Vetronics Architecture with in-vehicle Networking

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ABSTRACT

The effectiveness of combat and combat support vehicles platforms can be improved significantly by incorporating Vetronics concept at the platform design stage itself which allows on-board systems to be interconnected as networks and enables them not only to share the information with-in the platform but also with the neighbouring platforms. The Vetronics concept not only optimises the on-board computing resources and other electronic sub-systems, also aids in easier platform integration. The Vetronics architecture with in-vehicle networking can be conceived and optimised based for vehicle type, requirement of types of systems envisaged for integration and having a balance between standard and customised components. The conceptual architecture proposed in this paper brings out the benefits offered by Vetronics approach for integration of on-board sub-systems thereby enhancing the platform effectiveness and Battlefield Management System for in-service and futuristic platforms considering the space as one of the major constraints. The proposed concept is adaptable, flexible and scalable enabling integration of the various electronic sub-systems.

Keywords: Mechanised forces; Vetronics, Platform effectiveness, networking; Battlefield management system; Command control; Combat vehicles

1. INTRODUCTION

The advancement in the information technology has its impact on the nature of the warfare. Future wars will be short and intense and mechanised forces will have a broader mandate and decisive role across all types of terrain & combat scenarios. The basic role and requirement will be same i.e. mobility, firepower and survivability, Mechanised forces will be employed across broad spectrum ranging from operation in mountainous and amphibious terrain, urban conflicts to overseas deployment as a part of country commitment[1]. Over a period of time, the armoured fighting vehicles, infantry combat vehicles and wheeled vehicles platforms of the mechanised forces (aka combat and combat support vehicles) are progressively equipped with electronic information and command control systems to improve the firepower and survivability. However, these upgrades have remained in silos. The militaries globally have been working closely with the industry to bring out vehicle electronics (Vetronics) Standards to enable the vetronics technology development and bring about system upgrades at much faster pace.

The effort is also in the direction of standardising this architecture for future tracked and wheeled vehicles.

The transformation of the platforms is focused around key components i.e. Networking, automation and situational awareness (SA). The vetronics will play a role of enabler for all the three component. Networking will seek to integrate all the elements on-board in real time and enable the commander

to take the timely decisions. Situational awareness has always been goal of the military. It rely closely on networking of on- board sensors, shooters, computing and communication devices to collate, distill out the crucial information and share automatically to the relevant entities, both on-board and among other platforms.

The aforementioned vetronics concept can certainly benefit the new and futuristic platforms, but the existing platforms can also be modified (to the extent possible) with vetronics architecture to reap its benefits, considering the size, weight, power and cost.

2. EXISTING ARCHITECTURE

The military land platforms, in–service today for more than three decades, have been subjected to upgrades throughout their life. The approach adopted was to fit the systems wherever space is available[2]. These vehicles become increasingly complex and expensive. The drive for cost effectiveness requires that these vehicles should have longer in-service lifetime than current vehicles. Over period of time, the need for upgrades to address the new threat scenarios has been fulfilled by "bolt-on" approach, as these platforms were designed with little thought to changes during the lifetime of the platform. This traditional approach to platform design and upgrades resulted in stove piped upgrades which resulted in exponential growth in complexities with the increased number of sub-systems on board. Additionally, such piecemeal and tightly coupled integration approach would result in reduced flexibility when it comes to technology insertion and obsolescence management.

The closed system design and interfaces usually led to lock-in with original equipment manufacturer (OEM) for maintenance and support.

Some of the limitations of existing architecture are listed as follows

i.   *Integration complexities*: The insertion of technologies over a period of time causes crucial integration issues of the sub-systems from different OEMs. One of the major integration related issues is the out-of-design increase in on-vehicle processing, storage and network capacity for communicating, storing and processing the large volumes of sensor derived data as varieties of sensors are integrated. Another complexity is the growing network security loop-holes with the addition of newer elements and network components.

ii. *Lack of standardisation:* The absence of any standard architecture increases customised development which not only increases dependability on OEMs but also increase the development time.

iii. *Lack of interoperability*: The integration challenges, if not addressed, lead to interoperability issues or sometimes augmentation of additional systems with functionality overlap, resulting in ineffective system utilisation.

iv. *Under exploitation of systems*: Absence of sub-systems which can provide the visualisation of information becomes a hindrance for effective exploitation by the crew members.

v.   *Limited scalability*: The bolt-in type of upgrade approach severely affects the scalability towards implementation of comprehensive solution.

vi. *Size, weight and power constraints*: Most of the vehicles are already stuffed with systems and personnel gears used by the soldiers. More the number of systems, more the heat generation; which requires more metal and space to dissipate it. Hence, addition of equipment causes severe SWaP constraints and affects the ergonomics and crew comfort.

vii. *Training and maintenance of personnel*: Separate training for vehicle crew members and maintainers to be provided to ensure the availability of the platform.

viii. *Vendor lock-in*: Implementation of system with proprietary standards and protocols leads to dependence on OEM and vendor lock-in for longer periods.

ix. *Increased total cost of ownership*: The aforementioned challenges, in particular integration and interoperability aspects, in the existing architecture result in higher total cost of ownership.

3.   PROPOSED METHOD

Vetronics architecture in its true sense relies on a high-speed communication network. A diverse set of sensors that continuously feed the SA and enable the military decision support is at one end while the other end is the vehicular platform hardware that provides the means to deliver timely, meaningful military action. Between the sensors and the mechanised platform hardware comes the automation enabled by suitable processing modules and servers to store and process the sensor data into valuable information in near real-time.

Mechanised forces of next generation are expected to have integrated and networked weapons and sensor suite to achieve the dominance and victory in the battlefield. The risk of increasing integration complexities as a result of integrating multiple sensors and weapons as well as need to facilitate insertion of new technologies has led to the adoption of vetronics architecture. The vetronics architecture concept proposed is to facilitate the integration of on-board systems, including C4I system, into tracked and wheeled vehicles. The proposed approach is a modular *Integrated Harness* approach for next generation fighting vehicles.

The proposed vetronics concept, depicted in Fig. 1, will enable the user to have seamless secure intra and inter vehicle communication capabilities[3]. It includes the following key sub-systems:
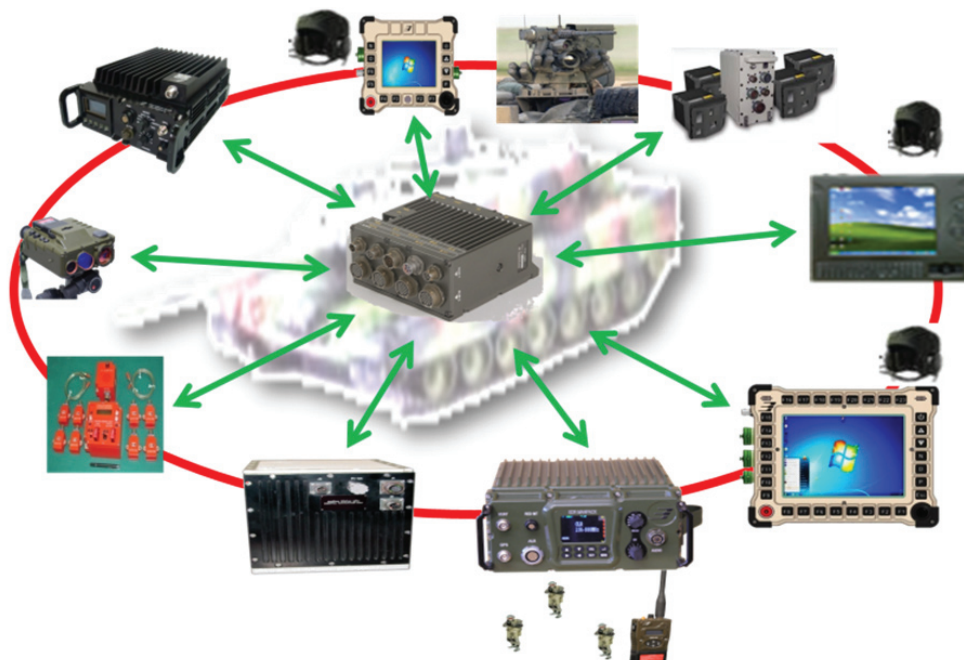

Figure 1. Vetronics concept.

- Vehicle health management (engine, fuel etc)
- Surveillance systems
- Fire control system
- Vehicle electronic warfare systems
- Vehicle protection systems
- Battlefield management system
- Communication system
- Intra vehicle communication system
- Navigation system

The architecture is IP based with the flexibility of using the existing network protocol stack and modifications for replacing with proprietary algorithms, if required. It will enable the integration of sensors systems, intercom system, vehicle parameter systems, protection systems and communication systems. It will provide integration of voice, data and video services delivered ubiquitously across a secure network infrastructure to provide the increased mission effectiveness.

The Vetronics architecture is guided by the following basic principles:

i. *Ease of integration*: It is the integration of the various sub-systems on-board that contributes to increase the combat effectiveness of fighting vehicles. The capabilities broken down into modular approach will lead to better management of integration risks. Ideally, both equipment and functional modularity is desirable. Functional modularity will allow functions to be combined within specific modules to meet platform specific requirements and it will aid in achieving the scalability, portability & extensibility.

ii. *Data processing and distribution:* The proposed architecture will support distributed processing with acceptable quality of service (QoS) which is desirable for mission critical operations. The ability to process various types of data (images, sensor data, relevant map overlays on GIS backdrop etc) and to share with all the relevant entities enables soldier's on-board and outside platform to understand the situation around and respond to it accordingly. The data distribution concept coupled with advanced digital communication such as software defined radio or satellite communication system will enhance the operational effectiveness. The architecture has provision for redundant centralised server, if required, thereby avoiding single point of failure.

iii. *Network Security*: The architecture can include security of the data carried on-board network should be secure from interception and tampering.

iv. *Scalability*: Adopting with an all IP based approach with centralised server will allow the insertion of newer technologies.

v. *Portability*: Having a mix of embedded software, application software and adopting open interfaces standards with adaptive middleware approach will facilitate the insertion of new technologies.

vi. *Interoperability*: An all IP based approach, to the extent possible, will result in better interoperability. Use of open standards and interface will open up the sub-system suppliers market and will result in wider competition.

vii. *Extensibility:* Use of adaptors and middleware based approach will allow the adoption of different architectures.

viii. *Enhanced operational effectiveness:* The increased interaction between the sub-systems on-board will facilitate the maximum use of information by mounted and dismounted entities.

ix. *Power management:* The increased quantity and complexity of the sub-systems, the intelligent power management is crucial for performance of Vetronics. This will require ability to isolate the power from low priority equipment to high priority equipment. The power management will ensure that the faulty sub-system on board doesn't bring down the entire power to other sub-systems. The use of alternative energy sources for combat vehicles will be boon for Vetronics. The use of Fuel Cell based technology can be experimented for Combat vehicles. The use of Direct Methanol Fuel Cell based power source and charger can also be used as power source.

x. *Lower maintenance cost:* The reduction in platform maintenance cost can be achieved by implementing intelligent Built-in tests, automated simplified diagnostic to aid preventive maintenance.

xi. *Reduced life cycle cost:* There is always a requirement of reducing the life cycle cost associated with land platforms like AFV & ICVs.

The Fig. 2 broadly depicts the vetronics integrated approach. The components on-board platforms are catagorised based on the functional domains as automotive, sensors, weapons, command & control, protection measures. The Ethernet data bus can be adopted for intra vehicle communication. It can include the exchange of voice, data, imagery and video among the crew members on board platforms. The platform information such as fuel, ammunition, situation awareness, vehicle health state etc
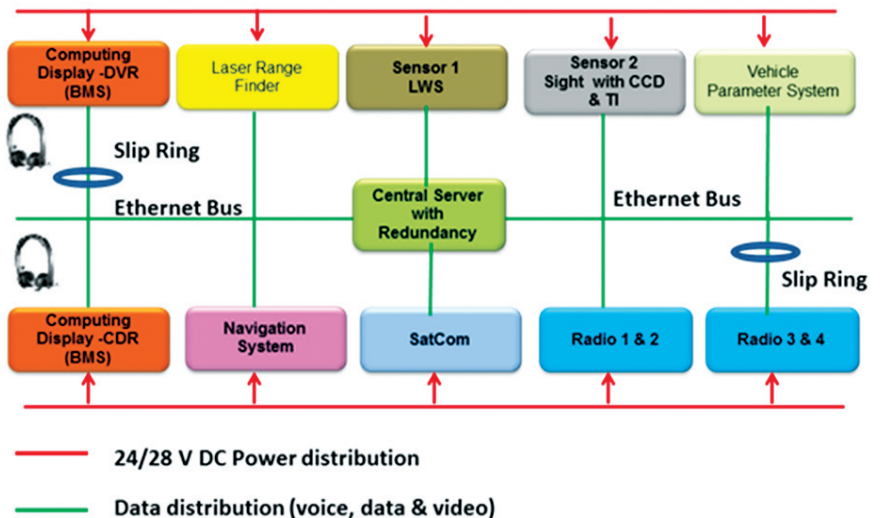

Figure 2. Vetronics integrated approach.

which is required to be shared with the other platforms can be shared via centralised server to which V/UHF communication sets are connected. The centralised server houses middleware which takes care of prioritisation of time critical data and dissemination of the data to the relevant entities on-board vehicles as well with other vehicles with the relevant QoS.

4. RELATED WORK

The various studies have been done in last two decades in the area of Vetronics by researchers who have come up with many architecture approaches addressing future requirements[4]. According to a market research[5], Vetronics market is expected to garner USD 4,362 million by 2022.

One thing that had emerged clearly was that there is a need for vehicle architecture to meet the demands of future. The findings in this area bring out the set of standards for data transfer, software and power distribution mechanisms. Vetronics Research Centre[6] is the only Academic Centre of Excellence in the UK conducting research and training in the field of vehicle electronics. It conducts training programme on Vetronics technologies and architectures to disseminate the knowledge and experience in the area of Vetronics.

5. CONCLUSION AND FUTURE WORK

In this paper we have explored the challenges and limitation of the existing architecture of the military vehicle platforms in terms of integration, scalability, maintenance and SWaP point of view. The study brings out the advantages offered by adopting Vetronics architecture approach. The Vetronics approach is covered at high level and building blocks can be adopted based on the type of the vehicle, upgrade approach and for new vehicles. The proposed architecture has a combination of centralised approach with redundancy to address the single point of failure.

The use of alternative energy source such as fuel cell can be considered for further study as energy efficient and cost effective alternate energy source to support future weapons like high intensity lasers and active protection systems.

The basic principles brought out in proposed architecture are conceptual and each of the principle can be further studied, and explored. The necessary customisation w.r.t individual sub-systems of various types, to meet the requirements of variety of vehicles in-service and futuristic can be considered for use primarily for tactical military applications.

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His contribution is in studying the advantages of Vetronics architecture, formulating an adaptable, flexible and scalable architecture with in-vehicle networking, and proposing a conceptual architecture for use primarily for tactical military applications.

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His contribution in the present work is to analyse the Vetronics architecture as co-author and review the proposed concept, with a view of enhancing the platform effectiveness.