Optimizing Simulators Logistics & Product Support

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ABSTRACT

Planning and executing the movement and support of training and modeling/simulation products remains a critical enabler to affordable readiness. How these functions are packaged to field and maintain readiness, and then doing so within standardized and interoperable environments, requires constant improvement. Simulators Logistics & Product Support optimization is focused on today's modeling/simulation environment, tools to enable a cross-domain training architecture, facilitating a synthetic-to-live/live-to-synthetic capability, and on actions supporting an Integrated Digital Environment (IDE). What will be the new sustainment strategy given each program physical and digital decision? Optimization efforts will include plans to meet sustainment requirements necessary to satisfy the model-based acquisition strategy requirements (Technical Data Strategy/Intellectual Property Strategy) and progress on sustaining development of Model-Based Systems Engineering (MBSE) applications for product support. Numerous challenges exist across multiple product domain applications, multiple Services with diverse internal Commands, industrial base intellectual property and market share, and program affordability. This paper will examine logistics and product support for program delivery that will include driving common architecture and support cost avoidance; standardizing measurement of existing readiness baselines; enhancing platform-to-training system organizational relationships by Command then Service; and leveraging industry/government best practices. This paper will culminate with examination of new devices in a digital environment, and a roadmap of lessons learned with targeted recommendations for logisticians. It will also help to expand knowledge sharing, guidance for workforce development, and demonstrate how AF Simulator programs remain a trusted agile provider of innovative, timely, and cost-effective capabilities.

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MODELING/SIMULATION AND LOGISTICS

Expertly designed warfighting capability modeling/simulation is only effectively employed and efficiently sustained if its reliability expectations are met, and if its users and maintainers interact as planned. The modeling/simulation capability itself is not our emphasis here. However, readiness measurement of that capability is our focus, derived from a Commander's assessment of available data on how well she can accomplish and perform mission employment levels (AFI10-201, 2020). Mission failure can result if a modeling/simulation training device is not on-hand when needed, is on-hand but does not work reliably, or is on-hand and reliable but its users are not properly trained. Readiness baselines are the measurement current state from which we assess progress over time.

To realize effective readiness we first need to address our problem: AF and DoD have a lack of sustainment strategy standardization across training systems, multiple readiness information sources, and multiple independent information system networks and logistics providers. In this context AF logisticians are still required to enable AF Digital Campaign, Line of Effort (LOE) #1: Integrated Environment – Models and Tools, and LOE #2: Standards, Data and Architectures, and also to project those impacts to program Life Cycle Sustainment Plans (LCSPs) (AF Digital Campaign, 2022). Our analysis begins with the product level required for readiness measurement, then examines modeling/simulation stakeholder awareness of Logistics and Product Support strategies as enablers for innovation. Stakeholders in this context are DoD, Services, FMS, and Private Industry. Our belief is that recognition of existing device readiness baselines in common logistics terms, awareness of organizational relationships that may drive product support strategies, and an understanding of how those devices can better integrate in the physical and digital environments, can uncover opportunities for not only objective measurement of mission modeling/simulation employment but also enterprise cost avoidance.

We will refine our analyses as we execute a roadmap for targeted adjustments to product support strategies, readiness measurement, and stakeholder interactions.

EXISTING DEVICE READINESS BASELINES

So where do we start a modeling/simulation sustainment standardization effort? One AF Major Command (MAJCOM) can be responsible for operational deployment and employment of multiple weapon systems platforms, each requiring multiple training systems with unique performance thresholds, and each system requiring multiple training devices. Each device can then have unique product support requirements and logistics providers, and have contracting strategies that may not provide profit potential. Each device can also have different supply, maintenance, and transportation concepts employed at the operational, intermediate, and depot levels. Further, each MAJCOM usually requires platform strategic dominance and operational effectiveness, and concurrently needs training systems to have only positive impacts to readiness. We are going to start this examination at the lowest product level required for a readiness measurement and that allows us to set a baseline for measuring our progress: a device.

Training Readiness Measurement

Effective training devices teach personnel operational skills/behaviors (AFI16-1007, 2019). Training measures depict performance levels attained by users and maintainers, to the standard set by the designed capability (AFI10-201, 2020). The authors in this instruction identify how Training readiness measurement complements Supply (i.e. S- % of on-hand/authorized) and Equipment Condition (i.e. R-% of available/on-hand) (see Figures 1, 2, and 3 (notional data)). To build these measures logistics providers use either authoritative automated information systems or non-authoritative manual processes. In most cases today this is a snapshot (i.e. point in time data-set) of the current fleet health for one product technology (i.e. device) and is most often conducted only once per year due to its manual intensity and high margin for manual errors. It can also be a contract deliverable with deliberate timelines. Unit Commander's continuously assess this device data and use it to drive improvement planning.

Supply

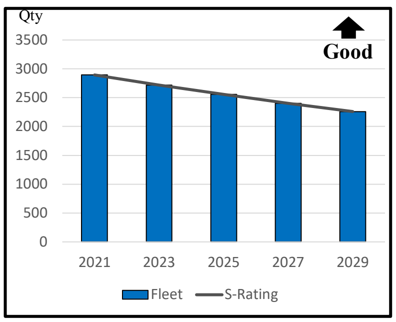

Figure 1. Device On Hand

Equipment Condition

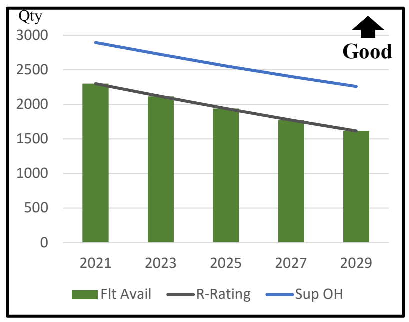

Figure 2. Device Available

Training Events

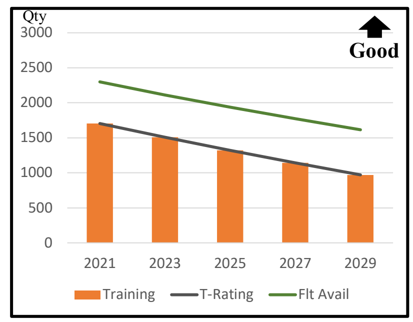

Figure 3. Device Training

These figures have a predecessor/successor relationship; meaning (from right to left) you cannot train if the device is not mission capable (i.e. condition is available) and the device cannot be capable for that specific mission if it is not in the unit's possession (i.e. on-hand). Training data from events can reveal negative results (i.e. when less than current platform design), gaps in training task completion, or the number of repetitions in a simulator. Supply on-hand data helps measure quantity authorized, redistribution orders, and excess. Maintenance availability (i.e. equipment condition) data helps assess scheduled and unscheduled events and failure rates. Measurements listed here are not inclusive, however, the point is that each possible data point can reveal opportunities for modeling/simulation performance standardization at the device level. More importantly, this may suggest that the most effective acquisition strategies should include logistics/product support analyses before managers expend additional resources.

Product Support Contracts and Organic Providers

The various logistics and product support provider types, arrangements, and statutory requirements are not our interest here. We instead want to review areas of contractor logistics/product support strategies for improvement opportunities. Our focus may also contribute to knowledge of model-based acquisition strategy requirements.

Government program managers use a Performance Work Statement (PWS) to direct product deliveries, services, actions, results, etc. from private industry to the government at required levels and timelines. During the acquisition strategy development and approval process for a contract provider, government logisticians align logistics and product support requirements to PWS and Contract Data Requirements List (CDRL) deliverables. Logisticians document this alignment in the program Life Cycle Sustainment Plan (LCSP) and then work with program managers to manage contractor performance through Integrated Product Support (IPS) elements such as maintenance planning/management, sustaining engineering, and supply support. Due to portfolio complexities, logisticians must constantly work to interject IPS elements in discussions with senior materiel leaders, so they can assess where and how logistics is involved throughout the life cycle. Risk assessments from trend analysis follows and drive corrective actions, e.g. condition-based maintenance strategies that can prevent mission failure. These trends are also successive data points within each readiness measurement process already discussed—and for one device.

Current Environment for Standardization

Constraints and vulnerabilities. Contracting strategies can constrain data. The majority of training systems use actual aircraft "peculiar" line replaceable units (LRU) and other aircraft assets such as seats. The Platform Program Office (PO) is the responsible party for life cycle logistics for these LRU type assets, including quantity deemed required for spares and the reparable cycle. The training system can be a trade-off when higher level platform requirements are needed, and when the platform formulates a plan to modernize (replace, enhance, or change) existing LRUs through the acquisition of "form-fit-function" due to obsolescence or Diminishing Manufacturing Source/Material Shortages (DMSMS). Additionally, the aircraft itself can be a trainer when the training system is either not current with the aircraft design (i.e. negative training), or when the existing training system capacity is insufficient to meet student throughput. The solution here can often be increased training system production. Some procurement strategies enable contractors to cultivate training requirements, creating an ecosystem for future opportunities. The systems are manufactured primarily with training system "unique" parts with no applicable use by the platform. Once manufactured and tested by government representatives the systems are sold to the government. The majority of training systems are also identified as Contractor Logistics Support (CLS) for life leading the training system PO to award CLS contracts. Under the mandatory CLS construct the contractor is holistically responsible to determine supply chain, sparing, and kitting requirements for daily maintenance and long term "depot" sustainment, including hardware and software Engineering Change Proposals (ECP), Concurrency, and Modernization efforts. The internal CLS supply chain routinely experiences obsolescence, DMSMS issues and has been exasperated by COVID related supply disruptions. Additionally, the CLS provider establishes an agreement with the local LRS to facilitate the induction of aircraft "peculiar" LRU assets into the reparable cycle.

Commonality and Interoperability. Acquisition and product support strategies can cause common component and software unknowns. What is known is that common parts and sub-assemblies can drive down fleet device costs. In our CLS environment the prime contractor can have the greatest motivation to drive component interchangeability across its systems, meaning where an airmen could install and maintain the same component among multiple devices. The prime contractor primarily does this through control of the technical data Illustrated Parts Breakdown (IPB) and manuals needed for maintenance, flight characteristics, and training. However and though less common in today's environment, non-Original Equipment Manufacturers (OEMs) can also be effective given the right conditions. The results here most often are lack of common data to analyze and share across primes or government sources. Likewise, this affects interoperability of devices and its components outside the prime contractor's responsibilities. Government choices to own or access technical data, at all Military Specification levels, may too frequently constrain sustainment information, and therefore standardization and cost avoidance. If not accurately established in the PWS or CDRL and priced, government logisticians will not have access for trend analyses and forecasting.

As an example, our HAF Operational Training Infrastructure (OTI) 2035 Flight Plan strives to transfer stand-alone trainers to a network of systems capable to interact in a synthetic environment with other weapon system trainers. For this our Mobility Branch conducted a study to determine functional standards with applicable attributes to drive not only commonality but interoperability. The study recommended 12 standards (Screen, Image generator, projectors, Visual Database, Processor, Motion (leg & base), Motion (control logic), Synthetic training Environment, Communication, Network Interface, Audio, & Facilities) to aid system trainers and to enhance their ability to become the digital twin of each respective aircraft. The resulting issue again is lack of data to defend implementation of study conclusions across training systems. Training system "unique" parts are assigned to the CLS provider, and the provider develops an internal proprietary sparing methodology for "unique" assets. Currently, the "unique" assets are assigned part identification numbers by the provider and within an information system that does not always have standard interfaces to government systems. This again is a government choice that constrains analyses.

Supply chain analysis. Each weapon system, sub-system, component and interface most often has its own supply chain. Contracting strategies can require industry to manage this and provide CDRLs that demonstrate performance.

Material shortages still occur, however, when prime and subcontractors struggle to maintain internal communications. This can create situations where parts are needed from platform production to enable training device availability. The chains are also so lean that any disruption could cause a training delay that can equate to mission failure. To address this, US Army program managers partnered with industry to deliver a visual supply chain capability that overlaid logistics data with vendor information (from raw materials to manufacturing); this enables a near-real time view of non-controllable constraints (like a pandemic) that affect each vendor's capabilities (Bacon, C., 2020). Information overlays of this scope have tremendous capability for projecting issues and solving them before they become problems affecting mission. However, from our research this partnership does not appear to be common practice. Instead, what appears to be more common is that our logistics capabilities may not be as resilient as they could be.

Reliability. Our training devices and subordinate systems/interfaces must work as designed. It is expected practice for the PO to use actual ECP and obsolescence issues to drive upgrades and to modernize the training system fleet. There are many instances (mostly cost driven) of a government choice for limited information that, if gained, could be used to assess Key Performance Data (see Table 1). If ownership of complete technical data is not chosen, it becomes a subjective assessment for logisticians to determine the Mean Time Between Failure (MTBF), Failure Modes and Effects, and Mean Time to Repair (MTTR) that were behind upgrades and modifications. Training system reliability, however, can be partially inferred from the % Availability Standard in contracts. The OEM built the system to meet this standard, and the CLS provider develops sparing requirements using the availability %. To meet this standard whether the training system is newly procured or near its end-of-life, the CLS provider can simply adjust sparing requirements for "unique" assets. However, government engineers and logisticians can also employ MBSE analyses to build a snapshot of this data. What is needed, however, is a recurring MBSE-driven process. Until that is realized government logisticians need to strive for objective assessments, and should work to incentivize more contractors to deliver Reliability, Availability, and Maintainability (RAM) studies. This is critical because using this data can enable increased product reliability. And as device reliability increases, product maintenance, fleet size, and operating cost should decrease.

Table 1: Key Performance Data Needs *(includes relationship to Figures 1, 2, and 3 above)*.

Metric	Existing Goal (i.e. Government Choice)	Impact
Materiel Availability (Am) *(equals Figure 1; predecessor to Figure 2)*	*Unknown*	On-hand; unit possessed
Operational Availability (Ao) *(equals Figure 2; predecessor to Figure 3)*	95%	Capable for training event, student throughput
Mean Time Between Critical Failures (MTBCF) *(subset of Figure 2)*	Threshold (T): *Unknown* hours Objective (O): *Unknown* hours	Capable for training event, student throughput
Mean Time Between Failures (MTBF) *(subset of Figure 2)*	(T): *Unknown* hrs (O): *Unknown* hrs	Capable for training event, student throughput
Mean Repair Time (MRT) *(subset of Figure 2)*	(T): *Unknown* hrs (O): <*Unknown* hrs	Capable for training event, student throughput
Customer Wait Time *(subset of Figure 1)*	(T): *Unknown* hrs (O): <*Unknown* hrs	On-hand; unit possessed
Logistics Response Time *(subset of Figure 1)*	(T): *Unknown* hrs (O): <*Unknown* hrs	On-hand; unit possessed
Total Ownership Cost	*Unknown*	Affordability and platform integration
Cost Per Unit of Operations	*Unknown*	Affordability and platform integration

Authoritative Data Sources. Given government choices on technical data ownership and information systems, objective data from an authoritative source may not be available to share with other government agencies and contract providers. Lack of information sharing can further constrain sustainment standardization.

ORGANIZATIONAL RELATIONSHIPS

Stakeholders are of course driving the acquisition, product support, and funding decisions for simulator training systems and the weapon systems platforms they support. World-class engineering, logistics, and sustainment sources are all too apparent in today's industrial and government organic bases. Competing interests among stakeholders influence advocacy, resources, and accountability. Therefore, addressing existing relationships is needed.

Weapon System Platforms, MAJCOM/A3/A4/A5, and Joint

Each AF MAJCOM is Lead Command for specific weapon systems and non-weapon systems as directed (DAFPD10-9, 2021). And each weapon system platform program office is the acquisition and life cycle manager for the MAJCOM customer capability. MAJCOMs drive capability decisions and the program manager provides the context for delivering that capability in cost, schedule, performance, and risk terms. Both the MAJCOM and the program office defend the investment and sustainment portfolio to Corporate Structure senior leaders to obtain funding. This partnership is a balancing act, and a struggle, though can be highly effective.

Inherent in Lead Command is also the responsibility for support systems and equipment directly associated with a particular weapon system. Aircrew and Maintenance Training Systems are recognized as a non-weapon system, where the Deputy Chief of Staff Operations (AF/A3) is the operational training funding advocate for aircrew training devices, mission system training devices, space training devices, cyber training devices, and missile training devices. However, this may be an overwhelming task to lead for nine MAJCOMs. Maintenance Training Systems recognition is exacerbated as maintenance devices associated with the weapon systems have default ownership to their respective Lead Command (i.e. MAJCOM/A3T). However, both contexts can drive questions. Can one Lead Command/program office relationship better manage the training system portfolio and set enterprise common requirements and risk that leads to more tenable advocacy to the Corporate Structure, especially for common innovation like digital? Perhaps most importantly, can a singular Lead Command/program office relationship increase the influence on standard training readiness measurements, and be the most adaptive to accelerating testing and training environments? DoD regulations already require Services to conduct Program Support Reviews, led by Lead Commands, through cross-functional and cross-organizational teams that assess program interdependence and support corporate funding decisions. Likewise, Lead Command/program office relationships drive Product Improvement Working Groups with members from interdependent program offices, operational users, and functional managers.

Industry and Organic Sustainment

OEM and non-OEM design, engineering, testing, and production capabilities have been world-class and resilient for decades. Performance Based Logistics, Contractor Logistics Support, and Third-Party Logistics concepts have equally proven their merit. Likewise, organic government sustainment organizations continue to demonstrate highly competitive capabilities at best value, and have effectively and efficiently maintained performance as the legally mandated ready and controlled sustainment source. What has not always been apparent is the optimal contractor/government management and sustainment mix for training systems that under one Lead Command and program office influence could more quickly meet affordable readiness objectives. For example, due to the nature of Aircrew and Maintenance Training Systems and the difficulty to breakdown and ship a device to a depot, AF leadership has deemed nearly all devices to be sustained non-organically via Contractor Logistics Support for life. The CLS contractor is designated to accomplish all upgrades, concurrency, and modernization efforts to ensure the devices are close to mirror images of the weapon system platform. Relatively few systems of devices are designated to be organically sustained through a DoD depot. In these instances, the designated DoD depot accomplishes all upgrades, concurrency, and modernization efforts. More questions surface here. If the government chooses a prime contractor acquisition and sustainment strategy that could later include transition to organic, how does the contract itself affect industry and organic source behavior?

DIGITAL TRENDS AND JOINT SIMULATION ENVIRONMENTS

A discussion on sustainment standardization and its associated organizational relationships should include our digital environment today. How rapidly are we moving toward what the former SAF/AQ described as “authoritative automation and/or virtualization” and digital/physical twin coevolution (Roper, W., 2020)?

Leveraging the AF Digital Campaign

Methods to push forward in our digital campaign include “multi-domain physics-based digital modeling,” from platform down to each sub-system component and starting day one on product life cycle (AF Digital Campaign, 2022). Our leaders are equally advocating MBSE, Modeling/Simulation & Analysis (MS&A), and Government Reference Architecture (GRA) as tools for digital standardization. We want to help clarify how logistics and product support strategies are evaluated/refined in the transition to an environment that is predominately digital. For training devices already fielded we believe the system rack is one available pathway to a digital twin. Each program office could leverage vendors with that expertise through contracting strategies that will deliver system rack(s) designed to replicate the physical training device itself as software. This may already be happening within major platforms with high fidelity training requirements. Digital twin employment should also drastically increase data availability for logistics, even enabling maintenance and infrastructure digitization. In addition to driving fewer devices and cost avoidance, Key Performance Data from commonality and interoperability studies may also drive fewer system racks and enable those capable of supporting one or multiple platforms.

Directed cloud-based environments and their data-service computing capabilities offer enormous collaboration, data assimilation, data analyses, and cost avoidance for AF platforms (SAF/CN, 2021). This can lead to faster adaption to operational and acquisition changes, and acceleration of digital, common synthetic environments. Faster, objective decision-making from cloud-based computing can enable smaller, more adaptive training devices with smaller infrastructure requirements. Contracting strategies that maximize flexibility in the year of execution may also help realize this. Sustainment strategy planners should evaluate trends and prepare for rapid, tailored IPS element responses to smaller device/network capabilities, and concurrent needs of the emerging cloud-based model/simulation environment (see Figure 4).

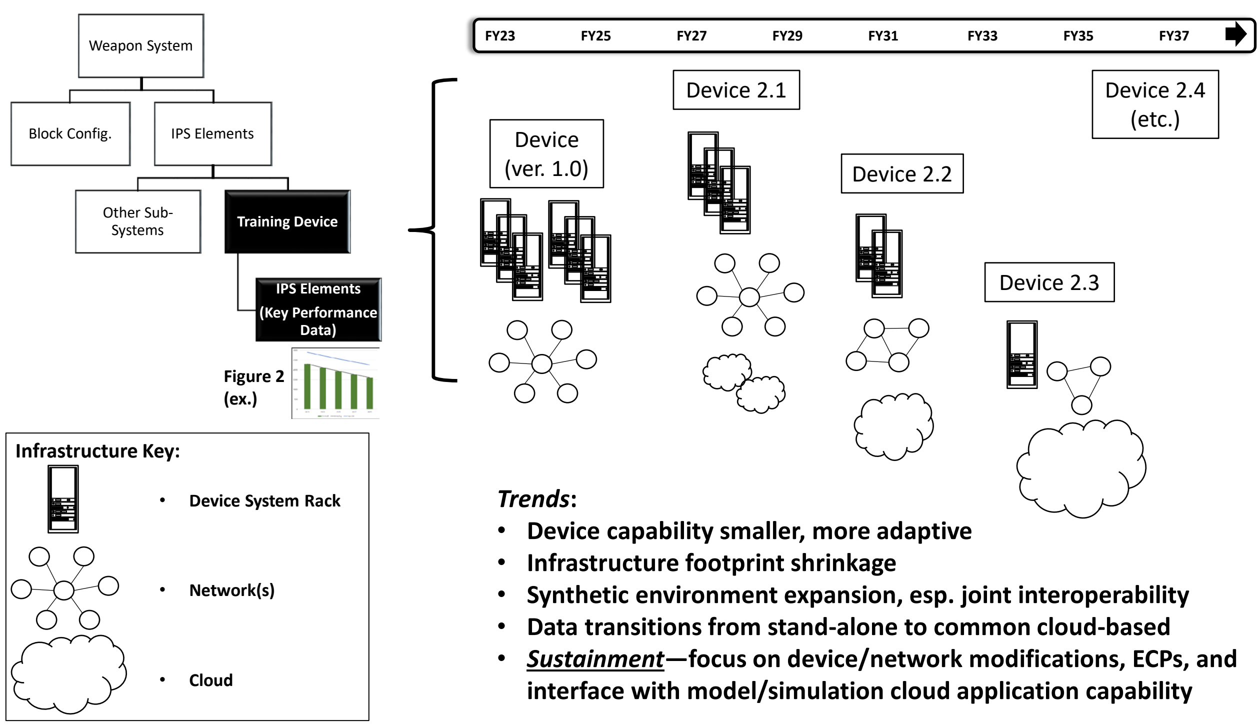

Figure 4. Future Systems

Supporting an Integrated Digital Environment (IDE)

Software is the critical growth field, and device/software synchronization requires constant communication among stakeholders. Logisticians help anticipate and identify problems as part of Product Improvement Working Group processes. Modeling/simulation logisticians also help facilitate standardization efforts like Simulator Common Architecture Requirements and Standards (SCARS) by enabling all associated IPS elements, readiness projections, and cost avoidance. SCARS capability expansion may increase the likelihood for cloud computing and digital twins, thereby helping logisticians decrease physical twin footprints and associated costs. Simulator program managers, engineers, and industry partners deliver capability for MAJCOM training in a simulated environment by platform, and use Operational Flight Plan (OFP) software instances to create that. Devices running on platform OFP are modified by existing OEMs or Non-OEMs to run SCARS, and those devices are then connected to a standard network for Distributed Mission Operations (DMO) with AF and Partner Nations. To deploy this capability, SCARS program managers are fielding a hardware system rack, called On-Premise Equipment (OPE), and a SCARS Operations Center (SOC). Also derived from MBSE analyses, SOC is the current modeling/simulation cloud (i.e. application and database) that also essentially integrates device, software, and network capabilities. This emerging SCARS/SOC/DMO relationship is perhaps the first operational training instance of AF Digital Campaign LOE #1 and #2, and may be the early AF operational equivalent to the "Joint Force Data fabric" needed by the Joint All Domain Command and Control Strategy (DoD JADC2, 2022). More importantly, this relationship may be scalable to multiple platform modeling/simulation capabilities and cloud-based environments. Program manager and engineering teams are taking steps to prove this context through an AF virtual warfighting environment at the Virtual Test and Training Center (VTTC). And organizations driving directed cloud environments are continuing multi-layer security and bandwidth updates in order for SCARS/SOC/DMO interface discussions. Next, AF Simulator program managers are evaluating the Joint Simulation Environment (JSE), a Navy-owned program that has proven very effective as a stand-alone capability for high-fidelity training. JSE could be an enterprise application, as a shared environment, that will run on SCARS OPE and that would enhance the DMO network. For logisticians, IPS element integration continues.

CONCLUSION AND RECOMMENDATIONS

Increased knowledge of standard, device-level effective, mission modeling/simulation employment can successfully enable rigorous, affordable readiness baselines from which to objectively measure variation. Deltas from each could then become the next opportunities for cost analyses and knowledge growth.

We have attempted to explain existing modeling/simulation device readiness baselines in common logistics terms, how organizational relationships influence product support strategies, and how devices can better integrate in the physical and digital environments. Increased awareness and implementation of these can uncover targeted standardization opportunities that may not only enable objective measurement of mission modeling/simulation employment, but also realize enterprise cost avoidance. To address objective measurement needs within the Future Years Defense Program (FYDP) and to enable cost avoidance opportunities, we recommend logisticians do the following.

1. Logisticians are continuously investing in industry provider, program manager, and functional relationships. Many contractors may already be collecting this information, even if they are not required to deliver it. Through monthly team meetings we identify existing contract Periods of Performance and provide monthly data collection updates to team leadership. Results influence PWS and CDRL specifics by program and AF MAJCOM. We recommend logisticians consistently negotiate device-level Key Performance Data needs within existing contracts and organic agreements.

2. Logisticians continuously assess existing product support gaps against Service standards. These standards help to increase MAJCOM, Cross-Center/-Functional engagements, and are excellent training sources for enabling informed decision making. Logisticians identify Service offices of primary responsibility and publication update timelines, and also reconcile standards against existing PWS and CDRL specifics. Most importantly, we work to insert prioritized results from evaluation of mission, business impacts, risks, and sensitivities (e.g. supply chain and logistics resilience) within the next scheduled source selection negotiation. We recommend logisticians drive device-level Key Performance Data requirements within each source selection, program re-compete, or organic agreement.

3. Logisticians seek to discuss, insert, and analyze IPS elements at weekly/monthly staff meetings, quarterly program management reviews, annual MAJCOM summits, and Service/Industry engagements. Our objective is to enable senior materiel leaders and program managers to make the best value acquisition and mission decision each time. We are especially sensitive to realizing cloud-based environments and their data-service computing capabilities. We recommend logisticians constantly interject IPS elements in senior materiel leader/program manager discussions.

4. Logisticians identify data collection responsibilities/leads by program, industry deliverables, data repository locations, and sustaining engineering requirements. Teams then establish monthly meetings with engineering counterparts to develop common/interoperable options based on MBSE analyses, reliability centered maintenance, and other failure-related analyses. The team then makes recommendations to branch materiel leadership. We recommend logisticians maintain a rapport with engineering and contractor teammates to aggressively analyze device-level Key Performance Data for determining and delivering increased product reliability, common/interoperable devices, and software improvements.

5. Logisticians identify integration barriers between Platform and Modeling/Simulation program managers and report these monthly to branch materiel leadership. This report includes potential improvement options for Lead Command advocacy. Teams then implement quarterly meetings to ensure sustained alignment. We recommend logisticians continuously re-assess organizational relationships for readiness and cost best value, especially given the accelerating digital environment.

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