An Automated System Framework for Pre-Mission Success Evaluation of Medical Emergency Helicopters Operations – Pre-Mission Success Evaluation Sub-Module

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Abstract

Helicopter medical emergency services are resorted to, when time, accessibility and medical attendance are critical factors in life saving. Time-based mission analysis to support decisions is critical for mission accomplishment. Presently, pre-mission analysis for decision support is crew-judgment dependent; and hence, prone to human errors. A systems methodology to holistically analyse mission and support crew decisions has been developed. The factors considered for analysis are operational, human and machine. As decision are time critical, the system methodology for pre-mission analysis needs to be automated. In this paper, the overview of an automated pre-mission success analysis is presented, followed by detailed discussion on the development of 'Pre-Mission Success Evaluation' (PMSE) sub-module. The PMSE sub-module is designed to evaluate the probability of mission success based on the available and required mission capabilities.

Introduction

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

Sinha et al. (Ref 5) adopted a systems 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 (Ref 6). 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 of medical emergency missions; and the 'outputs' were the mission accomplishment of the medical emergency mission. The factors considered for a realistic analysis of the mission accomplishment were 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 (Ref 5) needs to be automated for time-based analysis and critical decision support. To facilitate automation, an 'Automated Medical Mission Analysis System' (AMMAS) was explored by Sinha et al. (Ref 7-9). The AMMAS is based on an 'Integrated Decision Support System' concept developed by Kusumo et al. (Ref 10) (Figure 1). In this paper, the overview of AMMAS system framework is presented, followed by detailed discussion on the design of a 'Pre-Mission Success Evaluation' (PMSE) sub-module. The PMSE sub-module considers the defined and derived mission capability to evaluate the probability of success in medical emergency missions.

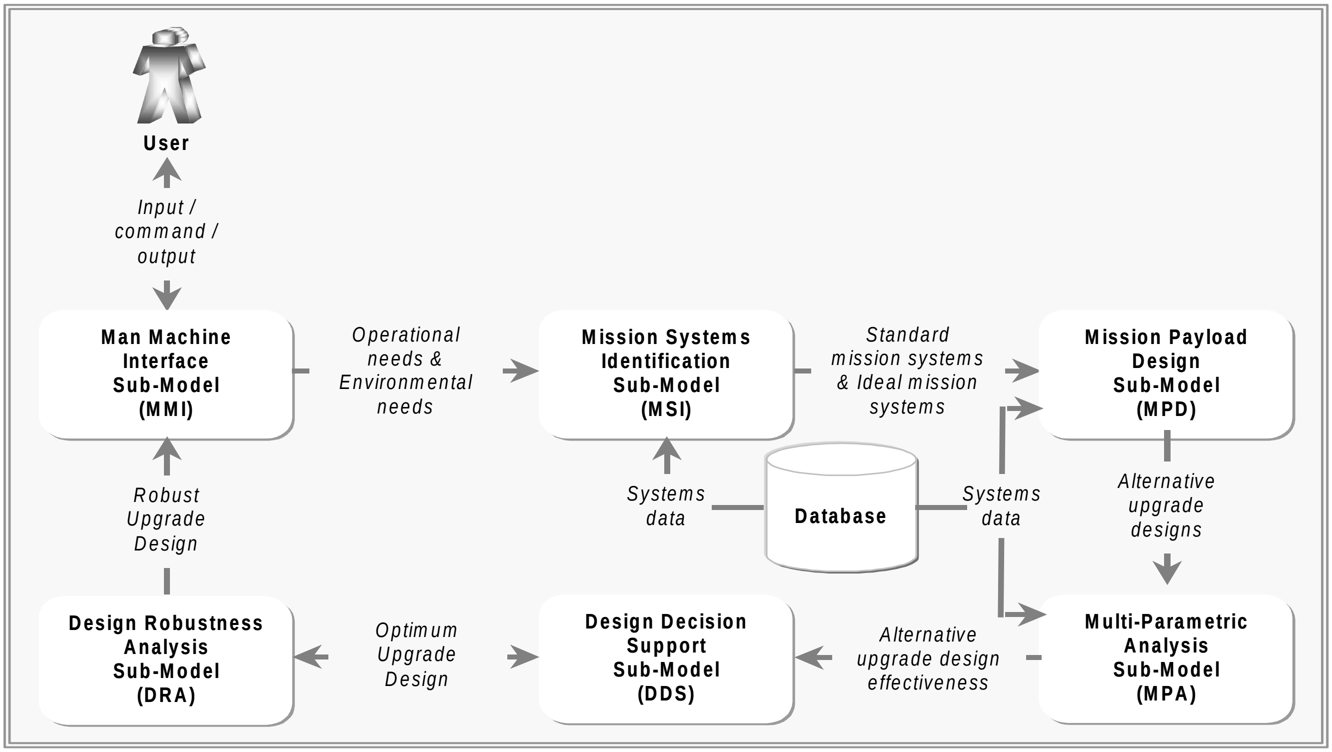

Figure 1. Framework of an Integrated Decision Support System for Automation of Systems Methodology for Mid-life Upgrade

System Methodology

Sinha et al. (Ref 5) adopted a systems approach to develop the 'Medical Mission Analysis System' (MMAS). The MMAS was conceptualised in a typical input-process-output configuration (Ref 6). The key inputs consisted 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 designated of the MMAS was to evaluate the degree of capability to accomplish the mission. The process 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 'defined 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 the database (crew and helicopter) that provide the levels of crew competence and helicopter performance. The defined and derived capabilities, when integrated; provides the degree to which the mission is accomplishable. The system structure of MMAS is presented in Figure 2.

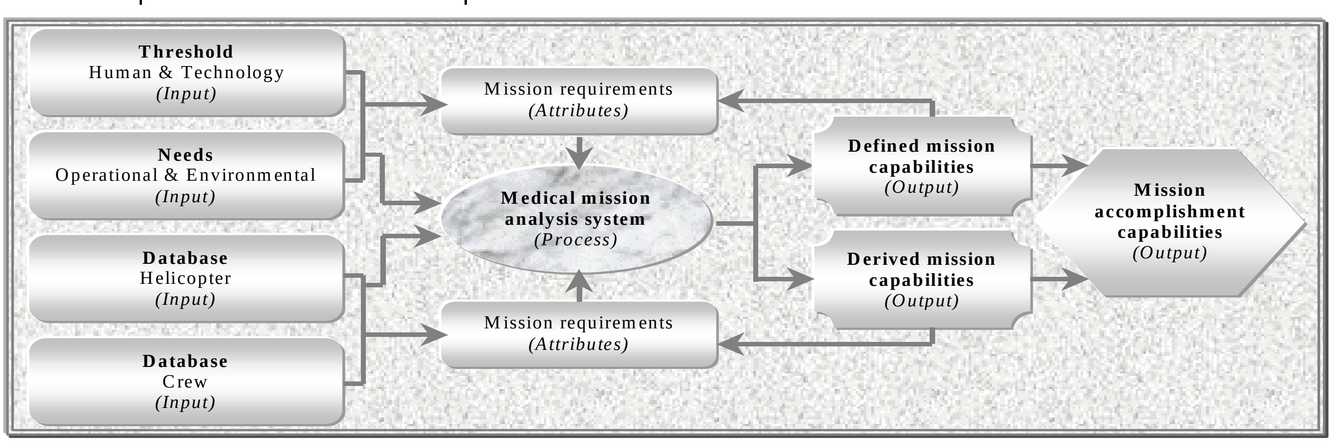

Figure 2. System configuration of medical mission analysis system

The mission requirements are identified by 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 MMAS. The operational and environmental aspects were established based on research by Sinha et al. (Ref 11). The identified inputs, mission requirements and outputs of the MMAS are presented in Table 1.

Table1. Inputs, attributes and outputs of medical mission analysis system

Inputs		**Attributes (Mission Requirements)**	**Outputs**		
Threshold	Human	• Knowledge base • Experience base • Physical fitness • Mental robustness • Endurance • Stress level • Risk level	Human capabilities	*Defined capabilities*	*Mission accomplishment capabilities*
	Technology	• Speed • Rate of climb • Endurance • Hover	Technology capabilities		
Needs	Operational	• Search & rescue • First aid • Resuscitation & recovery • Transfer	Required capabilities		
	Environmental	• Built-up area • Mountains • Jungle • Desert • Sea state • Weather • Time			
Database	Crew	• Knowledge base • Experience base • Physical fitness • Mental robustness • Endurance • Stress level • Risk level	Crew capabilities	*Derived capabilities*	
	Helicopter	• Speed • Rate of climb • Endurance • Hover	Machine capabilities		

With the MMAS system configured, the system elements – components, attributes and relationships can be identified (Ref 12). The components consists of 'threshold analyser' to study the human capacity and technology limitations; 'database' to store information on crew competency and helicopter performance; and 'needs analyser' to study the operational needs. 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. 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 3.

- **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.

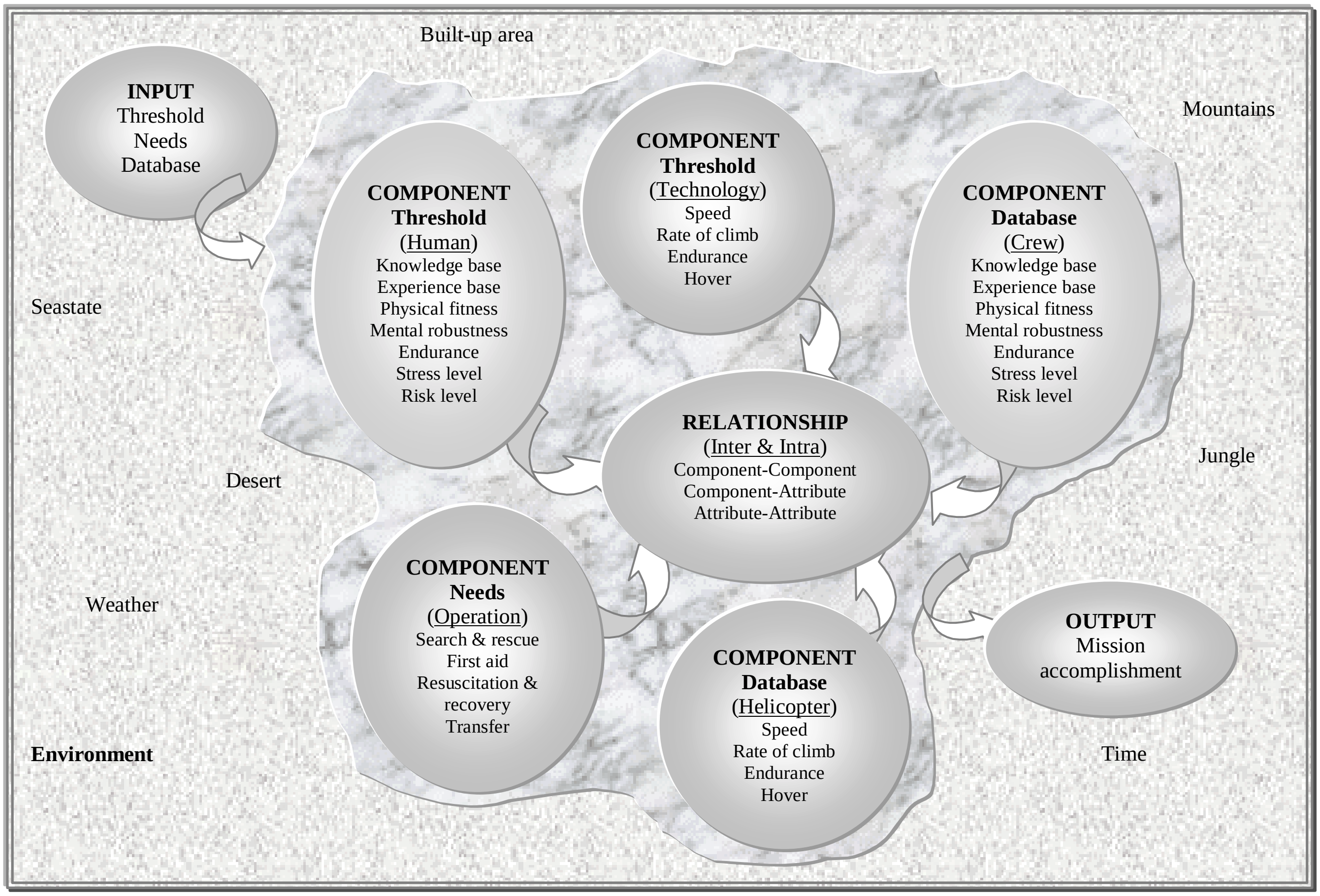

Figure 3. System structure of medical mission analysis system

<u>Automation of System Methodology</u>

Having formulated the system structure of MMAS from a systems perspective, the framework for an 'Automated Medical Mission Analysis System' (AMMAS) is explored (Ref 7-9). 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):** To retrieve operational needs and environmental conditions, and human and technological thresholds;

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 4.

procured inputs are processed into probability of mission success; as outputs. The output of PMSE sub-module provides the base for critical mission decision, governed by a pre-set benchmark.

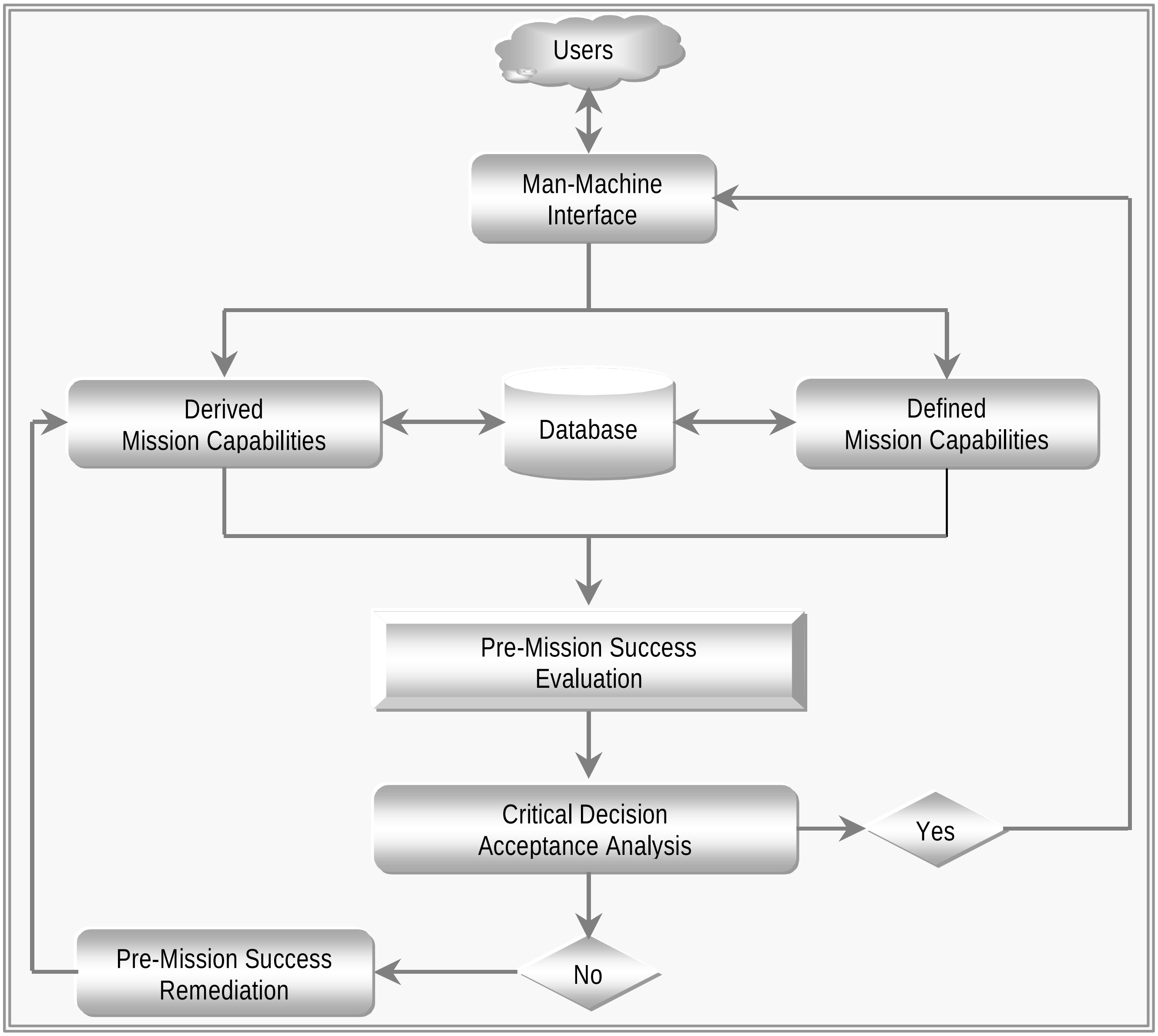

Figure 4. System framework for an automated medical mission analysis system

Pre-Mission Success Evaluation

The nucleus of AMMAS is to analyse the the probability of mission success for critical mission decision support. The AMMAS sub-module that automates the analysis of mission success probability is the 'Pre-Mission Success Evaluation' sub-module (PMSE). To facilitate automation, the PMSE sub-module receives inputs that comprises of the defined mission capability and derived mission capability from their respective sub-module. The

To transform the inputs into outputs, the PMSE process needs to be developed. The process involves a comparative analysis of the derived and defined mission capability. The comparative analysis results in the identification of the degree of mismatch in the mission capabilities. Based on the identified mismatch, the shortfalls in mission capability to meet the mission accomplishment is identified. The risk associated with the mission capability shorfalls is then analysed, to determine the impact on mission accomplishment. If the associated risk is within the acceptable limits, then remedial measures to address the shortfalls is not required. On the other hand, for associated risks that are beyond the acceptable limits, the identified shortfalls are prioritised in order of severity; followed by capability enhancement process to remediate the 'highly influencial' shortfalls. A feedback loop from the mission capability enhancement provides the means to re-analyse the enhancement in the derived mission capability. The PMSE process is iterated until the derived mission capability matches the defined mission capability or the shortfalls in mission capability inherit an acceptable risk to mission accomplishment. The final stage of PMSE process is an evaluation of the probability of mission success, which is then relayed to CDA sub-module for further analysis.

Having identified the functions of PMSE sub-modules, the system framework is developed to facilitate automation of mission success evaluation. The PMSE system framework is presented in Figure 5.

Results and Discussion

A comprehensive framework has been formulated for the development of a 'Pre-Mission Success Evaluation' (PMSE) sub-module. The PMSE functions consist of the following: (a) Comparative analysis; (b) Mission capability shortfalls identification; (c) Mission risk acceptability analysis; (d) Mission capability shortfalls prioritisation; (e) Mission capability enhancement; and (f) Mission success probability analysis. Further analysis is required to determine the acceptability of mission success probability computed by PMSE sub-module.

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

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 PMSE sub-module facilitates the automation to analyse the probability of mission success based on the defined and derived mission capability. The analysis involves holistic studies of mission capability shortfalls, mission risk acceptance, mission capability enhancement and mission success probability.

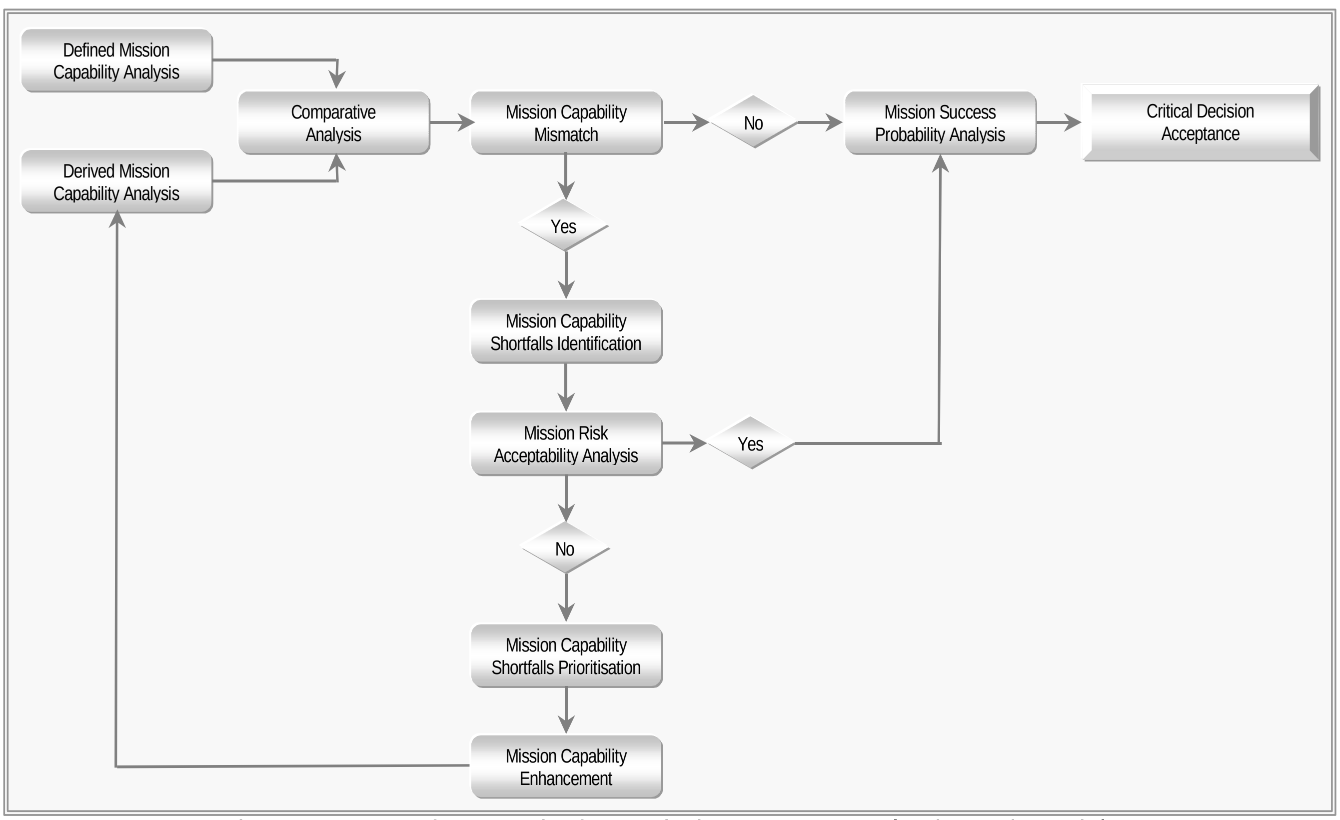

Figure 5. System framework of Pre-Mission Success Evaluation Sub-Module

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