Optimising Land Vehicle Life Cycle Cost through Health and Usage Monitoring Systems

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Abstract

The Strategic Reform Program has enabled Land Systems Division to implement initiatives that leverage proven industry technology to improve Land materiel sustainment. With the aim of reducing the cost of ownership and improving platform availability Defence has engaged industry to automate the collection of on-vehicle sensor data and convert it into information that will enable managers to make timely decisions.

Keywords: Health and usage; improved sustainment; Maintenance Engineering; Condition Based Maintenance.

Introduction

The Australian Defence Organisation continues to implement logistics reforms aimed at achieving improvements in the delivery of through life support and reducing the cost of materiel sustainment. A key enabler to realising these reforms is the provision of timely information essential for supporting the Fleet Management decision making processes. Within the Land environment these decisions are based largely around ensuring that the necessary logistics support is in place to support agreed levels of equipment availability. There is an opportunity to ensure that the Fleet Manager has access to the data necessary to deliver the agreed levels of availability at a cost that represents value for money.

Defence is not a profit motivated organisation and as such their business drivers differ from those of industry; however, managing cost of ownership remains a high priority second only to delivering effective combat capability and safety. Defence remains committed to ensure that public funds are being expended efficiently in line with Australia’s national interests. Within the Defence capability life cycle it is estimated that between 55% – 70% of the capability cost will be expended under sustainment while the equipment is in-service [1]. To this end the Defence Materiel Organisation is continuing to reform sustainment to provide Government the maximum economical benefit available throughout the capability life cycle

The diverse nature in which the fleet is employed coupled with its geographic distribution makes accessing reliable and timely information problematic. There remains an over reliance on the efforts of equipment operators and maintainers to identify and then notify management when an equipment situation is emerging. In a push to develop real improvement the organisation must lean forward and seek out the issues before they become a problem. The challenge is to deliver quality timely information about the equipment condition to the responsible manager enabling a more responsive decision loop and supporting the aim of achieving effective materiel sustainment resulting in agreed levels of availability.

This paper briefly discusses how the Land Systems Division (LSD) of Defence Materiel Organisation (DMO) is taking steps to secure that information chain. This initiative will further empower the Fleet Management function allowing it to transition from a reactive posture. Having established automated information feeds through proven commercial on-vehicle sensor technology the LSD will target equipment performance and condition issues before they jeopardise the operational mission. This proactive approach in maintenance engineering will support the investigation of reliability issues, improve maintenance planning, reduce equipment downtime and assist in repair parts inventory optimisation.

Background - Reactive Logistics

Life of Type Studies: In 2011 the Land Engineering Agency (LEA) was tasked to conduct a Life of Type study to determine the feasibility of supporting one of the older light armored fleets out to 2025. After much effort was invested in mining data from the corporate logistics systems the answers were found but the method of gaining the information was considered inefficient and too resource intensive to be incorporated into on-going business processes. It had taken too long to deliver answers that were out of date and in which the organistion had little confidence as the information was based on what is believed to be erroneous data. The logistics information systems did not enforce standarised data entry through the use of mandatory fields or data vailidation which led to significant variation in the quality of data.

Although the organisation had concerns over the data it was agreed that there existed an ongoing need to better understand and predict supportability issues and manage future fleet costs; however, this requirement could no longer remain tethered to low quality 'best efforts' data. In order to drive future decisions it had become essential to secure an information feed which was based on quantifiable data and not casual subjective comment and free text entry.

Maintenance Engineering: One area that suffers significantly from out of date and poor quality logistics information is the discipline of Maintenance Engineering. In nearly all cases within the Land environment the maintenance staff are reactive and can only advise the Fleet Manager after an equipment failure has occurred. Often, Maintenance Engineering are only able to generate a repair solution as they don't have ready access to the systems that would be needed to support fault detection and failure prevention options.

This reactive approach is no longer tenable for Land vehicles under the current reform program, as presently maintenance and repair parts account for up to 60% of a fleet's annual sustainment budget. Visibility of how the individual vehicles are performing in their environment is essential when evaluating the effectiveness of the current fleet maintenance plan. If the fleet is failing and its overall condition is deteriorating then the Fleet Manager must take action before the cost per kilometre becomes prohibitive. Additional to these monetary considerations is the significant labour impost on uniformed personnel involved in the delivery of maintenance and logistics support at the Army operational unit level.

The soldier has many other tasks that need to be performed in order to remain at a directed level of operational preparedness. While it is acknowledged that equipment husbandry is essential to maintaining combat effectiveness, conflicting priorities make it difficult for the soldier to allocate sufficient time to perform accurate data entry. As discussed, the over reliance on the soldier to supply quality data represents risk within a system that is reliant on accurate and timely information. The introduction of new equipment based capabilities must take into consideration the opportunities and overheads of technology. The initiative to develop automated systems within the Land environment aims to reduce the data effort required by the soldier to maintain equipment. In turn this automation will limit the need human interaction with the system which, by extension offers the potential to reduce errors and improve data quality.

Opportunity through Technology

Vehicle Health and Usage Monitoring: In conjunction with the vehicle Design Authorities, LSD has developed Vehicle Health and Usage Monitoring Systems (VHUMS) that harvest data from on-vehicle sensors and automatically transfer the data into a data historian for processing. The system accesses the vehicle CANBus [2] to harvest the sensor data and place it in an on-vehicle data logger for temporary storage. The stored data is converted into a standard format before being compressed and sent to the data historian via an encrypted Message Queue over the commercial 4G network. The Land Engineering Agency have developed the DEF(AUST) 11008 which describes the requirements of the VHUMS as well as the basis for the Interface Control Document which details the format for the encrypted file and its method of delivery to the data historian.

The data historian receives, stores and processes the time stamped vehicle sensor data by equipment, by date and by data channel, and then applies filters and calculations before outputting the results to the Military Integrated Logistics Information System (MILIS). Once in MILIS the data is stored as equipment daily usage statistics or as condition monitoring measurements. These statistics and measurements will be used to automatically generate a maintenance work orders tasking a tradespersons to implement a repair action.

Proof of Concept Trials: Commencing in 2012 LSD initiated a Proof of Concept trial to determine the viability of implementing a VHUMS capability onto selected legacy fleets. The findings of this work informed the follow-on pilot programs and so concurrent to the development of the data historian interface LSD have established three vehicle based systems that are currently automatically harvesting and process data from forty (40) Protected Mobility Vehicles, ten (10) M113AS4 and twenty-six (26) Mercedes G-Wagon.

These VHUMS pilot programs have demonstrated that vehicle data can inform the early detection and likely prevention of equipment component failures. Through the use of commercial software such as MATLAB, data analysts have identified patterns in the data such as increasing temperatures and declining voltages that point to potential faults. The early detection of these faults will assist in averting the impacts inherent in catastrophic failure and additional costs associated with collateral damage to related components.

Improved Logistics: Timely detection of faults will enhance maintenance planning at the operational unit and support a reduction in the need for "just in case" inventory holdings. The success of this approach will realise an improvement in equipment availability and reduction in maintenance down time. This reduction in vehicle down time will release uniformed maintenance and logistics capacity allowing it to be reallocated to other equipment types, in turn reducing the reliance on contracted commercial support services and imbedded labour hire resources.

Early in the acquisition of a new Defence capability, Operational Concept Documents are developed to describe the equipment's mission profile and how it may be supported in-service. The successful tenderer will then design and develop a vehicle based on that mission profile and a set of operational and support system scenarios. Included in these scenarios are performance measures for reliability, availability and maintainability which are tested under controlled conditions. As the vehicle's actual operational environment is not controlled and is considered potentially extreme, it is not unreasonable that the designers would increase the safety margins when prescribing maintenance actions and intervals. These margins are intended to offset any commercial or warranty risk.

Through the use of sensor technology and data analysis Maintenance Engineering staff will map the vehicle fleets' actual in-service mission profile in an effort to determine the balance between risk of equipment failure and cost to maintain. An initial analysis using Reliability Centred Maintenance techniques indicates that Army is over maintaining and performing servicing that is not directly linked to preventing failures or reducing overall maintenance downtime. Instead the finding suggest that in the absence of accurate condition based information and failure rates, the maintenance approach and repair parts holdings are based on a 'just in case' methodology.

Implementation Strategy

Reducing Through Life Costs: In order to manage the VHUMS program costs not all the vehicles within the identified fleets will initially be installed with monitoring systems. The agreed approach has been to install sufficient equipment to return a 90% confidence level (+/- 5%) that patterns in the data seen within the installed vehicles are representative of the whole fleet. On this basis decisions can be made to apply changes to servicing intervals and tasks that will provide an initial reduction in logistics cost and uniformed labour effort.

The second stage will be to distribute the instrumented vehicles across the different mission roles. The aim is to tailor logistics to suit the training environment as distinct from the operational theatre. For example a vehicle that is used to train new operators in tactical cross country fire and movement will exhibit different wear out patterns than one that is employed in a static defensive role within an area of operations. These two examples will present different failure modes and will require different repair parts stock holdings. The objective is to balance the supply chain to ensure an economical distribution of repair parts to suit the mission profile without introducing logistics delay into the repair process. Consider the provision of logistics in the operational area where the movement of stores and equipment must be kept to a minimum. The unnecessary transportation of repair part and oils by strategic air is an expensive use of a limited asset, while movement by road convoy increases our troop's exposure to the enemy.

Condition Based Maintenance: Lastly, the end state will see Land vehicles subjected to Condition Based Maintenance (CBM) where sustainment resources are allocated to provide a near 'just in time' solution. In this way the right maintenance is performed at the right time and at a place and time of our choosing. This approach permits adequate planning time to ensure an economical balance between cost and operational availability. A condition based approach within Defence must acknowledge that on operations the economic drivers become secondary to mission imperatives and so flexible solutions are required to ensure the maintenance plan survives the first shot.

Conclusion

The Fleet Manager in the Land domain has for too long remained reactive to the adverse effects of employing military vehicles in the Land environment. With the advent of on-vehicle sensor technology, information on how well or otherwise a fleet is performing is now available to the manager, enabling the organisation to transition from a reactive to proactive Land Materiel sustainment. Through the use of Vehicle Health and Monitoring Systems the Land System Division can employ equipment management methodologies including Reliability Centred Maintenance and Condition Based Maintenance which were previously considered too resource intensive. The introduction of on-vehicle sensors coupled with automated data transfer and processing will enable Defence to drive down the cost of ownership while maintaining economical levels of operational availability.

Acknowledgment

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Reference

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2. ISO 11898-1:2003; *Abstract:* a serial communication protocol that supports distributed real-time control and multiplexing for use within road vehicles.