Temasek Defence Systems Institute

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APPROACH TO ACHIEVE HIGH AVAILABILITY IN CRITICAL INFRASTRUCTURE

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Objectives

B&I is a complex domain to decipher and manage. The purpose of this research is to determine if there is a best maintenance approach coupled with the appropriate contract and management approach to ensure the high availability of critical infrastructure, through a sensitivity analysis on the operational availability to validate Koeneman (2009)'s findings that condition-based maintenance can increase availability as opposed to no-preventive maintenance and time-based maintenance.

The three key maintenance approaches for performing operations and maintenance are analyzed based on the results of the sensitivity analysis for suitability for different critical infrastructure, namely fuel, airfield, power, water, cooling, blast protection and fire protection systems. In addition, the suitability of contracts for different maintenance approaches, as well as the use of computerized maintenance management systems and configuration management are discussed for a more holistic means of ensuring high availability of critical infrastructure in the support of key military operations.

Key Ideas

Availability of systems can be impacted by the maintenance approach as well as the type of contract and its management approach. The maintenance approach is determined primarily by the maintenance approach adopted by the agency. The two approaches adopted by the NAVFAC and AFCEC, which were primarily the time-based maintenance and condition-based maintenance will be compared with the no-preventive maintenance approach.

B&I maintenance could be done in-house or through outsourced contractors. For example, NAVFAC works primarily through outsourced contractors, while AFCEC works primarily with in-house staff. With the growing dependence on outsourced contractors for maintenance activities, a key focus by the operational organizations is to manage contractors to ensure an acceptable quality of work. On the other hand, with the increasing shortage of manpower, in-house maintenance is increasingly overloaded and prioritization of tasks is required, which is clearly demonstrated by AFCEC's prioritization of PM assets, and to focus on PM and sustainment work before addressing enhancement work. The differences between the various types of contracting mechanisms and the means to ensure high availability of critical infrastructure is discussed.

Finally, a computerized maintenance management system suitable for military B&I is discussed in the context of providing an effective configuration management, maintenance management, and contracts management support. The requirements of the CMMS to enable high availability of critical infrastructure is also discussed.

Potential for follow up

An area for further research would be the manpower and personnel requirement in the implementation of the maintenance approaches. This is from both the in-house and outsourced perspective, and requires in-depth knowledge of the workings of the DOD and the U. S. building maintenance industry.

It is also recommended that further study in the use of quality assurance and audits to ensure a robust implementation of the maintenance approaches be conducted. At the same time, an in-depth study of the reliability of various systems for the selection of maintenance approaches is recommended. In particular, the use of the loss function to determine the maintenance approach could be used for other variables than risk-adjusted cost. As this thesis focuses on both the maintenance approach and the implementation using contracts, cost was the key variable used, and a more holistic study on the use of the loss function might provide more insightful analysis.

The use of risk management strategies in the selection of maintenance approaches and contracting mechanisms is also recommended as a future scope of study.

The effectiveness of various sensor used for condition-based maintenance is also recommended for future study.

Results

This thesis corroborates the research by Koeneman when the models used are adjusted for a much longer and, and a larger fpt to be consistent with ship maintenance. This validation of the infrastructure maintenance model for use with critical infrastructure confirms the functional approach, boundary conditions, and the availability assumptions used in the analysis.

The results from the sensitivity analysis shows that the availability is insensitive to both frequency of maintenance and slightly more sensitive to time to perform maintenance. However, this arises from the fact that the MTBMu and MTBMs is significantly higher than and (years as compared to days and months as compared to hours respectively).

A proper configuration management plan is recommended for critical infrastructure, and should include approval process for the use of critical infrastructure requested by cross platform systems. At the same time, there should be a single approving party as a gatekeeper for authorizing the use of the critical infrastructure. The creation a separate vote for possible upgrades and repair to the critical infrastructure are recommended.

In general, systems with observable failure can be maintained using the no-preventive maintenance approach, while the condition-based maintenance approach could also be adopted if the risk of failure is high. Further, systems with unobservable failure can be maintained using the time-based maintenance approach, while the condition-based maintenance approach could also be adopted if the risk of failure is high. Regular inspections should be scheduled and performed on all systems. Specifically, the use of the no-preventive maintenance approach for the power distribution system is recommended unless the risk due to failure of the system outweighs the cost to perform condition-based maintenance in which case the condition-based maintenance approach should be chosen for the power distribution system. The time-based maintenance approach is recommended for cooling systems unless the risk due to failure of the system outweighs the cost to perform condition-based maintenance in which case the condition-based maintenance approach should be chosen for cooling system. Blast doors, fire protection systems, water distribution systems, fuel distribution systems and airfield pavements should be maintained using the time-based maintenance approach.

A key enabler for the optimal maintenance approach is suggested by an accurate inventory management system. The system should be implemented with a good, integrated, computerized maintenance management system that fits well with the organization's process. Logically, with a good, integrated, computerized maintenance management system, the basic infrastructure to support the organization's maintenance approach would be ready. With the inventory listing, the organization can make a decision on the choice of maintenance approaches to each system. This may form the backbone of achieving the highest operational availability at the optimal cost.

The correct contracting mechanisms would also seem to be important for the implementation of the maintenance approach. The no-preventive maintenance approach requires the use of inspection and CM contracts, which can be contracted using the performance-based contract and the prescriptive contract respectively. The time-based maintenance should comprise of the use of inspection, PM and CM contracts, which can be contracted together as a single performance-based package. Condition-based maintenance should comprise the use of inspection, PM and CM contracts as a single package, of which the first two could be performance-based and the last prescriptive.

Additionally, the organization should be careful to reduce interdependent performance indicators across different contracts in the beginning of the performance-based contracts, as these may be the key areas of conflict. And, each system was analyzed using the risk-based cost analysis to identify the most suitable maintenance approach from the cost perspective . Finally, steps must be taken to reduce the MDT for all systems to optimize the operational availability, particularly in the reduction of LDT and ADT.

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