A Guide to the Generic Vehicle Architecture

How open standards enable the world’s most digital fighting vehicles.

abaco SYSTEMS
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Introduction

The land forces of countries around the world are increasingly looking to design and implement vehicle electronics architectures that conform to a standard, providing them with significant benefits in terms of flexibility, upgradability, interoperability, maintainability and lower acquisition and lifetime cost. The US Army’s VICTORY initiative is perhaps the most high profile of these. This white paper describes a similar initiative by the UK’s Ministry of Defence.

The UK MoD (Ministry of Defence) has a long history of actively developing cutting edge vehicle electronics. The Chieftain tank (1965-1995) contained sophisticated electronics and was the United Kingdom’s Main Battle Tank (MBT), an evolutionary development of the Centurion tank (1945-1980s) which dated back to WWII. Chieftain featured a fully stabilized gun controlled by a computerized integrated control system when it was first deployed in the mid-1960s. It was later upgraded to include a digital ballistics computer, increasing accuracy and survivability. Much of this technology has evolved and is still in use in the Challenger 2 tank (1993 - present) today.

The Generic Vehicle Architecture (GVA) is one of the latest open standards initiatives to try and commoditize vehicle electronics in the latest generation fighting vehicles.

History

The first armored vehicle to take full advantage of the microprocessor was the experimental MBT-90 which was designed in the late 1970s (and later dropped in favour of the Challenger 1). It was clear early on that a new approach was needed to ease integration of the microprocessor and power distribution systems and the SAVE program (Systematic Approach to Vehicle Electronics) was born out of MVEE (Military Vehicles and Engineering Establishment) Chertsey. It defined a set of standards for electrical subsystems and power distribution that could exploit modern microprocessors while maintaining reliable operating in harsh conditions.

SAVE was the foundation for VERDI (Vehicle Electronics Defence Research Initiative) except it was driven this time by DERA (Defence Evaluation and Research Establishment) out of their HQ in Farnborough. A demonstrator was produced consisting of a telescopic mast (comprising a thermal imager and image intensifier) connected to a crew station made up of two CRT (Cathode Ray Tube) displays showing mapping information, GPS data, symbology and sensor information with the two crew stations being fully interchangeable.

The WASAD (Wide Area Surveillance Automated Detection) was another project in the nineties that built on the work done by MVEE. It examined remote vision and external cameras (as opposed to earlier optical vision systems). MVEE concluded that the technology at the time was not mature enough for deployment and WASAD took another look. Day and night vision systems were developed including target detection and recognition while on the move. Systems were tested on a modified Challenger 2.
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The fusion of sensor data provided the commander with firing options and was advanced for the time - and the modern era of vetronics (a blend of words vehicle and electronics) was born. It was a system that could truly improve performance while reducing the number of crew needed to operate it. WASAD had shown the potential of electronic systems integration in combat vehicles while highlighting the need for greater standardization to ease implementation.

Next came VESTA, VSI...

The DERA-sponsored VESTA (Vehicle Standards Architecture) project was to provide the architectural foundation for the work completed by the VSI (Vehicle Systems Integration) research program. The VSI research program underpins much of the current GVA specification and is well worth a read. It maintains the Vetronics Infrastructure for Video Over Ethernet (VIVOE) published as Def-Stan 00-82.

The replacing of legacy analog video systems which required point-to-point wiring with Ethernet-based video greatly reduced the amount of wiring required while providing a greater level of flexibility with what it was possible to achieve with the video (multiple displays, record, compress transmit video links). Camera wiring is especially awkward through a turret’s slip ring, so placing a switch in the turret can greatly simplify the camera wiring while using the same cable carrying the control and telemetry data into the body of the vehicle.

The VSI website describes its aims as:

1. The identification and evaluation of open standards that will underpin the implementation of such architectures.
2. Maintaining a close link between research communities and Industry to ensure maximum technology transfer.
3. Maintaining a close link with the international vetronics community and, wherever possible, forming international collaborations that are of benefit to the UK.

DERA was dissolved in 2001 with research and development being split between QinetiQ and the Defence Science and Technology Laboratory, an agency of the UK Ministry of Defence.

Land Open Systems Architecture (LOSA)

GVA is an integral part of the Land Open System Architecture (LOSA) and MoD initiative which aims to allow disparate systems to work together more efficiently. LOSA enables operational- and capability decision-makers to better plan for the unknown conditions of the future by implementing a modular architecture for a platform – e.g. soldier, vehicle or base.

This enables capability development through iterative or evolutionary technology insertion even where that capability is not yet planned. GVA sits within a larger set of standards including the Generic Base Architecture (GBA) and Generic Soldier Architecture (GSA) within LOSA.

Generic Vehicle Architecture

Referred to as GVA or Def-Stan 23-09, it is a set of open standards designed to put information exchange at the heart of the electronic system. Its objective is to create a single standard digital electronic architecture and electrical architecture for UK combat vehicles.
The nine basic principles of the GVA approach and Def Stan 23-09 are that they must:

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.

Advantages of GVA include:

1. Vehicle availability and reliability will be improved: instead of wasteful time-based maintenance intervals, condition-based maintenance will be possible
2. Availability-based contracts will be possible as vehicle usage data will be available against which to negotiate
3. Vehicle running costs can be reduced because condition-based information will be available
4. Processing and storage can be shared across multiple systems
5. Vehicle capability can be increased as sensors could be shared and intelligence automatically gathered and presented
6. Costs will be reduced by avoiding supplier lock-in, increasing competition and lowering the barriers to entry for smaller manufacturers
7. Weight and power requirements will be reduced as equipment-specific cabling will be eliminated
8. Reduced training
9. Reduced space for ‘systems equipment’
10. Vehicles can be quickly reconfigured for different roles
11. New sensors can be quickly fitted to vehicles to counter developing threats, this can be done quickly, in essence, plug and play for sensors

The MoD, along with QinetiQ, publishes the standard on an 18-month cycle. There are a number of collaborative partners including BAE Systems, General Dynamics, Selex, Thales, Lockheed Martin, L3, Raytheon and RTI to name but a few.

Def-Stan 23-09 (GVA) is arranged into the following parts:

- Part 0 – GVA Approach
- Part 1 – GVA Infrastructure
- Part 2 – GVA Human Machine Interfaces (HMI)
- Part 3 – GVA Health Usage Monitoring System (HUMS)
- Part 4 – GVA Physical Interfaces

![Diagram of Data Distribution]

![Diagram of Power Management and Distribution]
In addition to the infrastructure definitions, the GVA specification Part 2 goes further in describing the physical interfaces - the 'look and feel' or HMI (human machine interface) - of the hardware within the vehicle. As the army is facing increased pressure to reduce the numbers of operational soldiers, each must be able to operate a variety of vehicles. Standardisation of the HMI can reduce training costs and brings a reduction in integration costs and overall reduced cost of ownership.

GVA is driving the development of the next generation of armored fighting vehicles such as Foxhound (the first GVA-compliant vehicle to be deployed) and AJAX, currently being developed by General Dynamics for deployment in 2020.

To be a GVA-compliant vehicle such as AJAX also means that data interfaces and HUMS (Health and Usage Monitoring System) data capture is DDS (Distributed Data Service) enabled. Vehicle video distribution must conform to Def Stan 00-82 and the data infrastructure data flows conform to the format requirements of the GVA Data Model (as maintained by LOSA).

Def-Stan 00-82 (VIVOE, vetronics Infrastructure for Video over Ethernet) is an important part of GVA and is arranged into the following parts:

- Part 0 – Guidance
- Part 1 – Standards and Protocols
- Part 2 – Extensions for Audio and Acoustic Data

GVA for Video
Def-Stan 00-82 Part 1 describes three methods for video distribution using Ethernet wiring, with each leveraging existing standards but constraining their use to suit specific needs within the vehicle.

In each case, the video streams comply with the RTP(V2) / SAP (Real Time Protocol / Session Announcement Protocol) definitions provided within the standard. RTP runs over UDP which is connectionless and does not resend lost packets (unreliable). Fault tolerance was considered within the proposal for the three modes of operation.

Uncompressed video streaming is used where any latency cannot be tolerated between the source and destination i.e. the driver does not want to see any lag in the drivers display. Video is encoded using YUV 4:2:2 color space representation delivering greater bandwidth efficiency (over RGB). This mode still consumes significant bandwidth and is fault-tolerant (lost packets cause only the line/s in that packet to be lost). Uncompressed RTP streams can be joined instantly by subscribers and the video is raw (lossless and free from any compression artefacts). Scan lines can be sent as they are processed within the sensor in real time. This format is the most useful on a vehicle where bandwidth is not an issue.

A JPEG 2000 (ISO/IEC International Standard 15444 1 | ITU-T Rec. T.800 video stream is formed by extending from a single image to a series of JPEG 2000 images. Each image is compressed and formed into a JPEG 2000 RTP stream for video streaming. This format is typically used in medical and satellite imagery because the high-quality frame-based video with no inter-frame coding produces higher quality streams.

Finally, there are two H.264 profiles defined within the standard - MPEG-4 Part 2 Advanced Simple Profile (ASP) and MPEG-4 Part 10 AVC (Advanced Video Coding). These two profiles allow a choice of MPEG-4 video depending on the specific application. ASP provides lower performance compression when processing resources may be limited, while AVC provides higher performance but requires more processing to compress...
and decompress. Such compression can introduce latency into the video stream due to the inter-frame compression (need to collect multiple frames before the delta can be calculated) but offers significant benefits where bandwidth is limited. H.264 compression is used for storage of video streams where capacity is limited and for RF transmission where limited bandwidth is available.

**GVA for Audio**

Audio was not part of the original release of the specification, but is being added to the specification alongside the latest release of Part 1 (Issue 3, due September 2016) is Part 2 (Issue 1). This standard describes a method for audio distribution using RTP/SAP as for Video over Ethernet.

G.711 is an audio telephony codec that delivers toll-quality audio at 64 kbit/s, providing uncompressed Pulse Code Modulation (PCM) of voice frequencies. It is a standard for the encoding of narrowband speech (300 to 3400 Hz) audio with a sampling rate of 8 kHz and 8 bits per sample.

Interestingly, SIP (Session Initiation Protocol) was not adopted for session control but this could be introduced in the NATO version of GVA (NGVA discussed later) being adopted across Europe. Periodic SAP announcements indicate the presence of an audio stream.

**GVA for everything else DDS / SNMP**

The OMG (Object Management Group) describes DDS as “a middleware protocol and API standard for data-centric connectivity from the Object Management Group (OMG). It integrates the components of a system together, providing low-latency data connectivity, extreme reliability, and a scalable architecture that business and mission-critical Internet of Things (IoT) applications need. Its use in GVA is varied and can be exploited, but many different subsystems make it particularly useful for HUMS data collection.

A VIVOE architecture allows for the use of SNMPv2 for session control. SNMP is a standard protocol for collecting and organizing information about managed devices on IP networks and for modifying that information to change device behavior. Messages are organized into hierarchies with data (in the form of description and value) described in a Management Information Block (MIB).

**And then there is MilCAN**

MilCAN is a deterministic protocol that can be applied to a Controller Area Network. It was developed by the MilCAN Working Group formed in 1999 when it was recognized that there was a need for a standardized CANbus implementation for use inside military vehicles.

MilCAN is low cost and versatile, and its determinism and resilience make it ideal for low bandwidth data (below 1 Mbit). Although not officially part of the GVA specification, MilCAN is commonly found in many military ground vehicles and viewed as a necessary interface.
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The MoD has created a comprehensive framework for development of current and next generation of combat vehicles which can evolve over time to allow for new innovation. The GVA specification may be owned by the UK MoD but have a life beyond the borders of the UK.

NATO GVA (NGVA) or, more precisely, STANAG 4754 NATO Generic Vehicle Architecture, launched a project in 2012 with the goal of studying open standards and developing a strategy for the future.

Recommended
The project was called the Land Vehicle with Open System Architecture (LAVOSAR) sponsored by the Organisation for Joint Armament Cooperation. In 2014, LAVOSAR recommended the adoption of the UK’s Def Stan 23-09 Generic Vehicle Architecture as a NATO standard with extensions.

In the United States, VICTORY (Vehicle Integration for C4ISR/EW Interoperability) systems take a similar approach to GVA but have a narrower scope. VICTORY shares the GVA goal of creating a modular “bolt-on” open architecture that can accept future technology without significant redesign. It will be interesting to see how these three standards evolve and coexist.

With the introduction of open standards and open systems architectures, there is a need for an increased awareness that systems could be more prone to virtual and physical tampering. Data integrity, anti-tamper and intrusion detection technologies are being developed at every level to address security concerns.

From very low level memory buses to the CPU, PCB and LRU, system- and network level OEMs are implementing strategies to enable developers to secure their platform. Abaco Systems is introducing ever more sophisticated anti-tamper techniques in new single board computers and mezzanines designed to providing data assurance through encryption, better board design and the addition of active anti-tamper devices on the board dedicated to enforcing the board’s security strategy.

The bulk of the processing, Ethernet switches and video and data servers on the General Dynamics GVA-compliant AJAX program is provided by Abaco Systems.

What’s next...

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Evolve
These subsystems provide the backbone of the vehicle electronics architecture on AJAX and will be in service for decades to come. No doubt this capability will evolve and be the inspiration for the next generation of vehicles with increasing sophistication. Modular, flexible and standardised open systems design will be the key to future success.
WE INNOVATE. WE DELIVER. YOU SUCCEED.

Americas: 866-OK-ABACO or +1-866-652-2226   Asia & Oceania: +81-3-5544-3973
Europe, Africa, & Middle East: +44 (0) 1327-359444
Locate an Abaco Systems Sales Representative visit: abaco.com/products/sales

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