2012 NDIA GROUND VEHICLE SYSTEMS ENGINEERING AND TECHNOLOGY SYMPOSIUM
SYSTEMS ENGINEERING AND INTEGRATION (SE) MINI-SYMPOSIUM
AUGUST 14-16, MICHIGAN

Bridging the Gap - Applying Performance Driven Aviation Technologies in Cost Driven Ground Platforms

Mr. Marion P. Hensley
Raytheon Technical Services Company, LLC
Indianapolis, Indiana

ABSTRACT

The complexity of ground vehicle mission systems has evolved significantly over the last few years resulting in over-taxed platforms with federated mission suites. Department of Defense (DoD) is pursuing platform evolution toward integrated mission suites. Opportunities exist to apply aspects of previously developed methodologies from the aviation sector to ground platforms. This paper describes the parallels of the evolution of aviation platforms with the similarities to ground platforms. Solutions from the military aviation community will be discussed that could reduce development risks, schedules and costs and improve mission capabilities for ground applications. Specific discussion will be on opportunities and techniques to transition performance driven, high cost, low volume technologies into mission suitable and affordable high volume solutions. Discussion of the feedback opportunities into the aviation community will be addressed. This paper is not intended to be a tutorial on systems engineering but rather a stimulus for industry and the DoD to discuss commonality and design reuse opportunities between the ground and aviation communities resulting in a "system of systems" bridging aviation and ground solutions.

Background

Combat ground vehicles have changed significantly in recent years. In recent conflicts, such as Iraq, our adversaries have stimulated the development of new mission systems such as Counter Improvised Explosive Device (CIED) systems by the Department of Defense (DoD). This influence as well as the natural growth of mission requirements and complexity has driven the evolution seen in typical ground vehicles. **Figure1** illustrates the similarities between ground vehicles and aviation mission suite complexity evolution over time.

Not long ago a typical manned ground vehicle mission suite consisted of a radio for communications and a .50 Caliber machine gun. Today, it is a complex collection of federated mission systems and functions on heavily loaded platforms. Some typical examples are listed below:

- Communications(voice, data and satellite)
- Global Positioning System (GPS) (sometimes multiple GPS on the platform)
- Situation Awareness (SA), Blue Force Tracker (BFT)
- IED Jammers and Electronic Warfare (EW)

- Directed Energy (DE)
- Specialized IED countermeasures
- Intelligence, Surveillance, Reconnaissance (ISR)
- Remote control guns, fire control systems
- Hostile fire detection and location
- Mine rollers
- Embedded training/simulations
- Other capabilities

In time, the future will bring integrated mission suites as "System of Systems" for ground platforms. This path parallels the evolution of the aviation community.

Lessons learned and resources are available from the aviation community that could be applied to the path forward of ground vehicles. Opportunities to aviation, especially tactical UAV's, result from new affordable capabilities developed for the ground vehicle community based on higher production volumes. Many mission types and technologies are now on ground platforms that not long ago were only common in the aircraft domain such as radar, EW and ISR.

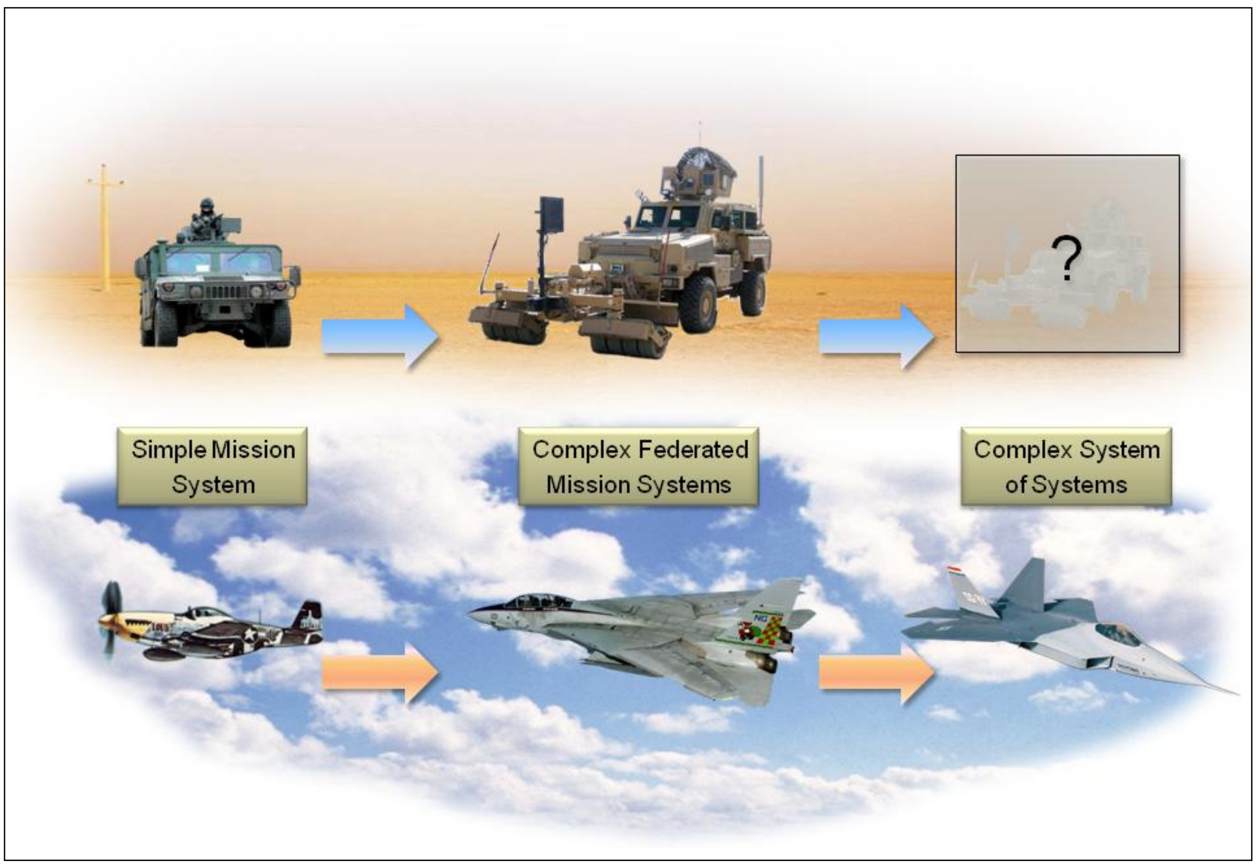

Figure 1: Mission System Evolution

Discussion

This paper will discuss the application and collaboration of architectures, mission technologies and ground/ air integration opportunities. The reasons that government and industry stakeholders should consider dialog and action for these topics are presented as well along with the proposed near term actions. The philosophy of this approach is illustrated in an operational view of the proposed technology transfer as shown in **Figure 2**.

Figure 2: Technology Transfer Operational View

Mission Domain Comparison

Ground vehicle requirements are different than aviation in many ways. It is important to recognize that the product cost/performance trade space is significantly different. Aviation products are commonly performance driven and typically produced at low production volumes. On the other hand, a ground product typically requires much higher production volumes and is significantly more cost driven. Both operational environments are harsh but do not share the same trade-offs and priorities. Different maintenance philosophies are expected as well.

As ground missions become increasingly complex, mission technology needs are becoming more common with traditional aviation technologies. Ground forces are facing increasingly more complex missions, similar to the aviation evolution some years ago.

A distinction should be noted that ground and aviation products are different but the technologies required in the respective products are much the same.

Architecture Opportunities

The US Army has developed the VICTORY architecture as a vision for ground vehicles. As it matures, increased requirements will be identified for the architecture growth path. The evolution beyond the current scope may benefit by increased collaboration with US Army and with other services aviation growth paths. It is envisioned that identifying common goals and opportunities could facilitate technology reuse, lower costs and improved mission performance for both ground vehicle and aviation programs. In addition, dialog on lessons learned from aviation may benefit the ground community by reducing the need to reinvent solutions.

Specifically, it is envisioned that collaboration would identify common and unique requirements derived from respective ground and aviation projected CONOPS growth paths. Specific topics such as the following are envisioned:

- Features and functions
- Interfaces
- Modularity
- Scalability
- Priorities
- Maturity timeline
- Cost/ performance trade space

In simple terms, the goal is to maximize commonality that makes sense for both communities.

Example Mission Technologies

Many products and technologies are in use or needed in the ground vehicle mission area. Opportunities to transition technologies from aviation into cost effective ground vehicle solutions are noted in Figure 3. This list is intended to stimulate dialog on potential synergy and reuse opportunities and is in no way a complete list.

Aviation	Ground

• EW/Radar
  • Software Defined Radio (SDR) modules
  • High Power RF Amplifiers & MIMICs
  • ESA Antennas/T/R modules
• Helmet Mounted Displays
• Multifunction Aircraft Samrt Displays
• Condition-Based Maintenance (CBM)
• EO/IR
• Others?
	• Multifunction RF Systems
	  • CIED Jammers and Directed Energy (DE)
	  • Radar Sensors and Communication
	  • GPS
	  • LO Conformal Antennas/Antenna Farm
	  • Non-lethal Denial Weapons/Active Protection
	• Helmet Mounted Displays
	• Smart Multifunction Ground Display Processors
	• CBM
	• EO/IR
	• Others?

Figure 3: Example Technology Mapping

Specific examples include the significant investment of airborne EW in wide band Software Defined Radio (SDR) technologies. These could be applied to multifunctional ground based systems such as sensors, communications, GPS, ISR, CIED jammers and directed energy as an integrated mission capability. Radar technologies such as advanced solid state high power amplifiers, MMIC's, electronically scanned array antennas and T/R module techniques could find application in multifunctional ground systems. Some of these technologies have already facilitated ground based active protection capability. Airborne helmet mounted display technology further enables advanced ground applications for helmet mounted SA and targeting. Smart airborne multifunctional displays technologies are being applied to multifunctional smart ground display application based on technology developed for aviation. Airborne electro-optical technologies have fostered the development of advanced ground based EO/IR products. Common tools and methods that can be applied for condition based maintenance (CBM) between aviation and ground applications could lower life cycle cost solutions. As one can imagine, there are many other potential technology transfer opportunities not discussed.

Ground and Air Integration Opportunities

In a perfect world ground and aviation mission systems could behave as a large "system of systems". Steps toward that ultimate goal can ease the task. Inherently, common usage of architectural elements, technologies, product building blocks or modules can aid in interoperability and a migration toward a "system of systems" mission behavior goal.
Situation awareness (SA) is one significant example of an important mission capability and ground/air mission integration that would benefit greatly from additional commonality. One can imagine the significance of improved operational compatibility across traditional domains in the following operational context:

- Ground to Ground
- Ground to Air
- Air to Ground

It is proposed that the government and industry can "Bridge the Gap" one step at a time by cross domain collaboration and; thereby bringing increased value to the war fighter.

Stakeholder Impact

With the harsh reality of declining DoD budgets the services have very difficult challenges of providing the mission systems the war fighter needs for the next conflict. The combat experiences in Iraq and Afghanistan have rapidly driven an evolution of requirements over the last ten years and the future may very well bring more rapid changing war fighter requirements.

Both ground and air war fighters need improved affordability even with increasing and more demanding capabilities and requirements. Increasingly complex systems have driven programs to longer development schedules; technology reuse has the potential to reduce development schedules and reduce risk when properly implemented.

Performance driven aviation products contain many technologies that can be tooled for high volume and value engineered to bring affordable solutions to the ground vehicle community. As an added benefit, the aviation community, especially unmanned aerial vehicles (UAV) could benefit by potentially bringing costs down for mission functions.

More commonality will drive inherently toward improved interoperability and a vision of a Ground/ Air “System of Systems” capabilities.

Lastly, with DoD budget uncertainty, industry is shy to invest as heavily as in the past for new technologies. Government and industry collaboration on common solutions brings improved focus and predictability to industry thus enabling more positive return on investment than would be otherwise.

Proposed Actions

It is envisioned that improved cooperation between Government and industry can identify new opportunities for advanced concepts that build upon the VICTORY architecture, technology reuse and promote a path to a larger system of systems. Joint Government/ industry working groups are proposed to increase dialog and understanding of the constraints of all stakeholders.
These working groups would identify synergy and priority opportunities for reuse and drive toward collaborative Ground/Air development of new technologies and architectures that plan for multiple cross domain uses of common components and requirements.

These activities focus the marketplace toward more predictable budgets and technical objectives enabling industry to invest wisely and achieve acceptable return on investment.

Within Raytheon, methods are being studied to bring performance driven technologies into cost driven applications. Technology areas such as Transmit/Receive (T/R) modules have a legacy of optimizing aggressive performance and cost objectives for advanced electronically scanned array (AESA) radar systems used in demanding environments. These advanced concepts have application for high volume ground multifunction electronic systems that can be implemented with microwave monolithic integrated circuits (MIMIC) and advanced manufacturing techniques.

It is envisioned that the government has other ideas and concepts to foster collaboration and cooperation on this subject.

Conclusions

Ground vehicle requirements and products are different than aviation. A distinction should be noted that ground and aviation products are different but the technologies required in the respective products are much the same.

Tailored lessons learned from the aviation community could benefit the ground vehicle community in the context of architectures, mission technologies and ground/ air integration.

Potential cost advantages are available to the aviation community from high volume ground use of common components and technologies.

Within Raytheon, methods are being studied to bring performance driven technologies into cost driven applications.

It is proposed that the Government forms a joint Government/Industry working group to address these opportunities and coordinate future direction across the stakeholders.

REFERENCES

Images		
YF-22	http://en.wikipedia.org/wiki/File:YF-22.jpg	This image or file is a work of a U.S. Air Force Airman or employee, taken or made during the course of the person's official duties. As a work of the U.S. federal government, the image or file is in the public domain
P-51	http://en.wikipedia.org/wiki/File:P-51-361.jpg	This image or file is a work of a U.S. Air Force Airman or employee, taken or made during the course of the person's official duties. As a work of the U.S. federal government, the image or file is in the public domain.
F-14	http://en.wikipedia.org/wiki/Grumman_F-14_Tomcat	This file is a work of a sailor or employee of the U.S. Navy, taken or made during the course of the person's official duties. As a work of the U.S. federal government, the image is in the public domain.
Humvee	http://en.wikipedia.org/wiki/File:Slohmmwv.jpg	Source: Wikimedia Commons
SPARKs on MRAP	https://search.usa.gov/search/images?utf8=%E2%9C%93&sc=0&query=SPARKs&m=&embedded=&affiliate=www.army.mil&filter=moderate	Photographs and imagery on the Army's website at https://search.usa.gov/search/images?affiliate=www.army.mil, unless otherwise noted, are in the public domain.