LAVOSAR

“Land Vehicle with Open System Architecture”

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- Public Executive Summary -

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Project Facts Table

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1 Motivation

In military land vehicles there is a permanent and increasing need for networked information technology that will enable better situational awareness and faster, more efficient and precise effects to be achieved by the crew during missions.

There are a number of national projects underway that aim to standardise certain information technology features in order to manage complexity and provide a coordinated approach to future procurement and whole life equipment support.

Recognising these, and following previous EDA land vehicle studies, it was decided that a study of the technical and financial aspects of a common European Land Vehicle approach to Mission System open architecture would be worthwhile; focussing on the mission systems of typical vehicles to be used by participating member countries. The LAVOSAR project was conceived for this purpose and let to Rheinmetall as prime contractor leading a multi-national team.

2 Aims & Objectives

The objectives of the LAVOSAR study were to:

- Analyse Standards and Best Practices, current and potential future Technologies and other activities in the domain having applicability to an open electronic mission system.
- Create a Normative Framework containing agreed definitions of context and terminology as a basis for more detailed study.
- Study and develop a functional and technical Mission System architecture, making recommendations to form the basis of a common approach used by multiple member states in Europe.
- Study and develop a Business Case supporting an Open Architecture approach.

3 Approach

The study was structured to include the following topics:

- Analysis of Background Material
- Information Collection from Stakeholders
- Normative Framework
- Business Case and Roadmap
- Standards
- Technologies
- Operational Aspects
- Mission System Aspects
- Design Guidelines
- System Acceptance Framework

4 Findings

This study provides a **comprehensive approach** formulated as an architecture which covers overarching concepts and methods rather than deciding on specifics, like other approaches such as

the UK Generic Vehicle Architecture (GVA) or the NATO Generic Vehicle Architecture (NGVA). As an example, data model abstraction levels and its sub-domain areas are provided and described in the architecture rather than defining the data model specifics with the detailed object, attributes and data types. As such, the study results are meant to be used as a **guideline** to determine the areas that shall be standardized, especially on how to develop the NGVA.

The architecture consists of a **number of views** covering all aspects of **Military Land Vehicle Mission Systems** for the different stakeholders. Typically, each stakeholder is only interested in a smaller subset of views. It is intended that all stakeholders are able to find those views which represent their aspect of interest.

Analysis of **background material**, information collection from stakeholders and the development of a normative framework as well as the identification of standards and technologies build the basis for the work. Especially, **VSI, UK GVA, NGVA, VICTORY, SCORPION, AUTOSAR, CEN Workshop 10 - Expert Group 9, EDA FLSG, EDA EG20, and FACE™** where identified as similar activities, at least, touching the LAVOSAR domain. It was pointed out that logistics and training shall also be considered.

The study focused on qualitative statements and uses estimated assumptions for the quantitative statements for the **Business Case View**. This view was explicitly requested but the government response to the questionnaire was weak.

It was estimated that **cost savings** were **10% to 25%** of the mission system cost and were not as high as originally expected. This was due to

- the rather **low procurement number** of vehicles assumed (500 APC in Europe over the next 5 years) and
- additional costs **for transforming legacy equipment**,
- the necessary **development and maintenance of the standard**, and
- the setup and hosting of an **"App Store"** for the software.

Other qualitative advantages, e.g. **situational awareness, operational efficiency and effectiveness in a networked environment** would be improved drastically with no significant cost increase and should be much more important for **driving this approach** than pure cost saving.

Another issue was the required three **security levels** (Unclassified, Restricted and Secret). The major problem is that security is treated as nationally closed issue with the lack of a common EU approach. The other challenge is the implementation of several security domains with cross domain solutions in a vehicle with little space and users with different clearance levels. Technically, it is recommended to use modern virtualisation technology for computers and networks (hypervisors, virtual private networks, time triggered Ethernet) for domain separation as an European approach.

One important requirement to be concluded from the analysis is the **fast exchange of higher volumes of information between vehicles** belonging to the same convoy or to the same patrol. Today, such exchange can usually not be achieved by the rather slow C4I-System with their long range radios with rather low data throughput (VHF). In the study, this information is called "Local Situation Picture" and treated separately from the C4I systems. Local Situation Picture data might be any information needed on the lowest tactical level and information exchange, e.g. between drivers of different vehicles in a patrol, for which exchange shall be possible without interference of the vehicle commanders. The information might range from simple coordination information to video streaming data.

The **Integrated Mission System View** defines a harmonized or common infrastructure which consists of the system and software architecture as well as the computer environment (e.g.. Figure 1).

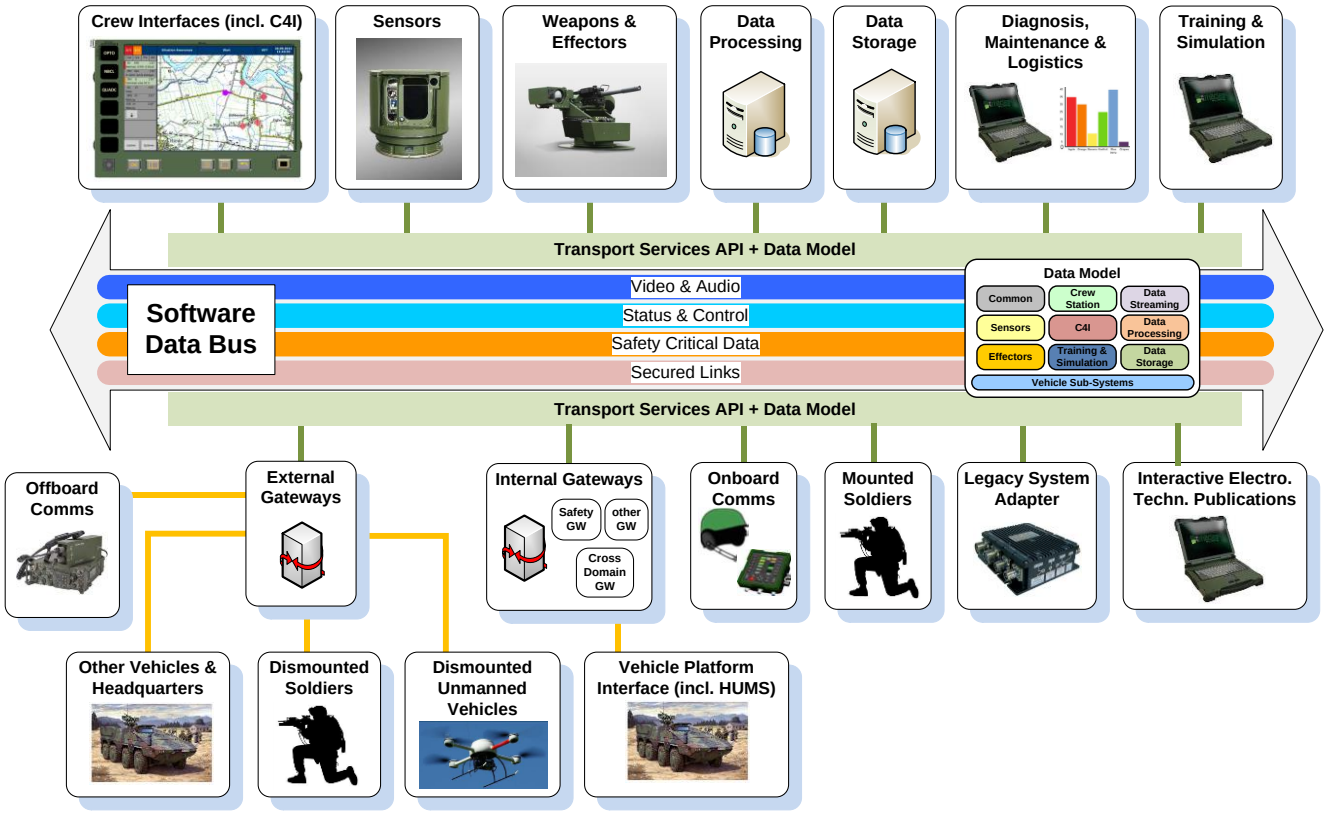

Figure 1 - LAVOSAR Bus-Centric System Overview

A **framework for modular software** was adopted from FACE™ which allows arbitrary distribution of software Apps in the network which is useful to fulfil the requirements from system setup and from limitations for data throughput on the network. These plugable software modules are proposed with a defined API which is common to all Mission Sub-systems. A **software layer approach** enables the exchange of information using any appropriate middleware and enables the use of required hardware with very low effort for hardware specific adaptations. These Apps are especially suggested for the **Crew Station** which shall be built along the same framework as the other sub-systems and makes it modular and flexible.

The preferred choice of **middleware is the DDS** which is briefly analysed and described. However, for specific purposes, e.g. Mission Subsystem configuration, Web Services might also be used which allow simple Browser based access. Mainly, **Ethernet based** standards are proposed. For safety critical solutions, **CAN-bus** is suitable and used alongside the Ethernet based intra vehicle communication network. Standards for safety critical Ethernet are emerging but still expensive.

For offering proven and robust software application from the best vendor or developer, an **“App Store”** is recommended where integrators are able to select and acquire the software modules.

The **separation of the mechanical, electrical and software segments** using defined interfaces such as operating systems and formfactors enable innovation for individual parts in spite of different **innovation speeds** inside the complete Mission System.

For the required data model, an approach using different abstraction levels is suggested as well as a comprehensive list of sub-domains for which a data model should be defined. Defining a common Data Model for information exchange is a challenge and is not solved satisfactory also outside the vehicle mission system domains. Cost and effort for a good and useful date model shall not be under-estimated. Successful data models need to be maintained and continuously developed further.

Architectural **templates** are provided **for safety and security solutions** which can be chosen depending on the specific needs.

Gateways are proposed to be used for external, cross security or safety domain communication or for communication with legacy sub-systems. **Network topologies** shall be chosen depending on the application, data throughput, and safety and security requirements.

Also **embedded simulation and training as well as diagnostics, maintenance and logistics** are considered.

A list of **crew interface services** is defined based on the operational requirements.

Concerning standards, there is a danger that the closed VICTORY or SCORPION may **preclude future multi-national interoperability** unless appropriate interfaces can be **opened** for the development of a common standard.

For the Technology View**, no single technology** can be recommended for the wide application range necessary. Rather a **list of selection criteria** is provided to choose the best technology for the individual purpose**. Virtualisation and middleware** are technological areas which become more and more suitable and necessary for military vehicles. Virtualisation is now supported also by the hardware.

For the Specification and Design Guidelines View, a process consisting of **"Operational Analysis", "Mapping of Operational Tasks to System Functions" and "Definition of Deployment Specific Architecture and System Parameters** (Target Architecture)" is proposed.

A **System Acceptance Framework** based on current practices and life cycle models is described with **conformance testing procedures, assurance cases and test beds**. Horizontal and vertical integration is considered as well as supporting standard such as ISO 15026.

The original idea of using **AUTOSAR** or some aspects of it was given up as it was developed **for micro controllers** and not for the powerful mission system computers which normally provide their own operating system such as LINUX, QNX, etc. For Mission System, the **multimedia activities** created out of AUTOSAR could be more useful. **AUTOSAR is not suitable for military land vehicle mission systems**.

5 Recommendations

A Comprehensive Open Reference Architecture for Military Land Vehicle Mission Systems as a European Standard is regarded as key for the European Member States to a cost efficient approach throughout the whole vehicle life cycle and improved operational effectiveness.

From such a Reference Architecture, Target Architectures for the vehicles to be procured would be derived using compatible MOTS Mission Sub-Systems or Components provided by a competitive market. These sub-system or components could be easily integrated into a military vehicle according to the specific needs as they use the necessary interfaces and implement the necessary functionalities.

A vehicle which is build according to this standard can sustain the respective state of technology by simply adding, replacing or upgrading sub-systems. In the same way, a specific or a changing mission need can be satisfied by adapting the set of sub-systems accordingly. Logistics are simplified and exchange of spare subsystems across various types of vehicles and even European nations is possible.

Rec-1. The results of **LAVOSAR should** therefore **be standardized** as a comprehensive and abstract, higher level concept in order to enable better standard development on the lower level (c.f. DefStan 23-09 or NGVA). As NGVA will probably be not equipped with the funding for work on such a higher level concept and also for additional concepts, such as the software framework, EDA should complement these activities. However, care should be taken that these follow-up activities stay coherent with the NGVA.

Such standardization work could be carried out as funded project or by establishing an Open Working Group which develops and maintains the standard. However, it is doubtful that an approach without funding will be successful as the situation with the low numbers in the military field is quite different from those in the civil market where such an approach has led to the successful AUTOSAR.

Best practice is to accompany such standard development by demonstrations and experiments which prove that the approach

- is described comprehensively enough,
- is working and proves to be useful and
- provides valuable feedback.

EDA should **identify the European standard authority** to establish an European approach on vehicle architecture.

EDA should also investigate if the LAVOSAR standardisation approach could be **transferred to Navy, Air Force or Space** applications.

Rec-2. The development of a demonstrator for the **App Store** with all the aspects of the application to a vehicle including the detailed definition of the APIs, the Data Model, specs, etc. is recommended.

Rec-3. The development of a proposal for a **Validation, Verification and Accreditation (VV&A) organisation and procedures** incl. suggestions for a test bed is recommended.

Rec-4. The LAVOSAR result should be considered as **guidance for the development** of other more specific layers of Mission System standards.

Rec-5. The currently developed LAVOSAR Reference Architecture is abstract. A **more specific layer** needs to be defined in order to make the architecture directly applicable to target applications. A part of this layer is already defined in the UK GVA or is currently being defined in the NGVA. However, a significant part is still missing or not satisfactorily solved, such as

- interfaces between disciplines of **different innovation speeds** (operating systems, form factors, etc.),
- **data model** for data exchange,
- gateways for **external** communication,
- **APIs** for the software framework,
- data exchange **between vehicle** of a convoy or patrol, and
- **selection** of further standards to be used

Rec-6. Data Models are key to interoperability. This includes syntactics as well as semantics. However, such Data Model are prone to continuous changes. Currently, there is no sufficient concept for achieving compatibility for different Data Model versions. A **rule set**

for extending or modifying Data Models should urgently be developed as well as **data mediation** approaches which additionally allow the mapping to data models of other domains (e.g. MIP).

Rec-7. The software concepts adopted from FACE™ are very promising and not covered by UK GVA or NGVA. However, FACE™ targets the airborne domain where costs have a much high order of magnitude. Therefore, an approach needs to be developed to make **"FACE™" affordable for Land Systems**.

Rec-8. Most of the current developments are national and will lead to different incompatible national standards, e.g. UK GVA, SCORPION, VICTORY. Such developments may preclude future multi-national interoperability unless the necessary interfaces are published. EDA should try to influence **nations to make their approaches available**.

Rec-9. Raising the new **Mission System approaches from national to EU level** would increase numbers and competition. It is recommended that EDA identifies common fleet procurement possibilities which could be coordinated by an appropriate office (e.g. OCCAR-EA) and which would benefit from the EU approach.

Rec-10. The **business case** is important for deciding on the economic importance and should cover at least the next 10 years. It was not possible to the study to acquire meaningful numbers or requirements for Mission Systems for this time frame. **Further effort** is recommended here, especially for government input on coordinated fleet training and support policies on the broadest possible European level.

Rec-11. **Security** was identified as a difficult unsolved issue as security is currently mostly treated nationally and on headquarters level. The Study could not acquire any information from EDA about security. When a concept for several Security Domains inside a vehicle is required, as stated in the Government Workshop, a **community of interest** needs to be set up in order to achieve an acceptable common solution **at EU tactical level**.

Rec-12. **Inclusion of the military users** as additional stakeholder was not required in the study but would have been useful as they are the persons who need to operate the system and whose tasks are supported by this technology.

Rec-13. EDA should raise a **press release** with the major results of the LAVOSAR study.

Rec-14. EDA should establish an **Expert Working Group** for evaluating the LAVOSAR results and instantiating the necessary actions but also for the pure exchange of detailed information on specialised matters.