The Global Leader in DDS

September 2011

The UK MOD Generic Vehicle Architecture

A Compelling Case for Interoperable Open Architecture

Real-Time Innovations

www.rti.com

US HEADQUARTERS
Real-Time Innovations, Inc.
Tel: +1 (408) 990-7400
info@rti.com

Tel: (408) 990-7400
Fax: (408) 990-7402
info@rti.com

Executive Summary

The adoption of an Interoperable Open Architecture (IOA) by the UK MOD will have a profound impact on defense procurement. With its new Generic Vehicle Architecture (GVA) and Def Stan 23-09, the MOD has arguably been one of the most innovative and impactful defense procurement agencies (DPA) of any democratic nation.

The MOD has raised the bar for systems-of-systems integration management by initiating a fundamental shift in perspective regarding collaboration between DPAs and systems integrators (SIs). This new approach provides for the development of all future vehicles using a single, logically connected, cohesive and coherent architecture for maximized utility while enabling field command to derive the best logistically from military assets. IOA adoption also sets the stage for a more competitive procurement process that can only improve the economics of future vehicle development. The MOD's initiative would not have been successful without the support of industry leaders who invested time and effort to validate this approach.

Driven by clear economic imperatives, both the MOD and the SIs have had to change, accepting or divesting themselves of key responsibilities in the process. The MOD has less money and needs to spend it more wisely to meet field requirements. For SIs, on the other hand, risk reduction is essential. The contractual belt has been tightening globally. Risks of delivery and other penalties for prime SIs have been increasing, which in turn forces them to push down on tier-2 and tier-3 SIs and push back on DPAs to ensure there is enough "fat" in a contract to mitigate risk. This downward economic spiral had to be stopped.

This white paper outlines the innovative aspects of this new IOA and acquisition approach and highlights the confluence of thinking and events that led to a new engagement model between the MOD and the SIs.

The Procurement Process Problem

The approach to defense procurement follows a common model in democratic economies. First, a major programme is defined, commonly around the need for a specific vehicle, aircraft or ship. Next, a tier-1 prime SI is selected to deliver the system. The prime SI is responsible for the overall systems integration and timely delivery. Contracts are commonly tied to through-life maintenance and management, and possibly training as well. With system lifecycles being extended into decades, such contracts are becoming an issue. DPAs' and SIs' struggle to sustain the supply chain for multiple proprietary vehicle designs. There is limited or no commonality of sub-system supply or economy of scale opportunity for the DPAs across their multiple vehicle procurements, which inevitably drives up costs as each vehicle is extended in a proprietary "one off" fashion.

The Army's Concern

For military vehicle deployments, the nature of the threat is changing. The enemy is now most commonly asymmetric in nature and is adapting in the field to the high-tech capabilities of vehicles that have taken years to develop and deploy. In fact, by the time a new capability is fielded, the enemy has often already countered it.

"Not a problem," says the field commander. "I will adjust them in the field." However, the commander cannot. Each vehicle was uniquely developed by a separate prime SI, each meeting its contractual requirements to the letter and seeking to amortize up-front development costs across the maintenance lifetime as part of its business-model. The SIs are incentivized by the procurement system to sustain their sole or primary supplier status for system components. The field commander cannot use his highly skilled engineers to adapt vehicle systems in the field unless he has access to a system specialist from each SI for each vehicle. More importantly, he cannot take a capability from one vehicle and integrate it into another, because each vehicle has a unique systems integration structure.

After identifying this issue, the MOD began to analyze its basic systems engineering precepts, seeking a methodology that would enable a more responsive and iterative process of integration that would enable the MOD to deploy systems of systems that are ahead of the enemy's abilities to change its modus operandi.

The MOD consulted extensively with industry and heavily leveraged years of previous work from the Vehicle Systems Integration (VSI) research programme and decided upon an Interoperable Open Architecture approach to address their system integration challenges.

Full-System IOA Solution

The MOD's IOA and acquisition approach is particularly innovative in its whole-system view. Def Stan 23-09 addresses integration for the entire electrical system, meaning everything from the automotive control systems to power management, sensors, Human Machine Interfaces, Health and Usage Monitoring Systems, weapons, C4I etc. Anything with a processor, software and communication paradigms between subsystems are included in the GVA.

The decision to drive OA as both an implementation pattern and a business process to suppliers is in itself truly innovative. The MOD wanted a common technical integration approach across all future vehicle architectures and a more open approach to the procurement process. They also had to avoid unnecessarily constraining SIs in their innovation and adoption of technologies.

Communication between two subsystems of any type requires at least two common properties: the consumption and production of data. The MOD has assumed full responsibility for defining and maintaining a System Data Dictionary (SDD) of the complete vehicle defined on a subsystem-type basis (sensors, C4I, HUMSs etc), a dictionary and vocabulary for communication between subsystems. This SDD—called the Land Data Model—forms the core of the MOD's strategically different engineering approach to systems architecture design. It is a fundamental change from the traditional Interface Control Document (ICD)-based approach, which defines the low-level protocol and messages characteristic of the stovepipe system architectures that have inhibited field responsiveness to changes in threat.

The MOD mandated the use of the Object Management Group (OMG) Data Distribution Service (DDS) standard for the open-standard middleware for all data communication within the vehicle. Industry collaborators in the VSI research programme recommended DDS as the most appropriate open standards middleware for the communication of data in a real-time mission-critical environment. DDS ensures interoperability between independently developed subsystems when used in conjunction with the Land Data Model. DDS was originally architected to support data-centric development paradigms. The MODs decision to implement their IOA through the specification of a data model leads directly to a data-centric development approach.

The beauty of this data-centric approach is that the SDD can be openly shared. Most of the Land Data Model has now (April 2011) been de-classified (all except the C4I components), thus enabling ready sharing with the SI's, but also opening the door to collaboration between nation states – a publically stated objective of the MOD.

Def Stan 23-09 goes much further than the SDD and DDS mandate, of course, mandating specific physical system interconnects, cable connection mechanisms, and HMI and power-distribution objectives. However, the SDD + DDS is the glue that will ensure interoperability between independently developed software and applications. DDS middleware becomes the logical bus all software systems must use for communication and control, as shown in Figure 1; DDS delivers the software Data Distribution function outlined in this diagram.

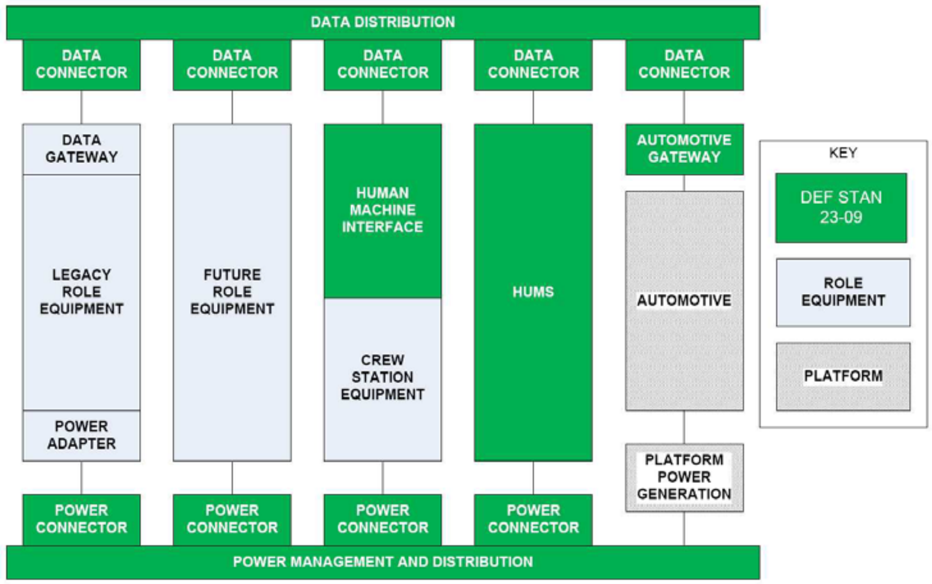

Figure 1: GVA Def Stan 23-09 architectural overview

Demonstration of Interoperability

At a VSI open day sponsored by the MOD at the Defence Academy in Shrivenham, just two months after the Def Stan was published, several VSI vendors provided an impressive demonstration of systems interoperability. Qinetiq, Selex-Galileo and Thales each had a booth with independently developed complex video systems featuring varying types of camera and joystick controllers, each with their own multi-function displays. The systems used DDS middleware from different suppliers. Because of the common SDD, within a few hours each could connect to the other's cameras, controllers and displays. The three vendors were then able to take control of each other's cameras or obtain video streams from another's camera. By interfacing DDS to each controller and using a common SDD, they were able to come together and integrate a working system over a standard Ethernet backbone in an extremely short timeframe. Plug-and-play has become reality in future military vehicles.

OA Principles for Success

The support material at the VSI day read: "VSI provides a coherent MOD-Industrial approach to vehicle integration. It will: increase vehicle effectiveness; enhance adaptability upgradeability and reconfigurability in the face of ever-changing operational demands; and reduce whole life costs. The GVA approach enables the retrofit of a wide range of products with the minimum of vehicle impact and logistic support in theatre."

Def Stan 23-09 uses nine principles for the ongoing success of GVA. These were hard-won objectives established in the process of defining Def Stan 23-09:

1. Take account of previous MOD investment
2. Be applicable to current and future systems
3. Use open, modular and scalable architectures and systems
4. Facilitate technology insertion (upgrade, update, replace, repair, remove and addition)
5. Not needlessly implement in hardware any functionality that can be implemented in software
6. Take a 'whole platform' systems view, through life (including cost)
7. Be done in conjunction with industry and all relevant MOD stakeholders
8. Be MOD owned and maintained;
9. Specify the minimum necessary to achieve MOD's desired benefits avoiding unnecessary constraint in implementation

The MOD requires vehicle systems to deliver the objectives and benefits of principles 1 through 6. The MOD recognizes it must take a measure of responsibility (principle 8) while balancing that with the caveats of principles 7 and 9. Only through these principles can a common, workable management infrastructure for all vehicle developments be achieved over time. The fact that the MOD takes ownership of a key aspect (the systems integration architecture) of the SI function and mandates its use are the central changes in philosophy GVA embodies, denoting a change in the way the MOD and SIs will work together in the future.

The SI Opportunity

The MOD's philosophical change in approach does not fundamentally change the procurement infrastructure of the MOD. There is still a need for a prime SI to bring together the various tier-2 and tier-3 SIs and manage the systems integration of future vehicles. However, now the SIs will work within the architectural guidelines of the GVA.

As IOA based systems are deployed, there will be a significant change in through-life maintenance procurement. Instead of 'big bang' upgrades, smaller maintenance and upgrade contracts can be initiated at much more regular intervals.

Instead of stifling innovation, the Land Data Model enables rapid innovation and development outside the context of a specific vehicle programme, because now the SIs can have confidence that subsystems innovated according to the GVA specification can and will be viable in future military vehicles and their upgrades.

For the prime SI, a significant component of the integration function is defined and owned by the SI's customer, the MOD. However, if it appears that a subcontractor will jeopardize the delivery schedule or contract deliverables, the prime SI now has the option and opportunity to seek alternative suppliers. Because the data model ensures interoperability, the SI knows integration will not be a significant issue and can therefore focus on functionality, usability, price, durability and so on. The business benefits to industry of mitigating the risk of subcontractor failure for such huge programs cannot be underestimated.

For tier-2 and tier-3 SIs, OA provides the freedom to invest resources in subsystem development. These SIs can be confident of successful integration into any number of future vehicle programs regardless of which prime is awarded the contract. Competition will be tougher, but the cost of integration into proprietary (stovepipe) architectures will be removed. Since this is a non-returnable cost, everyone in the value chain benefits, right back to the MOD.

Even legacy subsystems can be brought forward into the GVA architecture. Figure 1 shows that legacy subsystems can be "wrapped" with a GVA-compliant power adaptor and a data gateway to become an integral part of vehicles that use more recent IOA system-integration technology. This provides a low-cost legacy transition mechanism for both the MOD and SIs.

Through-Life Benefits

Perhaps the biggest savings will come in through-life maintenance and upgrade cost reductions and Integrated Logistics Support (ILS) simplification. GVA will create a market that is increasingly open for military vehicle components and subsystems, which in turn will drive a more competitive market and lead to cost reductions. Simultaneously, innovation will increase as suppliers work to differentiate their solutions.

Additionally, the existence of a common logical data bus makes the development and integration of simulation and training systems orders of magnitude easier because these systems can leverage the actual vehicle software through the same OA interface across a range of vehicle training systems.

Systems will also become easier to enhance because integrating new functionality is as simple as defining an extension of the data model. The logical data bus of DDS ensures that new data providers and consumers can be discovered dynamically by the system. A new function can select the data it needs from the data bus while adding itself as a provider of new sets of data to the vehicle environment. For full realization of the benefits of a new function existing subsystems may need to be enhanced. This is addressed by principle 5 which ensures that leveraging such functional enhancements should merely be a matter of a software upgrade.

Conclusion

The MOD has set a world-leading example of how to manage defense procurements in the face of changing threats as the enemy becomes increasingly shrewd in leveraging their asymmetric capabilities. With GVA and Def Stan 23-09, the MOD has developed a procurement strategy for delivering military vehicles that are coherently designed, while maximizing utility and enabling field command to get the best logistically out of its military assets. The architecture empowers field command to plug-and-play to strategically adjust to rapidly changing threat profiles.

Through GVA, the MOD has been able to respond proactively, successfully addressing challenging procurement support requirements for military vehicles. What is most impressive about the new approach, however, is that the drive towards IOA will also drive a more competitive procurement framework for future military vehicles, promising to reduce the up-front costs and, more importantly, the through-life costs of these systems of systems while simultaneously increasing the opportunity for innovation and technology adoption in new sub-systems.

References:

1. A full copy of Def Stan 23-09 can be found at www.dstan.mod.uk/standards/defstans/23/009/00000100.pdf.

2. Information on the VSI research programme and the supporting industry partners can be found at http://www.vsi.org.uk/.

3. The programme of events demonstrating GVA at the U.K. Defence Academy can be found at http://www.vsi-2010.com/.

4. More information on the Open Standards Data Distribution Middleware (DDS) can be found at http://www.omgwiki.org/dds/ and http://www.rti.com/resources/

