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Planning System-of-Systems Capability Solutions: The Current Challenges

Systems of systems have been gaining increased attention during the last decade due to their increased applications in different areas such as aerospace and defense, electronic systems, transportation systems and healthcare systems. According to Sage [1], an SoS is a combination of heterogeneous systems that are operationally and managerially independent of each other. Some other characteristics of SoS are emergent behavior, evolutionary development and geographic distribution of its elements.

These characteristics of SoS make it suitable for providing new capabilities as more flexibility will be provided through adding/removing systems during operation over time. However, providing a new required capability through an SoS approach raises unique planning and development challenges. There exist three distinct cases for providing a new required capability through an SoS approach. One case is the need for a quick response SoS solution to meet capability requirements within a short time. Examples are search and rescue operations and response to a crisis such as a major earthquake. Another case is the need to respond to changes in the business environment. Examples are for an airline to respond to the competition's lower cost structure by selecting a new aircraft to replace a less efficient model or for a healthcare system to add a new service. The third case is the need for a new capability that will require mostly new development. An example is a planned space probe by NASA. The shorter the time at which a capability is needed derives the feasible solution to be an SoS comprised of existing systems. For some SoSs, it may not be possible to define a life cycle due to the SoS changing objectives, structures and resulting evolution. However, for an acknowledged SoS with purpose and central management the SoS life cycle can be defined as four cycles of Planning, Acquisition, Deployment and Dispersal (for either a single SoS mission or a recurring SoS mission). The life cycle for SoS could span a short time, e.g., several days or a long period of time, e.g., years.

For any of the above-mentioned cases, understanding complex aspects of SoS capability planning and acquisition/development is necessary to enable informed decision-making. Some of these challenges are discussed in this article.

Integrating Existing Systems

For cases in which there is not enough time for new developments, an SoS solution is comprised of existing

Calvin Swartz, Guest Editorial

The 16 Degrees of R(a)MS Leadership: A Pragmatic RMS Engineering Approach to Human Capital Management

The most carefully engineered and structured system can go completely awry when human beings come into the mix. People bring myriad opinions, agendas, feelings, perspectives, experiences, personal mores and beliefs, and other factors into play that can combine to create a predictably unpredictable set of responses in the workplace. An RMS approach to human capital management (HCM) becomes a viable strategy for administering a work system and calls for focus on three important areas: Reliability, Maintainability,

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systems. For instance, in a search and rescue operation such as the search mission for the missing Malaysian flight MH370, more than 100 systems got involved within days to accomplish the mission. In such cases, systems that are assigned to the SoS mission have usually not been developed for the purpose of SoS or meeting the mission objectives. The selected systems are often independently developed, and consequently they are diverse in many ways such as design, control structure, communication capabilities, life cycle maturity, etc. [2]. In this case, the challenge is putting different systems, including new and legacy systems, to work with each other with no compatibility issues, as they are each at different stages of their own life cycles.

SoS Stakeholders

In engineering a single system, there is usually a clear set of stakeholders, however, in an SoS, there are stakeholders at both system level and SoS-level, including users community and system owners with competing interests and priorities. Since the SoS mission is often dynamic, stakeholders may change throughout the SoS life cycle. Sometimes the system owner has no vested interest in the SoS and sometimes all stakeholders may not even be recognized during the capability planning phase [3]. As stated by Barry Boehm, "the key to successful SoS development is the ability to achieve timely decisions with a potentially diverse set of stakeholders, quickly resolve conflicting needs, and coordinate the activities of multiple vendors who are currently working together to provide capabilities for the SoS" [4]. Therefore, one major challenge in planning and development of an SoS capability solution is to consider and satisfy stakeholders' expectations for a large and dynamic set of stakeholders.

Selection of Decision Factors in Comparing Various Alternatives

Successful accomplishment of mission requirements through an SoS solution depends on a variety of technical and non-technical factors. Some of these factors are: availability, vulnerability, resilience, and programmatic factors. Although all of these factors are important and depend on each to some extent, considering all of them in planning a capability solution may not be possible. Here, the question is how to select the best subset of factors to consider in comparing alternative SoS capability solutions.

SoS Mission Reliability Modeling and Analysis

Another challenge in collaboration of operationally independent systems (SoS) is in achieving interoperability among systems and evaluating the key performance metric for SoS mission effectiveness, namely mission reliability. The DoD's acquisition policies mandate that reliability be a Key Performance Parameter (KPP) for all systems and System of Systems (SoS) [5]. When selecting or developing systems for an SoS, engineers and decision makers are interested in developing or identifying those systems that when connected to the network of the SoS increase the SoS probability of mission success. Therefore, reliability modeling and analysis of the SoS mission is an integral element to consider in planning a SoS capability solution.

Mission reliability modeling and analysis of SoS is a challenging task as SoS can be very dynamic during operation. During SoS operation, the SoS can be dynamic such that the systems and subsystems involved, their failure characteristics, or the reliability configuration (series/parallel) at both SoS and system level may change from one phase of the mission to another to accomplish different capability objectives. Also, systems may start their own phased mission before the SoS mission starts, they may join or leave the SoS, their status may change from active to standby or they may no longer be required during the mission.

Further complicating the reliability modeling and analysis of SoS missions is the degree of interoperability of the constituent systems. Interoperability refers to the ability of systems to work with each other with no compatibility issues and is the key enabler for systems of systems, as it provides SoS capabilities that are greater than the sum of its constituent systems capabilities [6].

Determining the degree of Autonomy in SoS solutions

Next generation systems especially in avionics and automotive applications involve unmanned autonomous systems. Autonomy means machines make decisions, not humans, and behaving in ways that are not preplanned and pre-programmed as in automated systems (rule based). One of the challenges in planning an SoS solution is to determine the degree of automation in an SoS mission, which ranges from all systems being autonomous

systems to all systems being legacy systems. Methodologies and models are required to systematically define the degree of automation (man vs machine) in SoS missions based on both SoS performance and cost.

SoS Life Cycle Capability Sustainment

A challenging area during planning an SoS capability solution is the consideration of SoS life cycle capability sustainment. A capability solution requires sustainment over its life cycle for three main reasons: (1) change in operational environment, or threat and (2) advances in technology that increase effectiveness or affordability and (3) capability degradation due to obsolescence [7]. The SoS operational environment and threats constantly change over time. An acquired or developed SoS solution should be monitored to identify and address capability gaps to ensure that SoS can continue its operation to face new operational requirements and threats, which requires analysis and assessment of SoS capability (e.g., flexibility) over its life cycle which should be considered during the planning phase. ●

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Jerrell Stracener *is associate professor and founding Director of the Southern Methodist University (SMU) Systems Engineering Program (SEP). He teaches graduate-level courses in systems analysis methods and applications, and directs and conducts engineering of systems research. He is the SMU lead senior researcher in the DoD-sponsored Systems Engineering Research Center (SERC). Prior to joining SMU full time in January 2000, Dr. Stracener was employed by LTV/Vought/ Northrop Grumman. He conducted and directed systems engineering studies, and analysis, and directed systems reliability and supportability programs, on many of the nation's most advanced military aircraft. Jerrell was co- founder and leader of the SAE Reliability, Maintainability and Supportability (RMS) Division (G-11). He is an SAE Fellow and AIAA Associate Fellow.*

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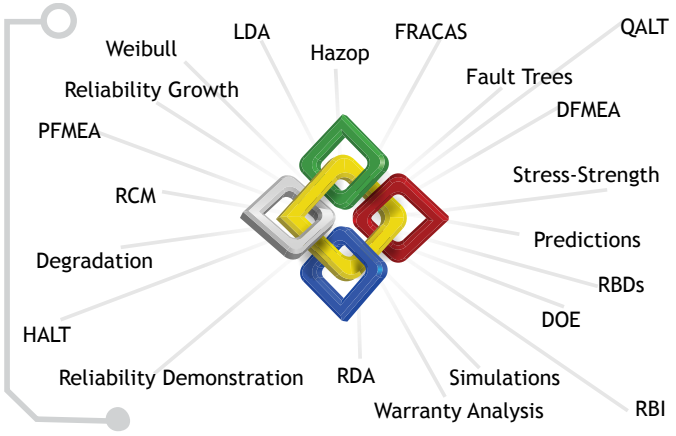

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Lincoln Hallen

A Sharing of Information

"Sharing isn't always the right thing-like when its chicken pox."[1] On the other hand, sharing data as part of the Government-Industry Data Exchange Program (GIDEP) is an important and meaningful enterprise. GIDEP is a joint service program that enhances the partnership between government and industry seeking to reduce or eliminate expenditures of resources by facilitating the exchange of information.

It looks like data and information are interchangeable. However, you need to distinguish between data and information. If you strictly define *data*, it refers to facts and statistics collected together for reference or analysis. Data is distinct information that is formatted in a special way. The results of the references or analyses can become useful *information*. Hence, if a company decides to submit a maintenance report, data on a counterfeit part, a reliability analysis, or a white paper about most anything, it becomes useful data that others can mine with other data to develop information that may save millions of dollars in time and resources. GIDEP reported that the cumulative utilization savings from all users since 1964 is over $2.2 billion.

GIDEP is used by the U.S. Army, Navy, Air Force, NASA, Defense Logistics Agency, Defense Contract Management Agency, Department of Energy, Canadian Department of National Defence and many industry partners. "Flowers and pricker bushes grow out of the same dirt."[1]

When GIDEP started in the 60s it had limited usage and meaning. It was a parts repository that many of us started using to see what problems may exist with some part or piece of equipment. We also looked for reports for possible reliability estimates of similar equipment. Now, with the expanded knowledge of diminishing sources of parts and material shortages, GIDEP has become a key focal point for the housing and subsequent mining of large amounts of data.

"There are a lot of different ways to get to the top of the jungle gym."[1] There are a number of data types that are in the GIDEP database:

- **Failure Experience Data** provides a means to exchange information about nonconforming and suspect counterfeit items in government and industry systems. These documents (ALERTS, Safe Alerts, Problem Advisories and some Agency Action Notices) inform the participants that a problem situation exists and help prevent usage of problem products.
- **Product Information Data** contains mainly Product Change Notices issued by the semiconductor manufacturers that affect the form, fit, function or the production processes of a product.
- **Diminishing Manufacturing Sources and Material Shortages (DMSMS)** notices originate when a part manufacturer announces that a part or a production line will be discontinued. This information is downloaded, augmented with value-added data, and then stored in GIDEP as Product Information Data. DMSMS also occurs at the module, component, equipment or other system indenture levels and includes microcircuits, brake pads, fasteners, software, valves, filters and more.
- **Metrology** covers a wide range of measurement related subjects. The major emphasis for GIDEP is on calibration procedures and technical manuals. The Army, Navy and Air Force metrology centers are the major contributors of calibration procedures to the GIDEP database.
- **Engineering Data** is a repository of documents and reports generated during the life cycle of parts, components, assemblies or systems from concept and acquisition to operation and disposal. Such data can be on, but not limited to, research development, testing, production, management

procurement or any logistic support operation. Members have exchanged information to help avoid costs and additional labor, and even spawn ideas to bring about new methods or techniques for better, leaner business practices.

- **Reliability/Maintainability Data** consist of technical reports on various reliability concepts, practical maintenance operations and engineering tools for making reliability or maintainability decisions. There are a number of Failure Analysis Reports on parts suspected to be counterfeit.

"You can sit around and wait for a ride, or you can start walking."[1] As a participant or user of GIDEP, you become a part of a growing and important resource for government and industry. Because of users, two key features have developed within GIDEP: Suspect Counterfeit Parts and Obsolescence Management.

Suspect Counterfeit: The counterfeiting of components and assemblies found by government and industry has increased notably during the past decade. GIDEP contains data on equipment, parts, and assemblies that are suspected to be counterfeit. GIDEP members provide formal fact-based reports on items received that after visual inspections and in many cases extensive testing and analysis, are suspected to be counterfeit.

GIDEP can be a key to mitigating this risk by informing members of suspect counterfeit incidents as well as providing a process for reporting them. Counterfeit parts are not only a problem with the military and related industry, a Consumer Reports news item published November 17, 2014 reported that 'counterfeit' tires pose a consumer risk and that tested Chinese tires underperform and could prove dangerous if the product should prove to be defective. "Before you trade sandwiches, check between the bread."[1]

Obsolescence Management: Manufacturers are regularly discontinuing production of selected products. GIDEP is the DOD central repository of DMSMS Notices regarding discontinued products. The DMSMS Knowledge Sharing Portal (DKSP), in cooperation with GIDEP and hosted by the Defense Acquisition University, provides a single entry point for DMSMS support by providing access to a full array of centralized informational services working with both government and commercial entities. The DKSP homepage is located at http://www.dmsms.org.

The continuing issue of DMSMS has opened the door for counterfeit products to enter the supply chains of the military and their industry partners. By being a member of GIDEP, you are part of a community that is tackling this critical issue. To gain access and become a member of GIDEP, go to www.gidep.org. "Half the fun of pizza is sharing it."[1]

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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About the Author

Lincoln Hallen *is an independent logistics consultant based in the Washington, D.C. area. Mr. Hallen has more than fifty years of experience in systems engineering, logistics support engineering and computer science. He teaches various courses in logistics for industry and government activities.*

Mr. Hallen works as a logistics consultant for many companies worldwide and is known for his skills concerning automated systems in logistics product supportability, logistic supportability analysis, Logistic Support Analysis Records, Reliability Centered Maintenance, Level of Repair Analysis, Life Cycle Costing, Reliability and Maintainability modeling, supply support and parts provisioning.

Mr. Hallen is an active member of the Counsel of Logistic Engineer Professionals, a member of The Management of In-Service Reliability, Cost & Effectiveness (MIRCE), a member of the RMS Partnership, a representative to the Government/Industry Data Exchange Program, and a member of the Parts Standardization Management Committee. He is the author of many articles on logistics, space logistics engineering and computer systems. He has published a nationally distributed computer book, has university degrees in mathematics and business administration and technical training in aviation electronics, missile systems and logistics engineering.

The 16 Degrees of R(a)MS Leadership, from page 1

and Supportability—and let's add one more important consideration to that success formula: Availability.

A systematic RMS engineering approach is essential to successful management of undertakings such as scientific experimentation, research and development, manufacturing processes, software and hardware development, new product creation and other such endeavors. An RMS approach can be equally applicable and successful when used in the management of human capital—that means effective management of the people who do the work.

*DEAL*ING WITH HUMAN CAPITAL

More than 30 years' experience in the business of human resource development training has revealed that generic theoretical management systems usually fail to work in real life operations. This is because, in and of itself, no theoretical approach can adequately address all of the many factors and situations that occur across the vast array of business types, missions, and motivations. Every organization has its own inherent challenges that are different from other organizations. More importantly, there are people involved. People need pragmatic solutions that apply directly to their specific problems and situations. And when people work together, there are always interpersonal communication issues to DEAL with.

DEALing with human resource management requires recognizing four key factors that people in the workplace bring to any situation:

***D*ifferences.** Today's workforce is multi-generational and multi-cultural, more so than at any other time in history. People of different age groups and genders have different values and are motivated by different incentives than their older, younger, and opposite gender colleagues. They respond differently to nonverbal gestures and expressions and have different belief systems about others based on their cultural backgrounds and personal experiences.

***E*gos.** People sometimes bring personal bias and inflated opinions to situations at work. They are so convinced that they know all the answers, they believe no one else could possibly know more or have a better idea. People can become excessive in their exercise of authority, or resist change and ignore "evidence to the contrary" if their minds are already made up. Likewise, people can suffer from lack of ego—inability to stand up for what they know to be true or to recognize the value of their input.

***A*ttitudes.** There may be no place for drama in the workplace—but that does not mean it never happens. Emotional intelligence in attitude and action is not necessarily a given. People come to work with defense mechanisms in place, preoccupations with personal issues, and lack of motivation and engagement with their work. In fact, research is continuing to reveal that the majority of people in the workforce are not engaged and not particularly happy with their jobs – and that has a big impact on performance and whether or not a work system succeeds or fails.

***L*anguage.** Choice of words that presume, threaten or provoke can seriously impact the success of a project. Sometimes just the way a person speaks—the structure of personal delivery, tone and voice quality, gestures and body language, and the value or lack thereof of useful content – can alter the trajectory of a work system.

All of these factors interact in predictably unpredictable ways. It is safe to predict that when people are involved, some conflict is inevitable, occasional breakdowns in interpersonal communication, some differences of opinion, and imbalances between organizational and personal goals are bound to occur when people and their differences intersect and interact in the work environment. How those situations manifest themselves can be unpredictable. However, a pragmatic RMS engineering approach to people management can result in positive interaction and successful organizational control and accomplishment of mission. Use the following R(A)MS engineering principles to manage people in 16 valuable ways.

RELIABILITY

Reliability, in human capital management terms, is a factor that addresses the probability of failure—failure in performance, failure in achievement, failure to move the organizational mission forward. A good leader strives to be reliable in the following ways:

1) **Functional under stress.** Every system encounters difficulties, setbacks and unexpected impacts, whether internal or external. No matter the circumstances, leaders must be reliable to function from a position of strength, think quickly under pressure, and not fold under the stress of uncertainty.

2) **Durable over time.** A good leader is reliable to meet the test of time, to see tasks and projects through to fruition and channel productivity to its highest level over the long haul.
3) **Performs as expected.** A good leader not only meets but strives to exceed the expectations of managers above and employees below in the organizational chain of command. Negotiation of expectations is a key strategy that is often a missing element when a work system is found to be unreliable. When the leader expects one thing and his or her boss expects something different, negotiation of expectations becomes key to the success of their relationship.
4) **Adapts to changing conditions.** A reliable manager recognizes the need for change and doesn't get stuck in the tried and true. Sometimes the factors that created what was "true" before no longer exist or no longer have the same impact. A good leader can be relied upon to re-evaluate, develop a new strategy, and shift direction as needed to keep momentum in a forward-moving direction.

AVAILABILITY

In an RMS system, availability addresses a system's operational state of readiness for tasking. In HCM terms, a leader must be available to managers, peers, colleagues, and employees in the following ways:

5) **Open to communication.** A good leader is available for communication exchanges. An open door policy—one in which employees feel free to approach managers with their ideas, opinions, and concerns about work issues—has been a subject of debate in human resource management circles. Though an open door can be misused to jump the chain of command or advance a personal agenda, a good leader knows how to keep lines of communication open and information flowing efficiently up and down the organization, by being available to those in need of assistance, information, and guidance.
6) **At the ready.** A good leader is available on a daily basis, showing up on time and willingly taking a seat at the head of the table, ready to direct and control, ready to work, sleeves rolled up if need be, and actively contributing to overall productivity.
7) **Considerate of new ideas.** Leaders who make themselves available to hear, consider, and implement new ideas and innovations experience the most success. Good leaders recognize that others can contribute ideas for system improvement and operational productivity that result in increasing the organization's overall success.
8) **Making sound decisions.** A good leader is available and ready, after careful research, consideration of presented options, and evaluation of input from research and staff, to make sound decisions. Great leaders may even have to stand ready to reverse a decision in the presence of mitigating factors. In the heat of battle, a great leader can see a bomb falling and quickly order all to evacuate while a not so great leader can stand there evaluating the probabilities of explosion. A leader who is ready and available to make a "good" decision fast is more successful and a better contributor to positive outcomes than one who makes a "perfect" decision but takes too long to make it.

MAINTAINABILITY

Maintainability is a characteristic that goes hand in hand with availability and looks at how quickly a system can be restored to functionality when availability fails. In HCM terms, maintainability translates to a leader's ability to correct errors when or before they happen and take disciplinary action if bad behavior causes projects to go awry or the work is not getting done.

9) **Establishing preventive measures.** Good leaders put preventive maintenance systems in place so that problems are least likely to occur. Preventative measures can include project management techniques such as milestone checks and status reports, strategically timed to bring critical factors to attention before it is too late to correct them.
10) **Consistent application of discipline.** To maintain

productivity, leaders sometimes have to take disciplinary action to correct the behaviors of personnel who are failing to do their work. Discipline must always be administered fairly and consistently—all parties being subject to the same punitive actions without favoritism or discrimination.

11) **Adherence to policy.** Policies and regulations are put in place for one main reason—to establish work system procedures and maintainability of order within the organization. Along with administration of discipline, administration of general policy should be applied in the same way for all personnel involved, without favoritism or discrimination.

12) **Forming a status quo.** Maintaining the status quo in an organization establishes an efficiency of functionality. A good leader oversees this process. However, a good leader is also cognizant of the need for continued re-evaluation of the status quo and readiness to implement changes of policy and/or procedure in order to maintain and build system functionality and productivity levels to a new status quo.

SUPPORTABILITY

Supportability addresses the value and costs of an engineered system and the rationale behind expenditures. HCM considers the value of the people who do the work and the return on investment derived from building their knowledge, skills, and abilities (KSAs). Good leaders exhibit supportability through the following:

13) **Listening and exchange.** Effective leaders place great value on listening to their staff members and exchanging ideas. Employees like to feel supported and to know that their input is valuable to management. They are encouraged by opportunities to share what they know firsthand. Their pragmatic contributions to discussion are based on firsthand experience and can often be enlightening to leaders who are not always as in touch with the grassroots factors that impact results. Listening and exchange creates an environment of mutual supportability.

14) **Challenge and opportunity.** Leaders exhibit supportability to their staff members by offering challenges to learn more and opportunities to accept increasing levels of responsibility as they learn and grow in their roles. People like to be challenged and cite boredom as a major contributor to lack of fulfillment at work.

15) **Tools and training.** Where KSAs are lacking, great leaders support employees by offering tools that can improve efficiency and quality training to use them. Tools may include more efficient software applications, hardware and equipment, while training may involve participation in courses and webinars, conference attendance, lunch-and-learn sessions, and individual coaching opportunities.

16) **Motivation and engagement.** Most critical to productivity, good leaders provide supportability to their employees and enhance productivity by finding out what motivates their employees on an individual basis and providing incentives that engage each employee. By being recognized as individuals, employees feel supported and valued and are therefore more likely to be positively engaged with the tasks at hand and motivated to do the work.

Human errors exist. That is just a fact of life. Conduct a Root Cause Analysis (RCA) to mitigate human error, whether deliberate or unintended, when interpersonal operations and productivity are failing. It may just be that a pragmatic approach to managing human capital can make the difference between having a personnel management system that is fraught with failure and one that is available, Reliable, and Supportable. Then simply put preventative measures in place to keep the system Maintainable for the foreseeable future. ●

About the Author

Calvin Swartz, *President of Progressive Success Corporation (PSC), is an expert training facilitator, executive, management, and supervision coach, and keynote motivational speaker, specializing in interpersonal communication. Following a distinguished military career and retirement as an Army Colonel, Cal established PSC to provide "people skills for business professionals" and help them achieve their leadership potential.*

Another Day At The Office

by Russell A. Vacante, Ph.D.

Training in the form of continuous education is critical to hone employees' skills, as well as for maintaining managerial and technical proficiency in support of organizational goals and objectives.

Having the correct course content fit with individual and organizational requirements should take priority over certified training programs that often have a "one-size fits all" course content. The RMS Partnership training motto is "tell us what are your training requirements and we will exceed your professional training expectations."

It is important that training providers correctly identify student and organizational training requirements to help ensure relevance and competency to work related tasks and employee career advancement. Similarly, the organizations requesting the training need to accurately communicate course requirements so the training provider can appropriately tailor course content.