Fundamentals of Weapon System Sustainment

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For sustainment managers and all weapon system sustainers, this paper provides a summary and rationale for the critical actions required for effective and efficient management of weapon system sustainment activities. Successful weapons system sustainment is the continuous, effective support of the weapon system. In today's austere climate of fewer new program starts and continued used of older weapon systems, sustainment must be carried out as economically as possible. Often lacking is the overall understanding of what it takes as a sustainment manager to keep the weapon system sustainment processes moving forward as affordably as possible. This model includes assessment, risk, and long-range planning subsystems as well as describing the critical role of processes, technology, and people. Managers and team leaders can use this practical model to add additional actions to their "real-life" daily required activities to help improve the chances that successful sustainment will happen.

Nomenclature

APB	=	Acquisition Program Baseline
DoDI	=	Department of Defense Instruction
FBD	=	Free Body Diagram
FRACAS	=	Failure Reporting, Analysis and Corrective Action System
IMS	=	Information Management System
KPP	=	Key Performance Parameters
LCSP	=	Life Cycle Sustainment Plan
LRPMS	=	Long Range Planning Management Subsystem
O&S	=	Operating and Support
SRMS	=	Sustainment Risk Management Subsystem
WSAP	=	Weapon System Assessment Program
WSSMM	=	Weapon System Sustainment Management Model

I. Introduction

SUSTAINMENT leaders and their teams need a comprehensive model that describes the core activities they must perform for effective and affordable management. Figure 1 illustrates the reason for this need via the example of aircraft: fewer new weapon systems are created while existing weapon systems are being employed longer. This leads to more funds than ever before expended on keeping weapon systems effective. Shifting warfighter requirements are nowadays often not met with new weapons, but by ensuring existing weapons keep pace. And constantly evolving non-warfighter real world considerations continually present new challenges.

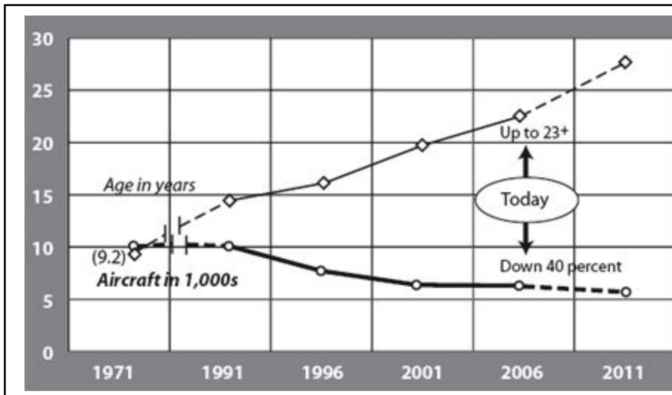

Figure 1: Example of aging weapon systems in the DoD[1]. *The increasing age of weapon systems emphasizes the need for affordable, effective sustainment.*

To be useful, the comprehensive model described here must be a) directly applicable to the sustainment of the very complex weapon systems employed today; b) integrated, that is, internally consistent; c) practical, easy to apply; d) self-improving; and e) constant, unaffected by changing public laws, regulations, and management fads. It should be easily called to mind visually and via a short list of core principles.

Many top leaders at the senior colonel or general officer level have a vision of such a model earned through decades of experience. But then they find themselves struggling to give the members of their vast organization this vision. Compounding this problem, they must expend precious time and effort advocating alternate management models designed only to enforce compliance to the rules. On the one hand, this is a good use of time since adherence to rules will likely keep the team away from abject failure and potential legal problems. But a fundamental understanding of what they are attempting to achieve is also needed as it will garner more successes in affordable, effective sustainment. Without a management model focused on sustainment success, leaders and teams will more likely move from one crisis to another and never create, execute, and husband an effective, affordable sustainment management system.

This paper is a short description of such a management model. It includes the model's rationale. The model described here evolved over half a century of Intercontinental Ballistic Missile (ICBM) Weapon System Sustainment.

Due to brevity, this paper is organized around only the 3 most important primary management subsystems (assessment, risk, planning) and 3 supporting, but still critical, management subsystems (processes, technology, and people) required in sustainment management. Interspersed are 5 key principles. A complete model may be found in the author's textbook of the same name, scheduled for completion by the end of 2016.

II. Definitions

A good model description starts with definitions. The first definition required in a management model is what is meant by a success. The DoDI 5000.02 definition of sustainment program success is:

> A successful program meets the sustainment performance requirements, remains affordable, and continues to seek cost reductions by applying Should Cost management and other techniques throughout the O&S Phase. Doing so requires close coordination with the war-fighting sponsor (i.e., user), resource sponsors, and materiel enterprise stake holders, along with effective management of support arrangements and contracts. During O&S, the Program Manager will measure, assess, and report system readiness using sustainment metrics and implement corrective actions for trends diverging from the required performance outcomes defined in the APB and LCSP.

The DoDI definition is written in an effort to focus the program manager on regulation and requirements as the means to avoid failure and making sure key tasks are accomplished adequately. Avoiding failure is a worthy goal and the program manager, and the team, needs to study DoDI 5000.02 and all similar regulations and public laws. Sustainment should be considered during design and acquisition. But this definition can lead sustainers to focus too much on requirements established during acquisition and not enough on current warfighter needs in the constantly evolving playing field. It also does not emphasize the responsibilities inherent in being a member of the sustainment team.

The definition of sustainment for the model described in this paper leads to practices that focus all sustainers on performing great sustainment management while continually moving towards even better sustainment management. Successful weapons system sustainment is defined as:

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

This leads to further definitions.

"Weapon system" is everything required for the warfighter to employ the combat hardware and embedded software to achieve the mission. For instance, 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. If the aircraft has unique in-flight refueling requirements, for example, it could even include the associated unique airborne tanker subsystems such as the unique radios installed in KC-135Qs that only function to communicate with one fuel receiver, the SR-71. In this model, the weapon system must be comprehensively identified for effective sustainment. Yet, the ability to correctly define your weapon system will be your first stumbling block. A good effort at this definition for your system will most likely result in the realization that your weapon system sustainment organization does not control important parts of the weapon system. Do not be discouraged, this is what a management model is for. Now that you see the problem clearly, over time you will create the processes needed to mitigate this sustainment risk. More on this later.

“Self-improving” means the management system can repair itself like a wounded or diseased person and build itself up in specific bones and sinew like an athlete. That is, the organization can improve itself by incorporating lessons learned over time, correct its mistakes, and realize efficiencies. The processes for continuous improvement in the required areas are built into the day-to-day sustainment management subsystems. Sustainers operate a management machine that changes as it is employed. They have a responsibility for it to change for the better. Creating an organization that follows this model is not a one-day revolution. It starts with small changes to the existing risk management system. More on that later.

“Complexity” is the next definition required. Whether the weapon system is “complex” or simple is a judgment call. But generally any weapon system employed by the United States nowadays is most likely going to be complex. This paper deals with the complex system, not only for that reason, but because the less complex the system, the more likely critical sustainment actions are taken as mere “common sense” and not analyzed nor properly designed and executed. For example, a simple system may reveal its deficiencies with little effort and present its risk mitigation solutions easily. On the other hand, the need to observe and analyze the performance of a complex system demands an understanding of how to design a thorough assessment program. Once the sustainment management model is learned, the user can discard portions of it if their tasks in that area prove simple. For instance, well-understood wear mechanisms need not be thoroughly tracked if they become thoroughly predictable.

Similar to the definition of “weapon system”, the more complex the weapon system, the more likely in the “real world” its sustainment is partitioned into pieces that make a holistic view of processes and goals hard to understand. This hard-to-understand environment is one of the reasons this model is needed: to provide the manager and team a vision of what good weapon system sustainment management looks like despite the fog of day-to-day organizational and bureaucratic realities.

This model is called “practical” because it provides an idealized and stripped-down management model that can be compared with the reader’s real world experience. The model, even the fully-described model provided in the textbook, does not attempt to include every minor influence. This is done to keep it as simple as possible to ensure it is used, especially by the novice who too often find themselves surrounded by a morass of apparent confusion and contradictions. The model, as a common paradigm, helps the team understand organizational requirements, justify process changes, and enforce discipline. Sometimes it keeps individuals from “losing heart” and quitting-in-place as it helps them realize that things are not forever “going wrong”, but that this is how sustainment management actually works. That is, there is something they can do to control their environment.

The management model must be fully integrated, that is, internally consistent. This consistency can be achieved analytically by starting with the reason for the weapon system, the warfighter’s mission. From this “watershed requirement”, all the management subsystems and their internal processes flow. In other words, the warfighter’s mission is the prime requirement that drives all others, especially the sustainment management model.

Sustainment Principle #1: The warfighter’s mission is the watershed requirement for weapon system sustainment.

III. Weapon System Sustainment Management System Top-Level Model

See Fig 2. Consider WSSMS as a kind of “free body” as in a free body diagram (FBD), isolated but with inputs and outputs acting as the “loads” or “forces”. The “body” in this FBD is the overall Weapon System Sustainment Management System (WSSMS) and is composed of all the management subsystems and associated processes required for effective weapon system sustainment. In this admittedly imperfect analogy, the inputs and outputs to this so-called FBD push and pull at the WSSMS. This is one way the analogy breaks down. A good understanding of these forces leads not only to the design and execution of the needed processes, but also to the realization that the sustainment organization only exists to serve these forces. The unfolding of the model in this paper reveals that the warfighter mission depicted on the left primarily provides the reason for the existence of the weapon system sustainment organization and the funding depicted on the right drives the design of most of the management subsystems in the WSSMS. The middle portion of the diagram shows those requirements external to the WSSMS that must be dealt with, but are not in direct support of the warfighter.

The “forces” pushing and pulling at the WSSMS on the left are the requirements coming from the warfighter and the warfighter’s mission. Flowing to the warfighter are the physical items associated with the deployed and employed weapon system. Based on the definition of “weapon system” above, that is a plethora of hardware, software, and documentation. On the right is the funding stream. The organizations which can flow funding to the WSSMS need to receive the prioritized program list to justify the release of funds. The middle arrow depicts the “fact-of-life” requirements which are not directly associated with the weapon system, are sometimes recklessly shot gunned across all weapon systems indiscriminately, and leave sustainment teams scrambling to implement as best they can -- forever dealing with their aftermath.

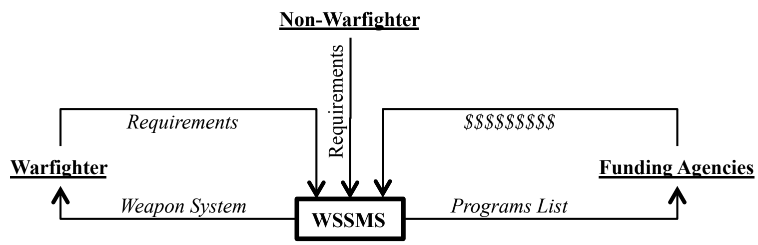

Figure 2: WSSMS Top-Level Model. *The major influences on the WSSMS are warfighter requirements that justify the existence of the WSSMS organization and the prioritized, justified program list which is the primary driver to obtaining the funds needed to run the organization. Non-warfighter requirements must also be accounted for.*

The WSSMS is not, of course, really isolated from uncountable other forces whose effects can be cumulative over time, but this simplified diagram allows for the analysis of the major forces that drive successful sustainment. Details follow.

A. Non-warfighter Requirements

Any real world organization that is the realization of the WSSMS has many “bosses” which have the power to impose both good and bad requirements -- often with no associated direct funding to realize the solutions. The middle inputs of Fig 2 depict these “fact of life” realities. This is illustrated in the diagram by not showing any input arrow that might modulate these requirements. In practice, the organization may have some small influence on the decisions made about standard DoD software development models, prohibited chemicals, or import restrictions, for example. But the influence is so minor that this model depicts the WSSMS as primarily reacting to outside influences over which it has little control. That is, processes must exist to not only recognize and respond, but anticipate or push back in those rare circumstances where this is absolutely mandatory to sustainment success.

B. Warfighter Requirements

The left hand side of Fig 2, the requirements flow and the deployment of the system, help drive the design of some important WSSMS processes. But most processes are created and executed in response to the pressures on the right hand side of Fig 2. These smaller design influences on the processes will be discussed later in the context of the internal WSSMS management subsystems, after those subsystems have been described. The left side of the diagram depicts the forces most important for providing the very reason the weapon system and the weapon system sustainment organization exists. That is, there is a requirement for a weapon system to support a mission. That weapon system must have specific readiness features that support that mission. The reason the WSSMS exists is to sustain those capabilities.

A weapon system is designed and deployed with certain readiness features or capabilities in mind. The designer may intend a 90% availability rate at the flight line, for instance. Once employed, the capability will naturally degrade, as implied by the DoDI definition above, unless steps are taken to constantly improve it. (That is, based on experience, simply maintaining the system will not be sufficient to avoid the “creeping entropy” that afflicts aging systems. This is most likely due to a certain complacency that sets in within the assessment program.) The warfighter may discover the capability is not as advertised or simply not sufficient. The more subtle of these issues is when the capability far exceeds the design requirements (the designer’s baseline). At this point, the warfighter will see this capability as the new standard and will be insistent they get nothing less.

More subtle is the flow of the weapon system itself to the warfighter. This is best imagined by the example of a weapon system modification which was thought to be just what was needed, but turns out to have unexpected issues once employed. An example of this is the new add-on Doppler navigation system fielded in the late 1970s in KC-

135s which displaced the radar display away from the view of the aircraft commander who needed it for, among other things, KC-135 formation flying in poor weather. Feedback to the sustaining agency was immediate, but only occurred once the modification had started fielding. The ability of the weapon system to perform its mission is the primary witness to how well the sustainment management system is working.

Figure 2 does not show a direct linkage between warfighter requirements and the stream of funding. A naïve sustainment team member might think that requirements come with the funding to realize them. In fact, that linkage *is* the WSSMS. That naïve sustainment team member *is* the link, as explained in the next sub-section, “Funding”.

C. Funding

The right hand side of Fig 2, the funding cycle, drives the creation and use of the primary management subsystems described next. The link between the warfighter requirements and funding is the WSSMS.

Sustainment Principle #2: In achieving sustainment goals, it is a daily, often hourly, fight to justify funding needs.

Funding flows to the WSSMS from multiple sources along with multiple time-factors and rules of use. These funding sources require specific information from the WSSMS to enable them to allocate and distribute funds. The information that funding organizations need from the sustainment organization, in summary, is a rank order and time-phased list of programs and projects needed to mitigate or eliminate risks to the mission. The list must be integrated with accurate information about the risk being mitigated in terms of effects on the mission.

The plural, “funding agencies” depicted in Fig 2, refers to the reality that many agencies control funding that the sustainment organization needs for success. And within each agency, there are likely multiple types of funding available. Different types (usually referred to informally as “colors of money”) come with different rules such as how fast it must be committed, what it can be spent on, and types of reporting requirements. This complexity comes from the need for organizations, starting with the US Congress, to track the funds and report on them. So this complexity will not be simplified anytime soon.

This complexity means that the beginner will likely feel overwhelmed with the process. But the beginner will become an expert over time, and this complexity serves the expert well. A roadblock in one funding stream might be overcome with some creative re-programming from another funding stream while still remaining within the rules and public law. The expert will find it important to keep their eyes open to new funding streams that will appear from organizations with vested interests in promoting certain types of solutions. For example, Air Force Material Command may have funds available to support creative engineering solutions to common sustainment problems.

The interface between the sustainment management organization and the funding agency is worked by individuals on both sides who have the same need for quick, accurate communication concerning up-to-date weapon system knowledge and prioritized risk mitigation solutions, that is, programs. Both types of individuals need a strong grasp of the rules and how the weapon system functions to meet the warfighter’s needs. For instance, a sustainment organization may have a program manager desperate for funds to complete a high priority flight line test equipment modification that boosts weapon system availability. The funding manager on the other side of the interface must be able to cogently and concisely convey this need to their management based on an accurate understanding of current local support realities (e.g. critical bottle-necks created by low reliability support equipment). They must also help their bosses prioritize this weapon system’s needs against other weapon systems.

Beginner or expert, in the organization or just outside it, all need the information generated within the sustainment management organization. And they need it formatted in a way that makes it easy to justify their needs to the agencies and easy to get creative with funding streams. The majority of the remainder of this paper will focus on how the various processes within the WSSMS can be derived from this need.

IV. Primary Management Subsystems

Within the WSSMS, several management subsystems exist with their attendant internal processes. These processes are created and executed in response to the need to continually create a rank-ordered and time-phased list of programs. Refer to the right side of Fig 2. Funding will not flow without submitting the rank-ordered and time-phased list of programs. Without this funding, your WSSMS organization would not long remain in existence. With the wrong funds at the wrong time, the weapon system becomes more expensive to employ. This section summarizes the 3 major management subsystems: assessment, risk, and planning.

The information referred to in shorthand as "Programs List" on Fig 2 is primarily produced and formatted by acting on the information flowing from the Sustainment Risk Management System (SRMS). The SRMS, in turn, requires the information flowing from the Weapon System Assessment Program (WSAP). All of this helps create the long and short range plans which are primarily a description of the many programs and projects required to mitigate the identified risks. Although some activity described can be relatively immediate, this planning function is called the Long Range Planning Management Subsystem (LRPMS).

WSAP is called a program and not a management sub system because various short term projects can occur to provide risk management and long range planning. But only an on-going program can consistently support the weapon system with the information required for risk and planning. That is, WSAP is an ongoing program that continually assesses the state of the weapon system. Observations from WSAP are used to determine risks to mission capability. These risks are prioritized and fed into long range plans to determine what efforts need to be performed to maintain or enhance mission capability.

Explanation of these sub processes begins in the center, with sustainment risk processes.

Figure 3: Assessment, Risk, Planning. *The Primary Management Subsystems within the WSSMS link weapons system expected capabilities with the plans to keep it capable*

A. Risk

The position of risk at the heart of Fig 3 is revealing. If the sustainment risk program cannot take assessment data and efficiently transform it to risk mitigation plans the entire weapon system sustainment process breaks down. This results in a sustainment via crisis management model. Alternately, incorporating this model starts with simple changes to the existing risk management system.

Risk management is extremely popular and there are many rules within the military about how to run a good risk management program. There are many vendors willing to sell a risk management program. This is usually an information management system (IMS) of some kind. Your organization likely already has rules and processes on risk management. In order to decide the best way within this model to implement the rules and the best IMS to buy or create, a few key principles must be followed. In addition, the organizational rules and processes need to be reviewed in light of these principles and this model because, in some cases, the accepted common practice violates good sustainment management practices.

Sustainment Principle #3: Sustainment risk management is the primary driver of efficient sustainment management.

The Risk Management process and its supporting rules and software applications must be, first, a "sustainment" risk management system. Good and useful risk system exists for a variety of reasons. But if an item identified in the risk system is focused on mitigating a risk to a program, or helps ensure a contractor makes the desired profit for the year, it is certainly not a risk that should be listed in a *sustainment* risk management system. The key to ensuring a management system that is operating on risks to the sustainment of the weapon system is to expend the effort first to identify the warfighter's mission and second to identify a handful of key parameters critical to the mission.

For instance, a manned bomber (the weapon system) supports a warfighter's mission to destroy any target worldwide within a specified time period. The sustainment professional creating or improving their SRMS must research this mission and understand it.

Next, the professional needs to propose a handful of readiness measures that can be tracked to ensure the mission can be adequately performed. Usually "availability" is the first one. If a sufficient number of weapon systems are not mission capable and cannot be generated in the specified time, the mission fails before the aircraft take off. Another typical parameter is survivability. The weapon system must reach the point where, in this case, bombs are dropped. There is likely a requirement for it to return home as well. Depending on the mission and the weapon system, there will be other parameters such as accuracy, loitering, recon spectrum, etc. Finally, as a special subset to availability, there will be existential parameters such as safety or surety. If a weapon system is deemed unsafe to use, it cannot be used until the issue is fixed.

All this is needed because when a risk is proposed, it must be tagged to one of the key readiness parameters. If this cannot happen, the risk must be discarded as not a sustainment risk, *or the key parameters must be updated to include the broad requirement behind the current issue*. This last part is an example of the self-improvement built into this sustainment management model. It also explains why these readiness parameters may or may not be previously identified Key Performance Parameters (KPPs) as defined early in weapon system development. In this manner, the risk system is kept focused on sustainment and the readiness parameters are updated with up-to-the minute understanding of the weapon system's role in the mission. Both of these functions, updating the risk list and keeping the risk process healthy, are the two key tasks to be performed in each and every risk review.

Leadership may decide that it is more efficient to discuss all risks (sustainment, programmatic, etc) in a single recurring meeting. The danger of doing this is that it confuses the team and causes them to lose focus on sustainment. The risk meeting does far more than identify sustainment risks and their mitigations. It indoctrinates the entire team on what defines a sustainment risk, helps them memorize warfighter readiness concerns, and weapon system capabilities.

So who attends a sustainment risk meeting and when do they occur?

Monthly risk management meetings hosted by the "Level 1" leadership are a must. Various levels underneath the boss can be tagged as "Level 2", "Level 3", and so on as needed. Each of these tiered management levels will be charged with having their own risk reviews to identify and refine risks to be presented. For this to work properly, as a minimum each level 2 organization must have an individual commissioned to develop the expertise to use the risk system and be able to dialog with the key experts to draw out emerging risks. This is the risk integrator. This can be an additional duty. The level 1 risk meeting should be open to anyone desiring to be there. However, most of the indoctrination for most sustainment team members will occur at level 2 or level 3 meetings that are facilitated by the level 2 risk integrator and run by the level 2 or level 3 manager respectively.

Items listed in the SRMS will have a rank-order in a priority list based upon their impact to sustaining the weapon system, and the likelihood the impact will occur. A third factor relates to the time-value of the risk. Just as a dollar today is not equal to a dollar in ten years or ten years ago, a risk has a time-value. Risks may be anticipated to come to realization in the near term, mid-term, or long term. These 3 time periods vary with the risk and are associated with the lead time to implement the mitigation. Rules governing these rules must be precisely defined, widely communicated, and changed as needed. These process-change issues are part of the Level 1 Sustainment Risk Review meeting.

Risks must be identified as soon as they are well enough understood to be defined. The process cannot wait for a suitable mitigation to be thought up. The corollary to this is, the risk management chair must never castigate a speaker for not having a remedy for a risk which is new.

You know you have a good sustainment risk management program when a) process discussions occur during risk management meetings illuminating understanding of readiness metrics, and b) some routine risks can be successfully processed via emails with risk integrators and managers.

Risks are usually found because of new information from the Assessment program or a fresh look at existing information.

B. Assessment Program

Sustainment requires an affordable, systematic assessment program to sufficiently observe the weapon system and compare it to not only the designed-to requirements, but also the capabilities expected by the warfighter, also called the capabilities baseline. This must be done with sufficient coverage to detect degradations and with enough time to mitigate the degradations successfully.

Sustainment Principle #4: Without an effective assessment program, sustainment is flying blind.

There is no hope of ensuring a weapon system remains capable of carrying out its mission if it is not sufficiently observed. “Sufficiency” is achieved by processes that not only observe and assess the observations against expected capabilities, but also assesses the assessment process to ensure there are no gaps in coverage. Example: the sustainment organization has expended $100M each year to carefully track cracks in the fleet of aircraft to ensure structural integrity. Meanwhile, avionics boxes associated with mission critical items start to fail at alarming rates and availability plummets because degrading components are not being detected at the repair depot and therefore get reused.

The Assessment Program can never be completely sufficient, or in other words, perfectly thorough. But a credible effort can be made to minimize surprise breaches of failure limits and warfighter capability expectations. The program must be designed as multi-year, with a built-in opportunity to review it each year for improvements. The program is guided by the handful of readiness factors mentioned above such as availability and accuracy. The responsibility for the weapon system is parceled out and allocated across the organization at each management level. At each level a comparison is made between assessment observation and testing, readiness, and weapon system components. Testing and observations are made ideally as a whole weapon system during operation. There are limits to full observation at this level and often issues detected at this level are detected too late to respond before significant degradation is a reality. So observation and testing must occur at subsystem, component, and part level as well.

If the sustainment organization does not have a formal understanding of the weapon system “as-employed” capabilities, the warfighter definitely does. And any loss to that baseline will be seen by the warfighter as a failure of the sustainment organization. At the same time, the sustainer must thoroughly understand the designed-to and as-built capabilities so that they have the clearest picture possible of weapon system effectiveness. Example: a fleet of rockets is experiencing aging of its solid fuel. The warfighter expects 100% reliability of the fuel. The mission specifies that the rockets be designed to 90%. The as-built rockets were tested to 95%. The sustainer detects degraded fuel and creates a program to re-load existing rockets with new fuel, but over the course of the program, reliability will drop to 88% for 3 months and be below 95% for 8 months. Can this be sold to decision-makers? If 88% for any length of time is completely unacceptable, the primary fault lies with the observational power of the assessment program.

The sustainer should enshrine this warfighter-expected capability as the new capabilities baseline because the warfighter will no longer settle for the designer’s baseline. However, the warfighter and the sustainer can come to an agreement that a certain excess capability can be considered “margin” against future degradation. That is, some capability may be lost as fixes are designed and sent to the field. The warfighter may be willing to accommodate a temporary breach of expected capabilities if the benefits are real and no other solution is possible. The sustainer may wish to have some “management” margin as insurance against late detection of issues.

If the sustainment program is not systematic, the sustainer will not be able to prove to top leaders that the weapon system will achieve its desired life. A systematic program has documented proof that it has followed sound scientific approaches for testing and monitoring. Testing and monitoring results are also well-documented. With complex systems this will involve one or several IMS to hold the data in a retrievable fashion. Example: top leaders expect a recon UAV to meet needed capabilities until it is replaced in 7 years by the next generation. However, all the test data indicating stable reliability and weapon system configuration is stored on paper in file cabinets and the engineers are unsure if the tests that created the data are the same from year to year or exactly what the configuration of the deployed force is. Decision-makers are not confident in this weapon system or its estimated life.

Care must be taken to ensure the same data are not retained in more than one IMS since this will increase data maintenance costs and data will drift apart if neglected. Example: A repair depot keeps track of the serialized subassemblies as they transit repair but no effort is made to double-check accuracy. As the assessment program compares epoxy upgrades across the force, the same serial number components appears in multiple locations at the same time, reducing decision-maker’s confidence in the upgrade.

An affordable assessment program starts with a survey of all “free” data which is generated during the normal use of the system. The term “free” is used very loosely here as there will be costs to the Assessment Program.

Operational data are captured by flight line maintenance logs, post-flight maintenance briefings with crews, mission documentation, and similar sources. A rich source of degradation and overall system health is the repair depot. Often, especially in military depots, the focus is on throughput and production to drive down repair costs. The sustainment organization, if it does not control the repair depot, must enter into a relationship with the depot to supply funding in exchange for information. A good model to use as this is initially established is the FRACAS[3] programs used in weapon system production. Material Review Boards are replaced with Failure Review Boards. Additional diagnostics will be run beyond the needs for simple diagnostics and repair. Depot IMS will interface with deployed systems IMS to tease out information like components that fail, get re-installed in another vehicle, and fail again with the same symptoms.

Most depot maintenance organizations are thoroughly incentivized for throughput efficiency. This can be the enemy of the Assessment Program. The solution is to levy formal requirements on the repair depot for the required data and to pay for this data. This places the repair depot in the position of finding the most efficient means to secure the needed data while remaining responsive to the bill-payer.

The standard should be set that all failures will be understood and repairs will be consistent with the symptoms spotted in the deployed asset. Failures of components during repair will get the same scrutiny. This does not mean, however, that every failure and repair will result in full post mortem analysis down to the dissected part. The majority of failures will be repeats and can be categorized with minimal effort. The Assessment Program has a continuous role keeping the repair depot aware of what data are of great importance and what data are not worth collecting. Example: flight controls degrade over time in a mechanism clearly tied to the leakage and usage of hydraulic oil. When these components transit the repair depot for disassembly, cleaning, reassembly, and refilling, additional diagnostics or parts analysis are not called for if the failure occurred in the expected time frame. Predictive maintenance can drive frequency of repair cycles.

There will be gaps between what this “free” data can reveal and the requirement for full observation. Those gaps can be filled with age surveillance, revised repair depot processes, and special tests. These tests are expensive and must be well-planned to ensure scarce funds are used wisely.

Age surveillance is an assessment program that first establishes via analysis which components may age out or wear out. Periodic observation or testing is established to track the parameters that will reveal the rate of this wear. Key affordability characteristics include the use of alert limits to help establish wear rates, and then, if wear is detected, actual failure limits are discerned. This is because establishing actual failure limits for all components is too expensive and unnecessary unless trends are detected.

Special tests will be needed from time to time to fill in the gaps in knowledge that the various processes above do not cover. Special tests are performed at the most logical site. They may be associated with lack of knowledge of a failure mechanism, a surprise degradation, or age surveillance that only needs to be executed rarely such as electronics degradation.

Assessment is, at its core, a pursuit requiring attention to the scientific method and proper use of statistics. Like any scientific pursuit, numbers and what they measure are at the heart of the method. The handful of readiness attributes (such as availability and reliability) must have numbers associated with them such as “the warfighter must have 90% of their weapon systems ready for combat within 1 hour”. With this precise metric, the assessment team can fashion inspections, monitoring, and testing to estimate whether that criteria will be met.

It cannot be proven in any scientific or mathematical way that any particular set of statistics can predict the future. However, the sustainment team has to be willing to assume the philosophy that trends can be mathematically estimated, the physics behind the trends can be understood, and the best approach is to expect the trend to continue into the future unless altered by another emerging degradation mode or risk mitigation action.

All of this means that the sustainment team must have members knowledgeable about the science and engineering inherent in the weapon system, members who are statisticians, and managers with a good working knowledge of both. For example, a statistician spent two weeks thoroughly analyzing battery test data and proudly showed the battery engineer his prediction. The engineer applauded the mathematician’s efforts but sadly informed him that “this kind of battery just doesn’t behave that way when it gets old and worn out”. Engineers (not necessarily degreed, but possessing engineering knowledge of the weapon system) and statisticians must be paired in their analyses. And managers must understand enough technology to explain the issue and enough statistics to explain why the technique used was appropriate.

The handful of readiness factors such as availability and reliability, must be constantly honed to be precisely accurate descriptions. At the same time, they must be measurable. The associated breakout of metrics the sustainment team estimates must be simple to understand and drive appropriate organizational behaviors. Every member of the assessment team must know them and compare them to their daily actions. Both assessment and risk, being revelatory in nature give the opportunity to better understand and precisely define the warfighters' core needs. On the measurement side, attempts at calculating the precision of estimates of actual performance against these factors are frustrating, but will serve to caution managers against believing the estimates themselves are precise.

Sustainment Principle #5: Readiness must be concisely, precisely, numerically defined and scientifically pursued.

Frequently, the assessment program will come up short and this in itself creates a risk to sustainment. When this happens, a risk must be written and presented to the SRMS.

You know you have a good Assessment Program when degradations to readiness are detected soon enough that mitigation actions or programs can keep the weapon system operating at the capabilities baseline. This is an impossible task. The sustainer should not be surprised to occasionally break through the capabilities baseline. But this must happen with full knowledge of the warfighter, must not break through the mission requirements baseline, and should result in assessment program improvements.

C. Programs / Long Range Planning

The output of the risk management program is a prioritized list of risks and their mitigations. These mitigations will range from simple changes to technical orders to large acquisition programs to acquire new support equipment or weapon system modifications. Another major step is required before these actions can be funded and started. They must be integrated into an overall long range plan.

This is a necessity not only because justifications for various funding streams require it. But the various fixes must be internally coordinated within the weapon system. If this does not happen, inefficiencies result. For instance, aircraft that have just completed programmed depot maintenance (PDM) immediately return to get a modification that could have been included in the PDM. Support equipment is pulled from the field for modification just as it is needed for a surge. Technical order updates become confusing because they were not synched with on-going modifications.

V. Supporting Management Subsystems

The following management subsystems are "supporting" only in the sense that their existence is driven by the primary management subsystems. In fact, they are critical to affordability.

Sustainment organizations cannot consistently evolve to meet emerging needs without agile processes and IMS. Federal organizations also often have demonstrated difficulties creating and executing affordable and agile information technology. Process discipline that includes processes that can be updated within days is rare. But complex weapon systems generate massive amounts of data that without an affordable, automated way to manage all this data and process management that allows teams to evolve and improve as they deal with it, the weapon system becomes unobservable and sustainment fails.

A. Processes

Many Federal organizations, including the DoD, have demonstrated difficulties in creating and maintaining agile management processes. However, the need exists for the WSSMS to respond quickly and affordably to both warfighter and fact-of-life requirements changes. Great organizations are able to do this by constantly improving their efficiency despite changing out of personnel, new laws and regulations, and other impacts on how business is accomplished. Failing to respond because your processes have not kept up is unacceptable. This leads to the requirement for the WSSMS to have consistent processes that get updated in a timely manner. This is accomplished by placing emphasis on a) the processes used to update processes and b) the audit process.

Audit processes must be consistently about reviewing the process and not reviewing the person. The auditor 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. Metrics on audit coverage and process update times are critical to the managers and leaders to ensure they take the time each week to focus on whether the organizational processes are healthy and improving. 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.

A great process system allows for changes to processes to occur within one week and never take longer than two weeks.

B. Technology

The affordable use of technology, especially information management system, is critical to the affordable functioning of an organization charged with sustaining a complex weapon system. Complexity leads to massive amounts of data associated with massive subsystems, components, and parts. Tracking the associated data so that the weapon system can be evaluated is a complex task on its own. Creation of and updating of information management systems is critical to managing this vast amount of data. This massive amount of data means that you must have information management systems to reduce the data in a way that is both manageable and meaningful.

Information management systems are often mis-designed, are duplicated leading to divergent results, and are often hard to correct. It is well worth the manager's time to ensure these problems are recognized and solved.

The first step in managing the organization's IT tools is to understand that the organization heavily depends on these tools for their day-to-day work. Encouraging the evolution of the organization and its processes results in tremendous frustration unless the tools can evolve along with them. New information management system must be developed in small, rapid cycles which takes into account the parallel evolution of the organization and its processes along with the new tools. Old tools must be able to be rapidly updated to ensure they keep pace. This requires active management which respects the users' needs while balancing the need to not make too many changes at once. Adequate budgets, actively seeking user inputs, and a track record of responding to organizational needs are the signs of healthy IT support. Lengthy contractual actions to create data bases, poor and difficult to access data, and contradictory data are signs that this part of the WSSMS needs attention.

Put a different way, we are beyond the point where resource-holders deny any funds for software maintenance and most intend that the use of automated information management systems will change the way our organizations perform for the better. Yet we still too often establish long lists of requirements that take far too long to implement, leaving the organization to evolve as the IMS stays static. The organization does evolve as it faces new problems and challenges. These normal changes in organizational structure, responsibility, and processes create continued frustration with the old IMS.

Thus, managers must allocate resources with a priority towards quick implementation, real expertise, and affordable solutions. Never let "better" be the enemy of "good" if it slows implementation. Give user's groups the power to allocate the scarce IMS creation and improvement resources with a light touch of management oversight.

C. People

Individuals on the government payroll, even uniformed military and contractors, are too often characterized by outsiders as lazy incompetents or evil dictators. The reality is that working for a massive bureaucracy that compartmentalizes work to the point of enforcing seemingly meaningless rules to achieve obscure goals will crush anyone's soul. This is the opposite of what motivates most people, which is, meaningful work.

It is especially easy for leaders to ensure those assigned to sustainment duties never lose heart. But time must be spent thoroughly indoctrinating them in the warfighter's mission, how their weapon system helps achieve that mission, and the supreme necessity to know and protect those handful of readiness factors that are key to weapon system effectiveness. Once this motivation is set in motion, constant reinforcement will result in team members reminding each other of the importance of their mission.

Common people issues are interpersonal conflicts, frustrations aimed at perceived laziness, and intolerance of ignorance. Focus on the mission leads to arguments about the best way to support the mission, focus on actions that will support the mission, and willingness to teach people who are ignorant of the processes required to support the mission.

Senior decision-makers are people too. And they need the help of the sustainment team to make good decisions. They do not get that help from people who have been so compartmentalized that they no longer can see the sun shine. An example of this is an interview I held with a senior parts engineer working for a major defense contractor that supported one of the premier USAF aircraft. After years of attempting to work parts logistics solutions, he was ready to give up and "simply do my job". This would mean, of course, that he would stop giving help and advice to anyone. After explaining to him the sustainment model described in this paper, he lit up and started getting excited about how he could use the sustainment risk management system to get his good ideas executed.

VI. Conclusion

In today's austere climate of fewer new program starts and continued used of older weapon systems, sustainment is not only becoming a critical means to support future missions, but it also must be carried out as economically as possible. Leaders are too often distracted from ensuring core sustainment processes are created, used, and constantly improved. Teams are thrown from one crisis to another as they find their capabilities to perform sustainment degrade. Integrated sustainment of complex, wide-spread weapon systems suffer from a stove-piped, geographically and organizationally divided sustainment team. In an environment where new starts get the most attention and management modeling. This paper provides the sustainers, leaders and the separated 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 weapon system to the warfighter and take appropriate action. These actions are not always easy or simple, but knowing the correct path forward is half the battle.

Further, this model is not inherently limited to weapons and could form the basis for a more general management model for sustainment of any complex system, regardless of whether it is a weapon system, or even man-made.

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 warfighter 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 allocated resources, time, and priority for process improvements
- Everyone in the sustainment organization can recite the warfighters' mission, needs, and readiness factors

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very much owes a debt to the systems engineers of TRW, Inc who first helped the USAF create ICBMs and stayed up through the millennium sustaining them to ensure their continued success.

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