‘Sense and Respond’ and ‘Autonomic’ Logistics: a review of US and UK developments[1]

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Introduction

Until recently, platform-based logistic applications required data to be physically downloaded and transferred between systems to analyse the status of key components. However, in both the ‘sense and respond’ (S&RL) and ‘autonomic’ (AL) logistics systems being developed in the US and UK, prognostics have been added to monitoring functions. These real-time and predictive aspects are relatively new developments, facilitated by the real-time communication of data from operating platforms to the on-board crew/operators and through external links into the logistics support chain.

While the ADF’s ‘Military Integrated Logistics Information System’ (MILIS) proposes to extend the reach of supply chain information to sub-unit level, it falls short of crossing the gap to link ‘Health and Usage Monitoring System’ (HUMS), platform-based data into the logistics continuum to provide end-to-end visibility and a ‘foxhole-to-factory-to-foxhole’ perspective of the supply chain.

This article reviews developments in recent military applications of S&RL and AL in the US and UK, as well as considering their suitability to ADF programs. It will state the case for the application of both systems to the ASLAV (Australian Service Light Armoured Vehicle) and Bushmaster armoured vehicle platforms, in a similar fashion to those employed in the US and UK, as a source of accurate and up-to-date combat service support information for various levels of command.

HUMS and issues for the ADF

At present, key ADF decision makers do not have access to complete logistical data impacting on the tactical aspects of immediate operations; for example, the answers to questions such as what is the current and projected ammunition and fuel usage of critical vehicles, and can that helicopter make another mission based on actual maintenance required, as opposed to flight time limitations. Such critical questions require answers best provided by accurate and timely information. Yet many such capabilities are already available, evidenced in some of the current initiatives in the US and UK, as well as programs in the commercial sector.

HUMS-related data has existed for decades. A well-known example has been the engine monitoring system developed for the F-15 and F-16 combat aircraft, consisting—in basic terms—of an engine diagnostic unit and a ground diagnostic unit. The former records the operating conditions and any anomalies. Once the aircraft is on the ground, data is downloaded to the latter for analysis.

The same concept was transferred to the automotive arena, with some form of diagnostic system now incorporated into most family cars. But even here, the car typically has to be taken to a workshop and hooked up to a ‘ground diagnostic unit’ so that the system’s data can be downloaded for analysis. The real potential of HUMS data will not be realised until it is available synchronously to the entire logistics system, in real time, which is the stated goal of both the US and UK armed forces.

S&RL and AL in the US

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The S&RL concept is being employed by the US Marine Corps to enhance the quality of logistics decision making. It was initially trialled on its Light Armoured Vehicle (LAV) platform, using 'bolt on' sensors to generate vehicle status and prognostic information, such as fuel consumption and other operating data including the rate of ammunition consumption and the number of rounds remaining. The information was provided to the vehicle crew, with consolidated data available to various levels of command. In a 2007 study by Pennsylvania State University, the authors stated that 'one of the key benefits of the project to date has been the organizational learning.... In our opinion, 'sense & respond' has significantly increased the Marine Corps' institutional knowledge'.[1]

The same study asserted—through the extrapolation of data gained from trials—that when utilised by the entire fleet of similar vehicles, the following benefits would be realised:

- *Cycle time*. An estimated reduction in customer 'wait time' of ~50 per cent through the ability to provide early warning of abnormal conditions, thereby enabling the logistics, operations and maintenance planners to optimise the repair and return-to-service timeframes.
- *Cost avoidance*. Estimated at >US$10m annually, based on an inventory of ±400 LAV-25 variants (and an estimate of US$22.35 per mile cost of operating, including personnel and depreciation costs).
- *Reliability*. An estimated increase in 'mean time between failure' of >14 per cent (from 64 to 73 hours).
- *Availability*. An estimated 7 per cent increase in operating availability, translating to 34 additional vehicles based on the data above.[2]

In the S&RL system, data is gathered for current-level usage of various classes of supply and transmitted to the next level in the chain of command for aggregation, review and decision making. The US Marine Corps' Evaluation Division has noted that:

> With information technology, S&RL receives, recognizes and responds to consumption and requirement patterns through the use of equipment embedded Intelligent Agents. S&RL leverages the capabilities of network-enabled forces to share logistics information, share a common perspective of the battle space, and provide early awareness of consumption and needs, allow commitment tracking and allow for reconfiguration of the logistics system when needed. It will tell the Commander 'how much fight is left' in his units.[3]

While the US Marine Corps has invested significant effort in developing S&RL, the Office of Naval Research is the lead US agency of this program. Its view of the benefits is that:

> The Sense and Respond Logistics program will enable commanders to more accurately assess their environment, identify when a plan is executing differently than intended, and help develop alternatives ahead of real time. The technology developed for the program will combine the commander's intent with 'ahead of real time' data and use that information to develop potential courses of action and evaluate the impact of those decisions.[4]

On the other hand, AL was developed by the Lockheed Martin Corporation, specifically for the Joint Strike Fighter (JSF/F-35) program. It links data from S&RL into the supply chain continuum, reaching back to 'original equipment manufacturers', enabling them to become more active participants in the logistics support chain. The system links real-time platform-level data on JSF/F-35s to Lockheed Martin's headquarters in the US and various suppliers around the world. Based on this information, the status and requirements of individual aircraft are aggregated so that a 'picture' for the whole fleet can be determined and acted on.5 More recently, the system has been expanded to support test aircraft at the Edwards and Eglin Air Force Bases and the US Navy's Patuxent River flight test centre.[6]

A further logistics layer in the JSF/F-35 program is the 'Autonomic Logistics Global Sustainment' solution being developed by Lockheed Martin. It will integrate existing and planned production and sustainment capabilities in the partner nations of the JSF/F-35 program.[7] While many of the developments associated with the program are US-centric, its reach will be far more extensive—not least because of the involvement of Lockheed Martin and as it extends to all partners of the program.

Evidence from the UK

The UK Ministry of Defence (MoD) has embarked on the 'Logistics Network Enabled Capability' (Log NEC) program—which, in some respects at least, reflects the goals of Australia's MILIS program—as an attempt to transform 'the current complex web of processes and systems into a streamlined, optimised, agile and effective end-to-end logistics support chain'.[8]

However, Log NEC exceeds the scope of MILIS in two important dimensions: firstly, its reach includes 'front line' platform-level data and, secondly, it includes contractors.[9] The latter objective is facilitated by the establishment of a 'Green Box' to enable input from industry into 'the requirements of Defence's future logistics information architecture, so that the system supports the needs of both Defence and industry'.[10]

Specifically, the Log NEC program has identified a suite of 'significant improvements to the joint support chain across the whole of Defence … [that] will deliver major benefits to operational performance, [namely]:

- More accurate data and information,
- Greater visibility across the support chain,
- Better management of stock,
- Improved operational planning and decision making,
- Increased availability of spares, platforms and units, and
- Increased operational flexibility'.[11]

One of the key elements is the 'Joint Asset Management and Engineering Solutions' (JAMES), established in July 2005, and now subsumed under the Log NEC umbrella. It:

> … currently manages more than 60,000 pieces of equipment for the British Army, giving users and commanders the ability to identify the availability, status, condition, ownership and location of a piece of equipment in moments.[12]

The UK MoD has announced Phase 2 (JAMES Land), which covers all land vehicles for the Navy and Air Force, as well as the Army. One of the vehicles covered by the JAMES program, which has the ability to be fitted with a suite of equipment to provide HUMS data, is the Bushmaster armoured vehicle, manufactured in Australia by Thales and in service with the ADF.

Other projects within the Log NEC suite include:

- MJDI (Management of the Deployed Inventory);
- MMiT (Management of Materiel in Transit);
- CONVIS (Consignment Visibility);
- AMO (Air Movements Operations); and
- EBC (Electronic Business Capability).13

It is difficult to determine, at this stage, how anticipated cuts to the UK defence budget will impact on the Log NEC program. The consensus would seem to be that any cuts 'are being applied gradually and are often not as dramatic as feared'.[14]

Applications in the private sector

In considering the requirements that joint operations in a coalition environment impose on contributing partners, there are obvious and significant parallels between the logistic needs of the US, UK and Australia. Moreover, similar developments are occurring across all three, to varying degrees, with the lead in several areas coming from commercial activity. Notably, the private sector has moved

swiftly to embed HUMS-related systems into the aviation industry, taking a leading role globally and, through platform acquisition, in Australia. For example:

> QANTAS Airbus' 'AIRTRAC' system provides a link between the airframe and a dedicated support facility staffed with specialist engineers available 365 days a year. The A380's onboard software monitors every system and instantly sends an email to AIRTRAC if any anomaly is spotted. The instant the email is received, the required part is ordered so it's ready for the arrival of the A380.[15]

Other manufacturers offer a similar 'logistic information system' for platforms in ADF service, such as the RAAF's C-17A Globemaster III heavy-lift aircraft.16 Elsewhere, the agriculture sector has adopted the concept, using sensors in every aspect of planting and harvesting. State-of- the-art tractors have 'telematics' and remote monitoring features, whereby 'if a service issue develops in the field, technicians at the dealership can remotely identify the problem, determine the tractor's location and proactively address the problem'.[17]

Implications for the ADF

When acquiring a new system, a general rule in estimating the life cycle costs is that the platform acquisition accounts for one-third of total costs, with logistics and operational costs making up the other two-thirds. An example is the JSF/F-35 program, where it has been noted that:

> The true cost of owning a modern jet fighter includes 25 or 30 years of maintenance support, and pilot and ground crew training …. This is often twice or more the original purchase price [and] that doesn't include the cost of fuel and weapons.[18]

Australia is planning to buy 100 JSF. The purchase cost (based on a per aircraft cost of US$50m) would be around US$5bn. Applying the general rule above, the support and operating costs could equate to an additional US$10bn. The supplier, Lockheed Martin, estimates a 20 per cent reduction in the logistics costs over the life cycle due to the application of AL, which would equate to a potential US$2bn savings for the Australian program.[19] While the financial aspects are impressive, the theatre commander would be more impacted by the reduced turnaround times and availability, which would be based on the actual condition of platforms, rather than modelling.

This discussion raises the obvious question of the current status of HUMS in the ADF. The need has been identified in the Department of Defence's 2007 'Network Centric Warfare Roadmap'.[20] Logistics is included under 'Collaborative Planning' and the target state for 2020 is described as:

- Key logistic function networks within the National Support Area are linked with those in theatre, and provide connectivity and a collaborative ability with industry and coalition partners.
- Commanders have an end-to-end visibility of the logistic system, providing the ability to rapidly and effectively prioritise scarce resources required to generate and sustain deployed force elements.
- Automated ordering and replenishment takes place as supplies and ordnance are consumed by platforms and field units.
- The deployed force has minimised its vulnerabilites and greatly enhanced its mobility through more effective 'reach back', optimum force presence and the precision sustainment for the majority of logistics requirements.21

When the JSF/F-35 is introduced into service in Australia, it will bring with it participation in Lockheed Martin's AL system.22 But what about the rest of the ADF? MILIS was cited in the 'Network Centric Warfare Roadmap'—and this project certainly has addressed many concerns, notably the reduction of legacy systems in Defence, improved interconnectivity between information systems, and the introduction of technology, such as 'radio frequency identification' devices, for asset tracking. However, MILIS does not provide real-time information to decision makers in the supply chain or related logistics areas. It was conceived as a system which, at the theatre end, terminates at

unit level. There is, therefore, an 'air gap' between the platform and MILIS at this point, and data is not available as a synchronous input into MILIS.

Since HUMS-related data is not available real time to all stakeholders, the logistic 'end states' described in the Network Centric Warfare Roadmap cannot be met. Most importantly, the forward commander does not have the information required to make the best use of allocated assets. Indeed, farmers on the Darling Downs arguably have better visibility of the capabilities, connectivity and support for their machinery than an Australian Commander in Afghanistan.

This concern impacts across the board, with the ADF potentially 'missing out' on:

- Financial savings on all operational and maintenance costs of 7-20 per cent;
- Increased platform reliability;
  Reduction in repair cycle times;
- Increased asset availability; and
- Enhanced situational awareness.[23]

It is acknowledged that concerns have been expressed about the ADF's participation in the proprietary logistic information systems of commercial, non-Australian entities, including in terms of the 'sovereignty' of operational information and the ability of such systems to integrate with MILIS.24 It is also accepted that the capture and transmission of vast amounts of platform-level data will impose an additional burden on communication networks. These certainly are issues that need further consideration, including the potential vulnerability of such data to targeting.

Conclusion

This article has reviewed developments in S&RL and AL in the context of military applications in the US and UK. It has shown that recent developments in the logistic support chain in both countries have focused on the integration of data at platform level as the foundation of an end-to-end approach to logistics. It has argued that the way forward for the ADF is for HUMS-related data to be recognised as an important factor, not only as a maintenance tool but as a critical input into the management of military assets. Several examples of commercial applications have been provided to illustrate the deployment of readily available enabling technology to better manage assets.

The ADF will eventually adopt the concept of a true end-to-end logistics system, if for no other reason than the need to inter-operate with US and UK forces. However, it would obviously make sense to provide ADF commanders with the best logistics support available—and to reap the financial and efficiency benefits—as soon as possible. As a first step, this could be achieved relatively quickly and at reasonable cost, by procuring kits, proved by the US Marine Corps, for the ADF's ASLAVs. The same application could be trialled with the ADF's Bushmaster armoured vehicles to evaluate the UK's JAMES approach. Other platforms could then have the capability retrofitted, where no direct interface exists between them and the MILIS/theatre level communications system. Without such initiatives—and a sustained focus on S&RL and AL, or similar programs—the ADF will struggle to achieve the 'end states' laid out in its Network Centric Warfare Roadmap.

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NOTES

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