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You've Invested, Now Sustain It: Insights into the Sustainment Review Process

Authors:

Alex Bonich: abonich@technomics.net

Adam Kidwell: akidwell@technomics.net

John Liss: jliss@technomics.net

Contributors:

Brandon Bryant: bbryant@technomics.net

Kathleen Hudgins: khudgins@technomics.net

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Abstract

Congress, in NDAA 2017, established Sustainment Reviews to assess the planning and execution of Major Defense Acquisition Program (MDAP) product support strategies. Readiness is a critical aspect of Defense operations, and rising supply chain costs highlight the fact that effective planning, budgeting, and execution of a program's Sustainment Strategy is crucial to its long-term success. This paper provides an objective, experience-based perspective of Sustainment Reviews and best practices to ensure successful outcomes.

Session Summary

Defense acquisition has historically centered around the acquisition phase of programs, with multiple requirements for estimating and defending development and procurement costs in major Defense Programs. The 2017 NDAA introduced Title 10 U.S. Code 4323 – Sustainment Reviews, a new acquisition event that focuses on the planning, budgeting, and execution of System readiness and costs of ACAT I weapon systems during sustainment. Operations and sustainment activities comprise the majority of the life cycle and costs of a weapon system. Additionally, with readiness being a critical aspect of Defense Operations, and considering rising supply chain costs, it is not surprising that Congress has an interest in the sustainment-related performance metrics and costs.

As with any new policy, there are implementation challenges. Whether it is the collection of accurate and sufficient data to evaluate performance or resource limitations within program offices, these are challenges that the Defense department, services, and program offices must face and overcome. This paper will provide an overview of Sustainment Reviews and their requirements, discuss major challenges faced during their execution, and identify lessons learned from our experience conducting five Sustainment Reviews between the Army and Navy.

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1. Introduction

1.1. What is a Sustainment Review and What is Required?

A 2021 report by the Government Accountability Office (GAO) highlighted that planned aircraft procurements by the Department of Defense's (DoD's) F-35 Program were estimated to cost US taxpayers about $400 billion [1]. While a significant bill, the more eye-opening cost estimate is the anticipated ~$1.3 trillion to operate and sustain the nearly 2,500 aircrafts (i.e., 300% greater than procurement cost), making the F-35 the most costly weapons system in DoD's history.

Not surprisingly, the F-35 sustainment estimates continue to grow despite concerted efforts to identify operations and sustainment (O&S) cost reductions for the Program. GAO suggests that without significant and specific plans to address F-35 cost reduction, DoD "may continue to invest resources in a program it ultimately cannot afford." GAO highlights the costly DoD trend of major investments being made prior to consideration of decades-long O&S phase affordability. Historically, little focus has been placed on O&S phase costs of major defense programs; meanwhile, a number of statutory cost estimating requirements have been imposed on acquisition programs from early development through Milestone C when system production begins. Lack of focus on sustainment planning, estimating, and incentivizing during the design and initial production phase – prior to design finalization – has led to pervasive DoD affordability problems in maintaining its aging defense systems. The issue has been exacerbated by a lack of formalized requirements for programs to deliver sustainment phase cost and other metrics that would assist in budgeting, planning, identifying cost growth drivers, and making trade-offs to manage shortfalls.

In fiscal year (FY) 2017, Congress approved the National Defense Authorization Act (NDAA) 2017 [2] that mandated each Secretary of a Military Department (MILDEP) to conduct Sustainment Reviews for current and past Major Defense Acquisition Programs (MDAP) every five years after Initial Operational Capability (IOC).[1] At this time, 10 USC 2441 [3] formalized statutory requirements for Sustainment Reviews, establishing the new major effort at a point in programs' life cycles when previously little estimating and reporting requirements existed. Up to this point, after entry into Full-Rate Production (FRP) and achievement of IOC, MDAPs enter

[1] A Major Defense Acquisition Program (MDAP) is a program with estimated expenditure for research, development, test, and evaluation (RDT&E), including all planned increments, of more than $525 million (FY 2020 constant dollars) or, for procurement, including all planned increments, of more than $3.065 billion (FY 2020 constant dollars).

their O&S phase and typically hold annual reviews or nothing at all depending on service. The Sustainment Review requirement establishes a comprehensive, recurring assessment of the planning and execution of a system's product support strategy, indicating the breadth and depth of analysis that is expected for DoD's milestone events.

Sustainment reviews require multi-functional teams spanning logistics, product support, depot/supply, program office, and cost estimating expertise. A complete Sustainment Review includes an assessment of the effectiveness and costs of the current product support strategy, including evaluation of: system reliability and availability, use of consumables and depot-level reparables, obsolescence, and software maintenance. Additionally, the Sustainment Review must address a comparison of available product support alternatives and quantify the total remaining life cycle cost of the program (including O&S costs plus any remaining development and acquisition). A program office will likely spend 6-12 months preparing for each Sustainment Review event, and it must be repeated every five years.

This paper discusses Sustainment Review requirements – with specific focus on the cost analysis, estimation, and reporting requirements – as well as how to manage and execute a review effectively as a program office, and lessons learned for implementation.

1.2. Applicability

According to 10 USC 4323 (which replaced 10 USC 2441), Sustainment Reviews are required for defense programs meeting the following criteria:

- A “Covered Program,” defined as a program that is currently or was at any time an MDAP having an ACAT 1 designation
- At least five years since program completed IOC
- Five years since the program last completed a Sustainment Review
- Includes all fielded and planned future systems

1.3. Why Is It Important?

Historically a program’s acquisition cost (primarily RDT&E and procurement) has been prioritized, both by program leadership and stakeholders from service budget accountability departments, and even US Congress. Acquisition costs, reported regularly and formally through program Selected Acquisition Report (SAR) or Acquisition Program Baseline (APB) documentation, often experience growth as a program matures and requirements evolve. Congress has defined strict measures of critical acquisition cost growth for MDAPs, where

significant growth can lead to Nunn-McCurdy breaches and potentially program cancellation.[2] Until the establishment of Sustainment Review requirements, the focus on program cost growth excluded O&S costs. However, O&S costs represent the majority of the defense budget, typically amounting to 60-80% of program life cycle cost, as displayed in Figure 1.[3] Further, the Congressional Budget Office (CBO) estimates that O&S costs will increase by 11% from 2025 to 2035 [4], which further highlights the importance of these Sustainment Reviews.

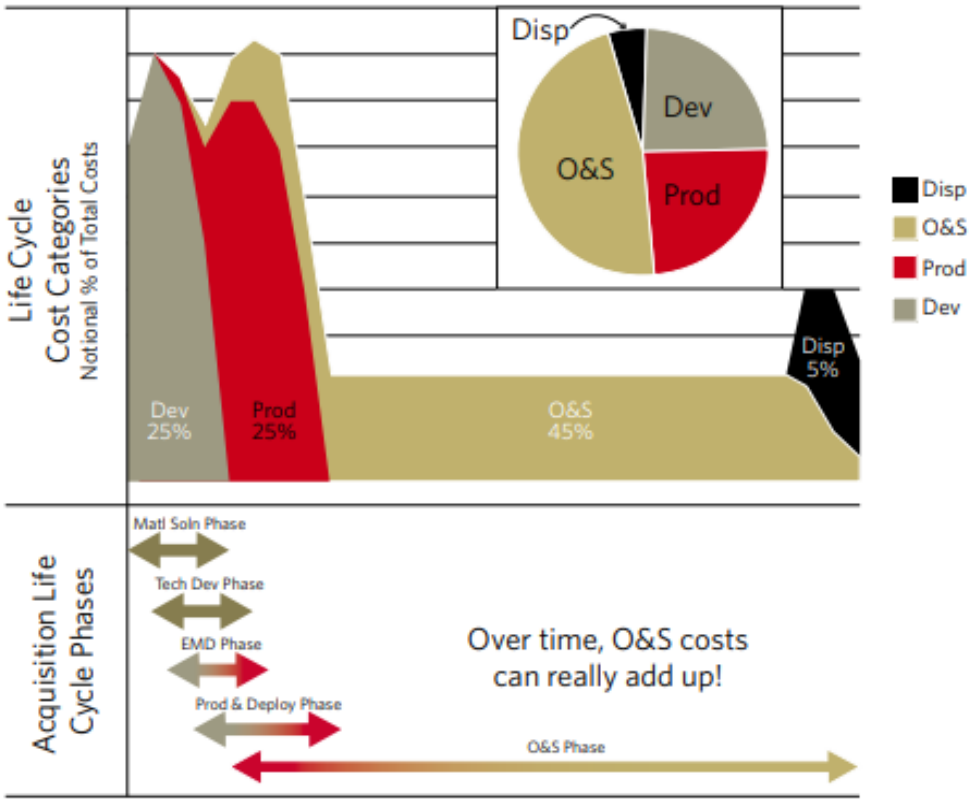

Figure 1: Notional depiction of life cycle costs by category [12]

DoD's historical focus on acquisition costs has been further demonstrated through a lack of systemic requirements to identify design or production-related changes that impact O&S costs in the long term prior to Full Rate Production Decision (FRPD). The execution-year focus of

[2] Title 10, U.S.C. § 2433, Unit Cost Reports (UCRs) was introduced by Senator Nunn and Congressman McCurdy in the NDAA for Fiscal Year (FY) 1982. Requires that Acquisition Category I (ACAT I) program managers (PMs) maintain current estimates of Program Acquisition Unit Cost (PAUC) and Average Procurement Unit Cost (APUC). If the PAUC or APUC increases by 25 percent or more over the current Acquisition Program Baseline (APB) objective, or 50 percent or more over the original APB objective, the program must be terminated unless the Secretary of Defense (SECDEF) certifies to Congress that the program is essential to national security. [14]

[3] FY2023 DoD Budget Request reflects Military Personnel (MILPERS) and Operations & Maintenance (O&M) appropriations represent, in summation, approximately 64% of the overall Budget Authority.

DoD budgeting and planning often means that decisions are made with a myopic focus on *today*, which oftentimes costs taxpayers a significant amount of money *tomorrow*. Design decisions being made today translate into aircraft, ships, and vehicles that will still be flying, sailing, and transporting – and breaking down and requiring repair – decades from now. Does DoD have any estimate of its total O&S liability decades into the future? Congress' establishment of recurring Sustainment Reviews on the largest defense programs can fill a critical information gap for sustainment cost planning across DoD.

2. Sustainment Review Cost Estimating Process

With most defense budget resources attributed to sustainment, it is no surprise that a major area of focus in the Sustainment Review process is the cost estimate. But how is an accurate, defensible sustainment cost estimate elicited, who are the players involved in the process, and what are the most important takeaways? For many defense programs, this will be their first time addressing these questions at the level of detail that has now become a formal requirement. This includes standardized documentation, reporting, and approval procedures. Having a path forward to navigate the anticipated challenges of these uncharted waters is a driving factor in determining outcome success and the resulting impact on leadership decision-making regarding a program's viability for future congressional support.

For a program expected to conduct a Sustainment Review in the next fiscal year, notification is made to program leadership approximately six months prior to the fiscal year start by the Service Secretary. To support longer-term planning, each DoD Service maintains a draft plan of when each of their covered programs is planned to conduct their review, with subsequent five-year Sustainment Reviews also noted.

2.1. Cost Estimating Initial Planning

A successful cost estimate is the result of a collaborative process. The stakeholders involved in a successful Sustainment Review represent a range of functional teams – primarily program cost, logistics, and engineering teams, as well as external cost organizations among others. The level of engagement between each stakeholder and the cost team varies based on their influence on the cost estimate. Note that these stakeholder groups include parties internal and external to the program office undergoing the Sustainment Review, and thus include a variety of different priorities and perspectives. Together the stakeholders represent the Integrated Product

Team (IPT). Each functional team's primary contributions to the sustainment cost estimate are identified below:

- Program Business Management Office (BMO) Team: Composed of both cost and budget analysts in the program office. The BMO Budget team provides prior executed transactions for the major system/technology and planned future budgets based on the latest Presidential Budget (PB) or Budget Estimate Submission (BES), or future planned execution. Cost analysts from the BMO team are responsible for coordinating with the independent cost estimating organization by sharing compiled data and estimate methodology to inform the cost estimate development and reporting for the Sustainment Review.
- Logistics Team: Primary functional area for overseeing the Sustainment Review, with the Product Support Manager (PSM) designated as the lead since it is a congressionally-mandated position for programs. The PSM and logistics team has intimate knowledge and oversight of the product support (sustainment) strategy that largely informs cost drivers and data leveraged for the cost estimate. This functional team provides relevant data regarding fleet size, age, current and future planned fielding, and Reliability, Availability, and Maintainability (RAM) metrics used to develop relevant schedules, future personnel, and contract support for the fleet.
- Engineering Team: The main source for data and information specific to technical characteristics and performance metrics for current and future systems yet to be fielded, and assists with understanding the impacts of future design changes that may impact the costs of while a system is being sustained.
- External Cost Organizations: Dictate Defense-wide/Service-level cost policy, reporting requirements, and standards of practice for all cost efforts. Additionally, they provide guidance, consistency, and resources such as annual inflation indices to all Defense programs. For Sustainment Reviews, these agencies may either lead the Sustainment Independent Cost Estimate (S-ICE) or, if the program is delegated to the Service, they will provide support, verify and help frame the assumptions and scope of the S-ICE, and attend Stakeholder reviews during the process. Such organizations include OSD CAPE, Service Cost Centers (Army DASA-CE, Air Force Cost Analysis Agency (AFCAA), and Navy FMB-6), and cost departments within NAVSEA, NAVWAR, and NAVAIR.
- Service Secretaries: Oversight organizations that guide the Sustainment Review by providing input and validation of the information presented during the Sustainment

Review. Newly formed Sustainment Secretaries have been designated to ensure timeliness and completeness of the Sustainment Reviews. These organizations include Deputy Assistant Secretary groups within each Service, including DASA-S and DASN-S.

- System Command Logistics Support Centers: The organization responsible for performing product support activities once the system is past the materiel support date and in Sustainment. This category includes organizations such as NAVSUP, AFLC and ILSC.

In parallel to the cost estimate, each of these parties is responsible for assessing the program's product support strategy and execution by leveraging their different functional perspectives. This translates to a large volume of evolving information as members develop an understanding of their own requirements and state of the program under review. To manage the large amount of required data and documentation for the Sustainment Review and specifically the cost estimate, it is imperative to identify primary points of contact and establish channels of communication – both written and verbal – as well as a centralized document repository for the entire team.

Once informed of the Sustainment Review, early-stage IPT engagement will include schedule planning. Schedule planning includes both Stakeholder and Program Office expectations and clearly defines key events for the cost estimate leading to the Sustainment Review. In general, preparation for a Sustainment Review can be expected to require at least nine months with additional time necessary to formally close out of remaining reporting requests. Depicted in Figure 2, on the following page, is a notional schedule overview for cost requirement planning.

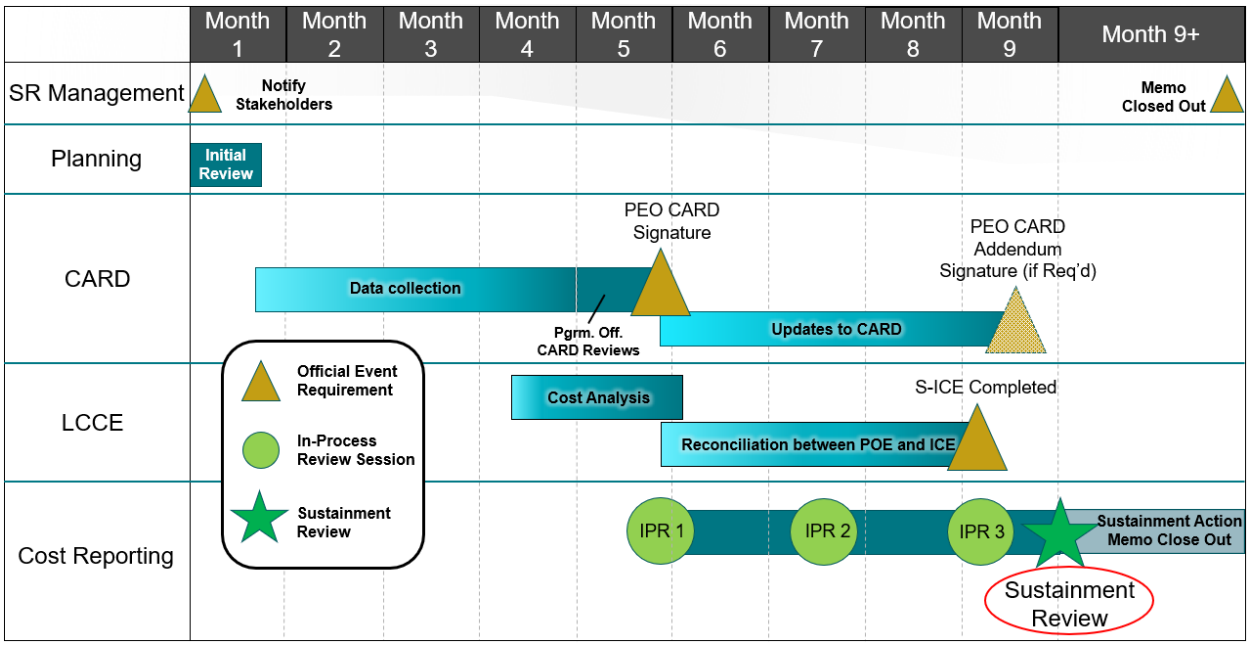

Figure 2: Notional Tier 0 schedule of cost reporting development for Sustainment Review

Over the course of a five-year period between Sustainment Reviews, the magnitude of changes incurred may vary widely from program-to-program. The scope of updates to incorporate in a cost estimate will drive the schedule planning expectations, impacting the phasing from element-to-element of the schedule. Therefore, the first action of the cost analyst should be to comprehensively begin an assessment of existing cost estimating resources. Examples of material sources include prior Milestone estimates, existing Business Case Analysis (BCAs) or Analysis of Alternatives (AoAs) related to product support, as well as the preceding cost estimating documentation. Having an understanding on the evolution of the program will assist the analyst in identifying the major programmatic changes since the prior estimate, including: major strategic/scope changes, technology updates/insertions, and increase in service life or quantity of assets.

2.2. Cost Estimating Requirements

According to 10 USC 4323, formal documentation requirements for a Sustainment Review include the completion of a Cost Analysis Requirements Description (CARD) and Sustainment Independent Cost Estimate (S-ICE). After assessing the most recent cost estimate and identifying the latest programmatic updates, transition to CARD update and cost estimate activities begin. As will be illustrated in subsequent sections, the two requirements share strong connective tissue.

2.2.1. Cost Analysis Requirements Description (CARD) Development

The CARD serves as the programmatic and technical baseline for a DoD system that a cost estimator uses to the develop the cost estimate. It contains data and assumptions representative of the current system operations compiled by the program office cost team primarily through outreach across the supporting stakeholder functional areas. CARDs are a statutory requirement for all ACAT I programs and, in contrast to a Sustainment Review, must be updated annually.

A multitude of factors such as the length of time the program has been in sustainment or ongoing production can influence the type of updates required annually. The latest program CARD of record should be assessed by the cost analyst for completeness, recency, and quality of data. This process should occur at the outset since it informs the schedule event planning thereafter. Due to cost estimator reliance on the CARD, emphasis should be placed on refining the data and assumptions through coordination with the appropriate stakeholders.

The process of collecting data for the CARD should be done in a manner that emphasizes rigorous criteria standards. The strength of any cost estimate is influenced by the completeness, documentation, recency, and basis of the data. Decision making regarding each component will be thoroughly assessed at varying levels of leadership in lead up to the Sustainment Review. Table 1 highlights key considerations for data assessment to mitigate potential pitfalls.

Table 1: Data evaluation criteria

Data Criteria	Definition
Availability	Data exists in a formal system or database, and is accessible for analysis
Accuracy	Reliability and completeness of the data
Granularity	Level of detail at which the data is reported (across cost estimating categories, temporal dimensions, or by asset or variant)
Timeliness	Recent and updated regularly
Well-documented	Complete explanation of data source, date, available data fields and values, data basis, and assumptions
Applicable	Representative of current system and requirements

A typical question posed about data collection relates to accuracy alone: "*Is the data correct?*" But data used to support cost estimates that is documented in the CARD needs to meet a wider set of criteria than purely accuracy to bolster the cost estimate. A more complete assessment

asks "*Is the data representative of the system today and in the future?*", where useful data must necessarily be available, accurate, detailed (or granular), documented, and recent. In the authors' experience leading CARD data collection, it can be a challenge to meet all of the criteria (see Section 4.2). Close coordination with members of the program office and larger Sustainment Review team is important to resolve each data limitation, or at the very least document limitations and assumptions clearly.

Developing/updating the CARD is the most crucial aspect of the Sustainment Review cost estimating process. It includes the consolidation of large amounts of data, assessment, and analysis to determine the correct inputs. Given that the systems being assessed during the Sustainment Review are fielded, it is expected that primary data (such as Unit-Level fuel usage) is used to inform the CARD. However, under the scope of the S-ICE, it is unlikely that all necessary data is available due to data quality or availability. The sections that follow propose top-level approaches to mitigate these issues. Once the development of the draft CARD is complete, a comprehensive review by the program office and program executive office staff should be conducted to ensure and completeness and accuracy.

2.2.2. Life Cycle Cost Estimating

As the CARD begins to mature, life cycle cost estimate (LCCE) development can begin. The LCCE leverages the data collected in the CARD to create a framework for delivering cost estimate reporting. Focus at this stage shifts away from data collection to data analysis and estimating methodology. Although the focus of Sustainment Reviews is O&S costs, an estimate of total life cycle cost (LCC) must be created. This includes total acquisition and O&S costs incurred to date and expected in the future (excluding items from other Services, significantly changed configurations, and Foreign Military Sales).

The task of creating a LCCE is levied on both the program office and SCC in the form of a program office estimate (POE) and S-ICE, respectively. Both stakeholders follow the aforementioned steps in the developmental process and initially carry out the estimating process separately.

2.3. Reconciliation

Per the Sustainment Review statute in 10 USC 4323, the reported cost figures for a Sustainment Review are to be based on the S-ICE developed by the SCC. To ensure consistency between the POE and S-ICE it is imperative to have constant communication with the SCC staff. This communication ensures that CARD inputs, cost data, and methodology used

is consistent. It is also necessary to discuss concerns with data, such as Visibility and Management of Operating and Support Cost (VAMOSC) system issues and contractor data requirements.

Reconciliation activities are not limited to discussions between the program office cost team and Service Cost Center. With the use of recurring In-Process Reviews (IPRs) during the planning phase of the Sustainment Review schedule, all stakeholders can present their findings and queries as a precursor for the Sustainment Review. In each IPR, information presented across the stakeholders begins to mature – including from a cost estimate perspective. Presenting cost methodology and results in each IPR will provide each stakeholder the opportunity to critique the estimate. After each IPR, outstanding actions pertaining to inputs reported in the CARD are updated and the POE and ICE estimates are reevaluated. The Sustainment Review is an iterative process for all parties involved, especially for cost analysts.

The flowchart in Figure 3 depicts the cost estimate maturation process and its importance in supporting IPRs and the sustainment review.

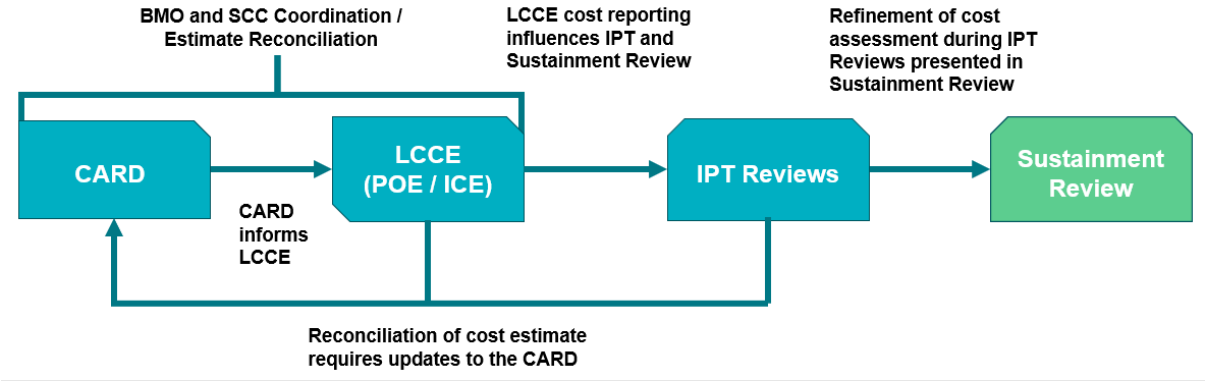

Figure 3: Sustainment Review cost estimating event sequence

Due to the nature of an evolving process, the CARD will likely require updates throughout cost estimate development. This is due to newly available data, prior unknown product support elements/strategies that need to be considered, or poor assumptions in the early stage of the analysis uncovered in the reconciliation process. Regardless, the CARD is considered a living document and these assumptions must be addressed as part of the final documented CARD and LCCE.

2.4. Reporting Requirements (Critical Growth Assessment)

The sentiment upon guiding a DoD system program through acquisition to IOC can be one of accomplishment and finality. Indeed, the feeling is legitimized by the challenges and milestones commonly associated with the acquisition phase. However, from a cost and budgetary perspective this is not the finish line, but rather a continuation. Figure 4 illustrates the difference in the timeframes of the acquisition and O&S phases for a notional major acquisition program.

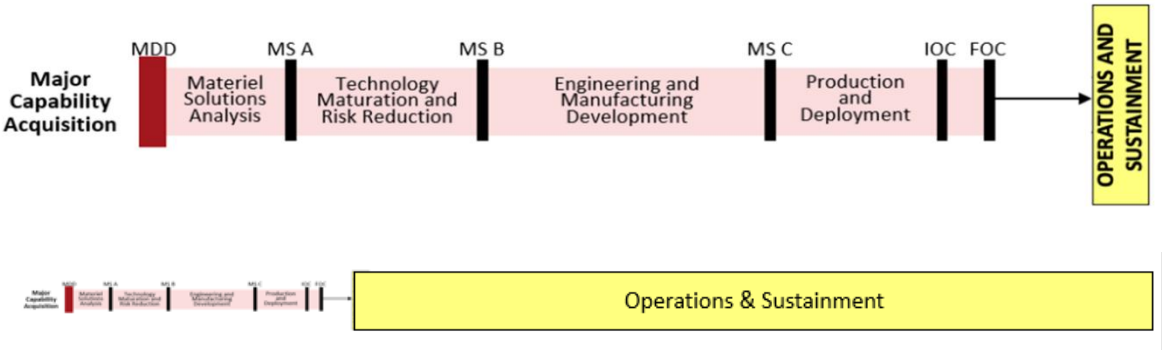

Figure 4: Notional DoD major capability acquisition system phases (top); and notional phases adjusted proportional to phase duration in program life cycle (bottom) [5]

Without a similar series of milestone events at which sufficiency checks are performed in route to a program reaching IOC, the likelihood of operational inefficiencies during sustainment becomes real. By establishing a cyclical five-year Sustainment Review requirement for major DoD systems, Congress is seeking to address this issue. As the state of a DoD program in sustainment continues to evolve (e.g., new systems being fielded, changes in maintenance requirements, etc.), the program necessarily grows. While fielding of additional systems up to the inventory objective is a positive sign, it can also result in major, undesired cost overruns that can last decades.

In a Sustainment Review, each program must assess and quantify its O&S cost growth against previous estimates based on two categories – Category A and Category B – and compare against thresholds to identify critical O&S cost growth. Table 2 summarizes the requirements of a Category A and B cost growth.

Table 2: Sustainment Review critical cost growth categories

Cost Growth	Baseline Estimate	New Estimate	Critical Growth Threshold %
Category A	Most Recent ICE	New ICE	≥ 25% increase
Category B	Original Baseline	New ICE	≥ 50% increase

- Category A cost growth is measured between the sustainment cost estimate developed as part of the new ICE and the estimate documented in the *most recent prior ICE*. Category A critical cost growth occurs when the O&S costs in the new estimate are at least 25% more than the estimated O&S costs documented in the most recent ICE.
- Category B cost growth compares the sustainment cost estimate from the new ICE to the *original baseline*. The original baseline can go as far back as a Milestone event from the Acquisition phase of a program, oftentimes Milestone B. For a Category B critical cost growth to be met, the O&S cost growth must be at least 50% higher than the original baseline.

Both category comparisons are part of congressionally mandated reporting requirements of the Sustainment Review. This includes the original estimated sustainment cost (i.e., from the baseline or previous ICE), the new sustainment estimate, and percent change between the two, in addition to the same comparison at the unit level. Table 3 illustrates an example of a notional program's cost growth assessment for a new estimate developed in FY2023 with the most recent ICE and baseline Milestone B estimate from FY2018 and FY2014, respectively.

Table 3: O&S cost growth assessment for a notional program

Cost Growth Category	Baseline Estimate (BY23$M)	New Estimate (BY23$M)	% Change	Baseline Cost/Unit (BY23$M)	New Cost/Unit (BY23$M)	Per Unit % Change
Category A: 2018 to 2023	$21,568 (prev. ICE)	$28,364	32%	$0.041	$0.049	20%
Category B: 2014 to 2023	$19,357 (orig. baseline)	$28,364	47%	$0.039	$0.049	26%

Based on the results of the notional example above, the program is reflecting a Category A critical cost growth, however, a Category B critical cost growth threshold is not met (i.e., < 50% increase). If either a Category A or B critical cost growth is reported for a program, Congress requires additional context and details to be provided. Required documentation includes the dates of each estimate used to derive cost growth percentages, a summary of cost drivers, and a written certification of the cost growth being justifiable, such as assumption changes that more accurately reflects the programs execution. If cost growths are caused by an insufficient product support strategy, then a remediation plan to reduce O&S costs must be provided to Congress as stated in Section 802 (d) of NDAA 2021 [6].

In practicality, it is often the case that cost estimates dating back to the original baseline of a program can be difficult, if not impossible, to locate. In other cases, the original baseline estimate of a program includes only acquisition costs. Either scenario makes adhering to the Category B statute a challenge and specific to the program. For example, previous DoD policy exempted acquisition programs from certain mandatory acquisition reporting, including maintaining an approved APB once a program has reached a specified percentage threshold of total program procurement. The absence of an original baseline O&S estimate on a Program implies that Category B cost growth cannot be calculated for a Sustainment Review, and thus critical cost growth in this category cannot be assessed against the threshold.

The cost growth assessment should begin well in advance of the Sustainment Review and be reported during the IPRs. In the event critical cost growth is present or anticipated after estimate finalization, the program office will need to develop a narrative to describe and defend the O&S cost growth. This entails an expansion of reporting requirements from the cost estimate, including reporting the new and old sustainment costs to DoD Service's cost element structure and identifying notable differences between the estimates. Cost analysts must help to identify drivers of O&S cost growth, discerning those that require additional research and remediation by the program versus those that are explainable due to increased fielded systems (quantity of systems or duration of fielded life), or changes to cost estimating methodology, assumptions, CES, inflation/escalation policy, etc. Furthermore, "the Service Secretary [can] ... submit a statement of certification that the cost growth is necessary to meet national security requirements" illustrated in DAU's Sustainment Review article [13], thus removing the requirement to generate a remediation plan.

Upon Sustainment Review conclusion, the independent cost estimating organization and oversight leadership will deliver a Sustainment Actions Memorandum (SAM). The SAM identifies the remaining actions to close out the Sustainment Review process and is unique to each Sustainment Review based on oversight guidance. Tasking can encompass delivering additional analysis into cost drivers, such as energy and manpower, and identifying strategies for cost reduction to retain program funding. The memorandum is a requirement independent of critical cost growth determination for the system program.

2.5. Additional Sustainment Review Requirements

Sustainment Review statute also requires "an analysis of whether accurate and complete data are being reported in the cost systems of the military departments," as well as a plan to update

data or improve accuracy or completeness if systems are found to be deficient. The cost team is best equipped to carry out this requirement since supporting or validating data is already being collected to generate the LCCE. This requires a data export from one of the Service's VAMOSC systems – Army OSMIS, Navy VAMOSC, or Air Force AFTOC – and assessment of this data's accuracy and completeness. A challenge is that these systems' original goal was to be the systems of record for accurate and complete O&S data, but there are still shortfalls within the databases because some cost element data is omitted and/or difficult to validate. Cost teams should at a minimum compare VAMOSC system data to Program Office expenditures from ERP, depot reported funding, and other reliable sources to identify missing data or anomalies. It is important to understand when comparing data that differences in scope, payer responsibility, appropriation, and other qualifiers may explain differences between systems that report different answers. A summary of this assessment should be included in the Sustainment Review briefing material or documentation to satisfy the requirement.

Additionally, Services in FY2022 requested an assessment be completed for Cost and Software Data Reporting (CSDR) compliance on O&S-related contracts within the Sustainment Review process.[4] The cost team should assess: (1) Do all qualifying contracts (based on OSD thresholds) have approved CSDR plans in place? and (2) Are these contracts in a satisfactory or delinquent status in terms of CSDR compliance? Both this assessment and the VAMOSC system assessment are useful feedback loops regarding strength of data collection within DoD; the results reported during Sustainment Reviews can be used to improve data systems and reporting compliance in preparation for subsequent Reviews.

3. Differences among DoD Services

Due to the overarching Congressional requirements, most aspects of Sustainment Reviews are similar across the Services. Each Service must comply with latest Review requirements defined by 10 USC 4323, including calculations of critical O&S cost growth and associated thresholds. Additionally, all Services leverage common resources such as work breakdown structures defined by MIL-STD 881F and the OSD CAPE O&S Guide [7]. All DoD Programs comply with Cost Estimating processes outlined in DoDI 5000.73, dictating timelines, roles, and critical milestones. And for all Services, the official Sustainment Review cost estimate requirement falls

[4] CSDRs are contractor cost and technical standard data reports collected for contracts greater than $50 M. These reports reflect the actual to develop, manufacture, and support weapon systems. For additional information, visit: https://cade.osd.mil/policy/dd2794

on OSD CAPE, which can choose to delegate to SCCs. Finally, each Service's Covered Systems include common types of major systems including aircraft, ground vehicles, and/or ships, as well as the smaller, unique onboard systems and combat systems that equip them with critical capabilities.

Sustainment Review statute enables each Service Secretary to carry out review activities in their own manner, which leads to some differences across the Services. Differences listed below focus on Army and Navy programs with which the authors have most experience, although the Air Force may have additional differentiators.

At a basic level, the terminology for Sustainment Reviews varies by Service. While "Sustainment Review" is the universal term as defined by Congressional statute, the Army utilizes the terms "Operational Sustainment Review" or "OSR." And the Navy refers to the requirement as a "Gate 7" Review or an "SR" – this difference likely aligns with the Navy's existing Gate process (Gates 1-6) that is interwoven within the Milestones (A, B, and C) in Major Acquisition programs. For Navy Programs in Sustainment, a Gate 6 review is carried out annually to summarize major product support activities, challenges, and costs to Leadership. Thus, the new requirement for five-year recurring Sustainment Reviews was added on as a "Gate 7" event.

Though Sustainment Reviews have been statute since FY2017, their implementation has varied by Service. Based on OSD CAPE's FY2018 Annual Report on Cost Activities [8], "The Army has made significant progress in addressing this legislative requirement. The Army, supported by the Army cost agency, has established a formal process known as Operational Sustainment Reviews (OSRs)... The Army conducted eight OSRs in FY 2018." The prioritization of Sustainment Reviews early by the Army has enabled the Service to refine and evolve the process each year. To date, the Army has completed over 30 Sustainment Reviews and has continued to refine the process and metrics reported. The refinement has allowed the Army to identify other critical areas that impact Operational Readiness, such as more detailed reliability and maintainability (RAM) analysis and corrosion prevention. The Air Force and Navy have both taken steps in the last two years to implement a formal process for conducting Sustainment Reviews. In their report, *Air Force and Navy – Actions Needed to Address Sustainment Risk* [9], GAO states that the Air Force and Navy were taking steps to address the Statutory Requirement by developing guidance and conducting pilot programs, but formal implementation wouldn't occur until FY2021. This puts both Services behind in comparison to the Army as they'll need to refine and mature their process to identify which metrics and Product Support

Elements need to be assessed. Ideally, they can leverage lessons learned from Army implementation and process maturity along the way.

4. Challenges in Sustainment Reviews

Cost analysis executed for Sustainment Reviews presents unique challenges. The authors have identified common pain points experienced while working these efforts. These include issues in scope definition, data, collaboration/coordination, workload planning, and estimating.

4.1. Sustainment Review Scope Definition

As discussed in Section 3 above, each Military Department (MILDEP) has developed Sustainment Reviews at different rates and with their own nuances. Implementation of any new requirement tends to be laborious due to limited guidance and/or scope definition and the "new" Sustainment Review is no different. Though the statutory requirement hasn't evolved significantly in the past five years, the process that each MILDEP employs has. This is in response to challenges faced and general maturation of the process.

Program offices have demonstrated a lack of familiarity with the statutory requirements of Sustainment Reviews. This could be caused by the learning curve associated with any new process or by mixed interpretation of the statute. For example, with the statute's requirement to analyze O&S cost growth, one may assume the Sustainment Review's cost estimate pertains only to O&S costs of the program. However, the Sustainment Review cost estimate must contain a full LCCE of both acquisition and O&S costs (sunk cost included) and be compared meaningfully to prior baselines. Further, five out of the nine elements required in a Sustainment Review, according to 10 U.S.C.-4323, instruct the program to provide "an analysis" or "an evaluation" of some aspect of the program's product support strategy. This allows for different interpretations of what constitutes an analysis or evaluation, how these analyses or evaluations are to be performed, and how they should be documented or reported on. It is important for analysts performing a Sustainment Review LCCE to communicate with their SCC to ensure alignment with expectations, formatting, and documentation of each Service policy requirement. Various instructions and memos from DoD and Service-level guidance agencies have been released in the public domain to steer analysts working on Sustainment Reviews in the right direction.

4.2. Data

Data is the most important ingredient in any cost estimate, and a Sustainment Review LCCE is no exception. Keep in mind:

- Sustainment Reviews are a high-visibility process involving many stakeholders
- Sustainment is the longest and most expensive phase of a system's life cycle

Collecting accurate, comprehensive, and timely data is necessary for a successful and informative Sustainment Review LCCE. This presents a series of challenges to analysts developing a Sustainment Review LCCE. Collecting data pertaining to system sustainment can be difficult as the data may:

- **Not exist within the program's CARD, even if the CARD satisfies requirements.** Even a high-quality CARD can exclude useful data for sustainment cost estimating - CARD requirements generally focus heavily on acquisition-phase data. As a result, cost analysts will need to identify other data sources to gain a complete understanding.
- **Exist in disparate sources.** For example, operational hours data may be collected in a different system from consumables costs, which are both separate from the costs and labor hours associated with fielded system maintenance. The analyst will have to normalize data consistently so it can be leveraged together meaningfully.
- **Come with little or no context on its collection, origin, or basis.** Lack of contextual basis makes it difficult to assess and compare data sources, understand limitations, and accurately draw conclusions. Oftentimes, data is collected by a functional group to meet its specific mission. This data may require modification, translation, or combination with other data to provide value for cost estimating.
- **Be updated infrequently.** The data may be out of date or represent outdated assumptions.
- **Require explanation by the collector.** A data dictionary explaining the data fields and values can mitigate this challenge. Calculated fields within a report from a database may require additional context on its methodology.
- **Contradict another source.** Assessment of each data source's assumptions, reliability, recency, and limitations may assist in adjudicating which to utilize.
- **Not be accessible or known to exist.** Most DOD data sources require users to have unique accounts with client approval. They may require certain network access,

classified resources, or specific descriptions of what the data will be used for. Account provisioning can also take time.

- **Be owned by another organization.** This can require a non-disclosure agreement (NDA) or memorandum of agreement (MOA) between organizations to enable data sharing.

Ultimately, analysts must use their best professional judgement to determine which data is best to use to support their estimate. Effective understanding and use of data may require extensive communication with the program office, team members from the in-service engineering agent (ISEA), contractor depot, etc.

Consolidated databases mandated by DoD requirement, such as Navy VAMOSC or Army OSMIS, can be very useful for certain programs or weapon systems. The database could contain a wealth of information that is easy to ingest, transform, and make available to cost analysts with appropriate documentation. But, ultimately, data applicability and completeness in these systems depend on the data source, data granularity, and data transformation algorithms inherent in the databases. For example, the system under review may have consumables that are handled by a private depot or shipyard. This organization may not collect data in a format that is compatible with the VAMOSC database, so it may not appear at all, or it may be incorrectly ingested by the database. Keeping these types of issues in mind, analysts should ask themselves the following questions, regardless of the data source:

- Can the data be trusted? Is the source of the data known, and can the analyst easily understand any transformations performed on the data before it is exported for use?
- Does scarce cost data represent the truth (little cost), or is the data missing?
- Are derived calculations following a traceable methodology?

Ultimately for Navy systems, the Navy VAMOSC database is a strong source for Ship programs and other major commodities. Conversely for shipboard systems, where maintenance is often completed by private shipyards or other contracted labor, the VAMOSC data has limitations due largely to data granularity and availability from its sources. The Navy VAMOSC documentation provides details regarding these limitations.

The Army's OSMIS database has strengths with certain cost elements for weapons systems, such as consumables and reparables, depot maintenance, manpower FTE costs, fuel, and OPTEMPO (activity data). However, the remaining elements of cost and associated cost driver data are missing. This presents an issue with determining what data are most representative of

the operational use and maintainability requirements of the system. For example, knowing the exact full-time equivalents (FTEs) or hours associated with maintaining a ground vehicle system is currently unavailable. In situations like this, cost analysts must leverage the other functional areas (e.g., logistics) to collect data to estimate costs through assumptions or planning factors versus reliance on historical costs.

A strong Sustainment Review requires linking the sustainment costs of a system to its reliability and availability metrics. Values reported in the final brief – both cost and operational metrics – will help craft a cohesive narrative to DoD leadership and subsequently Congress about the health of the system under review. The data collected and utilized during a Sustainment Review is the backbone of this narrative. It is imperative that the story told by the LCCE results aligns with the main threads prepared by the product support team, such as system reliability and maintainability. Analysts developing the Sustainment Review LCCE must think critically about how to use data effectively, present results effectively, and understand the interdependencies of cost and system performance.

4.3. Collaboration / Coordination

Collaboration between a program's functional areas is key to a successful Sustainment Review. These activities may not communicate on a regular basis, and it's likely that the Sustainment Review process has spurred new communication between the parties. Each of these groups possess different information about the system at varying degrees of relevance to a Sustainment Review. It requires diligence on the part of each group to determine which data they possess can contribute to a Sustainment Review. That said, since Sustainment Reviews are a new requirement for the Services, this diligence is not a given.

A cost analyst may not have the extensive knowledge and awareness of the more "plugged-in" members of a product team regarding the system under review. Knowing details like the different variants in the fleet, maintenance philosophies, and system modifications are just a few examples of the many complexities that arise when developing a holistic LCCE for a Sustainment Review. Cost is a common aspect of all the different facets of a program. Broad knowledge of the cost-pertinent characteristics of a program, as well as detailed knowledge of the inner workings of the product, are required to deliver a well-rounded LCCE for a Sustainment Review.

A large data call with specific deliverables requested from each member of the broader team is required to start the estimating process. While program office/field activity personnel may have

vast knowledge of a system, they don't usually know how it relates to building an accurate LCCE. The cost analyst must request exactly what kind of data is needed from each point of contact. Program office personnel may assume the estimator has more knowledge of the system than they do – which could make for omissions of pertinent information helpful to the estimator.

4.4. Workload Planning

Developing a comprehensive Sustainment Review LCCE is a long-lead, labor-intensive effort. Program offices tasked with Sustainment Reviews are challenged by the fact that their staffing required to accomplish this 'new' work had previously been reduced to the steady-state level required to support the system in operations. Prior to the Sustainment Review requirement, little program office manpower was necessary in O&S programs for major milestone-level reporting events. Furthermore, a program office is unlikely to retain the additional staff in between Sustainment Reviews since they recur every five years. This effort must also be balanced with the typical cost analyst workload, such as cost drills, IGCEs, CDRL Review, etc. For example, the authors of this paper have worked in teams consisting of 2.0 dedicated FTEs during their experience in Sustainment Review development - a clear indication of the significant level of effort required.

4.5. Estimating

Developing a cost estimate for a Sustainment Review involves creating a full LCCE for use in assessing against prior baselines. It is advantageous for an analyst to be familiar with the rigor involved in preparing an estimate of this size for other program milestones. The LCCE within a Sustainment Review will be assessed and scrutinized by key decision makers within MILDEPs. Estimate accuracy and defensibility are of greater importance than other post-IOC cost reviews.

The additional analyses and evaluations that a Sustainment Review requires beyond the typical cost review translate to more work for the analyst developing the LCCE. These analysts must think beyond the numbers into the realm of system availability and reliability – and how they may influence or be influenced by cost. Analysts must derive cost-pertinent information from program office and field activity personnel who might only be able to give piecemeal information about availability and reliability.

Program lifespans are often extended beyond original projections in order to meet newly discovered fleet needs. The LCCE for a Sustainment Review might extend cost projections beyond the timeframe previously covered in other LCCEs. Careful consideration should be

made when applying programmatic or estimating assumptions far into the future. For example, the system may have different configurations, each with their own projected lifespan. Since Sustainment Review LCCEs extend so far into the future, minute changes to inputs and assumptions can have significant effects on the total estimated cost.

The cost estimating process during a Sustainment Review is iterative and will require additions and changes to inputs within the cost model over time. Having a well-designed, dynamic cost model that can respond to these changes is vital. The consequences of poor model design can lead to significant rework when new data is added.

5. Lessons Learned

As stated above, Sustainment Reviews come with many challenges that must be navigated to ensure a successful outcome. Application of early planning, critical coordination, and utilization of reliable data are effective strategies to mitigate challenges and meet all requirements. This section provides analysts lessons learned for mitigating the challenges identified in the prior section.

5.1. Scope Definition / Evolving Process

As stated in Section 1.1 when a program conducts a Sustainment Review the process should begin 6-12 months prior. However, a best practice is to begin at least 9 in advance. It is essential to understand the requirements to deliver a successful result. Success is determined by providing a cost estimate that covers all aspects of the product support strategy to ensure Senior Leaders have a full picture to make informed decisions. The goal is to positively impact the operational readiness of the program. The process for Services continues to evolve due to the newness of its implementation. Specifically identifying the right metrics and information to explain the current and future operational readiness, cost impact, and maintenance requirements. The best way to manage the requirements for a cost estimate is to develop a detailed plan for the CARD (see Section 2.2.1) and ensure alignment with the product support elements. Alignment can be achieved through scheduled IPRs to cover all product support elements. These IPRs create accountability and visibility across all functional areas, ensuring a concise message to Senior Leaders. Lessons learned for mitigating challenges associated with scope definition/evolving process follow.

Table 4: Scope and process lessons-learned

Question/Issue	Lesson Learned
What is required for a Sustainment Review?	Cost requirements for a Sustainment Review are twofold. First, there are two primary deliverables needed for the Sustainment Review, the CARD and the LCCE. The CARD informs the LCCE by providing the programmatic, technical, and cost information on the system. The current LCCE is then compared against prior estimates to assess the change in costs from the previously developed estimates. The goals are to quantify cost impacts and to explain operational readiness and maintenance requirements for the system. One should assess: operational availability (Ao) and factors that inhibit its growth; driving of maintenance requirements; and whether maintenance efforts are experiencing cost growth for the system.
What is needed for the CARD?	All product support elements that drive costs for a given system need to be captured within the CARD. Elements such as maintainer and operator manpower, systems engineering/program management (SEPM) positions and man years, consumables and depot level reparables, funding, etc. Experience has shown that existing CARD templates are insufficient to capture all elements included in the product support strategy. Additional data collection and analysis are imperative to ensure the CARD includes all associated cost drivers needed for the Sustainment Review.
How should a cost analyst prepare for a Sustainment Review?	A cost analyst should prepare for a Sustainment Review by evaluating the recency and comprehensiveness of the existing Program CARD and LCCE. This will assist the analyst with determining the current gaps and beginning to identify the best POCs for collecting updated data and assumptions.
What challenges might programs face trying to implement this relatively new requirement?	While the US Army process is more mature by a few years of practice, the Navy and Air Force completed their first Sustainment Reviews in FY2021. This created a challenge for early reviews since Service-level guidance, policies, roles, lead stakeholders, and templates were being revised while Reviews were being carried out. It is imperative for a Sustainment Review team to be agile enough to react quickly to changes, and it helps immensely to communicate consistently with external stakeholders to ensure your team is up to date. It is likewise important to review any new instructions or policies released prior to initiation and throughout the Sustainment Review. As each Service matures its process further, this challenge will be minimized.

Question/Issue	Lesson Learned
What is the required scope of the Sustainment-ICE (S-ICE)?	The statute refers to the required cost estimate as a "Sustainment ICE" but does not explicitly stipulate the required scope of this ICE. Contrary to the initial interpretation one might have, the ICE for Sustainment Reviews is required to cover both sunk and to-go Program costs, and it must contain all life cycle costs of the program to include development and procurement. Templates developed for presenting Sustainment Review cost estimate results also focus in on to-go O&S costs only, but modifications can be made to display acquisition costs and sunk costs for meaningful comparison to existing Program LCCEs.

5.2. Data

Sustainment Reviews are dependent on the quantity and quality of the data. The notion of "Garbage In – Garbage Out" holds true when it comes to Sustainment Reviews, since poor data can lead to insufficient or misleading findings. As stated in Section 2.3 the independent cost organization supporting your Sustainment Review delivers their cost estimate to assess cost impact. The program office is tasked with creating their own internal cost estimate that is used in a comparative analysis during the reconciliation process. Operational and Sustainment costs often time have a multitude of data sources that can be used in assessing programmatic cost. It is good practice to meet with the independent cost organization to align on which data source will provide the most representative estimate. If there is limited data, reaching out to independent cost organizations can assist with obtaining other data sets to support the cost estimate [12]. Lessons learned for mitigating data challenges follow.

Table 5: Data lessons-learned

Question/Issue	Lesson-Learned
What is the status of the CARD?	Assessing the status of the CARD is a crucial step to understand the level of effort for updating the CARD. Since they are required for milestone estimates, CARDs are acquisition-centric. For this reason, it is likely that the CARD under evaluation will require significant updates to meet the needs of a Sustainment Review, i.e., account for items not previously tracked and reflect where the program is today. Even if the CARD is sufficient to prepare your LCCE, it is important to validate the assumptions to ensure alignment with other aspects of the Sustainment Review.

Question/Issue	Lesson-Learned
What data is available to me?	There is no one-size-fits-all solution to every Sustainment Review when it comes to determining the best data sources. Discussion with Sustainment Review stakeholders about the available data can assist in determining the best data for the estimate. For example, program ABC has historical activity rates from a Service VAMOSC system that can be used to forecast activity rates; however, after discussing the data with stakeholders it was determined that a planning factor was the appropriate data source as it reflects what senior leaders are projecting. Frequent communication will shape which data sources are best for the estimate. Given that Service O&S data has had limited visibility into Contractor Logistics Support, it is often augmented with another data source (CSDRs) for understanding total cost [7]. Congress mandated OSD CAPE to develop a centralized VAMOSC system called EVAMOSC whose main goal is to address the challenges associated with O&S data to specifically support Sustainment Reviews. Though EVAMOSC isn't available yet, and methods/approaches will need to be understood, the concept of the system is promising.
What data is required to support the LCCE outside of the CARD?	A sound LCCE for the Sustainment Review may require data from various additional sources if not already woven into the CARD. These additional sources include but are not limited to: Service schoolhouse data systems to document training courses, attendance, costs, and durations; detailed logistics data pulls showing consumable usage by system over time; OPTEMPO or flying hours/operational hours for systems historically; detailed maintenance data, including Casualty Reports (CASREPS) or defect descriptions, parts, material and labor costs, maintenance duration, etc. for all depot-level repairs. Often the biggest challenge is identifying whether a certain type of data is being collected in addition to who owns it and how to gain access to it. The next major challenge is dissecting these external data sources, typically requiring document review or discussions with the data owners to understand nuances and details.

5.3. Collaboration / Coordination

It is essential during the Sustainment Review process that the cost estimating team and members of the IPT communicate to provide updated findings, potential adjustments, and concerns. The cost team should initiate their Sustainment Review efforts prior to the other functional areas. This can lead to revisions over the course of the Sustainment Review. Additionally, to develop and deliver results it is the best approach to collaborate with the IPT throughout the process to address issues. Lessons learned for mitigating collaboration/ coordination challenges follow.

Table 6: Collaboration/Coordination lessons-learned

Question/Issue	Lesson-Learned
How do I establish collaboration for my Sustainment Review?	Scheduling regular interactions throughout the Sustainment Review process ensures regular status updates that will help facilitate discussions on progress as well as issues that may arise with assessing information. It is equally important to establish a document repository where data can be shared, discussed, and combined among functional areas.
Who do I want to collaborate with to increase the probability of success?	As discussed in Section 2, it is best to set up recurring communication among the larger program office Sustainment Review team, as the process requires significant time and effort and works best when collaboration is ingrained in the process. This provides recurring opportunities to request data from internal stakeholders who are critical to the cost estimate. The program office cost team should interface regularly with the independent cost team developing the ICE and external cost oversight group (i.e., Service Cost Center) to ensure alignment of expectations and assumptions.
How often should the Sustainment Review team collaborate?	Recurring weekly or biweekly interactions are vital to Sustainment Review success. Optimal periodicity and attendance will become apparent early in the Sustainment Review process for each Program depending on the status of the program's data, documentation, and available information on hand, which could fluctuate during execution.

5.4. Workload Planning

Every Sustainment Review is different depending on the defense system's previously conducted reviews, data quality, and documentation. Those items will determine how much support is needed. DoD CAPE (5000.73) [10] recommends a kick-off meeting 180 days prior to the Sustainment Review due date. It is best practice to begin at least 9 months in advance of the Sustainment Review. As stated in Section 4.4, Sustainment Reviews present the challenge of staffing to sufficient levels. It is best to assess the level of support necessary well in advance of the kickoff date. The Sustainment Review can be supported organically or through outside support. If outside support is used, then past experience should be a requirement. Lessons learned for mitigating workload planning challenges follow.

Table 7: Workload planning lessons-learned

Question/Issue	Lesson-Learned
How much support do I need?	Research what other defense programs required to conduct their Sustainment Reviews in terms of time and manpower. Additionally, conduct an up-front assessment of where the program stands on the basic ingredients of success, including but not limited to: access to baseline performance data; existing cost estimates; cost data; etc. Assess whether increased resources can be achieved organically. If not, reliance on external resources, whether government civilian or contractor, could help achieve the staffing necessary.
What type of support do I need?	Sustainment Reviews require multi-functional teams with diverse knowledge sets. Your program may require additional support for completing the Sustainment Review from various teams. For cost estimating requirements specifically, it makes sense to bring on cost analysts to help gather the information necessary to build and defend an estimate.
Why do I need to staff up for the Sustainment Review?	Sustainment Reviews are rigorous and time-consuming efforts that span almost an entire year and recur every five years. Additionally, the requirements span across all facets of the sustainment of a defense system. It is best to bring on support to divide and conquer tasks to ensure the Sustainment Review development is a successful process.

5.5. Estimating

Cost modeling can be a very complex process. It is best practice to set up the cost model with the foresight of future analyses in mind to address potential questions throughout the Sustainment Review process. It is crucial to fully understand both new and old data sources being leveraged in your LCCE for comparative analyses to assess cost growth findings. Due to Sustainment Reviews being a sprint this can be challenging without expert support. Lessons learned for mitigating estimating challenges follow.

Table 8: Estimating lessons-learned

Question/Issue	Lesson-Learned
How can the estimate effectively tie costs to system operational performance?	Best practice within the LCCE is to utilize RAM metrics to derive and/or support cost estimation. For example, cost analysts can use historical Mean Time Between Critical Failure (MTBCF) values, unique to system variants, to estimate the number of maintenance events or CASREPs required per year, which in turn can be used to estimate annual quantity of DLRs or cost of depot repairs. Additionally, cost analysts can incorporate operational hours or miles data into calculations of historic operations costs (e.g., consumable usage) per system, and then use this to estimate future requirements. These strategies ensure the LCCE can be leveraged to estimate how costs change when systems have worsened or improved reliability.
How can the estimate account for uncertainty of program status and support strategies decades in the future?	Decisions are being made in real-time by DoD senior leaders, which presents difficulty when estimating costs that reflect *current* operations and maintainability requirements of a weapon system. It is critical to develop ground rules and assumptions early in the Sustainment Review process for use in establishing the baseline for the estimate. Additionally, it is just as important to gain concurrence from the Sustainment Review stakeholders. The best way to get this buy-in is use quality data to support those ground rules and assumptions.
How can we ensure the cost estimate supports the overall findings of the Sustainment Review?	A critical element of a successful Sustainment Review is a unified message, marrying the major points of the product support strategy assessment with the results of the cost estimate. A disjointed story will lead to confusion among leadership about the state of the program and reduce credibility of the cost estimate. An important lesson-learned is that this unified message can also benefit the program by virtue of the cost estimate bolstering the program office's main conclusion that additional funding is needed to improve operational availability or ensure software maintenance is not falling behind. Alignment of message can be powerful – the cost estimate requirement for a 2022 Navy Sustainment Review revealed an OMN funding shortfall and provided the program office a strong basis to request a funding adjustment (which was subsequently approved).

Question/Issue	Lesson-Learned
How do we best prepare for easy updates to the LCCE in five years?	With the Sustainment Review requirement recurring every five years, it is helpful to ensure the LCCE and other data analysis and transformation tools are set up to reduce rework the next time. Some effective strategies to ensure model and tool utility for future reviews is to document meticulously. This includes data, approaches, assumptions, cross-checks, etc. It is also important to ensure the model is built to be adaptable to commonly changing information, such as updates to fielding profiles, additions of new system variants, or extensions of system fielded life. Additionally, building the estimate at the lowest, most detailed level of the work breakdown structure can make it more flexible to changing inputs or assumptions.

6. Conclusions

It is common practice for DoD acquisition professionals to prioritize acquisition over Operations and Sustainment. Acquisition is often the focus of major headlines in news articles because it is oriented to maturing and procuring a new capability that can be delivered to the warfighter, a compelling outcome. Additionally, it is clear senior DoD leaders and Congress have historically prioritized the acquisition given the visibility of the major milestones, each of which has significant financial and contracting implications.

However, the mission of acquisition professionals is to ensure the warfighter has the equipment and capabilities needed *and* to ensure that their equipment is operational. Therein lies why Sustainment Reviews are crucial to DoD and each Service. Much like milestone events ensure that capabilities are maturing in route to being fielded, Sustainment Reviews ensure product owners take the necessary actions to ensure their systems are operational, product support strategies are effectively executed, and costs are being managed. Sustainment Reviews are a tool to assess and identify issues, and proactively address these issues with senior leaders.

Cost analysts are essential members of the Sustainment Review process. They have three major responsibilities discussed in detail in the paper:

- Development of the CARD
- Development of the LCCE
- Reporting results and O&S cost growth against requirements

Cost analysts' primary responsibility is to develop realistic LCCEs that serve as an indicator for potential product support strategy vulnerabilities. Prior to development of the LCCE, they are responsible for translating the requirements and strategies from various documents (e.g., Acquisition Strategy and Plan, Test and Evaluation Management Plan (TEMP), and Life Cycle Sustainment Plan (LCSP)) into a CARD that serves as the Programmatic and Technical baseline for program undergoing the Review. It requires a significant amount of data collection and analysis, collaboration with internal and external stakeholders, reviews with senior leaders, and constant revisions as new information becomes available. It is the cost analyst's responsibility to ensure that every product support element applicable to a program is captured.

Once the LCCE is completed, a cost growth assessment is conducted comparing the current estimate against two baselines estimates. If the program has previously conducted a Sustainment Review, then the cost estimate from the previous Sustainment Review is used to quantify a Category A cost growth assessment. Should that program experience cost growth greater than 25%, then detailed findings must be provided either justifying the cost growth or a remediation plan to address the cost growth. A separate cost growth assessment is conducted against the Milestone B estimate and similar findings are reported if there is cost growth greater than 50%. Though Sustainment Reviews are still in their early stages, it has been apparent that most programs are experiencing cost growth that is justifiable. The justification is largely due to supply chain impacts from COVID, fuel costs, access to better data, increased fielded quantities or fielded duration of assets, or increased requirements of the systems.

As discussed earlier, new requirements of this magnitude are difficult to implement. The paper identifies five primary challenges observed while conducting Sustainment Reviews: scope definition, data collection, collaboration/coordination, workload planning, and estimating. Each are issues that occur during a program's acquisition phase; however, these issues can be exacerbated during the sustainment phase if a program office isn't sufficiently staffed. Each challenge has mitigation strategies that can be applied, but ultimate success depends on smart planning and knowledgeable personnel. The paper provides important lessons learned that are applicable to the primary challenges and based on the authors' first-hand experience conducting five Sustainment Reviews across different Services. As each Service evolves their processes and identifies new insights from their Sustainment Review experience and findings, it is reasonable to expect Sustainment Review requirements to continue to grow. While a daunting task, Sustainment Reviews are necessary to ensure that fielded systems remain operational,

and that costs are being adequately planned for and then managed. No matter how the process evolves, effective planning, support, and expertise will mitigate each challenge.

7. Appendix A: Resources

7.1. Completed Sustainment Reviews by Service

The table below lists all known programs, by service, which have completed Sustainment Reviews through FY2023. The FY2023 programs (denoted with an asterisk *) are scheduled (in-progress) and may be shifted after publication of this paper.

Table 9: Completed Sustainment Reviews by Service

Air Force	Army	Navy
▪ B-1 ▪ B-2 ▪ B-52 ▪ C-130J ▪ E-3 ▪ F-15E ▪ F-16 ▪ KC-135 ▪ MQ-9 Reaper	▪ TOW 2 Missile ▪ GMLRS ▪ M777A2 Towed Howitzer ▪ Hellfire Missile System ▪ MRAP ▪ WIN-T ▪ HIMARS ▪ Shadow RQ-7B ▪ Excalibur ▪ Shield & IFMC PATRIOT ▪ CROWS ▪ AVN Blackhawk Program ▪ TMC ▪ MQ-1C Gray Eagle ▪ HEMTT* ▪ PLS* ▪ AN/TPQ-53 (V)* ▪ FMTV* ▪ Stryker* ▪ M88A3 HERCULES* ▪ AN/PAS-13 (V) TWS* ▪ JAGM* ▪ Javelin* ▪ M109A7 SPH M992A3 CAT*	▪ Cooperative Engagement Capability (CEC) ▪ Tactical Tomahawk (TACTOM) ▪ Littoral Combat Ship (LCS) ▪ Navy Multiband Terminal (NMT) ▪ F/A-18E/F ▪ EA-18G ▪ T-45 Goshawk ▪ KC-130J ▪ AIM-9X* ▪ SSN-774* ▪ EPF* ▪ P-8A* ▪ H-60* ▪ MTVR* ▪ LPD-17* ▪ ESB*

7.2. Author Biographies

Alex Bonich is a Senior Associate who joined Technomics in February 2021. He currently supports the Army in cost estimating and analysis for Transportations Systems and the Robotic Combat Vehicle program, and has experience supporting the Army in the development of Life Cycle Cost Estimates across various vehicle programs. Alex graduated from the University of Michigan in 2019 with a B.S.E. in Mechanical Engineering.

Adam Kidwell is a Senior Associate at Technomics and has been with the company since February 2020. He currently provides cost support to the Navy within its Integrated Warfare Systems (IWS) PEO. He has prior experience designing aircraft parts for use in military flight simulators. Adam has a BS degree in Mechanical Engineering (2018) from the University of Maryland Baltimore County.

John Liss is a Lead Analyst who joined Technomics in October 2020. He has led and supported OSRs, Cost Estimate developments, and data collection improvements for the Program Management Transportation Systems (PM TS) office. Additionally, he supports TACOM Security Assistance Management Directorate (SAMD) and IWS A in dashboard creation efforts to visualize large data sets in easy formats to make decisions.

7.3. Acronyms, Initialisms & Abbreviations

Acronym	Definition
ACAT	Acquisition Category
AFCAA	Air Force Cost Analysis Agency
AFLC	Air Force Logistic Command
AFTOC	Air Force Total Ownership Cost
Ao	Operational Availability
AoA	Analysis of Alternatives
APUC	Average Procurement Unit Cost
APB	Acquisition Program Baseline
AVN	Aviation
BES	Budget Estimate Submission
BMO	Business Management Office
BS	Bachelor of Science
CAPE	Cost Assessment and Program Evaluation (Office of the Secretary of Defense)
CARD	Cost Analysis Requirements Description
CASREPS	Casualty Reports
CAT	Carrier, Ammunition, Tracked
CBO	Congressional Budget Office
CDRL	Contract Data Requirement List
CE	Cost Estimate
CEC	Cooperative Engagement Capability
CES	Cost Estimating Structure
COVID	Coronavirus Disease (COVID-19)
CROWS	Common Remotely Operated Weapon Station
CSDR	Cost and Software Data Reporting
CTAR	Counter Fire Target Acquisition Radar
DASA	Deputy Assistant Secretary of the Army
DASN	Deputy Assistant Secretary of the Navy
DoD	Department of Defense
DoDI	Department of Defense Instruction
EA	Electronic Attack
EPF	Expeditionary Fast Transport
ERP	Enterprise Resource Planning
ESB	Expeditionary Sea Base

EVAMOSC	Enterprise Visibility and Management of Operating and Support Costs
FMB	Deputy Assistant Secretary of the Navy Budget
FMTV	Family of Medium Tactical Vehicles
FRP	Full Rate Production
FRPD	Full Rate Production Decision (FRPD)
FTE	Full-time Equivalents
FY	Fiscal Year
GAO	US Government Accountability Office
GMLRS	Guided Multiple Launch Rocket System
HEMTT	Heavy Equipment Mobility Tactical Truck
HERCULES	Heavy Equipment Recovery Combat Utility Lift and Evacuation System
HIMARS	High Mobility Artillery Rocket System
ICE	Independent Cost Estimate
ICEAA	International Cost Estimating and Analysis Association
IFMC	Integrated Fires Mission Command
ILSC	Integrated Logistics Support Center
IOC	Initial Operational Capability
IPR	In-Process Reviews
IPT	Integrated Product Team
ISEA	In-Service Engineering Agent
IWS	Integrated Warfare Systems
JAGM	Joint Air to Ground Missile
LCC	Life Cycle Cost
LCCE	Life Cycle Cost Estimate
LCS	Littoral Combat Ship
LCSP	Life Cycle Sustainment Plan
LPD	Landing Platform Dock
MDAP	Major Defense Acquisition Program
MILDEP	Military Department
MIL-STD	Military Standard
MOA	Memorandum of Agreement
MRAP	Mine-Resistant Ambush Protected
MTBCF	Mean Time Between Critical Failure
MTVR	Medium Tactical Vehicle Replacement
NAVAIR	Naval Air Systems Command

NAVSEA	Naval Sea Systems Command
NAVSUP	Naval Supply Systems Command
NAVWAR	Naval Information Warfare Systems Command
NDA	Non-disclosure Agreement
NDAA	National Defense Authorization Act
NMT	Navy Multiband Terminal
O&S	Operations & Sustainment, or Operations & Support
OMN	Operation and Maintenance, Navy
OPTEMPO	Operations Tempo
OSD	Office of the Secretary of Defense
OSMIS	Operation & Support Management Information System
OSR	Operational Sustainment Review
PATRIOT	Phased Array Tracking to Intercept of Target
PAUC	Program Acquisition Unit Cost
PB	President's Budget
PEO	Program Executive Office
PLS	Palletized Loading System
PM TS	Program Management Transportation Systems
POE	Program Office Estimate
PSM	Product Support Manager
RAM	Reliability, Availability, Maintainability
RDT&E	Research, Development, Test & Evaluation
SAM	Sustainment Actions Memorandum
SAMD	Security Assistance Management Directorate
SAR	Selected Acquisition Report
SCC	Service Cost Center
SECDEF	Secretary of Defense
SEPM	Systems Engineering, Program Management
SPH	Self-Propelled Howitzer
SR	Sustainment Review
SSN	Nuclear-powered Attack Submarine
TACOM	Tank-Automotive and Armaments Command
TACTOM	Tactical Tomahawk
TEMP	Test & Evaluation Master Plan
TMC	Tactical Mission Command

TOW	Tube-launched, Optically-tracked, Wire-guided
TWS	Thermal Weapon Sight
URL	Uniform Resource Locator
US	United States
USC	United States Code
VAMOSC	Visibility and Management of Operation and Support Costs
WIN-T	Warfighter Information Network - Tactical

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