The Benefits and Costs of Land Vehicle Health & Usage Monitoring Systems: A multidisciplinary approach for In-service fleets

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Abstract

Military operators and stakeholders generally accept that there is a benefit to installing Health Utilisation and Monitoring System (HUMS)[1]. Accordingly, as land vehicle fleets increase in complexity and cost the application of Vehicle HUMS (VHUMS) to a variety of platforms is becoming more attractive to operators as well as supporting entities.[2]

That said, there is limited publicly available information on the quantifiable benefits and costs of operating HUMS on Land Vehicles. The challenge is compounded by the desire of many operators to install HUMS to existing fleets, some of which do not have modern CANBus systems that can provide the majority of sensory input cost effectively.

The Australian Department of Defence (DoD) has identified the deficiency in fleet and VHUMS data associated with costs and benefits of implementing a VHUMS capability to support Land Vehicle operations. A task was established to conduct an analysis that would provide sufficient information to determine the costs and benefits of implementing VHUMS in an Australian Defence Force (ADF) context. Accordingly, three military armoured vehicles fleets were selected including wheeled and tracked platforms representing 250-400 vehicles per fleet.

This paper will discuss the methodology employed to establish baseline cost variance as well as the outcomes associated with installing a HUMS to tracked and wheeled platforms.

Keywords: Life Cycle Costing Analysis, Land Vehicle Health and Usage Monitoring.

Introduction

1. The Australian DoD has been investigating the feasibility of introducing a Vehicle Health and Usage Monitoring System (VHUMS) to existing armoured and wheeled vehicle fleets. Accordingly, Tectonica Pty Ltd and Systematiq Engineering Pty Ltd were engaged to produce the Functional Performance Specification (FPS) and cost options model. However it was acknowledged that whilst fleet data was available it was not consistently gathered or measured across all fleets. A methodology was required that could use both existing fleet data and parametric data to establish a cost options recommendation.

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[1] Vehicle Health Management System Report by Goodrich Integrated of 2003.
[2] Prognostic Health and Usage Monitoring of Military Land Systems by Dr A. Halfpenny of 2005.

Scope

2. The analysis was conducted in order to determine the following:

   a. Establish the cost of introducing a VHUMS to specific in-service vehicle fleets; and

   b. Identify the benefits of such a system primarily by quantifying improvement to availability versus the recovery of acquisition and sustainment costs.

Assumptions and Constraints

3. The CoA identified two fleets for assessment being an Armoured Fighting Vehicle (AFV) fleet and an Armoured Mobility Vehicle (AMV) fleet. By selecting these two fleets it was assumed that the analysis would provide a valid result for both wheeled and tracked vehicles.

4. In the absence of a common data set for both fleets, existing Australian DoD published data was used to estimate missing fleet data. Table 1 details the references used to source data to populate the respective models.

Table 1: Published data sources for incorporation into VHUMS cost model

Fleet	Assumption	Reference
1	MTBF	RAM Report
	MTTR	Army Logistics Instruction MM 09-08 (ALI MM 9.8.)
	MTBCF	ALI MM 9.8
	Mission Profile - km per year	Actual with 900 h estimated on the total 379,000 h for the fleet
	LOT	ALI MM 9.8
2	MTBF	MILIS
	MTTR	Army Logistic Instruction MM 09-07 (ALI MM 9.7)
	MTBCF	ALI MM 9.7
	Mission Profile - km per year	Actual with 100 h at 45 kmh-1 for off road
	LOT	ALI MM 9.7

5. In order to determine the cost of acquiring the VHUMS itself, an industry survey was conducted of existing military VHUMS suppliers. This was a voluntary activity and only a small number of returns were provided. However, the pricing information and estimated performance of the various systems was used in the analysis to provide cost and performance data for the model. The sum of the VHUMS hardware costs are utilised to support assessment of acquisition and sustainment costs for comparison to the base line generated in the models. The remaining costs were replicated by metrics based on the Minor Capability Acquisition Decision Support (MCADS) algorithm.

Methodology

6. The estimation of the total cost incurred throughout the life of a capability, materiel system or asset is essential to decision making in the Australian DoD.[3] Life Cycle Costing Analysis (LCCA) methodologies provide mechanisms whereby these costing predictions are subject to analysis.

7. Cost estimates are a prominent requirement of the capability development process noting that whilst the LCCA may not produce a definitive Life Cycle Cost (LCC), the analysis results are important in determining which system is the most cost effective. An LCCA is

[3] DIG Log 004-05-004 Defence policy on Life Cycle Costing Analysis of 14 Nov 03.

most commonly utilised to predict the cost of acquisition and sustainment of a system being considered for acquisition. However, the cost analysis can also provide a means of comparing existing fleet operating costs with the costs of operating the same fleets fitted with VHUMS.

8. The methodology for LCC entails a literature review in order to establish an understanding of the capability, the operating environment and a degree of confidence in the information provided. Model selection as well as an initial construct of the Cost Breakdown Structure (CBS) follows the literature review. The model selection is primarily predicated on the availability of actual versus metric data. To the greatest extent possible, actual data acquired is utilised noting the dependence on existing fleet data and OEM sourced information.

9. Consequently, the LCC model employed for assessing the introduction of VHUMS allows for the utilisation of actual data in combination with metrics to support a projection of LCC throughout the nominated Life of Type (LOT). This provided flexibility in utilising data that addressed the inconsistencies in the data between the vehicle types. For the analysis activity described in this paper, the data obtained included:

a. Mission profile and Reliability, Availability and Maintainability (RAM) data from the respective vehicle Army Logistics Instructions;

b. Historical data on the acquisition costs of each vehicle fleet; and

c. VHUMS cost data provided by commercial suppliers.

d. Sustainment costs were derived from the metrics established in the MCADS database. The MCADS database was established by the Defence Materiel Organisation (DMO) Land Systems Division (LSD) ILS Section in the early 2000s and employed primarily in support of B Vehicle related projects. The CBS for the support system broadly aligns to that of Figure 1.

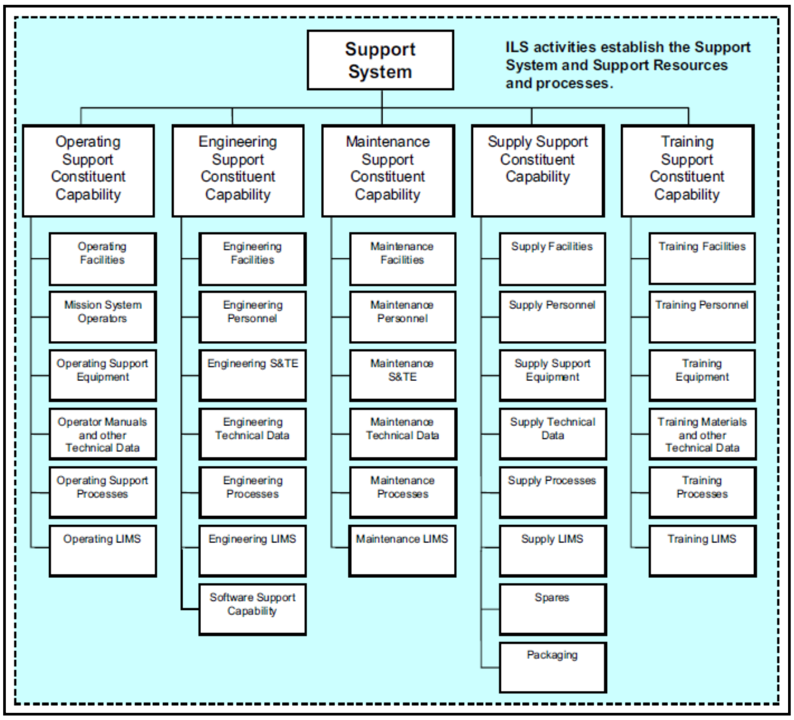

Figure 1. Support System CBS.

10. Annex A further defines the CBS as applied to the LCC models noting that the parametric data is based on a contractor and ADF combined supportability solution for a non-developmental item. Note that the following criteria are to be considered in conjunction with the metrics:

a. Exceptions for the AFV fleet include communications and maintenance support, which are subject to developmental item metrics primarily due to the scope of recent vehicle upgrades.

b. The model employs data that represents the use of Commercial Off The Shelf (COTS) diesel engines supported through a combined ADF and contractor effort.

c. The model includes a limited cost for the development of existing facilities and uses established maintenance support elements. This reflects the limited facility requirements of introducing a VHUMS capability into existing fleets.

d. The model presumes training and training support as a continuance of an existing program. Note that the training metric is a holistic representation of the requirement to instruct maintainers, operators and suppliers associated with the platform.

11. The factors utilised for cost variance were derived from the literature review with particular regard to the principle reference 'Gaguzis, M.P. *Effectiveness of Condition Based Monitoring in Army Aviation,* United States Military Academy, West Point, 2009'. Acknowledging that the reference pertains to the aviation industry, there is limited information publicly available that relates to land vehicle systems. The increasingly sophisticated technology applied to evolving combat vehicles provides some parallels to air systems while commercial technology has reduced the cost of VHUMS making it cost effective when compared with base platform costs.

Model Validation

12. Validation of the LCC model was required however this needed to be conducted efficiently due to the limited resources and time available for the analysis task. A validation method was used that compared the parametric LCC model based on individual vehicle 'hull' costs with the actual fleet acquisition and management costs.

13. The results of the parametric model were within 2.5% of actual costs. By establishing that the model of the baseline fleet was accurate and measure of confidence was achieved that enabled the model to be used to estimate the costs and benefits of implementing a VHUMS capability in the existing vehicle fleets. Whilst the validation of the LCC model established confidence, the limited fleet data means that the specific dollar values provided by the model have a low confidence attributed to them. Therefore the ratio of costs and benefits compared to the baseline fleet costs were used to establish a relative cost and benefit estimate.

Summary of Results

14. The analysis conducted across the fleets in questions provided the following results:

a. Any change to Operational Availability for the fleets under consideration was minimal.

b. There was an associated cost increase during acquisition due to the acquisition of the VHUMS. A sensitivity analysis was built into the model and the resulting increases were identified:

   (1) Fleet Engineering cost increase of 150% where Engineering costs are calculated at 0.02 of the capital or acquisition cost;

   (2) Hardware acquisition cost increase of 100.9%; and

   (3) Support and testing equipment acquisition and sustainment cost increase of 110%.

c. The financial benefits derived from the introduction of VHUMS were identified as:

   (1) Cost reduction to maintenance support of 15%.

   (2) Cost reduction to personnel of 20%.

   (3) Cost reduction to supply support of 15%.

   (4) Cost reduction to the whole of life cost for the fleets ranged from 8.77% to 7.19% over their respective LOT.

15. The benefits to the capability were also expressed as organisational benefits. These benefits were:

a. Automation of vehicle performance data acquisition and transfer which reduces transcription errors and failure to submit data that occurs with the current paper and computer based systems.

b. Improved visibility of fleet asset across a wide user population. By using one data repository and generating reports specific to each user class, the system can improve communication and understanding of the fleet capability

c. Provides the enabler to implement condition based monitoring of vehicles. This was not costed as part of the analysis, however it has the potential to significantly reduce fleet operating costs.

16. Considerations for operating VHUMS include:

a. The addition of a non-essential sub system to an extant capability may reduce reliability and increase maintenance and engineering costs. Any additional costs should be monitored to ensure they do not exceed the improvements gained by using VHUMS

b. There was an initial increase in cost to acquire, install and sustain the VHUMS over and above the cost of acquiring the vehicle capability. The additional cost should be carefully considered against the benefits identified previously

c. There is a requirement for data storage and transmission in administrative and operating environments. Additional infrastructure and security considerations will increase the cost of implementing VHUMS in militaries that do not have existing communications and data storage infrastructure.

d. There is a training liability associated with interrogating and maintaining a VHUMS. The cost of this liability was included in the analysis however it has a wider effect on training school capacity and training durations that was not considered as part of the analysis. The impact of the introduction a VHUMS capability appears minimal on training competencies however each training school would need to consider the impact on their schedules and through-put of trainees required by the additional competencies.

Conclusion

17. It is feasible to use an LCC model based approach to conduct a cost and benefit analysis of the implementation of VHUMS on in-service military vehicle fleets. The approach enables the use of inconsistent data sets to be compared.

18. The financial and logistics impacts can be estimated with a high degree of confidence as the analysis is based on proven LCC methodology.

19. The benefit to an organisation implementing VHUMS may be identified and expressed subjectively. This enables fleet and project staff to adequately quantify the benefits of utilising a VHUMS to a diverse stakeholder group.

Annexes:

A. Cost Breakdown Structure Definition.

References:

1. Commonwealth of Australia / Tectonica Pty Ltd Conference of 06 Feb 12.

2. Commonwealth of Australia / Tectonica Pty Ltd Conference of 19 Mar 12.

3. Army Logistics Instruction MM 09-08 Version 2.1 M113 AS4 of 24 Jul 09.

4. Army Logistic Instruction MM 09-07 Infantry Mobility Vehicle of 01 Nov 07.

5. Land Warfare Doctrine 5-1-2 Staff Officer’s Aide Memoir of 04 Oct 10.

7. DIG Log 004-05-004 Defence policy on Life Cycle Costing Analysis of 14 Nov 03.

8. DIG Log 003-06 Defence Policy on Integrated Logistic Support of 17 Mar 05.

Annex A

Cost Breakdown Structure Definition

1. Table A-1 details the definitions of the Cost Breakdown Structure (CBS) to which the metrics are ascribed. Note that:

- PM refers to Project Management which relates to the standing practices for acquisition in the Department of Defence.
- TLS refers to Through Life Support which relates to the standing practices for modifying existing platforms or purchasing equipment to replace or supplement existing sub assemblies.

Table A-1: Cost Breakdown Structure Definitions

Ser	Criteria	Definition
1	Administrative cost	Includes costs incurred through the acquisition and maintenance of personnel, accommodation, assessing, planning, travel and subsistence.
2	Certification and compliance	Includes quality assurance costs.
3	Consumables	Includes commodities consumed whilst fulfilling a mission such as ammunition, battery and fuel consumption.
4	Disposal	Includes costs of disposing a capability or materiel system and associated inventory, the recovery or salvage value as well as the disposal cost of waste and obsolete materiel throughout the life cycle.
5	Engineering support	**PM.** Includes the costs incurred through systems engineering including engineering planning, developing and reviewing the design, assessing RAM data, assessing human and mechanical interfaces and designing models and prototypes. **TLS.** Includes the costs incurred during the conduct of trials, RAM data validation and configuration management.
6	Facilities	Includes costs incurred through the acquisition and maintenance of land, facilities and utilities.
7	Information system support	Includes costs incurred through the acquisition and maintenance of consultants, equipment, hardware, networks, software and upgrades.
8	Maintenance support	**PM.** Includes the costs incurred through maintenance planning activities such as level of repair analysis and spares optimisation. **TLS.** Includes the costs incurred during the modification, repair and servicing of materiel.
9	Packaging Handling Storage Transportation	**PM.** Includes the costs incurred through supply chain planning activities. **TLS.** Includes the costs incurred through the provision freight, insurance, mechanical handling equipment and packaging material.
10	Supply support	**PM.** Includes the costs incurred through the acquisition of initial consumables, parts and repair items. **TLS.** Includes the costs incurred through the provision of consumables, parts and repair items. The consumables are segregated within the CBS and may include such commodities as batteries and fuel.
11	Support and testing equipment	Includes costs incurred through the acquisition and maintenance of calibration of equipment, software and tools.
12	Technical data	Includes costs incurred through the acquisition and maintenance of codification data, engineering data, management data and technical publications.
13	Training	**PM.** Includes the costs incurred through the conduct of a training needs analysis and acquisition of documentation, equipment, facilities, personnel and services. **TLS.** Includes the costs incurred through the provision of currency training, maintainer training and operator training.