CREW CAPABILITY EVALUATION FOR HELICOPTER EMERGENCY MEDICAL SERVICE OPERATIONS - REVISED METHODOLOGY

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Abstract

Helicopter medical emergency service *operations are life saving missions with reaction time a critical issue for mission accomplishment. Presently, crew knowledge and experience govern the pre-mission analysis of the operations. No computing tools are available for pre-mission analysis and to support crew decision making. This paper presents a revised methodology to evaluate required crew capability for pre-mission analysis of helicopter emergency medical operations and discusses the issues related to its implementation into a decision support system.*

Introduction

Air-ambulance medical emergency services involve critical life saving decisions. These decisions are based on the knowledge and experience of the air-ambulance crew. The crew is responsible for conducting on the spot pre-mission analysis that includes the assessment of mission requirements, available capabilities and associated risks. The results of this analysis govern the crew's decision to proceed with a mission. (Sinha et al. 2000) [1]

A recent report on "Decisions for Life" (Anon, 2002) [2] concluded that there is a need for a decision support system to aid crew on air ambulance missions; particularly helicopters. Sinha et al. (2001) [3] developed a framework for pre-mission success evaluation of helicopter emergency medical service operations, to support crew decision. The framework includes the following:

- A statement of mission requirements, comprising operational and environmental needs and crew and technical thresholds;
- A statement of available mission capabilities as they relate to each of the mission requirements; and
- An assessment of mission feasibility.

This framework adopted by Sinha et al (2001) [4] is based upon an "input-process-output" configuration (Figure 1). The approach considers the operational and environmental needs and the human and technology thresholds as the key "inputs". The "process" identifies the defined and derived mission capabilities; and the "output" is a measure of mission accomplishment feasibility. The governing factors relating to mission feasibility considered for analysis are as follows: (a) operational requirement; (b) environmental condition; (c) human capacity; (d) technological state; (e) crew competence; and (f) machine performance.

<table>
<tr><th colspan="2">Inputs</th><th>Attributes (Mission Requirements)</th><th colspan="3">Outputs</th></tr>
<tr><td rowspan="2">Threshold</td><td>Human</td><td>• Knowledge base
• Experience Base
• Physical Fitness
• Mental Robustness
• Endurance
• Stress Level</td><td>Human Capabilities</td><td rowspan="4">Defined Capabilities (Required)</td><td rowspan="6">Mission Accomplishment Feasibility</td></tr>
<tr><td>Technology</td><td>• Speed
• Rate of Climb
• Endurance
• Hover</td><td>Technology Capabilities</td></tr>
<tr><td rowspan="2">Needs</td><td>Operational</td><td>• Search & Rescue
• First Aid
• Resuscitation & Recovery
• Transfer</td><td rowspan="2">Required Capabilities</td></tr>
<tr><td>Environmental</td><td>• Built-up Area
• Mountains
• Jungle
• Desert
• Sea State
• Weather
• Time</td></tr>
<tr><td rowspan="2">Database</td><td>Crew</td><td>• Knowledge base
• Experience Base
• Physical Fitness
• Mental Robustness
• Endurance
• Stress Level</td><td>Crew Capabilities</td><td rowspan="2">Derived Capabilities (Available)</td></tr>
<tr><td>Technology</td><td>• Speed
• Rate of Climb
• Endurance
• Hover</td><td>Machine Capabilities</td></tr>
</table>

Figure 1. Inputs, attributes and outputs of proposed pre-mission analysis decision support system. Sinha et al (2001) [4]

With time being critical in helicopter emergency medical operations, Sinha et al. (2002) [4] identified a need to automate the evaluating methodologies and to integrate these into a decision support system. Identified was a module that automated the analysis of the crew factors that contribute to mission accomplishment.

Past studies on human factors have focused on issues such as the behavior, physiological and psychological state of crew (Weiner and Nagel; 1988) [5]; but none have addressed the crew factors that contribute to mission accomplishment. Today these issues are critical in military and medical missions. In this paper a methodology to evaluate the crew capability required for helicopter emergency medical service operations is discussed.

Revised Methodology

Air-ambulance medical emergency operations involve critical life-saving decisions. Pre mission analysis and in-flight changes to mission plans are entirely based on the knowledge and experience of the flight crew and medical staff. No computing tools currently exist to aid in this analysis. The present operating procedure for pre-mission analysis is to some extent subjective and can be open to decisions being influenced by emotions and the ever-present urgency of helicopter emergency medical operations.

The study of crew capabilities is challenging. Crews are eligible and qualified for service with helicopter emergency medical operators based on successful completion of approved training courses. Local air and medical regulatory authorities define minimum competency standards and experience levels for the crew to be operational. Once in service, the crew gain experience and enhance knowledge through internal training programs and assigned operational tasks. These govern the crew capabilities and hence capabilities are either enhanced or remain dormant depending on the active service of the crew.

In addition to knowledge and experience there are other factors that contribute to the crew's capabilities. These include physical and mental fitness, endurance and each individuals ability to cope with stress. Each of these factors contributes to the crew's capabilities and when integrated can provide the overall capability. The crew capability evaluation considers the factors listed below. These factors are a key contributor to mission accomplishment.

- Knowledge: Local air and medical authorities regulate training requirements and curriculum. Crew must meet requirements in order to be eligible to operate;
- Experience: Minimum experience levels are set by regulatory authorities for the crew. Experience is gained thru training and practical involvement in missions;
- Physical Fitness: Annual physical health checks ensure that crew members meet required levels of physical fitness for missions;
- Mental Robustness: Represents the crew's capacity to remain stable, concentrate and think clearly while on the mission. Excessive stress greatly reduces this capability;
- Endurance: The capacity of the crew to concentrate and perform for an extended time. Fatigue greatly influences endurance; and
- Stress Level: Stress can lead to anxiety and degradation in crew performance. Hence, stress must be kept to an acceptable level.

The above factors and their sub-factors need to be investigated for their inter and intra relationships in relation to how they impact mission accomplishment. To quantify the relationships [5] a binary scale is applied to indicate whether or not a relationship exists between a pair of crew factors/sub-factors. To illustrate the quantification process; the crew factors are considered in accomplishment of a search and rescue mission of helicopter emergency medical operations. The value '1' is assigned to the pair of crew factor being considered, when an inter-relationship exists, or alternatively the factors are interdependent for mission accomplishment. The value '0' is assigned where no inter-relationship exists. The result of the quantification process is presented in Table 1. The process needs to be repeated separately for all the factors relevant to other medical missions such as first aid, resuscitation and recovery or patient transfer.

Table 1. Binary quantification process of crew capability factors in a search and rescue mission

CF1	0	1	0	1	0	1
CF2	1	0	0	1	1	1
CF3	0	0	0	1	1	0
CF4	1	1	1	0	1	1
CF5	0	1	1	1	0	1
CF6	1	1	0	1	1	0
	CF1	**CF2**	**CF3**	**CF4**	**CF5**	**CF6**

Where:
CF1 :Knowledge; CF2 :Experience;
CF3 :Physical fitness; CF4 :Mental robustness;
CF5 :Endurance; and CF6 :Stress level

Where a relationship exists further classification can be made to indicate its relative importance in mission accomplishment, which may be an indirect measure of the importance of the attribute being analysed. Originally a scale of '1 to 3' was selected to indicate the relative importance of the relationship being considered. Use of this scale however resulted in many relationships having the same classification. The lack of differentiation prohibited effective ranking of the relationships, thereby limiting the usefulness of the process for pre-mission analysis of HEMS. For some types of mission the three-tier scale resulted in up to three of the six attribute relationships sharing the same ranking. Consequently a five level classification system has been developed and is summarised in Table 2

Table 2. Classification of crew capability interdependence

Significance	Assigned Value
The relationship has no influence on the outcome of mission – mission continues.	1
The relationship is only slightly beneficial to mission accomplishment	2
The relationship aids mission accomplishment.	3
The relationship significantly contributes to mission accomplishment	4
Mission cannot be accomplished without the relationship (mission aborted).	5

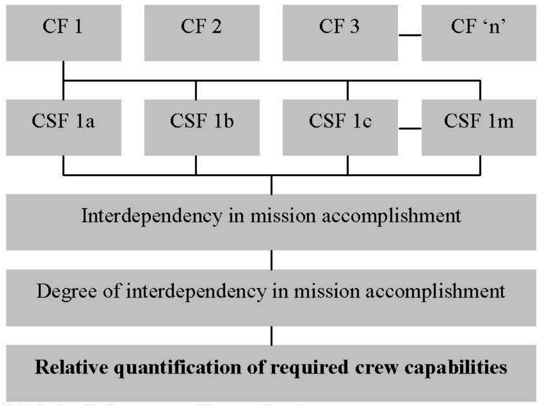
The degree of interdependency of the crew factors is then aggregated and normalised relative to its contribution to mission accomplishment (%). The aggregated result of each crew factor denotes a "mission accomplishment value". The mission accomplishment value is then normalised to evaluate the relative degree of the crew capability factor that is required for mission accomplishment. The relative quantification of required crew capability factors in a search and rescue mission of helicopter emergency operations is presented in Table 3.

Having developed a methodology to quantify the crew factors required for helicopter medical emergency operations, a framework can be developed. The framework comprises of steps to evaluate and quantify the crew capabilities. This is presented in Figure 2.

Table 3. Relative quantification of the required crew capability factors in a search and rescue mission

CF1	0	5	0	1	0	3
CF2	5	0	0	4	3	4
CF3	0	0	0	2	4	0
CF4	1	4	2	0	4	4
CF5	0	3	4	4	0	3
CF6	3	4	0	4	3	0
MV	**9**	**16**	**6**	**15**	**14**	**14**
NV	**12**	**22**	**8**	**20**	**19**	**19**
	CF1	**CF2**	**CF3**	**CF4**	**CF5**	**CF6**

Where:
MV :Mission accomplishment value; and
NV :Normalised mission accomplishment value;



CF1 to 'n' : Crew factors
CSF 1a to 1'm' : Crew sub-factors

Figure 2. Framework for relative quantification of the required crew capability factors

<u>Results and discussions</u>

A methodology has been developed that transforms the qualitative crew capability requirements into a quantitative measure for helicopter medical emergency operations. A framework has also been developed to identify the processes within the methodology.

In search and rescue missions, the crew factors of experience and mental robustness contribute the maximum towards mission accomplishment, and together account for 44% of the capability requirements. These are followed by endurance and stress with a combined ranking of 36%.

The quantification process outlined in this paper uses a series of matrices on a binary and tertiary scale, to quantify crew factors in terms of their interdependency for mission accomplishment. The assignment of an interdependence value is subjective and governed by the operational experience of the assigner. It was originally planed to have the exercise completed by a set of highly experienced crew and the results averaged for further analysis. However, upon further consideration it is thought that this to will be subjective. It is now proposed that the subjectivity of the results can be reduced by a survey using carefully worded questions that address the crew attributes and their contribution to mission accomplishment. HEMS crew would then respond to the questions using 1-5 scale score (5: strongly disagree, 4: disagree, 3: uncertain, 2: agree, 1: strongly agree). The results of these surveys could then be compiled to quantify the attributes without the subjectivity associated if only a handful of people conducted the exercise.

At this stage crew capability sub-factors have not been investigated. Sub-factors need to be identified an the process used to analyse the interdependence of a pair of factors needs to be repeated for the sub-factors. A methodology is required to integrate the results of interdependency analysis of the sub-factors.

In terms of the system framework developed by Sinha et al. (2001) [3] this research presents a methodology that addresses defining the required crew capabilities for helicopter emergency medical service operations. However in order to integrate a crew capability module into the proposed decision support system, research is required to develop effective methodologies that enable the crew members capabilities in each of the identified factors to be readily measured.

Concluding remarks

A methodology has been developed to evaluate the crew capability requirements for pre-mission analysis of helicopter emergency medical operations.

Significant feedback from a variety of operators within air ambulance services is essential to refine the quantification process and verify the results.

Research is needed to develop effective methodologies that will enable the crew member's capabilities in each of the identified factors to be readily measured. This will allow crew capabilities to be assessed against those required and permit the development of a human threshold module for integration into a pre-mission analysis decision support system.

If successful this process has potential for application in other aviation operations for identifying risks directly associated with specific types of flights or mission. This will contribute significantly in enhancing aviation safety.

References

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