AN AUTOMATED SYSTEM FRAMEWORK FOR PRE-MISSION SUCCESS EVALUATION OF MEDICAL EMERGENCY HELICOPTERS OPERATIONS – DEFINED MISSION CAPABILITY SUB-MODULE

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Abstract

Helicopter medical emergency services are required, when time, accessibility and medical attendance are critical factors in life saving. Analysis of the mission to support critical decisions is important for mission success. Presently, pre-mission analysis for decision support are dependent on crew-judgment, and hence, prone to human and machine operation error. A system methodology for a holistic pre-mission analysis has been developed for crew decision support. For holistic analysis, the factors considered in the methodology are operational, human and machine. Due to a small time frame for critical decision-making, the system methodology for pre-mission analysis needs to be automated for time-based accurate decision support. In this paper, the overview of an automated pre-mission success analysis is presented, followed by detailed discussion on the development of 'Defined Mission Capability Analysis' (DFCA) sub-module. The DFCA sub-module is designed to identity the capabilities required to ensure mission success.

1 Introduction

Helicopter medical emergency services are vital in life saving where time, accessibility and medical attendance are critical factors to mission success [1]. The degree, to which a mission can be accomplished, depends on the operational needs, environmental needs, crew competence and machine performance [2]. Pre-mission analysis of helicopter medical emergency that considers factors such as operation, environment, human, and machine is required to determine the degree of mission success and support critical mission decisions. Presently, these factors, when considered for decision support, are sketchy and based on the knowledge and experience level of crew [3]. A "decision support system" is required, to holistically consider these factors for mission analysis [4].

Sinha et al. [5] adopted a system approach to develop a 'Medical Mission Analysis System' (MMAS) to facilitate the pre-mission

analysis of helicopter medical emergency. The MMAS was conceptualised in an 'input-process-output' configuration [6]. The approach considered the operational needs and the environmental conditions of the helicopter as the key 'inputs'. The 'process' identified the defined and derived mission capabilities of medical emergency missions; and the 'outputs' were the mission accomplishment of the medical emergency mission. The factors considered for realistic analyses that governs the mission accomplishment are as follows: (a) operational requirement; (b) environmental condition (c) human capacity; (d) technological state; (e) crew competence; and (f) machine performance.

With time being a critical factor in medical emergency missions, the MMAS developed by Sinha et al [5] needs to be automated for time-based analysis and critical decision support. To facilitate automation, a system framework for an 'Automated Medical Mission Analysis System' (AMMAS) was developed by Sinha et al. [7]. The AMMAS system framework is based on an 'Integrated Decision Support System' concept [8]. In this paper, the overview of AMMAS system framework is presented, followed by detailed discussion on the designed of 'Defined Mission Capability Analysis' (DFCA) sub-module. The DFCA sub-module considers the operational needs, environmental conditions, human and technological thresholds to identify the capabilities required for medical emergency mission accomplishment.

2 System Methodology

Sinha et al. [5] adopted a system approach to develop the 'Medical Mission Analysis System' (MMAS). The MMAS is conceptualised in a typical input-process-output configuration [6]. The key inputs consist of the following: (a) operational and environmental needs; (b) the threshold levels of human capacity & technological state; and (c) crew competence and machine performance. The output of MMAS is to evaluate the degree of mission accomplishment of medical emergency service helicopters. The processes slated for the MMAS was to identify "mission systems" that provide mission capability to meet the mission requirements. The mission requirements are translated from the operational and environmental needs. To analyse the mission accomplishment, the 'define mission capabilities' and 'derived mission capabilities' need to be analysed. The 'defined mission capabilities' analysis is based on the threshold levels (human & technology) and needs (operational & environmental), whilst the 'derived mission capabilities' is analysed from database (crew and helicopter) that provide the levels of crew competence and helicopter performance. The defined and derived capabilities, when integrated are to meet the slated mission requirements for mission accomplishment. The system structure of MMAS is presented in Figure 1.

The mission requirements are identified by

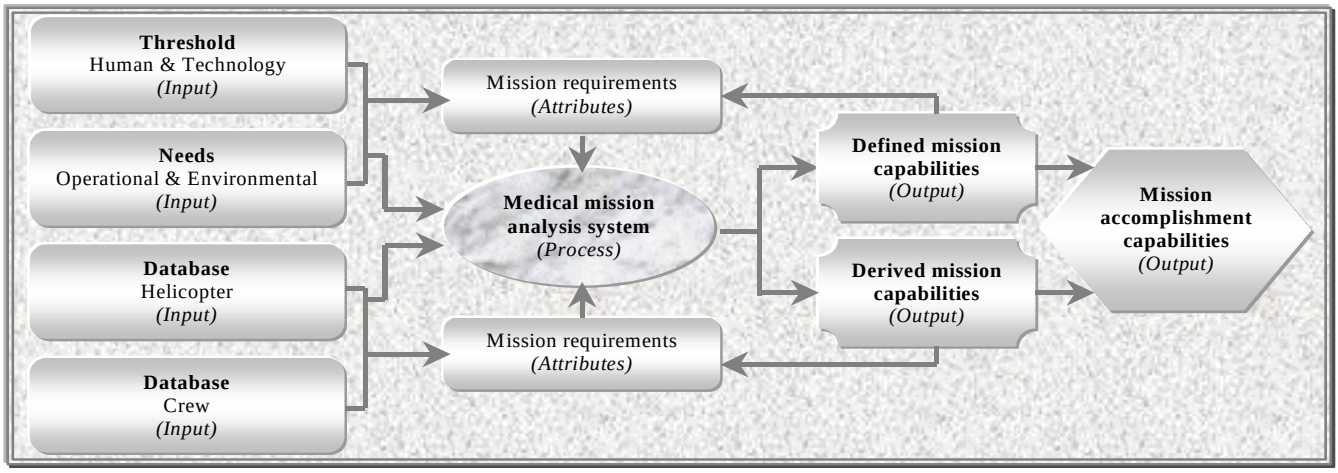

Figure 1. System configuration of medical mission analysis system

the translation of the threshold levels, operational & environmental needs, crew competence and machine performance in mission-related terms. The mission requirements are the attributes (functional characteristics) of the developed MMAS. The operational and environmental aspects were established based on researched by Sinha et al. [9]. The identified inputs, mission requirements and outputs of the MMAS are presented in Table 1.

With the MMAS system configured, the system elements – components, attributes and relationships can be identified [10]. The components consists of 'threshold analysis' to study the threshold of human capacity and technology limitations; 'database' to store information on crew competency and helicopter performance; and 'needs analysis' to study the mission requirements in search and rescue, first aid, resuscitation and recover, and transfer. The study of human aspects comprises of knowledge, experience, physical fitness, mental robustness, endurance, stress level and risk level. The helicopter performance can be studied by considering the speed, rate of climb, endurance and hover.

Table 1. Inputs, attributes and outputs of medical mission analysis system

<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
• Risk level</td><td>Human capabilities</td><td rowspan="4">Defined capabilities</td><td rowspan="5">Mission accomplishment capabilities</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
• Risk level</td><td>Crew capabilities</td><td rowspan="2">Derived capabilities</td></tr>
<tr><td>Helicopter</td><td>• Speed
• Rate of climb
• Endurance
• Hover</td><td>Machine capabilities</td></tr>
</table>

The relationships between the components and attributes needs to be considered as inter and intra – components & components; components & attributes; and attributes & attributes. The operational environment ranges from different terrain, weather to time of operation. The system structure of MMAS considering the system elements discussed, is presented Figure 2.

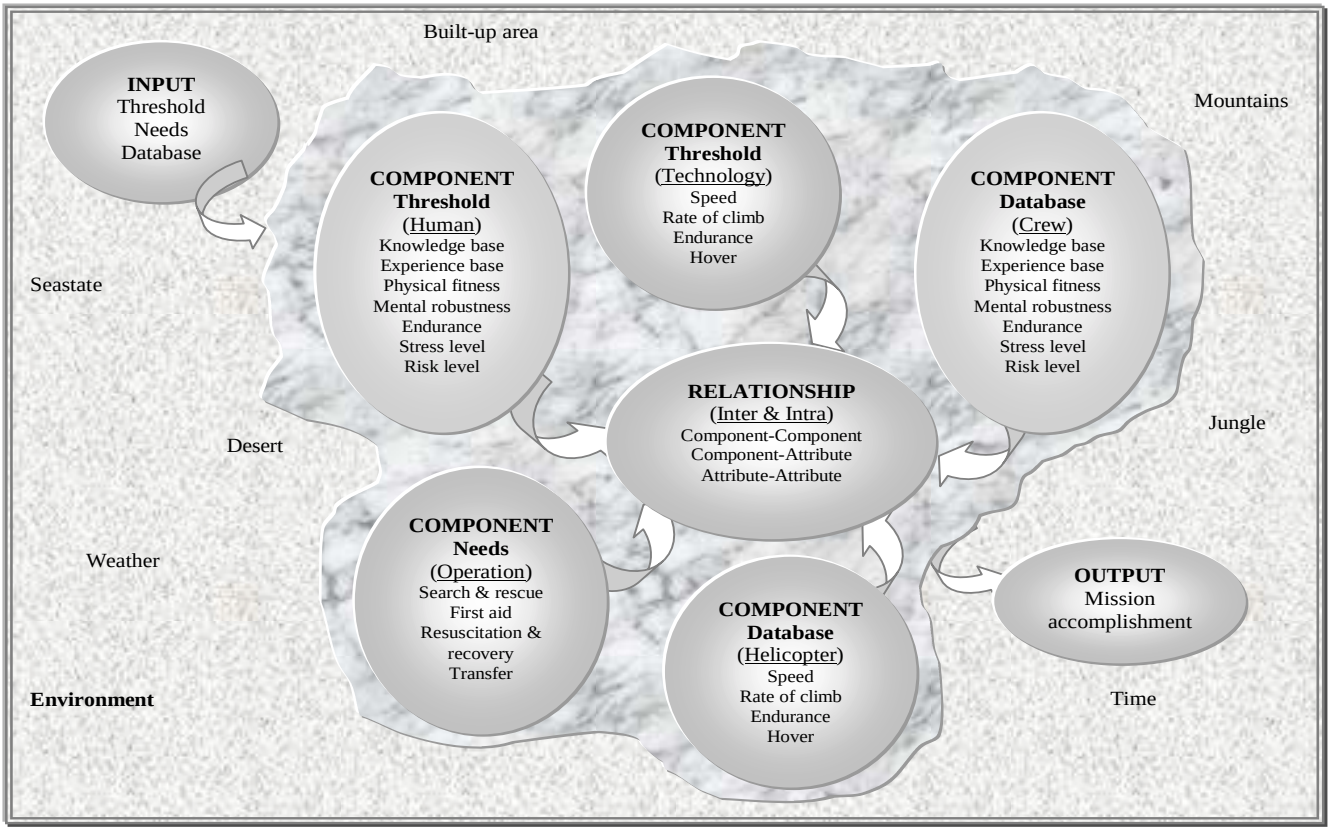

Figure 2. System structure of medical mission analysis system

2.2 Automation of System Methodology

Having formulated the system structure of MMAS from a systems perspective, the framework for an 'Automated Medical Mission Analysis System' (AMMAS) is developed. The modules of the AMMAS were identified from the MMAS system components; and the attributes were designated as functions of the modules. The AMMAS modules and their slated functions are as follows:

- **Man Machine Interface (MMI):** Retrieve operational and environmental needs, and human and technological thresholds;
- **Defined Mission Capability Analysis (DFCA):** Define the required mission capabilities from the slated operational and environmental needs;
- **Derived Mission Capability Analysis (DRCA):** Derive the available mission capabilities from the helicopter and crew configuration for the mission;
- **Database:** Store operational doctrines, helicopter specification and crew data;
- **Pre-Mission Success Evaluation (PMSE):** Evaluate the degree to which the derived capabilities meets the defined capabilities, for computation of mission success probability;
- **Critical Decision Acceptance (CDA)**: Analyse the acceptance level of mission success probability and the robustness of computed results; and
- **Pre-Mission Success Remediation (PMSR):** Produce alternative solutions

to increase mission success probability and robustness of computed results.

With the modules and their functions identified the AMMAS framework is developed to facilitate time-based-robust decision in medical emergency mission. The AMMAS system framework is presented in Figure 3.

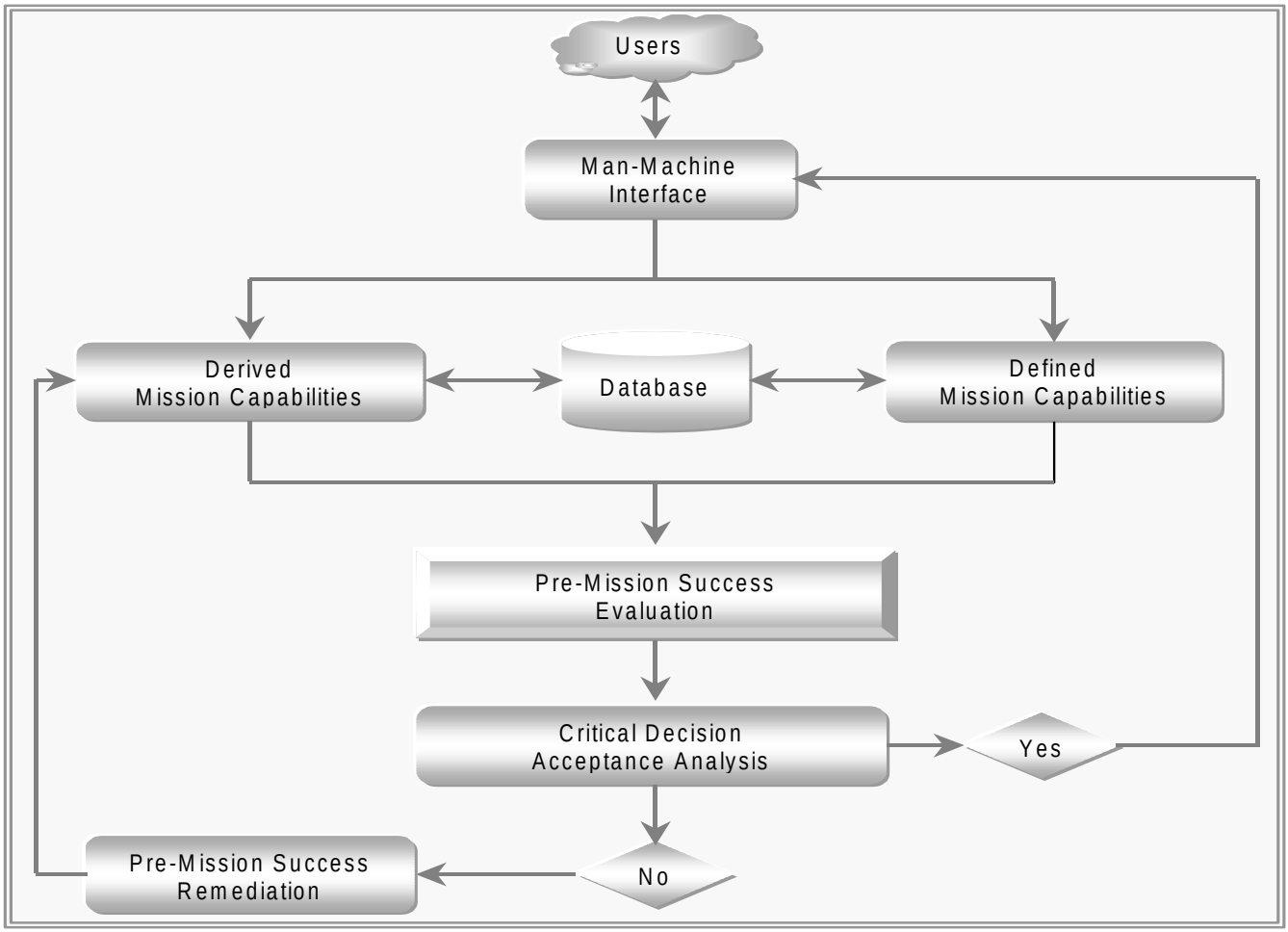

Figure 3. System framework for an automated medical mission analysis system

3 Defined Mission Capability Analysis

The AMMAS sub-module that identifies the required capabilities for mission accomplishment is the 'Defined Mission Capability Analysis' sub-module (DFCA). The DFCA is to receive inputs from the MMI sub-mudule and Database sub-module; and provide outputs to the PMSE sub-module. The inputs from the MMI sub-module are the operational needs, environmental conditions, crews and aircraft considered for the mission. The Database sub-module provides information on crew charateristcis and aircraft specifications. The output of the DFCA sub-module is a list of mission capabilities that are required to ensure mission accomplishment.

With the inputs and outputs of the DFCA sub-module in place, a process needs to be devised for transformation of the inputs into outputs. The operational needs and environmetal conditions slated by the user are to be initially transformed to mission requirements. A detailed study of the operational needs and their related mission expectation (Table 1) provided the means to transform the operational and environmemtal needs to mission requirements. The human and technological thesholds are considered to match the mission requirements. The DFCA sub-module then integrates the slated mission

requirements with the human and technological thresholds, to identify the required mission capabilities. The required mission capabilities is refered as 'defined mission capability'.

Having identified the functions of DFCA sub-modules, the system framework is developed to facilitate automation of required capability analysis. The DFCA system framework is presented in Figure 4.

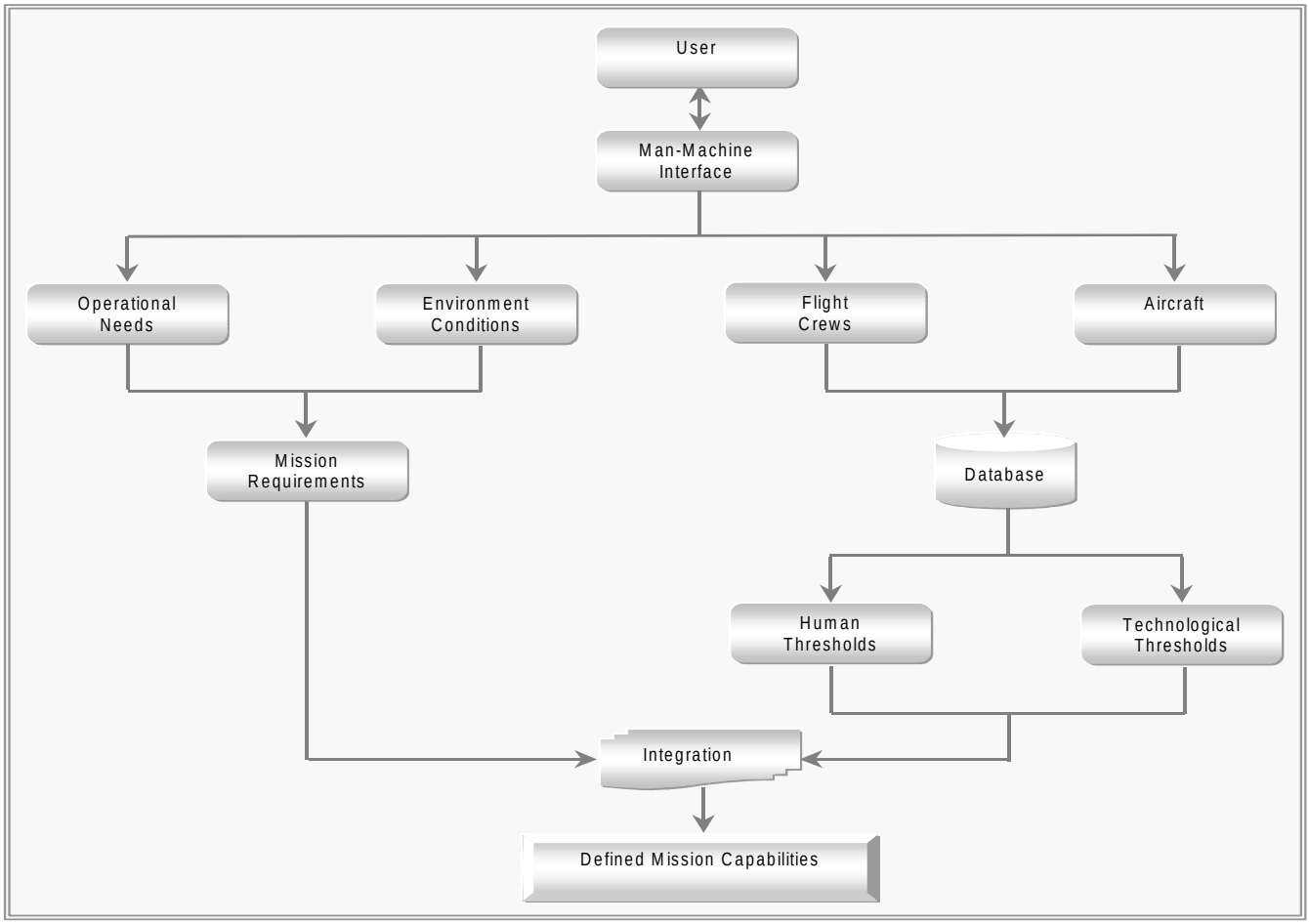

Figure 4. System framework for Defined Mission Capability Analysis

4 Results and Discussion

A comprehensive framework has been formulated for the development of a 'Defined Mission Capability Analysis' (DFCA) sub-module. The DFCA functions consist of the following: (a) Mission requirements analysis; (b) Human thresholds analysis; (c) Technological thresholds analysis; (d) Integration of mission requirements and thresholds; and (e) Required mission capability identification.

The AMMAS framework is on a generic format, hence, the application is wide to cover different medical helicopters and missions. The remaining AMMAS sub-modules need to be designed for synergistic integration, to provide the avenue for the development of a user-friendly software-based decision support system.

5 Conclusion

The system methodology of MMAS provides the base to develop a decision support tool for pre-mission success evaluation of medical emergency service operations. The automation framework of MMAS developed by adopting a system approach is generic and can be customised to suit various medical

helicopters. The DFCA sub-module facilitates the automation to define the required mission capability. The identification process involves a holistic analysis of mission requirements, human and technological thresholds.

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