PRE-MISSION ANALYSIS FOR HELICOPTER EMERGENCY MEDICAL SERVICE OPERATIONS

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Abstract

Research is currently being undertaken, in close collaboration with Air Ambulance Victoria, to develop an intelligent system for the pre-mission analysis of Helicopter Emergency Medical Service (HEMS) operations. This research is being conducted for the next two years as a project under the Australian Research Council. The aim is to develop a system that will assist flight-coordinators and crew in the decision-making processes faced prior to aero-medical operations.

HEMS operate around-the-clock, in all-weather conditions, and often with no fore-warning. In a time critical operation, where precious minutes may cost lives, the crew must decide which cases dictate a HEMS response and if so, whether the conditions are safe to conduct the mission. The time constrained environment and the occupational stresses faced by aeromedical decision-makers create non-idealistic conditions, which are susceptible to overlooking important information and producing errors. It is expected the project will help manage the risk associated with HEMS operations by providing a structured decision support system that limits erroneous decisions and ensures no factors are ignored in the pre-mission analysis of operations.

This paper discusses the development of a decision support system which aims to support the decision-making processes faced prior to aero-medical operations.

1. Introduction

This research has been conducted in conjunction with Air Ambulance Victoria as part of Australian Research Council Linkage Project LP0347412. The aim is to develop a system to support the pre-mission analysis of helicopter emergency medical service (HEMS) operations.

The helicopter has been recognised for its unique ability to reach remote areas, often in difficult terrain [1, 2]. This capability has made it highly valuable in the recovery, resuscitation and transfer of critically ill patients to major hospitals and in the search and rescue of people at land and sea. The capability of the helicopter is reflected in the world-wide growth of HEMS operations. In Australia the annual number of aeromedical transports by helicopter has increased from 1,278 patients in 1992 to 6,982 patients in 2002. [3]

Nevertheless, HEMS operations are associated with risk [1]; A recent study found that in America the risk of death for a HEMS crewmember (per hour engaged in the activity) was similar to that of rock climbers and skydivers [4]. This high HEMS accident rate has prompted HEMS operators across the globe to address the management of risks inherent to their operations. Crew error has been identified as one of the key causes of accidents in HEMS operations [4, 5]. In-flight decision-making, pre-flight planning, failure to follow standard operating procedures, delayed remedial actions, and misinterpretation of environmental cues are areas that have been identified as needing to be addressed for safe HEMS operations [5].

Australian HEMS operations are not immune to risk. For the period 1992-2002 the accident rate for HEMS operations in Australia was 4.38 per 100,000 flying hours, and the accident rate for HEMS operations in the state of Queensland was 25.03 per 100,000 flying hours [3]. Australian HEMS operations are perhaps further complicated by the vast distances and the predominantly hot conditions, which challenge both aircraft and crew performance [6]. Adding to this Australian HEMS are generally required to fulfil multiple roles, performing critical care interhospital transfer, land-on-scene response, hoist operations and search and rescue (SAR). In North America and Europe, there is generally a distinction between hoist and SAR operators and those who undertake interhospital transfers and land-on-scene response [6].

HEMS operations are complex, being a joint exercise between the flight crew, paramedics and supporting agencies. Operations occur around-the-clock, in all-weather conditions, and often with no fore-warning. In a time critical operation, where precious minutes may cost lives, the crew must decide which cases dictate a HEMS response and if so, whether the conditions are safe to conduct the mission.

This decision making process is compounded due to the disparate mission requirements, operational environment, crew capability and machine performance. Presently, most HEMS operations are minimally planned with decisions usually being made 'on the fly' [7] with operators depending upon the crew and their experience to perform pre-flight planning. However given the time-critical environment and emotional stresses which accompany HEMS operations this decision-making process is susceptible to human error which can ultimately produce accidents. Subsequent reports has identified the need for decision support systems to reduce the likelihood of such erroneous decisions in the pre-flight planning phase of HEMS operations [8, 9].

Working in close collaboration with Air Ambulance Victoria this research aims to prototype an intelligent system for the pre-mission analysis of HEMS operations. Through the holistic analysis of operational, technical, environmental and human factors, the system plans to assist pilots and crewmen with pre-flight planning as well as support flight coordinators with the allocation of resources. It is planned that such a system will help manage the risk associated with HEMS operations by providing a structured decision support system which enables all critical factors to be considered.

2. Overview of Air Ambulance Victoria

The first Australian helicopter emergency medical service (HEMS) began operations in Sydney in 1973. Since then, HEMS operations within Australia have grown considerably. HEMS programs now operate in all Australian states and territories except the Northern Territory [3].

Air Ambulance Victoria (AAV) is part of the Metropolitan Ambulance Service (MAS) and is responsible for aeromedical services within the state of Victoria. AAV commenced operations on 1 May 1962, with the role of supporting the Victorian Ambulance Service in the urgent and non-urgent transportation of patients over long distances. Today AAV wet leases four dedicated Beechcraft Kingair B200C aircraft and three dedicated aeromedical helicopters: one Eurocopter Dauphine N3 and two Bell 412 EP. AAV also specialises in interstate and overseas retrievals, which are completed, either by its own fixed wing aircraft, charter jet or commercial airliner. [10]

AAV's three helicopters are based at Essendon, the Latrobe Valley and Bendigo; their primary role being to provide:

- rapid transport of time critical, medical, surgical and trauma patients;
- rapid primary response of paramedical personnel and equipment to an incident or location; and
- access and/or removal of patients from remote or inaccessible locations

In 2004 the three aeromedical helicopters transported a total of 1380 patients, involving a mixture of inter-hospital transfers and primary responses to the scene [11]. Since 1998, AAV's HEMS operations have increased in the number of patients handled, however operations have stabilised from 2001 with the introduction of a third helicopter based in Bendigo (HEMS 3) (Figure 1). AAV also undertakes fixed wing operations to support the Victorian Ambulance Service in the transportation of patients with a fleet of four dedicated Beechcraft Kingair B200C. In 2004 these four aircraft were responsible for transporting 4652 patients [11].

AAV has recently refined its dispatch processes and increased accountability through the establishment of a Flight Coordination Centre at Essendon Airport. The Flight Coordinator is responsible for ensuring the appropriate utilisation and the efficiency of helicopter and fixed wing responses.

Preparation for a flight begins with the Flight Coordinator receiving initial contact from the requesting agency. Preliminary data and information is obtained and a general go/no go decision is made on the appropriateness and feasibility of the request. This decision is generally based upon case priority and resource availability. If a request is deemed appropriate and feasible, coordination of the individual flight begins and an appropriate resource must be selected, crews assembled, and necessary ground transportation arranged. Following this the Flight Coordinator contacts the allocated resource with the mission details, and the crew conducts a brief flight plan and either accepts or declines the mission based upon safety and regulations.

Consequently there are two distinct parts to AAV's pre-mission analysis for HEMS operations: resource allocation and flight planning. Flight planning is the responsibility of the pilot and is based upon legislation, safety and piloting requirements, whilst resource allocation is the responsibility of the Flight Coordinator and is based upon:

- clinical needs – urgency, skill sets & equipment,
- resource availability & type of resource, and
- locations – number of sectors involved.

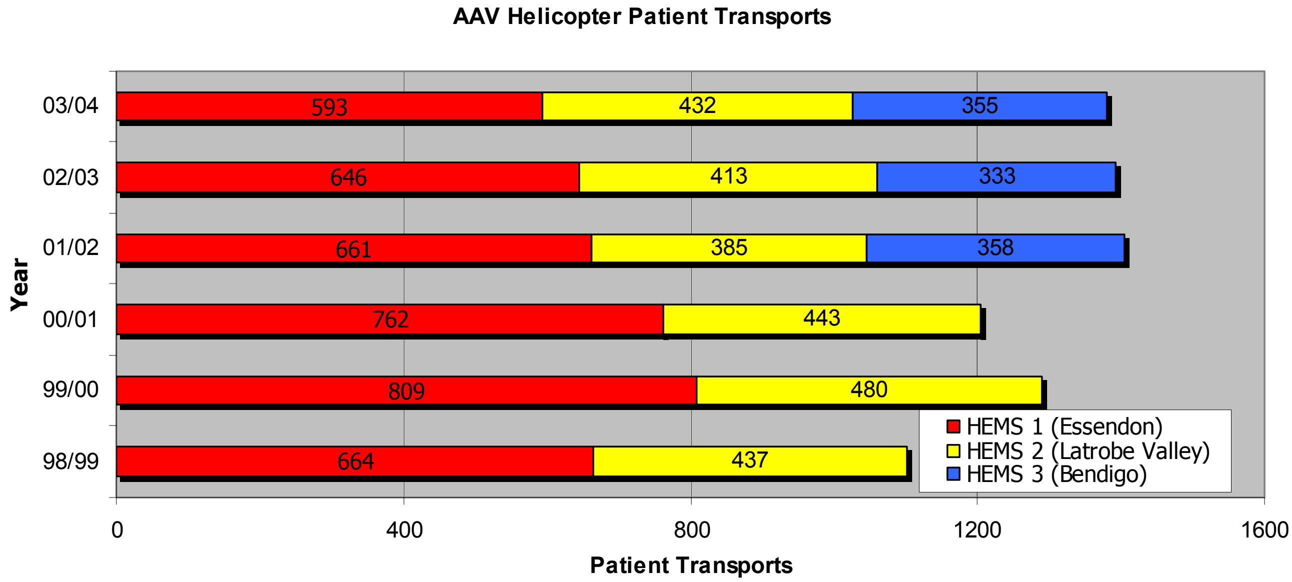

Figure 1. Total number of patients transported in HEMS operations by AAV

3. System Framework

As a result of crew error being one of the key causes of accidents in HEMS operations [4, 5], Sinha et al. [8] developed a conceptual framework for an intelligent system for pre-mission analysis of HEMS operations in order to reduce the probability of errors in the pre-mission analysis phase. This work suggested that available mission capabilities be compared against required mission capabilities to quantitatively determine the probability of mission accomplishment and to suggest actions to address the shortfalls in the required mission capabilities.

Sinha et al. [8] provided a foundation on which to base this research and develop a system that can assist AAV's flight-coordinators and crew in the pre-mission decision-making process. In conjunction with AAV this previous work has been developed and revised in order to accurately reflect the decision making process. Consultation with pilots, crewmen, paramedics, flight coordinators and AAV management has been undertaken to establish tangible and achievable requirements for the system which allow the original framework to be developed into functional system. Top level factors identified for consideration in pre-mission analysis for AAV operations are presented in Table 1.

Table 1 – AAV pre-mission analysis factors.

Analysis Factors	
Medical	**Operational**
• clinical urgency • clinical details • clinical requirements • paramedic crew	• meteorological conditions • location & landing areas, including alternates • range & fuel • lowest safe altitude • flying/recovery crew • resource performance

Intelligent systems generally fulfil two roles: (1) they function as intelligent assistants to augment human expertise; and (2) they act as a substitute for human expertise that saves cost, time, and life. Intelligent systems have demonstrated that they are ideally suited for tasks such as search and optimisation, pattern recognition and matching, planning, uncertainty management, control, and adaptation [12]

Similarly Aven and Korte [13], contrast two different approaches to decision making: (1) Decision-making as an exercise of modeling alternatives, outcomes, uncertainty and values, and choice of the alternative which maximises/minimises some specified criteria. (2) Decision-making as a process with formal risk and decision analyses to provide decision support, followed by an informal managerial judgment and review process resulting in a decision.

Following the review of AAV operations, a framework which augments human expertise and aids the decision-making process has been adopted. The system is to be work-centered, in that it will find, fuse, format, present information, and respond to user requests [14], and shall avoid the use of pseudo-quantitative numerical risk scores and matrices, which are easily manipulated to obfuscate the real risk level [7].

This new framework is divided into two primary modules, a "resource assigner" module and a "route planner" module, which reflect the two distinct phases in AAV's pre-mission decision making process. In each module rule-based algorithms exist that reflect AAV operating procedures and safety regulations, and notify the flight coordinator/pilot of non-compliance.

The "resource assigner" establishes a priority for each mission, based on the patient's location and condition, and assigns the most appropriate resource to the mission, based upon resource availability, priority, time and level of care. Using their judgment the Flight Coordinator has control to change the level of priority and/or assign any available resource.

The "resource assigner" passes information to the "route planner" which creates a flight path tailored to the mission. The flight path is segmented and bounded by mission defined points. These include accident scenes, helicopter landing sites, airfields, hospitals and refuelling points. Based upon the patient location and injuries the route planner will automatically define the flight path, with the operator having control to edit or change any or all of the specified points. Based on the flight path the route planner informs the pilot, of expected meteorological conditions, NOTAMs, estimated arrival times, fuel consumption and IFR lower safe altitudes for the mission. Following a review of this briefing the pilots must use their judgment to make a decision as to the safety and success of the mission.

4. Discussion

Primary HEMS missions allow very little time for pre-flight planning, with pilots generally taking off within 10 minutes of being notified of a mission. This time-critical environment and the emotional stresses which accompany HEMS operations make the flight planning susceptible to human error which can be fatal. The "route planner" aims to quickly provide the pilot with all the necessary information required to successfully and safely conduct flight planning and thereby reducing the risk of error and contributing to the safety of HEMS operations. The "resource assigner" aims to support the Flight Coordinator in ensuring the appropriate utilisation and the efficiency of responses to medical emergencies.

Previous research efforts [15] identified a number of requirements for a feasible and effective system which will meet the operational requirements of AAV. Recent research efforts have been directed towards developing functionality and methodologies capable of meeting these requirements and the module objectives. This has included the ability of the system to:

- convert map references to GPS coordinates,
- cross cross-check icing level with lower safe altitude,
- determine case priority,
- automatically prepare flight plans including refuelling,
- determine the required level of patient care,
- re-task resources to higher priority missions,
- co-ordinate a multiple resource to response (i.e. rotary and fixed wing), and
- calculate lower safe altitudes.

The determination of lower safe altitude for the mission flight path is an important part of this pre-flight planning. HEMS are routinely tasked on scene responses mission which do not involve established airfields or helicopter landing sites. Thus, these missions rarely occur in established flight paths and lower safe altitudes must be determined manually by consulting World Aeronautical Charts, which is a time consuming process. The accurate determination of lower safe altitude becomes even more imperative if the pilot is to encounter instrument meteorological conditions (IMC) and/or the pilot is unfamiliar with the area. The consequences of failing to follow or miscalculating lower safe altitudes can be deadly. Of the 107 American HEMS accidents between 1978 and 1998, Blumen [4] attributes controlled flight into terrain as the cause of 19 (18%) of the accidents.

The next phase of the project is to integrate all of the above into a prototype decision support system, capable of supporting both the resource allocation and flight planning phases of AAV's HEMS operations. This prototype will then be tested in conjunction with AAV to measure the merits of such a decision support system and to provide feedback for the future development of such a system.

5. Concluding Remarks

HEMS operate around-the-clock, in all-weather conditions, and often with no fore-warning about the next mission. In a time critical operation, where precious minutes may cost lives, the crew must decide which cases dictate a HEMS response and if so, whether the conditions are safe to conduct the mission.

A great deal of research has been spent developing Sinha et al's [8] theoretical framework for an intelligent system for pre-mission analysis of HEMS operations into a feasible and effective system which will meet the operational requirements of AAV. This revised framework aims to develop a work-centred, intelligent system which augments human expertise and aids the decision-making process. The system aims to reduce the risk of human error during pre-flight planning and contribute to the safety of HEMS operations.

Future research will now focus on further developing functionality and methodologies required by both of the modules as well as integrating these into the prototype decision support system. At the conclusion of this project, it is planned to have successfully demonstrated prototype decision support software capable of supporting both the resource allocation and flight planning phases of AAV's HEMS operations. It is planned that this prototype will then be commercially developed and customised to meet the individual needs of HEMS operators.

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