AUTOMATION OF PRE-MISSION SUCCESS EVALUATION MODULE FOR MEDICAL EMERGENCY HELICOPTERS OPERATIONS

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Abstract

Time, accessibility and medical attendance are all critical factors in the life saving operations performed by helicopter medical emergency services. The pre-mission analysis of these factors and more is critical if the mission is to be successful. Presently, such analysis depends upon crew-judgment and as such is prone to human error. A holistic pre-mission analysis system which supports such critical crew decisions is proposed. The factors considered for analysis by such a system are operational, human and technological. As the decision making process is time critical, the methodology for pre-mission analysis must be automated. Presented is an overview of such an automated system.

1 Introduction

The nature of helicopter medical emergency service (HEMS) operations, denote that time, accessibility and medical attendance are all critical life saving factors [1]. HEMS mission success depends upon the timely analysis of the operational needs, environmental conditions, crew competence and machine performance [2]. As such a “decision support system” is required, to holistically consider these factors for mission analysis.

Sinha et al. [3] adopted a systems approach to develop a ‘Medical Mission Analysis System’ (MMAS) which facilitated the pre-mission analysis of HEMS operations. The MMAS was conceptualised as an ‘input-process-output’ configuration [4]. The approach considered the operational needs and the environmental conditions of the helicopter as the key ‘inputs’. The ‘process’ identified the required/defined and available/derived mission capabilities; and the ‘output’ was the mission accomplishment feasibility. The factors considered by the MMAS were: (a) operational requirements; (b) environmental conditions (c) human capacity; (d) technological state; (e) crew competence; and (f) machine performance.

As the HEMS decision making process is time critical, an ‘Automated Medical Mission Analysis System’ (AMMAS) was explored by Sinha et al. [5][6][7][8]. The AMMAS is based on the ‘Integrated Decision Support System’ concept developed by Kusumo et al. [9] (Fig. 1).

2 MMAS System Methodology

Originally the purpose of the MMAS designed by Sinha et al. [5] was to identify “mission systems” that would provide the capability to meet the mission requirements. Mission requirements are translated from the operational and environmental needs, and the feasibility of mission accomplishment, derived from the analysis of ‘defined mission capabilities’ and ‘derived mission capabilities’. The analysis of defined mission capabilities being based upon threshold levels (human & technology) and

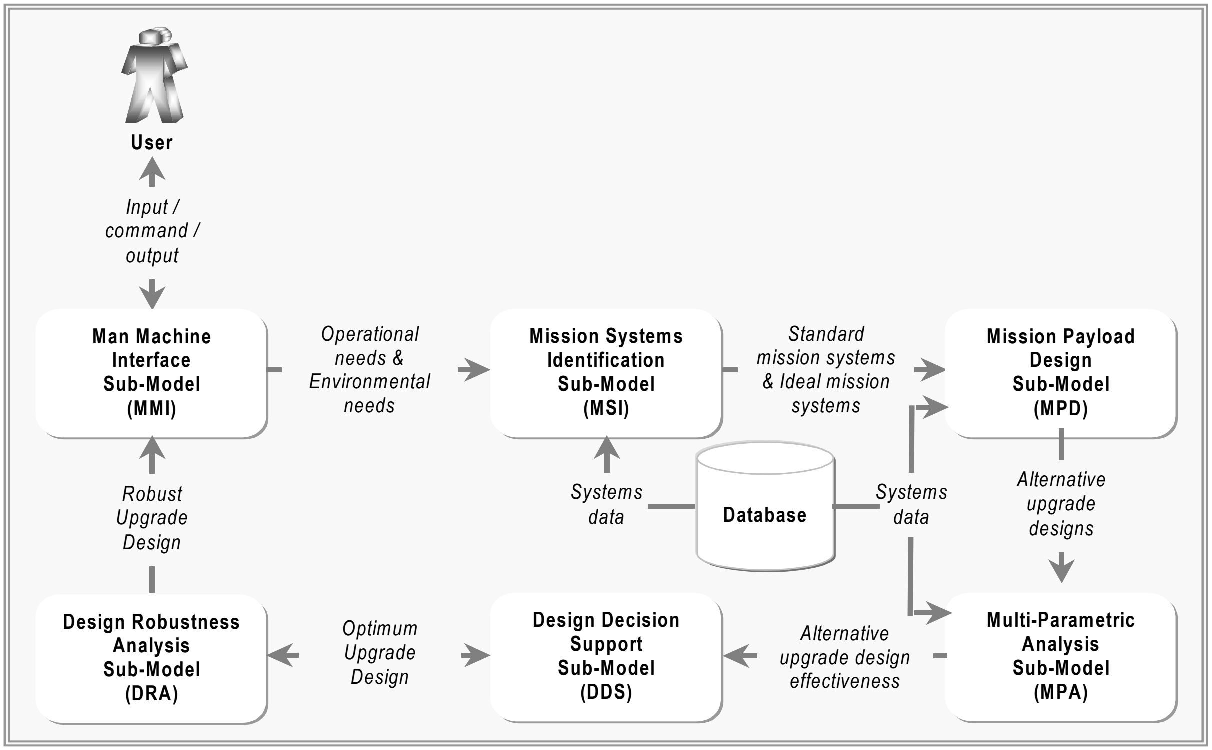

Fig. 1. Framework of an Integrated Decision Support System for Automation of Systems Methodology for Mid-life Upgrade

needs (operational & environmental), whilst the 'derived mission capabilities' analysis is based upon the database (crew and helicopter) which provides the levels of crew competence and helicopter performance. The mission success feasibility is the result of integration of the defined and derived capabilities. This system structure of the MMAS is presented in Figure 2.

The mission requirements are recognised by the translation of the human & technology threshold levels, operational & environmental needs, crew competence and machine performance in mission-related terms. The mission requirements are the attributes or functional characteristics of the MMAS. The operational and environmental aspects were established based on the research of Sinha et al. [3]. The identified inputs, mission requirements and outputs of the MMAS are presented in Table 1.

The system elements - components, attributes and relationships are identified from the MMAS system configuration [10]. The components consists of 'threshold analyser' to study the human capacity and technology limitations; the 'database' to store information on crew competency and helicopter performance; and the 'needs analyser' to study the operational needs. The study of human factors comprises of knowledge, experience, physical fitness, mental robustness, endurance, and stress level.

Relationships between the components and attributes are considered as inter and intra – components & components; components & attributes; and attributes & attributes. The operational environment ranges from different terrain, weather and time of operation and helicopter performance is measured by speed, rate of climb, endurance and hover. The system structure of MMAS is presented Figure 3.

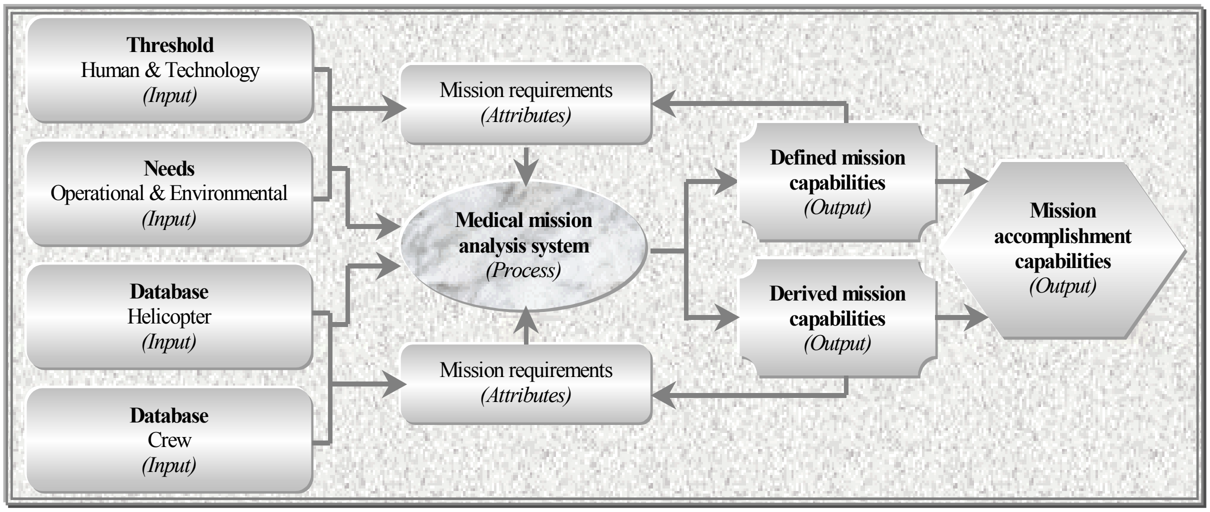

Fig. 2. System configuration of medical mission analysis system

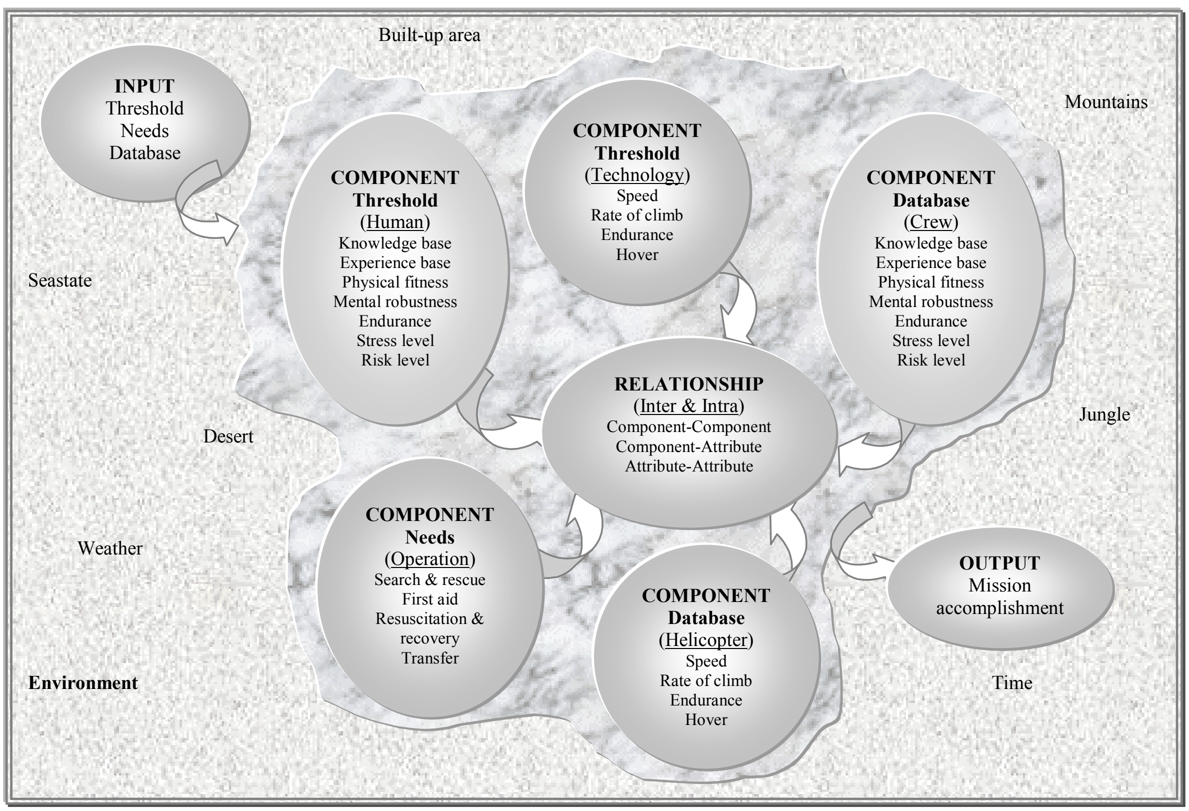

Fig. 3. System structure of medical mission analysis system.

<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</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>

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

3 AMMAS System Methodology

The modules of the AMMAS were identified from MMAS system components; and the attributes were designated as as functions of the modules. The AMMAS modules and their slated functions are as follows:

- **Man Machine Interface (MMI):** To receive the operational needs and environmental conditions, and human and technological thresholds inputted from the user ;
- **Defined Mission Capability Analysis (DFCA):** To define the required mission capabilities from the slated operational and environmental needs;
- **Derived Mission Capability Analysis (DRCA):** To derive the available mission capabilities from the helicopter and crew configuration for the mission;

- **Database:** To store operational doctrines, helicopter specification and crew data;
- **Pre-Mission Success Evaluation (PMSE):** To evaluate the degree to which the derived capabilities meets the defined capabilities, for computation of mission success probability;
- **Critical Decision Acceptance (CDA)**: To analyse the acceptance level of mission success probability and the robustness of computed results; and
- **Pre-Mission Success Remediation (PMSR):** To 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 framework is presented in Figure 4.

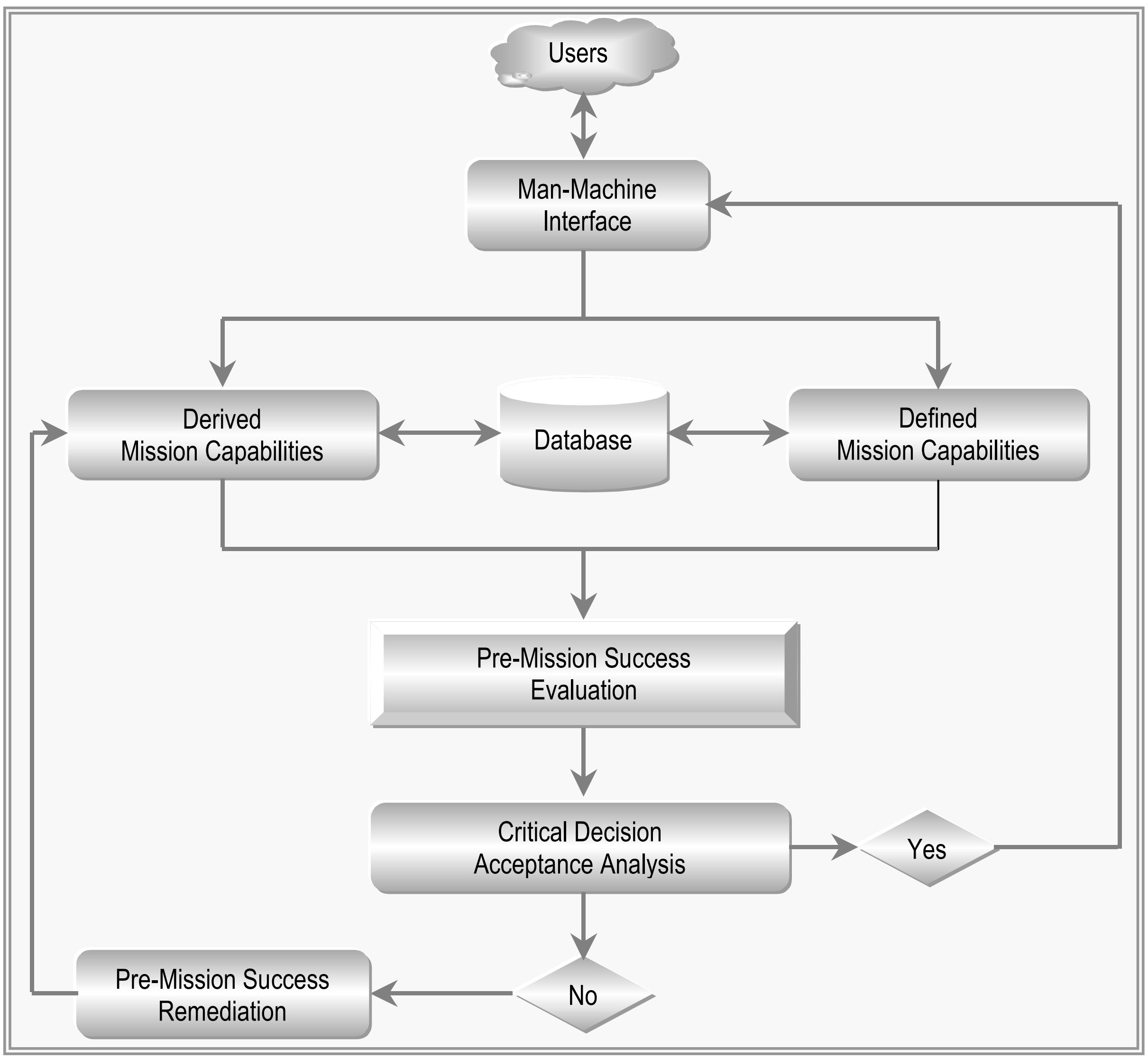

Fig. 4 System framework for an automated medical mission analysis system

4 Issues and challenges

To address the issues and challenges of supporting critical mission decisions by crew, the AMMAS needs to automate the acceptability analysis of the mission. The acceptability analysis considers the probability of mission success and operational risks to the flight crew and paramedics. The AMMAS sub-module that automates the mission accepability analysis is the 'Critical Decision Acceptability' (CDA) sub-module. To facilitate automation, the CDA sub-module receives inputs consisting of: (a) Probability of mission success from PMSE sub-module; (b) Operational needs and environmental condition from MMI sub-module; and (c) Crew / paramedic condition and human thresholds from the Database. The output of CDA sub-module is a high degree of mission acceptability that ensures high probability of success and minimum risks to the safety of the flight crew and paramedics.

To transform the inputs into outputs, the process of CDA sub-module initially derived the mission requirements from the operational needs and the environmental condition. The mission requirements were then compared with the crew and paramedic capability, to determined the shorfalls in crew capability to meet the mission requirements. The crew and paramedic capability are governed by their physical and mental condition at the time of operation; such as alertness, ability to handle stress, knowldege, etc. Having identified the shortfalls in crew and paramedic capabilities, the operational risks were then analysed to determine the potential hazards to crew and paramedics. With the operational risks identify and the probability of mission success retreived from PMSE sub-module, the acceptability of the medical emergency operation can be established. The acceptability analysis involves analysing the viable limits of the operational risks and the probability of mission success. The decision for operation 'go / no-go' is obtained by benchmarking the operational risk and probability of mission success against their respective viable limits. If the result is unacceptable, the operational parameters are fed to the PMSR sub-module, where the operational risk and the probability of mission success is optimised. Alternatively, the parameters of acceptable result is relayed to MMI sub-module for user decision support.

Having identified the functions of CDA sub-modules, the system framework is developed to facilitate automation of mission acceptability analysis to address the issues and challenges in decision making by crew. The CDA system framework is presented at Figure 5.

5 Results and Discussion

A comprehensive framework to address the issues and challenges of supporting critical mission decisions by crew has been formulated by the development of a 'Critical Decision Acceptance' (CDA) sub-module. The CDA functions consist of the following: (a) Capability analysis; (b) Crew capability shortfalls identification; (c) Operational risk analysis; and (d) Mission acceptability analysis. The results of CDA sub-module supports the user in decision making based on the pre-mission analysis.

The AMMAS framework is built around a generic design, hence its application to varying missions is broad. The AMMAS sub-modules need to be synergistically integrated, to provide an avenue for the development of a user-friendly software-based decision support system.

The CDA sub-module when developed through follow-on research will address the issues and challenges that face the crew in decision-making. The automated analysis output of the CDA sub-module will provide the confidence to the crew in critical decision-making.

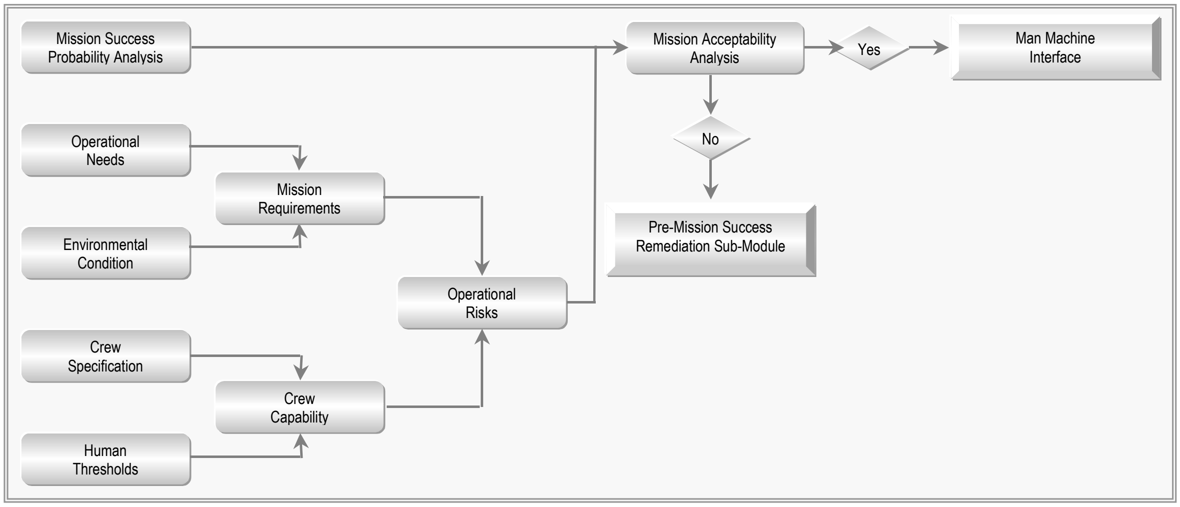

Fig. 5 System framework of Critical Acceptability Sub-Module.

6 Concluding Remarks

The system methodology of the MMAS provides the base to develop an automated 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 CDA sub-module facilitates to address the issues and challenges to critical mission decisions by crew by automating the acceptability of medical emergency operations based on probability of mission success and the operational risks to crew and paramedics. The analysis involves holistic studies of crew and paramedics capability shortfalls, viable limit of operational risk, and mission acceptability.

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