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in this issue

Data Becomes New Currency for IoT-Enhanced Maintenance, Repair, and Overhaul (MRO) by John Blyler

The explosive growth of data from connected Internet-of-Things (IoT) devices will ultimately be a major revenue generator in the avionics space—among many others. This article looks at one type of data—engine data—and how it will enhance the Maintenance, Repair and Overhaul (MRO) of fleet aircrafts.

Why Data?

Modern aircraft use a variety of different engines for flight. The one common factor among all these engines is incorporation of a large quantity of sensors, instrumentation and electronics for aircraft control and maintenance.

Today, the average number of sensors monitoring the health of aircraft engines is about 250 devices per engine. These devices provide a snapshot of data at any one time. But with the availability of inexpensive and "smart" sensors, that snapshot is turning into a continuous stream of data. The chal-

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RMS Partnership Alliances Increase the Scope Plus Expertise of Training and Consulting Services by Russell A. Vacante, Ph.D.

The RMS Partnership (RMSP) Inc. has recently expanded its range of professional training and consulting activities to complement those of our alliance team members.

The RMSP is a veteran-owned business that has a team membership alliance with a Service Disabled Veteran Owned Small Business (SDVOSB), an 8(a) firm and an Alaskan Native Corporation (ANC). Our alliance team membership with these three organizations makes it possible for us to reduce the acquisition time and cost of our clients. Our direct contracting capabilities, in addition, allow us for early-on discussions with clients to establish accurate and well-defined training requirements.

RMSP has now adopted an integrated approach to training to include instructional design, classroom and/or remote learning modules, and mentoring and professional follow-on services to ensure the students maintain acquired knowledge and skills that improve job performance in a manner that meets the goals and objectives of an organization.

The core training and leadership mission of the RMS Partnership Inc. is to provide professionals with

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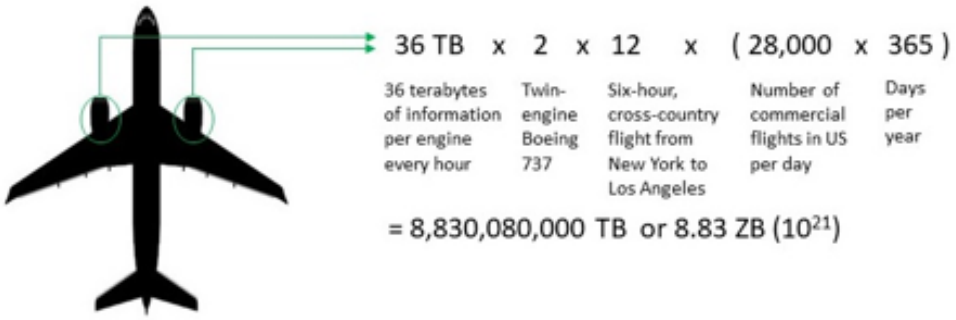

Figure 1: Estimation of sensor data created per year during an average of round trip, cross-country flights.

lenge is how to quickly analyze the higher volume of increasingly more accurate data. The same data challenges—although at a lesser level of volume—is also happening on the In-Flight Entertainment (IFE) commercial side of the aviation industry. (That will be a topic for another story.)

Modern aircraft engine monitoring systems are quickly growing from several hundred to several thousand sensors. For example, the Bombardier C Series jetliner carries a Pratt & Whitney's Geared Turbo Fan (GTF) engine, which is fitted with over 5,000 sensors that generate up to 10 gigabytes of data per second. Thus, a single twin-engine aircraft with an average flight time of 12-hours from Los Angeles to New York and back again can produce up to 864 terabytes of data for that flight. If that number is expanded to include the typical number of commercial flights in the sky over the U.S. on a given day (~28,000) times an entire year, then the amount of data is closer to 8,830,000,000 terabytes (see Figure 1).

By comparison, at the end of 2014, it was estimated that Facebook accumulated around 600 terabytes of data per day messages, chats and emails.

It's not just the sheer volume of data that's available to the commercial flight industry but the value of that data. Such data, as within other industrial businesses, has more potential revenue value than other types of data currently generated via social media on the consumer internet (Figure 2).

For the engine data to be of value, it must first be captured and then processed into useful information. Capturing the data is often the easy part. For example, modern geared turbofan engines come equipped with sensors that can potentially capture 5,000 parameters, or 10 gigabytes of data every second. The types of parameters that will be measured include temperature, air and liquid pressure, rotational speed and vibration—among many other things. The real challenge is deciding how much initial processing to perform locally near the sensors

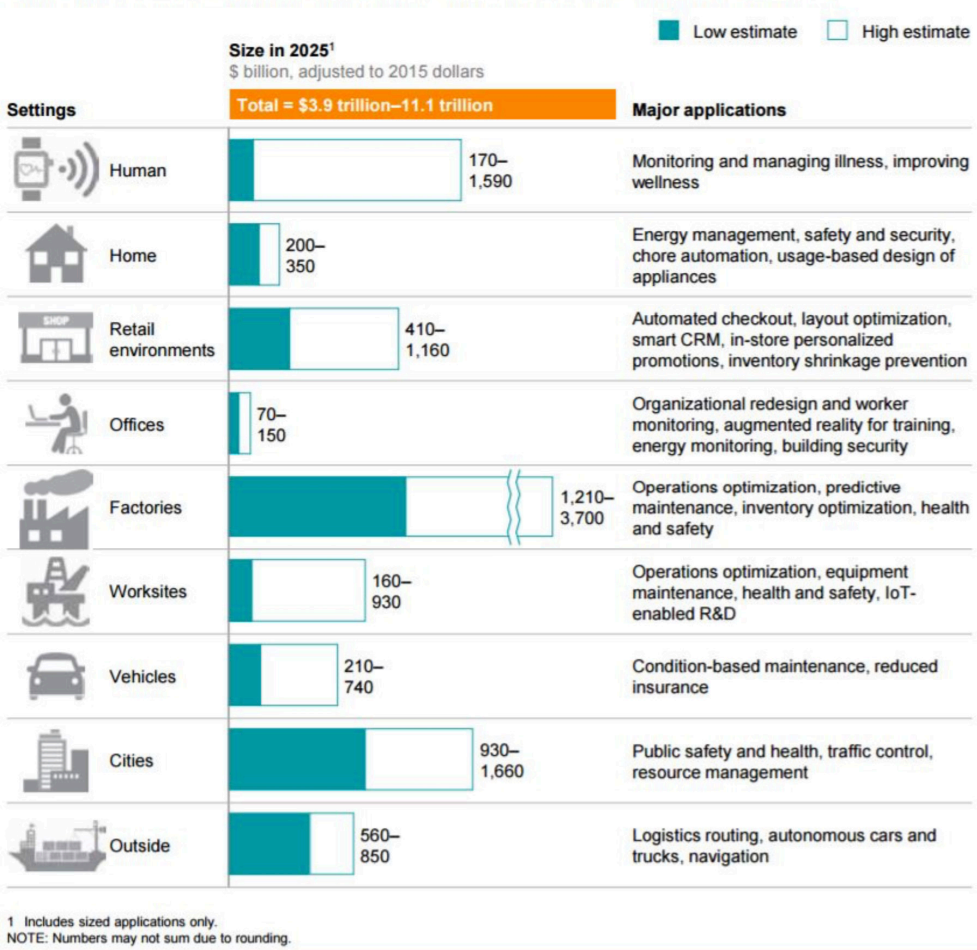

Figure 2: Potential economic impact of IoT data by category. (Source: McKinsey Global Institute analysis: "The Internet of Things: Mapping the Value Beyond the Hype," June 2015 https://www.mckinsey.com/.

and how much to send to the cloud for more intensive calculations. The cloud architecture will be part of the ground-based infrastructure capable of storing, processing and analyzing enormous amounts of data every year—measured in tens of petabytes to zettabytes of information.

Is it worth gathering all this data? Do we have the algorithms and know-how to process this raw data into useful information? The answers are (mostly) yes. This value of the potential information has already been demonstrated. For example, the GTF engine already uses such data along with artificial intelligence to predict the demands of the engine in terms of thrust levels during flight. As a result, GTF engines are demonstrating a reduction in fuel consumption by 10% to 15%, alongside impressive performance improvements in engine noise and emissions.

In addition to increasing the efficiency of engine and aircraft performance, analyzing big data real-time can help in the early detection of potential aircraft maintenance issues and even failures, e.g., component cracks in the engine. (see "Sensor System for Crack Initiation and Crack Growth Monitoring in Aero-engine Components," by A. Kumar; A. Nayak http://ieeexplore.ieee.org/document/4233023/?part=1).

The IoT movement goes beyond improving aircraft engine performance and maintenance to include almost every other aircraft subsystem. Consider the avionic communication subsystem, which traditionally transferred data up to a maximum of 12.5 KB/s up to more modern Boeing 787s and Airbus A350s Ethernet-based aircraft data networks that achieve rates up to 12.5 MB/s.

Higher network data rates makes it quicker and easier to transmit information via avionics systems within the aircraft and to the maintenance teams on the ground. This can include updates about current flying conditions and any faults that have occurred during the flight.

The importance of IoT data systems in the in-flight entertainment and connectivity (IFEC) systems are equally impressive. It has been predicted that by 2030, 90% of all aircraft will have some sort of connectivity. The new in-flight experience is being shaped by high-tech electronics like HD screens and touchscreens, as well as by low-tech advances like seats that accommodate tablets.

IoT-Enhanced MRO

The reason why commercial air

transport CEOs and product development managers care about Maintenance, Repair and Overhaul (MRO), is that current demand for these costs is about $64B, with Asia equivalent to North America and Europe in market size.

By 2025, the global MRO market is expected to reach $96B at a growth of 4.1% per annum. While the engine and component MRO markets remain the largest segments, the strongest growth will occur in the modifications market (e.g., interiors and connectivity). Conversely, airframe markets MRO will slow to improved efficiencies and increased check intervals due to the introduction of new fleets. [Ref: IFC Analyst Forecast in 2016, MRO Market Update & Industry Trends Presented by: Jonathan M. Berger, VP, ICF]

The Internet of Things (IoT) will have a significant impact in reducing costs by making the MRO industry more proactive than reactive. Smart, sensor-based platforms connected to the aircraft, cloud and ground stations will be a catalyst to eliminate unscheduled maintenance. This will be accomplished by joining analytics with an ever increasing number of factors to improve the business decision making process. These "other" factors might include weather and road closures that could potentially slow down a truck delivering needed parts to high-level traffic flow analysis. The real-time inputs from all of these factors will lead to improved algorithms that enhance machined-learned models for MRO.

An integral part of a successful application of the IoT is handling of big data. For example, one of the critical business aspects of MRO is the aftermarket pricing of parts. A precise history of an aircraft and its components would help in determining the valuation of parts. The IoT will help to enable this history by providing the as-delivered and as-maintained data. Of course, all of these benefits require the capability to analyze large amounts of data quickly and efficiently from the aircraft engines, control systems and frame. This is why some have referred to data as the new currency of IoT and analytics. ■

About the Author

John Blyler is the Founder and CEO of JB Systems Media and Technology. He is a technology professional with expertise in multi-discipline Systems Engineering, technical program life-cycle management (PLM), content development and customer-facing projects. He is an experienced physicist, engineer, manager, text-book author and professor who continues to speak at major conferences and before the camera. John has many years of experience leading inter-disciplinary (mechanical-electronic, hardware-software) engineering teams in both the Mil/Aero, avionic and electronics industries. Additionally, he has served as an editor-in-chief for technical trade journals and the IEEE professional engineering society publications. He was the founding advisor and affiliate professor for Portland State University's online graduate program in systems engineering. Finally, John has co-authored several books on systems engineering, RF-Wireless design, avionics and automotive hardware-software for Wiley, Elsevier, IEEE and SAE.

Interested In Contributing?

If you are interested in sharing your knowledge in future editions, please contact Russ Vacante at president@rmspartnership.org

Articles can range from one page to five pages and should be of general interest to our members.

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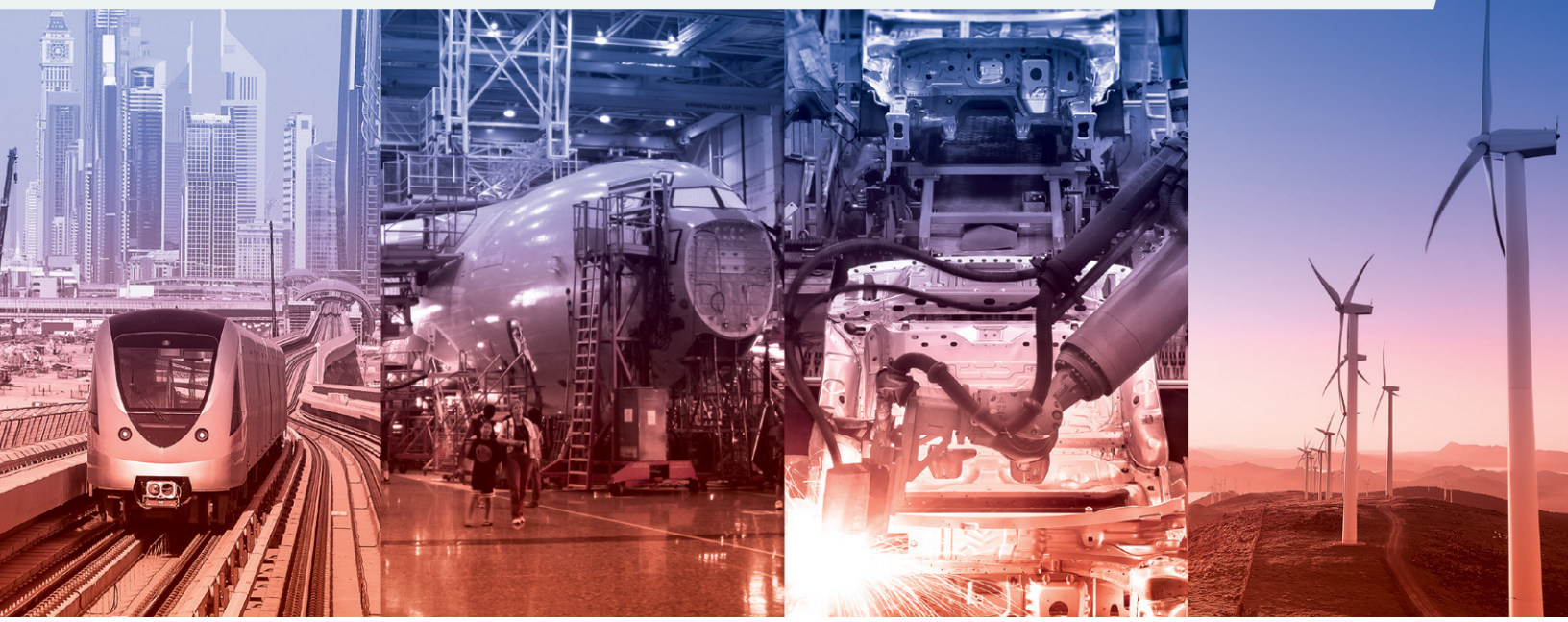
Reliability and maintainability software and services



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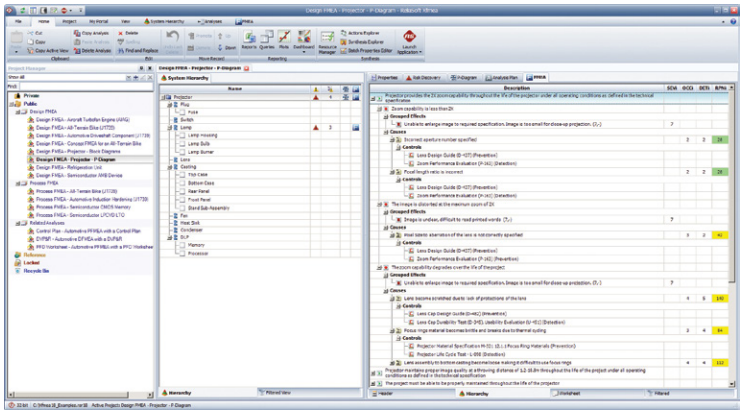

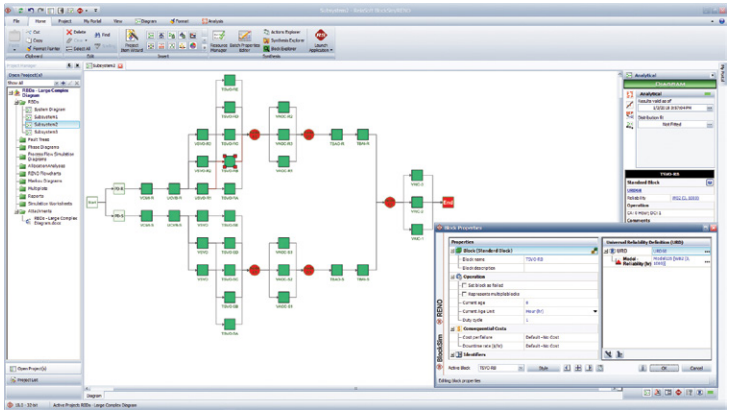

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Building Bridges to Environmental Groups by Katherine Pratt

As the Coordinator of Environmental Affairs within the Reliability, Maintainability, Sustainability (RMS) Partnership I invite your suggestions as we endeavor to build bridges with environmental groups on matters of a common interest through close collaboration. Environmental organizations that are interested in working with the Partnership on important reliability, maintainability, sustainability, logistics, safety and systems engineering supportability issues are requested to contact the RMSP so we can explore networking opportunities.

I believe the environment (or e-issues if you will), is becoming the new big business of tomorrow, and that we are now on the cusp of shaping these all-important new industries. So now allow me to briefly discuss bridging concepts between the RMS Partnership and environmental organizations.

Green Reliability is a generic term that is applicable to repeated tests involving the environment. Technically, it would show the extent to which the test scores are free from measurement errors; such as using a qualitative variable without defining its value. (i.e., Pick the "best" index to use for reliability; how is best defined)? Green Reliability measures would be used to determine the degree of inconsistency in scores due to random errors applied to an area of the environment.

Green Maintainability would define any action that restores failed units to an operational condition such as the ease and speed to repair, but perhaps their might be a waste disposal cost or re-use valuation to consider. Preventive Green Maintenance would still retain non-failed units in an operational state and the long-term benefits of preventive maintenance could include improved system reliability, decreased replacement cost, decreased downtime and better spares inventory management, (assuming the component has an increasing failure rate and the cost of the preventive maintenance is less than the overall cost of a corrective action). All of this could yield a net result in savings due to an increase of effective system service life, as well as, a lower environmental waste disposal impact.[1]

Green Sustainable development would still meet our present needs without compromising the ability of future generations to meet their own needs. Extrapolating, we would be designing for a community, (or municipality) comprised by elements such as:

- Water and wastewater
- Food, e-packaging, and e-disposal
- Green energy
- Green Design, Eco-building
- Green transportation
- Civic involvement and tourism
- Green development and Eco-land use
- Eco-common Land (Parks)

It would be a meeting of the minds between the environment (or ecology), economics, and highly reliable and sustainable systems.

Some of the drivers for these new e-industries include dwindling resources in various parts of the world, such as potable water in the Middle East and parts of Africa and Asia. In other areas of the world, such as China, the drivers may be industrial pollution.

Highly reliable, easy to maintain and supportable technologies are needed to forecast the increasing number of global weather shifts. These shifts are causing polar ice melts and subsequent worldwide rising tides. In addition, storms are said to be more severe and anticipated to be more frequent; even seismic activity appears to be increasing.

To counter-balance all of these ongoing environmental issues, the news is full of hopeful new technological breakthroughs, such as using combinations of solar and microbes to produce hydrogen that must be highly reliable, safe, easy to use and to maintain.[2] There is also new e-technology to reuse CDs to clean sewage water.[3]

Records are being broken for electric car acceleration up to speeds of 68 mph![4] The field of robotics is improving their power sources by using magnets.[5] Reliability standards and more should be developed and implemented to ensure safety of use and precautions against inflicting unnecessary environmental damage.

1 http://reliawiki.org/index.php/Introduction_to_Repairable_Systems#Maintainability
2 http://pubs.acs.org/doi/abs/10.1021/nn403082m
3 http://www.opticsinfobase.org/oe/abstract.cfm?uri=oe-21-6-7240
4 http://www.nrgsolar.com/projects/
5 http://designbuildbluff.org/

Even architecture is being influenced by green architecture e-solutions, such as creating colorful facades using solar panels with color! Bio-reactive facade systems provide shade and control light inflow. The heat resulting from this solar thermal heat process is available through a closed-loop system that stores and generates hot water. Sound systems engineering practices will help ensure the proper development and implication of green architecture solutions.

Housing for the poor on Navajo tribal reservations is being developed as a test for the first and second year students at the University of Utah, College of Architecture. This housing is being designed for extreme cold and heat in remote locations without access to electricity sources for power tools and the like. They are developing a 1,200 square-foot rectangular structure, with a double roof that can cool and heat itself naturally through a complex passive solar solution. The challenge is building highly reliable sustainable structures that have a relatively low total ownership cost.[6] These new product developments and business trends are all towards e-solutions! We need to ensure future e-solutions encompass the solid technological design basis of RMS-L, and for this to occur, your help is encouraged and welcome. We have already begun this initiative. If you have questions on how you can participate, please send your emails to Russell Vacante, president@rmspartnership.org. ■

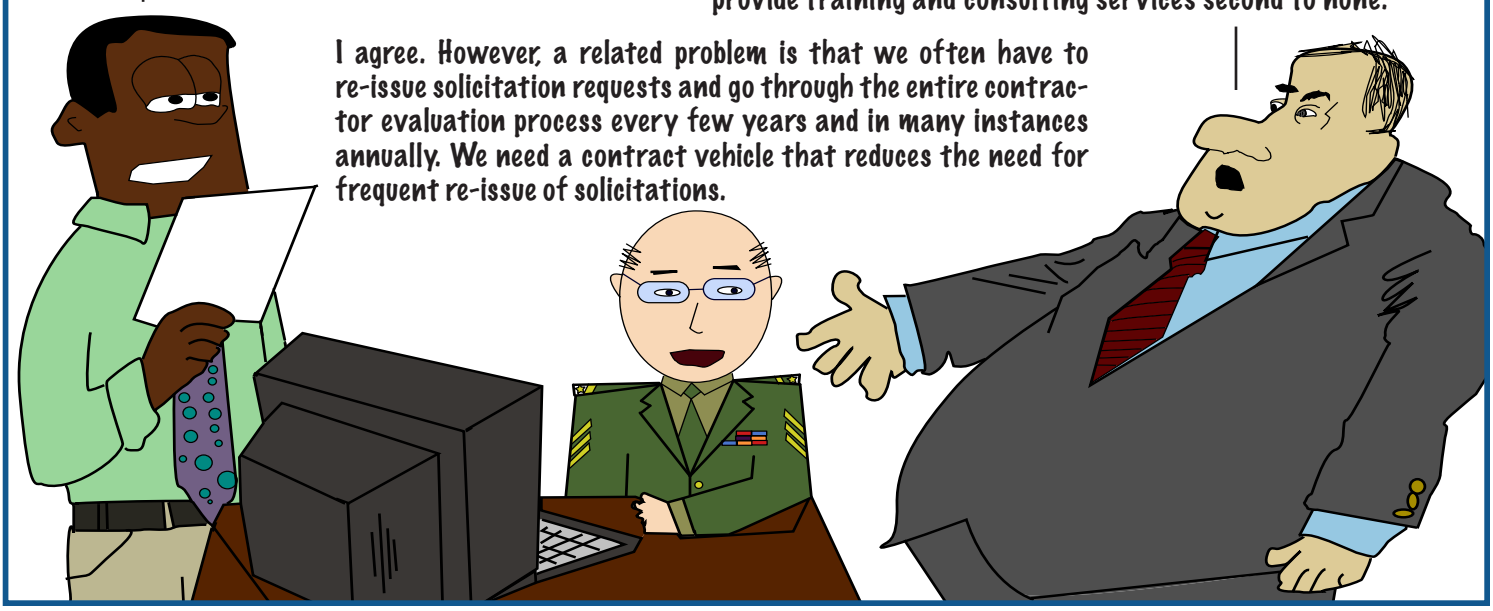
About the Author

Katherine Pratt holds a B.A of Business Administration in Management Systems from the University of Iowa. She is president of Enviro-Logistics Inc., West River, Maryland and has provided comprehensive services to agencies and corporations in the areas of Access SQL, technical writing and contract administration. She has been a professional logistician and contracts administrator for over 17 years, currently serves as the Coordinator of Environmental A airs for RMS Partnership Organization and has been a member of the Board of Directors for e Society of Logistics Engineers (SOLE).

6 "Improving Processes for Acquiring Better Products and Services", Software Engineering institute, Nov. 2010

Another Day At The Office

by Russell A. Vacante, Ph.D.



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job applicable training that relates to the employees' respective roles and responsibilities. Our approach includes, but is not limited to, experiential based learning. We work closely with our clients to develop and foster hands-on learning experiences based on appropriate learning styles. We provide our students with skills that can be immediately applied to their job and profession.

Our instructors offer a unique blend of both professional and instructional experience with many being ex-military, former top level executives and subject matter experts. Their expertise provides students with an interconnected learning experience resulting in their full engagement with course concepts. Our experts fully support the clients' leadership team based on industry best practices from the kick-off meeting and initiating the training requirements of their organization through finalizing course offerings to their employees. This strategy allows us to determine if client needs can be met with our existing course offerings or if a course must be redesigned or newly created to fully support the organization's training requirements. Once the training requirements have been finalized a training plan which fully supports the client's needs is prepared and implemented.

The depth and breadth of our team's expertise allows our organization to provide a variety of training options to our clients, based on the students' learning style, level of skills, knowledge, background and experience. The main goal of the training offered is to ensure clients' employees are work-ready. Course modalities offered may include:

- In-person on-site traditional classroom training—to include post classroom instruction mentorship support
- Asynchronous web-based instructional led training
- Synchronous web-based instructional led training

- Student self-paced web-based tutorials
- Web-based lectures on demand
- Brown bag lunch webinars
- Virtual workshops and labs
- Hybrid courses

As previously stated, we work closely with our clients' leadership team to ensure the course needs' assessment, training objectives, action plans, training initiatives, and development and evaluation is in alignment with the clients' requirements and training expectations based on learning by doing and always in alignment with industry best practices. During and upon training completion we evaluate and revise training materials accordingly to ensure that the needs of our clients fully comply with requirements. We foster a proactive client relationship to ensure an efficient and cost effective real-world learning experience is provided under contract through both a virtual learning environment and classroom experience.

In addition, in conjunction with our alliance partners we provide a wide range of professional consulting services to add value to our clients and their organization. Contracting/acquisition, transportation, cyber-security and environmental consulting services have been added, as a result of our partnership alliances. Our existing reliability, maintainability, supportability, sustainability, logistics and systems engineering consulting services have been enhanced as a result of working with our alliance team members.

Since 2003 the RMS Partnership Inc. has been providing training and consulting to the Department of Defense Services (Navy, Army, Air Force and Marine Corps. In addition, similar consulting services have been provided to a host of industry clients (the Boeing Company, BAE, Alion Science & Technology, and Lockheed Martin Corporation etc.). With the expansion of our professional activities and by working in close conjunction with our alliance partners we can now provide much improved and a greater range of training and consulting services to government and industry clients. ■