THE UK'S APPROACH TO OPEN SYSTEMS ARCHITECTURE FOR THE LAND DOMAIN

Antony White
Ultra Electronics – Precision Air & Land Systems
Cheltenham, UK

ABSTRACT

This paper proposes that within the Land domain, there is not only a need to define an approach to open architectures, but also to mandate their use, in order to provide an agile framework for our fighting forces going forward. The paper sets out to explain such an approach; that taken by UK MOD and industry to produce the Generic Vehicle Architecture (GVA) defense standard. It will discuss how the GVA standard was formed, how it is currently being used and how it contributes to the wider MOD initiative for Open Systems Architecture for the Land domain. Finally the paper considers how the UK GVA relates to the US Victory standard and how interoperability may be achieved.

INTRODUCTION

During the recent operations in the Gulf there were a number of rapid deployments of new vehicles and regular updates to their mission fits. There were numerous issues regarding the integration of the vehicle sub-systems, compounded by the need for regular mission specific upgrades.

It became apparent that a new way of working was needed and that MOD and Industry would have to work together to create a framework that would support faster, smoother integration of platform systems that was modular and scalable enough such that it could be applied to any class of fighting vehicle.

Platform Integration

Stove pipe systems in military vehicles have been the norm for decades. Platform integrators have had little choice but to try and plug together sub-systems with closed interfaces and in many cases create overall platform architecture that itself is closed with respect to future (third party) integration.

Traditionally capability has evolved through the fielding of specific systems that have been procured independently of each other to meet specific military needs.

Any cross-system functionality has generally been achieved by improvisation, typically involving voice and/or human interaction by the crew.

Like many other countries, the UK demands its equipments to be in service for several decades. Recognising the need to maintain operational effectiveness, technology insertions are now common place.

There has been no standardised approach to systems integration. The impact of this often results in sub-optimal installations, with operational challenges placed on the platform users, the maintainers and logistics chain. Training and through life support is also affected.

The cost involved in upgrading the platform, whether to cover obsolescence or to increase capability is measured not just in monetary terms but also in time. Unfortunately in the recent campaigns, this cost has also been measured in lives lost.

MOD & INDUSTRY RESEARCH

VSI

In 1997, the UK MOD launched a research program called Vehicle Systems Integration (VSI). The programme is still live today and continues to provide the underpinning research for the Generic Vehicle Architecture initiative. VSI's aim is ensure that the full benefit of digitized platform can be realized and, its charter states that

"*All future military land platform procurements, selected legacy platforms and their updates will adhere to the Vetronics standards and guidelines which have been proposed and developed under the Vehicle Systems Integration (VSI) programme, and which are promulgated in the detailed Standards and Guidelines for VSI documentation.*"

An industry led working group (including Ultra Electronics) was formed, and over the following decade produced and maintained a 300 page document entitled "The VSI standards and guidelines". The document attempted to capture the emerging open standards in terms of power, data and video and looked at how to apply them to military vehicle systems. Being just a set of guidelines, and despite the charter, there was no real authority to mandate or force compliance. The industry members of the VSI group tended to adopt the VSI principles as best they could, often investing their own money to further the VSI concepts.

Recognizing the importance of digitization, the VSI work also fed into other international interest groups within NATO as well as the UK/US TRACER-FSCS programme.

Later, the VSI Standards & Guidelines were to provide the cornerstone of the GVA defense standard.

FRES EA TDP

The Future Rapid Effects System (FRES) was a name given to a UK programme to deliver a fleet of some 4000 vehicles to the British Army. Intended to be a mix of platform capabilities ranging from an Ambulance to a reconnaissance vehicle, with the need to be rapidly deployed into a variety of operational scenarios a modular scalable approach to the platform systems was essential.

In 2005, the UK MOD contracted two parallel Technology Demonstration Programmes (TDPs), whose aim was produce an Electronic Architecture that was modular and scalable enough to fit all of the envisaged FRES fleet of vehicles. The two teams, led by BAES and Lockheed Martin, produced and demonstrated two independent Electronic Architecture solutions that were shown to meet the intent of the VSI standards & guidelines.

Ultra Electronics worked within the Lockheed Martin team to produce a VSI compliant architecture and subsequent platform demonstration. The EA made use of distributed power and data architecture, using an Ethernet based Publish/Subscribe mechanism.

The FRES programme has since been restructured; however aspects of the FRES EA TDP architectures are to be found in the current GVA defense standard.

VTID

In early 2007, the UK MOD contracted a consortia led by QinetiQ to investigate the concept of Modular Integrated Survivability. The 3 year programme, called VTID (Vehicle Technology Integrated Demonstrator) pulled in various domain experts, including Ultra Electronics who were to lead both the Power and Electronic Architecture aspects of the programme.

Survivability of Armored Fighting Vehicles (AFVs) is a central pillar supporting their ability to fulfil a mission. This is particularly true in a political and social climate that is increasingly intolerant of casualties. Traditionally, survivability has depended on the use of passive armour to protect against attack. However, recent improvements in threat armour penetration have made this an increasingly unviable option, particularly in the face of a defence doctrine predicated on the rapid deployment of light and medium weight forces.

Maximising survivability and maintaining this level of capability across a broad range of scenarios in the face of a rapidly evolving threat is a key aspiration for all military platforms. This survivability may be achieved using a number of tools, including using appropriate technologies, intelligence, and tactics, techniques and procedures. To maximise survivability requires that the technologies used are sufficient to match the threats that they must counter. These threats continually develop and change, therefore it is necessary to constantly monitor, improve and adopt survivability technologies that may enhance performance – the Mission Modular Approach.

The VTID Vehicle programme investigated the hypothesis that reconfigurable IS can be developed that can offer a flexible and effective protection mechanism for land vehicles across the complete spectrum of the 'Survivability Onion'.

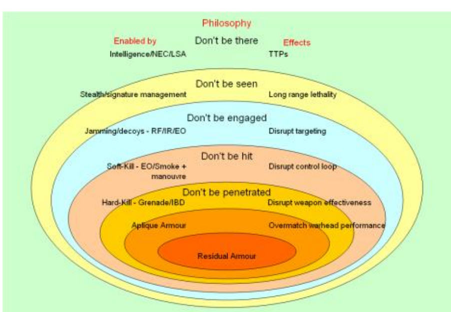


Figure 1 – Survivability Onion

Taking into account both safety and security requirements, Ultra Electronics carried out various architectural studies, investigating Power Architectures, Computer Processing, Network Topologies and the use of Middleware. The principles within VSI standards & Guidelines were also adhered to. A new concept called Modular Dependability (conducted by the University of York) was also considered within the final architectural recommendations, driven by the need to develop a modular approach to certification.

Working with QinetiQ and consortia partner Thales UK, Ultra Electronics produced a modular vehicle demonstration system that was used in a series of live firing trials to show how a Modular Integrated Survivability system could be realized. The VTID architectural concept documents have been taken into account in the formation of the GVA defense standard.

OPERATIONAL CONTEXT

Driven by the need to integrate a multitude of rapid technology insertions and upgrades (so called Urgent Operational Requirements), quickly and efficiently, the Gulf war has perhaps been the catalyst to solidify the years of research work into Electronic Architecture.

The UK army found itself owning a raft of new capabilities and indeed new vehicles. The new 'Force Protection' fleet, bought in from the US and 'anglicized' had a range of Theatre Entry equipment fitted. A lack of common architecture slowed down not only the installation of the equipment, but also the training and subsequent re-training, as more and more rapid technology insertions and uplifts were carried out. The vehicles were harder to maintain, with different configurations proving a burden on the logistic chain. This resulted in additional expense, and not least frustration; something needed to change!

FPMS WORKING GROUP

Formed in 2009 and mandated at senior (3 star) level, the Force Protection Mission Systems Working Group objective was to try and resolve the integration issues on the rapidly growing Force Protection fleet in theatre.

Created as an MOD and cross Industry forum, the FPMS WG was charged with finding quick wins for the operational pressures at the time. This involved identifying the problem areas, identifying exploitation pathways and initiating and monitoring detailed technical working groups to deliver the solutions.

Particular focus was given to three areas of coherence and integration; RF Antennas, the creation of a Generic Vehicle Architecture and Systems Information Exploitation.

Ultra Electronics remains part of the FPMS WG team specifically looking at the GVA problem and helping to pull through the successes of research work in that area.

GVA TECHNICAL WORKING GROUP

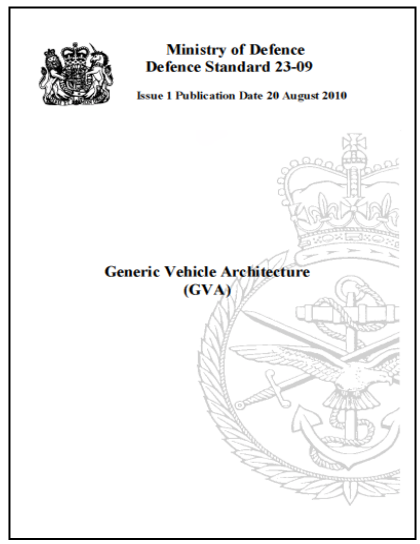
From the FPMS working group, the MOD established the GVA Technical Working Group (TWG) to pull of the threads around common vehicle architecture into one cohesive document. The group was made up of domain experts, bringing together the previous research work along with current industrial best practice.

In the summer of 2009, the GVA TWG formed a number of teams to show the art of the possible. The various industry teams presented a number of possible architectures along with a whitepaper explaining their approach. These were then assessed by staff at the Defense Science & Technology Labs, who took aspects of all the whitepapers and in November 2009. Allocated the reference 23-09, DSTL published an initial draft of the Defense Standard for the TWG to review.

The TWG matured the standard to a point whereby they were confident that a 2nd draft could be released, with the intent of implementing it on several vehicles for demonstration and assessments. The objective was to validate that the standard was ready for publication to a wider audience via the MOD standards website.

Defense Standard 23-09 Generic Vehicle Architecture

The GVA standard was officially release at version 1, in August 2010.


Ministry of Defence
Defence Standard 23-09

Issue 1 Publication Date 20 August 2010

Generic Vehicle Architecture
(GVA)

Figure 2 – GVA Def Stan 23-09

Version 1 was then successfully implemented on the Foxhound vehicle, setting the benchmark for all UK vehicle architectures going forward.

The GVA working group received formal recognition from the Government in 2012, when it was presented an ‘achievement of excellence” award from the Minister for Defense Equipment, Support and Technology

Figure 3 – GVA Award

Due to the complexity of the architecture document, there have been a number of clarifications necessary during the detailed implementation and as a result there have been two subsequent updates, with version 3 now extant.

AN OVERVIEW OF GVA

Objectives

The purpose of Def Stan 23-09 is to enable the MOD to realise the benefits of an open architecture approach to Land vehicle platform design and integration, especially in regard to the vehicle platform electronic and power infrastructure and the associated Human Machine Interface (HMI).

The aim is to improve operational effectiveness across all Defence Lines of Development (DLOD), reduce integration risks, and reduce the cost of ownership across the fleet by applying appropriate standards and design constraints.

Physical Interfaces

Def Stan 23-09 defines the design constraints on the electronic interfaces and protocols that form the GVA Infrastructure, including the physical cables and connectors that provide means of distributing data around a vehicle platform.

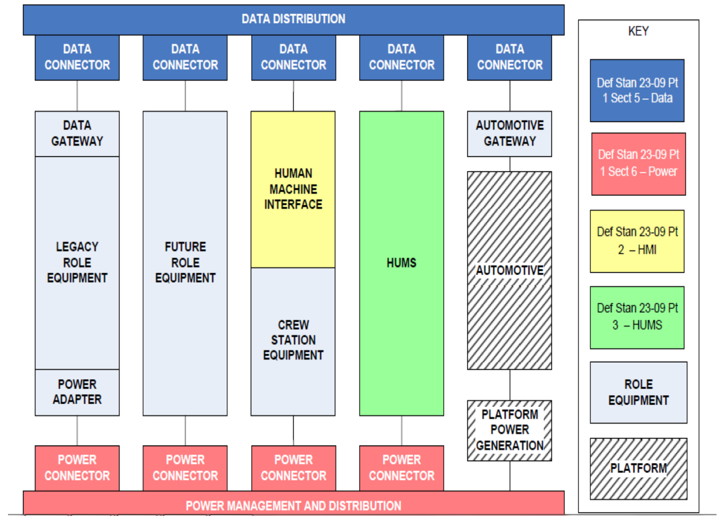


Figure 4 –GVA Interfaces

The standard also describes the enabling logical components and functions e.g. interface software, transport protocols and message definitions.

Defining and standardising these common elements enables interoperability between platform sub-systems and also reduces the time taken to integrate new sub-systems. The aim however is to constrain design options as little as possible to allow for flexibility and innovation.

GVA defines the connectors and pin allocations for Power, Ethernet (both copper and fibre), USB and CANbus. In doing so, platform integrators can be sure that the electrical interface boundaries for each sub-system are common.

Human Machine Interface

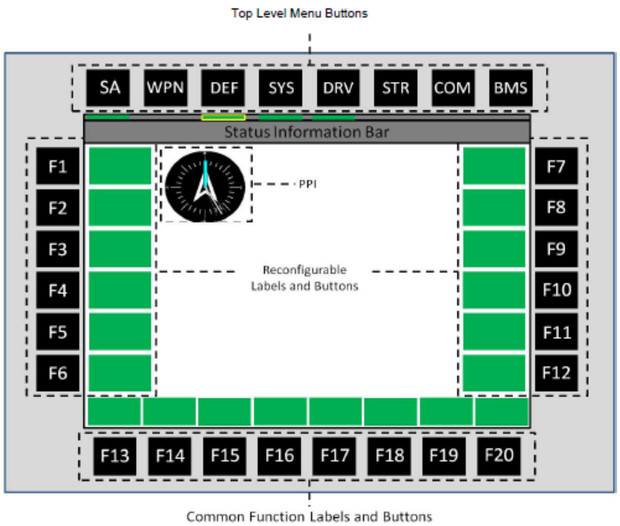


Figure 5 –GVA HMI overlay

The Human Machine Interface section of the defiance standard sets out to define common features that all GVA vehicles will have. This 'look and feel' is important as it not only reduces the training burden, but gives the user confidence in that the vehicle is GVA enabled.

The HMI section defines how keyboards and switch panels may be arranged, but Figure 4 shows the most predominant feature of this section the layout of the Crew Station Display.

Top Level menu buttons across the top of the display allow immediate access to the platform critical functions. Menu buttons F1 – F20 are re-configurable for each sub system and sub-system menu.

Middleware

The GVA standard mandates the use of Data Distribution Service or DDS, which is an open standard middleware, produced by the Object Management Group [2]. DDS defines a near real-time, publish-subscribe architecture for connecting up sub-systems, rather like the way stories are published in a newspaper.

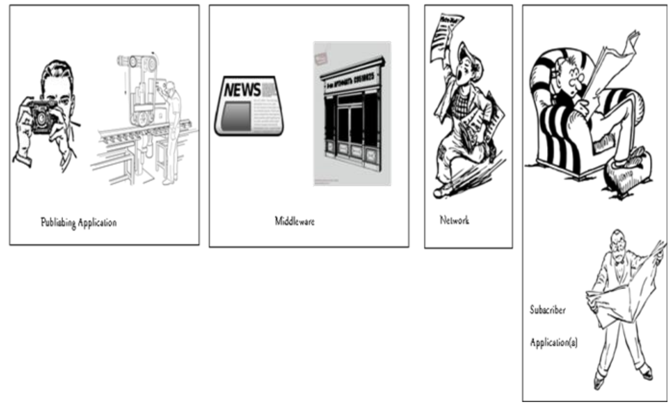


Figure 6 – Publish/Subscribe

A data provider publishes information, called 'topics', to which data consumers can subscribe. A sub-system may simultaneously fulfil the roles of data provider and consumer. In GVA, the DDS architecture provides the mechanism by which various applications can exchange information.

To describe the actual data transfers a data model has been created. This defines in detail, the data type definitions, quality of service patterns and profiles, as well as the actual data 'topics' for military vehicle applications and hence standardise the information flows for a GVA platform.

The data distribution around a GVA compliant vehicle platform must use the DDS stack, the DDSI wire protocol and the messages must comply with the GVA Data Model.

Video Distribution

The use of a common standard for transmitting digital video on a platform supports interoperability of present and future land platform digital video systems. The use of high speed Ethernet to provide video connectivity and

streaming has become de-facto in many vehicle installations.
Defence Standard 00-82, Vetronics Infrastructure for Video Over Ethernet (VIVOE), describes the methods and protocols to facilitate the distribution and control of digital video on a vehicle.

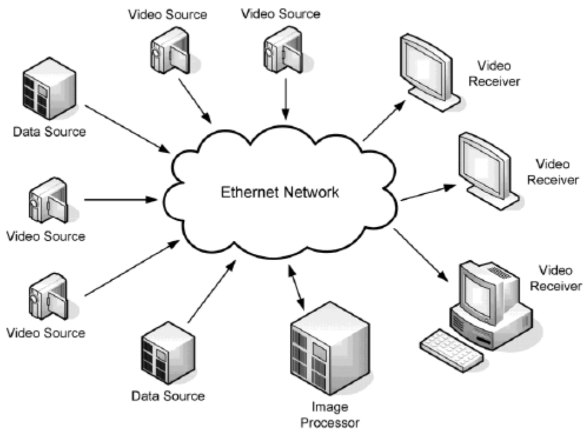


Figure 7 – Digital Video concept

Making use of the openly available Real-time Transport Protocol (RTP), which allows numerous defined video payload formats (including both uncompressed and compressed video formats), Def Stan 00-82 is mandated as part of the wider GVA standard.

Def-Stan 00-82 also specifies the methods used to incorporate session control using Simple Network Management Protocol (SNMP) and metadata within the video stream. This allows camera features such as zoom, gain, contrast and so on to be controlled via the Ethernet connection.

In addition, Def Stan00-82 has recently been incorporated into NATO STANAG 4678 for digital video (also known as PLEVID).

GVA TODAY

The Generic Vehicle Architecture standard is owned and managed by the GVA office [1] located within the MOD department for Defence, Equipment and Support (DE&S).
Led from the GVA office, the GVA Technical Working group still meets regularly with the aim to keep the GVA standard current and aligned with future technologies. As such, a GVA roadmap has been produced to ensure that the underlying research programmes (such as VSI) can be used to inform any updates to the standard as technologies mature and become more relevant.

GVA is a key part of a wider Open Architecture initiative wit in the UK MOD called Land Open Systems Architecture, and has achieved international recognition as a way forward in an approach to providing future platform architectures.

NATO GVA

The Military Vetronics Association (MILVA) [3] has been tasked by NATO to develop a NATO Generic Vehicle Architecture and publish it as a STANAG.
Ultra Electronics is a member of MILVA, which as an association of government agencies and industrial representatives, promotes Vehicle Electronics (Vetronics) within the military environment. MILVA is associated with NATO via the Land Group on Close Combat Armor of the National Army Armament Group (NAAG).

The approach to developing NGVA is to use the UK GVA as a starting point. It broadly covers the same areas of defining interfaces, HMI, the use of DDS middleware and the adoption of digital video but is expecting to be tailored for each host nation. The first version is due for publication by 2015.

LAND OPEN SYSTEMS ARCHITECTURE

The UK army is being re-shaped, in terms of equipment, man power and how it will be deployed. Called 'Army 2020', this design for the future British Army will make it more adaptable and flexible to undertake a broader range of military tasks at home and overseas.

A recent UK government whitepaper on national security identified the need to use open systems across all aspects of defense and security.

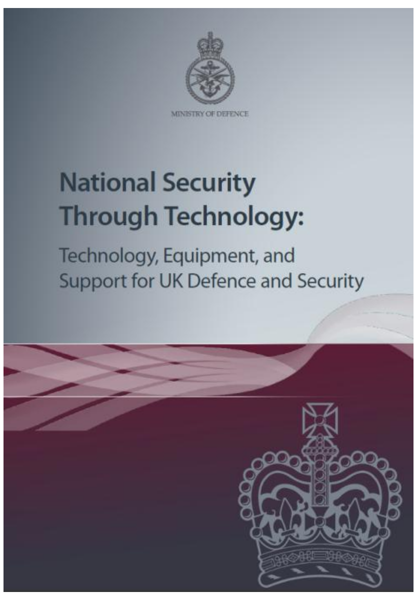


Figure 8 – National Security Whitepaper

Developed to exploit the benefits of open systems architectures, LOSA is an open, service based architecture for systems integration and interoperability in the whole Land Environment in order to deliver coherent, agile Force Elements.
Its purpose is to provide system coherence and interoperability both within the Land Environment, centered on a deployable brigade, and with the other environments and domains.

LOSA has been formally adopted by Army HQ, whose drive towards Army 2020 makes Open System Architecture a necessity.

LOSA is owned at 3 star level Commander Force Development and Capability (Comd FD & Cap), Army Headquarters, supported by Chief of Materiel (Land) (COM(L)), Defence Equipment and Support (DE&S).

LOSA defines architectures and mandates open (non-proprietary) technical standards for not just for vehicles (Generic Vehicle Architecture – GVA), soldiers (Generic Soldier Architecture – GSA), and bases /HQs (Generic Base Architecture – GBA). It also defines the Common Open Interface Land (COIL) by which the platforms interoperate with each other and with other environments such as Maritime and Air.

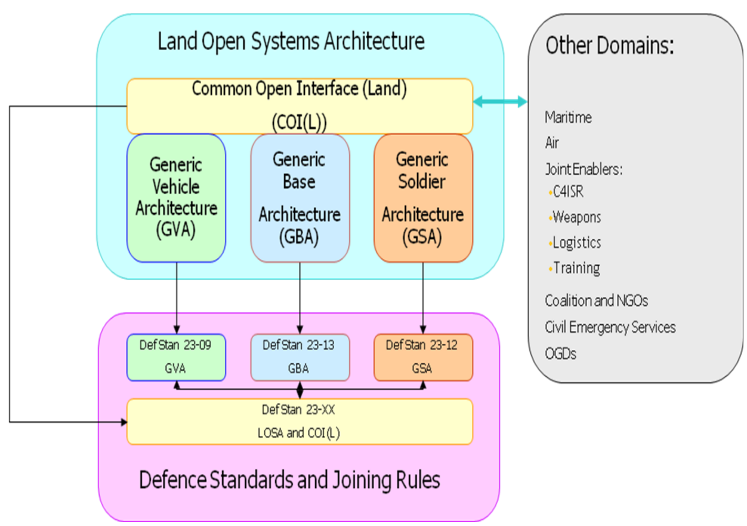
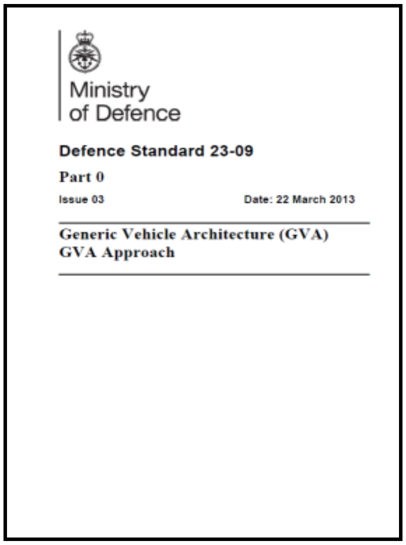


Figure 9 – LOSA context diagram

The UK's approach to Opens Systems Architecture for the Land domain.

Vehicles

As described in the previous sections, and now at Issue 3, the GVA standard determines the 'internally facing' architecture regarding power, data, video and HMI interfaces.


Ministry of Defence

Defence Standard 23-09

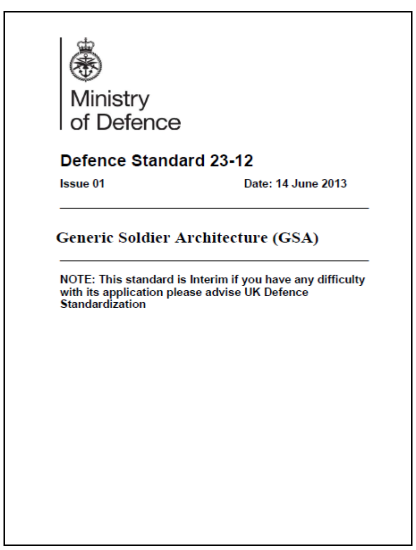
Part 0

Issue 03 Date: 22 March 2013

Generic Vehicle Architecture (GVA)
GVA Approach

Figure 10 – GVA Def Stan 23-09

Soldiers


Ministry of Defence

Defence Standard 23-12

Issue 01 Date: 14 June 2013

Generic Soldier Architecture (GSA)

NOTE: This standard is Interim if you have any difficulty with its application please advise UK Defence Standardization

Figure 11 – GSA Def Stan 23-12

The purpose of the Generic Soldier Architecture (Def Stand 23-12) is to realise the benefits of a common approach to the Dismounted Soldier System (DSS) by defining the power and data infrastructure and the characteristics of the interfaces to it which will be used.

Adopting the same principles as GVA, by establishing a technical working group, the standard defines the Power and Data interfaces necessary for the soldier. GSA is considered in 3 parts; Torso, Helmet and Weapon.
Ultra Electronics sit on the GSA TWG and contributes to the authoring of the standard and its maturation through the LOSA RED programme.

GSA will reduce the burden on the individual soldier from a weight, cognitive and thermal perspective, whilst enabling a 'plug and play' approach for legacy and future soldier systems

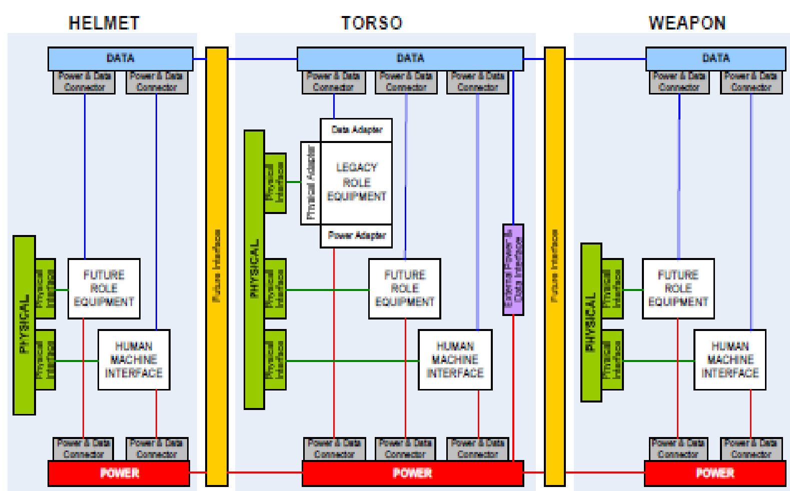
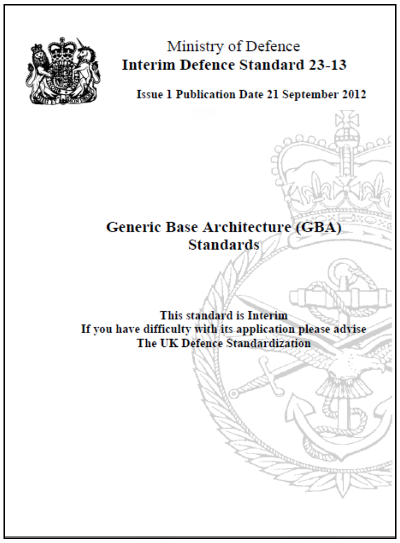


Figure 12 – GSA Interfaces

Work on this is ongoing, with a Technology Demonstration programme delivering the first cut of GSA compatible hardware by the end of 2014.

Bases & HQs


Ministry of Defence
Interim Defence Standard 23-13
Issue 1 Publication Date 21 September 2012

Generic Base Architecture (GBA)
Standards

This standard is Interim
If you have difficulty with its application please advise
The UK Defence Standardization

Figure 13 – GBA Def Stan 23-13

In line with the approach to GVA, the Generic Base Architecture standard (Def Stan 23-13) covers the internally facing interface requirements for Power and Data, along with Water, Waste and Fuel.

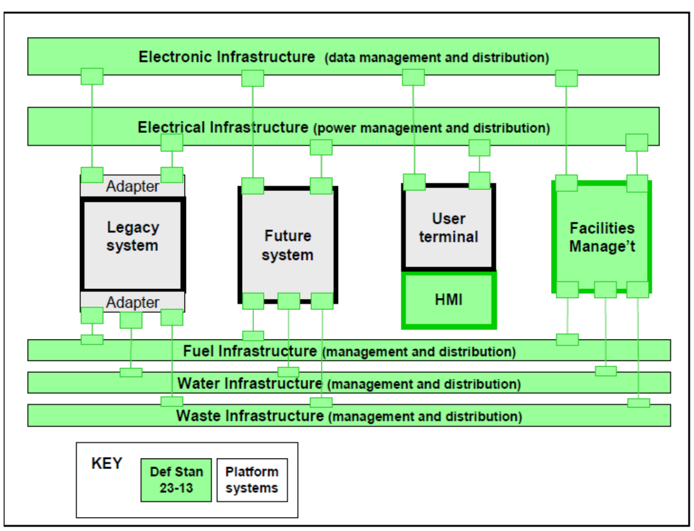


Figure 14 – GBA Interfaces

In reality, a Base Infrastructure is a physical instantiation of the architecture and is comprised of 5 separate infrastructures, Electronic, Electrical Water, Waste and Fuel, which deliver the core Base Infrastructure Services.

These services are used by systems delivering platform functions. The methods adopted for the Base Infrastructure are all open standards.
GBA is the least mature of the LOSA architecture sand there is ongoing work to mature its implementation via a series of Research, Experimentation and Demonstration exercises called LOSA RED. The GBA technical working group is represented by a large collective of industry members including Ultra Electronics.

Common Open Interface (Land)

Created by a small technical working group (including Ultra Electronics), and yet to be formally published, Def-Stan 23-14, Common Open Interface (Land), provides the means to exchange data and information *between* the various Land platforms.

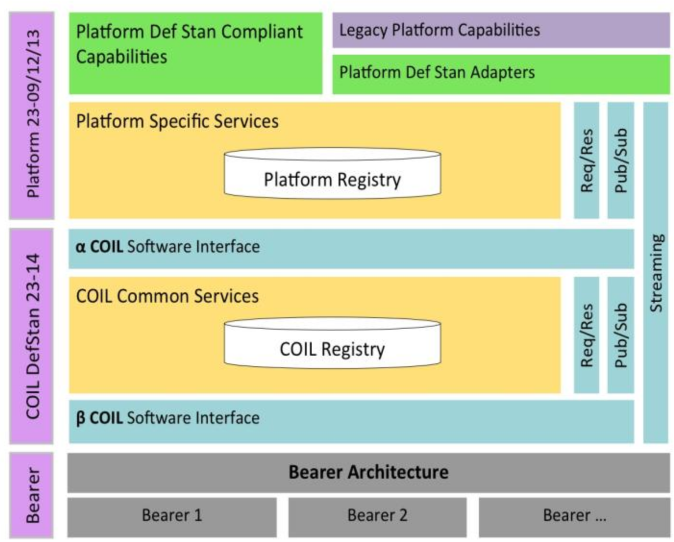


Figure 15 – COIL node architecture

In essence it provides an outwards facing link from the each of the internally facing generic architectures (the Alpha interface). This is then transposed into COIL messages via software adapters (the Beta Interface), and then sent via any available bearer, where the reverse process transposes the data back into the appropriate format for the receiving platform.

Discovery mechanisms and service registries in both parts ensure that a database of capabilities, security policies and management checks are adhered to before data is passed between the COIL layers.

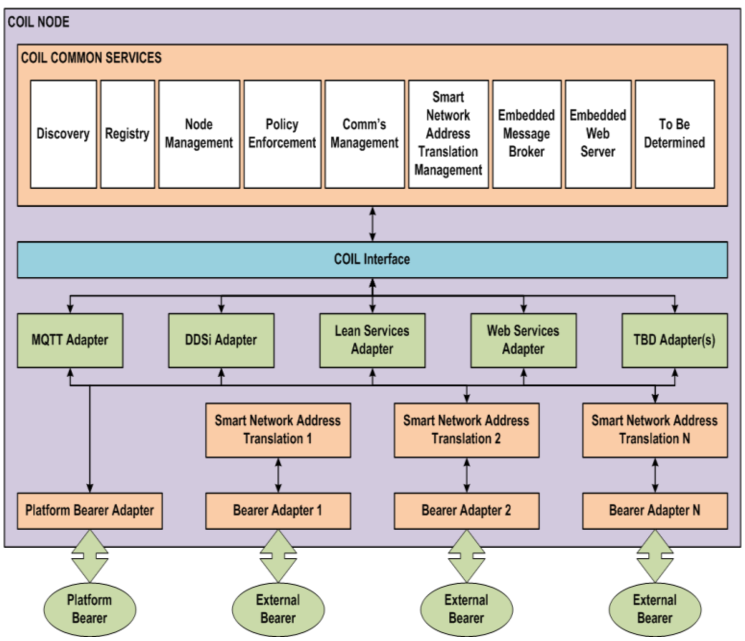


Figure 16 – COIL node adapters

COIL does not need to be heavy weight in terms of processing or bandwidth.
During recent trials in the UK, Lean Services have been successfully deployed as a means of carrying COIL data, with the possibility of using it to provide data transfer across different security domains.

Whilst aimed at the Land battlespace, COIL is not intended to be domain specific and the standard, implementations and design concepts will be taken forwards to the Joint, Air, Maritime and coalition partners so that interoperability can be realized across all of the force elements.

Coalition Interoperability

It is envisaged that a coalition partner would write their own Alpha interface within the COIL node. This way, only data and relevant information would be exposed to COIL and the Platform

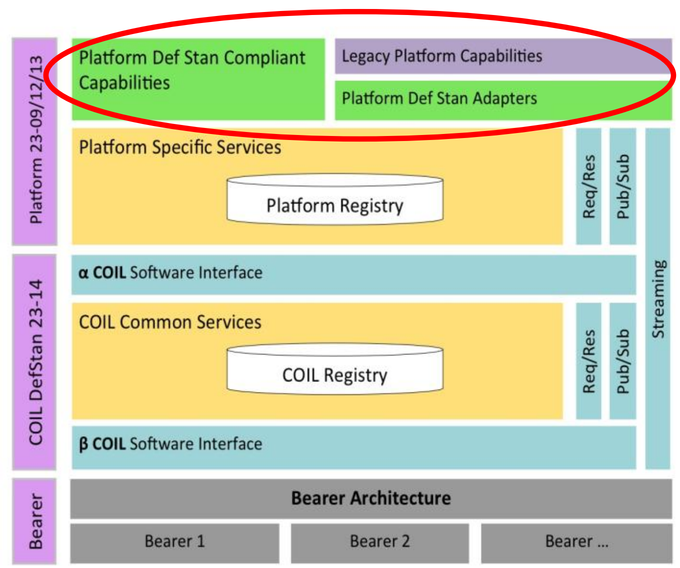


Figure 17 – COIL Coalition Adapter Location

The Platform Registry would facilitate the rules checks and security policies to ensure that only authorized data was allowed to be exchanged. This of course would be configured by the host platform.

In this way, COIL could provide a gateway into architectures such as the US Victory initiative, without having to expose the host vehicles internally facing architecture.

CONCLUSION

The paper concludes that the adoption of Open Architectures is not just a possibility, but a necessity if we are to succeed in future combat operations. It is no longer acceptable or practical to have the timescales and cost for re-integration and test in a rapidly changing battlefield. The UK's lead on GVA has been admired and adopted by several nations. Even NATO has a Generic Vehicle Architecture standard underway.

Concepts such as COIL offer a means to provide true coalition interoperability, whilst maintaining the sovereign independence that is so often is required. A series of practical experiments and demonstrations (under the programme LOSA RED) wild deliver real evidence of how open architectures will benefit defense going forward.

REFERENCES

[1] DESLE-DEFSTANS@mod.uk

[2] http://www.omg.org

[3] http://www.milva.org

[4] http://www.victory-standards.org/