Elicitation of stakeholder insights to military platform current and future sustainment challenges

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Abstract

This paper describes the findings from a recent Defence stakeholder engagement that aimed to explore current and future issues for sustainment of military platforms that could benefit from innovations in advanced sensors or data analytics. The elicitation sought information from an initial questionnaire followed by a workshop, and engaged stakeholders across the defence sustainment enterprise in order to capture as wide a pool of perspectives as possible. The elicitation was facilitated to provide information and insights at the platform, fleet, and force levels of the sustainment enterprise of military platforms. The stakeholder engagement provided a unique insight to current sustainment challenges, and generated ideas that can be further explored as potential areas of benefit from research and applications including into advanced sensors and data analytics.

Keywords: military, sustainment, elicitation, data analytics, sensors

Introduction

Defence strategy has defined the need for the transformation of warfare in the Information Age [1]. Information is being defined as the *currency of the age*, and its value extended beyond the battlefield into the logistics, sustainment and supply chain enterprises. Strategic guidance defines the need for agile and resilient systems that exploit the full potential of military platforms and systems to better support a fifth-generation force, and strongly advocates for innovation in Defence to achieve it [2-3].

The sustainment of military platforms is an enduring priority area for Defence and has received continuing support from Defence Science and Technology (DST) in the form of innovative solutions and trusted advice. As the sustainment landscape moves away from the support of aging legacy platforms to the management of fifth generation fleets, there is more attention directed to more effective use of data which can be harnessed to provide sustainment decision superiority. The generation, aggregation, analysis and interpretation of data from military aircraft and the sustainment information management systems may facilitate more intelligent, better informed and faster decisions at all levels of the sustainment enterprise.

DST engaged with Defence stakeholders in an elicitation process to gain insights into military platform sustainment issues that are perceived as current or potential future challenges. By gaining a better appreciate of the sustainment landscape and its associated problems and constraints, DST aims to better target potential application of advanced sensors and data analytics solutions, two areas of strategic interest to DST Aerospace Division.

Advanced Sensors considers the design, development and application of advanced sensors and edge computing for enhancing material state awareness of vehicles. Data Analytics explores the application of big data analytics to improve the speed and quality of aircraft sustainment decision making by taking advantage of the enormous amounts data and information being

generated by and about the aircraft fleet. The current scope of the Advanced Sensors and Data Analytics thrusts are shown in Figure 1.

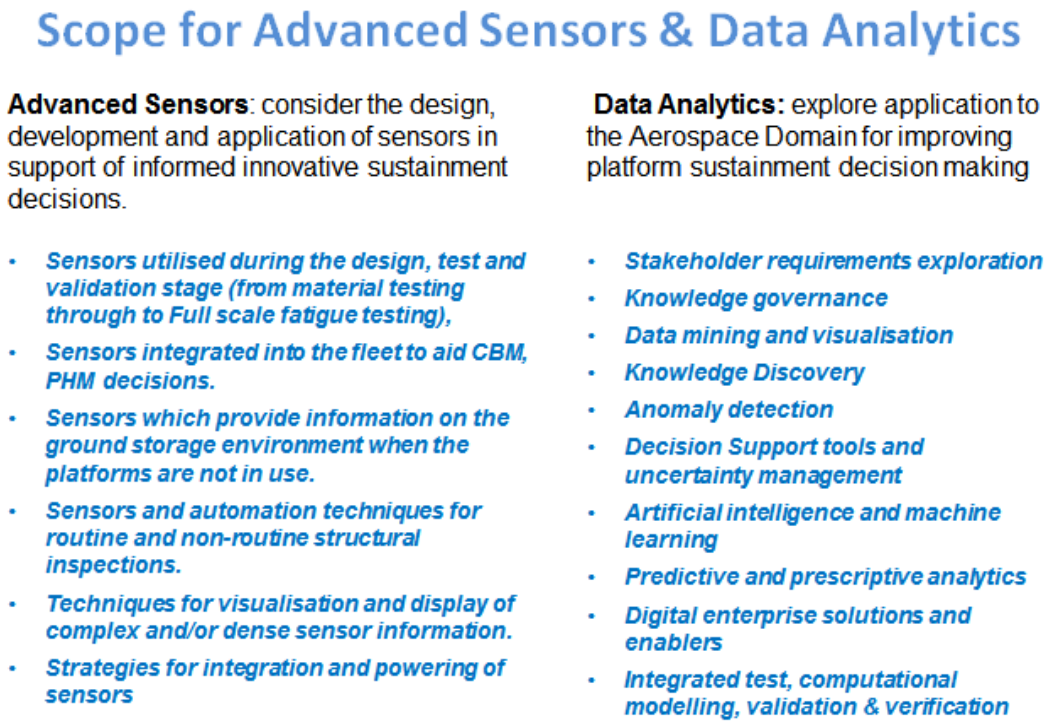

Fig. 1: DST Aerospace Division Advanced Sensors and Data Analytics thrusts.

Elicitation Planning and Process

The primary objective for the stakeholder engagement was the identification of sustainment challenges in which advanced sensors and data analytics could potentially be leveraged to provide solutions. The stakeholder engagement workshop planning was conducted over four weeks. A high-level process map of the sequence is shown in Figure 2.

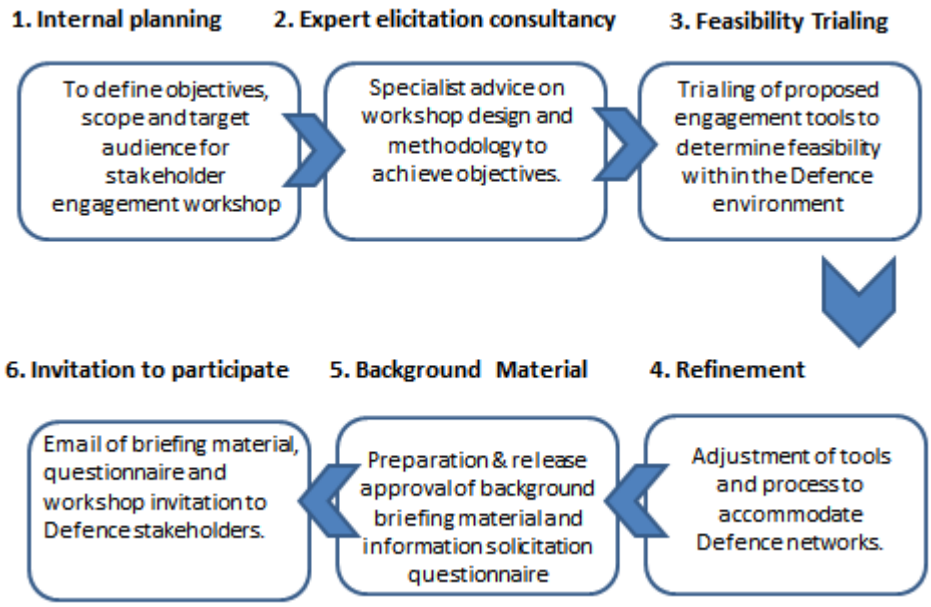

Fig. 2: Process map of external engagement planning sequence.

Specialist advice was provided on methodologies and tools for the generation and analysis of elicitation ideas. This resulted in a two-stage process; an initial pre-workshop online discussion forum for generation of ideas and feedback, followed by synthesis of these ideas for refinement and further expansion at a face-to-face workshop. Further refinement of the process took into consideration availability of online tools, defence information network requirements, and schedule constraints. The pre-workshop expert elicitation process was supported by an online survey tool using an excel workbook template. Functionality was added to allow all users to view and provide feedback on ideas generated.

The survey was designed for brevity to encourage participants to engage with three key questions posed to solicit challenges from the perspective of stakeholders at each of the aircraft, fleet and force level. The three levels and their associated, recursive decomposition, shown in Figure 3, were chosen to stratify participant responses as a reflection of DST's experience of how the ADF Aerospace Domain is organised. Additionally, this construct clearly demonstrates the connection between the layers and foreshadows that challenges and issues identified could be present at multiple levels. Figure 3 shows the questionnaire that was issued to the stakeholders. Feedback was sought on the content and clarity of the questionnaire prior to the release of the online survey. Instructions were provided to defence participants to ensure input was platform agnostic and supported release to the public domain, and to encourage review and feedback to fellow participants input.

Briefing material including the workshop invitation and the survey tool were provided to stakeholders describing the scope of activities to be considered and contextual information to define the different lenses through which to consider the questions posed in the accompanying questionnaire. Tracking of the survey access logs revealed that although the briefing material was accessed by many of the Defence stakeholders, there was limited input to the survey in the time prior to the workshop. This modified the planning with the workshop becoming the prime means of eliciting stakeholder input.

The workshop was facilitated to encourage stakeholder engagement to explore, from their perspective, the sustainment challenges and formulate them into a set of high-level requirements, as well as identifying related beneficiaries and defence impacts. The workshop focused initially on the articulation of a small number of sustainment challenges, followed by rapid idea generation, and finally, by a prioritisation of ideas by the participants.

Participants to the workshop represented a diverse cross section of Defence, including Logistics Branch RAAF, Air Domain Centre CASG, Navy Aviation Systems Program Office, Defence Aviation Safety Authority, Office of Air Force Scientific Advisor, Defence ERP Project.

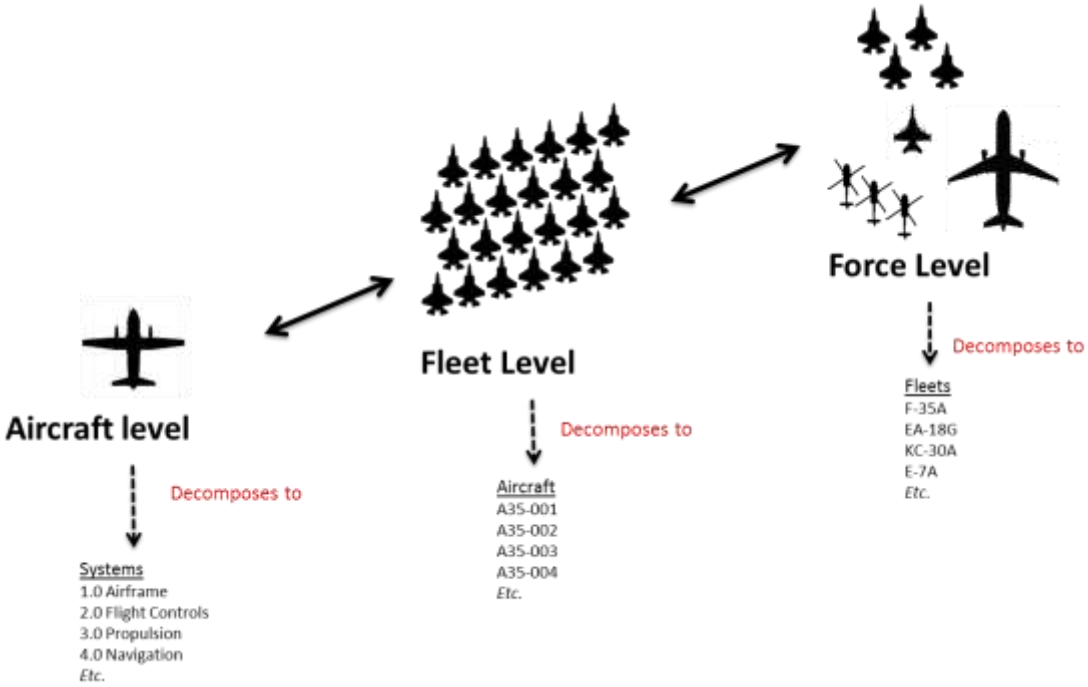

Fig. 3: *Recursive decomposition of the concepts of Force, Fleet and Aircraft*

Level and context	*What are the current and future sustainment challenges which you face and why?*	*What is the information or knowledge you need to address these challenges?*	*What would the impact and/or benefit of addressing these challenges be?*
Aircraft level Sensors and related analytical tools which provide specific information about the state, response, health or behaviour of an individual aircraft or sub component on that aircraft.	*The mission profile of future unmanned platforms may include more frequent, shorter range, varying altitude sorties. These operating environments combined with aircraft designs which encompass large composite wingspans will lead to an elevated risk of attrition due to damage caused by hail, bird strike and lightning.*	*The ability to autonomously detect and localise impact events associated with these mission profiles followed by rapid and autonomous quantitative inspection of these locations post sortie to determine whether damage is flight critical.*	*With a small operating fleet, the ability to rapidly detect, inspect and quantify the structural significance of damage will be critical to inform better decision making on operational availability and mission readiness.*
Fleet level Data analytics for fleets of aircraft and associated global support systems that can measure, diagnose & forecast health, longevity, availability and cost	*The current fleet management information systems do not fully exploit the data available from the aircraft health management systems and the wider sustainment enterprise to support users making informed decisions.*	*Knowledge of the drivers for unscheduled maintenance and system reliability trends across the fleet would help make better decisions about spares planning.*	*Improved supply chain planning, maintenance resource planning, and overall fleet health awareness.*
Force level System analytics for mixed assets, logistics, supply chains that can enable complex analysis of enterprise information to assure readiness, flexibility and resilience.	*It is hard for the Air Operations Centre to visualise the mission capable status of the deployed joint aircraft fleet and their supporting supply chains.*	*Daily flying program, aircraft maintenance status (ACSTAT, CAMM2), maintenance workforce status, aircraft repairables and consumables status (MILIS), weapons status, commodity consumables status (fuel, lubricant, specialist gases)*	*Would initially enable better planning and efficiency of deployed operations. In a mature state it would enable more dynamic mission planning.*

Fig. 4: Sample of questionnaire eliciting input at three levels.

Results from Elicitation

The workshop identified numerous military platforms sustainment challenges and generated a high number of good ideas on stakeholder requirements for improving sustainment. Results are displayed in Tables 1-3 for the aircraft, fleet and force level respectively.

Findings are reported at three levels:

a) Text on the right side of the tables corresponds to responses received on the day, sometimes re-worded or clustered from the original input.
b) Text on the left side of the tables corresponds to categorisation of the responses.
c) Blue text corresponds to ideas that received high voting numbers in the poll conducted on the day.

	Aircraft
Inspection	More portable, easier to use NDT
	How to integrate new sensors with existing systems; how to retrofit
	More consistent inspection data
	Better identification of areas of interest
	Better utilization to facilitate decisions
Diagnostics	**Improved flight line trouble shooting**
	Aircraft state awareness to reduce inspection, facilitate real time battle damage assessment
Prognostics	**Mature prognostics to include all aircraft systems & drive maintenance decisions**
	Data analytics to mature & validate prognostics
	Developing trust in prognostics
Data flow	Rapid/automatic post flight maintenance download

Table 1: Workshop results-sustainment challenges at the aircraft level

Table 1 shows the results at the aircraft level arranged into four emergent categories: Inspection, Diagnostics, Prognostics and Data Flows. The largest number of responses was for the Inspection category. The high priority responses were from the Diagnostics and Prognostics categories.

Table 2 shows the results at the fleet level arranged into 6 emergent categories; Asset Management, Improved Information and Data Access, Improved Data Integrity, Real Time Fleet Status, Improved Workforce allocation and Management and Cyber. It was immediately apparent that there were a much greater number of responses at the fleet level than for the aircraft level (20 for the fleet level and 11 for the aircraft level) and that the high priority responses were comparatively more evenly distributed. The largest number of responses was for the Asset Management category, which also contained the largest number of high priority responses.

Table 3 show the results at the force level arranged into 6 emergent categories; Air Base Operations, Dynamic Operational Planning, Access and Utilisation of External Information and Data, Access and Utilisation of External Information and Data, Managing Uncertainty and Data Fusion. The force level generated the largest group of results (27) from the workshop. The high priority responses were confined to the Air Base Operations (three responses), Access and Utilization of Internal Information and Data Fusion categories. The largest numbers of responses were for the Air Base Operations and Access/ Utilization of Internal Information and Data categories.

	Fleet
Asset Management	**Improved repairable & consumable management**
	Better quantification of maintenance process changes
	Ability to understand implication of short, medium and long term budget changes
	How to extract meaningful trends from large, complex data sets
	Proactive airframe fatigue management
	How gain insights on spares pooling for forward planning
	Integrated fleet supply management of spares
Improved Information and Data Access	**Understanding enterprise information system requirements for all stakeholders**
	How to live with ITAR and other restrictions
	How to understand requirements for IP and Technical Data management
Improved Data Integrity	Processes to ensure data integrity
	How to develop trust in outputs from advanced sensors
Real Time Fleet Status	**How to visualize fleet status in real time**
	How to aggregate and fuse data to generate fleet status
	How to automate decision making
Improved Workforce Allocation and Management	Better understanding of maintenance effort and duration
	How to minimize maintenance errors
	How to improve maintenance workforce flexibility (virtual reality, augmented reality)
	How to better understand resourcing requirements (SPO and SQN)
Cyber	**How to protect sustainment Information Systems from Cyber-attack.**

Table 2: Workshop results-sustainment challenges at the fleet level

	Force
Air Base Operations	**How to gain insights into the issues, fragilities and constraints caused by the base**
	Understanding sortie failure rates and causes
	Understanding minimum infrastructure requirements for bases
	Understanding force mission degraders
	How to understand force planning for new operating concepts
	Exploring deployable infrastructure for agile basing
	How to understand the best logistics and maintenance investments for maximum operating effect
Dynamic Operational Planning	How to generate real time understanding of maintenance and logistics constraints
	How develop a logistics common operating picture
	Dynamic planning tools and processes for deployed operations
Access/Utilization of External Information and Data	How to generate a data 'bablefish' for the different aircraft sustainment systems
	How to incorporate local environmental information into logistics, maintenance and mission planning
	How to share knowledge across weapon systems
	How to understand the effects of local geopolitical instability on sustainment and logistics
	How to model an understand global environmental impacts and impacts form climate change
	How to crowd source naming conventions and standards
Access/Utilization of Internal Information and Data	**How to effectively utilize historical data for decision making at portfolio, program and project level**
	How to identify sources of local supply and manufacture
	How to develop consistent force package models
	How to get information and knowledge to flow bi-directionally
	How to leverage intelligence analysis techniques for maintenance and logistics
	How to understand what information and data is held by industry and allies
	How to capture data at enterprise level and provide metrics
Managing Uncertainty	Developing planning models that incorporate uncertainty and variability
	Prescriptive analytics to provide options for decision making
	How to gain insights to harden against adversarial effects
Data Fusion	**How to integrate and fuse disparate information and data at air bases and ships**

Table 3: Workshop results-sustainment challenges at the force level

Discussion

The complete interpretation and analysis of the elicitation findings requires further consideration and will be the subject of further engagements with the stakeholders. For the purposes of this paper we will hazard some guesses based on the initial guidance given as context for the workshop.

At the Aircraft level, the Inspection category generated the largest number of responses whilst the Diagnostics and Prognostics generated the high priorities. The commentary framed inspection as manual, time consuming, requiring specialist skills and generating results that are often subjective and difficult to interpret. The feedback was that these inspections need to be improved in all ways, but that the desired end state would be rapid automated inspection combined with intelligent image analysis tools to inform objective and trusted decisions. In-situ material state awareness was highlighted as a high priority both to reduce inspection intervals and to inform in-service battle damage assessment. The desire for better fault diagnostics suggests the need for enhancing fault detection and isolation, eliminating false alarms and reducing troubleshooting time and logistics footprint. The use of multispectral sensing to provide symbiotic data from multiple sources for validation of diagnostic decisions was proposed. Finally, the desire for improved prognostics, infers the need for early detection of system performance degradation to avoid catastrophic failures as well as greater flexibility in scheduling maintenance activity for individual aircraft based on operating tempo and maintenance constraints. Taken together these results suggest that innovative solutions in both, advanced sensors and data analytics, can support generating higher individual aircraft readiness levels to meet future operating concepts.

The categories that emerged from the Fleet level responses were particularly interesting. Three of the categories were subject areas for analysis (Asset Management, Real Time Fleet Status and Workforce Management) and the remaining related to information and data (Improved Information and Data Access, Improved Data Integrity and Cyber Defence). Key issues identified were how to understand the stakeholder requirements to generate suitable ICT infrastructure, how to use large complex data sets for decision making, how to access the right type, trusted data and how to defend systems against cyber-attacks. A central theme from these inputs is that data analytics can be utilised to facilitate better quality, more timely fleet management decisions as required for the future concepts of operation.

The responses at the force level were the most diverse and eclectic. They appeared to reflect a desire to better understand heterogeneous fleet operations from a range of different airbases including the Canberra Class LHD. They inferred a desire to understand the base as a weapon system in its own right. Some categories of results were similar to the fleet level, such as access to data and how to integrate it and apply it to make tactical and strategic decisions. Some categories were very distinct however such as Air Base Operations, Dynamic Operational Planning and Managing Uncertainty. At the force level, the application of data analytics across the enterprise, and particularly of prescriptive analytics, appeared the most versatile in support of agile decision making and a logistics common operating picture.

Lessons Learnt and Recommendations

The elicitation activity provided good lessons for future similar exercises. The workshop participants were willing to openly discuss issues as the topic mattered to them and had direct relevance to their work units. The workshop arrangement over one day provided enough time and the dedicated workshop setting, away from workplace distractions, resulted in a productive arrangement. In contrast, there was limited response to the online questionnaire.

This could be interpreted as an indication of uncertainty about the objective or process, or could be a result of time and priority constraints, or show an issue with accessibility and usability of the data gathering tools. Future similar engagements will consider process and tools that can be employed to improve usability of online surveys.

As this exercise generated ideas that can be further explored, the following recommendations are made:

1. Elicitation refinement and further contributions be sought from an extended pool of Defence stakeholders.
2. Engagement be extended to industry and academia for assessing landscape and sharing awareness for similar technology undertakings.

Conclusions

This paper reported the findings of a recent Defence stakeholder engagement that aimed to explore current and future issues for sustainment of military platforms that could benefit from innovations in advanced sensors or data analytics.

Through a carefully developed expert elicitation workshop, 58 responses were collected, categorised and sub-categorised and prioritised at aircraft, fleet and force levels.

Whilst these responses provide important initial insights into the challenges of future sustainment, further work is required to confirm and refine these results to direct high value activity in the Data Analytics and Advanced Sensors strategic themes.

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