Maintenance Performance Modeling to Sustain System Operational Requirements for Complex Military Platforms

Glen Kerr, ASC Pty Ltd. Glen.Kerr@asc.com.au
Dr Sergey Nesterov, DASI, Uni of South Australia
Sergey.Nesterov@unisa.edu.au

Introduction

- Modelling using computer simulations is widely applied to new system development. However, less work has been undertaken in applying modelling techniques to analyse performance of existing in-service maintenance systems performance against potential alternatives.
- The 2007-08 Australian defence budgets were in total A$22 billion dollars, A$6.2 billion dollars of which was capital investment. Notwithstanding these record levels of investment, significant shortfalls for ongoing maintenance of assets, rising personnel costs and escalating research levels are expected (Thomson 2007).

Problem definition and Solution Approach

- For existing in-service systems, the sustainment process needs to be re-evaluated and optimised based on the collected data. Applying a Systems Engineering approach to change management, user needs must be analysed and implemented to provide “best fit” within the holistic set of objectives related to the system in question.
- Our paper discusses the applicability of computer modelling techniques to conduct case studies, sensitivity analysis and evaluation of the overall effectiveness of various maintenance solutions for existing military platforms, as a case study.

Paper Scope

- This paper presents maintenance policies modelling, describes the details of suggested variants of maintenance.
- The presented model and performance analysis produce information about the system characteristics before significant resources are committed for actual change in system operation and maintenance.
- A concluding summary of the models performance, observations and limitations are presented with suggestions for further research directions to be undertaken.

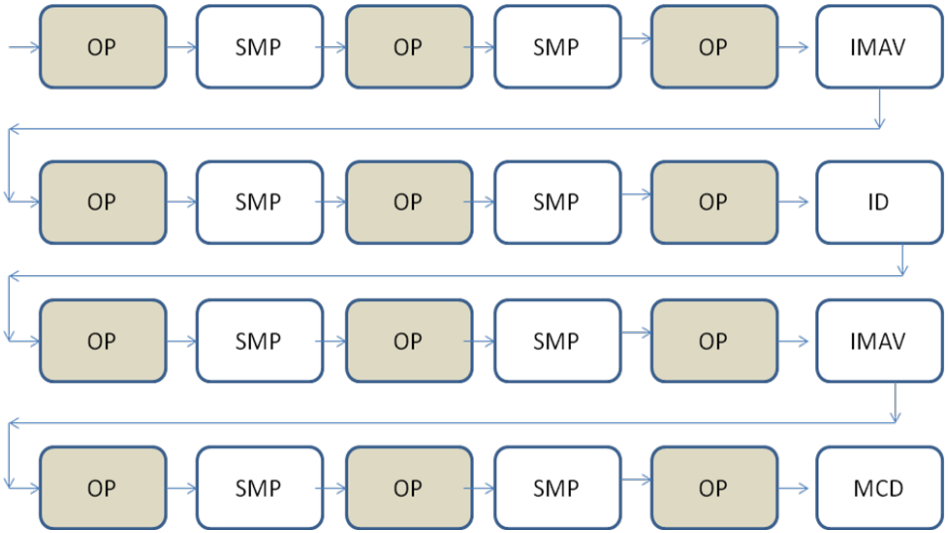
Specifics of Maintenance of Complex Military Systems

- The maintenance of a complex military system includes various activities: encompassing condition monitoring, spares inventory, Computer Maintenance Management System (CMMS) and personnel management.
- For military systems, criticality and safety are a significant attributes necessary to consider in handling system alarms or making resulting decisions of system maintenance and operation.
- Other unique features of some Complex Military Systems are
  - (1) a relatively small number (dozens) of unique platforms included in the system and
  - (2) the priority of platform availability for operation over maintenance cost savings. Most systems have a relatively limited time life span, which has to be carefully considered for statistical modelling with limited number of individual states.

Summary of Modeling Specifics

- All mentioned characteristics make model behavior sensitive to initial conditions of platforms and an initial predefined maintenance schedule, typically used as a benchmark. Complex military systems failure analysis and modeling are not trivial or standard; usually failure of platform has a complex dependency upon the states of subsystems and comprising units, having individual failure rates distribution. Thus, accurate modeling of system (platforms) failures representing assumed dependencies is mandated to satisfy verification and validation requirements.
- Due to the complexity of platforms, subsystems and units' states analysis, policy rules, application of the decision logic for maintenance acceptance and level of maintenance category is also not trivial and straightforward. Therefore accurate and correct modeling of different policies for maintenance decision making is required to find out the most appropriate and acceptable solution.

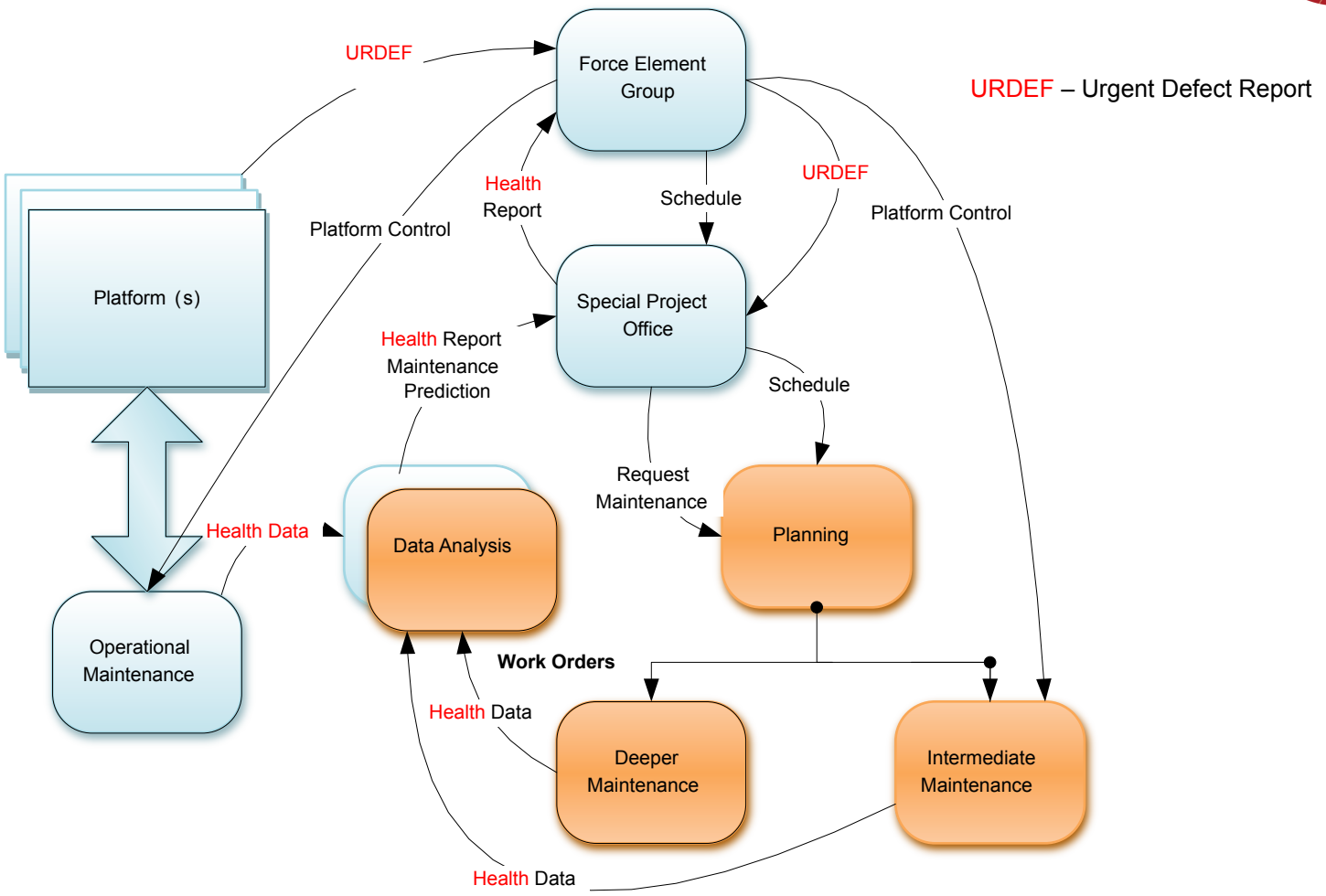
Current Maintenance Characteristics



Platform Upkeep Cycle

Upkeep Cycle	State code	Notes
Operational	OP	Ready for Mission Execution
Light Maintenance	SMP	Preventive plus Operational unit repairs
One Year Maintenance	IMAV	Preventive plus Minimal subsystem repair
Two Years maintenance	ID	Preventive plus Subsystems repair
Four Years Maintenance	MCD	Preventive plus Subsystems repair and upgrade
Eight Years Maintenance	FCD	Complete boat refurbishment

Maintenance Management Processes

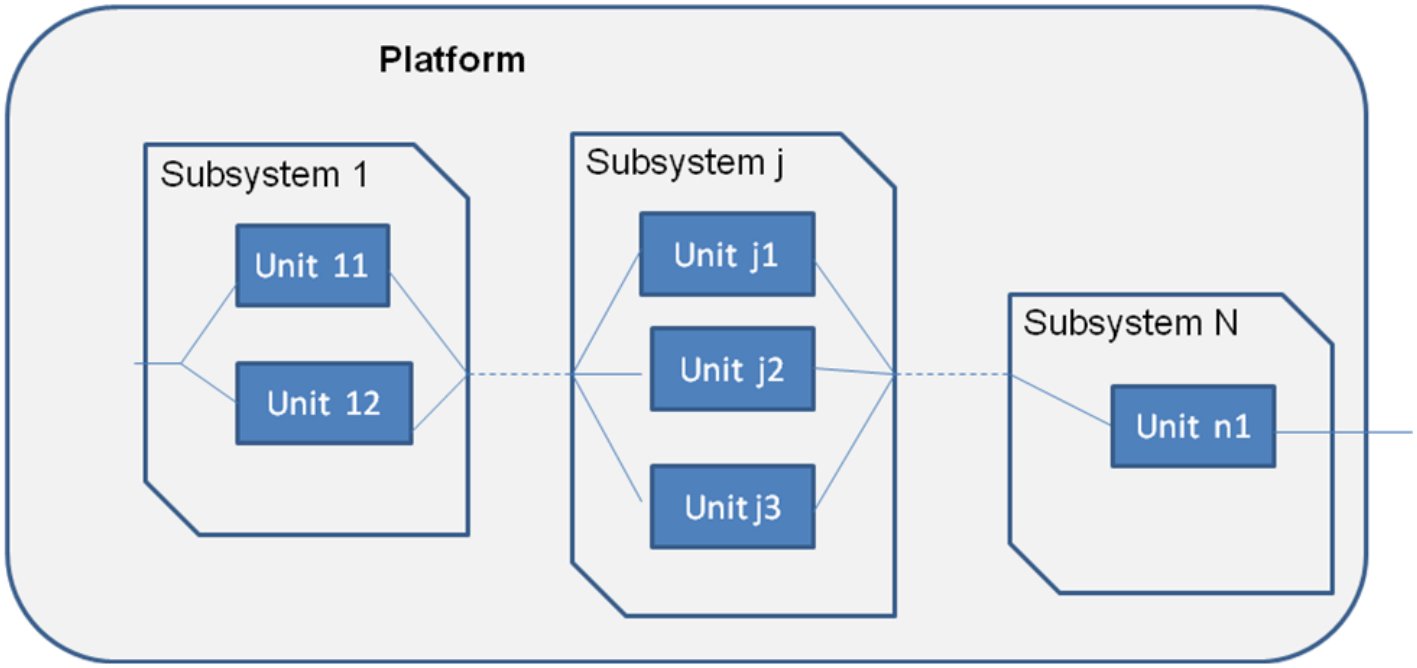


Maintenance Policy and MOE

- Stakeholders determine operational and maintenance schedules in consideration of:
  - Manning;
  - Endurance;
  - Cost;
  - Tasking;
  - Certification; and
  - Operational readiness.
- The Measures of Effectiveness (MOEs) for this platform agreed with the stakeholders and can be defined as:
  - Average Number of Sea Days available for missions per platform per year.
  - Probability of having more then certain threshold number of platforms available for operation

Maintenance Model Design

Two significant maintenance scenarios for modelling comprise:
Reactive: where subsystems are run to failure; and
Proactive: where subsystems are maintained through preventive maintenance routines, inspections and replacement in advance, before a likely hardware failure



Reliability model for a platform

Agents functions and states

- Each subsystem agent is characterised by state variables:
  - Health,
  - Subsystem Redundancy (K out of n subsystems),
  - Time to Repair,
  - Failure Rate,
  - Failure criticality,
  - Minimum Maintenance Period, and
  - Refurbishment maintenance period,
- The Platform agent reports:
  - Its health based on the health of its Subsystems,
  - Its age within the context of the model timeframe, and
  - Its status in terms of whether it is operational or under maintenance.

Model Verification & Validation

- Verification has been undertaken as in iterative process through the definition and coding phases of this research. Because the process is largely a prototyping exercise, initial requirements have been reviewed and modified regularly. The output log allows subsystem events and decisions to be traced and reviewed.
- The model inputs, specifically MTBF and usage factor, are mean values that are useful for providing a failure distribution for a meaningful population of like items over a reasonable sample. A series of experiments have determined that 50 runs per experiment provide a reasonable 95% confidence interval of around 20 days for 1 boat over 3650 days.

Modelling Results

#	Experiment Criteria	Platform Effectiveness (% of Sea Days)
3	6 platforms with no condition based monitoring.	50.65%
4	6 platforms with condition based monitoring @ 30%.	57.5%
5	6 platforms with Condition Based Monitoring @ 50%.	58.1%
6	6 platforms with Condition Based Monitoring @ 10%.	55.98%
7	6 platforms with Condition Based Monitoring @ 30% plus condition based preventive maintenance.	57.6%

CBM is effective because it provides advance warning of an impending failure through monitoring degradation of system components by monitoring certain characteristics. The standard model determines that detection of degradation is valid at 30% of the remaining life of a subsystem unit. This means that degradation is detected and reported in the last 30% of the life (MTBF) of the unit.

Conclusions

military platform does provide insight into how we can improve a maintenance process and how these improve a maintenance process and how these improvements can be measured.

-

are the key preconditions for successful maintenance process change to achieve the desired benefits.

- While this paper provides practical insight into the much opportunity for further research to improve the

much opportunity for further research to improve the

Questions


The image cannot be displayed. Your computer may not have enough memory to open the image, or the image may have been corrupted. Restart your computer, and then open the file again. If the red x still appears, you may have to delete the image and then insert it again.