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in this issue

Future of Product Development in the FA&D Sector - Now! by Brent Baker, Sr., Maj Gen, USAF (Ret) & Alexander Daly

The Dream of the End State

It can be unrealistic and even dangerous to dream about the future, but then again you can't afford not to either. That about sums it up in all walks of life: family, business, education, politics, conflict, etc. What was the dream of the Internet itself when its promises were far on the horizon 25 years ago? Back then the 'Information Superhighway' promised to dramatically change our lives in fundamental ways with monochrome PCs connected through telephone networks.

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Let's Export a Broader Concept of Transportation Reliability

by Russell A. Vacante, Ph.D.

To better understand what is meant by transportation reliability in the current U.S. driving environment we should adopt a systems of systems methodology. That is, as opposed to restricting reliability to technology associated with vehicles, the term transportation reliability should be viewed from a much broader perspective. This perspective is all inclusive in that it focuses on vehicles, roadways, technology, and customer driving satisfaction as well as environmental factors.

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A generation later, despite the many drawbacks, was the dream worth it? Most would argue that the upside of newfound capabilities has more than offset the downside: instantaneous personal and business communication as well as the ability to trade stocks, shop, share ideas, telecommute, pay bills, and even watch newly released films - all from home. Was it dangerous to be the early adopter and herald in these fundamental changes years ago? Yes, but the reward was well worth the risk. We are at another crossroads.

Similarly, on the horizon today there is an evolving 'dream' about the impact the Internet of Things (IoT), Artificial Intelligence (AI) and other emerging tech will have on our daily lives in future years; and as a subset – how technology platforms could be used inside the DoD and the defense industrial contractor base. Given the risks involved on this front, the difference between reasonable planning and engaging in utopian fantasy is razor thin. Take any high-profile aircraft program as an example. Given the projected maintenance costs over the lifecycle, is it unrealistic to imagine the beneficial impact on availability and cost of the following types of use cases?

- **Diagnostics and Remediation -** A landing gear could diagnose its own problem and order a replacement part, or at least alert ground crews of an impending breakdown before it happens.
- **Knowledge Management -** Tribal knowledge type insights and gained expertise unique to the maintainer of one aircraft could be verified with empirical data, and then shared through Augmented Reality (AR) with other maintainers across the fleet.
- **Use of Legacy Data -** Historical flight data coming from sensors could be automatically analyzed to create the basis of new mission profiles.
- **Spares Optimization -** A set of optimal sparing scenarios could be created given unique parameters for aircraft availability for specific mission profiles or combat deployments.
- **AR for Maintenance -** Using a tablet or wearable device (such as an AR headset) maintainers could determine where the malfunctioning part is, 'see' it in context, then be guided step by step through its repair procedure.

All excellent ideas, but the interactions between the DoD and the defense industry OEMs have been somewhat like a junior high school dance; lots of interest on both sides, but neither making the first move. On one side is the DoD, still recovering from the readiness impact of sequestration years ago

yet eager to use the recent uptick in spending to counter near peer threats in hypersonics, cyber, and AI. And on the other, industry is trying to be as proactive as possible in bringing new capability concepts to the DoD but still needs enough guidance to de-risk R&D expenditures, which directly impacts M&A posture.

In the meantime, clearer demand signals are often coming from non-government customers, where cost of sale is lower and acquisition timeframes faster. Thus, FA&D (Federal Aerospace & Defense) is underserved for many emerging technologies relative to other sectors of the economy. This is ironic as it was the Pentagon that gave the world technological marvels like GPS and 'electronic mail' decades ago. But both sides are highly interested and will make a move - more likely with toe-in-the-water steps rather than through one galvanizing, catalytic event. That said, there are green chutes emerging that will spur adoption.

Near-Term Horizon Product Development Trends

So many people are justifiably reluctant by the prospect of emerging technologies in the DoD that they are only speaking about them in the abstract. But to adopt faster than near-peer competitors, we must have the collective courage to speak about them in the specific. Below are a few specific trends:

Real Time CAD Simulation - One emerging trend is the concept of real-time simulation inside CAD systems. Up until very recently, most of the structural, thermal, modal analysis for new products happened only after porting CAD data into a simulation system, then back again post analysis; an error prone and clumsy process. Those days are ebbing away now, with simulation that is happening inside CAD itself. This sounds like a minor technical distinction, but it will have significant impact on quickening product development by narrowing the feedback loop. It will also mean a migration away from physical prototyping to purely digital simulation. There has been much talk of the so-called 'CAD Renaissance' of late and real time sim inside CAD will clearly be an engine fueling that renaissance.

Digital Twins - Many players in the FA&D sector have been amplifying their portfolios with a capability that allows data flow between physical products and their digital equivalent (a 'digital twin'). The DoD is actively exploring the use of Digital Twin type capabilities from industry. This tightening of the feedback loop will help the DoD and defense industrial base reduce costs for design, manufacture and support as well as open up new landscapes for invention and growth. As a demonstration of the demand strength in this nascent area of enterprise software, Digital Twin software is currently a $1.8B market, expected to grow at a 35% CAGR between 2019 and 2024.

AI for Design and PLM - Another concept on the near-term horizon is 'generative design', in which AI algorithms - not human beings - will be designing the products of tomorrow. A design engineer will determine design requirements and intent, and the AI will create multiple, optimized solutions based on those requirements. The AI has no human biases, which will mean a step function for innovation with designs that meet requirements in entirely new ways. This will ultimately drive the need for enhanced PLM capability through linkages to additive manufacturing (certified 3D parts libraries, blockchain for custodial chain). When generative design is eventually coupled with real time simulation and digital twins, the impact on product development will be immense, both for the defense industrial base and inside the DoD.

But design isn't the only arena of product development that will be using AI. Think about the implications for AI on PLM itself. It will mean a capability to comprehensively validate large PLM data sets in seconds or do natural language processing in searching though unstructured data. Another capability could be to quickly assess risk within a PLM system and make proactive, remedial decisions. Such smart PLM systems will have an awareness built-in that quickens product development times.

When we move to an era of 'explainable AI' from the black box systems of today, users will also be given a traceability tree to determine how those AI results were derived, further enhancing value. The DoD's budget for AI is skyrocketing. According to Bloomberg Government analysis, AI funding will be increasing from $1.4B FY 2019 to $4.0B in FY 2020. In addition to exploring AI for predictive maintenance, network mapping, 'maneuvers and fires' and other warfighting and humanitarian capabilities, the DoD will likely be looking at applying AI to product design and PLM as well.

Migration from Documents to Models - Ever since the DoD issued a groundbreaking policy directive for Digital Engineering adoption in 2018, there has been a push among the services to migrate from a document-centric approach to product data to adopting a models-based approach. The idea is to view engineering as a continuum across the product lifecycle vs. merely existing in one early phase

of it. This also applies figuratively to product support models, design models, and management models. PLM is at the core of the Dept. of Defense Digital Engineering Policy. In the last year since the policy was released, the Air Force and Navy have both made broad-sweeping moves toward enterprise-level PLM acquisitions, partly to meet the requirements laid out in the policy directive.

Augmented Reality - The DoD is starting to make decisive moves in adoption of Augmented Reality (AR) as well. In 11/2018, the Army awarded a $480M contract to Microsoft for up to 100,000 HoloLens headsets to be used for both personnel training and in live combat missions. Among the Army's stated goals for AR include night vision and thermal sensing, measurement of vital signs, concussion monitoring and hearing protection. This will be the tip of the adoption iceberg as the Navy and Air Force will ultimately be making similar moves. In a program called 'Optical Dominance' the U.S.

Special Operations Command (SOCOM) has also been considering combining AR with AI machine learning and other technologies for rehearsal and targeting before missions as well as telemedicine.

Using AR for Maintenance is another consideration. As of last count in 2016, there were 617,000 military and civilian maintainers in the DoD. Many of these maintainers will be leaving the workforce soon. Could AR be a means to capture the expertise of maintainers to train the next generation? In 6/2018, the Air Force Research Laboratory (AFRL) issued an RFI for virtual, augmented and mixed (VAM) reality technologies specifically for aircraft maintenance.

A forcing function on the industry side of AR adoption has to be Foreign Military Sales (FMS) of U.S. defense equipment to U.S. allies, primarily in Europe and the Middle East. Due to a policy change lowering the cost of these transactions, deals skyrocketed 33% to $55.6B between 2017 and 2018. Most of those contracts require the U.S. firm to provide equipment maintenance as well as in-country offsets for economic development, including workforce training. In order to de-risk the delivery of these contracts, many of the U.S. firms must be considering technologies like AR to help quickly train their own

maintainers or bring in-country maintainers up to speed.

Conclusion

Today's aerospace and defense leaders must work harder and faster than ever to meet the increasing demands of their missions, constituents and markets. Smart warriors adapt. The prospect of FA&D sector readiness improvements and efficiency gains from emerging technologies like Digital Twin and AR is quickly shifting from theory to legitimate use cases and acquisitions.

But the threat surface from these technologies is expanding so rapidly that it now includes what used to be safe ground under your feet. From the designer's desktop, to the factory floor, to operating environments on land, air, sea and space - the digital thread is being stretched across the entire product lifecycle. How shall we meet this challenge? There are no easy answers, but in general start fast and secure, fail small, then scale what is working. Induce tight feedback across multiple OODA loops. Your near peer competitors are doing the same. Can you afford to stand still?

Authors:

Brent Baker, Sr., Maj Gen (Ret), USAF is Vice President, Federal Aerospace and Defense of PTC, Inc. General Baker was previously Vice Commander, Air Force Materiel Command, at Wright-Patterson Air Force Base, Ohio. The command employs some 80,000 people and manages $60 billion annually in research, development, test and evaluation, while providing the acquisition management services and logistics support required to develop, procure and sustain Air Force weapon systems. In his role at PTC, he is responsible for strategic planning and business development in the worldwide FA&D market vertical with a specific focus on gaining first-to-market competitive advantage in the adoption of technology and smart, connected enterprise solutions.

Alexander Daly is Director, Federal Aerospace and Defense of PTC, Inc. He leads PTC's Federal Aerospace and Defense efforts for DoD programs to government and industry customers. In this role, he creates strategies for improving processes around product design, manufacture and support through the application of software platforms from PTC. Mr. Daly also leads PTC's government relations efforts on Capitol Hill and manages a team of external consultants focused on strategic business development.

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Editorial from Page 1

In high-density traffic corridors such as Rt. 95 and its surrounding highways and bi-ways in the greater Washington D.C. vicinity, we see traffic congestion, especially during business rush hours, significantly increasing every couple of years. The official government's response to the congestion is to increase traffic lanes and toll roads which has proven to be a short term, expensive solution. As we have heard said many times, "build a road and the people will come." This expression acquires much legitimacy when we take into account the growing number of road rage incidents, the growing experience of traffic delays, the ever increasing loss of worker productivity, the adverse impact on the driver's health due to exhaustion plus the increased number of sedentary hours associated with a long drive time.

A joint government-industry response to worsening driving conditions has resulted in advance technology in the form of autonomous, or self-driving vehicles. This emerging technology purportedly will increase road safety with the suggestion that the driver will be more rested, thus more productive, and the drive-time possibly reduced due to the responsive efficiency of autonomous vehicles. While pros and cons to each one of these factors can be extensively discussed to determine the true merit of autonomous vehicles (which certainly have some merit) the fact remains that traffic congestion, increased drive time, and driver frustration, will persist. That is to say, that regardless of the advent of autonomous vehicles (coupled by the expanded number of traffic lanes) the fact remains that present and future road infrastructure is nearing a point of near or total dysfunctionality.

Given that the definition of reliability is "the ability of a system to perform its intended mission when operating for a designated period of time" (Blanchard and Fabrycky p.369) it is quite clear that our present highway and road systems are increasingly becoming unreliable. There is not enough road space, now and in the foreseeable future, to efficiently and safely accommodate the seemingly never-ending increase in vehicular traffic. Thus, a system of system solution is required to reduce travel time in geographic areas that seem to defy current technological and design ground solutions.

The time has come to look off the ground and upward for innovative answers to resolving traffic problems. Allow me to suggest one, probably of many, of the ground transportation solutions. As the photo below suggests, ski lift type gondolas may be a feasible alternative transportation solution to solving our

traffic problems. Gondolas of this type can accommodate multi passengers that will result in fewer cars on the road, improved traffic safety, reduce adverse environmental consequences, lessen construction and maintenance costs relative to road infrastructure, has the potential to reduce the number of road rage incidents, will enhance travel time efficiency, and most importantly, improve the health by reducing traveler's exhaustion.

Regarding the use of a gondola-type transportation system in and around Rt. 95 in the greater Washington D.C. area, I envision a step cost effective process. The first step is to install space efficient gondola boarding platforms in the commuter parking lots. Multi passengers would board gondolas at set time intervals. The gondolas would travel on a cable system over the local to Rt. 95. Route 95 would be the dedicated north-south travel route for the gondolas. At designated locations there will be an enclosed platform with steps where passengers can disembark. The transportation footprint of such a system would be relatively small when compared to the existing and future planned highway expansion and overpass infrastructure transportation projects.

By adopting a system of system transportation perspective we can begin to realize that ground solution to improving traffic flow is not required, and some instances may be obsolete. A gondola type infrastructure network is a cost-effective alternative to highway expansion projects, is less damaging to the environment, will result in less driver stress, and promises to decrease traffic fatalities and injuries. It will get the travelers to get where they need to be within a relatively predictable timeframe. Off the ground transportation systems, gondolas or otherwise, will greatly improve the reliability of the U.S. transportation system in exceedingly high volume traffic areas.

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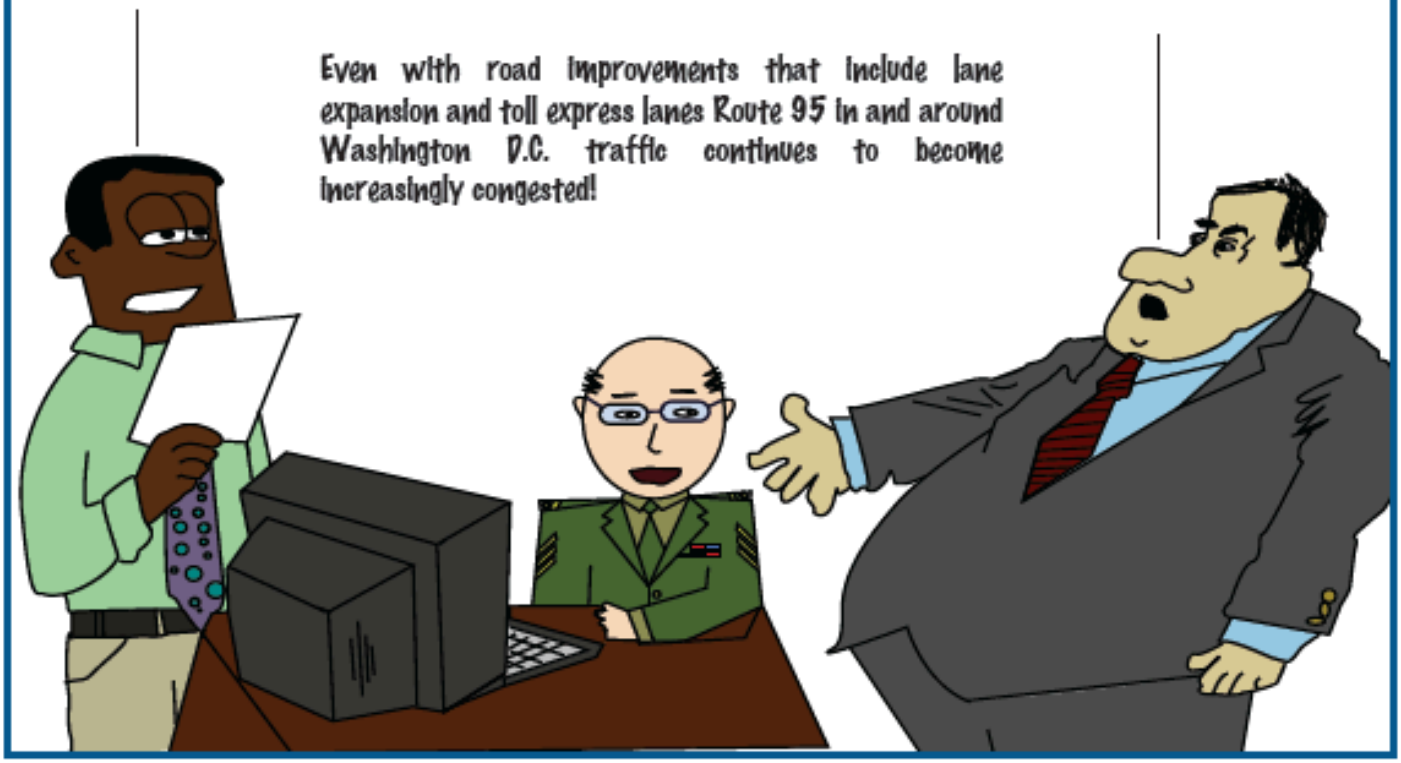
Another Day At The Office

by Russell A. Vacante, Ph.D.

Every year my commute along the Virginia-Washington D.C. traffic corridor gets increasingly frustrating and longer. I'm getting to work and returning home exhausted due to battling heavy traffic.

A system of systems design methodology is needed! Let's explore alternative ways to make travel time to and from designated destinations more cost efficient. A transportation system that does not restrict travel to ground transportation modes is required. Highly reliable, cost effective transportation systems, similar to ski gondolas, that follow highway routes 20-30 feet off the ground may be our answer.



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H&DR Logistics and RMS

by Dr. Lloyd H. Muller, CPL

For the past several years, I have been teaching the principles of logistics as they apply to disaster relief operations. In many respects, responding to Ebola outbreaks in Africa, hurricanes in Puerto Rico, and tsunamis in Asia are very similar to military operations. A problem arises and a sudden surge of materiel and people come pouring onto the scene. A typical comparison was the rapid build-up in Thailand after its devastating 2004 disaster and during the early days of the Iraq invasion.

With this being the case, the lessons learned from military expeditionary warfare can be effectively applied to humanitarian and disaster relief (H&DR) operations. If the resources are properly identified early on, then they can be moved efficiently and effectively to the afflicted area. For example, the US military sent 14,800 commercial meals and 11,760 liters of bottled water. Other examples abound, but the point is made.

All of this fully conforms with the definition of logistics offered by the Council of Supply Chain Management Professionals (CSCMP): "that part of supply chain management that plans, implements, and controls the efficient, effective forward and reverses flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements." That is, the definition assumes that the materiel and services are all in excellent working order. It also assumes that the delivery infrastructure is fully functional.

This definition meets the distribution requirements of commercial industry. But, it is a dangerous one for the chaos of a disaster environment. Going back to Puerto Rico, the hurricane virtually wiped out the island's infrastructure. Roads were impassible. Telecommunications were non-existent. People were stranded in remote villages simply because vitally needed resupplies could not be moved the "last mile."

Of course, political blame became the game. But, the simple fact is Puerto Rico was unprepared logistically for the challenges that confronted them. Its internal infrastructure was not strong enough to withstand the winds. Roofs were blown off. Trees were uprooted. Water supplies were broken. The list goes on. But, the investments needed to withstand seasonal storms were lacking and the island's infrastructure was too fragile.

This is not an uncommon situation. Several years ago, I taught an H&DR course wherein the students had to find a real world problem to solve. They went to a fire station in a Florida county and offered to review their preparedness for the hurricanes that were annual events. The list of problems was long. Trucks were not maintained properly nor were records kept of any maintenance being done. Training of personnel to respond effectively was lacking. Communications were not tested. Operating procedures between

county agencies and their state counterparts were lacking.

A report was submitted to the fire chief and proper thanks were given. But, it was obvious from their remarks, they really didn't care. What was more important was attending a national conference on disaster preparedness. A good party was not to be missed.

Now, this horror story does not reflect the efforts being made elsewhere. There are many localities and disaster agencies that work hard to be prepared. But, still, even with the best of intentions, similar results can occur if proper procedures are not developed and followed.

To alleviate this situation, I prefer the definition given by Virginia Tech Professor Emeritus, Benjamin Blanchard: "The art of science and management, engineering, and technical activities concerned with requirements, design, and supplying and maintaining resources to support objectives, plans and operations." This concept is more comprehensive than the supply chain definition. It requires thought be given to the environment where the disaster will be occurring. From there, design and maintenance policies relevant to the environment must be developed. Then, and only then, can thought be given to using it as expected by the supply chain definition.

Going back to Puerto Rico, had comprehensive laws been passed and enforced to upgrade buildings and roads that would withstand category 4 storms, they might have allowed goods and services to reach helpless victims. This fits into design and maintenance of an important logistics element: facilities. The same would be true for another element, communications. Then, periodic drills to ensure that another element, personnel and training

would have helped immensely to ensure prompt relief. Now, after the storm, concerted efforts need to be taken to repair and upgrade damaged resources. Life cycle, integrated logistics is the key to effective H&DR operations.

The field of humanitarian relief is a new one. Indeed, current writings that reflect even the integrated supply chain definition are only a few years old. For example, traditional concerns focused on the provision of staples such as food, water, sanitation, etc. Now, network concepts relate to tracking and tracing, procurement, customs clearance, and service standardization. That is, planners are no longer focused simply on dumping food. Rather, they are taking a broader perspective that talks about how needed services and materiel are provided. Effective and efficient processes are emphasized to ensure delivery of resources.

This evolution is excellent. Already, improvements in humanitarian responses can be seen. But, until a life cycle approach is adopted such as outlined by Blanchard, improvements will ultimately be stunted. Consequently, as academia develops programs that prepare professionals for their challenges, it must ensure that this preparation effort be as comprehensive as possible.

The Author:

Dr. Lloyd Muller, CPL, is a logistician with many years of military and academic experience. He has practiced in many different "hotspots" around the world employing all aspects of his expertise. He now teaches for the Florida Institute of Technology and has published numerous books and articles.

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