First Steps in Implementing Weapon System Sustainment Model

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At SciTech 2016, the Weapon System Sustainment Management Model was introduced and explained. No management model can be imposed on an organization on day 1 with the expectation that success will be achieved on day 2. And it is not enough to simply say that the model should be taught, since learning has occurred only when behavior has been seen to change. Depending on the organization and its members, creating these shifts in behavior can be a long and arduous task beyond the tenure of any one leader. However, every organization contains many processes and habits that are congruent with the Weapon System Sustainment model. These can be reinforced, spread, and other new behaviors congruent with the model created. This is accomplished by starting first with a new approach to risk management. This paper describes the key features of a sustainment risk management program, explains how to shift to this new approach, and describes how its implementation will set the entire organization on the path to the full weapon system sustainment management model within a few years.

I. Introduction

SUSTAINMENT managers and their teams would benefit greatly from a practical management model that describes the core activities they must perform for effective and affordable management of their complex systems. Even if the model were only used as a common lexicon to discuss daily required chores or if it were simply used as a checklist, sustainment would become more focused and affordable. Such a model was described in my paper[1] from AIAA's SciTech 2016.

This paper is written for the leader who has spotted the historical trend to long-lived complex systems, realizes that they are working in an organization responsible to sustain a complex system, sees their organization's shortcomings, and wants to give this model a try.

This person is most likely at a loss as to where to begin. They may not even have sufficient positional authority to impose the use of this model. This is good. Simply enforcing the model as an edict will not yield significant benefit. Management support and team support are essential for success. Implementation by edict will be seen as selling a product you never owned to begin with. The manager loses credibility because they are seen as selling yet another empty set of management buzz-words. For the model to become a permanent part of the organization's culture, support must be earned by executing it and celebrating its successes.

Refer to the paper mentioned above for details of the model. It describes the method used to keep ICBMs a viable deterrent by considering the warfighter's mission, the definition of the system, and the system's readiness factors such as reliability and availability. It goes on to describe a method to observe the system, identify risks to sustainment, and explain how to mitigate the risks with sufficient lead time to satisfy the warfighter. Key enablers of people, process, and technology are discussed. It points out that the novice's anxiety over the disconnect between warfighter needs and organizational funding is understandable and revealing. It is the sustainment organization's task to close that gap, not simply expect requirements to arrive with funding. And the sustainment risk management model is key to mounting a campaign to get the funding. The model demands some hard work, top skills, and courageous leadership to be successful. However, successful and affordable sustainment occurs without it only by luck and chance.

The SciTech paper suggested that the model could be applied, not only to any weapon system, but to any sufficiently complex system requiring sustainment. (Sustainment of non-complex systems would find costs

outweigh benefits when applying the rigor and discipline of this model.) So another paper[2] by the author and Kugler, presented at AIAA Space 2016, described how this model could be applied to one category of complex systems, commercial space. The author has also presented this model at an Internet of Things conference in Provo Utah, authors a blog on the subject, and proselytizes the model in other ways as well. When the model is applied outside of weapon systems, "warfighters" are "operators". And "government funding sources" become "commercial funding sources". But the model remains pretty much the same.

The Space 2016 paper also presented a short discussion on why this practical model is needed now: Complex systems are becoming more common and they are expected to live longer.

This sustainment management model is practical in that it is a) directly applicable to the sustainment of complex systems employed today; b) integrated, that is, internally consistent; c) easily called to mind on the fly; d) self-improving; and e) constant, that is, unaffected by changing public laws, regulations, and management fads.

However, it is merely a model. That is, it is an idealized concept, albeit based on decades of practical experience. In response to a question at AIAA's Space 2016, I responded that this management model is very much like Camelot: an idealized place or time. Or if the reader prefers, it is Plato's "shadows on the cave wall" that reflect some idealized reality that exists somewhere, but only its shadows exist in our world. Like Camelot or Plato's Shadows, the closer it is followed, despite the forces acting against it, the more ideal the outcomes. Unfortunate activities such as "management by crisis" are avoided, funding is more sure, and the warfighter (or operator) is happier.

An apparent oxymoron like "practical model" must have a practical approach to implementation to be taken seriously. To be practical, the approach must take into account the organization's current path to better sustainment management, the implementer's sphere of influence, and the forces acting against its implementation.

Since the risk identification function touches and influences all the other aspects of this management model, it is the best place to start. It can be used to assign a risk to poor system observation, create the information needed to create projects to mitigate the risks, tutor the team in relevant readiness metrics, and generally instill a devotion to the mission. Important questions of "what is sustainment", "what is included in my complex system", and "why process discipline?" will repeatedly be raised, and hopefully usefully answered, at risk management meetings.

This paper begins with a review of the standard definitions and an overview of the model. It then discusses in each subsequent section,

- implementing a new (or tweaking an existing) risk system, including evaluating your outcomes,
- evaluating the maturity of your organization to accept these risk management program changes,
- how your personal sphere of influence influences your approach, and
- what pitfalls to expect and how they can be overcome.

The conclusions section expands on evaluating the efficacy of your approach and suggests areas of future research.

II. Definitions and Model

`Successful weapons system *sustainment* is defined as:

> "The continuous, effective support of the system to ensure continued mission capability".

"*Mission*" is the reason the system was built. For the USAF Strategic Air Command, the ICBM mission was "Deter nuclear war". A good mission statement leads to precisely-defined *readiness factors* that allow the enterprise to measure their ability to reach this goal, today and tomorrow. In ICBMs, the system had to be available, reliable, accurate, and able to withstand nuclear attack.

"*System*" is everything required for the mission. For instance, in the USAF, it is not just the aircraft, but also the entirety of maintenance, supply, engineering, test equipment, support equipment, and so on, required for the aircraft to function.

"*Self-improving*" means your sustainment management system can repair itself like a wounded or diseased person and build itself up in specific bones and sinew like an athlete.

"*Complexity*": Whether the system is complex or simple is a judgment call. The model, once mastered, can be tailored to suit. For example, well-understood wear mechanisms need not be thoroughly tracked if they become thoroughly predictable.

See Figure 1. The core of the management model is "observe, identify, and fix". How these 3 functions work and how well they work in your sustainment organization is dependent greatly on how well your processes are crafted, executed, and improved. To do so successfully, the processes impacting them must be understood.

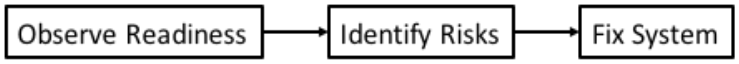


Figure 1: The CSSMS is "Observe - Identify – Fix".
Identifying risks to the mission soon enough for timely fixes only occurs if the system can be adequately observed.

See Figure 2. This is the weapon system sustainment meta model developed and used by ICBMs. The activities in the "Fix System" box include long-range planning, short term planning, deployment planning, requesting funding, and flowing funding to programs and projects.

The raw data needed to do this work comes from identifying risks to the weapon system mission with lead time to get them fixed. This is the "identify risk" function, also known as the Sustainment Risk Management System. Risk are written against the readiness factors mentioned above. So they are tied to the warfighter's mission.

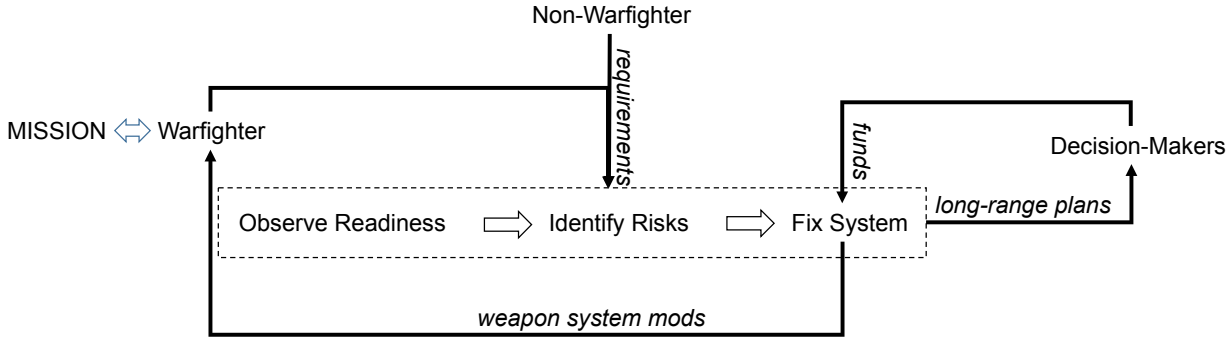


Figure 2: Weapon System Sustainment Management Meta Model

Risks cannot be identified unless the weapon system is sufficiently observed so that data and analysis can point to future degradations of the weapon system. For instance, monitoring batteries in the ground launch system can predict when replacement will be needed with more precision than a manufacturer's stated life. For remote sites, this can save a lot of resources.

Warfighter requirements, such as missile accuracy, drive the readiness factors which directly impact how sustainment risks are written. There are also "fact of life" requirements like DoD standard desktop directives or environmental law which have little direct bearing on the mission, but must be responded to.

The sustainment organization has direct feedback to the warfighter, mostly in terms of delivering the weapon system and weapon system modifications they expect. That is, the warfighter has come to expect a

certain capability in their weapon system. Failure to maintain that capability is failure of the sustainment organization to do its job.

Now that the non-military world is building systems just as complex as ICBMs, how does all of this translate?

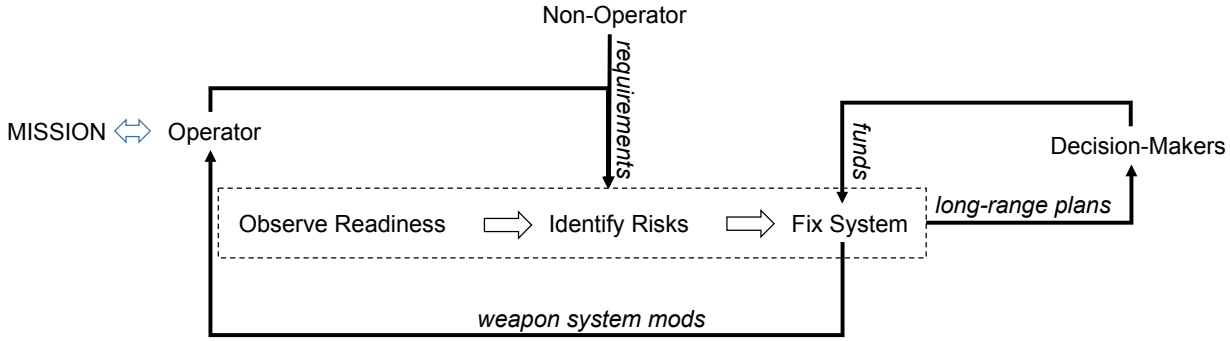


Figure 3: Complex System Sustainment Meta Model

See figure 3. The Weapon System Sustainment Model becomes the Complex System Sustainment Model. The raw data needed to do this work still comes from identifying risks to the system mission with lead time to get them fixed. Risk are written against the readiness factors mentioned above. So they are tied to the operator's mission. Risks cannot be identified unless the system is sufficiently observed so that data and analysis can ferret out future degradations of the system.

Operator requirements, not warfighter requirements, now drive the readiness factors which directly impact how sustainment risks are written. There are still also "fact of life" requirements like company software standards or environmental law which have, at most, indirect bearing on the mission, but must be responded to.

DoD funding sources are notable for their complexity, timing, use restrictions, and demands for detailed information on where, when, and why the funding is needed so that priorities can be set. Once in the commercial world, entirely new areas of funding open up with the related needs for information and data to secure them. Can the commercial enterprise effectively secure investors, please paying customers, and reinvest profits? Angel investors, savvy clients, and crowd-funding all need information about the mission and the system. This information is generated by observing the system, understanding risks to the mission before they develop, and setting up projects to mitigate those risks.

The commercial sustainment organization has direct feedback to the operator, mostly in terms of sustaining the system capabilities and system modifications that they expect. And if the sustainment organization fails to understand and honor the operator's sense of capability, great unhappiness on all sides will ensue.

III. Implement a New, or Tweak an Existing, Risk Management System

There is one segment of the sustainment management model that touches every part of sustainment activities: "identify risk". And because of this unique feature of this portion of the model, it is the ideal place to start implementing the entire model. "Identify risk" does not fare well without a good observation or assessment program. And a poor assessment program can be identified as a risk. The "fix system" activity can only proceed with a clear understanding of the identified risks and practical mitigations. So any activity which seeks funds and resources comes to depend on a good risk management system. Simply knowing a risk exists is far from sufficient. They must be precisely documented. When writing risks, it is imperative that each risk be written with a clear understanding of what the system is comprised of, what the system's mission is, and what capabilities the operator or warfighter expects. So the risk management meetings become the logical place to turn theory in to practical definitions, precise metrics, and useful approaches. The right people are there at risk meetings to thrash these out over time using specific practical examples

associated with real risks. Risk meetings need not be bogged down by this. What does not get resolved in the meetings will become action items for specific teams and team leaders to report back on.

For all these reasons, the logical place to start implementing this model is your risk management process. Emulation of success is always helpful. Some call this "fake it 'til you make it". At least try not to make the common mistakes, use *lessons learned* by others. Step 1: obtain and read the paper by Dewan and Lindblad: "Lessons Learned from Implementing Risk Management for a Legacy System"[3]. Key lessons discussed in that paper are:

a. Keep it simple
b. Ensure continuous management commitment
c. Design and standardize
d. Build in process improvement
e. Train your team
f. Work to keep open and continuous communication

Complicated approaches are less likely to be followed and are unnecessary. One example is the standard 3 x 3 risk matrix that assigns priority values to the two dimensions of consequences and likelihoods. See Figure 4.

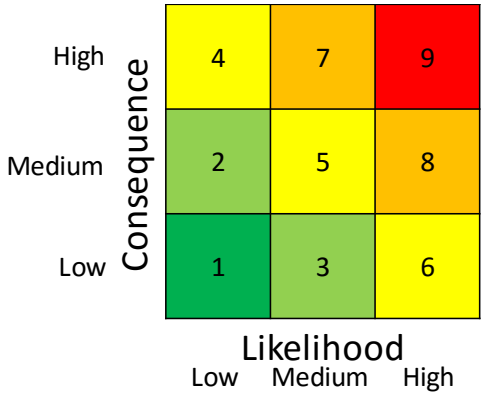


Figure 4: Risk Matrix. *Most managers are familiar with a risk management system. Consequence and Likelihood define the priority of the risk via a matrix.*

Many espouse 5 x 5 and even higher level matrices in an effort to automatically stratify all possible risks. This seems as if it would be a convenient feature. But higher level matrices suck up time and imply a level of team authority that is not real. Quick and dirty stratification during a risk meeting leaves more time for more important discussions such as reviewing more risks, probing the effects of the risk on readiness factors, or assigning actions to teams. The resulting risk priority list, if not sufficiently stratified, can be addressed by a smaller group of top managers who might apply other factors such as executive feasibility. Intense stratification like this at risk meetings implies a dishonest message from management to team that the team is given final say on final priority lists and not the top management. A combination of "leaving it to the team" and lengthy meetings could even leave the top managers feeling disenfranchised from the risk meeting and reduce their attendance. However, intense management involvement is paramount. Without continuous management commitment, the teams will work other priorities, leaving managers without the required data. The organization will quickly devolve to management by current crisis.

"Design and standardize" and "Build in process improvement" reveal why my previous paper emphasized the enabler of Process Discipline. It matters not how wonderful a risk management system is, if it is not followed.

"Train your Team" is another obvious "lesson which is typically not learned". While studying under Dr. CC Crawford at the University of Southern California, I was privileged to spend time with him in his

basement think tank in Los Angeles. One afternoon, he told me that by far the number one issue that was revealed in his workshops, where inputs were anonymous, was lack of training. "Look at these", he said, gesturing to tens of thousands of Crawford Slips[4] stored in his basement. "They all tell the same story: 'I don't know my job and I'm afraid to ask about it'."

"Communication is the hardest thing we do." This was practically a motto among the legacy TRW systems engineers. Sure, rocket science is hard, but… communicating is the hardest thing we do. One way this translated into action was ensuring a trained risk integrator helped each and every member of the team to identify risks to sustainment and then communicate those risks to the team and to management.

These were the key lessons communicated in the Dewan/Lindbald paper. They are important to study and practice. However helpful, in reality, you are not striving to locate and slavishly emulate the best sustainment risk management process you have ever heard of. Instead, you are striving to create an environment where that process will evolve out of your unique organization and specific mission. So two other dimensions are also needed to successfully begin your organization's transformation: disciplined approach and outcome awareness.

Disciplined approach:

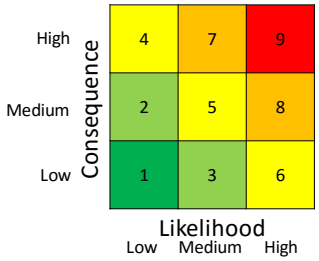
a. Process enforcement (see the next section of this paper)
b. Regular meetings (supported by management and key team members per lessons above)
c. A published set of rules (which are taught to all members per lessons above)
d. Risk summary statements that list as a minimum:
    - If…then statement of the risk
    - Readiness Factor affected
    - Summary of mitigation or mitigation options
    - Rough priority of the risk based on impact, probability, and lead time to mitigate

Figure 5 provides an example risk summary statement. The chart style helps facilitate discussions during the risk meeting. Notice the identifying risk number, A14, and title "A12 Avionics Box Final Test HW & SW". These are used as a short-hand method to identify this particular risk. The risk statement is fashioned as an "if-then" statement. Sufficient information needs to be present on the chart to facilitate discussions at the meeting. It is a certainty that whichever form you start your process with, the risk meeting members will find ways to improve it. These improvements must happen not only to help the process, but also to make sure the team members and managers feel ownership of the process.

A14 Priority 9 Availability

A12 Avionics Box Final Test HW & SW: If the A12 depot final test equipment and associated software continue to degrade, then A12 avionics will not be available for installation in the aircraft and aircraft availability rates will become unacceptable by March 2021.

This risk has high likelihood and high consequence. Production is already slowing down and lead time to fix this issue may be insufficient. Main issues are the power supply and cabling. But operating software issues present since manufacture have never been solved, resulting in significant re-testing.



Mitigation Plan: Acquisition program for new test equipment. Prioritize in-house repair of current testers' power supply modules and interface cables. Hire a software engineer to fix the operating system issues.

Figure 5: Sample Risk Summary Chart.
Your chart design will vary, and will contain information useful to you.

The most important point of the disciplined approach is to ensure the process improves and grows with the team and managers experience and skills. The proof of a good sustainment risk management system is not in which details are implemented but in the outcomes and the team's awareness of the outcomes.

When your monthly risk management meeting becomes "bogged down" with discussions of process, mission, system definition, readiness factors, and operator expectations, this is actually good. Evolution is occurring. Your sustainment risk management system should be reacting with new rules, methods, definitions, and approaches. The ultimate outcome awareness comes when you find you are implementing better observation and creating better plans, resulting in more resources allocated to you and your team is making better use of those resources because of your better planning.

IV. Your Organization's Maturity Influences Your Approach

In your efforts to follow the sustainment management model, your organization's maturity must be considered. Your organization will lay somewhere along a scale of "no understanding of sustainment" to "completely following the sustainment management model". Realistically, no organization will be at zero, since they all will have some inkling of how to perform some kind of useful work. And no one will reach or remain at the top very long if only because perfection is elusive. So every organization will have some components of the management model that are working. You must determine how much and how well before you can start encouraging tweaks to your risk program. This is the first skill you will learn and it is the skill required every day thereafter.

The most practical way to accomplish your evaluation is to approach your organization optimistically. Look for all the ways it is already following the model:

a. Do people agree that the organization has, in some sense, a responsibility to sustain a particular system?
b. Is there a general agreement on what the system you are sustaining is composed of?
c. Is there a process or approach that attempts to observe the entire system?
d. Does anyone work on long range plans for funding, deployment, resource integration, or etc.?

You must start by analyzing your organization. Is its stated purpose the sustainment of a particular system or systems? Or is it a collection of stove-piped activities engaged in something loosely defined as "logistics"? Or is it completely lacking direction?

If it is associated with a system or systems, is there a common understanding of what that system is composed of and what its mission is? Or this definition fluid based on who is speaking, what actions are occurring, who is providing funding, or other factors?

Is your organization leaping from crisis to crisis or does it have a clear path?

Is your organization's mission dependent on many sub organizations such as various contractors, government agencies, temporary workers who come and go, or other factors?

It may be that you need to take small steps. If your organization does not feel a responsibility for the entire system, push these processes for the piece of the system they do feel responsible for. If they don't understand the mission, use the risk management meeting to bring up the mission as often as possible in short "soundbites". If the observation and assessment of the system is nonexistent or poor, write this up as a risk. If your organization routinely gets funded, but finds it hard to keep its priorities straight, use the risk priority list to ensure the right funding is asked for at the right time.

All of this implies that your organization has adequate process discipline. Does your organization have any operating instructions, rules, or processes that are enforced and audited? If not, start there. Most critically, ensure the process system has an effective means of improvement, since you will be forcing improvements along the pattern of the sustainment management model. Audits must be focused on

improvements and not on punishing people. And processes must be capable of being changed within 7 to 14 days to keep your team motivated to improve.

The auditor, (in a small scale situation this may be you as the boss) must cultivate a cooperative atmosphere that draws out the needed changes from the process owners and implementers. Once these are identified, there must be a responsible person to grab the process changes and get them through review and sign-off. Top managers are key to this process as they cannot simply reject processes, but may at times even need to get "down and dirty" with the team to ensure process changes never linger due to management approvals. Without active leadership on a weekly basis, the organization and its processes will stagnate. Sustainment affordability and effectiveness will immediately suffer without immediately understanding the real cause.

At this point, if you are fully understanding the directions in this paper, you may be asking "when do I get any *real* work done?" All this management model and process discipline seems like a lot of wasted energy when the crisis is upon me *now*. If you have no crises, your organization will have no motivation to change its approaches to sustainment. If you are in constant crisis, your only way out is a management model and process discipline. Still, it is very difficult in the midst of daily work and frequent crisis to lead your organization to improved sustainment via this management model. It will take real leader. Fortunately, you are a leader.

V. Your Personal Sphere of Influence Drives Your Approach

Whether you are a senior manager or a new hire, you have a leadership role.

My SPACE 2016 paper explained that everyone benefits when everyone is a leader. Leaders remind people that their purpose is worthy, useful, and valued. At the core of every human being is a desire to be needed and valued. Simply noticing those who are starting to lose heart and encouraging them and having a vision of what needs to be accomplished not only helps others, but also gives you greater status and influence than you realize. Eventually, your steady vision will take you to positions of greater influence.

If you actually have some power today, such as a senior manager, not only work diligently to instill purpose, but also organize your team to achieve their purposes. An optimal organization for sustainment is described in the SPACE 2016 paper. In Minuteman III sustainment, several IPTs are focused around subsystems, for instance, propulsion, guidance, ground. And there are lower level IPTs within these subsystems responsible for the components of these subsystems. The focus in each IPT is how the readiness factors are faring within their area of expertise. Top management comprise the level 1 IPT. Major subsystems and functions form level 2 IPTs, and so on. This could be called "nested integrated product teams". A similar organizational structure could be what you need for your complex system. Creativity, a willingness to experiment, and resistance to organizations based on individual career needs is required.

Whether a new hire, top boss, or somewhere in-between, you can help celebrate successes and own defeats. Celebrations can be scaled to your influence. Thanking people for their efforts and pointing out the metrics that prove success can be done by anyone. Seeking out the truth about where the plan went wrong can also be accomplished by anyone. Recognizing problems without focus on blame is crucial to pushing improvements that steer the organization towards the sustainment management model.

When your team owns the purpose, expect them to correct *you* from time to time. You need to be open to the corrections.

VI. Pitfalls

Your organization will be far from Camelot. It will:

- Not see itself as charged with the responsibility for sustainment
- Not know what is included in its complex system
- Not know warfighter's view of system's key capabilities
- Only be responsible for a portion of sustainment / a portion of the system
- Exclude key team members

- Focus solutions sub-optimally, not system-wide
- Avoid process discipline
- Encourage hiding problems and tend to manage by crisis
- Avoid measuring anything seen as critical of the managers
- Misunderstand funding sources and decision-makers' needs
- Criticize any and all changes to the status quo

In each case, these are overcome by you owning the vision and being clear about it, creating allies by demonstrating and celebrating successes, and hard work.

VII. Conclusion

The trend in this new century is towards complex systems that remain viable for decades. Therefore, sustainment is not only becoming critical, but must also be carried out as economically as possible. If leaders do not make effective and economical sustainment processes a priority, their teams will be thrown from one crisis to another. This paper provides sustainers, leaders and their teams a simple model to compare with the reality of their day-to-day activities. The hope is that they will recognize when and why their approach is not providing the best system to their customers and operators, and take appropriate action. These actions are not always easy or simple, but knowing the correct path forward is half the battle.

You will know this or similar model is being applied in your organization when:

- Risk management meetings are held monthly.
- Risk Meetings include discussions of how the risk impacts the mission.
- Any meeting can be paused to discuss the governing process with an eye to improvement.
- Assessment results lead not only to risk identification, but also assessment program improvements.
- The assessment parameters are clearly defined and measureable.
- Long range plans are updated continuously.
- Information management systems routinely get updated at the request of the using team.
- Managers and leaders allocate resources, time, and priority for process improvements.
- Everyone in the sustainment organization can recite the mission, needs, and readiness factors.

As the third paper in a series defining this sustainment management model, it is appropriate to suggest continued research in this field. Using the model described herein, research could be performed in the following areas:

- Do costs increase and organizational efficiencies suffer when separate organizations are optimized for, for instance, parts control of jet engines, rather than using this model to sustain the entire weapon system?
- How many members of organizations in a particular military branch, charged with sustaining a weapon system, see themselves primarily as sustainers and secondarily as engineers, item managers, program managers, etc.? Does this identity hamper better sustainment decisions?
- Can every weapon system in a particular military organization's inventory be precisely defined? Is its configuration precisely identified? Is the engineering authority defined? Do these definitions correspond to the span of control, authority, and responsibility conferred on the sustainment organization?
- Do organizations with process change mechanisms of less than 2 weeks out-perform those who take longer?
- How many members of the sustainment organization under study can state how the warfighter's mission is supported by the weapon system? Can they do this in terms of precisely defined readiness factors? Can they recognize when a problem with readiness is emerging?
- What factors go onto the design of the sustainment organization's organizational chart? Are separate entities such as uniformed military, civil service, and contractors effectively bound into teams?

- Do all the members of a sustainment organization feel they have a method to voice their concerns about risks to the weapon system's mission? Are they motivated to do so?
- To what extent is each sustainment organization in a military component compelled to use a one-size-fits-all risk management approach? What inefficiencies does this create?

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[4] Dettmer, H. William, Brainpower Networking Using the Crawford Slip Method 2003 (With Dr. Crawford's own monographs difficult to find, "Crawford Slip Method" and "Productivity Improvement by the Crawford Slip Method", this is the best readily available text on the subject.)