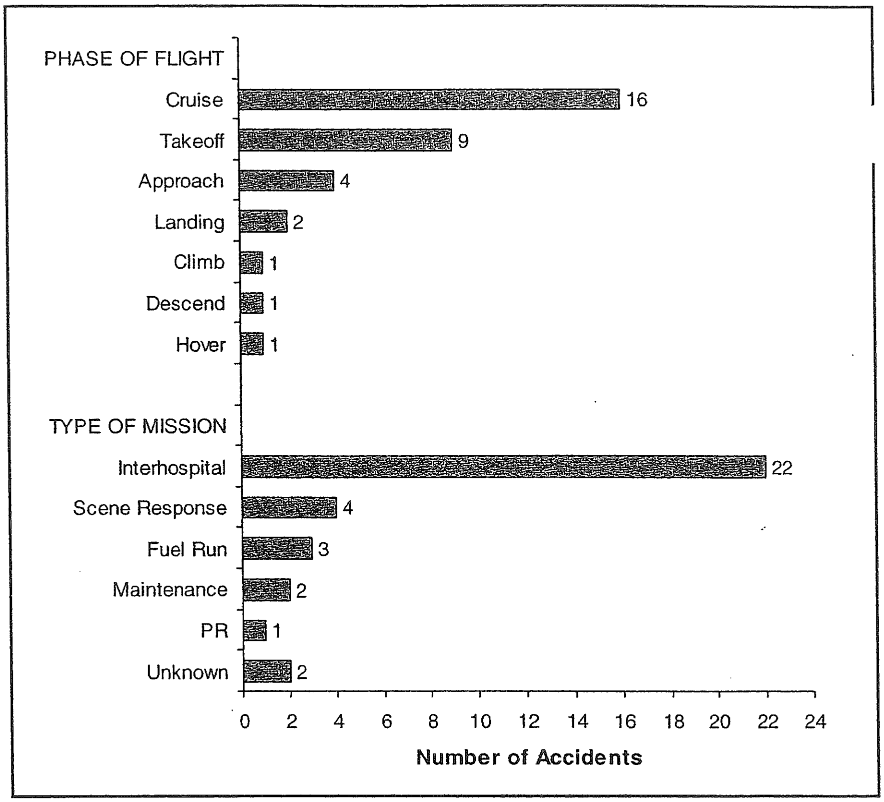


Figure 1–18: Maintenance-related Accidents—Phase of Flight and Type of Mission *Adapted from: Frazer, AirMed, May/June 2002*

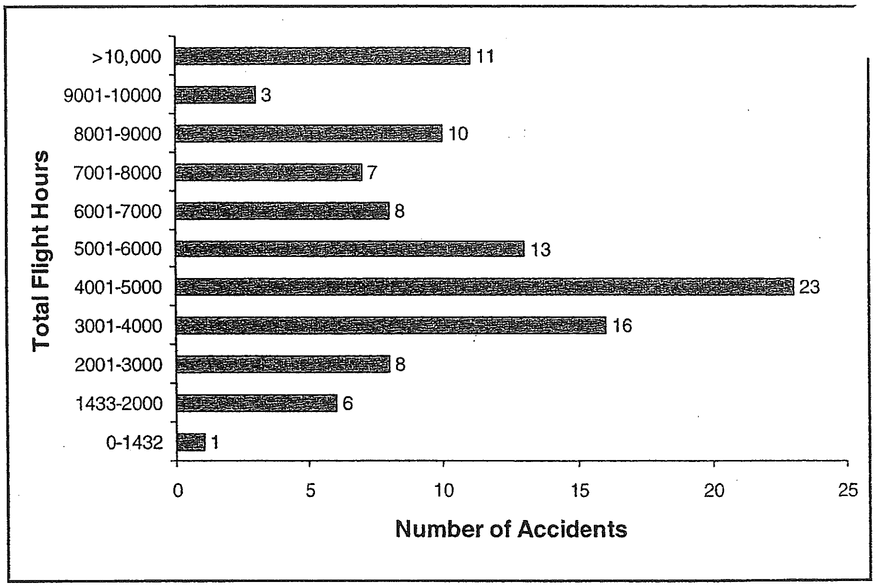


Figure 1–19: Pilot Experience *Adapted from: Frazer, AirMed, Sept/Oct 1999*

Engines

A frequent debate with regard to safety is whether "two engines are better than one." Of the 17 accidents attributed to engine problems, 12 were single-engine and 3 were twin-engine. However, this does not help resolve the debate, knowing that in the early years of HEMS, most helicopters were single-engine. Therefore, more of the accidents were in single-engine aircraft. In another section of this report is accident data collected by the Helicopter Association International (HAI) comparing single- vs. multi-engine helicopters which shows a lower accident rate overall for multi-engine helicopters.

Aircraft Damage and Post-Impact Fire

In the NTSB accident reports, aircraft damage is classified as either destroyed or substantial. Of the 122 air medical transport accidents, 70 (57%) aircraft were destroyed and 51 (42%) were reported as having suffered substantial damage. At the time of Frazer's report, one was listed as unknown. Of note, when looking only at the weather-related accidents, 84% of the helicopters and 100% of the fixed-wing aircraft were destroyed.

Post-impact fire is often perceived as another major concern with regard to HEMS accidents. Frazer's data, seen in Figure 1–20 shows that the vast majority of HEMS accidents do not result in a post-impact fire. While fixed-wing aircraft accidents resulted in fires 67% of the time, only 15% of helicopter accidents sustained post-impact fires. There were, however, six accidents that had an in-flight fire.

NATIONAL TRANSPORTATION SAFETY BOARD SAFETY STUDY: COMMERCIAL EMERGENCY MEDICAL SERVICE HELICOPTER OPERATIONS – 1988

Frazer's 20-year review provides a comprehensive look at the HEMS industry and our accident history from 1978 to 1998. This next report by the National Transportation Safety Board (NTSB), however, looks at a narrower time frame. When published in 1988, it became the hallmark safety study at the time of our industry's highest accident and fatality rate.

During the early 1980s, the increased use of helicopters as air ambulances came at a high price. While the number of flight programs more than tripled from 1981 to 1986, the NTSB began to identify a significant rise in the number of accidents. In 1984 there were 7 HEMS accidents. The next year, there were 11 and in 1986, there were 14 accidents investigated by the NTSB. These 14 accidents corresponded to 9 percent of the total commercial HEMS industry operating that year. As a result, a formal safety study was undertaken by the NTSB and published in 1988.

The NTSB studied 59 commercial HEMS accidents that occurred between 1978 and 1986. Nineteen of these accidents resulted in fatalities, taking the lives of 53 people (19 pilots, 28 medical personnel, and 6 patients). A total of 47 accidents were on patient mission flights and 12 while on other activities (refueling, PR, training, etc.). However, in the calculation of accident rates, the NTSB only included the 47 "mission" accidents. In addition, this study did not include any public-use aircraft.

According to the NTSB report, from 1980 through 1985, HEMS had an estimated accident rate of 12.34 accidents per 100,000 hours of flight, nearly double that of nonscheduled Part 135 ("air taxi") helicopter operations (6.69/100,000 flight hours). They also determined that the fatal accident rate for HEMS was 5.40—nearly 3.5 times higher than the 1.60 determined for other nonscheduled Part 135 helicopter operations.

The NTSB identified four major factors in the 59 HEMS accidents studied. Human error (i.e., pilot error) was attributed as the cause, directly or indirectly, of the majority of these accidents (68%). Weather was the second most common cause of these HEMS accidents (30%), followed by mechanical failure (25%), and obstacle strikes (20%). The weather-related accidents accounted for 61% of the fatalities and the NTSB concluded that poor weather poses the greatest single hazard to EMS helicopter operations.

The NTSB report identified several disturbing trends involving HEMS operations. They were concerned that the rapid increase in the number of programs and resulting competition could result in a focus on transport volume instead of flight safety. Pilots might feel self-imposed or externally imposed pressure (i.e., by management) to accept and complete flights despite marginal operating conditions. In addition, pilot training was often deficient in interpretation of weather conditions and in instrument flight procedures. They also found that modified EMS interiors and various program practices often compromised crashworthiness standards, resulting in an increased risk of injury and death.

The NTSB report ended with specific recommendations—some to the FAA and some to the American Society of Hospital-Based Emergency Air Medical Services (ASHBEAMS, which changed its name in 1989 to the Association of Air Medical Services). Included in these recommendations were: improved interior modifications that would not compromise crashworthiness; the use of shoulder harnesses and protective clothing (e.g., helmets, flame-resistant suits, protective footwear); the development of program safety committees; improved training in a number of areas, including marginal weather operations, emergency procedures, pilot-crewmember coordination, and communications.

In reviewing the NTSB data an interesting observation is made with regard to inclusion criteria and selection. A 1986 Chicago accident is included that did not

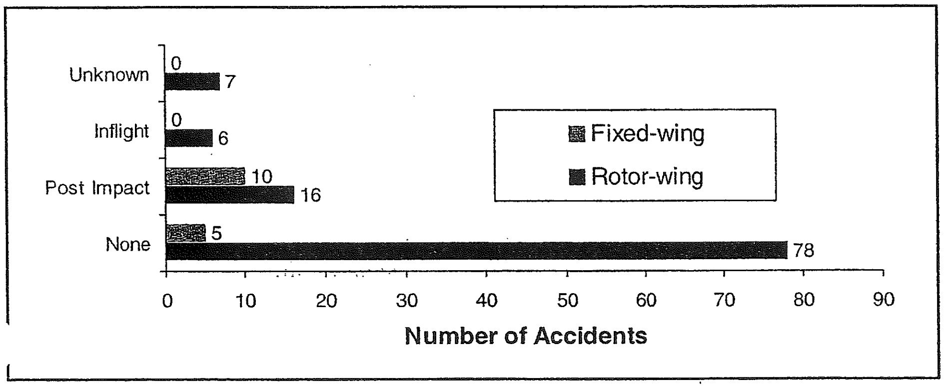


Figure 1–20: Air Medical Accidents with Fires *Adapted from: Frazer, AirMed, Sept/Oct 1999*

involve a medical helicopter, but a corporate helicopter that suffered a tail rotor strike upon departing a hospital helipad after dropping off a passenger. The NTSB, however, chose to include this as a medical helicopter accident even though, in this author's opinion, the helicopter did not meet the NTSB inclusion criteria (aircraft dedicated to the EMS mission, has trained medical personnel on board, and the pilot is employed primarily to fly dedicated EMS missions).

The NTSB report identifies a total of 88 accidents that occurred during their designated study period (1978 through 1986). Based upon their inclusion criteria, the study group was reduced to the 47 "mission" accidents. The "Industry Reported EMS Accidents" came from six different reporting sources and their respective databases: American Society of Hospital-Based Emergency Air Medical Services (ASHBEAMS, now AAMS), Aviation Safety Institute, Hospital Aviation Magazine, FAA Accident/Incident Data System, National Emergency Medical Services Pilots Association (NEMSPA), and the NTSB Accident database.

FLIGHT SAFETY FOUNDATION: HUMAN ERROR AS MAJOR CAUSE OF U.S. COMMERCIAL EMS HELICOPTER ACCIDENTS

Patrick Veillette, Ph.D., studied a total of 87 HEMS accidents and 56 incidents from January 1987 through December 2000. Of interest, Veillette's 2001 study and his database begin where the 1988 NTSB report concluded.

Much like Frazer's studies, this comprehensive report analyzes many common factors related to HEMS accidents, including phase of flight, weather-related accidents, collisions with obstacles, and mechanical-related accidents. Veillette, however, also presents his findings regarding human error as a major factor in HEMS accidents. His discussions also include the findings of numerous other safety reports, FAA Advisory Circulars, and publications.

Veillette concluded that human error was associated with 66 of the 87 (76%) HEMS accidents studied. Of the fatal accidents studied, human error was associated with 84% (27 of 32). Recurring human error factors identified and the number of accidents for which they were cited is shown in Figure 1–21.

Veillette also reviewed the effect human error had on the various phases of flight accidents. He found that human error accounted for 68% of the en route accidents, 91% of the accidents during approach and landing, and 82% of the accidents during takeoff. Of the approach and landing accidents, 41% were due to a collision with an obstacle, while 50% of the takeoff accidents were collisions with obstacles. Figure 1–22 shows the most common phase of flight accident categories.

As mentioned, Frazer and Veillette have reviewed many of the same characteristics surrounding HEMS accidents. Although their findings are similar, several differences are noted. Since the NTSB database was the major source for both studies, the variations must take into account the different years each author included in their study and the fact that Frazer also included fixed-wing accidents. Veillette's review of 1987–2000 excluded many of the years with the highest number of HEMS acci-

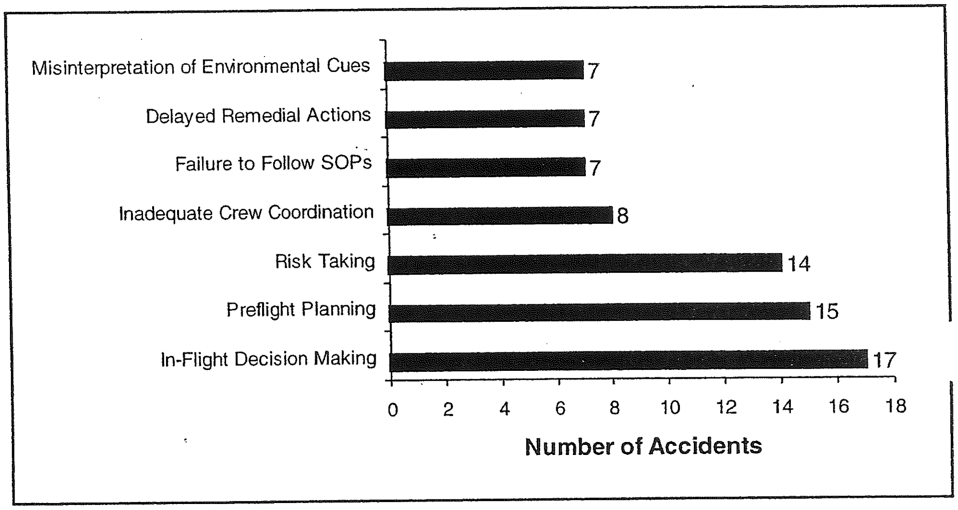


Figure 1–21: Human Error Factors in HEMS Accidents, 1987–2000

Adopted from: Veillette, Flight Safety Digest, April/May 2001

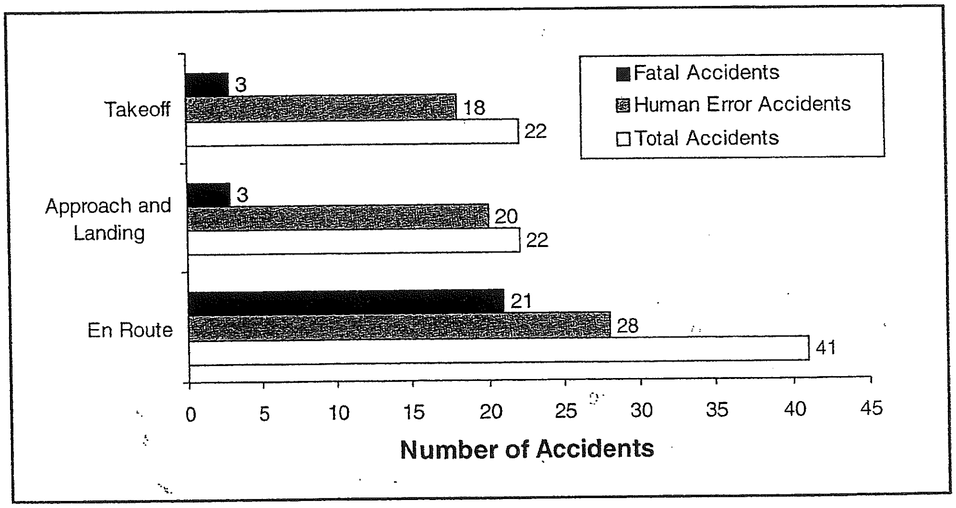


Figure 1–22: Phase of Flight Accidents, 1987–2000

Adopted from: Veillette, Flight Safety Digest, April/May 2001 dents (1982–1986) that were included in Frazer's study. However, Veillette may have been able to identify any significant trends that may have changed *after* the high number of accidents of the early '80s.

Frazer's 2001 study found that 18% of the accidents were the result of collisions with obstacles, while Veillette's report identified 31%. Another difference noted was with regard to aircraft damage and post-impact fires. In Frazer's study of 122 aircraft accidents, 57% were destroyed and 42% had substantial damage. Veillette's data is nearly reversed, with 41% destroyed and 59% sustaining substantial damage. Frazer also found that 15% of the helicopter accidents resulted in a post-impact fire, while Veillette study found less than 6% resulted in a fire.

Veillette identified 47% of accidents occurring en route compared to 36% in Frazer's study. This difference, however, could be due to the number of categories identifying the various phases of flight. Veillette listed only 5 categories (takeoff, en route, maneuvering, approach and landing, ground), while Frazer listed 8 (takeoff, cruise/en route, maneuvering, approach, landing, hover, descent, climb). Finally, as previously noted, Veillette found 76% of the accidents to be associated with human error, while Frazer's study found this to be 65%.

Veillette made several references to the crew in his analysis of the accident database. He found that inadequate crew coordination was cited in eight accidents. Each of these accidents involved a collision with obstacles that occurred during takeoff or landing. Other factors included incorrect or untimely information and distracting comments or movements by the medical crew during a critical phase of flight. He also cited four accidents and six incidents that were caused by cowlings and panels that separated from the helicopter. In half of these events, the medical crew had closed the cowlings improperly prior to flight.

Unique to this study, Veillette reports on his personal observations made during more than 400 HEMS transports between 1995 and 2000. His observations were categorized by the type of flight—scene response (128), interhospital transfer (58), and repositioning (247). It was not mentioned if these observation flights were all with the same program or with different programs. Veillette observed that during none of the transports was the medical crew wearing helmets, while the pilots wore helmets more than 70% of the time. The author did not mention whether helmets were available to the medical crew or to all of the pilots.

Most surprising was his observation regarding the use of seat belts and shoulder harnesses by the medical crew. In 100% of the repositioning flights, the medical crew was wearing seat belts during takeoff, but only 45% were wearing shoulder harnesses. However, on takeoff from scene responses, only 11% were observed to be wearing seat belts and only 4% had shoulder harnesses fastened. The percentage was even lower on takeoff from interhospital transfers, with seat belts buckled only 6% of the time and shoulder harnesses only 4%. While this would appear to be a serious breech of routine safety protocols, Veillette only comments that "because of their in-flight medical duties, medical crewmembers frequently are not seated in energy-absorbing seats with their seat belts and shoulder harnesses fastened."

Veillette's article concludes with a complete listing of the accidents and incidents included in his database. In this same issue of *Flight Safety Digest*, Veillette offers a second comprehensive study that specifically addresses EMS airplane accidents. This second article, which spans 1983–2000, may be the most complete analysis of fixed-wing air medical accidents available. Both of these articles provide excellent information and detailed insight into various aspects of air medical accidents.

EMERGENCY MEDICAL SERVICE HELICOPTERS INCIDENTS REPORTED TO THE AVIATION SAFETY REPORTING SYSTEM

All too often, helicopter accidents include pilot fatalities. Many of these accidents do not provide investigators with adequate and complete information as to the chain of events that led to the accidents. With the high number of fatal HEMS accidents, information from alternative perspectives could be helpful to identify potential problems and prevent future accidents. One such perspective is reports of aviation incidents that did not result in accidents. The U.S. National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System (ASRS) has the world's largest database on aviation incidents and serves as an important resource for this alternative perspective.

The NASA-Ames Research Center searched the ASRS database for reports related to EMS helicopter incidents. From 1986 through 1991, 68 of 81 HEMS incident reports were considered relevant and were included in their study. These reports, which were voluntarily submitted by EMS helicopter pilots, air traffic controllers, and pilots of other aircraft, (i.e., anyone who observes an incident) often included the crucial "chain of events" and the successful resolutions of the incidents. The benefit of these reports was that they enabled the pilot to report what he/she was thinking at the time of the incident.

The objectives of the Ames study were to: (1) identify the types of safety-related incidents reported to ASRS in EMS helicopter operations; (2) describe the operational conditions surrounding these incidents, such as weather, airspace, flight phase, and time of day; and (3) assess the contribution to these incidents of selected human factors, such as communication, distraction, time pressure, workload, and flight/duty impact.

The type of information obtained from the ASRS incident reports and their narratives is very different from the type of accident data already presented. The data were evaluated according to incident variables, operational variables, and human factor variables.

Incident Variables

The Ames report found that non-adherence to the Federal Aviation Regulations (FARs) was identified in 53% of these reports. This included violations of flight/duty limitations, maintenance requirements, and so on. Airspace violation ranked second (23%). Conflict or near-midair collision (NMAC) and in-flight encounter with instrument meteorological conditions (IMC) were reported in 14% of the reports. It should be noted that 22% of the reports identified problems that could not be specifically addressed by other incidents. Figure 1–23 lists the anomalies reported in the ASRS reports.

Operational Variables

This category includes phase of flight, weather conditions, time of day, and type of airspace involved at the time of the incident. Most commonly, HEMS incidents occurred during cruise and during good weather. The time of day most often involved was from 1201 to 1800 hours, which generally corresponds with the busiest time of day for flight programs. The reported incidents occurred in all types of controlled and uncontrolled airspace.

In comparing their findings with the 1988 NTSB report, the Ames report found several similarities and one significant difference. The Ames report found that in comparing the two studies, the weather conditions (i.e., unplanned entry into IMC), airspace, phase of flight, and experience levels of the pilots were similar. In addition, the quality and interpretation of weather information was noted as a concern in both studies. In the Ames report, they found that pre-flight weather briefings had been obtained in 80% of the incidents, but 75% of the briefings did not match the actual weather conditions the pilots encountered in flight.

One difference noted between the NTSB and Ames report was IFR currency. In the ASRS study, 68% of the HEMS pilots had an instrument rating and 66% were IFR current at the time of the incident. In contrast, in the NTSB report 86% of the pilots were IFR-rated, while only 6% were IFR current. The Ames report concluded that "this finding appears to be a compelling reason to advocate IFR currency for EMS pilots, although additional research is necessary to reach this conclusion because of the limitations of the ASRS data." The narratives in these ASRS incidents reported that IFR rating and currency were very helpful, if not invaluable.

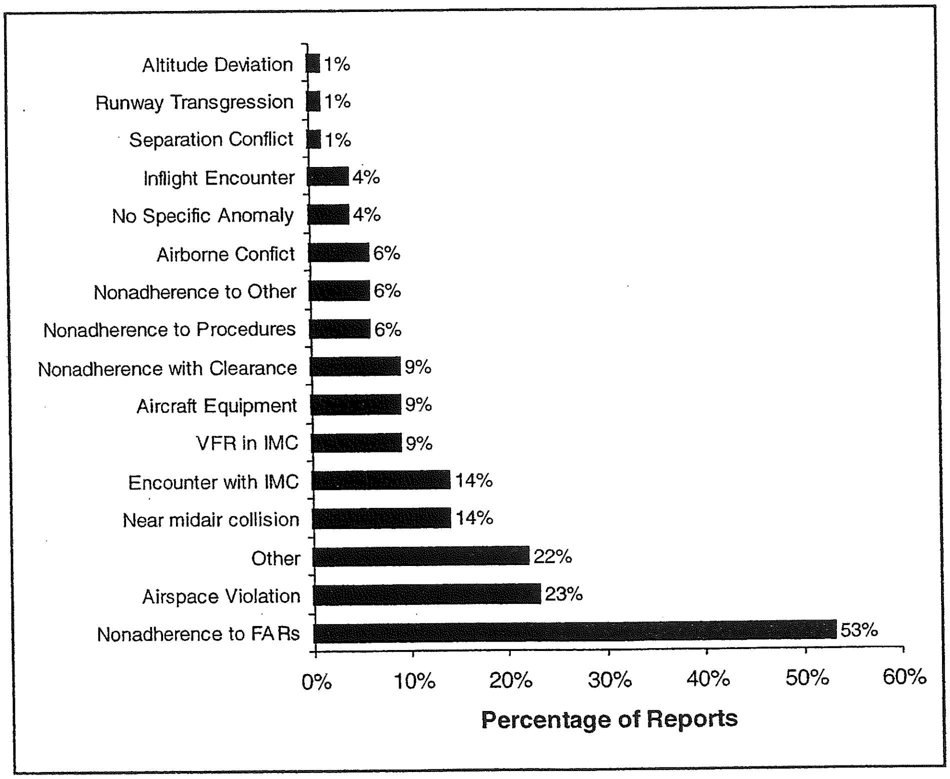


Figure 1–23: Frequency of ASRS Reported Anomalies HEMS, 1986–1991 (n=68)
Adapted from: Connell, Flight Safety Foundation, 1995.

Background Information: Instrument Rating, Currency, and Proficiency

Rating: The FAA defines "rating" as "a statement that, as a part of a (pilot's) certificate, sets forth special conditions, privileges, or limitations." To achieve an instrument rating, a pilot must pass a written test and a flight test given by the FAA. Upon passing these tests, the instrument rating becomes part of the pilot's certificate (license) and the pilot is now legal to fly under instrument conditions for the next six months.

Currency: To maintain currency, a pilot must have flown, within the preceding six months, at least six (6) instrument approaches in a helicopter, completed holding procedures, and intercepted and tracked courses through the use of navigation systems. The flight experience must be repeated at least every six months to maintain IFR currency.

It is important to note that an IFR flight must be to a location (e.g., an airport or helipad) that has an authorized instrument approach. IFR flight *does not* facilitate travel to the scene of an accident or to most hospitals. Recent technology, however, has enabled dozens of hospitals to develop these instrument approaches.

Proficiency: If a pilot does not meet the instrument experience outlined in "currency" within the prescribed time (i.e., the preceding six months) or within 6 calendar months after the prescribed time, he/she will not be able to fly under IFR conditions until he/she passes an instrument proficiency check. This must be in an appropriate aircraft (i.e., for helicopter pilots, it must in a helicopter) and must be given by an examiner, a company check pilot, an authorized flight instructor, or an individual authorized by the FAA to conduct instrument practical tests. Once the pilot has passed this check he/she may fly under instrument conditions for the next 6 months.

Human Factor Variables

Concerns related to communications, time pressure, and distractions were reported at very high rates as seen in Figure 1–24. In addition, workload and flight/duty conditions were also identified in the ASRS reports.

Communications

Of the communications incidents, 60% involved pilot-air traffic control (ATC) communications. Another 13% were communications problems between pilots and weather services (i.e., poor or inaccurate weather information that became a major contributor to in-flight encounters with IMC). Communication difficulties between pilots, HEMS dispatchers and ground personnel (e.g., police, firefighters, paramedics, ground crew, maintenance) were also reported as a frequent problem, especially if they interfered with ATC communications.

Time Pressure

Time-related pressures were cited as a frequent contributor to the ASRS incidents. These pressures centered around our different considerations: patient condition, rapid mission preparation, flight to the patient pick-up location, and low fuel. Patient condition was reported 44% of the time and was the most important contribution to time pressure. The critical condition of a patient could create a sense of maximum urgency. As a result, preflight planning may be inaccurate or preflight inspections and checklist may be hurried and incomplete. Other reports cited such oversights as not stopping for refueling; failure to obtain or review correct charts; overflying scheduled aircraft maintenance; inadequate or less-than-thorough weather briefings; and inadequate evaluation of weather briefings preceding the go/no-go decision. The Ames report found that time pressure associated with the patient's condition seemed to be present regardless of whether the patient was already onboard the aircraft or the pilot was en route to patient pick-up.

Most programs strive to isolate the pilot from knowing any medical information so that their flight decisions are made objectively. Unfortunately, we may not be as successful as we would hope. HEMS pilots are well aware that their services are generally requested when there is a critically ill or injured person in need of transport. In addition, the pilot may be faced with a sense of urgency from both verbal and/or nonverbal signals from the medical crew. One ASRS report stated, "No flight is so important that the lives of the flight crew should be jeopardized due to incomplete or inaccurate preflight planning."

Distractions

Distraction from the primary task of flying the aircraft was reported in many of the ASRS incidents. External factors created many distractions that were cited in the reports. These included in-flight aircraft equipment problems, the need to monitor multiple radio frequencies, traffic avoidance in high-density traffic areas, interruptions, radio frequency congestion, poor visibility due to haze or night operations, marginal weather, noise from on-board medical equipment, and impending low-fuel situations. Many of these distractions could also lead to time-pressure situations.

Internal factors were also reported which led to significant distraction. This included personal or family-related concerns, anxiety in the current situation, disorientation, involvement in patient condition, confusion about procedure, and general inattention.

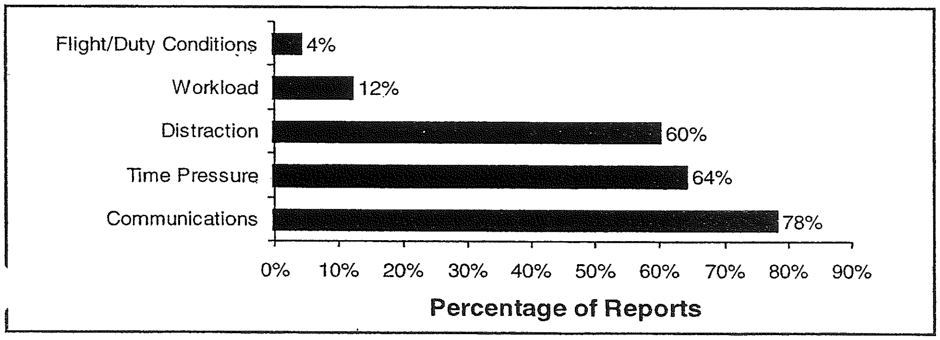


Figure 1–24: Human Factors in HEMS Incident Reports (n=68)
Adapted from: Connell, Flight Safety Foundation, 1995.

Distractions can lead to accidents. In our daily activities, it is common to try to do multiple things at the same time—to multitask. While driving, it seems to make perfect sense to get something else done. Many people use their handheld cellular telephones. There are several recent studies that indicate a strong correlation between the use of cell phones and the increased probability of an auto accident due to the distraction.

Aviation is no different. The idea of the sterile cockpit began in commercial airlines and has been around for years. By eliminating unnecessary talking during critical stages of flight, we can reduce distractions and improve our safety record significantly. Medical crewmembers, patients, passengers, and even other pilots, despite good intentions, can be significant distracters.

Workload and Flight/Duty Considerations

While workload (12%) and flight/duty considerations (4%) were reported in the ASRS incidents, the Ames study concluded that they were not a significant contributor to any HEMS incident.

However, workload, flight/duty length, crew rest, and the number of duty days can influence many factors, including judgment, error recognition, concentration, forgetting tasks, fatigue, and ultimately can lead to aviation incidents.

An unexpected finding in the HEMS ASRS reports was that cruise flight was a common time for HEMS safety incidents. Airspace violations and near-midair collision most frequently occurred in cruise flight and in VFR weather. In-flight weather encounters were also reported as occurring most often in cruise flight. During cruise, it would be anticipated that cockpit activity would be low—unlike takeoff and landing. However, it appears that the HEMS pilot might be attending to tasks inside the cockpit, rather than watching for conflicting traffic, low clouds, or airspace boundaries. These cockpit activities might include providing position reports to dispatch, coordinating with the medical center, programming navaids, or communicating with other EMS personnel.

The Ames report focused on the unique demands placed on the HEMS pilot that led to distraction and time pressure. It concluded that these demands could compromise good communications, thorough planning, cooperative teamwork, and safe flight during patient transport. It recommends that steps need to be taken to improve communication, decrease distraction, decrease time pressure to realistic levels, and assist in workload management.

Ames proposed that Crew Resource Management (CRM) was not just for major airlines or big companies. Effective communications among all HEMS team members—pilots, flight nurses, paramedics, doctors, administrators, and communication specialists—are vital if the HEMS team is to perform its duties efficiently, successfully, and safely. CRM will be discussed in more detail in Section 4 of this report.

AIR MEDICAL ACCIDENT ANALYSIS

In April 2000, an Air Medical Safety Summit was convened to address the rising number of air medical accidents. From this Summit of industry leaders and safety experts came the Air Medical Safety Advisory Council (AMSAC), the Air Medical Service Accident Analysis Team and several other initiatives.

The Air Medical Service Accident Analysis Team was created to study past accidents, analyze the root causes of these accidents, and identify effective and feasible interventions that would prevent future HEMS accidents. Chaired by Richard Wright, Jr., of the Helicopter Association International, the main focus of the Team was human factor accidents. It was felt that identified interventions in this area might have the greatest impact on accident prevention and safety.

The Team identified 20 HEMS accidents between November 1993 and November 1999 whose Final NTSB Accident Reports included extensive data for review and evaluation. The process used to examine these accidents is referred to as "root cause analysis."

Event Sequence

A timeline of events was developed for each flight from the available accident report. This included all aspects of the transport, from prior to the flight, during the flight, and ending with the accident itself.

Problem Statements

Any and all "problems" that could have contributed to the accident were then identified. Among the 20 flights, a total of 56 individual problems were identified. They were then classified as: pilot performance issues (23), aircraft issues (9), infrastructure issues (9), environmental issues (6), landing zone issues (5), and corporate and/or program management issues (4), as identified in Figure 1–25.

Intervention Strategies and Ratings

Interventions were next identified for each problem to determine what might have prevented the problem, potentially averting the accident. A total of 65 unique interventions were proposed, which were categorized as Training Interventions, Equipment Interventions, Air Traffic Management Interventions, Regulatory or FAA-sponsored Interventions, National Airspace (NAS) or Infrastructure Interventions, or Miscellaneous Interventions.

Each intervention was evaluated and scored by the Team for its effectiveness, yielding a ranking, or *Effectiveness Score*. The combined score was then divided into thirds to group the interventions that rated *High* (21–17), *Moderate* (16–13) and *Low* (12–8) *Effectiveness*.

The next step was to evaluate and score each Intervention to determine it's technical feasibility, financial feasibility, regulatory feasibility, and operational feasibility. A range from 48 to 13 was obtained for the 65 interventions. As before, the combined scores were then divided into thirds, to rank the interventions as *High* (48–37), *Moderate* (36–32), and *Low* (31–13) *Feasibility*.

Recommendations

The results were combined into a matrix, with interventions classified into nine different categories. It was the Team's recommendation that AMSAC focus efforts within the air medical industry to develop implementation strategies for those interventions that ranked highly effective and highly feasible. Recommended for consideration were those interventions that were identified as highly effective but moderately feasible, highly feasible but moderately effective, and those that were moderately effective and moderately feasible. Interventions classified as low effectiveness and/or low feasibility were not recommended by the Team for implementation or further pursuit. Figure 1–26 lists the nine categories and the Team's recommendations to AMSAC.

This document is an excellent resource that takes a detailed and comprehensive look into the specific problems and events that have led to previous HEMS accidents. The Team has also provided a comprehensive list of specific technologies, training, regulations, and operational enhancements and rankings of their effectiveness and feasibility as interventions that can improve the safety of air medical transport and reduce the number of accidents. However, in making their recommendations, the Team divided the scores into thirds to yield their *High*, *Moderate*, and *Low* ratings. In doing so, it is inevitable that some interventions will miss a cut-off by a mere point or two. For example, full motion simulators, improve safety programs and improve safety cultures were each classified as *"High Effectiveness"* but fell one point short of *Moderate Feasibility*. Following the specific recommendations of the Team, these highly effective interventions would not be pursued. Clearly, the most highly ranked interventions in both effectiveness and feasibility should be investigated very carefully for possible implementation. However, operators, manufacturers, associations, and programs should review this entire list of possible interventions to identify opportunities, such as full-motion simulators, that are within their capacity for improvement and enhanced safety.

AIR MEDICAL ACCIDENT ANALYSIS: CONSOLIDATED PROBLEM STATEMENTS

Pilot Performance Issues:

- Loss of situational awareness
- Poor aeronautical decision making
- Limited experience in make/model
- Flight check not conducted in operational type of aircraft
- Pilot disregarded company policies
- Inadequate preflight planning
- Pilot failed to obtain weather briefing
- Pilot ignored weather briefing
- Pilot not wearing helmet
- Pilot continued VFR flight into IMC conditions
- Pilot descending to avoid IMC
- Pilot fails to maintain safe altitude
- Pilot fails to conduct area recon
- Pilot fails to conduct pre-departure briefing
- Improper response to inflight emergency
- Inadequate Nr (rotor RPM) control
- Pilot failed to recognize and avoid power settling
- Improper pilot technique
- Pilot took off with sun in eyes
- Destination position not entered in navigation equipment
- Pilot failed to use aircraft searchlight to detect wires
- Pilot failed to hear or respond to ATC special VFR clearance
- Pilot's attention is diverted to inside the cockpit

Environmental Issues:

- Night VFR operations
- Night IMC operations
- Reduced visibility
- Mountain operations
- High altitude operations
- Featureless terrain

Aircraft Issues:

- Aircraft not IFR certificated
- No autopilot or second pilot
- Poor configuration of navigation equipment
- Pilot unable to determine altitude above LZ
- Pilot unable to detect weather
- Pilot unable to detect wires
- Misleading/inaccurate fuel quantity gauge
- Aircraft flotation inadequate for existing sea conditions
- Uncrashworthy fuel tank

Infrastructure Issues:

- ATC unclear regarding pilot's request
- Inadequate vector by ATC to intercept localizer
- Pilot unable to obtain ATIS (Automated Terminal Information Service) information
- Airport uncontrolled
- Airport congested, requiring landing on ramp
- Helipad small
- Helipad surrounded by obstacles
- Powerlines did not meet marking criteria
- Powerlines not depicted on aeronautical charts

Landing Zone Issues:

- Difficulty identifying landing zone
- No landing site supervisor
- Incorrect/inadequate obstacle information on LZ
- Congested landing zone
- Obstacle-rich environment

Corporate/Management Issues:

- Corporate pressure to complete the mission
- Personal pressure to complete the mission
- "Ready Aircraft" change required equipment transfer
- Preflight preparations rushed

Figure 1–25: Consolidated Problem Statements

Adopted from: Air Medical Accident Analysis, 2001

		EFFECTIVENESS		
		High	Moderate	Low
FEASIBILITY	High	• Enhance the training for night flying operations • Enhance the training for mountain flying operations • Equip aircraft with Terrain Avoidance Warning Systems (TAWS) • Equip aircraft with radar altimeters • Provide aircraft with mission-essential equipment • Improve the content of weather briefings	• Enhance the awareness of accident causes • Improve physiological training • Improve training with avionics equipment: usage, capabilities, etc. • Improve weather radar • Encourage greater utilization, interaction with and assistance from Air Traffic Management • Improve/enhance training of ATC personnel in rotorcraft operations and capabilities • FAA to enhance training elements of Biennial Flight Reviews and Pilot Training Standards	• Readily available crew/passenger briefing cards • Fuel flow indicators • Simplify calling FSS • Publish a mountain flying advisory circular • Publish a "flat light/whiteout" advisory circular • Require flight plans • Provide more UNICOM frequencies
	Moderate	• Conduct/enhance annual IFR proficiency checks • Conduct/enhance training to improve the understanding of weather briefings • Enhance overall training: recurrent, professional knowledge, etc. • Conduct/enhance training in ADM • Establish an integrated and structured Pilot Training Program • Conduct/enhance mission-oriented training • Conduct/enhance CRM training • Equip aircraft with Moving Map Displays to provide weather, obstacle, and terrain data • Equip aircraft with avionics to provide a vertical awareness display or warning • Standardize cockpits of similar make/model used in similar operations • FAA to enhance/improve contents of annual IFR proficiency checks • Establish national criteria for the marking of wires and towers	• Operators to enhance training for Biennial Flight Reviews and Pilot Training Standards • Develop helicopter-specific, mission-specific computer-based emergency procedures simulators • Develop satellite-based Communications, Navigation and Surveillance (C/N/S) technology • Increase the rate of commissioning of new AWOS/ASOS (Automated Weather Observing System/Automated Surface Observing System) facilities • Improve aeronautical charts (symbology, data, etc.)	• Improve pilot handbooks • Data link technology • Require annual calibration of fuel quantity gauges
	Low	• Horizontal Awareness From Terrain • Synthetic vision • Heads-up display • Night vision devices • Full-motion simulators • Enhance visibility/detection of wires and towers • Change corporate mind-set • Improve safety culture • Improve safety program	• ADS-B (Automatic Dependant Surveillance-Broadcast) Technology • Automated voice call-outs • Over-bank warnings • Excess terrain closure warnings • improve equipment with state-of-the-art technology • Prohibit night flying by non-IFR rated pilots • Require human factors/ergonomics in cockpit designs	• Increase dual-pilot time prior to solo PIC • Increase time requirements for "mission certification" • Obstacle database • Enhanced ice detection equipment • Raise minimums for night instrument approaches • Require ATC monitoring of instrument approaches • Prohibit night VFR • Update FAR Part 135 requirements • Require crashworthy fuel tanks for certification

Adopted from: Air Medical Accident Analysis, 2001

HEMS ACCIDENTS AND INCIDENTS, 1998 TO 2001

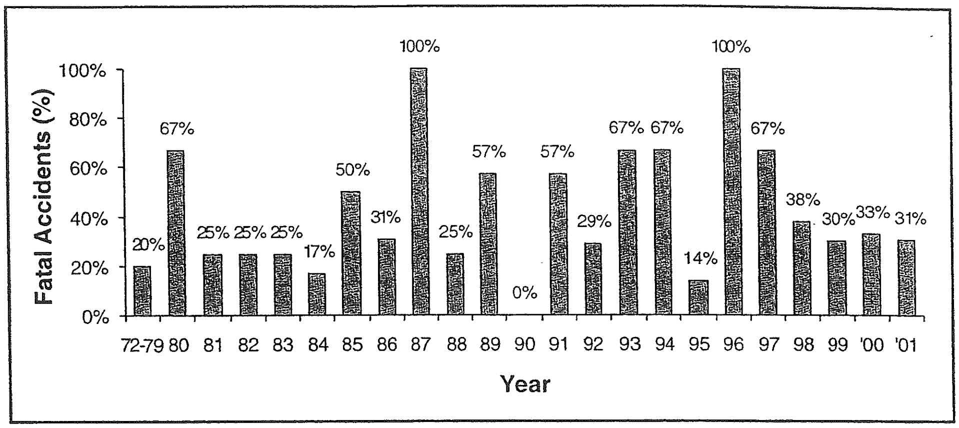


Figure 1–27: Percentage of Fatal Accidents per Year

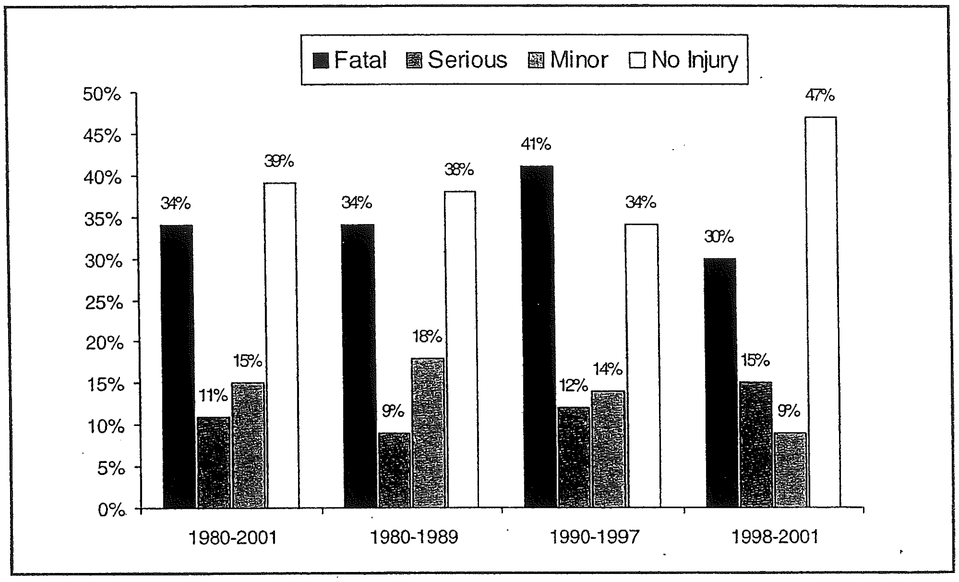


Figure 1–28: Severity of Injuries for HEMS Accidents, 1980 – 2001
(1980–2001, n=494; 1980–1989, n=247; 1990–1997, n=116; 1998–2001, n=131)

The past four years has seen an alarming increase in the number of HEMS accidents across the nation. No one is certain why there have been 43 accidents (plus one dual-purpose medical helicopter accident) in four years. From 1987–1997, dedicated HEMS has averaged 4.9 accidents per year. The past four years averaged 10.75 per year. Not since the four year period of 1983 to 1986 have we seen such a large number of accidents.

While a few of the reports that we reviewed included accidents from 1998 to 2000, none of these studies isolated these years from the rest of their accidents. Therefore, with no published review of the most recent series of accidents, we determined that it was necessary to do our own preliminary review of these accidents to see if any trends could be identified.

Several resources and databases were reviewed in the development of Attachment 1. This table presents the pertinent data on 44 HEMS accidents between 1998 and September 30, 2002.

Attachment 1 does not include any ed-wing EMS. In addition, we have not included an accident that killed three crewmembers in England, a non-EMS helicopter that crashed on a hospital helipad, or an "as needed" service that crashed after picking up three firemen to respond to a medical emergency in Hawaii. Finally, two additional accidents were not included which involved medical helicopters that had been "out-of-service" for at least several days and were undergoing post-maintenance test flights.

Of the 44 accidents from 1998 to 2001, 15 (34%) resulted in at least one fatality. For the 1980s, our accident database showed 39% of all accidents resulted in at least one fatal injury. From 1990–1997 the rate increased to 47%. Despite the increase in accidents over the past four years, the percentage of fatal accidents has declined by nearly 30%. Figure 1–27 depicts the percentage of fatal accidents since 1980. As the figure shows, the last four years has had the lowest consecutive 4-year fatality rate in HEMS history since the early 1980s.

Looking at the breakdown of all injuries (Figure 1–28), there is also a significant difference noted in the percentage of crewmembers who sustained no injuries in HEMS accidents. Figure 1–28 shows four different comparisons: the entire 21-year study period; the 1980s; 1990–1997; and finally 1998–2001. The percentage of fatal injuries has decreased in 1998–2001 and we now see 47% of the crewmembers and passengers sustained no injuries.

Since 1998, a slightly higher percentage of HEMS accidents occurred at night (52%). More accidents occur during the cruise phase of flight (16) than any other phase and we now see a similar number of accidents occur on takeoff and landing (8 each). More accidents (45%) are taking place during scene missions than previously noted (35%). Finally, our preliminary review of the HEMS accidents seems to show a decrease in the percentage of weather-related accidents. Frazer had noted an increase in weather-related accidents from 22% in the '80s to 32% in the early and mid-'90s. From 1998 to 2001, there appear to be 6 weather-related accidents, dropping the percentage to 14%.

HEMS ACCIDENT AND FATAL ACCIDENT RATES

The UCAN Safety Committee felt that an important aspect of our research would be to determine HEMS accident and fatal accident rates for our entire study period (1980–2001). In order to normalize the raw accident data for a meaningful comparison of dedicated HEMS accidents, it is necessary to have two key elements—the number of accidents (total and fatal) and the number of flight hours flown or the number of patients transported for the entire industry each year. We have already reviewed the accident data that is readily available from several sources. Unfortunately, as previously mentioned, a major obstacle is our lack of accurate HEMS exposure data (e.g., flight hours, patients transported) making it impossible for a meaningful year-to-year comparison. Dual-purpose medical helicopter accidents are not included in this portion of the report.

Methodology

Our research model required that an extensive review of the air medical literature be conducted to determine what data was available that could be used to normalize the HEMS information. We found that in 1982, *Hospital Aviation* began to track and publish statistics and accident rates that were based on the number of patient transports (rather than flight hours) for the air medical industry. In 1988, *Hospital Aviation* also looked at revenue flight hours as well as patient transports. Their survey found that the average patient transport corresponded to 1.05 revenue flight hours. Because of this finding, accident rates continued to be tracked based upon patient transports. No data were collected on total hours flown (training, repositioning, maintenance, PRs, etc.). In the journals, the "per 100,000 patients transported" accident rates were found through 1992 and resurfaced again in a 1997 article that provided a graph for the years 1978 through 1995.

"Annual Transport Statistics," the results of another industry-wide survey, was published first in *Hospital Aviation*, and then in the *Journal of Air Medical Transport*, the *Air Medical Journal*; and then in *AirMed*. This analysis provides information on *averages* per flight program (as well as highs and lows) for the year, region-by-region, and across the United States. This included information on the average number of patients transported, interfacility missions, scene missions, night flights, and loaded miles. In 1994, they also started to include average flight hours in the survey results. Personal correspondence with Bill Rau, who had authored the transport survey articles since 1996, stated that the survey asked for "total annual flight hours excluding PR flights."

A final source of HEMS statistics was the "Mid-Year Report" that identified (among other related data) the number of hospital-based programs and helicopters. This data was found from 1984 through 1989 in *Hospital Aviation* and subsequently in the *Journal of Air Medical Transport*. Several additional articles and the 1988 NTSB report were also reviewed to provide raw data.

Total flight hours and total patient transports were unavailable for more than 50% of the years reviewed. From the "Annual Transport Statistics" we did have the average number of patients transported per program per year and the average flight hours per program. Unfortunately, we lacked any estimate as to the number of HEMS programs in operation since 1992. In order to normalize the HEMS data, the missing information would need to be obtained or estimated.

In an effort to estimate the number of HEMS programs, several assumptions were made. If we could determine the number of programs and helicopters currently in operation (November/December 2000), we could estimate the total flight hours and patients transported during the year. In addition, unlike the early 1980s, we assume that the growth in the industry has been fairly constant over the past eight years. We would then be able to estimate the number of programs and helicopters for the years lacking data.

To determine a fairly accurate number of dedicated HEMS programs and helicopters, we undertook a review of the Association of Air Medical Services (AAMS) Membership Directory and the Directory of Air Medical Programs, published in the May/June issue of *AirMed*. Unfortunately, neither resource is complete. Not all air medical programs are AAMS members and neither directory includes the total number of aircraft. To supplement this data, a survey was posted on the Internet's *Flightweb* listserve. The survey requested state-by-state information on the number of dedicated HEMS programs (hospital-based, independent, etc.) and the number of dedicated helicopters.

Knowing the flight hours is the next consideration in an attempt to normalize the HEMS data. The NTSB document reported flight hours for 1980 through 1985, but did not specify if their figures correspond to revenue flight hours or total flight hours. In addition, the *AirMed* surveys provide average flight hours per program from 1993 to 2000. If we are successful in estimating the total number of HEMS programs in operation from 1993 to 2000, we will be able to estimate the total flight hours.

Total flight hours is an important consideration in our evaluation. In HEMS, a considerable number of accidents occurred on non-patient missions—including PRs, refueling, maintenance, training, and so on. The average flight hours per program, as published in the *AirMed* surveys, should have included all flight hours except PRs. The vast majority of HEMS flight hours are patient missions. Personal correspondence with several HEMS programs and operators suggests that non-patient flight time may range from 5 to 15%. PR flights made up approximately half of this for many programs.

In an effort to more accurately determine the average number of *total* flight hours per program, a survey of five of th largest HEMS operators was conducted. These operators were chosen with the knowledge that they account for the majority of the air medical programs in the country. The operators were asked for total flight time, total number of programs and total number of helicopters they operated for the years 1998 through 2000. The goal was to compare these flight hours with the information published in *AirMed* for 1998 and 1999. In addition, a correlation could then be made comparing revenue flight hours and total flight hours for other years.

Results

In review of the available published statistics, several limitations and problems were identified that make accurate yearly comparisons very difficult. Most important, the "Annual Transport Statistics" report only on hospital-based HEMS programs. Over the years, more and more HEMS operations have deviated from this original, yet still dominant model. In 1989, the journals began sending surveys to non-hospital helicopter programs, but the data was never included in the published average statistics. In 1989, the total number of patients transported by these non-hospital programs was referenced. However, these numbers included some dual-purpose helicopter programs as well.

Another problem was timing of the data collected. Some statistics regarding the number of helicopter programs and total number of helicopters were published in *Hospital Aviation* in a mid-year (July) report, while other program and helicopter statistics were based on the calendar year. The *Annual Transport Survey* was based on the calendar year until 1993 when it was switched to the academic (July to June) year for annual statistics tabulation. In general, annual accident statistics were based on the calendar year.

Since 1986 the journal surveys were sent to both helicopter and fixed-wing programs. The percentage of surveys returned ranged from a high of 96% to a low of 33%. In general, the yearly data was fairly consistent. The one exception was 1994, which had significantly *higher* average flight hours per program and much *lower* loaded miles than other years.

The results of the literature search and the following calculations can be found in Figure 1–29. The data obtained from the various publications is presented in ***bold italics*** while the calculations and surveyed data is in plain type.

Helicopter EMS Programs and Helicopters. Data was available for the number of HEMS programs from 1972 to

Figure 1–29: HEMS Program, Helicopter and Accident Statistics (Published data is in bold italics)

1	***Data for Year***	***72–79***	***1980***	***1981***	***1982***	***1983***	***1984***	***1985***	***1986***	***1987***	***1988***
2	Year Data was Published					[1984]	[1985]	[1986]	[1987]	[1988]	[1989]
3	Avg Pts Flown / Program		546	676	654	***553***	***570***	***590***	***623***	***698***	***697***
4	Avg Loaded Miles					***61***	***63***	***61***	***61***	***61***	***58***
5	Avg Hrs Flown / Program	See total hours below (Line 8a)							654	733	732
6	Avg Flt Hr / Pt Transport								1.05	1.05	***1.05***
7	Avg Total Hrs/Prog								710	795	794
8a	Total Flight Hrs (-PR)		***20,750***	***28,071***	***36,794***	***45,233***	***56,516***	***71,831***	84,385	106,271	113,437
8b	Total Flight Hrs		***20,750***	***28,071***	***36,794***	***45,233***	***56,516***	***71,831***	91,558	115,303	123,079
9	# of Programs		32	***37***	***49***	62	***76***	***101***	***129***	***145***	***155***
10	# of Helicopters		39	***45***	62	75	***91***	***119***	***151***	***184***	***195***
11	Total Pts Flown	***30,168***	***17,483***	***25,013***	***32,027***	***41,097***	***51,855***	***68,694***	***87,299***	***105,000***	***120,900***

14	***Year***	***72–79***	***1980***	***1981***	***1982***	***1983***	***1984***	***1985***	***1986***	***1987***	***1988***
15	HEMS Accidents	5	3	4	8	8	6	12	13	4	8
16	Dual-Purp. Acc.										
17a	Accident Rate (TFH)		14.46	14.25	21.74	17.69	10.62	16.71	14.20	3.47	6.50
17b	Accident Rate (-PR)		14.46	14.25	21.74	17.69	10.62	16.71	15.41	3.76	7.05
17c	Difference		0.00	0.00	0.00	0.00	0.00	0.00	1.21	0.29	0.55

18a	% programs w/ accidents		9.4%	10.8%	16.3%	12.9%	7.9%	11.9%	10.1%	2.8%	5.2%
18b	% helicopters w/ acc.		7.7%	8.9%	12.9%	10.7%	6.6%	10.1%	8.6%	2.2%	4.1%

19	Fatal Accidents.	1	2	1	2	2	1	6	4	4	2
20	Fatal Dual-Purp.										
21	Fatal Acc Rate		9.64	3.56	5.44	4.42	1.77	8.35	4.74	3.76	1.76
22	% Fatal Acc.	0.20	0.67	0.25	0.25	0.25	0.17	0.50	0.31	1.00	0.25
23	per 100,000 pts	16.57	17.16	15.99	24.98	19.47	11.57	17.47	14.89	3.81	6.62

Key to Lines:

2. *Survey results are routinely published in the following year.*
   83–99, *published data.* 80–82, *calculated (total pts flown / # of programs)*
   83–99, *published data.*
5. 93–99, *published data.* 86–92, *calculated (ave # pts transported per program X 1.05).*
6. 88, *published data.* 93–99, *calculated (ave hrs per program / ave pts flown per program)*
7. 98–2000, *operator survey.* 86–97, *calculated (line 5 X 1.085)*

1992 (Figure 1–29, Line 9) and information on the total number of helicopters was available for 1981 to 1991 (Figure 1–29, Line 10). From the *Flightweb* survey and personal follow-up, information was obtained from 45 of the 50 states (plus the District of Columbia). Program data for the remaining states was estimated from the *AirMed* directory. The survey results identified 231 dedicated HEMS programs, operating a total of 377 helicopters (not including back-up aircraft).

Additional follow up with several industry leaders and aircraft manufacturers suggests that, if anything, these numbers may be slightly underestimated. From a telephone survey of the five aircraft manufacturers, it was estimated that there were a total of 462 dedicated and backup medical helicopters in the United States. This did not include dual-purpose helicopters. From the operators' survey, there was an average of one backup helicopter for every 7.1 dedicated helicopter in their combined fleets. Using this ratio, it would appear that our state-by-state survey of 377 helicopters would have an estimated 53 backup aircraft yielding a total of 430 helicopters. This represents a variation of approximately 7% fewer aircraft compared to the number of helicopters from the manufacturers' survey. This may also indicate a slight discrepancy in the number of HEMS programs resulting from our Internet survey. In using the lower state-by-state survey results of 377 dedicated helicopters and 231 programs for our calculations, we realize that we may be underestimating our flight hours and number of patients transported. This also results in higher accident and fatality rates.

1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
[1990]	[1991]	[1992]	[1993]	[1994]	[1995]	[1996]	[1997]	[1998]	[1999]	[2000]	N/A	N/A
705	***709***	***869***	***876***	***805***	***812***	***813***	***845***	***827***	***796***	***880***	832	882
60	***58***	***57***	***55***	***49***	***33***	***47***	***47***	***47***	***55***	***58***	***50.76***	51
740	744	912	920	***876***	***1159***	***785***	***823***	***823***	***814***	***821***	813.22	911
1.05	1.05	1.05	1.05	1.09	1.43	0.97	0.97	1.00	1.02	0.93	0.98	
803	808	990	998	950	1258	852	893	893	***854***	***921***	***841***	***957***
122,141	129,534	162,416	169,141	166,245	226,778	158,221	170,727	175,573	178,447	184,839	187,854	210,396
132,523	140,545	176,221	183,518	180,376	246,054	171,670	185,239	190,497	187,216	207,327	194,271	217,584
165	***174***	***178***	***184***	190	196	202	207	213	219	225	231	231
213	***231***	***225***	242	259	276	293	309	326	343	360	377	400
125,200	***159,027***	154,682	161,087	152,771	158,881	163,865	175,291	176,427	174,501	198,098	192238	203,772

1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
7	1	7	7	3	6	7	1	3	8	10	12	13
2		1							1			
5.28	0.71	3.97	3.81	1.66	2.44	4.08	0.54	1.57	4.27	4.82	6.18	5.97
5.73	0.77	4.31	4.14	1.80	2.65	4.42	0.59	1.71	4.48	5.41	6.39	6.18
0.45	0.06	0.34	0.32	0.14	0.21	0.35	0.05	0.13	0.21	0.59	0.21	0.20

4.2%	0.6%	3.9%	3.8%	1.6%	3.1%	3.5%	0.5%	1.4%	3.6%	4.4%	5.2%	5.6%
3.3%	0.4%	3.1%	2.9%	1.2%	2.2%	2.4%	0.3%	0.9%	2.3%	2.8%	3.2%	3.3%

4	0	4	2	2	4	1	1	2	3	3	4	4
1		1							1			
3.27	0.00	2.46	1.18	1.20	1.76	0.63	0.59	1.14	1.68	1.62	2.13	1.90
0.57	0.00	0.57	0.29	0.67	0.67	0.14	1.00	0.67	0.38	0.30	0.33	0.31
5.59	0.63	4.53	4.35	1.96	3.78	4.27	0.57	1.70	4.58	5.05	6.24	6.38

8a. *72–85, published data. 86–92, 93–99 calculated (# of program X Avg flight hrs per program).*
8b. *72–85, published data. 86–2000, calculated (line 7 X line 9)*
9. *72–92, published data. 2000, Flightweb survey. 93–99, calculated assuming consistent growth for 92–00*
10. *81–91, published data. 2000, Flightweb survey. 92–99, calculated assuming consistent growth for 91–00.*
11. *80–90, published data. 91–99 calculated (# of programs X Avg # of pts transported each year).*
17a. *80–99, calculated. (100000 X number of accidents)/total flight hours for the year*
17b. *80–99, calculated. (100000 X number of accidents)/total flight hours for the year, excluding PR*

Our *Flightweb* survey results were entered into an Excel spreadsheet for the year 2000 along with the published data through 1991/1992. The estimated number of programs and helicopters for 1992/1993 through 1999 were then calculated assuming a consistent growth rate each year. The results are found in Figure 1–29, Lines 9 and 10.

Flight Hours. Total flight hours for the HEMS industry were available for 1972 to 1985 (Figure 1–29, Line 8a and 8b). In addition, the average total flight hours per program, excluding PR flight time, were published for 1983 to 1999 (Figure 1–29, Line 5). Total flight hours (less PR flights) for 1993 to 1999 could now be estimated (number of programs X average flight hours per program).

For 1986 to 1992, we had to first estimate the average number of flight hours per program. We relied upon Collett's previously documented average of 1.05 flight hours per patient flight in 1988 when the average loaded flight was 58 miles. To test this hypothesis, we calculated the average flight hours per patient transport from 1993 to 1999 (Figure 1–29, Line 6). Over these seven years, the average was 1.058 flight hours per patient transport—despite the fact that the loaded miles had decreased. Multiplying 1.05 times the average number of patients transported per program per year for 1986 to 1992, we were able to estimate the flight hours needed to normalize our data.

To determine the accuracy of the calculated total flight hours, we compared *AirMed's* average flight hours per program to the results of our HEMS operator survey. For the year 2000, the companies operated 160 programs and 269 dedicated helicopters. Comparing this to our *Flightweb* survey results (231 programs and 377 helicopters), the operators represent 69% of the HEMS programs and 71% of the helicopters. In 1999, the average total flight hours per program was 925 hours for our five operators. This represents a 12% increase over the 821 hours published in *AirMed.* Based upon our operators' survey, the 1998 average was 854 hours. This corresponds to a 5% increase compared to the *AirMed* survey for that same year. Taking into account our earlier estimates regarding non-patient flight time and PR flight time, these calculated increases (an average of 8.5%) seem accurate. Figure 1–29, Line 7 lists the average *total* flight hours per program from our operators survey results (1998 to 2000) and the calculated values for 1986 to 1997. This is done by multiplying the previously recorded average flight hours per program (Figure 1–29, Line 5) by 1.085. Total flight hours for each year can now be more accurately estimated, as documented in Figure 1–29, Line 8b.

Patients Transported. The journals published data on the total number of patients transported each year from 1980 to 1990. With the number of programs now estimated for each year, the total number of patients transported annually from 1991 through 1999 could also be estimated (number of programs X the average number of patients transported each year).

Accident Data. The yearly accident and fatal accident data (Figure 1–29, Lines 15 and 19) were obtained and summarized from several resources. The references included the NTSB and NASA websites, the CONCERN Network, and personal databases from several industry leaders.

Year 2000. For the year 2000, *AirMed* no longer published their "Annual Transport Statistics," which included the average number of patients transported and hours flown. In order to estimate these numbers, the *AirMed* survey results for the previous five years were averaged. It is interesting to note that our operators' survey shows a decrease in the average flight hours per program to 841 hours, a decrease of 9% compared to 1999 figures.

Year 2001. In order to include the 2001 HEMS accidents in our calculations, additional information was obtained from our aviation operators and aircraft manufacturers. Recognizing that the operators represented approximately two-thirds of the programs and helicopters in our earlier analysis, this seemed an appropriate perspective for year 2001 projections.

Operators were asked for their 2001 total flight time, total number of programs, and total number of helicopters operated. The combined results identified 159 programs and 286 dedicated helicopters. Compared to 2000, this was a decrease of one HEMS program, while 17 additional helicopters were placed in service—an increase of 6%. Follow up with the aircraft manufacturers, however, showed a one-year increase of 13% for the total number of EMS helicopters. Combined total flight hours according to the operators increased at the same rate, showing a gain of 13% over the previous year. These values were used to calculate 2001 data for our comparisons.

Accident Rates

The necessary data is now available to normalize the HEMS data and compare what has occurred each year. Accident rates were calculated using all of the accidents that were included in Figure 1–29. This included patient and non-patient missions. The only medical helicopter accidents excluded were several dual-purpose helicopter accidents, two maintenance flights where the aircraft were not in service to the HEMS program at the time of the accident, and a training flight of a newly hired pilot preparing for his check ride.

The first comparison for the HEMS accidents is a determination of the accident rates per 100,000 flight hours (Figure 1–29, Line 17a). The formula ([100,000 X number of accidents]/total flight hours for the year) used the total flight hours as calculated with the 8.5% increase (Line 8b) to account for all flight time (patient and non-patient missions). A second accident rates per 100,000 flight hours was calculated (Figure 1–29, Line 17b) using the total flight hours before the increase. The difference between these two accident rates for each year ranged from 0.05 to 1.3 accidents per 100,000 flight hours with an average difference of 0.39 accidents per 100,000 hours. When these two accident rates were graphed together, they virtually overlapped. As a result, we are only including the calculations from Line 17b in our graphic analysis, which depicts the slightly higher rate.

Figure 1–30 shows that there has been a dramatic decrease in the accident rate since the mid-'80s. As the raw data would predict, the accident rate since 1998 has steadily increased. However, despite this increase, the rate remains roughly one-third of what we experienced in the early to mid-1980s due to the overall increase in flight hours.

Looking at an average accident rate for the past 10 years 1992–2001 (3.53 accidents per 100,000 flight hours), the average HEMS program flying 911 hours per year, would have one accident over 31.1 years of flight time. Changing this calculation to include the accident rates for the past 5 years, (1997–2001), we see a moderate change. We now have a 5-year average of 4.56 accidents per 100,000 flight hours and the prediction for the average program decreases to one accident over 24.1 years. Naturally, if a program flies less, the number of years would go up, and if a program flies more, the time frame would decrease. Another way to propose the likelihood of an accident would be to compare the number of accidents to the number of programs (or helicopters). Again, using the most recent ten years, there has been an average of 7 accidents each year. With 231 dedicated HEMS programs, and assuming all things being equal, we would find a similar prediction of one accident per program every 33 years. If you base this comparison on the number of dedicated helicopters estimated for 2001 (400) rather than programs, the margin now goes up to nearly 57.1 years. Looking at the average number of HEMS accidents (9) for the past five years, we would expect one accident per helicopter every 44.4 years.

The second comparison is looking at the fatal accident rate per 100,000 flight hours (Figure 1–29, Line 21). Here too, in Figure 1–31, we see a dramatic improvement since the early and mid-1980s. Our current rate, despite having gone up slightly over the past few years, is approximately 75% less than our worst years. Once again if we take an average flight program and an average fatal accident rate for the past ten years (1.38 fatal accidents per 100,000 flight hours), we would predict one fatal accident while flying more than 79.3 years. When we focus on the average fatal accident rate for 1997–2001 (1.69) this figure drops to 64.8 years. The final normalized comparison will look at the HEMS data in much the same manner as was done in the '80s—comparing the accident rate per 100,000 patients transported (Figure 1–29, Line 23). With a high correlation of flight time per patient transport, Figure 1–32 is very similar to the Figure 1–30.

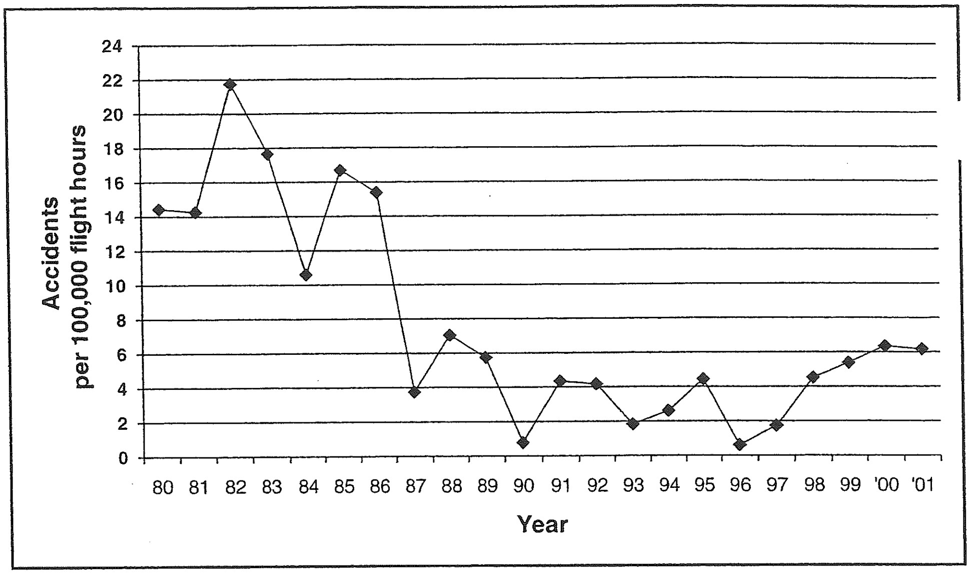


Figure 1–30: Accident Rates for HEMS Operations, 1972 – 2001

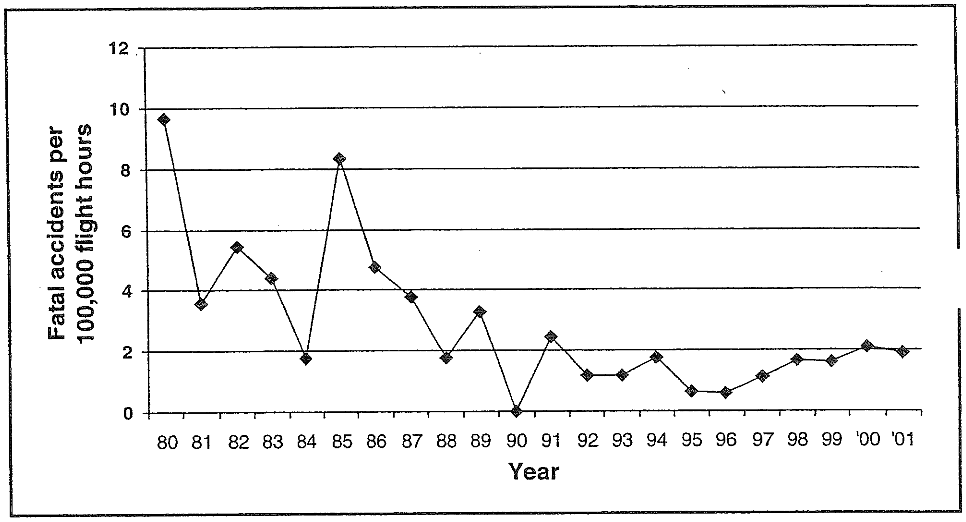


Figure 1–31: Fatal Accident Rates for HEMS Operations, 1972 – 2001

We would expect similar results if we again look at our average flight program. With a 10-year (1992–2001) average accident rate of 3.89 accidents per 100,000 patients transported and the typical HEMS program flying 882 patients in a year, a program would have one accident while transporting an estimated 25,700 patients over 29.2 years. Calculations for 1997–2001 (4.79 accidents per 100,000 patient transports) resulted in an estimate of one accident while transporting nearly 21,000 patients over a 23.74 year period.

It may be of interest to note a 1990 study by Rhee et al., that compared the HEMS accident rate in the United States to that of the Federal Republic of Germany. For 1982–1987, Rhee's calculations found an accident rate in the U.S. of 11.7 per 100,000 flight hours. The calculated accident rate for West Germany was found to be comparable at 10.9 per 100,000 flight hours. The fatal accident rates were also found to be similar. The U.S. rate was 4.7 fatal accident per 100,000 flight hours while the West German rate was 4.1. In contrast, using our own database and calculations for

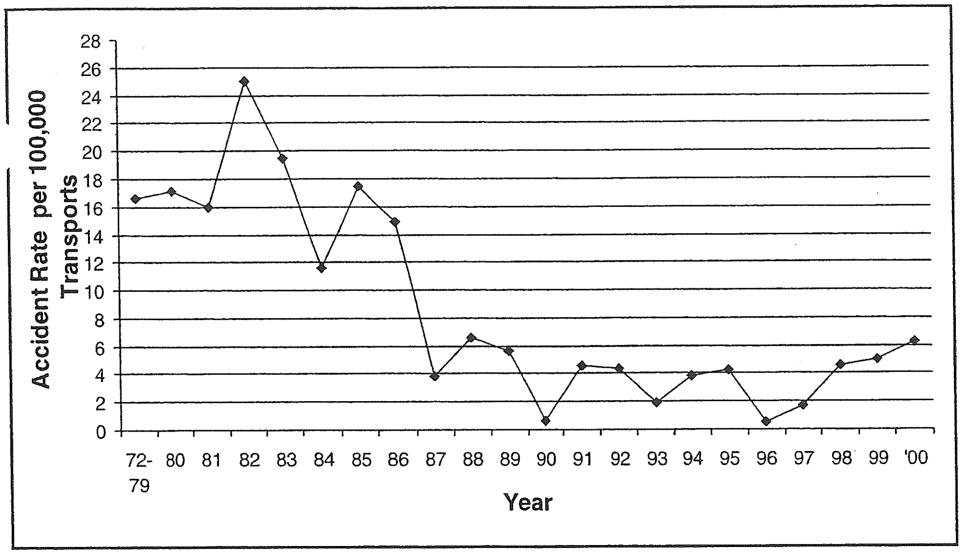


Figure 1–32: HEMS Accident Rate per 100,000 Patient Transports, 1972–2000

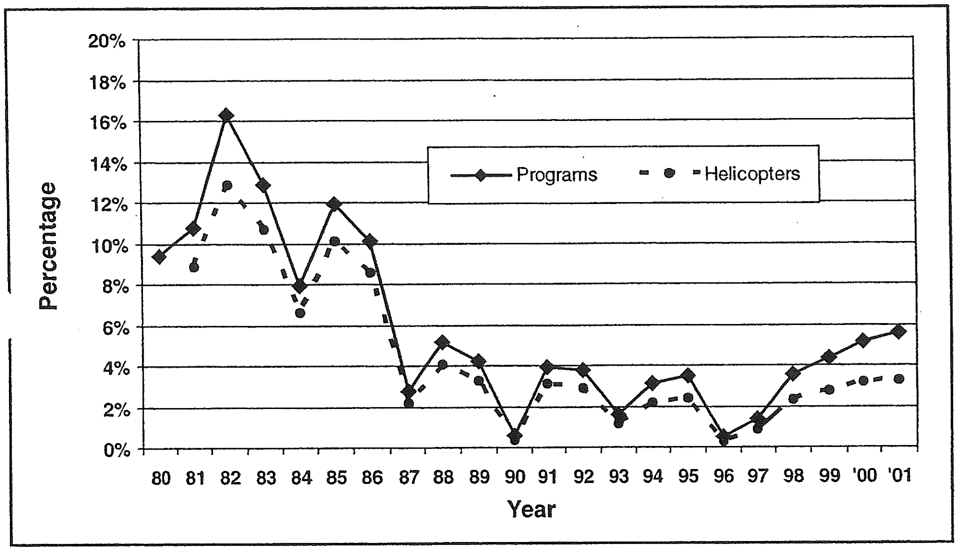


Figure 1–33: Programs and Helicopters with Accidents, 1980–2001

this same time frame (1982–1987), our statistics yield a much higher accident rate of 15.58 per 100,000 flight hours and a fatal accident rate of 5.2.

Percentage of HEMS Programs and Helicopters Involved in Accidents

Data is not available to accurately determine what percentage of HEMS programs have sustained an accident. Over nearly 30 years of civilian HEMS operations, dozens of programs have closed and others have merged operations. However, with the data that we have accumulated to estimate the number of programs and helicopters each year, we can determine annual percentages with some accuracy. Averaging these annual calculations, we can estimate the overall percentage of HEMS programs and helicopters that have had accidents. These calculations do not take into account the possibility that an individual program may have suffered more than one accident—which has occurred.

The calculated percentage of programs and helicopters that sustained accidents each year since 1980 is shown in Figure 1–29, Lines 18a and 18b. The five accidents that occurred prior to 1980 are not included, as we do not have annual statistics on the number of programs or helicopters before 1980. Figure 1–33 shows the wide range for our results. In 1982, an estimated 16.3% of the HEMS programs (8 accidents, 49 programs) were involved in accidents. The safest year was in 1996, when an estimated 0.5 % of the programs had an accident (1 accident, 207 programs). Overall, the average annual percentage over 22 years calculates to 5.8% of the programs having had accidents between 1980 through 2001. If you consider only the past five years, an average of 4.1% of the programs have had an accident each year.

Calculating the percentage of helicopters that were involved in HEMS accidents each year finds a high of 12.9% of the HEMS aircraft in 1982 (8 accidents, 62 helicopters). In 1996, there was 1 HEMS accident during a year when an estimated 309 dedicated medical helicopters were in operation, for a total of 0.3%. The average percentage over 21 years calculates to 4.4% of the HEMS fleet. Over the past 5 years, this percentage has averaged 2.5% for each year.

SECTION 2: A COMPARISON OF HEMS TO OTHER TYPES OF AVIATION

Having reviewed HEMS-specific data, this report will now compare HEMS accident and incident data to other types of aviation. This section first looks at two reports and then focuses on various aviation industry statistics. Finally, the accident rates for helicopter air medical transport is compared to other aviation operations.

HELICOPTER EMS vs. ALL HELICOPTER ACCIDENT DATA: 1990–2000

During the 2000 Air Medical Transport Conference (AMTC), Sandra Hart of the NASA-Ames Research Center presented a study that compared characteristics of helicopter EMS accidents with those of all helicopter accidents (EMS and non-EMS) over the same time period. In March 2001, Hart presented an updated report at the Proceeding of the 11th International Symposium on Aviation Psychology.

In her introduction at AMTC, Hart pointed out that in recent years, the number of HEMS accidents has increased. However, she emphasized that all we have is raw numbers. Accurate exposure data is lacking regarding the number of transports and the number of hours flown by helicopter EMS. Without this, we do not have accurate information to determine if the increase in accidents is related to an increase in the hours flown or whether HEMS had gotten less safe. As a result, the data presented in her lecture was based upon raw numbers and percentages rather than as accident rates.

In addition, Hart stated that "aircraft accidents are poor indicators of safety trends due to a low occurrence rate and limited information about what happened. Quite often, the immediate 'cause' may have little relationship to the underlying causes. But as risk factors begin to accumulate, something bad was bound to happen."

An analysis of 1,494 helicopter accidents over a 10-year period beginning in 1990 was conducted by the NASA-Ames Research Center. The database was obtained by reviewing the NTSB accident and incident reports, looking at narratives, probable cause, occurrences, findings and coded data (e.g., pilot experience, helicopter make/model, visibility, mission). A total of 58 HEMS accidents were identified within this database—both Part 135 (patient-related transports) and Part 91 flights (repositioning, maintenance, etc.). Of interest, 72% of the HEMS accidents were flown under Part 91 and only 30% were on patient-related missions. Some HEMS operations conduct the flight to the patient under Part 91 regulations, while other programs consider all legs of a patient flight to be Part 135.

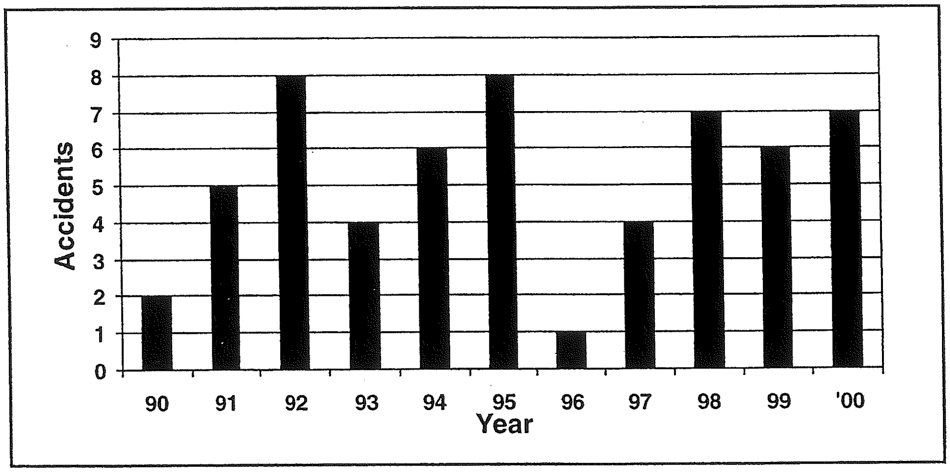


Figure 2–1: Number of HEMS Accidents per Year
Adapted from: Hart, Conference presentations, 2000/2001

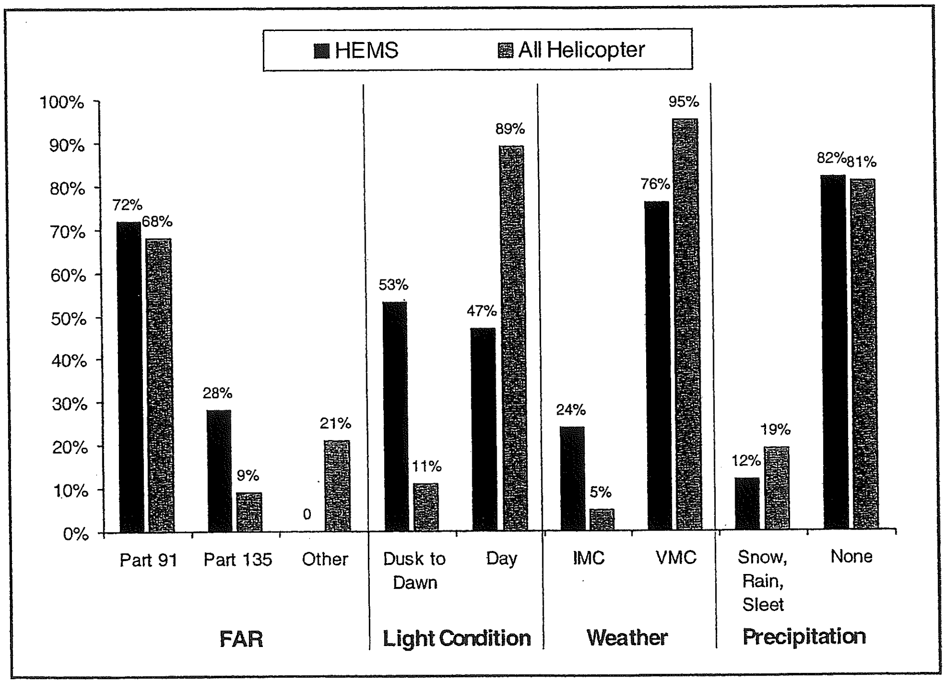


Figure 2–2: When Accidents Occur (HEMS: n=58; All Helicopters: n=1,494)
Adapted from: Hart, Conference presentations, 2000/2001

Figure 2–1 illustrates the number of accidents that were included for each year in the Ames report. Several 1999 and 2000 accidents lacked NTSB final reports and were not included.

When the Accidents Occur

When comparing the data, approximately 53% of the HEMS accidents occurred between dusk and dawn while only 9% of all helicopter accidents occurred at night. It is estimated that only 5% of all helicopter flights are at night.

Hart found that nearly five times as many HEMS accidents occurred in IMC conditions (24% compared to 5% for all helicopter accidents), with nearly all of them involving inadvertent flight into IMC conditions. This was consistent with the previous NTSB study. Neither snow nor rain was an identified problem, with very few helicopter accidents occurring with visible precipitation. This could be due to the fact that fewer helicopter flights occur during these types of weather conditions. Another possibility could be that pilots are more careful when they can see visible precipitation (rain or snow). In contrast, deteriorating weather conditions (decreasing ceilings or fog developing) may be less obvious.

Of the 58 accidents, weather conditions were cited as a contributing factor 29 times. It is important to note that these were *factors* and not the cause of the accidents. In some cases there was more than one weather factor cited with regard to an accident or incident. Weather is therefore likely to add to the risk of a flight. It may not cause the accident, but it may increase the likelihood that an accident could occur. Weather was cited only twice as the *cause of* an accident.

With regard to the phase of flight, there are some significant differences when comparing HEMS to all helicopter accidents. For all helicopter accidents the highest percentage of accidents were seen during landing (25%), maneuvering (21%), cruise (15%), hovering (11%), and takeoff (11%). This is significantly different from HEMS accidents that occurred most commonly during cruise (24%), takeoff (19%), approach (16%), and landing (14%). Figure 2–3 shows the distribution of accidents during the various phases of flight.

Pilot Experience

Experience of the pilots was carefully reviewed by the Ames study. In general the HEMS pilots averaged slightly fewer total hours than the total pilot database (6,307 vs. 6,424). However 79% of the HEMS pilots' hours (5,010) were in helicopters. The overall group included commercial fixed-wing pilots who did much less time in helicopter aviation (66% or 4,230 hours). HEMS pilots averaged fewer hours (753) in the make/model helicopter they were flying at the time of the accident compared to pilots for all of the helicopter accidents (1,273). In addition, unlike the NTSB report, pilot fatigue was not found to be a significant factor in these HEMS accidents. According to the study, the average HEMS pilot had flown only 1.88 hours in the 24 hours prior to their accident which was less than the average (3.00) for the "all helicopter accident" group.

The Ames researchers found a significant difference with regard to instrument ratings. EMS pilots were far more likely to have an instrument rating than all helicopter pilots involved in accidents. They may not have been current and they may not have been flying helicopters that were IFR equipped, but their training and experience was noted. According to Hart, while this additional training and experience should be considered an advantage to the EMS helicopter pilots, it may have worked as a disadvantage if the pilots felt that their training and experience would allow them to "push the envelope a little bit more."

Vehicle Characteristics

There were more HEMS accidents involving twin-engine helicopters than single-engine helicopters (63% vs. 36%, respectively). This is in contrast to all the accidents where the majority of the aircraft were single-engine aircraft (89%). It is important to note that no mention or comparison is made with regard to the percentage of single- vs. twin-engine helicopters in operation—only the comparison of those involved in accidents.

Accident Characteristics

HEMS accidents have a much higher likelihood of resulting in serious injuries or fatalities than other helicopter accidents. Of the 58 accidents studied, 38% resulted in at least one fatality compared to 17% for the overall database. These results are similar to the previous studies. While there tended to be very few post-crash fires in either group, aircraft in both groups were either destroyed or seriously damaged at very high rates (92% for HEMS vs. 97% for all accidents). HEMS aircraft, however, were destroyed at a much higher rate. Figure 2–5 shows the accident characteristics for both groups.

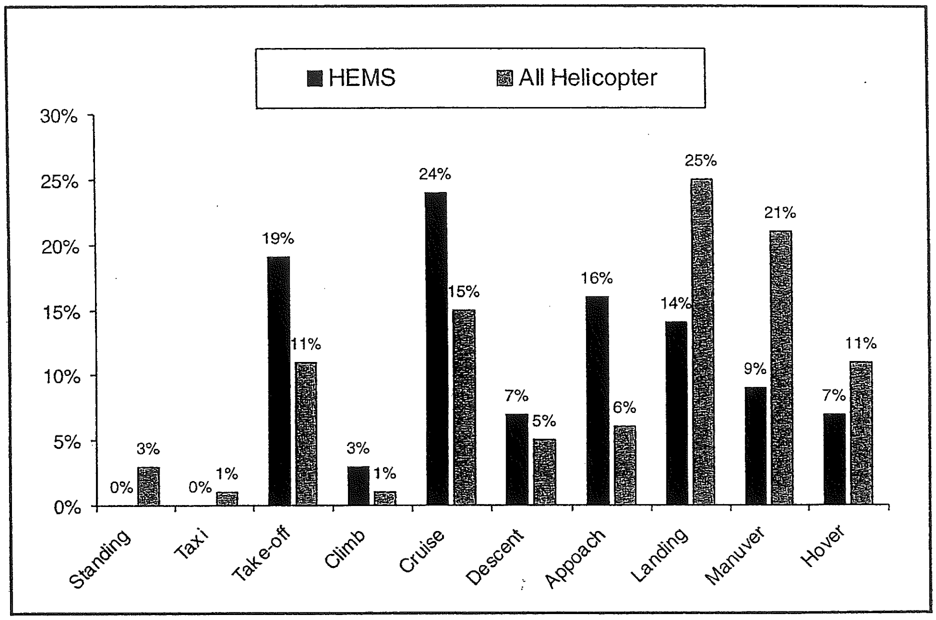


Figure 2–3: Phase of Flight (HEMS: n=58; All Helicopters: n=1,494
Adapted from: Hart, Conference presentations, 2000/2001

	EMS		All Helicopter	
	Average	Range	Average	Range
Total Hours	6,307	3,000–19,275	6,424	29–34,886
Helicopter Hours	5,010	27–17,380	4,230	8–25,000
Hours in Make	753	16–3,620	1,273	3–8,918
Instrument Hours	269	0–1,647	203	0–3,613
Prior 24 hours	1.47	0–6	3.00	0–15

Figure 2–4: Pilot Experience
Adapted from: Hart, Conference presentations, 2000/2001

Chain of Events and First Events

Hart's report emphasized that accidents are not caused by a single event. In most accidents, numerous risk factors can be identified. An accident might have an obvious identifiable cause, but there are likely to have been numerous risk factors that contributed to the event or the severity of the event. Acting on any of these risks might prevent an accident from happening or lessen the severity of the accident.

When the NTSB looks at accident data, they pay particular interest to the "first events"—the first obvious and measurable event that can be considered an accident. It is not the first occurrence in the chain of events that leads to the accident. Rather, it corresponds to the first event that would be considered evidence that an accident has taken place. First events are not causes. Their analysis tells us *what* has happened, but do not tell you *why* it happened.

The most common first event in HEMS was an in-flight collision with terrain, with wires being the primary offender. EMS helicopters were more than twice as likely to strike an object or terrain and nearly five times more likely to have an encounter with inclement weather. Relatively few of the HEMS accidents were caused by low engine power, airframe, or component failures compared to the all helicopter accident group. Hart concluded that this seems to suggest that, in general, EMS helicopters are well maintained.

The Ames study presented a cascading chain of events of what happens when an accident occurs. An in-flight encounter with weather is rarely the cause of an accident but is often the first event. It leads to an in-flight collision with an object or terrain or to a loss of engine power. Another frequent first or second event is loss of control in flight, which may follow some type of system failure (which is rare).

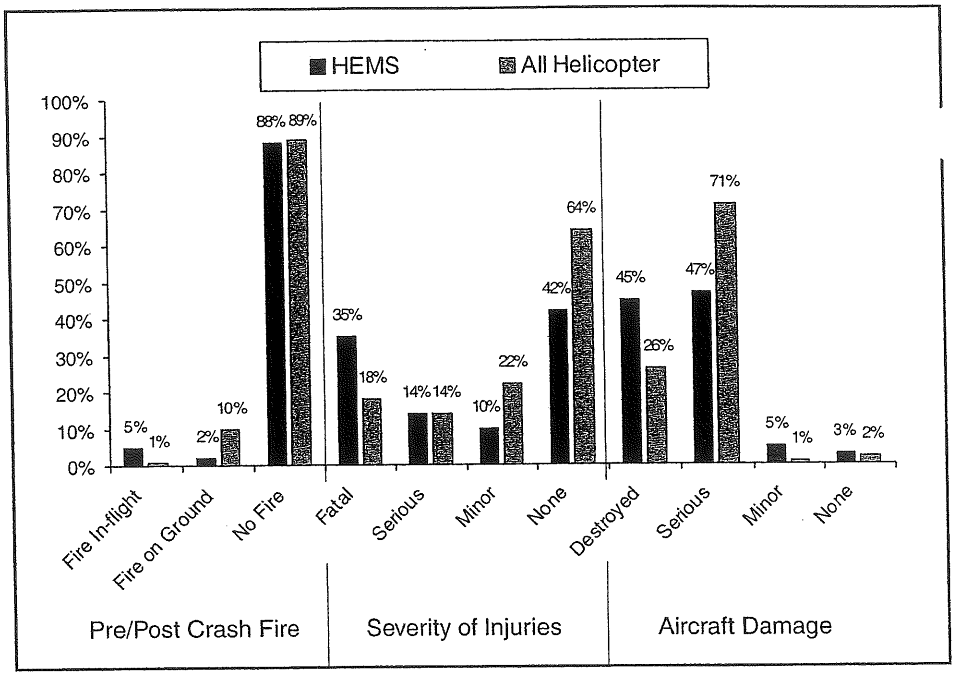


Figure 2–5: Accident Characteristics (HEMS: n=58; All Helicopters: n=1,494)
Adapted from: Hart, Conference presentations, 2000/2001

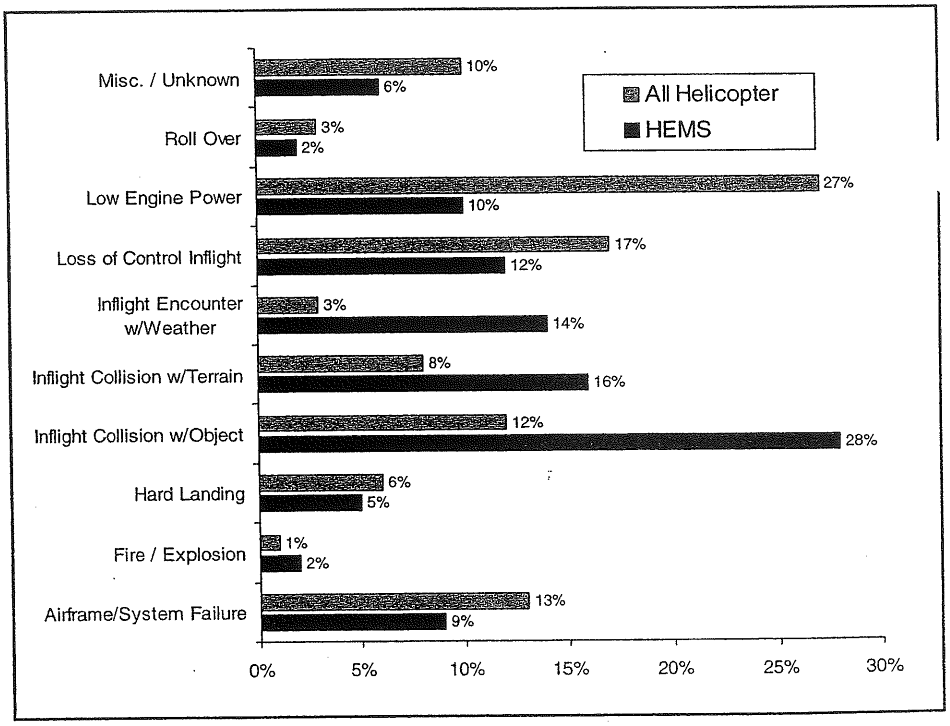


Figure 2–6: First Events (HEMS: n=58; All Helicopters: n=1,494)
Adapted from: Hart, Conference presentations, 2000/2001

Cause and Contributing Factors of Accidents

When the NTSB finalizes their accident reports they try to identify a cause of each accident. This is not necessarily the only event that contributed to the accident. Pilot-related factors (human factors) were cited 50 times in the 58 accidents. These factors included operating with known deficiencies, inadequate pre-flight planning, inability to evaluate the weather, inadvertent flight into IMC, failure to follow procedures, spatial disorientation, lack of experience, and failure to maintain proper speed, altitude, rate of descent or climb, or RPM. Of interest, Hart pointed out that in very few of these accidents was it identified that the pilot deviated from the FARs or company regulations. This is significantly different than the data reviewed earlier in the ASRS report.

Aircraft-related causes of the 58 HEMS accidents were cited 22 times, while fuel-related problems were cited twice. Weather was cited only once.

There are a number of contributing factors that increase the risk for an accident. Many of these are related to weather (e.g., icing conditions, clouds, fog, rain, snow, sleet), which was cited 29 times as a contributing factor in the 58 accidents. Person-related contributing factors were cited 25 times, which included distractions, pressure felt by the pilot, as well as the items listed under "causes." Terrain, which was cited 24 times, was another consideration and flying at night (dusk to dawn) was cited 18 times.

	Total		Non-survivable		Survivable	
	Crashes	Occupants	Crashes	Occupants	Crashes	Occupants
EMS	75	241	24	70	51	171
Non-EMS	147	485	20	50	127	435

Figure 2–7: Survivable and Non-survivable EMS and Non-EMS Crashes
Adapted from: Dodd, unpublished dissertation, 1992

	Serious Back Injuries (%)		Serious Head Injuries (%)		Minor Head Injuries (%)		Internal Injuries (%)		Fractures (%)	
Occupant Location	EMS	Non-EMS	EMS	Non-EMS	EMS	Non-EMS	EMS	Non-EMS	EMS	Non-EMS
Pilot	4.5	10.8	2.3	2.4	0	3.6	0	0	2.3	7.2
Front Seat	15.4	2.7	7.8	5.4	0	2.7	11.5	0	3.8	8.1
Main Cabin	28.6	9.2	14.3	1.3	5.3	1.3	7.1	2.6	10.7	5.3
Patient	14	N/A	7.1	N/A	0	N/A	0	N/A	7.1	N/A

Figure 2–8: Distribution of Injuries in Survivable Crashes—EMS vs. Non-EMS Crashes
Adapted from: Dodd, unpublished dissertation, 1992

FACTORS RELATED TO OCCUPANT CRASH SURVIVAL IN EMS HELICOPTERS

Much of what we have been reviewing has dealt with the associated risks and events surrounding accidents that have occurred in the past. It is also essential to assess the relative occupational risk to the crewmembers of EMS helicopters. Robert Dodd's 1992 Ph.D. dissertation evaluated the incidence and seriousness of crash-related injuries among EMS helicopter occupants in *survivable* crashes.

The study found that main cabin occupants in EMS helicopters have nearly 4.5 times the risk of serious injury or death in survivable crashes when compared to a comparable population of occupants in the main cabin of non-EMS air taxi helicopters. For front seat occupants, he found that there was no significant difference in injury risk between the two groups. This seemed to support his premise that EMS aircraft modifications, which are generally limited to the main cabin, were directly associated with the risk of injury and may contribute to occupant injury and death in otherwise survival crashes.

For his study, Dodd reviewed 75 EMS accidents from 1978–1983 and 1983–1989 (with 241 occupants) and 147 non-EMS helicopter accidents from 1983–1989 with 485 occupants. His comprehensive review and analysis of available reports identified survivable vs. non-survivable crashes and occupants, as seen in Figure 2–7.

Comparing occupant location in survivable accidents with specific injury patterns, Dodd concluded that EMS main cabin occupants were at a higher risk for serious back injuries and serious head injuries. Figure 2–8 compares the percentage of occupants with specific injuries and where they were seated in the helicopter.

Dodd's research included written surveys that were sent to survivors. Twelve injured EMS occupants indicated injuries that were the result of striking medical equipment inside the helicopter during the crash. This equipment included the stretcher, cardiac monitor, medical panel, oxygen tanks, and portable radio.

As part of his research, Dodd evaluated numerous variables to determine how they had influenced injuries. The variables included crash severity, post-crash fire, number of engines, helicopter weight, light conditions, use of shoulder harness, cause of the crash, age, and sex. For each of these variables, he calculated the relative risk of injury for EMS occupants compared to non-EMS occupants in survivable crashes. Dodd found that there was a significantly greater risk of injury (significant relative risk) in HEMS accidents compared to non-EMS accidents: where there was a post-crash fire; in single-engine helicopters; with helicopters weighing < 4,500 pounds; during daylight conditions; with EMS occupants who did not wear a shoulder harness; and mechanical-related crashes. There was a marginal relative risk of injury in helicopters that weighed > 4,500 pounds.

In contrast, he found no significant relative risk of injury in: the absence of post-crash fire; twin-engine helicopters; during dark (night) conditions; or crashes caused by loss of control, wire strikes, or bad weather. Even though significantly more EMS accidents (32%) occurred in bad weather compared to the non-EMS study group (14%), there was not a significant increase in the risk of injury. There was also no correlation between injury and the age or sex of the occupants between the two groups.

Dodd also evaluated the severity of the accidents and classified them as Crash Severity Level 1 (hard landing), Crash Severity Level 2 (hard landing with substantial damage), and Crash Severity Level 3 (high vertical impact or cruise collision with ground). Level 1 accidents resulted in no injuries to EMS occupants and only one non-EMS injury. Level 2 accidents yielded a significant relative risk for passengers in the main EMS cabin, but a non-significant risk for front-seat passengers. In Level 3 accidents, the significant relative risk for main cabin occupants was even greater in EMS aircraft.

Dodd's calculations of accident rates were similar to the NTSB report that had come out four years earlier. He found that EMS helicopters had an accident rate of 11.84 per 100,000 hours of flight. This is more than 2.5 times that of non-EMS air taxi helicopter operations that were found to have an accident rate of 4.43 per 100,000 flight hours. While Dodd did not compare fatal accident rates, he did compare the percentage of occupant fatalities for his two study groups. He found that 32% of the EMS occupants suffered fatal injuries, while only 9% of the non-EMS occupants died —a rate that is 3.5 times greater for the EMS group.

Dodd's report makes a convincing statement for addressing accident survival as well as accident prevention. EMS personnel are injured more frequently and more severely in survivable HEMS accidents when compared to occupants of non-EMS helicopter crashes.

Dodd presented a 1991 study by Crowley that evaluated the use of helmets in survivable military crashes. Crowley found that occupants without helmets were 4 times more likely to suffer a serious head injury and 6 times more likely to suffer a fatal head injury than occupants with helmets. Limiting the comparison to the main cabin increases the risk. Main cabin occupants with no helmet were found to be at 5 times the risk for a serious head injury and 7.5 times the risk for a fatal head injury than their helmeted counterparts. While Crowley's study was based on military data, he suggested that it might also be applicable to survivable HEMS accidents.

Another series of studies for the U.S. Army concluded that back injuries were the most common injury suffered by occupants in survivable helicopter accidents. These results are consistent with Dodd's findings. The Army studies found that shoulder harnesses were an important factor in reducing the incidence and severity of serious back injuries

Dodd concluded that the increased risk of injury to main cabin occupants of EMS helicopters represented an occupational risk that had not previously been addressed in the literature. He concluded that the EMS helicopter was a very hazardous place, even in a survivable crash. Dodd suggests that the use of energy attenuating seats, in combination with lap and double shoulder harnesses, and intelligently designed interiors could dramatically improve occupant injury tolerance.

HELICOPTER ACCIDENT ANALYSIS TEAM

This next study which is not limited to HEMS, reviews a series of helicopter accidents to determine what happened and what could be done to break the chain of events that lead to accidents. The Helicopter Accident Analysis Team (HAAT), was a cooperative effort involving the Department of Defense (DoD) the Federal Aviation Administration/Department of Transportation (FAA/DoT), and the National Aeronautics and Space Administration (NASA). It began in February of 1997, as mandated by the White House Gore Commission on Aviation Safety.

The approach in this analysis is similar to the "Air Medical Accident Analysis" described in Section 1, but this study included EMS and non-EMS helicopters. A *balanced sample* of 34 helicopter accidents was selected from the 1990 to 1996 NTSB database of helicopter accidents and incidents. HEMS accidents selected were those that involved a patient transport mission at the time of the accident

Three subgroups worked independently to address different aspects of these accidents. First they developed a sense of what happened—the ***chain of events*** that led to each of the accidents. Next they identified the ***problems***—issues with respect to the aircraft, environment, pilot actions, maintenance, air traffic control, and the quality of the information in the report itself. Finally, they brainstormed about what might have prevented the accident entirely or mitigated its severity—the ***interventions***. The goal of the HAAT analysis was to propose technology, training, and institutional interventions that might have eliminated one or more "links" in those chains of events, thereby averting an accident or decreasing the severity of an accident that does occur.

Chain of Events

The number of events identified for any particular accident ranged from 5 to 33, with an average of 16 events per accident. This resulted in a total of 536 events. Five different categories of events were identified. Figure 2–9 lists the categories and examples of the events.

Category	Examples of Events
Preliminary events	***Definition:*** Factors that influenced the accident but were not directly related to actions taken by those involved in the accident ***Examples:*** Pilot's health, pilot's experience, adverse weather
Preflight events	***Definition:*** Events that occurred prior to departure of the accident flight that could have influenced the outcome ***Examples:*** Failing to obtain a weather briefing preflight or ensuring that the aircraft had enough fuel
Flight-related events	***Definition:*** Events or actions that occurred during the flight and were associated with the accident ***Examples:*** Continued flight into adverse weather, poor air traffic control vectoring
Emergency-related events	***Definition:*** Events that occurred during the emergency/ accident sequence or precipitated the sequence ***Examples:*** Poor landing site selection, wire strike, fuel starvation
Survival-related events	***Definition:*** Events or actions that did influence, or could have influenced, occupant survival after the accident ***Examples:*** Helmet use, delayed rescue, inoperative ELT

Figure 2–9: Chain of Events Categories identified by HAAT

Adapted from: Helicopter Accident Analysis Team. Final Report, NASA-Ames Research Center, 1998

Problems

The accident analysis identified the number of problems for each accident, anging from a low of 3 to a high of 21. There was an average of 16 problems per accident, resulting in a total of 442 entries. Figure 2–10 illustrates the categories of problems identified and specific problems within each category.

Interventions

After identifying the problems, interventions were identified that could have prevented the accident or lessened its severity. The number of interventions identified for individual accidents ranged from 4 to 25, averaging 13 per accident. There were a total of 416 possible interventions identified across all the accidents. Figure 2–11 reviews the categories of interventions and the specific proposals made by HAAT.

The previously presented "Air Medical Accident Analysis" evaluated the effectiveness and feasibility of each of their recommended interventions. That was not done in this study. Instead, the final step of the HAAT analysis was the proposal of 26 specific *Safety Investment Areas* that were derived from their identified interventions. Rather than a single statement, each area had identified goals, background, opportunities for reducing future fatalities, research needs, timing, related work, and the primary beneficiaries. Their emphasis was no longer on specific interventions that might have broken the chain of events for a specific accident. Rather, the Safety Investments were more global and goal oriented. Their recommendations included specific goals directed toward the development of research and technology to enhance safety and to improve procedures and practices. Safety Investment Areas were identified in helicopter design and performance, situation displays, pilot aiding and automation, pilot training, improving the flight environment, crash survivability, and the improvement of safety data and analysis.

Problems Associated with...	Problems Identified
Pre-Flight Planning	Aircraft / operating limits not considered Weather or wind not considered Mission requirements / contingencies ignored Pre-flight process inadequate Passenger safety brief inadequate
Safety Culture of the Organization	Management policies / oversight inadequate Safety program / risk management inadequate Helicopter not IFR-equipped Problems with pilot's health not addressed
Inadequate Training or Experience	Emergency training inadequate Special operations training inadequate Training inadequate for inadvertent IMC Pilot inexperienced with area, mission, vehicle
Maintenance	Tools to detect failing parts inadequate Bogus, surplus, unapproved parts used Improper procedures/supervision Inadequate documentation Components used not built to manufacturer's specifications
Infrastructure	Inadequate oversight IFR system incompatible with helicopter missions Part 91 vs. Part 135 passenger-carrying operations Inadequate tower/wire markings
Pilot Judgment and Actions	Sense of urgency led to risk-taking Diverted attention, distraction Flight profile unsafe for conditions Poor cockpit resource management Perceptual judgment errors Procedural errors Pilot control/handling deficiencies Used unauthorized equipment
Communications	Coordination with ground personnel Coordination with ATC Coordination with other pilots
Pilot Situation Awareness	Aircraft position and hazards Aircraft state Local and en route weather
Vehicle Part or System Failures	Main rotor problem Engine failures (partial or total) Gear box failure Tail rotor/tail boom failures
Post-crash Survivability	Safety equipment not installed/failed Passenger/crew survival gear not used Vehicle did not withstand impact Vehicle sank and/or capsized Post-crash fire ELT inoperative/damaged by impact Inaccessible accident site/bad weather No flight following–slow to locate site

Figure 2–10: Problems Identified by HAAT

Adapted from: Helicopter Accident Analysis Team. Final Report, NASA-Ames Research Center, 1998

Categories	Proposed Interventions
Safety Culture Solutions	Adequately equip rotorcraft for mission Develop an inadvertent IMC policy Formalize passenger pre-flight briefing Develop clearly defined company policies
Training Interventions	Basic training materials/syllabus Aeronautical decision-making training Crew resource management training Training to recognize and resolve emergencies Ground personnel training Recovery from IMC/IFR training Simulation facilities for rotorcraft training Training for unique ops/maneuvers/missions
Maintenance Solutions	Non-destructive inspection techniques Improved maintenance procedures and quality control
Helicopter Design and Performance Solutions	Health and Usage Monitoring Systems Real-time performance monitoring Wire cutters/hardened blades Icing protection Miscellaneous design improvements
Helicopter Situation Display Solutions	Ground proximity warning system for rotorcraft Electronic map/position Obstacle detection and alerting Radar alt/distance from ground/water Enhanced/synthetic vision Weather display and alerting
Pilot Aiding and Automation Interventions	Autorotation display/aid Attitude hold/stabilization Automatic flight following PC-based Pre-Flight Planner and PC-based Risk Assess System
Infrastructure Interventions	Operating requirements for commercial rotorcraft Regulations/procedures for inadvertent IMC Review tower/wire marking requirements Navigation/landing systems for rotorcraft Review training and qualification requirements Requirements for company safety program Special operations regulations
Post-Crash Survival Interventions	Improved crashworthiness Crash-survivable ELT Survival equipment Restraint systems Flotation systems Crash-resistant fuel system Underwater egress training
Improved Reporting Interventions	Cockpit voice recorder/flight data recorder Improved NTSB accident forms Improved data acquisition Data dissemination/feedback to industry Inflight audio-visual recording in cockpit

Figure 2–11: Interventions Proposed by HAAT

Adapted from: Helicopter Accident Analysis Team. Final Report, NASA-Ames Research Center, 1998

HEMS VS. OTHER AVIATION OPERATIONS

Background

Generally speaking, there are three major categories of aviation regulated by the FAA. Part 135 corresponds to "air taxi" and is classified as *Scheduled* (commuter flights with fewer than 10 seats) or *Non-scheduled*, which includes air medical transport and other on-demand air taxi services. Part 121 aviation governs the airlines, both scheduled and non-scheduled (charter) airlines. The third category is General Aviation (Part 91), typically characterized by recreational (personal) flying, instructional, business, corporate, public use, and other vital services. Figure 2–12 summarizes the number and types of aircraft that were operated under the different regulations in 1998/1999.

As Figure 2–12 shows, helicopters account for a very small portion of aviation operations. Based upon our 1998/1999 statistics, EMS helicopters accounted for an estimated 5% of all helicopters and approximately 48% of the on-demand helicopters in operation. In 1980 there were an estimated 20,750 HEMS flight hours. By 1990, this increased to approximately 140,500. In 2001, HEMS hours were estimated at nearly 217,500 while all helicopters flew approximately 2.4 million flight hours, general aviation flew 26.2 million hours, Part 135 operations accounted for nearly 3.7 million flight hours, and Part 121 airlines flew 16.7 million hours.

HEMS, a Part 135 on-demand air taxi, is certainly a unique form of aviation. There are some similarities with other 135 operations, but also some similarities with General Aviation (Part 91). In fact, as Hart pointed out in her study, many of the HEMS accidents were operating under Part 91 at the time of their accident (e.g., ferry flight, reposition, instruction).

	Airlines (Part 121) 1998	On-Demand Air Taxi (Part 135) 1999	General Aviation (Part 91) 1999
Experimental		30	20,493
Piston Single-Engine	167	652	150,081
Piston Twin-Engine	44	1,607	19,469
Turboprop Single-Engine		75	943
Turboprop Multiengine	1,837	860	3,802
Turbojet	5,108	496	6,625
Helicopter	3	**746**	**6,701**
Total	7,159	4,466	208,114

Figure 2–12: Aircraft in Operation, 1998/1999

Adapted from: The Nall Report 2001, AOPA, http://www.aopa.org/asf/publications/01nall.pdf and The Nall Report 2000, AOPA, http://www.aopa.org/asf/publications/00nall.pdf

Operation	Percent of Flying (1999)	Percent of Total Accidents (2000)	Percent of Fatal Accidents (2000)
Personal	44.3	67.4	64.4
Instructional	22.1	13.1	8.2
Aerial Application	4.8	6.0	5.0
Business	13.6	4.0	6.1
Positioning	—	1.7	2.3
Ferry	—	1.0	0.3
Public use	2.2	0.7	0.9
Other work use	2.2	1.0	1.2
Aerial Observation	4.1	0.4	0.3
Corporate	5.5	0.4	0.9
Other/unknown	1.1	4.4	10.2

Figure 2–13: General Aviation Accident Data, 1999/2000

Adapted from: The Nall Report, 2001, www.aopa.org/asf/publications/01nall.pdf

In general aviation (GA), personal flights are consistently the most dangerous. An estimated 44% of all flying is done for recreational or personal reasons and results in nearly 65% of the fatal accidents. In contrast, business flying (i.e., business people who are not professional pilots), accounts for approximately 14% of the GA flight hours, but only accounts for 6% of the fatal accidents. Instructional flying, with 22% of the flight time, results in more than 8% of the fatal accidents. Corporate flying represents only 6% of GA flight hours and had a fatal accident rate of less than 1%. Business and corporate pilots may be more willing to scrub a trip, may fly more reliable equipment, or may have more experience. Likely, it is a combination of all these factors.

In significant contrast to HEMS accidents, nearly 70% of all general aviation (Part 91) accidents are "fender benders" and result in little or no injury. Like HEMS accidents, however, the majority of accidents (more than 70%) were pilot-related. Typically, GA takeoffs and landings account for less than 5% of a typical cross-country flight. However, an estimated 50–70% of the GA accidents occurred during takeoffs and landings. Like HEMS, weather-related accidents were more likely to be fatal than accidents with any other cause. In 2000, nearly 90% of these weather-related accidents resulted in fatalities.

Raw data and normalized statistics are available from the FAA for the different types of aviation operations. Figures 2–14 to 2–16 provide statistics from 1982 to 2001 with regard to number of accidents (total and fatal), flight hours, and annual accident rates for each category. Figures 2–17 and 2–19 graph the accident rates for side-by-side comparison.

In general, the FAA data for this 20-year period shows:

- Helicopter and general aviation accident rates are much higher than all other aviation operations, followed by non-scheduled Part 135 operations.
- The helicopter accident rate has fluctuated from a low of 6.17 accidents per 100,000 flight hours to a high of 12.26.
- General aviation has seen a general decrease in its accident rate.
- From 1982–1992, general aviation had the highest fatality rate among the various aviation operations. Beginning with 1993, helicopter operations have had the highest fatality rate in 7 of the last 9 years.
- Scheduled Part 135 operations have a very consistent and low accident rate from 1983 through 1996. The past five years, however, have seen a significant increase in this rate.

A Normalized Statistical Comparison

With all of this data, it is now possible to compare the different types of aviation operations. We have already estimated the accident and fatality rates per 100,000 flight hours for HEMS. These rates can now be included for a more meaningful comparison. It should be noted that we are beginning in 1982 rather than in 1980, as we did with the earlier HEMS graphs.

As the graphs indicate, accident rates for HEMS, all helicopters, and general aviation have always been higher than airline rates. There are many factors that contribute to this difference. In general, these three types of aviation operations involve risks that are not in common with the airlines. These differences include:

- Helicopters and general aviation pilots conduct a wider range of operations, often with less regulation and fewer support services.
- There is a wider variance in pilot qualifications and training.
- There are fewer cockpit resources. Air carrier operations require at least two pilots, while most general aviation and helicopter operation are single pilot.

	U.S. General Aviation						Helicopter					
Year	Accidents			Flight Hours	Accidents per 100,000 Flight Hours		Accidents			Flight Hours	Accidents Per 100,000 Flight Hours	
	All	Fatal	Fatalities		All	Fatal	All	Fatal	Fatalities		All	Fatal
1982	3,233	591	1,187	29,640,000	10.90	1.99	255	41	66	2,350,000	10.85	1.74
1983	3,076	555	1,068	28,673,000	10.72	1.94	234	35	55	2,272,000	10.30	1.84
1984	3,017	545	1,042	29,099,000	10.36	1.87	224	38	61	2,495,000	8.98	1.52
1985	2,739	498	956	28,322,000	9.66	1.75	205	36	50	2,154,000	9.52	1.67
1986	2,581	474	967	27,073,000	9.53	1.75	190	39	81	2,625,000	7.24	1.49
1987	2,494	446	837	26,972,000	9.24	1.65	180	28	44	2,283,000	7.88	1.23
1988	2,387	460	797	27,446,000	8.69	1.68	179	21	27	2,707,000	6.61	0.78
1989	2,242	431	768	27,920,000	8.01	1.53	187	30	44	2,829,000	6.61	1.06
1990	2,241	443	767	28,510,000	7.86	1.55	195	25	28	2,392,000	8.15	1.05
1991	2,197	438	799	27,678,000	7.93	1.58	170	30	51	2,756,000	6.17	1.09
1992	2,111	451	867	24,780,000	8.51	1.82	179	41	72	2,282,000	7.84	1.80
1993	2,063	400	740	22,796,000	9.05	1.75	180	37	71	1,833,000	9.82	2.02
1994	2,022	404	730	22,235,000	9.08	1.81	218	44	79	1,777,000	12.26	2.45
1995	2,056	413	735	24,906,000	8.24	1.65	161	25	45	1,961,000	8.21	1.27
1996	1,908	361	636	24,881,000	7.67	1.45	176	32	55	2,120,000	8.29	1.51
1997	1,845	350	631	25,591,000	7.21	1.36	164	28	46	2,084,000	7.87	1.34
1998	1,904	364	624	25,518,000	7.45	1.42	191	34	66	2,138,000	8.93	1.59
1999	1,906	340	619	29,713,000	6.41	1.14	198	31	57	2,171,000	9.12	1.43
2000	1,838	343	594	29,057,000	6.33	1.18	206	35	63	2,472,000	8.33	1.42
2001	1,721	321	553	26,220,000	6.56	1.22	182	29	51	2,381,000	7.64	1.22

Source: www.ntsb.gov/aviation/Table10.htm

Source: www.rotor.com/safety/stats70.01.xls

Figure 2–14: U.S. General Aviation and Helicopter—Accidents, Fatalities and Rates: 1982 through 2001

	Part 135: Scheduled						Part 135: Non-scheduled					
Year	Accidents			Flight Hours	Accidents per 100,000 Flight Hours		Accidents			Flight Hours	Accidents per 100,000 Flight Hours	
	All	Fatal	Fatalities		All	Fatal	All	Fatal	Fatalities		All	Fatal
1982	26	5	14	1,299,748	2.000	0.385	132	31	72	3,008,000	4.39	1.03
1983	16	2	11	1,510,908	1.059	0.132	142	27	62	2,378,000	5.97	1.14
1984	22	7	48	1,745,762	1.260	0.401	146	23	52	2,843,000	5.14	0.81
1985	18	7	37	1,737,106	1.036	0.403	157	35	76	2,570,000	6.11	1.36
1986	14	2	4	1,724,586	0.812	0.116	118	31	65	2,690,000	4.39	1.15
1987	33	10	59	1,946,349	1.695	0.514	96	30	65	2,657,000	3.61	1.13
1988	18	2	21	2,092,689	0.860	0.096	102	28	59	2,632,000	3.88	1.06
1989	19	5	31	2,240,555	0.848	0.223	110	25	83	3,020,000	3.64	0.83
1990	15	3	6	2,341,760	0.641	0.128	107	29	51	2,249,000	4.76	1.29
1991	23	8	99	2,291,581	1.004	0.349	88	28	78	2,241,000	3.93	1.25
1992	23	7	21	2,335,349	0.942	0.300	76	24	68	2,844,000	2.67	0.84
1993	16	4	24	2,638,347	0.606	0.152	69	19	42	2,324,000	2.97	0.82
1994	10	3	25	2,784,129	0.359	0.108	85	26	63	2,465,000	3.45	1.05
1995	12	2	9	2,627,866	0.457	0.076	75	24	52	2,486,000	3.02	0.97
1996	11	1	14	2,756,755	0.399	0.036	90	29	63	3,220,000	2.80	0.90
1997	16	5	46	982,764	1.628	0.509	82	15	39	3,098,000	2.65	0.48
1998	8	0	0	353,670	2.262		77	17	45	3,802,000	2.03	0.45
1999	13	5	12	342,731	3.793	1.459	73	12	38	3,298,000	2.21	0.36
2000	12	1	5	373,649	3.212	0.268	81	22	71	3,553,000	2.28	0.62
2001	7	2	13	330,500	2.118	0.605	72	18	60	3,400,000	2.12	0.53

Source: www.ntsb.gov/aviation/Table8.htm

Source: www.ntsb.gov/aviation/Table8.htm

Figure 2–15: U.S. Air Carriers Operating Under Part 135—Accidents, Fatalities and Rates, 1982 through 2001

(Since March 20, 1997 only aircraft with fewer than 10 seats)

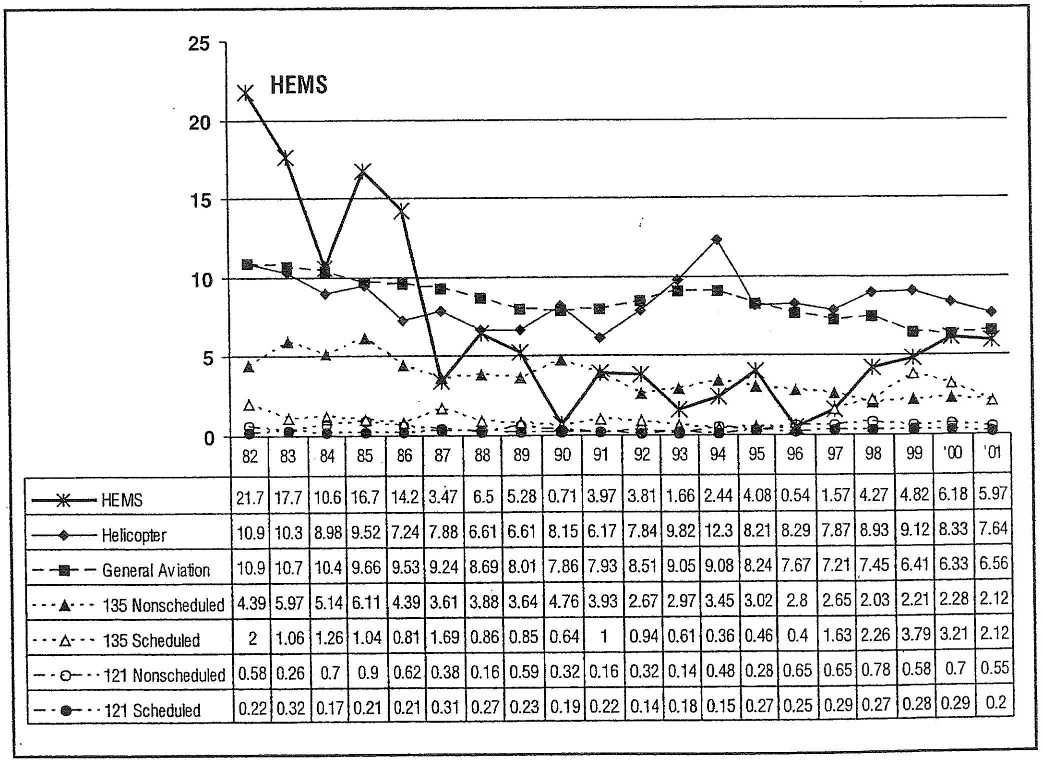
	Part 121: Scheduled Service						*Part 121: Nonscheduled Service*					
Year	Accidents			Flight Hours	Accidents per 100,000 Flight Hours		Accidents			Flight Hours	Accidents per 100,000 Flight Hours	
	All	*Fatal*	*Fatalities*		*All*	*Fatal*	*All*	*Fatal*	*Fatalities*		*All*	*Fatal*
1982	16	4	234	6,697,770	0.224	0.045	2	1	1	342,555	0.584	0.292
1983	22	4	15	6,914,969	0.318	0.058	1	0	0	383,830	0.261	
1984	13	1	4	7,736,037	0.168	0.013	3	0	0	429,087	0.699	
1985	17	4	197	8,265,332	0.206	0.048	4	3	329	444,562	0.900	0.675
1986	21	2	5	9,495,158	0.211	0.011	3	1	3	480,946	0.624	0.208
1987	32	4	231	10,115,407	0.306	0.030	2	1	1	529,785	0.378	0.189
1988	29	3	285	10,521,052	0.266	0.019	1	0	0	619,496	0.161	
1989	24	8	131	10,597,922	0.226	0.075	4	3	147	676,621	0.591	0.443
1990	22	6	39	11,524,726	0.191	0.052	2	0	0	625,390	0.320	
1991	25	4	62	11,139,166	0.224	0.036	1	0	0	641,444	0.156	
1992	16	4	33	11,732,026	0.136	0.034	2	0	0	627,689	0.319	
1993	22	1	1	11,981,347	0.184	0.008	1	0	0	724,859	0.138	
1994	19	4	239	12,292,356	0.146	0.033	4	0	0	831,959	0.481	
1995	34	2	166	12,776,679	0.266	0.016	2	1	2	728,578	0.275	0.137
1996	32	3	342	12,971,676	0.247	0.023	5	2	38	774,436	0.646	0.258
1997	44	3	3	15,061,662	0.292	0.020	5	1	5	776,447	0.644	0.129
1998	43	1	1	15,921,102	0.270	0.006	7	0	0	892,333	0.784	
1999	47	2	12	16,693,365	0.282	0.012	5	0	0	861,843	0.580	
2000	51	3	92	17,474,405	0.292	0.017	6	0	0	820,738	0.731	
2001	36	6	531	15,998,000	0.200	0.013	4	0	0	732,700	0.546	

NOTE: Effective March 20, 1997, aircraft with 10 or more seats must conduct scheduled passenger operations under part 121.

Source: www.ntsb.gov/aviation/Table6.htm *Source: www.ntsb.gov/aviation/Table7.htm*

Figure 2–16: U.S. Air Carriers Operating Under Part 121 (Airlines)—Accidents, Fatalities and Rates, 1982 through 2001

- General aviation and helicopters fly to more than 20,000 landing facilities, while the airlines serve only about 700 well-lit airline-served airports.
- Many operations, such as EMS, aerial application, and law enforcement, have special mission-related risks.
- There are more takeoffs and landings per hour, generally the highest risk phases for general aviation and many helicopter operations.



	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	'00	'01
HEMS	21.7	17.7	10.6	16.7	14.2	3.47	6.5	5.28	0.71	3.97	3.81	1.66	2.44	4.08	0.54	1.57	4.27	4.82	6.18	5.97
Helicopter	10.9	10.3	8.98	9.52	7.24	7.88	6.61	6.61	8.15	6.17	7.84	9.82	12.3	8.21	8.29	7.87	8.93	9.12	8.33	7.64
General Aviation	10.9	10.7	10.4	9.66	9.53	9.24	8.69	8.01	7.86	7.93	8.51	9.05	9.08	8.24	7.67	7.21	7.45	6.41	6.33	6.56
135 Nonscheduled	4.39	5.97	5.14	6.11	4.39	3.61	3.88	3.64	4.76	3.93	2.67	2.97	3.45	3.02	2.8	2.65	2.03	2.21	2.28	2.12
135 Scheduled	2	1.06	1.26	1.04	0.81	1.69	0.86	0.85	0.64	1	0.94	0.61	0.36	0.46	0.4	1.63	2.26	3.79	3.21	2.12
121 Nonscheduled	0.58	0.26	0.7	0.9	0.62	0.38	0.16	0.59	0.32	0.16	0.32	0.14	0.48	0.28	0.65	0.65	0.78	0.58	0.7	0.55
121 Scheduled	0.22	0.32	0.17	0.21	0.21	0.31	0.27	0.23	0.19	0.22	0.14	0.18	0.15	0.27	0.25	0.29	0.27	0.28	0.29	0.2

Figure 2–17: Accidents per 100,000 Flight Hours

Figure 2–17 shows that the accident rate for HEMS was dramatically higher than for all other aviation operations during the early and mid-1980s. Beginning in1987, we see a sharp decline in the HEMS accident ate, which has remained consisently below the accident rates for both general aviation and all helicopter aviation. In addition, from 1987 through 1997, the HEMS accident rate was lower than the overall accident rate for all Part 135 non-scheduled flights 6 of the 10 years. Since 1998, however, the HEMS accident rate has surpassed that of the non-scheduled Part 135 operations each year.

The data in Figure 2–18 represents the average accident rate for the past 20 years (1982–1999), 10 years, and 5 years for the five types of aviation operations, helicopters, and HEMS. Even with the high accident rates of the 1980s, the 20-year average for HEMS is below all helicopter operations and general aviation. For the 10-year average, the HEMS accident rate is less than 50% the rate of all helicopters and general aviation. For the past 5 years, the average accident rate for HEMS has gone up, but remains significantly lower than all helicopter operations and general aviation.

Figure 2–19 compares the fatal accidents per 100,000 flight hours for the various aviation operations. The results are similar to the total accident rates. Initially, the fatality rate for air medical helicopters was equal to or dramatically higher than all other aviation operations. In 1990, however, there were no fatal HEMS accidents. Then from 1992 to 1997, HEMS was consistently below both general aviation and all helicopter operations in fatal accidents. Since 1998, the HEMS fatality rate has been consistently higher.

The average fatal accident rate for the past 20 years, 10 years, and 5 years for the various aviation operations is seen in Figure 2–20. The 20-year average shows HEMS with a high fatal accident rate compared to all other aviation. However, the past 10 years has seen an improvement in the HEMS rate. For the 10-year average, HEMS has had a lower fatality rate than helicopters and general aviation (Part 91). For the past 5 years, however, the average HEMS fatality rate once again exceeds all other aviation operations.

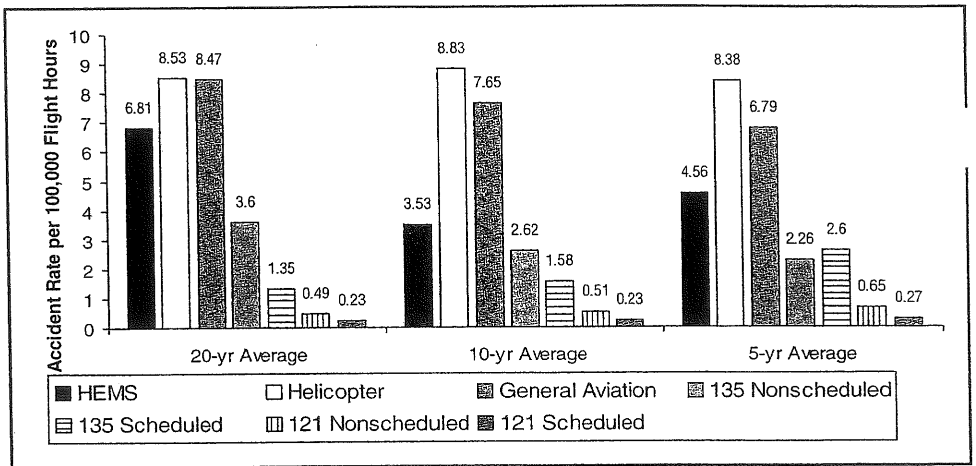
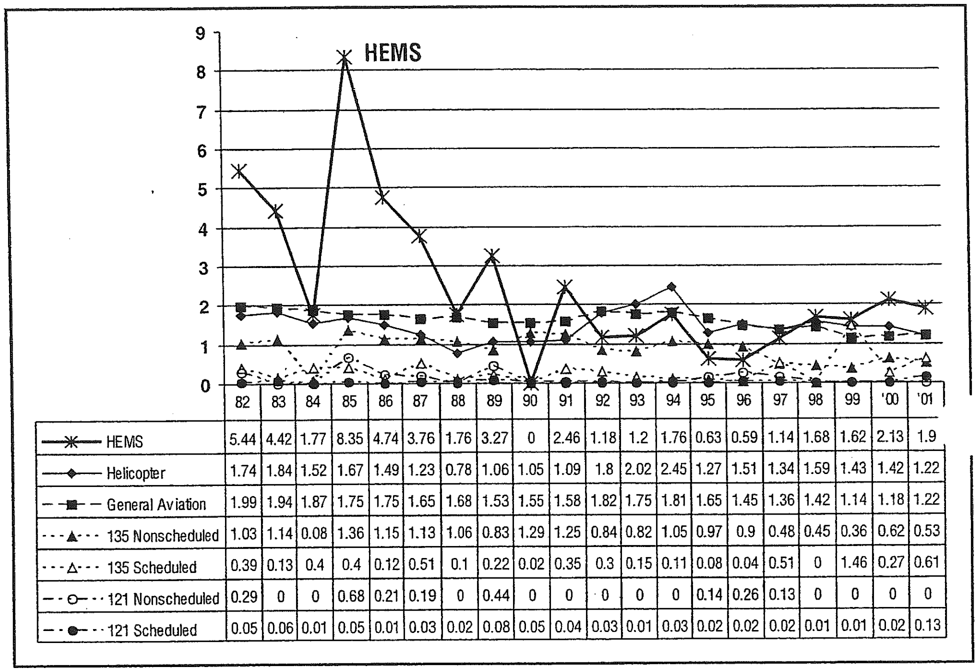


Figure 2–18: Average Accident Rates for Aviation Operations



	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	'00	'01
HEMS	5.44	4.42	1.77	8.35	4.74	3.76	1.76	3.27	0	2.46	1.18	1.2	1.76	0.63	0.59	1.14	1.68	1.62	2.13	1.9
Helicopter	1.74	1.84	1.52	1.67	1.49	1.23	0.78	1.06	1.05	1.09	1.8	2.02	2.45	1.27	1.51	1.34	1.59	1.43	1.42	1.22
General Aviation	1.99	1.94	1.87	1.75	1.75	1.65	1.68	1.53	1.55	1.58	1.82	1.75	1.81	1.65	1.45	1.36	1.42	1.14	1.18	1.22
135 Nonscheduled	1.03	1.14	0.08	1.36	1.15	1.13	1.06	0.83	1.29	1.25	0.84	0.82	1.05	0.97	0.9	0.48	0.45	0.36	0.62	0.53
135 Scheduled	0.39	0.13	0.4	0.4	0.12	0.51	0.1	0.22	0.02	0.35	0.3	0.15	0.11	0.08	0.04	0.51	0	1.46	0.27	0.61
121 Nonscheduled	0.29	0	0	0.68	0.21	0.19	0	0.44	0	0	0	0	0	0.14	0.26	0.13	0	0	0	0
121 Scheduled	0.05	0.06	0.01	0.05	0.01	0.03	0.02	0.08	0.05	0.04	0.03	0.01	0.03	0.02	0.02	0.02	0.01	0.01	0.02	0.13

Figure 2–19: Fatal Accidents per 100,000 Flight Hours

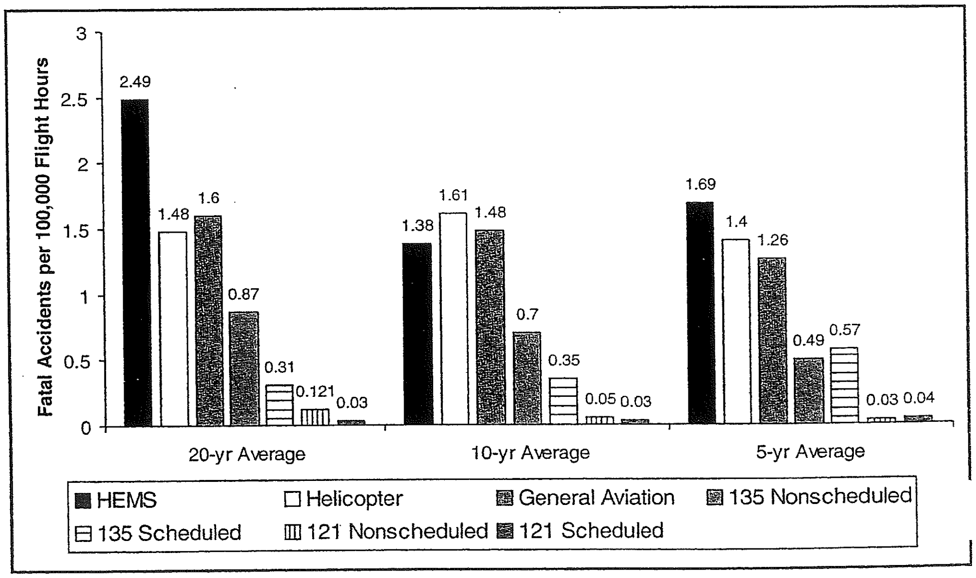


Figure 2–20: Average Fatal Accident Rates for Aviation Operations

U.S. Army Helicopter Accidents

In comparing HEMS to other aviation perations, we have not included any form of military aviation. However, much of the research regarding helicopter crashes and survivability has come from U.S. Army studies. It would seem a natural extension of our own study to compare Army accident rates with HEMS.

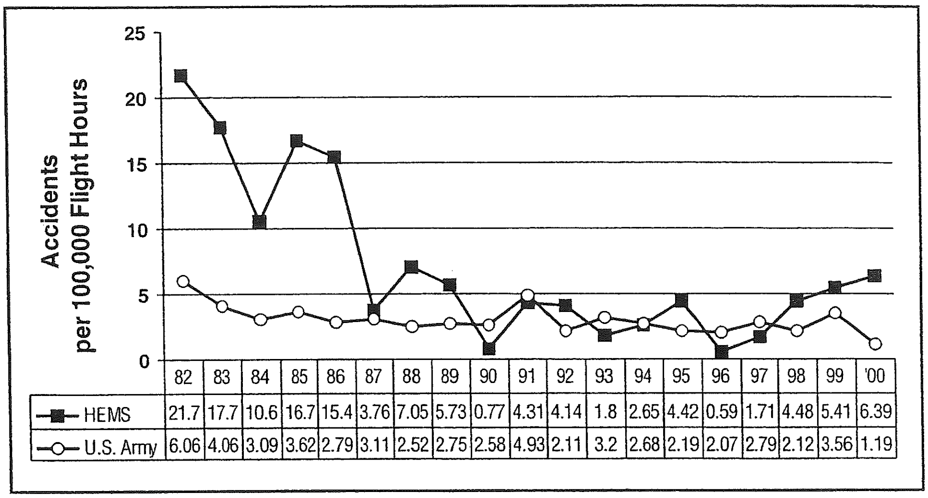
Information was obtained from the U.S. Army Safety Center at Fort Rucker, Alabama. From 1982–2000, U.S. Army helicopters flew an estimated 22.8 million flight hours worldwide, ranging from a high of 1.55 million hours in 1988 to a low of 753,000 hours in 1998. Total accidents that do not include any combat losses and accidents rates for nine different Army helicopters were also provided. Of these nine types of aircraft, the Army uses two models for medical missions—the UH-1 ("Huey") and the UH-60 ("Blackhawk"). Additional accident information was provided on these two aircraft for 1992–2000, for both the medical (UH1-V and UH-60 MEDEVAC) and non-medical (UH1-AC and UH-60) versions.

During the 18-year period, the U.S. Army recorded a total of 707 Class A and Class B non-combat helicopter accidents. Between 1992–2000, there were a total of 212 accidents. Looking only at the UH-1 and UH-60 from 1992–2000, there were 77 Class A and Class B accidents—11 in MEDEVAC aircraft and 66 in non-medical helicopters. There were an additional 253 Class C accidents reported for the UH-1 and UH-60 helicopters during these 9 years. A total of 44 involved medical helicopters and 209 were non-medical aircraft.

It should be noted that the U.S. Army Accident Classification is very different than the NTSB definitions of accidents and incidents. Clearly, Class A and B would qualify as accidents under the NTSB definitions. Class C however, seems to cross the line between the NTSB definitions of accident and incident.

Army Accident Classification
Class A. Damage costs of $1,000,000 or more and/or destruction of an Army aircraft, missile or spacecraft and/or fatality or permanent total disability.
Class B. Damage costs of $200,000 or more, but less than $1,000,000 and/or permanent partial disability and/or five (three as of 2002) or more people are hospitalized as inpatients.
Class C. Damage costs of $10,000 ($20,000 as of 2002) or more, but less than $200,000 and/or non-fatal injury resulting in loss of time from work beyond day/shift when injury occurred and/or non-fatal illness/disability causes loss of time from work.

Adapted from: http://asmis.army.mil/stats/pkg_definitions.class



	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	'00
■ HEMS	21.7	17.7	10.6	16.7	15.4	3.76	7.05	5.73	0.77	4.31	4.14	1.8	2.65	4.42	0.59	1.71	4.48	5.41	6.39
○ U.S. Army	6.06	4.06	3.09	3.62	2.79	3.11	2.52	2.75	2.58	4.93	2.11	3.2	2.68	2.19	2.07	2.79	2.12	3.56	1.19

Figure 2–21: U.S. Army Helicopter Class A and B Accidents vs. HEMS, 1992-2000 (n=77) *Adapted from: U.S. Army Safety Center, Fort Rucker, Alabama*

Unfortunately, our analysis of the Army accident data is limited by several factors. For 1982–2000, we have total flight hours, the number of accidents and the accident rate for the nine aircraft—but only for Class A and B accidents. For the UH-1 and UH-60, we have raw numbers of accidents for all three classes and for the medevac vs. non-medevac aircraft. However, we lack the corresponding breakdown of flight hours for the medical flights compared to the non-medical flights. Knowing the specific medevac flight hours would have allowed a more meaningful comparison. Finally, we do not have any fatal accident numbers.

Knowing the limitations of our comparison, we have plotted the combined Class A and Class B accident rates along with the HEMS accident rates in Figure 2–21. Over this 19-year period, the Army accident rate was as high as 6.06 accidents per 100,000 flight hours in 1982 and as low as 1.19 in 2000. In the '80s, the HEMS accident rate was consistently higher than the Class A+B accident rate. From 1990–1997, the rates are very similar and since 1998 the HEMS rates have again been higher.

While we do not know the specific accident rates for the Army medevac helicopters, we do know that from 1992–2000, there were six non-medical accidents for every one medevac crash involving the Huey and Blackhawk helicopters. However, if we were to also factor in the Class C accidents, our raw accident numbers would be increased more than four-fold.

Of interest, it should be noted that U.S. Army MEDEVAC missions are always 2-pilot operations. Most flights are "scene" flights and night missions, which account for an estimated half of all medical missions and are aided by night vision goggles (NVG).

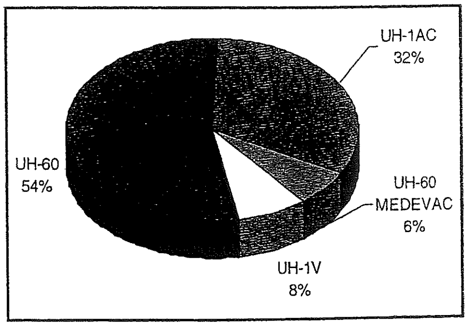


Figure 2–22: UH-60 vs. UH-1 Accidents 1992–2000 (n=77) *Adapted from: U.S. Army Safety Center, Fort Rucker, Alabama*

U.S. Forest Service Aviation Accidents

While the HEMS fatal accident rate has been higher than that of all other types of aviation for the past several years, it is not the most hazardous flying in the United States.

In August 2002, the NBC *Nightly News* reported that piloting Forest Service airtankers was the most dangerous flying in the United States. Since 1950, a total of 156 pilots had lost their lives fighting fires. NBC reported that the accident rate for Forest Service airtankers was found to be 13 per 100,000 hours of flight time. In comparison, they reported that the accident rate of U.S. military combat flight was 11 per 100,000 flight hours while that of civilian aviation was 3.6 per 100,000 flight hours.

Our own research into the Forest Service accident rates found that the reported accident rate of 13 per 100,000 hours of flight time represents a 10-year average for airtankers from 1992 to 2001. During that time, the annual range was from 0 to 51.36. During that same timeframe, other fixed-wing aircraft (not airtankers) had an average accident rate of 2.70 (range 0 to 15.13) and helicopters had an average of 8.93 (range 0 to 24.55). The 10-year average for all Forest Service aviation was 5.78 accidents per 100,000 flight hours, with a range of 1.58 to 11.67.

Figure 2–23 shows the annual accident rates and fatal accident rates for the four different Forest Service aviation operations compared to HEMS. Figure 2–24 plots the 5-year and 10-year averages for these operations.

Within this 10-year period, HEMS had the highest accident rates and highest fatal accidents in 1999 and 2001. In addition, in 1996, when HEMS had it's second lowest fatal accident rate, the U.S. Forest Service had a rate of zero. As the 5-year and 10-year averages indicate, HEMS is well below the accident rates for helicopters and airtankers used under contract by the U.S. Forest Service, but remains above the rates for fixed-wing aircraft.

	'92	'93	'94	'95	'96	'97	'98	'99	'00	'01	5-yr Avg.	10-yr Avg.
Accident rate per 100,000 flight hours												
HEMS	3.81	1.66	2.44	4.08	0.54	1.57	4.27	4.82	6.18	5.97	4.56	3.53
USFS Owned	0	0	6.94	10.11	8.58	0	0	0	7.84	0	1.57	3.35
Fixed-wing	0	15.13	2.22	0	0	0	3.08	0	2.85	3.76	1.94	2.70
Airtanker	19.42	51.36	9.9	24.07	0	0	27.13	0	0	0	5.43	13.19
Helicopter	14.29	8.31	14.22	0	11.01	24.54	4.09	3.97	3.76	5.06	8.28	8.93
Fatal Accident rate per 100,000 flight hours												
HEMS	1.18	1.2	1.76	0.63	0.59	1.14	1.68	1.62	2.13	1.9	1.69	1.38
USFS Owned	0	0	0	10.11	0	0	0	0	0	0	0.00	1.01
Fixed-wing	0	5.04	0	0	0	0	0	0	2.85	0	0.57	0.79
Airtanker	19.42	51.36	9.9	24.07	0	0	27.13	0	0	0	5.43	13.19
Helicopter	0	0	6.09	0	0	6.13	4.09	0	0	0	2.04	1.63

Figure 2–23: Accident Rates for U.S. Forest Service Aviation Operations vs. HEMS, 1992–2001

Adapted from: U.S. Department of Agriculture, Forest Service, http://www.aviation.fs.fed.us/library/fy01avsumm.pdf

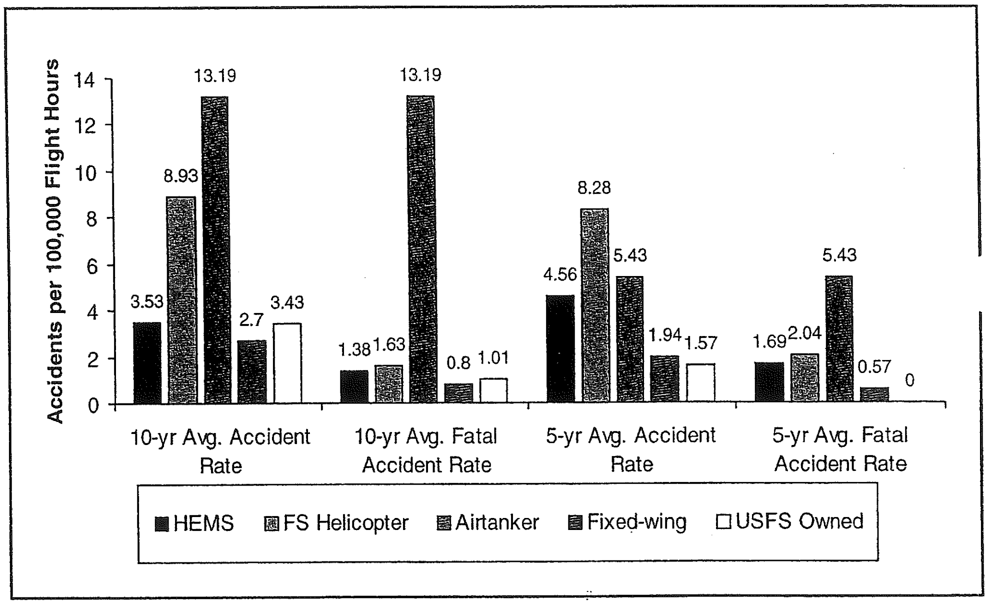
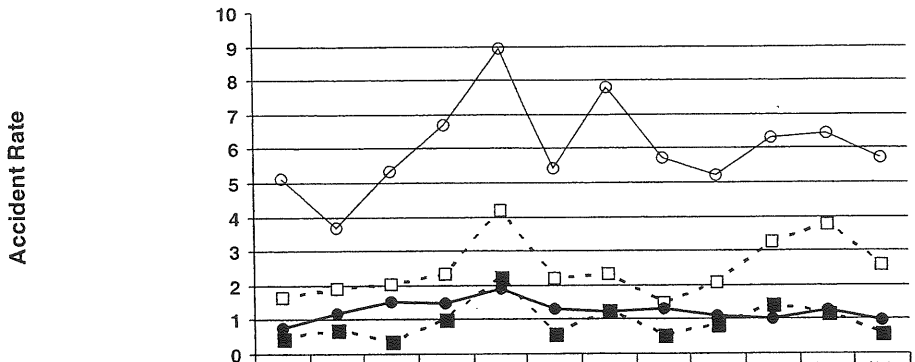


Figure 2–24: U.S. Forest Service Aviation Accidents vs. HEMS, 1992–2001

Adapted from: U.S. Department of Agriculture, Forest Service, http://www.aviation.fs.fed.us/library/fy01avsumm.pdf

SINGLE- VS. TWIN-ENGINE HELICOPTER ACCIDENT RATES

Since 1990, HAI has tracked the accident rate for single-engine vs. multi-engine helicopters, as well as the total helicopter flight hours. In general, it appears that single-engine flight hours have been approximately 3 times that of multi-engine flight hours each year. A dramatic difference is seen in the accident rate per 100,000 flight hours when comparing single- vs. twin-engine helicopters. The fatal accident rate however demonstrates less disparity. In fact, a 1999 study by the Flight Safety Foundation found the fatal accident rate of single- and twin-engine helicopters to be similar. Figure 2–25 charts the total accident and fatal accident rates for single- and multi-engine helicopters.



	90	91	92	93	94	95	96	97	98	99	'00	'01
—○— Single Engine -- Total	5.13	3.7	5.32	6.71	8.96	5.41	7.81	5.71	5.23	6.33	6.44	5.74
- □ - Multi-Engine -- Total	1.64	1.91	2.02	2.31	4.18	2.21	2.35	1.5	2.09	3.27	3.78	2.6
—●— Single Engine -- Fatal	0.76	1.19	1.53	1.49	1.91	1.33	1.22	1.32	1.12	1.02	1.26	0.98
- ■ - Multi-Engine -- Fatal	0.47	0.7	0.4	1.03	2.23	0.6	1.28	0.56	0.84	1.43	1.19	0.6

Figure 2–25: Total Accidents and Fatal Accidents per 100,000 Flight Hours Single- vs. Multi-Engine Helicopters, 1990–2002

Adapted from: Helicopter Association International, http://www.rotor.com/safety/stats70.01.xls

The Flight Safety Foundation study looked at turbine-engine helicopter accidents and compared them with all Part 135 operations and with general aviation. Figure 2–26 shows that the twin-engine helicopter accident rate was lower than the accident rates of general aviation aircraft, single-engine helicopters, and all Part 135 operations.

Nearly half (48%) of the twin-engine helicopter accidents were fatal. From 1993–1997, twin-engine helicopters were involved in 23 fatal accidents, or 1.4 fatal accidents per 100,000 flight hours. Figure 2–27 compares the fatal accident rates for helicopters (single- and twin-engine) general aviation, and air taxis.

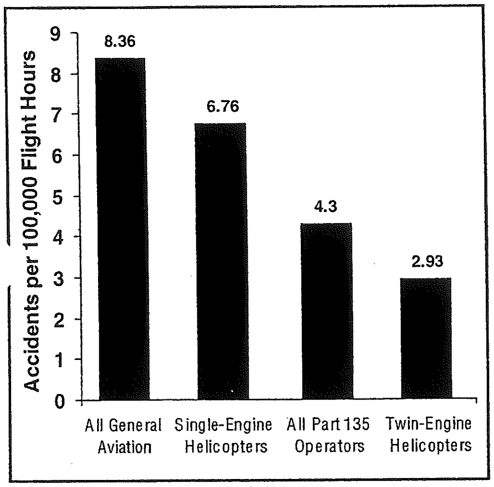


Figure 2–26: Accident Rate Comparison, 1993–1997

Adapted from: Harris, Helicopter Safety, Jan/Feb 1999

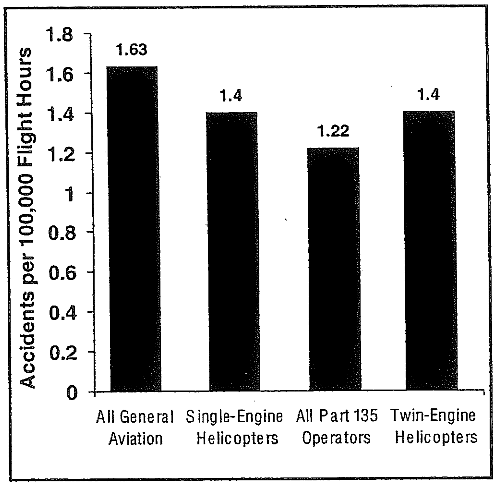


Figure 2–27: Fatal Accident Rate Comparison, 1993–1997

Adapted from: Harris, Helicopter Safety, Jan/Feb 1999

HELICOPTER ACCIDENTS, 2001

Year 2001 saw a 12% increase compared to 2000 when looking at all helicopter accidents. During the year, there were 217 helicopter accidents (see Figure 2–28), 42 of which were fatal, killing 105 people. Piston-engine helicopters accounted for 108 accidents, of which 19 were fatal. There were 95 single-turbine accidents (20 fatal) and 13 twin-turbine accidents (3 fatal). Of interest, this NASA "Safecopter" website lists only one of 12 air medical helicopter accidents as fatal.

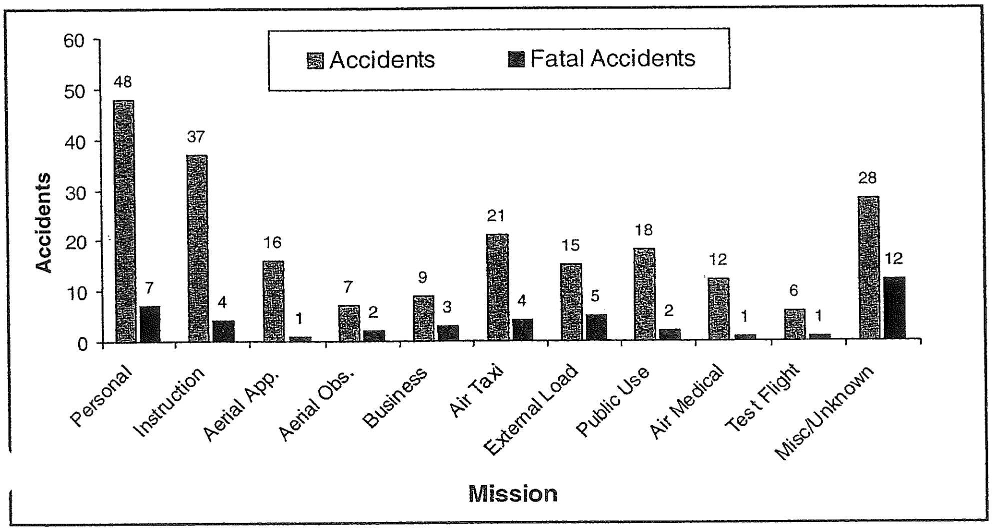


Figure 2–28: Helicopter Accident Statistics, 2001 *Adapted from: http://safecopter.arc.nasa.gov/*

SECTION 3: A COMPARISON OF RISK

Nothing is completely safe. Everything we do has some type of risk and these risks can never be totally eliminated from any situation. The issue is not one of avoiding risks all together, but rather one of managing risk in a sensible manner.

A 1999 *Time* magazine article, "Life on the Edge," states that "America has embarked on a national orgy of thrill seeking and risk taking." The article focused on the rise of extreme sports like BASE jumping, snowboarding, ice climbing, skateboarding, and paragliding but mentioned other risky activities—and occupations—as well. The article pointed out that Americans were taking greater risks than ever before in many areas. More than 30% of U.S. households owned stocks of some form or another, which was up from 12% just 10 years before. Social behavior had also become more risky, with unprotected sex on the upswing and illicit drugs like heroin on the increase. Finally, the article pointed out that many people assumed various risks in their chosen careers. From the MBAs who were trying to strike it rich in the "dot-com" world; to the 14.5% who voluntarily had left their jobs (highest in a decade) for new opportunities; to the options trader, neurosurgeon, fire fighter, and race car driver—all had chosen to assume a varying degree of occupational risk.

For all of these thrill seekers and risk takers, risk management requires a minimum of common sense and information about the character and magnitude of the risk taken. We must inform ourselves or be educated about the relevant risks and then act accordingly. Where you choose to live, your occupation, chosen modes of travel, recreational activities, or just staying at home—all have risks of accidents, injury, and death.

Determining Risk

Statistics on accidents, injuries, and fatalities are kept for nearly every activity and occupation. With raw data available, we need to be able to calculate the magnitude of a risk. This is especially important if we hope to compare different types of activities. In order to assess and compare risk, the relevant figure needed must be in the form of a ratio, fraction, or percentage. To arrive at these figures—to normalize the data—we need to know two numbers. The numerator of the fraction tells us how many individuals doing a particular activity were either injured or killed over a given period of time. The denominator represents how many people were engaged in that activity—the population at risk. By reducing all risks to ratios in this way we can begin to compare different types of activities and the relative risks. The larger the ratio, the riskier the activity.

There are two other options to normalize this data which are used more commonly by the National Safety Council (NSC). The first is to take the above fraction and normalize it to "1 in X," as in "the odds of something is 1 in X." The other option is to calculate death rates and injury rates per 100,000 persons.

There is risk of injury and death every hour of every day. The NSC estimates that while you make a 10-minute safety presentation, two persons will be the victims of unintentional deaths and approximately 370 will suffer a disabling injury. On the average, there are 12 unintentional-injury deaths and about 2,400 disabling injuries every hour during the year. Figure 3–1 shows a breakdown of the frequency and death rate of the major classifications of accidental deaths and injuries in the United States for 2000.

An individual is nearly twice as likely to be injured at work than in his/her car. Staying at home or going out in public is even worse. You are more than three times more likely to be injured at home or in public than in your car. However, in general, you are six times more likely to die in your car than die due to an accident at work and nearly one-and-a-half times more likely to suffer a fatal injury in your car than at home.

Where you choose to live will also impact your likelihood of dying from an unintentional injury. According to NSC statistics, Massachusetts and Rhode Island boast the lowest accidental death rates among the fifty states. However, if you live in New Mexico, Wyoming, or Alaska (the states with the highest accidental death rate), your chances of an unintentional death are 2.5 to nearly 3 times higher.

HEMS: ANALYZING THE POPULATION AT RISK

With injury and death statistics available for various occupations and types o activities, it would be necessary to determine the size of the "population at risk" in HEMS. To accomplish this—and with no such data available—we must make several assumptions and do various calculations.

Methodology

If one were to try to compare air medical transport to other occupations or "routine" risks to determine either the odds of death in one year or the fatality rate per 100,000 we would need to know two things. The first is the number of HEMS crew fatalities per year. The second would be the number of people engaged in HEMS transport (i.e., the number of HEMS pilots and medical crewmembers) for each year. The number of fatalities is known, but the number of crewmembers in HEMS has never been tracked or even estimated in the literature.

For the purpose of this study, we begi by estimating the average number of crewmembers per helicopter. We can assume that the typical flight crew for each dedicated medical helicopter includes 4 pilots, 6–8 nurses as the primary caregivers, and 10–12 second medical crewmembers (often paramedics, physicians, nurses, respiratory therapists, etc., who fly full- or part-time). Therefore, the average dedicated medical helicopter would have 20 to 24 crewmembers. For the purpose of our calculations, we will use an average of 22 persons.

Class	Severity	One every	2000 Total	Death Rate
All Unintentional	Deaths	5 minutes	97,300	35.3
	Injuries	1.5 seconds	20,500,000	
Motor-Vehicle	Deaths	12 minutes	43,000	15.6
	Injuries	14 seconds	2,300,000	
Work	Deaths	102 minutes	5,200	1.9
	Injuries	7 seconds	3,900,000	
Home	Deaths	18 minutes	29,500	10.7
	Injuries	4 seconds	7,100,000	
Public (nonmotor-vehicle)	Deaths	24minutes	22,000	8.0
	Injuries	4 seconds	7,300,000	

Figure 3–1: Unintentional Deaths and Injuries, 2000

Adapted from: National Safety Council, http://nsc.org/library/rept2000.htm

A review of the air medical literature showed there was no documentation as to the number of dedicated EMS helicopters from 1981 to 1991. Our Internet *Flightweb* survey provided us with a fairly accurate number of dedicated helicopters as well as HEMS programs for the year 2000. Assuming a steady annual increase in the number of aircraft between 1991 and 2000, we are able to predict the number of helicopters dedicated to the HEMS mission for each year. For 2001, we factored in the percent increase as determined from our operator and manufacturer survey.

We now have the necessary information to determine the approximate size of the population at risk. In 2001, there were an estimated 400 dedicated medical helicopters. Multiplying this figure by 22 crewmembers, we can estimate that the population at risk is approximately 8,792. Using this figure and knowing the number of crewmember deaths attributed to HEMS accidents, we are now able to compare some annual statistics in a more meaningful manner. In addition, we will be able to compare HEMS risk with other occupations and activities.

It is important to realize that in estinating exposure in this method, we are doing so for the *average* crewmember and the *average* flight program. The National Safety Council points out that predicting the rate for potential injury or death is strongly dependent upon the length of exposure to a particular activity for the specific population at risk. This would be similar to comparing the potential exposure rate for full-time vs. part-time HEMS personnel; four pilots vs. 6–8 nurses; programs that fly once a day vs. those that fly several times a day; programs that fly short distances to those that fly much further, and so on. When we normalize the raw data, it does not take into account the *amount* of exposure for an individual during the year. For this study, we are basing our calculations on the average program, which in 2001 transported approximately 882 patients, flying an estimated 957 hours over the course of the full year, and all crewmembers (pilots and medical crewmembers) flying an equal amount of time.

Results

Fatality statistics for HEMS personnel are presented in four different formats. In each case, the number of crew fatalities was determined for each year. From the total 171 HEMS fatalities, 21 patient fatalities, 7 dual-purpose aircraft crewmember fatalities and 6 other fatalities were removed from the appropriate years leaving only dedicated HEMS crew fatalities for our comparison. Figure 3–2 depicts the number of HEMS personnel who have died each year since 1980. The fatalities for 2002 (as of September 30, 2002) are included in this graph but are not included in any of our calculations. As the graph clearly shows, 2002 has had more crew fatalities than any year in HEMS history. Figure 3–3 shows the various calculations and the results used to determine the fatality rates.

The National Safety Council routinely normalizes fatality data to a death rate per 100,000 population at risk in a given year. Over the 21 years reviewed for this portion of the study (1981–2001), the HEMS population has grown from approximately 858 to 8,792. While this growth seems impressive, this is still a

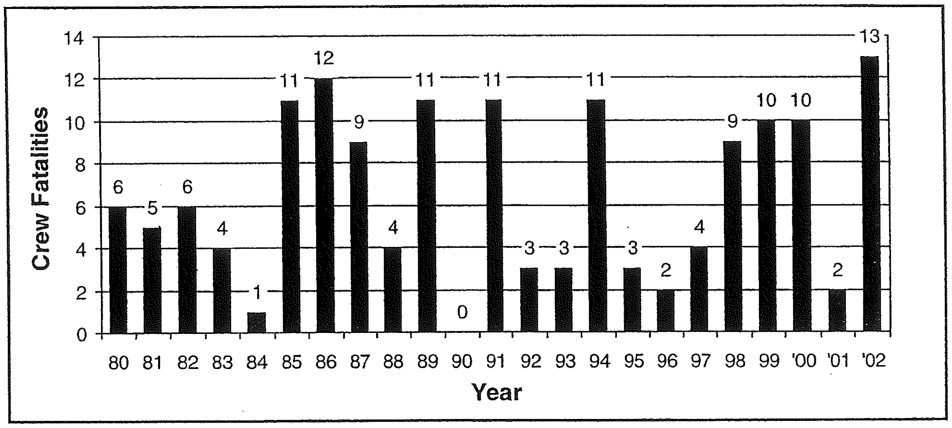


Figure 3–2: HEMS Crew Fatalities per Year, 1980–2002*
(as of September 30, 2002)

		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Totals
1	# of Helicopters	39	**45**	**62**	**75**	**91**	**119**	**151**	**184**	**195**	**213**	**231**	**225**	242	259	276	293	309	326	343	360	377	400	
2	Calc. Total Crew	858	990	1364	1650	2002	2618	3322	4048	4290	4686	5082	4950	5322	5693	6065	6436	6808	7179	7551	7922	8294	8792	185064
3a	Crew Fatalities	6	5	6	4	1	11	12	9	4	11	0	11	3	3	11	3	2	4	9	10	10	2	137
3b	Dual-Purpose Crew Fatalities										2		2							3				7
4	Patient Fatalities	1	1	1	0	1	1	1	1	1	3	0	3	0	2	0	0	1	1	2	0	1	0	21
5	Other Fatalities								2				1										3	6
6	Total Fatalities	7	6	7	4	2	12	13	12	5	16	0	17	3	5	11	3	3	5	14	10	11	5	171
7	Crew Fatality Rate	0.70%	0.51%	0.44%	0.24%	0.05%	0.42%	0.36%	0.22%	0.09%	0.23%	0.00%	0.22%	0.06%	0.05%	0.18%	0.05%	0.03%	0.06%	0.12%	0.13%	0.12%	0.02%	0.196%
8	1 in_______	143	198	227	413	2002	238	277	450	1073	426	N/A	450	1774	1898	551	2145	3404	1795	839	792	829	4396	1158
9	per 100,000	699	505	440	242	50	420	361	222	93	235	0	222	56	53	181	47	29	56	119	126	121	23	196
10	No Injuries	2	6	17	9	8	11	19	0	15	8	4	9	4	0	4	13	0	5	12	18	13	18	195
11	Injuries Serious	0	0	0	3	3	5	3	0	5	4	0	0	10	3	1	0	0	0	5	6	0	8	56
12	Minor	0	3	0	3	8	11	10	1	6	3	0	0	4	3	3	5	0	1	0	0	7	5	73
13	Total Injuries	0	3	0	6	11	16	13	1	11	7	0	0	14	6	4	5	0	1	5	6	7	13	129
14	Injury Rate	0.0%	0.30%	0.00%	0.36%	0.55%	0.61%	0.39%	0.02%	0.26%	0.15%	0.00%	0.00%	0.26%	0.11%	0.07%	0.08%	0.00%	0.01%	0.07%	0.08%	0.08%	0.15%	0.16%

Figure 3–3: Fatalities and Fatality Rates

very small sampling to translate to a ratio per 100,000. As Figure 3–4 shows, with such a small population base, each fatality has a significant impact on the fatality rate. In this format, the range for the fatality rate is from 0 to 699 per 100,000. With such a wide range, a 22-year average is calculated that will be used when we compare HEMS to other risks. The average annual death rate over the 22 years is 196 per 100,000 crewmembers.

Another way to look at the relative risk of HEMS transport is in the form of a ratio—dividing the number of fatalities by the number of crewmembers for each year. Since this uses the same data, but in a slightly different equation, the graph would look essentially the same as Figure 3–4. For this annual comparison (Figure 3–3, Line 7) the range is from 0.00% to 0.70%, with a 22-year average of 0.196%. The higher the percentage, the greater the apparent risk in that particular year.

The final relationship that is used to compare the annual number of HEMS crew fatalities is in terms of "odds." For example, in 2001 there were only two crew deaths out of an estimated crew population of 8,792. Looking solely at the numbers, the odds to an individual crewmember suffering a fatal accident that year would be considered to be 1 in 4,396. Contrasting this with what could be considered our riskiest year (1980), there were 6 crew fatalities out of an estimated 858 crewmembers industry-wide. This would correspond to fatality odds of 1 in 143. Excluding 1990 when there were no fatalities, the average odds per year over the 22-year period are 1 in 1,158. Figure 3–5 illustrates the odds of a fatality over the study time period.

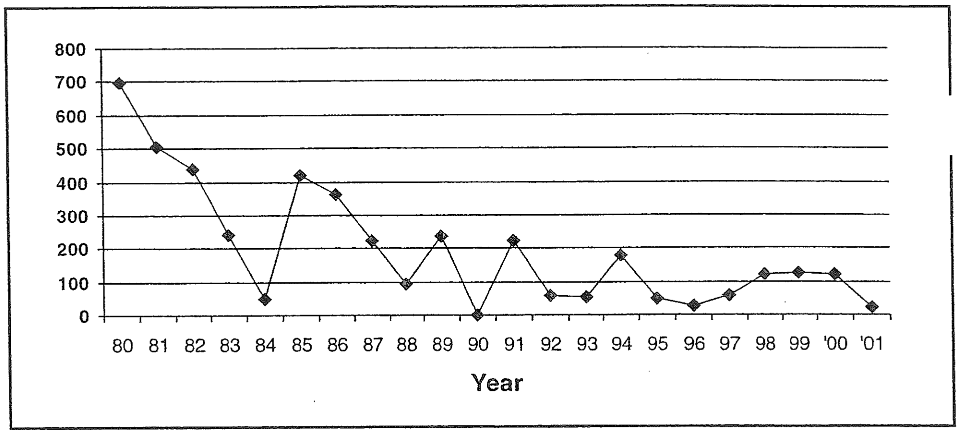


Figure 3–4: HEMS Fatality Rate per 100,000 Personnel, 1980–2001

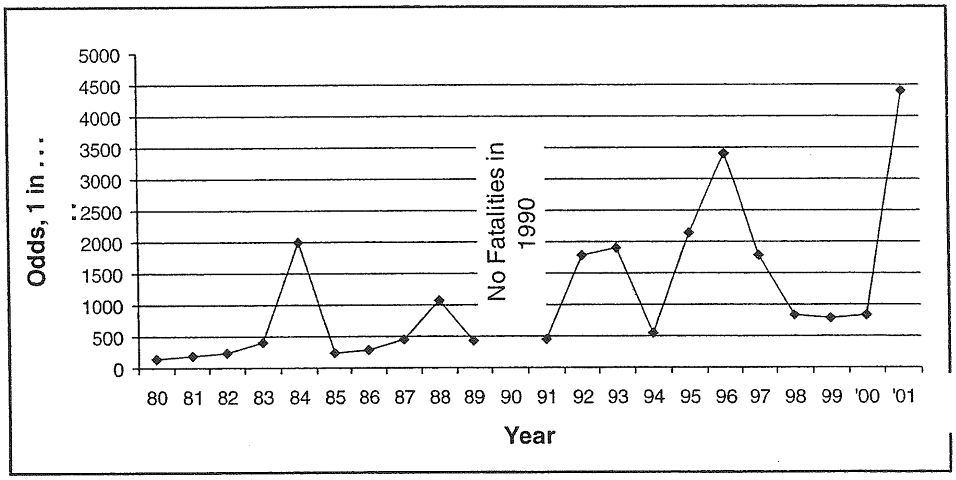


Figure 3–5: Odds of a Fatality for HEMS Personnel, 1981–2001

COMPARING HEMS TO OTHER RISKS

To further illustrate the risk related to HEMS transport, we can compare and contrast the above numbers with other activities, other types of accidents, and other causes of death. Taking into consideration the wide range of fatality rates and odds that we have estimated for each year in HEMS, the calculated *averages* will be used in subsequent comparisons.

Cause of Death – An Overview

Since 1921, the National Safety Council has been a source of accurate, comprehensive, and objective statistics on unintentional injuries, their costs, trends, and other characteristics. Accidents and unintentional injuries generally rank as the fifth leading cause of death worldwide behind heart disease, cancer, stroke, and COPD.

The NSC provides statistics looking at the total number of deaths and the relative death rate for various unintentional deaths per 100,000 population. The leading five causes of fatal unintentional injuries (motor vehicle accidents, falls, poisoning, drowning and choking) have been the same from 1970 through 1998 (1998 is the last year this data was available). Together, these five categories of injury accounted for nearly 80% of all accidental deaths (77,951 of the 97,835) in 1998. Figure 3–6 identifies the leading causes of accidental death, number of deaths, and death rate for 1998. In addition, we have included data on other causes of death (heart disease, cancer, and stroke) as well as a comparison to HEMS.

As you can see the 22-year average fatality rate for HEMS is very high. When you consider the average annual death rate over the 22 years reviewed, HEMS is surpassed only by heart disease and cancer when the data is normalized per 100,000 persons.

What are the Odds...

The NSC reports that motor-vehicle accidents cause more accidental deaths in the United States than any other unintentional injury. Looking at the

Cause of Death (in rank order)	Deaths, 1998	Death Rate Per 100,000
All Causes, all ages	**2,337,256**	**864.9**
Heart Disease	724,859	268.2
Cancer	541,532	200.4
HEMS *(range over a 22 year period: 0–699 per 100,000)*		***196***
Stroke	158,448	58.6
Chronic obstructive pulmonary diseases (COPD)	112,584	41.7
All Accidental Deaths	**97,835**	**36.2**
(Following is a select listing of accidental deaths)		
Transport Accidents	45,774	16.9
Motor-vehicle	*43,501*	*16.1*
Air and space transport	692	0.3
Water transport	692	0.3
Railway	*515*	*0.2*
Misc.	*374*	*0.1*
Falls	16,274	6.0
Poisoning by solids, liquids, gases, vapors	10,255	3.8
Drugs, medications, and biologicals	9,838	3.6
Drowning	3,964	1.5
Choking, Inhalation, ingestion of food or other object	3,515	1.3
Fire and flames	3,255	1.2
Complications/misadventures of surgery/medical care	3,228	1.2
Natural and environmental factors	1,521	0.6
Firearm, missile	866	0.3

Figure 3–6: Leading Causes of Death, 1998

Adapted in part from: National Safety Council, Injury Facts 2001 Edition

Type of Accident or Manner of Injury	Deaths, 1998	One-year odds	Life-time Odds
HEMS Accidents (22-year average)		***1,158***	
Total deaths due to injuries	150,445	1,796	23
All Accidental Deaths	97,835	2,762	36
Transport Accidents	45,774	5,904	77
Motor-vehicle	43,501	6,212	81
Railway	515	524,753	6,842
Other road vehicle	235	1,149,991	14,993
Water transport	692	390,532	5,092
Air and space transport	692	390,532	5,092
Poisoning by solids and liquids	10,255	26,353	344
Poisoning by gases and vapors	546	494,960	6,453
Complications, misadventures of surgical, medical care	3,228	83,720	1,092
Falls	16,274	16,606	217
Fire and flames	3,255	83,025	1,082
Natural and environmental factors	1,521	177,678	2,317
Excessive heat	375	720,661	9,396
Excessive cold	420	643,448	8,389
Lightning	63	4,289,651	55,928
Cataclysmic storms, and floods	204	1,324,745	17,272
Drowning, submersion	3,964	68,176	889
Inhalation and ingestion of food	1,147	235,613	3,072
Inhalation and ingestion of other object	2,368	114,125	1,488
Mechanical suffocation	1,070	252,568	3,293
Struck by falling object	723	373,787	4,873
Machinery	1,018	265,470	3,461
Adverse effects of drugs in therapeutic use	276	979,159	12,766
Hanging, strangulation, and suffocation	5,726	47,197	615
Firearms	17,424	15,510	202

Figure 3–7: Odds of Death Due to Unintentional Injury, Selected Causes, 1998 ("1 in ____")

Adapted in part from: National Safety Council, http://nsc.org/lrs/statinfo/odds.htm

odds, an annual risk of death of 1 in a million is equivalent to the risk of dying in a car accident if you travel in your car one mile a week for a full year. Driving (or riding) 10 miles per week in an auto increases your annual risk of dying in an MVA to 1 in 100,000. If you increase your weekly driving to 100 miles, your annual risk of death is now 1 in 10,000, while at 1,000 miles per week our odds of dying in a car accident is 1 in 1,000.

The NSC often fields questions about "odds." For example, "What are the odds of dying in a plane crash or being killed by lightning?" In response to questions like this, the NSC has determined the "Odds of Death Due to Injury" in the United States for various activities. For 1998 (the most recent year of these statistics) the one-year odds were calculated by dividing the 1998 population by the number of recorded deaths from specific injuries that year. To determine the lifetime odds, the NSC took the one-year odds and divided them by the life expectancy of a person born in 1998, which is 76.7 years. The NSC also published death and injury rates per 100,000 for various occupations, activities, and modes of travel.

For 1998, the NSC determined that the odds of dying from an injury (intentional or unintentional) during that year were 1 in 1,796. They also determined that the lifetime odds of dying from an injury for a person born in 1998 were 1 in 23. Looking only at accidental (unintentional) deaths in 1998, the odds decrease to 1 in 2,762 in that year and to 1 in 36 lifetime. Figure 3–7 shows the 1998 odds of death in the United States due to an unintentional injury for various causes. Included in the table are the average one-year odds for a HEMS crewmember to die in a fatal crash. As you can see, the odds of suffering a fatality in HEMS exceed that of motor-vehicle accidents and all other accidental deaths.

As previously discussed, one of the problems with data that is normalized in this fashion is that it does not take into account the true *amount* of exposure during the year. It assumes all exposures are equal. A more accurate approach would be to determine the exposure (time, etc.) that might result in a specified risk that can be compared to other activities.

We have determined that in HEMS there is an average one-year risk of death of 1 in 1,158. *The Book of Risks* has identified several activities that produce a 1-in-1,000 risk of death. In the 22-year HEMS study period an estimated 3,002,176 total hours have been flown. Adding together the estimated number of crewmembers each year yields a total of 105,922. This corresponds to an average exposure of 28.3 hours of flight time producing the estimated odds of 1-in-1,158. Adjusting the ratio to 1-in-1,000, we get an average exposure of 32.9 hours.

Activity	Time/Effort Involved
Rock climbing	25 hours
HEMS transport	***32.9 hours***
Skydiving	50 hours
Driving a motorcycle	55 hours
Skiing	340 hours
Flying on a scheduled airline	1,200 hours
Driving a car	52,000 miles

Figure 3–8: Activities Producing a 1-in-1,000 Risk of Death

Adapted in part from: Laudan, The Book of Risks, 1994.

HEMS: The Risk to the Patient

There is some level of risk related to all aspects of healthcare—every procedure performed, every medication dispensed, and every patient transported. The possibility of adverse events or medical errors represents a significant risk to each and every patient.

In *Human Error*, James Reason defines an error as "the failure of a planned action to be completed as intended (i.e., error of execution) or the use of a wrong plan to achieve an aim (i.e., error of planning)." An accident represents an adverse outcome after an error.

The results of the "1991 Harvard Medical Practice Study" concluded that 3.7% of New York hospitalizations resulted in adverse events, of which 13.6% led to death. A subsequent study published in 1999 found that in Utah and Colorado, 2.9% of the hospital admissions experienced an adverse event, with 6.9% of these resulting in a fatality. According to the Institute of Medicine publication, with over 33.6 million admissions to U.S. hospitals in 1997, the results of these two studies would suggest that between 44,000 and 98,000 Americans die in hospitals each year as a result of medical errors.

To put these figures in perspective, this would be roughly equivalent to the crash of a jumbo jet carrying 500 passengers every 2–4 days. In addition, normalizing the data yields a death rate between 131 and 292 per 100,000 patients due to medical errors.

It is noted that the total number of deaths and corresponding death rate is significantly different than the statistics presented for "complication of surgery/medical care" that are listed in Figure 3–6. The National Safety Council death rate is based upon the reported number of deaths in this category compared to the entire U.S. population. The researchers of the two cited studies based their estimates upon a comprehensive review of a sampling of medical records for adverse events. The estimated number of deaths was then calculated for the number of annual *patients* (1997) rather than the entire population. According to the U.S. Department of Commerce, the population in the United States in January 1997 was 266,490,000 people. Normalizing the estimated number of deaths from the New York and Utah/Colorado studies for the entire U.S. population yields a death rate per 100,000 between 16.5 and 36.8 due to medical errors. This is still significantly higher than the NSC rate of 1.2.

While air medical *transport* is not a medical *treatment* and aviation accidents would not be considered a medical error, some could argue that these accidents represent an adverse event in the healthcare environment. In our 22-year study, we estimate that a total of 2,745,207 patients have been flown by HEMS. Over this same time period, 21 patients have lost their lives in HEMS accidents. This corresponds to a death rate of 0.76 per 100,000 patients flown. This takes into account only fatal injuries as a result of helicopter accidents and does not address any medical errors or other adverse events that could take place during transport. Based upon these figures, it would appear that there is a far greater risk to the patient of dying from an adverse event while hospitalized than from an accident aboard a medical helicopter.

Occupational Risks: Deaths and Injuries in the Workplace

In 2000, there were 5,200 workplace accidental fatalities, while an additional 3.9 million American workers suffered disabling injuries on the job. The NSC reports an average death rate across all industries at 3.8 per 100,000 workers, with mining and agriculture having the highest rates. Figure 3–9 shows that if HEMS "workers" were compared to the published NSC data, the average annual HEMS death rate is approximately nine times greater than the riskiest industries tracked by the NSC. However, it must be pointed out that this comparison is greatly distorted when you consider the small HEMS "population." Even in 2001, with our largest estimated number of crewmembers, 2 fatalities resulted in a death rate of 23 per 100,000.

The picture changes dramatically if you look at the rate of injuries, not just

Industry	Workers	Deaths	Death Rate[1]	Disabling Injuries	Injury Rate
All industries	136,402,000	5,200	3.8	3,900,000	2.86%
HEMS (22 yr. Avg)			***196***		***0.16%***
Agriculture	3,380,000	780	22.5	130,000	3.85%
Mining, quarrying	520,000	110	21.2	20,000	3.85%
Construction	8,949,000	1,220	13.6	470,000	5.25%
Manufacturing	19,868,000	660	3.3	630,000	3.17%
Transportation and public utilities	8,084,000	930	11.5	380,000	4.70%
Trade	27,723,000	420	1.5	750,000	2.71%
Services	47,611,000	630	1.3	940,000	1.97%
Government	20,267,000	450	2.2	580,000	2.86%

Figure 3–9: U.S. Unintentional Work-Related Injuries and Deaths, 2000

[1] Per 100,000 workers. *Adapted in part from: National Safety Council, Injury Facts 2001 Edition*

fatalities. The overall injury rate for all industries is 2.86%, ranging from 1.97% to 5.25% of the workers. Over the 22-year period, the injury rate for HEMS anges from 0.0% to 0.61%, with an average of 0.16%. This injury rate takes into account only injuries that were suffered in helicopter accidents. It does not take into account any other etiology of disabling injury (e.g., back injury, falls) that could afflict an air medical crewmember while on duty.

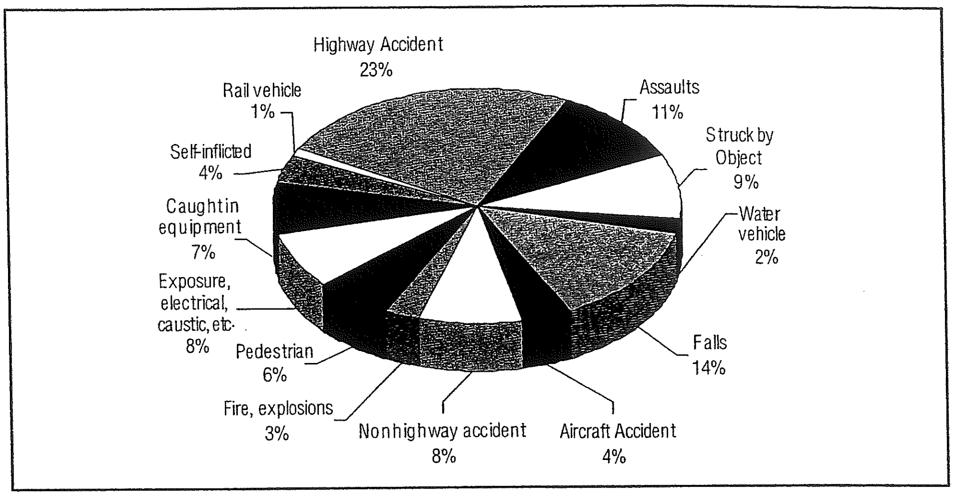


Figure 3–10: Fatal Occupational Injuries by Event, 2001
Adapted from: Bureau of Labor Statistics, http://www.bls.gov/news.release/cfoi.t03.htm

A Pittsburgh study by Doyle et al., however looked at occupational injuries in air medical transport. Presented at the 2002 Critical Care Transport medicine Conference (CCTMC), this 3-year study found that the risk per flight of a crewmember sustaining a reportable injury is very low. A total of 16,062 flights resulted in only 86 injuries. However, Doyle also concluded that of the 140 flight personnel, 59% had sustained a reportable injury.

Although industries differ, the types of injuries that occur are common. Figure 3–10 shows the various mechanisms of injury and the percent seen in all industries. As this chart clearly shows, there re inherent risks to all occupations that could result in injuries or death. In many ways the risks to health care providers may be similar to other professions, but there may also be greater risk in certain areas. For HEMS personnel, flying is indeed one of those risks. Health care workers, including HEMS personnel, may be exposed to other risks as well.

Violence in the workplace is an all too common problem, with homicide being the leading cause of occupational death among all workers in the United States. It is estimated that 1,000 deaths in the workplace are due to assault each year. Unfortunately, health care workers are not immune to work-related attacks.

According to a 1998 OSHA Publication, more assaults occur in the health care and social services industries than in any other. They cited Bureau of Labor Statistics (BLS) data that showed health care and social service workers having the highest incidence of injuries due to assault. According to one study by Goodman et al., in 1994, between 1980 nd 1990, 106 occupational violence-related deaths occurred among health care workers, including 27 pharmacists, 26 physicians, 18 registered nurses, 17 nurses' aides, and 18 health care workers in other occupational categories. A separate study using the National Traumatic Occupational Fatality database reported that there were 69 nurses killed at work between 1983 and 1989.

In a 1998 California study, they found that assault, hostage taking, rapes, robbery, and violent actions resulting in death were reported in emergency rooms, mental health hospitals and clinics, and social service offices. A 1983 study by Conn and Lion found that assaults by patients in the hospital setting occurred in psychiatric units (41%), emergency rooms (18%), medical units (13%), surgical units (8%), and even pediatric units (7%). A 1988 study by Lavoie et al., investigated 127 large, university-based hospital emergency departments and reported that 43% had at least one physical attack on a medical staff member per month. Seven percent of the reported acts of violence over a 5-year period resulted in death.

Violence in the emergency department (ED) has seen an increase in recent years. ED personnel face a significant risk of injury from assaults by patients and are often abused by relatives of patients or other persons associated with the patient. A study in the *Journal of Emergency Nursing* by Erickson and Williams-Evans found that 82% of nurses surveyed reported they had been assaulted during their careers—many going unreported. Stultz, in 1993 reported that nurses were the most frequent targets of assault and the greatest percentage (25%) of assaults occurred in the ED. Of 51 homicides involving health care workers, 23% were in the ED.

Unfortunately, air medical personnel are not immune to violent assaults. In January 2002, two flight crewmembers heard a motor vehicle collision on the street adjacent to their base. Upon approaching the vehicle to assist the driver, the two flight team members were shot—one fatally.

Health care workers are exposed to other dangers as well, with the risk of needlestick injury and the transmission of bloodborne pathogens is an industry-wide concern. These injuries can result in serious and potentially fatal infections from the hepatitis B virus (HBV), hepatitis C virus (HCV), or human immunodeficiency virus (HIV).

In the United States, there are more than 8 million health care workers in hospitals and other health care settings. Estimates suggest that 600,000 to 800,000 needlestick injuries occur annually, with about half going unreported. A 1999 study by the National Institute for Occupational Safety and Health estimates that in the average hospital, workers will incur approximately 30 needlestick injuries per 100 beds per year.

In the United States, between 1985 and 1999, there were 55 "documented" cases and 136 "possible" cases of occupational HIV transmission to health care workers. Combined data from more than 20 worldwide studies of health care workers exposed to HIV-infected blood found an average transmission rate of 0.3% (21 infections in 6,498 exposures).

HBV infections occur much more commonly in health care workers. In 1995 alone, an estimated 800 health care workers became infected with this virus. The HBV transmission rate after a single needlestick exposure ranges from 6 to 30% if the health care worker is not immune to HBV. However, treated with hepatitis B immune globulin and initiating the hepatitis B vaccine is more than 90% effective in preventing HBV infection. About one-third to one-half of persons with acute HBV infection develop symptoms of hepatitis. Most acute infections resolve, but 5% to 10% of patients develop chronic HBV infection that carries an estimated 20% risk of dying from cirrhosis and 6% risk of dying from liver cancer.

Hepatitis C virus infection, the most common chronic bloodborne infection in the U.S., is prevalent in 1 to 2% of the general population. Of the acute HCV infections that have occurred annually, 2% to 4% have been in health care workers exposed to blood in the workplace. Unlike HBV, chronic infection develops in 75 to 85% of patients, with active liver disease developing in 70%. Of the patients with active liver disease, 10% to 20% develop cirrhosis, and 1% to 5% develop liver cancer. On the average, 1.8% of the health care workers with percutaneous exposure to HCV become infected.

Another potentially dangerous and risky endeavor for many occupations, especially health care workers, is rotating shift work. Investigators have shown that disruptions in circadian phases due to rotating shift work are associated with decreased performance, lapses of attention, and increased reaction time. In 1992, Gold et al., found that nurses on rotating schedules reported more "accidents" (including on-the-job errors, on-the-job personal injuries, and auto accidents due to sleepiness) than did nurses on other schedules.

Sleepiness has been blamed for approximately 200,000 to 400,000 motor-vehicle collisions per year in the United States. Considering that the National Highway Traffic Safety Administration (NHTSA) recorded 6,279,043 motor-vehicle accidents in 1999, sleepiness would account for 3.2 to 6.4% of the accidents that year. In comparison, NHTSA estimates that alcohol was involved in 7% of all crashes in 1999.

The practice of driving home after a night shift appears to be a significant occupational risk for health care workers. Steele (1996) reported the results of a survey of emergency medicine residents that found nearly 75% of the auto accidents and 80% of the near-crashes occurred following a night shift. That same year, Novak reported that approximately 95% of night nurses working 12–hour shifts reported having had an automobile accident or near-miss accident while driving home from night work.

Travel-Related Risks

How we choose to travel to work, during work, or for recreation predisposes each of us to additional risks. Travel-related deaths account for nearly half of all accidental deaths, with passenger cars and taxis having a significantly higher death rate than all other modes of travel (Figure 3-11).

There is a motor-vehicle death every 13 minutes. However, mile for mile, it is far riskier to walk or jog—if it involves crossing an intersection—than to use any form of motorized vehicle, including motorcycles. Pedestrian deaths, estimated at nearly 6,000 each year, are more than double the rate of motorcycle deaths.

Figure 3-11 depicts the death rates per 100,000,000 miles of travel for a three-year period for the major modes of transportation. From 1997-1999, scheduled airlines were the safest mode of transportation. Transit buses and school buses were next, but had ten times the death rate when compared to the airlines. Fatalities by automobile were about 22 times greater per passenger-mile than by city bus. In 22 years, HEMS has flown an estimated 3,002,176 hours, covering an estimated 360,261,121 miles (using an average of 120 miles-per-hour). Normalizing our HEMS data for 137 crewmember fatalities yields a death rate of 38.0 per 100,000,000 miles traveled.

How do you manage the risk of being involved in an auto accident? While automobile accidents kill a great many people, there are ways to manage the risk and reduce your chances of suffering a fatal auto injury. In motor-vehicle collisions, large cars are generally safer than small ones. You are roughly twice as likely to die in a serious auto accident if you are in a small car rather than a large car. Yet, for various reasons, many of us choose to drive small cars. Driving at night, mile for mile, is almost four times more likely to end in a fatal accident than driving during the daylight. Yet most people still drive at night. The lap-shoulder seat belt reduces fatalities in front-end collisions by 42%, but it is reported that 32% of Americans never wear seat belts. However, when you take into account car size and seat belt use, you are less likely to die in a large vehicle accident wearing no seat belt than in a small car wearing a seat belt.

Mode of Transportation	Death Rate
Buses	0.04
Railroad	0.06
Scheduled Airlines	0.004
Passenger Cars and Taxis	0.87
HEMS	**38.0**

Figure 3–11: Transportation Accident Death Rates / 100,000,000 miles, 1997 to 1999

Adapted in part from: National Safety Council, Injury Facts 2001 Edition

Helmets are an important consideration when it comes to bicycles and motorcycles. Helmets reduce the risk of fatal injury to motorcyclists by 30%. Helmets can also reduce the risk of serious head injury in bicycle accidents by more than 70%.

Ground Ambulance Accidents

Emergency vehicle accidents are not unique to air medical transport. A frequent discussion among transport professionals and other health care providers involves comparing the risk vs. benefit of ground vs. air transport. EMTALA guidelines require that the risks and benefits of all inter-facility transfers be explained to the patient. This should include an explanation of the anticipated risks and benefits of the chosen mode of travel—air or ground.

Unfortunately, the availability and accuracy of statistics regarding ground ambulance accidents is even worse than that of air medical transport. Similar to HEMS, no exposure data exists for ground ambulances. There is no information nationwide as to the number of miles traveled, number of ambulances or the number of patients transported. The lack of this information makes it impossible to make a meaningful comparison between air and ground transport. However, some information is available regarding ambulance accidents.

The National Safety Council publishes data on crashes involving emergency vehicles in the United States. The NSC annual tabulations are based upon the Fatality Analysis Reporting System (FARS) and General Estimates System (GES) which are made available each year from the National Highway and Safety Administration. However, experts in the field of ground EMS transport question the accuracy of these statistics. There is no central tracking system to identify and capture ground ambulance accidents. Some accidents will be reported as "ground ambulance" accidents. In some systems, however, where EMS is a component of the Fire Department, the accident may be logged as having involved a "fire" vehicle. Some accident reports may list the vehicle as a "light truck." Some states track ground ambulances aggressively. In New York State alone, there are an average of 350 ambulance accidents each year, injuring an average of 2 people per day. However, many states do not have any system in place to track accidents accurately.

In April 2002, Robert Davis reported in *USA Today* that there might be an estimated 15,000 ambulance crashes a year. This estimate is approximately three times the number of ground ambulance accidents that we find in the NSC annual publications. Other sources suggest from sample data that it is very reasonable to estimate one fatal ambulance crash each week, as many as ten serious injuries every day and as many as 10,000 total injuries every year. Figure 3–12 presents three years of NSC data for ground ambulances, as well as other emergency vehicles (police and fire).

USA Today reported that with "relatively few fatalities each year (. . .out of millions of ambulance calls), federal officials say there is no pattern that triggers any alarms," and ". . . .there is not a huge safety problem."

There are obviously those who would disagree.

USA Today referenced a 1993 Houston study that found that ambulances were 13 times more likely to be involved in an accident than other vehicles based upon the number of accidents per miles driven. That study also determined that ambulances were five times more likely to be involved in an accident that resulted in injuries.

Our analysis of the NSC data for 1997–1999, found that ground ambulance had the highest percentage of fatal accidents when comparing each category of emergency vehicle. Over the 3-year period, 0.47% of all ground ambulance accidents resulted in a fatal injury. Fire vehicles were a little better at 0.39% and police were 0.32%. In addition, if you consider the number of total fatal injuries per 1,000 emergency vehicle accidents, the ambulance remains the most lethal. Over the 3-year period, the ambulance averaged 5.2 fatal injuries per 1,000 accidents, compared to 4.8 deaths for fire vehicles and 3.49 for police. The percentage of accidents that resulted in injuries is also the highest for ambulances (36%) compared to the fire (18%) and police (32%) vehicles.

From the 1997–1999 NSC data, in fatal, multi-vehicle ambulance accidents, only 25% of the deaths were occupants of the ambulance. Less than 3% of the fatalities were the ambulance "driver" according to the NSC data. Over 22% of those killed were "emergency vehicle passengers". The NSC tables did not differentiate between the patients, medical personnel, patient's family or others who were killed in the ambulance, making it impossible to know the total number of ground ambulance personnel killed in accidents. Of the remaining fatalities, two-thirds of those killed in these accidents were occupants of another vehicle and 8% of the fatalities were nonmotorists.

Recreational Risks

When it comes to sports and recreational activities, the National Safety Council and other publications make little if any effort to compare or rank the relative risk of injury or death. There are too many variables and unknowns to consider, including frequency and duration of exposure, number of participants and accurate numbers of injuries. The only injuries generally known are those that required emergency treatment. Most of the statistics come from emergency department logs.

The rising popularity of extreme sports was documented in the 1999 *Time* magazine article.

More Americans than ever are injuring themselves while pushing their personal recreational limits. BASE jumping (jumping from Buildings, Antennas, Span/bridges and Earth/cliffs) has one of the sporting world's highest fatality rates. In its 18-year history, 46 participants have been killed. Currently, there are more than a thousand jumpers in the U.S. and more getting into it every day. The sport has never been more popular.

While there has been a steady decline throughout the '90s in the participation in sports like baseball, touch football, and aerobics, there has been rapid growth in adventure

	Ambulance				Fire Truck/Car				Police Car			
	'97	'98	'99	Avg.	'97	'98	'99	Avg.	'97	'98	'99	Avg.
EV in fatal MVA	28	25	15	0.47%	20	17	17	0.39%	97	83	65	0.32%
EV in injury MVA	1,465	2,306	1,473	36.4%	997	781	677	17.6%	8,305	8,210	8,645	32.4%
Total number of MVAs	4,745	4,615	5,050		3,928	3,188	6,839		23,725	24,417	29,419	
EV driver killed	0	2	0	2.7%	5	4	5	21.2%	19	17	17	19.6%
EV passengers killed	8	7	2	22.7%	3	3	3	34.8%	6	3	4	24.4%
OV occupants killed	21	18	11	66.7%	13	12	9	51.5%	54	66	40	59.0%
Nonmotorist killed	2	2	2	8.0%	4	3	2	13.6%	24	10	11	16.6%
Total Deaths	31	29	15		25	22	19		103	96	72	
Total injuries	3,351	3,274	2,659		1,467	1,035	1,130		12,689	12,339	15,230	

Figure 3–12: Emergency Vehicles Involved in Motor Vehicle Accidents, 1997–1999 (EV=Emergency vehicle; OV=Other Vehicle)

Adapted from: Injury Facts: 1999 Edition, 2000 Edition, and 2001 Edition. National Safety Council.

sports. Snowboarding has grown 113% in five years and now boasts nearly 5.5 million participants. Mountain biking, skateboarding, scuba diving, and other more hazardous activities have seen more and more people participate. In 1997 the U.S. Consumer Products Safety Commission reported that 48,000 people were treated in hospital emergency rooms with skateboarding-related injuries—33% more than the previous year. Visits to the E.R. were also up for snowboarding injuries (up 31%) and mountain climbing (up 20%). The US Parachute Association reports that 10% of skydivers suffer injuries requiring medical attention. Annually, there are approximately 30 deaths, or 1.2 deaths per 100,000 jumps. In contrast, there have been only 20 serious injuries reported from an estimated 1,000,000 bungee jumps between 1988 to 1994. During the same time there were 7 deaths, for a death rate of 0.7 per 100,000 jumps.

Recreational Activity	Injury Rate
Skydiving	10%
Hockey	4.08%
Rugby	2.4%
Basketball	1.94%
Football	1.66%
Snowmobiling	1.34%
Bicycle Riding	1.21%
Baseball/Softball	1.07%
Skateboarding	0.76%
Roller/In-line Skating	0.41%

Figure 3–13 *Adapted: National Safety Council, Injury Facts 1999 Edition*

Some participation and injury statistics were available from the National Safety Council and other sources. While the accuracy of injury rates may not be precise for the reasons previously mentioned, some calculations are presented for comparison.

Any meaningful comparison between recreational injury rates and work-related injuries may be difficult. However, if you look at the "all industry" occupational injury rate of 2.86%, it would suggest that you are more likely to get injured on the job than participating in any of the above sports except hockey. On the other hand, looking at the injury rate for HEMS personnel of 0.16%, it would seem that you are less likely to get injured in a helicopter accident than participating in these sports.

SECTION 4: SAFETY AND RISK MANAGEMENT IN HEMS

No report on HEMS safety would be complete without trying to identify ways to enhance program (and industry) safety and reduce risk. While every air medical program has similar exposure characteristics, no two programs are exactly alike. This section will look at four basic requirements of a safety program, introduce some key aspects of risk management, and then highlight the benefits of a multidisciplinary approach to improve safety.

PRINCIPLES OF A SAFETY AND RISK MANAGEMENT PROGRAM

A safety and risk management program for an air medical program must encompass two aspects. Most important is doing everything possible to prevent an accident from occurring. If this fails and an accident does happen, everything must be in place to mitigate the impact of the accident.

Being safe does not eliminate risk—it reduces it. There are four basic principles that should guide the coordination, implementation, and evolution of a safety and risk management program for air medical operations. These principles are attitude, participation, education, and judgment.

Attitude

Safety does not just happen, it is not a specific event or a "thing"—it is an attitude. This perhaps is the most important component of the safety equation and may override all other aspects and variables. Everyone must have the right attitude about safety in order to participate and survive in an air medical transport program. This, along with a commitment to safety, is essential and must be exhibited by every crewmember and every manager. The attitudes should reflect the mission that safety *must* be the program's number one priority.

A number of obstacles may prevent the development of a sound safety program. An FAA Advisory Circular (AC) No. 60–22 defines attitude as "a personal motivational predisposition to respond to persons, situations, or events in a given manner that can, nevertheless, be changed or modified through training." Negative attitudes, however, are particularly difficult to overcome. Some people may think that safety is not their responsibility and their actions are not likely to impact the safety of flight or result in an accident. In some cases, identifying potential problems may seem to be too threatening to discuss and may simply be avoided. In other circumstances, denial occurs as team members insist that there is no safety problem.

Complacency is another serious problem and in many ways may represent a negative attitude. Merriam-Webster's Collegiate Dictionary defines complacency as "self-satisfaction accompanied by unawareness of actual dangers or deficiencies." Having learned things before or having done certain activities in the past may result in overconfidence and eventually to errors in performance. Never having an accident or incident does not assure continued safety if it results in complacent attitudes. It results in smart people sometimes doing dumb things. In 1901, Wilbur Wright wrote, "Carelessness and overconfidence are usually more dangerous than deliberately accepted risks." One hundred years later, this statement is still appropriate.

In 1997, the pilot of an Aerospatiale AS-365N Dauphin transported two passengers to a corporate ramp at Indianapolis International Airport. Upon shutting down the engines and applying the rotor brake, one passenger exited and walked forward of the helicopter and turned into the path of the rotor system. The passenger was struck in the left temple by a main-rotor blade and killed. In January 2001, a hospital security guard walked into the tail rotor of a Bell 206L as the helicopter was preparing to depart the base hospital helipad. The security guard died of his injuries. It may be very difficult to determine if complacency, carelessness, or overconfidence were contributing factors in these accidents.

Participation

A safety program must be planned, instituted and practiced every day and on every flight. It is not enough to assume that hospital administration, program management, the pilots, or the aviation operator will be completely respon ble for safety. The safety program must be multidisciplinary and responsive in order to be successful. Safety is dynamic. Things change. Crewmembers (pilots, mechanics, medical and communications) come and go, aircraft may change (primary or backup), weather conditions vary, and a program may fly to hundreds of different locations. Every flight is different. It takes teamwork, where individuals interact effectively and efficiently with fellow crewmembers to maintain a safe aviation operation.

There is no such thing as a "free ride." Whatever the role of a team member in the program, each individual must acknowledge the critical fact that safety is their prime responsibility. It requires active participation, rather than passive observation. While medical personnel are not expected to be experts in aviation, each must be proficient with their safety-related responsibilities. At times, when delivery of medical care and safety may seem to come into conflict, safety *must* always take priority.

Each crewmember must recognize his/her role to help identify, address, and help resolve (as appropriate) potential safety concerns. Every situation represents an opportunity to learn and to improve. A program should encourage every member to identify opportunities for improvement, either to enhance program safety or efficiency.

Education

Education is a key ingredient in identifying, understanding, and actively managing risk. For a pilot and air medical crew, being knowledgeable of the elements that may increase or decrease the related risk should lead to taking appropriate steps to minimize unnecessary exposure. The result would be to greatly reduce the chance of being involved in an accident or incident.

There are many aspects of education that may be considered part of a safety program geared to actively manage risk. Education and training obviously begin with the pilots and mechanics and continue with the medical crew and communication specialists. It must also include the security and public safety personnel who set up and/or secure landing zones or helipads.

Another important aspect of education is learning from past mistakes. In separate documents, both the Aircraft Owners and Pilots Association (AOPA) Air Safety Foundation and the Flight Safety Foundation support the belief that pilots can learn valuable lessons from analyses of past accidents and incidents. Accident data often yield clues to safer operations, and can be applied at relatively little cost and with no additional regulations. By analyzing mishaps, pilots, medical teams, and program administrators can learn about potential risks and take proactive steps to control them. The U.S. Air Force *Guide to Mishap Investigation* states, "the proper use of mishap experience is reducing mishap potential."

It is important to realize that education isn't everything —it is merely the beginning. Being able to apply the knowledge under routine and emergency conditions is expected of each and every crewmember. Each crewmember must be able to perform his or her safety-related functions proficiently and independently. It is an unnecessary distraction and risk for pilots and medical crewmembers to worry about someone else who does not do his/her job.

Judgment

FAA AC No. 60–22 defines judgment as "the mental process of recognizing and analyzing all pertinent information in a particular situation, a rational evaluation of alternative actions in response to it, and a timely decision on which action to take." In 1986, Arthur Negrette authored an article entitled "Spatial Orientation: It Plays No Favorites." He reported that on the average, it takes a helicopter pilot five seconds to recognize a hazard, determine the necessary corrective action, and respond.

Some people feel that good judgment is an inherent characteristic and not one that can be easily taught. Someone may be given the tools through education and months or even years of experience, but may still lack the ability to put it all together for optimal performance and outcome.

The AC goes on to define the Poor Judgment (PJ) Chain as "a series of mistakes that may lead to an accident or incident." The AC states that there are two basic principles that are generally associated with the creation of a PJ chain: (1) one bad decision often leads to another; and (2) as a string of bad decisions grow, it reduces the number of subsequent alternatives for continued safe flight.

In the HEMS environment with its limited resources (generally one pilot and two medical crewmembers), it is essential for each and every crewmember to be at the top of their game, using sound judgment to recognize individual limitations and changing conditions. Having alternate plans and knowing when to implement them can impact both aviation and medical safety. For example, in aviation, judgment is key when it comes to the decision to initiate a flight or when to abort a flight. In medicine, it may be exemplified in your management of the patient with a difficult airway. What drugs, if any, should be considered? What is the backup plan if the intubation is not successful? Having the knowledge and the skill is essential. Sound judgment and proficiency are more likely to yield a positive outcome. In HEMS this will enhance overall safety.

RISK MANAGEMENT

Risk management is a discipline for dealing with uncertainty; a science of looking to the future through today's vision. It enables us to make a range of informed decisions about our environment, health, safety, and our social and economic well being. It is about managing resources wisely, protecting from harm, and safeguarding assets. In HEMS, risk management should be directed toward optimal flight safety as well as providing the highest quality of medical care.

Effective risk management acknowledges and identifies threats, evaluates and prioritizes the risks, considers the probability a risk will materialize, and controls loss (preventing loss and reducing the severity should a loss occur). Results must be evaluated and strategies revised as appropriate. With this information, a person or organization is able to make an informed decision as to how they will deal with various risks.

Identifying Risks

In this report, we have already identified many of the issues that could represent threats to the safety of flight. In the reports from the Air Medical Accident Analysis and the Helicopter Accident Analysis Team specific problems that have led to accidents are identified.

Additional information is obtained from the *AirMed* "2000 Aircrew Survey" that identified the situations that HEMS pilots felt posed the greatest threats (i.e., greatest risk) to flight safety. Scene operations (64%), program complacency (44%), and mission-related stress (35%) were the three most common concerns. Figure 4–1 shows the various risks that were identified.

A more comprehensive "EMS Line Pilot Survey" was conducted by NEMSPA and HAI in 2000–2001, which yielded a combined total of 304 responses. In general, there were considerably more variables to choose from in this survey, which often resulted in lower percentages for each specific response.

The greatest risk to safety industry-wide was found to be management or crew pressure (11%). Inexperience was next (9%), followed by LZ operations/hazards and weather reporting/forecasting at 8% each. At 7% were poor decision-making, night operations, and marginal VFR/inadvertent IFR conditions. When asked what risk factors contributed to accidents in recent years, the most common response was pushing weather minimums (14%), followed by complacency (11%), pilot complacency (10%), inexperience (8%), and lack of IFR training (8%).

There were a number of questions in the "EMS Line Pilot Survey" that further clarified the types of pressure the pilots identified, as seen in Figure 4–2.

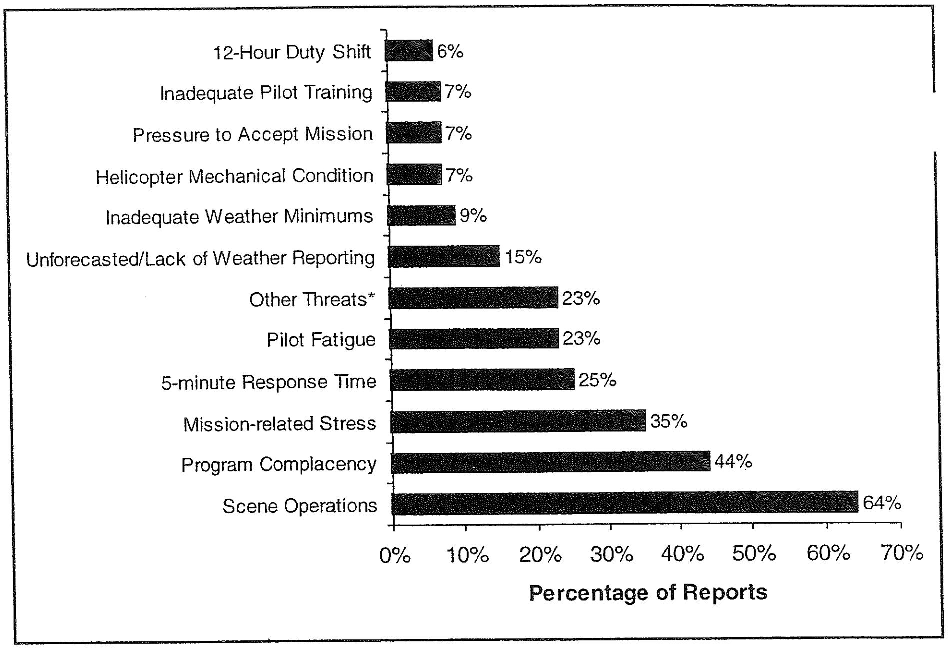


Figure 4–1: Greatest Threats to Flight Safety (n=148)

"Other threats" included night operation, general aviation traffic and negotiating geography/mountainous terrain and others. *Adapted from: Rau, 2000 Aircrew Survey, AirMed, Nov/Dec, 2000*

Survey Variable	Response
Undue pressure from:	
Program Management	32%
Flight crews	14%
Operator	13%
Dispatch	13%
Pressure from:	
Crew/management to speed up response or lift-off times	55%
Other pilots (indirectly) to launch/continue in marginal weather	13%
Crew/management to launch/continue in marginal weather	8%
Pilots pressure themselves to:	
Launch/continue in marginal conditions	13%
Fly when fatigued or ill	32%
Speed up response or lift-off times	48%

Figure 4–2: Pilot-related Pressures (n = 304)

Adapted from: EMS Line Pilot Survey, NEMSPA and HAI, 2001

Dealing with Risks

Techniques to Control Risk

There are six techniques to control risk. The first and most common option is *risk avoidance*. If it is not worth assuming the risk, avoiding the exposure may eliminate the risk. In air medical transport, an alternative would be ground transport, which has its own inherent risks. A program could also decide that scene accidents or flying at night pose too great a threat and elect to avoid these situations.

The second option is *risk prevention*. In this situation, the HEMS program would take the necessary action to try to prevent a loss through comprehensive training (pilots, medical crews and communicators), policies and procedures, and so on. A helicopter program may choose to do scene flights only during the day or only land at pre-designated landing zones. A program may also conclude that a twin-engine aircraft is less likely to have a potentially catastrophic malfunction (i.e., engine failure of a single-engine helicopter) or that two pilots will reduce the likelihood of pilot error. All of these options strive to decrease the possibility of an aircraft accident, but do not eliminate all possibility of that loss.

The third technique is *loss reduction*, which is an attempt to reduce the severity of the loss. The decision to wear helmets or nomex are forms of loss reduction in HEMS. Survival training and appropriate survival gear may also reduce the losses in an accident, but do nothing to prevent an accident from occuring.

Segregation of risk is the next alternative. While the technique has similar characteristics to loss reduction, it also has very distinct features. A program may choose to have separate helipads for their multi-helicopter program or for a visiting aircraft to use. If a helipad accident were to occur, only one helicopter would be involved. Some families use this technique to control the risk of travel on commercial airlines. Rather than all flying together on one airplane, the family will split up, taking two different flights, reducing the risk of an accident taking an entire family.

The next alternative is *risk transfer*, when someone else assumes the risk. In HEMS, this could include not having a flight program or having another flight program undertake your transports (similar to risk avoidance). It may also be a factor in considering who is responsible for the various aspects of the Part 135 aviation operation; who is responsible for the training of the pilots and mechanics; or who is responsible for the maintenance of the aircraft and compliance with all Federal Aviation Regulations. It could be the hospital or flight program, or this could be transferred to a full-time aviation operator. Risk transfer can also be represented by the various hull, liability, disability, and life insurance policies that are in place to address various losses. Power-by-hour is yet another form of risk transfer.

Risk retention is the final option, where a program or individual consciously assumes the risk, taking no specific steps to reduce the risk or the severity of a loss.

HEMS-Specific Risks

Dozens of intervention strategies have been recommended in the Air Medical Accident Analysis and the HAAT report. It is appropriate to highlight specific HEMS risks and several considerations to deal with these risks.

Scene Operations. The concern over scene operations, as identified in Figure 4–1, is long standing and justified—especially at night. Potential landing zone (LZ) hazards (trees, wires, etc.) represent a significant threat to safety. To improve safety, 9% of the responses to the "EMS Line Pilot Survey" favored night vision goggles.

Education plays an important role in scene safety. Educating pre-hospital personnel on the selection and preparation of the LZ is key. Educating the medical crew and their active participation to look for hazards on approach and landing is also essential. However, as the statistics showed, very few of the accidents that occurred on "scene" flights occurred while landing at the scene. More accidents occurred with the patient on board than on any other leg of the scene missions.

Complacency. Program complacency has already been addressed. It is important for pilots, crewmembers, communication specialists and administrators to recognize that complacency may be the greatest danger in HEMS—the silent killer. The complacent individual generally exhibits a low level of awareness and does not recognize the need for action or involvement. This leads to mistakes.

Someone once was asked, "What is the difference between ignorance and complacency?" he responded, "I don't know and I don't care."

Pressure and Stress. Mission-related stress has also been addressed, in part, with regard to both self-imposed and externally imposed pressure. In 1988, the NTSB report recognized both of these pressures as significant concerns. Thirteen years later, the "EMS Line Pilot Survey" identified management or crew pressure as the greatest risk to safety industry-wide. Have we made no progress over the past decade?

Weather. It is of interest that two factors that scored fairly low in Figure 4–1 were pilot training (7%) and unforecasted/lack of weather reporting (15%). In the *AirMed* pilots' survey, 85% of the pilots reported having made a forced landing once or twice in their HEMS career for deteriorating weather conditions. A responding 32% reported at least one forced or precautionary landing during the past year due to weather. This would seem to imply that the pilot's ability to identify and actively manage a risk diminishes the perception of a particular threat to safety. On the other hand, concerns that they may have little direct control over (i.e., scene LZs, program complacency, etc.) remain significant threats.

Weather, however, remains an all too common factor in HEMS accidents. Despite thorough planning and adherence to weather minimums, it is possible for any HEMS pilot to encounter unanticipated weather and enter inadvertent instrument meteorlogical conditions (IMC). The first line of defense for any pilot against inadvertent IMC is to take the necessary steps to avoid the situation. Comprehensive weather planning is perhaps the most important step. This should include access to updated weather forecasts and a working knowledge of weather charts and reports, as well as familiarity with local weather trends. Forecasts are not guarantees but forecasts for marginal conditions are usually accurate. It is only a short step from marginal conditions to unflyable conditions. A marginal forecast and wishful thinking that "the weather won't be as bad as they say" has no place in aviation, especially air medical transport.

The pilot's actions immediately after encountering IMC will determine the outcome of the flight. In many weather accidents the pilot waited just a little too long to change his mind. In a significant number, deciding to divert only a few minutes earlier would have kept the flight out of danger. Trained and proficient pilots, who have a plan of action in the event of inadvertent IMC, are more likely to experience a successful outcome. Another important defense against inadvertent IMC is a willingness to land the aircraft. Such willingness runs counter to the pressures HEMS pilots sometimes feel to complete their missions.

Although it is impossible to make a direct correlation, more experience in weather-related decision making should result in a gradual reduction in some of the VFR into IMC accidents and incidents.

Night and Spatial Disorientation. Flying at night poses its own unique risks in aviation. This is especially true in HEMS. The FAA manual, *Aeronautical Decision Making for Air Ambulance Helicopter Pilots*, notes that "even on the clearest night with VFR (visual flight rules) conditions, a pilot can come close to IFR (instrument flight rules, i.e., inadvertent IMC) operations if there is no moon and/or no ground lights to establish a horizon reference." In contrast, there could be an abundance of ground lights below and stars above that can seem to merge into a continuous sweep of pinpoints that can deprive a pilot of any horizon reference. In both situations, with the loss of the visual reference (the ground and/or horizon), the interpretation of motion and position in relation to the environment may be lost. An inexperienced pilot who becomes disoriented, or who does not trust his/her instruments, may change direction, altitude, speed, etc., and if unable to compensate is likely to have an accident.

Another risk lurking in the night sky is the unseen cloud. Clouds disappear easily in the dark and a pilot can fly into one without seeing it coming. In all of these nighttime situations, instrument training and proficiency may help mitigate the potential risk.

FAA Advisory Circular 60-4A (February, 1983) addresses pilot's spatial disorientation. In this AC, it states: "Tests conducted with qualified instrument pilots indicate that it can take as much as 35 seconds to establish full control by instruments after the loss of visual reference with the surface." While the tests were performed on fixed-wing aircraft, the results may be more dramatic with helicopters since they require even more pilot intervention to maintain control.

Another group of fixed-wing pilots were asked to identify their personal experience with spatial disorientation. The most common sensory illusions reported were:

- A sensation that one wing was low although wings were level (60%)
- On leveling after banking, a tendency to bank in opposite direction (45%)
- When in a turn, a feeling as if they were straight and level (39%)
- Becoming confused in attempting to mix "contact" and instrument cues (34%)
- On recovery from a steep climbing turn, the feeling of turning in the opposite direction (29%)

This AC also points out that while visibility may be above VFR minimum, the natural horizon and surface references may at times become obscured in low-visibility conditions, on over-water flights, and at night—especially in sparsely populated areas. The AC concludes "You and only you have full knowledge of your limitations. Know these limitations and be guided by them."

Pilot Training and Experience. This leads directly into the issue of pilot training and experience. In the *AirMed* survey, pilot training scored very low as a perceived risk to flight safety.

In the HAI/NEMSPA survey, however, when asked "what can be done to improve industry safety," the most common response was to improve the quality and frequency of training (17%).

The Frazer articles and Hart lectures have concluded that in the vast majority of HEMS accidents, this did not appear to be a major factor. This report is not about to address specific training requirements for the aviation (pilots and mechanics) professionals. However, a study by FlightSafety International (FSI) seems worthy of mention.

FlightSafety offers flight simulator training for both fixed-wing and rotor-wing pilots. Their full-motion simulators can reproduce various in-flight emergencies during various lighting and weather conditions. FSI conducted a study to determine the impact that simulator training had on the fixed-wing fatal accident rate. FSI estimates that they trained approximately 20% of the fixed-wing pilot population. Looking at five years of accident data, they identified a total of 471 accidents, or an average of 94 per year. They postulated that if simulator training made *no* difference, the FlightSafety trained pilots should have accounted for approximately 20% (92) of the total accidents. Instead, the FSI-trained pilots had only 3% (15) of the total accidents. The expected accident frequency was reduced by more than 80%. FlightSafety concluded that: "The benefits of simulator training are obvious. ...and the safety record proves it."

While simulator training may indeed be beneficial, other considerations may also be factors. It is also possible that the companies that went to the effort and expense of sending their pilots to simulator training are more safety-proactive in other areas as well.

Of interest, the *Air Medical Accident Analysis* rated full-motion simulators as highly effective, but low feasibility. Perhaps more interesting is the reponse to the "EMS Line Pilot Survey" when asked "what can be done to improve industry safety?" Of the 304 responses, only one selected "simulation."

AIR MEDICAL RESOURCE MANAGEMENT

Air Medical Resource Management (AMRM) is not a unique concept. Based upon more than 20 years of business and aviation models, AMRM is specifically designed for our industry. The goal is to provide the methodology to make optimum use of the capabilities of the individuals and aircraft systems to achieve the safest and most efficient completion of a flight.

In 1979, NASA suggested that business managerial concepts could be applied in the cockpit to reduce the high number of "human-factors" accidents occurring with the airlines. Within 10 years, *Cockpit Resource Management*—later expanded conceptually to *Crew Resource Management* (CRM)—was included in training worldwide at most major airlines. The U.S. Air Force had begun full-scale CRM training of all crews of multiperson aircraft. Today, there is sufficient evidence that CRM training and practice have improved aviation safety.

CRM is the effective *management* of all resources available to ensure that all group members are operating from a common frame of reference and toward a common goal of aviation safety. CRM provides a framework for accomplishing a given mission. In air medical transport, training programs have been and are being developed that teach CRM skills and principles not only to pilots, but also to medical personnel, communication specialists, maintenance personnel and management. In fact, at the 2000 Air Medical Safety Summit, the number one priority identified by the industry leaders (aviation, medical and management) was CRM and related training. At an all-day seminar prior to the Air Medical Transport Conference in September 2001, a new *Air Medical Resource Management* Train-the-Trainer course was presented for the first time.

The FAA's Advisory Circular identifies components of CRM to include teamwork, communication skills, decision making, workload management, situational awareness, preparation and planning, cockpit distractions, and stress management.

Teamwork is key in AMRM and must be maximized to facilitate the transfer of information. In HEMS, teamwork must include everyone who could impact the safety of flight, including the pilots, medical personnel, communication specialists, maintenance personnel, air traffic controllers (ATC), and management. Much like a sports team, each person must know his/her role, be an active participant and be able to execute his/her assignment when called upon. In sports, the goal is winning. In aviation, "winning" is a safe and efficient aviation operation resulting in the safe return of the aircraft and crew at the conclusion of each and every flight.

Effective communication skills are essential in developing teamwork. Pilots can increase the probability of a safe flight by overcoming barriers in communication and learning to effectively seek and evaluate information. Communication problems are often cited as a causal factor in aircraft accidents and incidents. At a recent air medical conference, a leading safety expert in HEMS stated, "open and effective communication might have prevented perhaps as many as 80% of EMS accidents."

Aeronautical Decision Making (ADM) refers to a systematic mental process used by pilots to consistently determine the best course of action in response to a given set of circumstances. ADM includes risk assessment and stress management. It also illustrates how personal attitudes can influence decision making and how those attitudes can be modified to enhance safety in the cockpit. Good decision making skills are not necessarily inherent and must be learned. A pilot must seek and evaluate all relevant information, using all available resources, before making an important decision. These resources may include people (medical crewmembers, ATC, communication specialists, other pilots) aircraft instruments, documentation (flight manuals, checklists, etc.), and sensations (vibrations, sights, smells, position).

Studies by a number of researchers have shown that there is a strong correlation between errors in decision making and the severity of accidents. While many skill-related problems may result in minor injuries and damage, faulty decision making processes often result in accidents with serious injuries and fatalities.

Situational Awareness is the accurate perception and understanding of all the factors and conditions going on around you. In aviation, this deals with the four fundamental risk elements that affect safety before, during, and after the flight—the pilot, the aircraft, the environment, and the type of operation that comprise any given aviation situation. This requires a pilot's full attention. Here too, cockpit distractions must be kept to a minimum. The Aviation Safety Reporting System (ASRS) identified pilot distraction as one of the most frequent causes cited in the reported incidents.

Managing the workload is critical to the single-pilot operation. Tasks must be carefully prioritized and the pilot must avoid being distracted from his/her primary duty of flying the aircraft. The single pilot can often benefit by utilizing his/her resources and sharing tasks. This could include having the medical crew handle some of the communications with dispatch or EMS ground personnel, looking for hazards while landing or taking off, requesting assistance or information from ATC or from dispatch, and prudently using automation such as an autopilot.

In the single-pilot HEMS operation, preflight planning and preparation is of special importance. Generally, no one else is available to confirm radio frequencies and make radio calls, fix positions and call out checklists. In a high-workload or stressful situation, the pilot must be able to call upon his/her training and items that may have been committed to memory, such as frequencies and emergency procedures, that otherwise might be difficult to confirm in an emergency. In addition, as appropriate, the pilot should utilize the other resources that may be available.

The effects of stress are often difficult to recognize and the inability to recognize this may be hazardous in aviation. Failure to manage stress often leads to eroded judgment, errors in decision making, decreased work performance, inattention, degraded communication skills, preoccupation, and complacency. A pilot suffering from stress may forget or skip procedural steps, accept lower performance standards, and exhibit a tendency toward spatial disorientation and misperceptions. These misperceptions may result in misreading maps, charts and checklists, misjudgment of distance and altitude, and loss of time perception. In a study of more than 700 naval aviators who had been involved in major aircraft mishaps over a four-year period, it was discovered that those pilots who exhibited the symptoms of inadequate stress coping were more likely to be involved in an aircraft mishap.

As you can see, the elements of AMRM are intertwined and do not stand alone. Together, they can be used to improve work performance and the safety margin in air medical transport. But crew resource management is not restricted to the aircraft. It can also be an essential learning tool for people who work together in any environment, including the emergency department or trauma room.

The Air Medical Accident Analysis recommended CRM training as highly effective and moderately feasible. The HAI/NEMSPA survey seemed to agree. Of the responses, 63% of the pilots surveyed found CRM effective in making the program safer and 41% found that CRM made the program more efficient. Unfortunately, the pilot survey also shows that we have several hurdles before us. A total of 38% of the respondents found CRM to be ineffective because it "doesn't work here" (3%), was not well presented (8%) or due to a lack of support from the program (6%), operator (3%), flight crew (9%) and some of the pilots (10%). The lack of support by some of the pilots is not surprising, as CRM proposes a way of doing things that is contrary to the way many pilots have trained and flown for years. Historically, pilot training leaves the pilot-in-command (PIC) as the sole arbitrator as to how to conduct a flight With AMRM, the PIC is still fully responsible but is encouraged to involve others who may be in a position to contribute to the decision–making process on behalf of safety.

SECTION 5: CONCLUSION

Every occupation has inherent risks. Medical professionals and transportation professionals are no different and are exposed to various risks every day. Transport Medicine combines these two fields into a unique medical specialty where the aviation and medical professionals face uncommon challenges and risks every day.

The risk of a helicopter accident is very real in HEMS. Since 1972, it is estimated that HEMS has flown an estimated 3.0 million hours while transporting approximately 2.75 million patients. In 31 years (through September 2002) there have been 162 accidents involving dedicated medical helicopters and four accidents involving dual-purpose helicopters in the United States. In 67 fatal accidents, 183 people have lost their lives, including 144 crewmembers. In the early and mid-1980s, during the HEMS industry's most rapid growth, we experienced an alarming number of accidents. The early and mid-1990s showed improvement, but 1998 to 2001 again showed an increase in the number of HEMS accidents across the nation. Despite this recent increase, however, the percentage of fatal accidents has declined by more than a third compared to the early 1980s. The fact remains, however, that since 1990, there has been an average of 2.5 fatal accidents annually, taking the lives of 5 to 6 crewmembers each year.

It must be pointed out that for all of the data that has been reviewed and analyzed in this report, many of our numbers are very small. To draw conclusions over a five-year or 20-year period may be somewhat reasonable. However, many of our calculations are greatly distorted due to the small numbers for year-to-year comparisons. Due to a low occurrence rate, aircraft accidents are poor indicators of safety trends. In addition, there may be limited first-hand information available as to the real cause of an accident if the accident resulted in fatalities.

There is no typical HEMS accident. However, several observations are noted. A disproportionate number of HEMS accidents occurred during night operations, during the cruise phase of flight, and on scene transports. Pilot error was attributed as the direct or indirect cause of HEMS accidents approximately three times more often than mechanical failure. Of the pilot errors, one-third were weather related.

In 1988, the NTSB concluded that poor weather poses the greatest single hazard to EMS helicopter operations. More than a decade later, deteriorating weather conditions continue to represent a significant risk in HEMS. In general, the cause of the weather-related accidents does not appear to be a pilot's disregard for established weather minimums at takeoff. Instead, it is the pilot's encounter with instrument meteorological conditions en route. In general, weather may not cause the accident, but it may increase the likelihood that an accident will happen.

Weather is the second most common factor or cause of HEMS accidents. Of the weather-related HEMS accidents, over 85% occurred at night. Approximately 75% of all weather-related HEMS accidents resulted in fatalities. The correlation between weather-related accidents and cruise flight is very strong. Degrading weather conditions can significantly compromise a pilot's ability to see and avoid obstacles—especially while at cruise speed.

Pilot fatigue and total hours of flight time do not appear to be significant factors in HEMS accidents. Looking at HEMS incidents, however, suggests that IFR rating and currency may be very helpful, if not invaluable, to overcome a situation and avoid an accident. In addition, communication problems, time pressures, and distractions are frequently identified as contributing risk factors in HEMS incidents.

The magnitude of injuries and aircraft damage are significant considerations in HEMS accidents. HEMS accidents are more likely to result in fatalities or serious injuries than other helicopter accidents. While pre- and post-impact fires occur in only a small percentage of HEMS accidents, nearly half of all the accidents result in the destruction of the helicopter. No conclusions, however, can be made regarding single- vs. twin-engine aircraft.

Our HEMS accident rates and fatality rates are based upon estimated exposure data. Data for the past fourteen years has been determined through several industry-wide surveys and various calculations. It is possible that our survey results have underestimated the number of HEMS programs and dedicated helicopters by ten percent or more. Therefore, our proposed exposure data may also be underestimated. As a result, our calculated accident and fatality rates could be overstated by an estimated ten percent. This difference, however, does not impact the overall trends identified in HEMS accidents nor our comparison with other aviation operations.

In the early and mid-1980s, the accident rate for HEMS was dramatically higher than all other aviation operations. Since 1987, however, we have seen a significant decrease in the HEMS accident rate to approximately one-third of what we experienced in the early to mid-1980s. The HEMS accident rate has remained consistently below the accident rates for both general aviation and all helicopter operations since the late 1980s. The fatality rate has also seen significant improvement since the late '80s. Despite a recent increase, the fatal accident rate is reduced by approximately 75% compared to the early 1980s.

Finally, comparing the HEMS risks to other occupations is very difficult due to the relatively small size of the "population" at risk. Looking strictly at the numbers, HEMS appears to have a significantly higher death rate than other occupations or causes of accidental death. Only heart disease and cancer have a higher fatality rate when compared to the 22-year average fatality rate for HEMS.

HEMS accidents are not caused by a single event, but by a chain of events. In most accidents, numerous risk factors can be identified. Acting on any of these risks and breaking the chain at any point may prevent an accident from occurring. The United States Aircraft Insurance Group (USAIG) has concluded that complacency is a factor in over 50% of all helicopter accidents. No one can afford to take a passive role in HEMS. The safety of flight requires the right attitude and active participation. Every pilot, mechanic, medical crewmember, communication specialist, and administrator must be fully knowledgeable of their role and responsibilities. Each must be committed to a safe operation and to ongoing risk management. To fly safe, a program must fly smart. Nothing takes the place of comprehensive training, proficiency, and sound judgment. An important training component should be Air Medical Resource Management. The goal of AMRM is to improve crew communications and interactions by addressing teamwork, communication skills, decision making, workload management, situational awareness, preparation and planning, cockpit distractions, and stress management. The focus of the team must be on doing "what is right" rather than on "who is right."

The risks in HEMS cannot be underestimated. In addition, the cumulative effects of multiple risk factors must be considered when making decisions on each and every transport. Risk management is a major component of the decision-making process. It relies on situational awareness, problem recognition, and exercising good judgment to reduce risks associated with each flight.

In the Forum section of the September/October 2001 *Air Medical Journal*, Ed MacDonald, the President of NEMSPA wrote about "the next accident". This article should be required reading for everyone in HEMS. It addresses the "it can't happen here" mentality and suggests why *it can happen to you*.

Tragically, there will be a next accident and more of our colleagues will lose their lives. Maybe not today, maybe not this month, or even this year. Hopefully, not for a long, long time. No one expects it and everyone assumes the next accident will involve someone else's program.

No one can eliminate the risks related to HEMS. Some may choose to avoid the risk. Programs may close and individuals may decide to pursue a different occupation. Others may choose to influence risk. Organizational culture can influence risk as much as any/all other factors. The cultures, in this case, represent the collective beliefs that shape behavior toward safety and a safe HEMS program. Working together, every member of a flight program must play a role to actively manage risk and to avoid taking unnecessary risk. Your safety demands it. Lives depend upon it.

Do whatever it takes. Don't be the next accident!

Acknowledgements

Nearly two years ago, the UCAN Safety Committee undertook a simple task to review a few articles pertaining to air medical accidents. Our Section Chief of Emergency Medicine, Dr. James Walter had challenged us for answers regarding the magnitude of risk in HEMS. Did we as a Safety Committee, flight program, or industry have enough information to fully appreciate the safety concerns and risks encountered every day? We decided to meet his challenge head on. Within a short time, this safety report took on a life of its own and our investigation and research were underway.

There are a great many people who participated and helped complete this project. My thanks to the entire UCAN Safety Committee for their dedication to this study and for enduring the endless revisions, additions, and various deadlines. I am also grateful to the entire UCAN crew and the Emergency Medicine faculty who encouraged us as we worked through the various phases of the project. Numerous individuals, operators and aircraft manufacturers shared database information that made our calculations possible. Without the endorsement of the AMPA Board of Directors and Pat Petersen, this report would never have been published in this format and in its entirety. The immediate response and support from Madeleine Byers (CJ Systems) and Sandy Kinkade (Bell Helicopter) further strengthened our resolve to pursue this publication and to obtain the necessary funding to make this document available to the entire air medical community.

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And finally, to Jane, Maddy and Jake. Thank you for putting up with the long hours needed to complete this project. Now, more than ever, I appreciate and understand the importance of putting "safety above all"—for myself, for my crew, for my colleagues. For my family.

—*Ira Blumen*

Attachment 1:
HEMS Accident Summary, 1998-2002

Date Time	Aircraft N Number	Program	City, State	Mission		Phase of flight	PI	Injuries	Day/ Night	Weather	Fire	Aircraft Status	Operator	Comments / Description / NTSB Probable Cause(s)
				Type	Phase									
1/11/98 @ 2250	222UT N222UH	AIRMED	Salt Lake City, UT	ONS	POB	CRU	1	4F	Night	Snow, wind >35mph	PIF	Destroyed	Air Methods	Storm front moving in, wind gusts exceeding 35 mph. Fatalities:3 crewmembers and 1 patient. **NTSB Final: Pilot Error.**
3/23/98 @ 0740	205A-1 N90230	Los Angeles City Fir Air Ops Unit 8060	Los Angeles, CA	ONS	POB	TKF	1	4F, 2S	Day	Clear, calm winds 20 mile vis.	Unk	Destroyed	Public	Enroute to MVA and during transport to LA Children's Hospital, pilot reported inflight emergency. Fatalities: 3 crew,1 patient. **NTSB Preliminary:** Separation of tail rotor blades and 90-degree gearbox during cruise flight
5/24/98 @ 1235	206 L-3 N27AE	Air Evac EMS	West Plains, MO	INT	PGT	TKF	0	3S	Day	Clear	No	Destroyed	Air Evac EMS	Aircraft lost power during take off at ~ 60 ft altitude and low air speed. Hard landing into parking lot, main rotor blade struck light pole and aircraft rolled onto its right side. **NTSB Final: Improper maintenance.** Engine's accessory gearbox was improperly assembled, reducing oil flow to the turbine shafting, leading to a total loss of engine power.
6/5/98 @ 0549	350BA N911VA	Valley Air Care	Harlingen, TX	ONS	PGT	CRU	0	3F	Night	5 miles, broken ceiling at 1,400 ft; Grnd fog	PIF	Destroyed	Tex-Air	En route to a rural scene, the helicopter crashed 19 miles past the accident site. Impacted trees and terrain. Visibility severely restricted by thick smoke from fires in Mexico. **NTSB Final: Pilot error.** Continued flight into adverse weather conditions resulting in a loss of control due to spatial disorientation.
7/29/98 @ 2248	222B N911RA	SkyLife of Central CA	Fresno, CA	ONS	PGT	LNG	0	3N	Night	Not a factor	No	Significant	Rogers Helicopter	While landing at scene of accident, encountered significant blowing dirt and dust ~ 5 ft from ground, resulting in loss of ground reference. Helicopter rolled to its left, landing on its top. Crew was extricated with assistance, but was uninjured. **NTSB Final: Pilot error.**
8/20/98 @ 2114	222 SP N30SV	Intensive Air	Sioux Falls, SD	INT	PGT	CRU	0	3F	Night	VMC 10 miles; 8,500 ft overcast; winds 12 knots, to 26 gust	PIF	Destroyed	RMH	Enroute to pick up a patient. Routine radio contacts up to 5 min out. At ~2125, comm center received a call from Spencer Hospital informing them that the helicopterhad not arrived. **NTSB Final: Mechanical failure.** In-flight break-up traveling at about 130 knots at 960 ft above the ground. A fatigue crack of the swashplate outer ring pin of the main rotor assembly resulted in the separation of the pin, and ultimately the in-flight breakup.
8/28/98 @ 1053	BK-117 N230H	Topeka Lifestar	Topeka, KS	MAT		LNG	0	3N	Day	Not a factor	No	Significant	St. Louis Helicopters	Returning from 2 days of maintenance at an altitude of 300-400 ft, pilot heard a "loud bang" followed by the aircraft rotating to the right. Pilot was able to touch down upright then the aircraft rolled onto its left side. NOT COUNTED IN TOTALS. **NTSB Final: Pilot error.** Pilot failed to assure the engine cowling was secured, resulting in the cowling separating from the helicopter and damaging the main rotor and tail rotor.
11/29/98 @ 1756	MD-900 N977LF	LifeFlight	Boise, ID	ONS	POB	TKF	1	4N	Dusk to Dark	Over-Cast 10mi vis	No	No Wind-screen and main rotor blades	Idaho Helicopters	Departing from MVA in a remote canyon, aircraft stuck and severed unmarked power lines 150 ft above the ground. Pilot then determined that the helicopter was controllable and displayed no unusual flight characteristics, and chose to proceed to his destination. Aircraft completed mission and landed uneventfully at hospital with patient and crew. Post-flight examination revealed crazing of the windscreen and damage to 4 of the 5 main rotor blades requiring major repair/replacement. **NTSB Final: Pilot error.**

Date Time	Aircraft N Number	Program	City State	Mission		Phase of flight	PI	Injuries	Day Night	Weather	Fire	Aircraft Status	Operator	Comments/ Description/ NTSB Probable Cause(s)
				Type	Phase									
12/13/98 @ 1745	AS 350-BA N911MV	Shannon Medivac One	San Antonio, TX	MAT		HOV	0	2N		Clear		Substantial	Southwest Helicopters	Instructor pilot (PIC) had been doing a 3-hr check ride with new pilot, with last maneuver "hydraulics off". PIC then initiated a normal takeoff (with hydraulics 'ON') and during the takeoff, the helicopter rolled over to the left. PIC reported it felt like a complete hydraulics failure. Rotor blades struck the ground, knocking tail nearly off, front of the aircraft was destroyed. **NTSB Final: Undetermined.**
2/12/99 @ 1720	AS 355 N355MF	LifeFlight	Toledo, OH	INT	PRF	LNG	0	3S	Night	IMC – Scattered snow squalls.	No	Destroyed	CJI	Flight aborted twice due to weather enroute to referring hospital. Pilot attempted a precautionary landing in decreased visibility. Aircraft struck tree and house 1.5 miles from hospital. **NTSB Final: Pilot error.** Inadvertent flight into IMC, subsequent spatial disorientation and loss of control; also inaccurate weather forecast.
2/13/99 @ 1645	BK-117 B-1 N220H	Hermann Life Flight	Houston, TX	ONS	POB	CLB	2	5N	Day	Clear	No	Substantial	Own Part 135	2-helicopter scene. During approach for landing approach, the pilot noticed power lines running parallel to the road but did not consider them to be a hazard. On take-off, the helicopter hit the power lines and the pilot landed the helicopter in an adjacent field. Undersides of the main rotor blades were damaged and 2 tail rotor blades were destroyed. **NTSB Final: Pilot error.** Failure to maintain clearance from power lines. Sun glare was a factor.
4/3/99 @ 2350	BO-105 N105HH	Flight for Life	Las Vegas, NV	INT	PRF	CRU	0	3F	Night	IMC Snowing	PIF	Destroyed	Metro Aviation	Helicopter crashed as they were returning to a remote base after delivering a patient to Valley Hospital Medical Center. **NTSB Final: Pilot error.** Continued VFR flight in deteriorating IFR conditions resulting in spatial disorientation and subsequent loss of control.
4/11/99 @ 1645	BK-117 N163BK	Bay Flight	St. Petersburg, FL	ONS	PGT	HOV	0	3N	Day	Clear	No	Significant	RMH	While lifting off and hovering, tail rotor struck hangar. Tail rotor and skids damaged. Damage to building. **NTSB Final: Pilot error.** Failure to maintain visual separation with building.
5/15/99 @ 2122	222UT N781SA	Lifeline	Rockford, IL	ONS	PGT	APP	0	3N	Night	4000 ft ceiling, 4mi vis.	No	Substantial	Air Methods	On approach to scene in rural area, hard landing occurred into field. Damage to skids, tail boom and nose cowling. **NTSB Final: Pilot error.** Misjudged flare during landing.
6/14/99 @ 2208	S-76A N2743E	University of Kentucky	Lexington KT	OTH	N/A	CRU	0	4F	Night	IMC Fog; < 1/4 mile visibility; Winds calm	No	Destroyed	PHI	IFR flight, 2 pilot aircraft. Relocation flight from remote airport (1,381 ft MSL) base back to hospital. After take-off, at about 1,600 feet, the co-pilot (SIC) who was flying, began a descending left turn and subsequently crashed into rising terrain on a tree-covered slope at ~ 1,000 ft elevation. **NTSB Final: Pilot error.** Failure of the PIC to adequately supervise the SIC, and maintain a positive climb.
7/17/99 @ 1231	BK-117 N110HH	Hermann LifeFlight	Houston, TX	INT	PGT	CRU	0	3F	Day	Rain in the area	No	Destroyed	Own Part 135	Helicopter was on approach to an intermediate refueling site during an interhospital transfer. A witness saw pieces of the main rotor system separate from the helicopter before the crash. **NTSB Final: Mechanical failure.** Corrosion of the tension-torsion strap resulting in fatigue cracking and subsequent separation of the strap and main rotor blade from the helicopter.
8/10/99 @ 1138	206L N810F	LifeBeat Air Medical	Cape Giardeau, MO	INT	PGT	TKF	0	3N	Day	N/A	No	Substantial	St. Louis Helicopter	A back-up helicopter was in service. Upon takeoff, reaching the edge of a rooftop hospital helipad, the aircraft did an abrupt and violet yaw to the left, the nose tucked downward and the aircraft started loosing clearance. Pilot landed the aircraft on the paved street below, but the tailboom hit a brick wall. **NTSB Final: Pilot error.** Inadequate preflight planning / preparation — auxiliary power unit cord was attached to the helicopter during the helicopter's takeoff attempt.

Date Time	Aircraft N Number	Program	City, State	Mission		Phase of flight	Pt	Injuries	Day / Night	Weather	Fire	Aircraft Status	Operator	Comments / Description / NTSB Probable Cause(s)
				Type	Phase									
9/10/99 @ 0314	BO-105 N911HR	First Flight	Melbourne, FL	ONS	PGT	APP	0	3S	Night	Foggy	No	Significant	Metro Aviation	Approaching a scene LZ, the helicopter began to descend rapidly from ~ 300 ft. Pilot applied collective control and engine power, but the helicopter continued to descend, colliding with trees and then rolled onto its right side in swampy terrain. **NTSB Final: Pilot error.** Failure to recognize entry into settling with power during approach to land and failure to take remedial action to escape from settling with power.
11/17/99 @ 1350	206L–1 N519EH	Mercy Flight/ Medflight	Great Falls, MT	ONS	POB	TKF	1	4N	Day	Wind gusts to 15 knots	No	Substantial	Omni-flight	Helicopter responded to a ski resort, with the LZ in an open area near ski lift towers. On take-off, with trees directly in front, the pilot decided to turn the helicopter to the left, hover to an open area and depart downslope. . . ." After the helicopter moved left 20-30 ft, the pilot felt the tail of the helicopter "rotate abruptly left." Pilot tried to maintain control and return to the LZ, but the tail rotor struck a lift tower. Helicopter landed hard. **NTSB Final: Pilot error.** Clearance from an object was not maintained. Gusting wind conditions was a factor.
02/26/00 @ 0200	412 N411UT	LifeStar	Knoxville, TN	ONS	PGT	MAN	0	3N	Night	Clear Night	No	Significant	Own Part 135	Aircraft had arrived on scene and was repositioning in the LZ due to presence of a steep slope. The tail rotor struck a small tree while maneuvering. After contact, the TR and TR gearbox separated from the aircraft. Flying debris from separating components caused further damage to aircraft fuselage. **NTSB Final: Pilot error.** Failure to maintain visual lookout resulting in collision with tree.
3/10/00 @ 0605	BO-105 N335T	Lifestar	Amarillo, TX	ONS	POB	CRU	1	4F	Night	Fog	PIF	Destroyed	Temsco	Responded to a scene reportedly close to the TX/OK state line. Fog reported forming while the aircraft was on scene. The pilot and crew lifted with a patient on board at ~0605. No radio communication was established after lift-off. Due to fog in the area, wreckage was not found until ~1100 hrs. **NTSB Final: Pilot error.** Failure to maintain control of aircraft as a result of continued flight into known adverse weather. Factors include dark night conditions, fog, low ceiling, and pilot's lack of total instrument flight time.
4/14/00 @ 1610	222 N225LL	Lifelink III	St. Paul, MN	OTH	PRF	CRU	0	2N	Day	Clear	No	Significant	Air Method	During cruise, pilot lost of control of aircraft and landed on a two story building. Major damage to skids. No injuries. **NTSB Final: Mechanical.** Pylon mounted support assembly separated from transmission case due to fatigue failure of the threaded studs and dowel pins, resulting in failure of the flight control system; also, inadequate maintenance procedures by company maintenance personnel.
4/25/00 @ 1215	BK117 N428MB	Bayflight	St. Petersburg, FL	INT	PRF	CRU	0	3F	Day	Not a Factor	No	Destroyed	RMH	Crew had dropped off a patient at Bayfront Medical Center. Departed for base (8 min flight), flying a new route in response to noise complaints from neighbors along the previously direct route. 3-4 min into flight, collided with the radio transmission tower guy wire and the steel tower 480 feet above the ground. **NTSB Final: Pilot error.** Failure to maintain clearance with tower resulting in collision.
5/6/00 @ 2335	BK 117 N911NC	University Hospital	Cincinnati, OH	FUL	N/A	LNG	0	1N	Night	VMC	No	Substantial	PHI	After crossing the edge of the LZ and almost in a hover, he heard a loud noise or bang from the rear of the helicopter. Simultaneously, the left rudder pedal pushed rearward, and the nose started to move to the right. Pilot made a hard landing. **NTSB Final: Pilot error.** Misjudgment of closure rate resulting in collision with building. Factors involved: tailwind and stuck windsock.

Date Time	Aircraft N Number	Program	City, State	Mission Type	Mission Phase	Phase of flight	Pt	Injuries	Day/ Night	Weather	Fire	Aircraft Status	Operator	Comments / Description / NTSB Probable Cause(s)
7/16/00 @ 0140	BK 117 N312LS	Life Star (Texas)	Allen, TX	ONS	PGT	LNG	0	3N	Night	Not a Factor	No	Destroyed	Omni-flight	While maneuvering aircraft at an LZ of a scene response, the tail rotor struck a tree. **NTSB Final: Pilot error.** Failure to maintain obstacle clearance while hovering.
7/24/00 @ 0230	A Star N911AM	Georgia Baptist Life Flight	Atlanta, GA	INT	PRF	CRU	0	3F	Night	Clear	No	Destroyed	Critical Care Med-flight	Aircraft was returning from a call in Sylvester, GA. Radio contact was lost at 0230. There was no Mayday or distress signal. The aircraft was found in a wooded area. **NTSB Final: Pilot error.** Pilot experienced spatial disorientation resulting in loss of control of aircraft. Factors involved: dark night light conditions.
7/28/00 @ 1140	222 UT N224LL	Life Link III	Minneapolis, MN	UNK	N/A	TKF	0	1N	Day	Clear	No	Substantial	Air Methods	On liftoff from the helipad, the tail rotor hit the pad light. The pilot landed and shut down the helicopter. **NTSB Final: Pilot error.** Inadequate preflight, improper vertical takeoff, and not obtaining clearance from helipad light. Factors involved: tailwind takeoff, helipad light.
10/16/00 @ 2355	AS355 N355DU	Duke Life Flight	Durham, NC	INT		CRU	0	1F	Night	Clear	UNK	Destroyed	CJI	Enroute to hospital, the main rotor gearbox (MGB) oil pressure warning light illuminated. After landing the crew went by ground. Mechanic believed the oil pressure switch had failed and disconnected the wire. The pilot did a run-up and hover. The AC then took off and was reported down 16 minutes later. **NTSB Final: Mechanical.** Failure to comply with manufacturer's instructions for correcting illuminated main rotor gearbox oil pressure warning light, resulting in failure of the main rotor gearbox due to oil starvation, loss of main rotor RPM, and an uncontrolled descent.
10/14/00 @ 1227	206 L N2233F	Classic Lifeguard III	Jacob Lake, AZ	ONS	POB	TKF	1	4M	Day	Not a factor	No	Destroyed	Own Part 135	On takeoff from scene, hit trees. Possible loss of tail rotor effectiveness. **NTSB Final: Pilot error.** In-flight loss of control during lift-off due to improper planning and decisions. Factors involved: high-density altitude, helicopter weight, and lack of suitable take-off area.
11/13/00 @ 2048	BO 105 911VH	Flight for Life	Pahrump, NV	ONS	PGT	LNG	0	3N	Night	Not a factor	No	Substantial	Metro Aviation	Responding to scene. 2 feet off the ground ready to land when a vehicle entered its LZ. The pilot was about to ascend when he noticed a set of power lines in his path. He powered up to turn around when his skid hit the ground and the helicopter landed on its side. Pilot was able to climb out, crew had to be "cut out". **NTSB Fact finding document.**
12/18/00 @ 1530	365 N1 N89SM	None	West Mifflin, PA	MAT			0	3M	Day	Not a factor	No	Destroyed	CJI	Tail rotor control loss during post-500 hr maintenance operation check. Several attempts were made to land. On the last attempt the pilot lost control and executed a controlled crash landing. NOT COUNTED IN TOTALS.
12/22/00 @ 0331	206 N288JB	Critical Air Medicine	Wilcox, AZ	INT	PRF	LNG	0	3M	Night	Not a factor	No	Substantial	Critical Air Med	Pilot experienced sudden onset of illness due to apparent food poisoning. A very hard landing was made at Wilcox Airport. **NTSB Final: Pilot incapacitation.** Due to nausea. Pilot collapsed onto cyclic causing inadvertent main rotor contact with ground.
01/22/01 @ 0005	206 L-1 N61AE	Air Evac	Quincy, IL	INT	PGT	TKF	0	1F on ground 2N	Night	Clear	No	Minor	Air Evac EMS Inc.	Hospital security officer walked underneath the tail boom while the AC was running. The officer was struck in the head by the tail rotor resulting in a fatal wound. **NTSB Final: Ground crew error.** Security guard failed to maintain clearance from tail rotor.

Date/Time	Aircraft/N Number	Program	City/State	Mission		Phase of flight	PI	Injuries	Day/Night	Weather	Fire	Aircraft Status	Operator	Comments/Description/NTSB Probable Cause(s)
				Type	Phase									
02/28/01 @ 1024	412 N412SM	St.Mary's Air Life	Grand Junction, CO	MAT			0	1F	Day	Not a factor	No	Destroyed	PHI	Departed the hospital helipad for post maintenance test flight that required autorotation. Impacted the ground approximately 24 minutes later, 11 miles south of Grand Junction. **NTSB Final: Pilot Error**. Pilot failed to maintain rotor speed during an intentional autorotation, resulted in a loss of control.
03/23/01 @ 1520	206L1 N2138Y	EMS Air Services of NY	Seneca Falls, NY	UNK	UNK	CRU	0	2S	Day	Not a factor	No	Substantial	EMS Air Services of NY	Pilot heard bangs and experienced yawing and power loss. He determined that tail rotor thrust was lost. Upon precautionary landing the aircraft rolled. **NTSB Final: Mechanical.** The loss of a bolt in a Thomas coupling on the tail rotor drive shaft, for undetermined reasons, during climb, while operating over unsuitable terrain.
04/06/01 @ 1715	222UT N222LF	Wyoming Life Flight	Alcova, WY	ONS	PGT	LNG	0	3N	Day	Not a factor	No	Substantial	CJ Systems	In hover, pilot attempted to reorient aircraft when the tail rotor struck a 55-gallon barrel. Aircraft landed with damage. **NTSB Final: Pilot Error.**
04/23/01 @ 1430	206L3 N215M	Critical Air Medicine	Phoenix, AZ	INT		CRU		3N	Day	Clear	No	Substantial	Critical Air Medicine	Aircraft experienced total power loss and pilot completed an autorotation landing. **NTSB preliminary.**
05/05/01 @ 1700	BO-105C N105RH	Mercy Flight	Medford, OR	INT	POB	CRU	1	4N	Day	Not a factor	INF	Substantial	Own 135	Power loss and fire in #1 engine. Emergency landing at airport and fire extinguished by airport personnel. **NTSB preliminary.**
06/03/01 @ 1620	369D N1109V		Hanapepe, HI	ONS	PGT	CRU	0	4N	Day	Not a factor	No	Substantial	Smokey Mountain Helicopters	Not dedicated EMS. Enroute with firefighters to pick up a "medical emergency" and experienced engine failure. Autorotated into trees. **NTSB preliminary.** NOT INCLUDED IN TOTALS.
07/20/01 @ 1603	BK117 N313LS	North Texas LifeStar	Addison, TX	INT	PGT	CRU	0	2S 1M	Night	Clear	NO	Substantial	Omni-flight	While enroute an engine failed. While turning towards the airport the 2nd. Engine failed. The AC crashed. **NTSB Final: Pilot Error.** Failure to follow preflight checklist and turn on fuel pumps resulting in fuel starvation and power loss.
07/21/01 @ 0049	S-76 N769BB		Los Angeles, CA					1M	Night	Not a factor	No	Substantial	Helinet Aviation	Had transported an organ harvest team to hospital. Helicopter rolled onto its right side while standing unmanned with both engines operating and rotors turning. **NTSB Fact.** NOT INCLUDED IN TOTALS.
08/18/01 @ 1425	355F1 N53LH	Care Flight	Reno, NV	ONS	POB	TKF	1	4N	Day	Clear	No	Substantial	RMH	Pilot lost visual reference upon takeoff from accident scene (brown out). Attempted to land and aircraft rolled over. **NTSB Final: Pilot Error.** Selection of unsuitable landing zone.
09/22/01 @ 2006	AS350 N911NT	Enloe Medical Center	Chico, CA	ONS	PGT	LNG	0	1F 1S 1N	Night	Clear	No	Destroyed	Enloe Medical Center	Approaching LZ at scene encountered a brown out and aborted landing. Attempted landing a second time with flight nurse using night vision goggles and encountered brown out and aborted landing. Impacted trees and crashed. **NTSB preliminary.**
10/07/01 @ 2250	AS355F1 N911BB	Southwest Helicopters, Inc.	Rosebud, TX	ONS	PGT	CRU	0	2M 1N	Night	Clear	No	Destroyed	Southwest Helicopters, Inc.	Difficulty finding scene and crew informed pt. to be taken by ground transport. Both engines lost power and pilot initiated autorotation resulting in a hard landing and slide. Aircraft separated from skids and came to rest on its side. Fuel system found to have a total of 2 quarts of fuel. **NTSB preliminary.**
10/19/01 @ 1458	350B2 N111DT	Med Air	Roswell, NM	PR	N/A	DEC	0	2F 2S	Day	Not a factor	UNK	Destroyed	Medical Air Transport	LZ training. 2 police officers killed, pilot and another police officer serious. **NTSB preliminary.**

Date Time	Aircraft N Number	Program	City, State	Mission Type	Phase	Phase of flight	Pt	Injuries	Day/ Night	Weather	Fire	Aircraft Status	Operator	Comments/ Description/ NTSB Probable Cause(s)
11/09/01 @ 1445	A119 N119RX	IHC Life Flight	Ogden, UT	INT	N/A	APP	0	2M	Day	Clear	No	Significant	Own Part 135	Upon approach, rotor RPM decayed and did not recover. Hard landing and skids torn off and aircraft rolled onto side. Flight was for a survey of new helipad. **NTSB Final: Mechanical.** Improper rigging of the rotary variable differential transformer by the manufacturer, resulting in incorrect fuel scheduling to the fuel control unit.
11/14/01 @ 0033	BO-105 N93LF	Bannock Life Flight	Pocatello. ID	MAT	N/A	CRU	0	1S	Night	Not a factor	PIF	Destroyed	Own Part 135	Pilot landed as a precaution secondary to fuel transfer pump problem, Medical crew and patient went by ground. Mechanic arrived 5 hours later to repair aircraft. Pilot took off and was returning to base and experienced decreased visibility and crashed. The mechanic saw "a bright glow" and followed the flight path of the aircraft. The mechanic extinguished the fire, disconnected the battery, and called for help. **NTSB Final: Pilot error.** Failure to maintain adequate clearance of terrain during initial climb.
01/18/02 @ 0025	BK 117 N626ME	University Hospitals MedEvac	Cleveland, OH	OTH	PGT	TKF	0	2F 1S	Night	Not a factor	UNK	Destroyed	CJ Systems	AC lifting from rooftop helipad when it struck side of hospital and crashed to ground. **NTSB preliminary.**
01/20/02 @ 0750	109 N55NW	Airlift Northwest	Seattle, WA	ONS	PGT	TKO	0	1S	Day	Light Rain 3000 ft. ceiling	No	Significant	CJ Systems	Power loss shortly after takeoff necessitating emergency landing from altitude of approx. 300 ft. Initial return flight aborted due to weather. Attempted to return to base the following day when crash occurred. **NTSB preliminary.**
03/21/02 @ 1335	AS-350B N1184H	Mountain Life Flight	Susanville, CA	OTH	PRF	CRU	0	1F 2S	Day	Not a factor	No	Substantial	Mountain Life Flight	AC returning to base and collided with the surface of lake. **NTSB preliminary.**
6/21/02 @ 1207	AS-350-B2 N852HW	LifeNet	Norfolk, NE	INT	PGT	CLB	0	3F	Day	VFR	No	Destroyed	RMH	Pilot informed dispatcher of a "pedal binding in the right pedal." At 50 to 100 feet AGL aircraft "started spinning and descending until the nose dropped and the helicopter impacted the terrain." **NTSB preliminary.**
09/07/02 @ 0428	222UT N417MA	Mercy Air Services	Nipton, CA	ONS	PGT	CRU	0	3F	N	VFR	PIF	Destroyed	Mercy Air	En route to accident scene. Witnesses reported aircraft was "flying low and very fast" and impacted the ground nose-low. Post-impact fire occurred. No distress call or problems reported. **NTSB preliminary.**
09/09/02 @ 2152	206 N400SL	Careflight	Sioux Falls, SD	INT	POB	UNK	1	4F	N	UNK	UNK	Destroyed	Omni-flight	Aircraft was enroute to Sioux Falls, SD. Last position report was at 2158. Aircraft was found by farmers in a soybean field at approximately 0930 (9/10/02), not far from last position report. There was no distress call. **NTSB preliminary.**

Key:

Mission Type		Mission Phase	Phase of Flight			Injuries	Fire
FUL Refueling	PR Public Relations	PGT Going to get the patient	APP Approach	DEC Descent	MAN Maneuvering	N None	INF In Flight
INT Interhospital	TNG Training	POB Patient on Board	CLB Climb	HOV Hover	TKF Takeoff	M Minor	No No Fire
MAT Maintenance	OTH Other	PRF Returning from patient	CRU Cruise	LNG Landing	TXG Taxing	S Serious	PIF Post-Impact Fire
ONS Onscene						F Fatal	UNK Unknown

Sources: LeRoy Jackson, Air Methods; Connie Schneider, Fitch and Associates; CONCERN Network; NTSB Aviation Accident Synopses, <http://www.ntsb.gov>; and Preliminary Helicopter Accident Reports, <http://safecopter.arc.nasa.gov>.

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EDITORIAL COMMENTS

RISK MANAGEMENT, BENEFITS AND COST

Dr. Blumen kindly asked me if I would comment on this penetrating and in-depth report. As someone who has never been shy about offering an opinion about EMS safety, I welcomed this opportunity to contribute as one who has loved this avocation for many years. First, I would like to commend Ira and the UCAN Safety Committee for this thorough and comprehensive labor of love. Much time and energy has gone into this effort and I hope it may change the way we look at EMS aviation safety evermore.

"Consensus is that the current EMS helicopter safety record is appalling. Unfortunately, that is the only consensus among the various participants. There is not even agreement about what constitutes an EMS accident. In 1986, for example, one can cite from reputable sources that there were 16 EMS accidents (*Hospital Aviation Magazine*), or 22 (*American Medical News*), or 28 as reported by CBS television's *Sixty Minutes* or *Helicopter News*, or 14 or 17, as reported by the FAA in two separate forums. Similarly, the number of EMS helicopter fatalities has been variously reported as 13, 15, 19, 21, and 25."[1] This is from an article by Ira Rimson, written in the National EMS Pilots Association's *Air Net* in 1987. Reporting methodology continues as a problem for statistical purists even today. We do, however, continue to see the same type of accidents with the same persistent causes as years past. Whether or not statistics indicate a trend or a community-wide problem does not override the fact that one (preventable) accident is too many.

Although this report attempts to collate all available information concerning EMS Aviation Safety or occasional lack thereof, quantifying EMS aviation operations and accidents has been imprecise, to say the least. Although the numbers and underlying causes have been a challenge to decipher due to inconsistent methods for classifying EMS accidents, incidents, forced, precautionary, and hard landings, we still can draw valid and helpful information as to the risks involved. The statistics at a macro level are important—but management of the risks happens at a local program and personal level. It is important not to get too wrapped around global statistics and get more concerned about managing safety at the level we can truly affect. As A. E. Housman states, "Statistics in the hands of an engineer are like a lamppost to a drunk—they're used more for support than illumination." I would recommend that you take all of these studies and boil them down to something usable at your base. A local risk assessment, based on the hard, cold lessons of others, may help you look more honestly at yourself. If you derive nothing worthwhile from this entire study or believe that it only happens to someone else, you may wish to look into the mirror for the problem.

Probably the first civilian EMS accident in this country occurred in May 1978 in an Alouette and its cause was reported as mechanical and engine-related. That was not, however, where an early underlying cause for EMS accidents was born. If we only look into accidents from the civilian sector of EMS we will miss some valuable clues to some very basic risks and causes of EMS accidents. Critical patients were being flown long before the first hospital-based program began in Colorado in 1972. As early as 1970, military air ambulance organizations returning from Viet Nam were beginning the Military Assistance to Safety and Traffic program (MAST). Helicopters had been extensively used to transport the wounded, sick, and injured in the Korean and Viet Nam wars and as far back as Burma.

The MAST program utilized military aeromedical assets and personnel to provide much needed assistance to the civilian sector. Military air ambulances began to provide emergency transportation of sick and injured from the streets and highways in several states. By the late seventies, more than two dozen locations throughout the nation were served by military emergency aviation services. The entire EMS arena in the United States was beginning its transition into the sophisticated and responsive systems we see today. The MAST program was a critical link in the system's genesis as well as a model for EMS aviation in the civilian sector. The MAST program also suffered from some of the similar stressors that have carried over to today's EMS aviation cultures. Pilots who risked their lives evacuating their fellow soldiers from the mountains and rice paddies of Viet Nam were now being asked to do the same for their fellow citizens on the farms, highways, and mountains of the United States. This ingrained noble and very human drive, which perhaps could be termed "the rescuer ethic," still compels much of what we do and feel today.

Having served in this avocation as both a military and civilian EMS pilot, it is a pressure that one feels every time the tones go off. It is why many of us do this work. It is the adrenalin jolt that drives us to do great things. It drives us into taking risks. It occasionally pushes us to take foolish risks and go beyond our best judgment. Sometimes that risk-taking pushes us beyond recovery. There is a time for heroes, but whether or not that is a risk we can really accept needs to be addressed directly with each member of an air medical team, management, and the communities we serve.

This underlying ethic is one common to the dispatchers, pilots, nurses, paramedics, physicians, program managers, policemen, firemen, and almost everyone involved in the emergency and public safety field. To deny that the "rescuer or hero mentality" exists is to somehow deny who we are or who we want to be. It is also something that rarely appears on an EMS aircraft accident report. It is difficult to quantify and a bigger challenge to manage. It is the "elephant in the road" that no one readily admits to. It is a very real characteristic that drives us to do what we do—yet is seldom addressed as a core value or accident cause.

Every time I read an accident report where the pilot and crew perish in a blinding snowstorm, foggy meadow, driving thunderstorm, or pitch-black hillside I always ask, "What were they doing there?" "Why didn't they turn back?"

"Why did they go at all?" Often as not, the team is on their way home or transferring a relatively stable patient who might as easily been transferred by ground ambulance or waited a few hours in their hospital room. Combine the *hero mentality* with *get-homeitis* and we have a deadly mix. Look at the statistics throughout this report and you will see some of the catastrophic results of pilots and crews unnecessarily flying into deteriorating weather conditions or pushing well beyond their personal limits. Most helicopter operators train their pilots to have a corporate, professional mentality. That is a good start. We cannot deny that there are many pressures on an EMS pilot that bring the "rescuer mentality" to the surface. How we as an EMS community deal with this intense drive to help others is a topic that the EMS aviation community must openly and regularly discuss. A written policy is just eyewash and falls far short of effective risk management.

If we look at NTSB accident reports and accept them at face value, we will be limited in truly understanding the core values that really created the accidents. In those reports we will find that "the pilot flew into a hill, hit wires or buildings, or disregarded regulations or company policies and procedures." Those are real causal elements—but simply do not go deep enough. We must understand the organizational culture and personal values that drove a pilot into a situation that was needless and preventable.

Human factors remain as the number one cause of EMS accidents. "A study of 87 accidents form 1987 through 2000 found that human error was the primary causal factor in 76 percent. The greatest concentration of human error occurred in the en-route phase of flight and often involved faulty in-flight planning and decision making or inadequate evaluation of weather information."[2]

In his 2001 study, Pat Veillette found that "forty-one of the 87 accidents (47%), including 26 of the 32 fatal accidents (81%) occurred during the en-route phase of flight. Of the en-route accidents, 68% resulted from human error."[3] "Twenty-six percent of the accidents—and 53 percent of the fatal accidents—occurred in low-visibility or instrument meteorological conditions."[4]

In the EMS Line Pilot survey conducted by NEMSPA and HAI in 2000-2001, pilots who flew Emergency Medical Service helicopters reported that management or crew pressure was most often the greatest risk to safety as a whole in the industry. It was closely followed by night operations, inexperience, weather reporting or forecasting, and poor decision making. When asked about factors that have contributed to the rise in EMS accidents, pilots responded with "pushing weather minimums, complacency, lack of IFR training, and inexperience."[5]

EMS pilots are routinely called upon to launch on a moment's notice, day or night, 24/7, to unprepared landing zones with marginal weather reporting for their destination(s) and routes. This substantially raises the risk over that of the average commercial pilot who is able to fly from approved airport to approved airport with adequate planning time and official weather reporting. Throw in a palatable sense of urgency and the stage is set.

The *Air Medical Accident Analysis* report, conducted by the subcommittee resulting from the April 2000 Air Medical Summit, performed a thorough study of 20 air medical accidents that occurred from 1993 through 2000. As background, this report stated: "Between 1987 and 1997, there were on average four air medical helicopter accidents per year for the industry. By 1997, the accident rate for AMS (Air Medical Service) operations had been reduced to 1.97 accidents per 100,000 flight hours from a high of 17.08 in 1987. In 1998, however, the number of accidents rose to a nine year high of seven, but more alarming, was the rise of fatalities to fourteen, the highest number since the peak year of 1986. In 1999, the number of accidents rose even higher to ten, the highest also since the peak year of 1986. Fatalities were down to ten but still higher than the average of six."[6]

We have discussed statistics and safety risks throughout Dr. Blumen's document. I would like to move our focus to the solutions. Some of these are technological and institutional. I would submit, however, that the real answers are in strong personal and organizational safety cultures enforced by proactive and aware management. Levelheaded professionals must replace risk takers and adrenalin junkies. Pilots and crewmembers who place safety values below that of personal thrill seeking or a mistaken sense of her ics must change their spots or find new professions. Managers, hospital administrators, accountants, and program directors must insure that their pilots and flight teams have proper tools and facilities to do their jobs safely.

Technology will provide stronger, more dependable, and ergonomically friendly equipment, both in the aircraft that we fly and in the gadgets associated with flight following, air traffic control, terrain avoidance, GPS, night vision equipment, avionics, flight instrumentation, and controls. Many are readily available today. Many flight programs today are using 30-year-old technology, underpowered, or marginally safe aircraft, and expecting their pilot and flight teams to make due. Some programs continue to ask their pilots to fly multiple and dissimilar airframes on a routine basis. Some programs utilize a spare aircraft that is dissimilar or inadequate for the mission. There is a managerial blind eye to the risks that those cost-saving measures create. Often budget constraints and a politically driven decision process exclude the pilot effectively from the aircraft selection process. Occasionally, the RFP process creates a situation where costs take priority over safety. Medical personnel often have the final word in selecting the aircraft and often do so based on medical needs with token regard to the most important tool in the process—the aircraft. There are many aircraft in use today that are missing what I would consider critical elements for an optimum EMS helicopter.

These critical aircraft requirements, in my opinion, are *one* single type aircraft with an adequate margin of power and performance to do any of the missions a program requires in its area of operations. This should account for weather, terrain, and all environmental factors. The aircraft should have adequate avionics, lighting, and safety features. It should have sufficient space, efficient medical configuration, and ergonomics to safely and efficiently treat the type and numbe of patients to be flown. A single type o helicopter model with similar ergonomics and systems in the program aircraft reduces risks and maintenance complications as well. Dissimilar aircraft create another obvious risk ignored by many programs and operators. Perhaps there is a sound risk management reason why a Southwest, United, or Delta pilot remains solely on one airframe, type, and model. Aside from the obvious training, standardization, and maintenance advantages, there are very valid and often ignored risk management reasons to keep pilots in only one aircraft type and model. If you've ever rented a car different than the one you drive at home and searched for the parking brake release or windshield wiper button in a dark parking lot or rainy freeway, you should understand the term "negative habit transfer." One question is whether or not thinly stretched community, hospital, or program director's budgets are willing and able to afford that in the future—or even in the present.

The other question is whether or not operators or programs are really willing to take ***all*** of the steps necessary to aggressively manage risks. Hospital and corporate CFOs who approve budgets must not be lured into false economies that elevate risks. Insurance companies and government agencies are now, or will be, exerting their influence on unsafe, ineffective or redundant programs. The MBA mentalities who believe profits and costs are the only measures of good business must add safety as an equal partner to their thought process. If we want to make a difference in our day-to-day risk management, we must take a hard look at how *"that's the way we've always done it"* affects us today.

The Air Medical Service Safety Summit's *Air Medical Accident Analysis Final Report*[7] concluded its study of 20 recent air medical accidents with the following interventions that rated high in both effectiveness and feasibility. They were:

- Enhance the training for night flying operations
- Enhance the training for mountain flying operations
- Equip aircraft with Terrain Avoidance Warning Systems (TAWS)
- Equip aircraft with Radar Altimeters
- Provide aircraft with mission-essential equipment
- Improve the content of weather briefings

The top six in the high effectiveness and moderate feasibility were:

- Conduct/enhance annual IFR proficiency checks
- Conduct/enhance training to improve understanding of weather briefings
- Enhance overall training in recurrent, professional knowledge, etc.
- Conduct/enhance training in Aeronautical Decision Making (ADM)
- Establish integrated and structured Pilot Training Programs
- Conduct/enhance mission-oriented training

This report was distributed to the Air Medical Services subcommittee of HAI, the Air Medical Safety Advisory Committee (AMSAC), and the AAMS/CORE Safety Committee for their review and suggestions. A major key to the training issue is that it should be mission oriented. If the pilot is expected to find and land in an LZ in the mountains on a pitch-black foggy night or land in a dusty or snowy LZ, regular and recurring training should meet that requirement. Unfortunately, many operators routinely train on safe and sterile runways or helipads. If we are to truly lower our risks, we must train in the same environment and mission conditions we will encounter. Instrument training should involve real inadvertent IMC situations under real mission profiles. In the real EMS world, this means that training dollars must come from vendors and programs alike to better manage risks. We have some real solutions. We must have the will as well.

When the EMS line pilots were asked for their suggestions to improve safety in the NEMSPA line pilot survey, the top vote getter was, "Increase quality and frequency of training." This was following closely by "Improve pilots' salaries and benefits," and "Night Vision Goggles." We need to stop ignoring the hard, cold fact that our pilots cannot see like bats in the dark. We have been pretending somehow for years that once you are an EMS pilot, you become magically endowed with built-in sonar and night vision skills. Pilots and crews must learn to say "no" when asked to perform outside of their limits. The right equipment includes things like night-vision devices, night suns, and skid lighting. If you don't have adequate lighting or NVG assistance, don't use your rotor blades as curb feelers as you plough through a dark night.

Another ominous finding in the NEMSPA/HAI survey was that over 25% of EMS pilots either had not received any crew resource management training or they felt it was ineffective or not well presented[8]. When asked about the effectiveness of their training or preparation for their present position, significant numbers (>10%) of pilots responded that the following areas were weak: Flight crew dynamics or interaction, Crew Resource Management, Aircraft systems, and mission planning.

In response to the need for improving and standardizing Crew Resource Management, the Air Medical Safety Advisory Committee (AMSAC) pushed the development of the Air Medical Resource Management (AMRM) program. Through the efforts of Michelle North, an exportable AMRM package was produced and "Train-the-Trainer" sessions initiated. It is the intention of the AMSAC that it become available to all programs and that they continually train in this invaluable resource.

We should all take heed of one particular result of the EMS pilot survey. *After years of warnings to the EMS aviation community about the need for pilots to make flight go-no go decisions independent of pressure, approximately 20% of pilots surveyed responded that "occasionally, some flight crews do pressure a pilot to launch or continue a mission."* Pilots also responded in significant numbers that they had been pressured to take flights by management and that local competition created some pressure to fly. Pilots were also pressured to speed up launch times creating opportunities to miss critical tasks. Most program managers as well as dispatchers, pilots, and medical crewmembers must control their perceived need to hurry up or pressure pilots. It is clear that some do not. Sometimes our most seasoned medic or nurse is also the most adamant about the "need for speed." Sometimes it is the crewmember who has watched too many

"911" TV shows or has a "Rambo" self-image. These human factors are clearly manageable and these risks avoidable with effective leadership and personal discipline.

The Air Medical Safety Advisory Committee (http://www.amsac.org/) "was envisioned to be an operator driven forum dedicated to the sharing and development of safety information and initiatives for the AMS industry." It is dedicated to seeking solutions to some of the EMS aviation community's tough issues as they relate to competition, flight and duty time, fatigue countermeasures, standardized criterion for Air Medical Services incident/accident reporting, and other EMS safety issues. The organization continues today with participation from operators, programs, NASA, FAA, insurance, and air medical professional organizations. Ask your operator if they participate. Unfortunately, a few operators have not thought it worth their time and effort.

The bottom line is that there are no new accident causes. If we want to fix what's broken at a human level we need only to look at Pat Veillette's chart at Figure 1-21 of this report and see what type of human factors are causing accidents. The top three are "risk taking, pre-flight planning, and in-flight decision making." We have met the enemy and it is us.

In conclusion, NO pilot should ever have to make critical flight decisions under the thumbscrew of peer pressure, competition, job security, or self-inflicted sense of urgency. If you want a quick barometer of your program's safety culture ask a few key questions such as:

When was the last time someone from the hospital, vendor, or corporate management attended a program safety meeting, rode along at 2:00 AM, or simply sat down in the crew lounge and chatted with the crews about the things that really matter?

When was the last time you did "hands-on" extrication, survival, or crash drills under realistic mission-oriented profiles?

What percentage of your annual and required training is devoted to the biggest and riskiest tool in your medical kit—*the aircraft*—or scene safety—or helipad safety—or weather—or Air Medical Resource Management?

Do your aviation maintenance technicians have adequate time, facilities, resources, and full support to do their critical work?

What happens when everybody knows that one of the pilots is a cowboy or is constantly pushing the envelope?

Who picks your monitors, defibrillators, IV kits, or traction splints? Who picks your aircraft?

What happens if a crewmember, flight communicator, manager, or doctor pressures a pilot or crew to fly?

How often do you train the folks who set up your LZs?

What happens if someone says "no" or "let's go back"?

Can you ask these questions in your organization?

When was the last time you did? Did anything change?

This is hardly a comprehensive list. Each of us should continually and honestly assess our safety attitudes, values, and culture. We don't need any more heroes and monuments to the tragic end of noble intentions. We need enlightened managers who will be fiercely independent and effective when it comes to safety issues. We need as much priority on risk management as we have on public relations, charting, medical training, nursing or paramedic or piloting skills.

How do administrators select their program directors or lead pilots? What skill sets does one need to be a manager? Must a program director be a nurse? Are leadership and management skills more important than medical, nursing, aviation, or technical skills for a manager? How much emphasis is there that leaders thoroughly know and use risk management principles? Do present-day EMS program management courses place a high priority on safety and risk management? How long will we continue to do things the way "we've always done them"?

We need corporations, programs, and operators who *always* put safety first through action not words. We need manufacturers who will produce aircraft that can do the job. There must be adequate, appropriate, and well-maintained equipment that can do the mission. We need pilots who will participate in the process and have the courage to speak out for safety issues and hold their ground. We need safety cultures that support those who say "no" for safety's sake. We need the will and the courage to change. "There are three kinds of people: Those who make things happen, those who watch things happen, and those who ask, "What happened?" –(Casey Stengel)

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CAN WE HAVE BENEFIT WITHOUT RISK?

We are pleased to contribute to defining a context for the extremely important ork being presented by Dr. Ira Blumen and his colleagues at the University of Chicago Aeromedical Network (UCAN).

The passion and commitment of practitioners in air medicine is legendary. Following from the successive military experience in Korea and then Vietnam, helicopter evacuation of the critically injured, often in the most dangerous and trying of circumstances, took on near mythic status. The ethos of "finding a way" came home and into the civilian world of air medicine. Thirty years after the first helicopter program began operation at St. Anthony's, the debates about value—the interface of benefit, risk, and cost—continues.

In recent months, Thomas and colleagues in Boston have reviewed and published annotations of the best empirical studies for the use of air medical intervention for critically ill and injured patients.[1, 2] In addition, recent studies comparing cost of intervention[3, 4], increased mortality after program closure[5], and a cost-benefit analy of air medicine[6, 7] increasingly support e evidence base for measurable benefits across a wide range of disease and injury processes. Marrying the unique technology of aviation with critical care medicine has not only improved care for the critically ill and injured, but improved access and equity within the healthcare system. But at what cost and is the cost worthwhile? In this case, it is not only the cost of care but also the human cost in lost or impaired lives through aviation accidents.

While the benefits for individual patients and the wider population are demonstrable, it is equally important to understand safety. The issues of aviation misadventure coupled with the Institute of Medicine Report[8], noting alarming rates of medical misadventure leading to preventable death, must give both patients and providers great pause in assessing safety.

Safety throughout medicine is of great concern to individual patients, the public, and providers of care. After a single accident recorded in 1996, the air medical community over the past five years has seen an upsurge in the number of aviation accidents and incidents leading to death and serious injury. How safe is this enterprise and do the benefits outweigh the risks? The earliest test of medicine—"first, do no harm"—must be answered.

The short answer is that it is difficult to answer these questions. We have long assumed that benefits outweigh risks while each of us wonders and worries about experiencing an accident firsthand. While the number of accidents has increased, it is impossible to understand if the actual rate is increasing. To measure rates one must have both a numerator and a denominator—in this case the number of accidents measured against exposure—the number of flights and the number of flight hours. Sadly, and frustratingly, it has been nearly impossible to measure and "how safe" remains virtually unknowable.

Competitive pressures between programs, Part 135 Operators, vendors, the lack of central data repository, and the costs of gathering and analyzing data have all played a part in the creation of a contextual black hole as regards the safety of air medicine. Operators, the FAA, NASA, air medical providers, and insurance underwriters have become increasingly frustrated with the current lack of data. While there have been a number of initiatives in the past two years—the creation of the Air Medical Safety Advisory Council (AMSAC) the ASRS program from NASA, the Root Cause Study Group Report, and the accident database from HAI—the overall understanding of risk and safety remains limited. Why is this important? Simply that the absence of good data and analysis is corrosive on many fronts from poor regulation—rules that do not fix problems, to escalating insurance premiums, media alarm, and most worryingly, to increasing distrust on the part of the public.

The publication of this paper changes the discussion on all fronts. Until this report there has been no real effort to collect or examine the underlying data to truly have any understanding of overall safety and the risks of air medical intervention. Understanding risk is essential for both providers and patients. There are risks throughout medicine and in all ambulance transport, whether by ground or air. The questions each of us must answer in the delivery of any medical intervention and therapy are:

Do we understand the risk and have we taken every step to minimize the risk?, and

Do the benefits outweigh the risks?

This paper by Blumen, et al., is a huge step forward in answering these questions. While the gathered research is still limited by the lack of a central repository, the gathered and compared data from many fronts allows a reasonable set of assumptions to measure risk and safety in air medicine. Stated another way, the real question is: Can we eliminate the medical risk in any given therapy and at what cost to benefit? The answer is no—without at least some risk we would not have benefits.

Most importantly the final sections of the report look at the risk to providers and patients. The news is sobering to providers while good for patients. Without question the issue of risk is tied to exposure. This is a message we must take home. Managing risk—identification, avoidance, reduction, and management are key strategies that each of us must employ ever day. Every provider and participant in air medicine should read and re-read this report, take it to heart, and then change your practice.

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ANGELS OF MERCY OR ANGELS OF DEATH

In the late 1980s a television newsmagazine referred to the air medical industry as the "Angels of Mercy or Angels of Death" in reaction to the high accident and fatality rate. This rate reached an all-time high of 13.14 accidents per 100,000 hours flown. In contrast, during this same time frame commercial airliners were experiencing a rate of .002/100,000 hours. As this safety report has shown, the accident rates and fatal accident rates per 100,000 flight hours are down dramatically from what we experienced in the mid-'80s. Unfortunately, from 1998 through 2001, we have had more accidents than in any four-year period in HEMS history, including the "death star" years. In addition, the fatal accident rates are the highest they have been since the early 1990s.

What has changed and what has not? We are flying more sophisticated equipment. Oddly enough, during a recent Helicopter Association International Exposition Safety Symposium, a group of helicopter manufacturers conducted a panel discussion on the high accident rate. It was their premise that they [manufacturers] have re-designed, re-engineered, re-structured, automated, and improved the basic flying machines, yet we are crashing at the same, if not higher rate than was experienced prior to all these improvements.

We added more pilots to air medical programs to reduce exposure and fatigue while on duty as fatigue was considered to be a major factor in the accident chain of events. We increased weather minimums in the hopes that standards would encourage better decision making. We formed an accreditation group to promote competition in achieving excellence and professionalism. Associations were formed to provide a forum and infrastructure to attack safety issues head on. The industry was aggressive and came together with safety as their coat of arms.

The fruits of this labor seemed to provide quite a harvest as 1990 came to a close with no fatalities. Had we nipped the beast in the bud? Unfortunately, we returned to a smattering of accidents in the early and mid-1990s. The number of accidents began to escalate in 1998 and continued through 2001 when we had 13 accidents.

The industry took a deep breath and said, "where do we go from here?" We re-grouped, met in mass, identified seven initiatives to break the chain of accidents and attempted to provide an action plan with which to proceed. The FAA was anxious for our industry to come up with an in-house solution. But did we?

Unfortunately, unilaterally there has been little change in the way we do business. An Air Medical Resource Management course has been developed. Fielding and implementation is slow as financial support for safety education and training is not uniformly endorsed throughout the industry. The Air Medical Safety Advisory Council was formed in the hopes that Part 135 vendors could provide some insight and solutions to industry safety trends and share information to aid in the prevention of repetitive safety infractions.

As in all organizational structures, progress is impeded by the very large geographical nature of our business. There is an underlying sense of "breath holding" until the end of the day in hopes that another significant event [accident] hasn't occurred. And then a new day begins, as do our hopes. We still hear of repercussions for "whistle blowers" on safety issues. Individuals within organizations are afraid to come forward with safety of flight issues for fear of losing their jobs. Aberrant behaviors are sometimes rewarded rather than punished. Between operators there is little exchange of information for fear of disclosing proprietary issues. Successes as well as failures are not shared. And in these tough financial times in the healthcare industry, competition is the dragon in disguise for faulty decision making, cutting safety corners, eliminating safety infrastructures, training and education, and general apathy toward developing a safety culture.

But all is not lost. There are multiple things your organization can do to get on the safety bandwagon and bring the accident rate to zero. This must, however, start at the top with management buy-in that safety is the only imperative to exceed mission accomplishment.

This report may raise your awareness with regard to safety and some unique risk assessments. But safety must be an integral part of everything your program thinks, says, and does. Safety has to become an attitude and a way of life. You don't "get safe" when you come to work. It must permeate the mind-set of your organization. Resources must be committed to safety training and education. Formal safety standards must be set, must be trained, and must be adhered to. Safe behavior should be rewarded and unsafe behavior should have serious consequences. Open communication must be encouraged. And above all, your organization must develop a safety culture that promotes the motto, "if it's not worth doing safely, it's just not worth doing!"

No, all is not lost, but without aggressive, proactive, and committed attention to individual organizational safety infrastructures, the accident rate will not change, and we may be re-crowned Angels of Mercy or Angels of Death.

Michelle North, Ph.D.
President
The Wisdom Well