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Optimizing Aviation Life Support System Process Efficiency through Standardized Maintenance Practices within Intermediate- Level Fleet Readiness Centers

September 2026

LT Dylan J. Caparo, USN

Thesis Advisors: Dr. Ira A. Lewis, Associate Professor
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Naval Postgraduate School

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Prepared for the Naval Postgraduate School, Monterey, CA 93943

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ABSTRACT

Aviation life support systems (ALSS) represent a life-critical domain within naval aviation, yet components frequently exhibit a time to reliably replenish (TRR) variance greater than 1.0, signifying severe maintenance delays. The purpose of this research is to create a quantitative framework to identify the primary drivers contributing to these TRR overruns. Employing a mixed-methods approach, this study analyzed a 37-month dataset from February 2023 to February 2026, consisting of 2,888 Maintenance Action Forms (MAFs) from the Naval Aviation Logistics Command Management Information System (NALCOMIS) intermediate maintenance activity (IMA) at the Fleet Readiness Center Mid-Atlantic (FRCMA) detachment in Norfolk. The results indicate that inadequate supply chains (awaiting parts) and internal work center backlogs (awaiting maintenance) are the most significant bottlenecks across all analyzed parachute assemblies. The study concludes that systemic delays are fueled by a combination of supply chain constraints, internal process friction, and outdated administrative standards. To reduce TRR and enhance fleet readiness, this study recommends establishing data-driven pre-expended bins (PEB), re-baselining specific TRR task standards, and implementing a lean-inspired tiered workload management system.



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ABOUT THE AUTHOR

Lieutenant Dylan J. Caparo earned his commission in 2020 through the Naval Reserve Officers Training Corps (NROTC) program at Embry-Riddle Aeronautical University, where he graduated with a Bachelor of Science in Aeronautics.

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LIST OF ACRONYMS AND ABBREVIATIONS

81A	Parachute Shop
81B	Aviators Safety Equipment Shop
81C	Oxygen Regulator and Equipment Shop
A1	pre-induction screening
AD	additive manufacturing
ALIS	Autonomic Logistics Information System
ALSS	aviation life support system(s)
AMO	Assistant Maintenance Officer
ASD	Aviation Support Detachment
AWM	awaiting maintenance
AWP	awaiting parts
CADPAD	cartridge actuated devices and propellant actuated devices
CM	configuration management
COMNAVAIRFORINST	Commander, Naval Air Forces Instruction
CP	contractor parts
DECKPLATE	Decision Knowledge Programming for Logistics Analysis and Technical Evaluation
DLA	Defense Logistics Agency
DoD	Department of Defense
DoW	Department of War
FAME	F/A-18 Automated Maintenance Environment
FIFO	first-in-first-out
FRC	Fleet Readiness Center
FRCMA	Fleet Readiness Center Mid-Atlantic
GAO	Government Accountability Office
genAI	generative artificial intelligence
GRGB	Get Real, Get Better
I-Level	intermediate-level
IMA	intermediate maintenance activity
IRAC	interim rapid action changes
IW	in-work



JC	job complete
JCN	job control number
M2	lack of support equipment
M3	backlog of work center workload
M4	off-shift hours
M5	other-weather, operations condition, training
M6	awaiting intermediate-level maintenance
M8	awaiting other shops or maintenance actions
M9	awaiting maintenance funding
MAF	Maintenance Action Form
MBSE	model-based systems engineering
MCN	Maintenance Action Form Control Number
MCO	Material Control Officer
MMCO	Maintenance Material Control Officer
MOC	Maintenance Operations Center
NACES	Naval Aircrew Common Ejection Seat
NAE	Naval Aviation Enterprise
NALCOMIS	Naval Aviation Logistics Command Management Information System
NAMP	Naval Aviation Maintenance Program
NATEC	Naval Air Technical Data and Engineering Service Center
NAVAIR	Naval Air Systems Command
NAVSUP	Naval Supply Systems Command
NPS	Naval Postgraduate School
O-Level	organizational level
OOMA	Optimized Organizational Maintenance Activity
P2P	performance-to-plan
PEB	pre-expended bin
PR	Aircrew Survival Equipmentman
QAO	Quality Assurance Officer
RFI	ready-for-issue
ROI	return on investment
SE	support equipment



SME	subject matter expert
SOP	standard operating procedure
SysML	Systems Modeling Language
TAT	turnaround time
TRR	time to reliably replenish
TYCOM	Navy Type Command
VR	virtual reality
WUC	work unit code



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EXECUTIVE SUMMARY

Aviation Life Support Systems (ALSS) are the final link in the chain of aircrew survival during emergency situations. Despite the life-critical nature of this equipment including parachutes, oxygen regulators, and survival vests ALSS component repairs frequently exhibit a significant adverse time to reliably replenish (TRR). Currently, assets are breaking a 1.0 variance in active repair, reducing component availability, consuming valuable maintenance man-hours, and degrading overall operational readiness. While the Navy's strategic "Get Real, Get Better" (GRGB) initiative stresses the elimination of maintenance delays, ALSS challenges often go unexamined. The purpose of this research is to create a comprehensive, quantitative framework to identify and measure the primary drivers of TRR overruns in ALSS maintenance, moving beyond anecdotal evidence to provide actionable, data-driven recommendations.

This study employs a two-phase, mixed-methods approach focusing on the intermediate-level (I-Level) maintenance activity at Fleet Readiness Center Mid-Atlantic (FRCMA), Detachment Norfolk. The analysis extracted a 37-month historical dataset from the Naval Aviation Logistics Command Management Information System (NALCOMIS) intermediate maintenance activity (IMA) spanning February 2023 to February 2026. The scope zeroed in on 2,885 scheduled and unscheduled Maintenance Action Forms (MAFs) across six primary parachute assemblies within the Parachute Shop (81A) work center. TRR variance was calculated to identify the most delayed components, followed by a root cause diagnosis that deconstructed the top ten highest-TRR MAFs for each assembly by tracking the time spent in specific job status codes.

The analysis revealed that severe TRR variance is not uniform across all components but is heavily concentrated in specific systems and driven by systemic delays. Three primary categories of delay emerged:

- **Supply Chain Inefficiency:** Awaiting parts (AWP) is the single largest driver of delay across all components. For complex assets like the A/P22P-20 parachute, AWP accounted for 65% of total cycle downtime, with critical components averaging wait times of hundreds of days (e.g., 738 days for a bridle assembly). Even modern systems, like the A/P28S-



32 series, wait months for standard consumables, highlighting a purely reactive supply posture.

- **Internal Process Friction:** Internal inefficiency is the second major driver. A significant portion of the delay stems from components waiting in an administrative backlog (M3) or waiting for functioning support equipment (M2). For standard work, components frequently spent double their standard repair time just waiting for an available technician or test bench.
- **Administrative and Funding Bottlenecks:** Legacy and complex assets frequently fall victim to administrative friction. For instance, the NB-8 and NB-6 parachutes spent massive portions of their life cycle in awaiting funding (M9) statuses or pre-induction screening (A1), reflecting an inability to swiftly support low-volume or aging “orphan” systems.

The findings conclusively show that the ALSS maintenance system’s primary point of failure is its inadequate supply chain. However, solving supply issues alone is insufficient; a substantial and quantifiable level of inefficiency exists within the work center’s internal workflow and handling procedures. Ultimately, reducing TRR requires a multi-faceted approach that targets parts provisioning, internal resource allocation, and bureaucratic financial procedures simultaneously.

To directly address these bottlenecks and support Navy-wide readiness goals, the following recommendations are suggested:

- **Establish a Data-Driven Pre-Expended Bin (PEB):** Utilize historical demand data to formally justify and fund a local PEB at FRCMA for the highest-demand, long-lead-time items, decoupling daily maintenance from supply chain volatility.
- **Re-Baseline TRR Standards for Specific Actions:** Replace the current, unrealistic blanket 156-day TRR standard with unique, tailored metrics (e.g., assigning a 10-day TRR for a 448-day inspection or 3-day TRR for a functional check) to ensure accurate performance tracking.
- **Implement Lean-Inspired Tiered Workload Management:** Create a visual, prioritized tier system (e.g., Red, Yellow, Green tags based on parts availability) to minimize context switching, reduce M3 backlog, and increase production flow.
- **Develop Proactive Funding and Contract Agile Management:** Vet the top 20 most common, high-cost parts for funding requirements and pursue streamlined ordering processes with vendors to drastically reduce administrative and procurement lead times.
- **Enhance Support Equipment Readiness:** Establish formal preventative maintenance schedules and rapid response agreements to keep critical



support equipment (e.g., packing presses) operational, eliminating localized process halts.



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DISCLOSURES

In the interest of transparency and academic integrity, and with the explicit permission of my capstone advisor, Ira A. Lewis, this section discloses the use of generative artificial intelligence (genAI) tools during the research and writing process of this capstone applied project. Specifically, OpenAI's ChatGPT and Google Gemini were utilized. These specific tools were selected over traditional word-processing grammar checkers (such as Microsoft Editor) and standard search engines because their advanced natural language processing capabilities allowed for dynamic, conversational brainstorming and highly context-aware structural feedback that traditional software cannot provide. GenAI was utilized as an assistive tool in the following specific ways:

- **General Writing Assistance:** GenAI tools were employed to review, proofread, and refine the text to improve overall clarity and readability. Specific applications included correcting grammar, ensuring consistency in verb tenses (present and past), converting passive voice to active voice, and generating recommendations for transitional phrases to enhance the flow between paragraphs. Additionally, genAI assisted in formulating concise and descriptive headings, as well as titles for figures and tables.
- **Brainstorming Structure and Format:** GenAI was used to help conceptualize the overall organization of the document. It provided recommendations on how to logically structure chapter content and offered formatting strategies to optimize the layout and presentation of data within tables.
- **Brainstorming Content:** During the foundational phases of this project, genAI served as a brainstorming partner. It was utilized to help develop and refine research questions, identify potentially relevant concepts and studies for inclusion in the literature review and background sections, and suggest prospective areas for further research.

The use of genAI introduces inherent risks, including the potential for fabricated sources ("hallucinations"), algorithmic bias, and stylistic homogenization. To mitigate these risks, a rigorous quality assurance process was implemented. All core analyses, data interpretations, and final content decisions were conducted independently and remain entirely my own original work. Any literature, concepts, or studies suggested by genAI during the brainstorming phase were manually cross-referenced, retrieved, and verified against primary sources in academic databases prior to inclusion. The use of these tools



was strictly advisory, and all generated suggestions were critically evaluated and verified as necessary to ensure accuracy, originality, and alignment with the objectives of this capstone applied project.



I. INTRODUCTION

Aviation life support systems (ALSS) represent a unique and life-critical maintenance domain within naval aviation.¹ Unlike the repair of support equipment (SE) airframes or propulsion systems, ALSS maintenance focuses on equipment such as parachutes, oxygen regulators, and survival vests whose proper function is directly tied to aircrew survivability in emergency situations. The failure of this equipment carries immediate and potentially fatal consequences, making precision, documentation accuracy, and standardized workflow execution nonnegotiable requirements.

In the span of just one year, from late 2023 to late 2024, naval aviation experienced at least nine Class A flight mishaps, including catastrophic crashes, engine fires, hard landings, and runway departures (Naval Safety Command, 2024). “On May 28, 2024, an F-35B crashed near Albuquerque, NM; the pilot survived only by successfully ejecting from the aircraft” (Naval Safety Command, 2024, p. 46). This event, along with the numerous other mishaps where aircrew survived aircraft emergencies, serves as a stark reminder of the critical importance of ALSS. When an aircraft fails, ALSS is the final link in the chain of survival, and its function is the only thing standing between the pilot and a fatality.

Based on current operational experience on the Naval Station, Norfolk flight line, ALSS component repairs are exhibiting a significant negative time to reliably replenish (TRR), with assets breaking a 1.0 variance in active repair from the standard time prescribed by local procedures. This excess repair time is a direct observation of process bottlenecks that reduces component availability; these assets consume valuable maintenance man-hours and degrade overall operational readiness. In a domain where equipment failure has immediate and potentially fatal consequences, these delays represent an unacceptable introduction of risk.

Despite the high-risk nature of this work, the ALSS maintenance environment is characterized by significant systemic challenges that introduce inefficiency and risk.

¹ The author of this research possesses six years of direct professional experience in naval aviation (see Appendix A for a short biography demonstrating subject matter expertise).



These issues can arise from the use of fragmented, non-interoperable digital maintenance information systems. Technicians must navigate and manually reconcile data across multiple platforms, including the Optimized Organizational Maintenance Activity (OOMA) system, the Naval Aviation Logistics Command Management Information System (NALCOMIS) intermediate maintenance activity (IMA), Decision Knowledge Programming for Logistics Analysis and Technical Evaluation (DECKPLATE), and the specialized Cartridge Actuated Devices and Propellant Actuated Devices (CADPAD) system. This digital fragmentation forces technicians to perform manual, duplicative data reconciliation, creating administrative burdens and increasing the potential for human error in documentation.

TRR deviation can also stem from internal factors such as workflow execution, specifically procedural variation, or “drift,” which is common across maintenance activities, driven by ambiguous, narrative-heavy technical manuals that often lack sufficient visual aids for complex tasks. This ambiguity leads to inconsistent interpretation and an overreliance on local practices and “tribal knowledge” rather than strictly enforced, standardized procedures. This phenomenon, academically defined as the “normalization of deviance,” occurs when “people within an organization become so insensitive to deviant practice that it no longer feels wrong” (Price & Williams, 2018, p. 1). In high-risk environments like aviation maintenance, this slow, imperceptible acceptance of shortcuts and workarounds systematically erodes safety margins, often with disastrous consequences.

According to Grove (2025) in MECH Magazine, in late 2023, a single Aircrew Survival Equipmentman’s (PR’s) vigilance uncovered a fleet-wide safety crisis. A critical quality assurance check was being missed on thousands of LPU-37A/P life preservers due to improperly sealed inflation lobes. What began as a local finding quickly escalated into a fleet-wide issue, “The result of the discrepancy report determined this was not an isolated problem and affected nearly all the FRCs across the Navy” (Grove, 2025, p. 20). The recall ultimately impacted 17 different aircraft platforms, proving that a seemingly small procedural failure at the local level can have massive, enterprise-wide consequences. This incident is not an isolated failure but a clear symptom of a deeper, systemic problem within ALSS maintenance.



These systemic bottlenecks stand in direct opposition to the Navy’s highest-level strategic imperatives. The Navy’s “Get Real, Get Better” (GRGB) initiative is a “Navy-wide call to action that empowers leaders at all levels to embrace proven leadership and problem-solving practices to drive exceptional performance” (U.S. Navy, n.d.-a, p. 1). To execute this vision, the Navy employs the Performance-to-Plan (P2P) methodology, a structured framework designed to “clearly define performance gaps” and “remove execution barriers” using data-driven analysis (U.S. Navy, n.d.-b, p. 1). The persistence of known maintenance challenges within the ALSS community indicates a failure to apply these proven frameworks, allowing critical execution barriers to remain and performance gaps to go undefined until they reach a crisis point.

While government and academic studies have analyzed broader naval aviation sustainment challenges, no research has specifically isolated the ALSS community to examine its unique maintenance procedures and operational sustainment metrics. This lack of dedicated, integrated analysis prevents the Navy from fully understanding and correcting the root causes of inefficiency and risk within ALSS maintenance. This capstone applied project aims to address that gap.

A. RESEARCH OBJECTIVES AND QUESTIONS

The primary objective of this research is to create a comprehensive, quantitative framework to identify and measure the primary drivers of TRR overruns in ALSS maintenance. By analyzing historical maintenance data to isolate the key factors contributing to these delays, this study aims to move beyond anecdotal evidence and provide actionable, data-driven recommendations specifically designed to reduce TRR, improve maintenance predictability, and enhance overall fleet readiness. To achieve this objective, this capstone applied project is guided by the following primary and secondary research questions:

1. Primary

What are the primary drivers contributing to a TRR ratio greater than 1.0 for ALSS components?



2. Secondary

- What is the baseline TRR variance across different ALSS subsystems, and how does it correlate with ready-for-issue rates (RFI)?
- To what extent do NALCOMIS IMA data integrity issues contribute to this observed variance?
- Which specific factors (parts availability, support equipment, process inefficiencies) have the most significant impact on repair time?

B. METHODOLOGY

This study employs a two-phase, mixed-methods approach to first quantify and then explain the root causes of maintenance delays at Fleet Readiness Center Mid-Atlantic (FRCMA), Detachment Norfolk. This methodology was chosen to facilitate an in-depth extraction and statistical analysis of a 37-month historical dataset from NALCOMIS IMA. The TRR variance was calculated for each maintenance action using the established TRR man-hours versus the actual in-work maintenance man-hours to statistically identify which components exhibit the highest variance of TRR. Processes or other factors were then analyzed to determine what the most significant primary bottlenecks contribute to TRR overruns.

According to foundational research on qualitative methods, this approach is ideal for discovering “how things work” within complex organizational systems, which directly aligns with this capstone applied project’s goal of understanding the ALSS maintenance process as a whole (Stake, 2010). This approach enables the development of a rich, contextualized understanding of how work is actually performed versus how it is prescribed, allowing for a root cause analysis of workflow variation and systemic misalignments.

C. SCOPE AND LIMITATIONS

The scope of this research is focused specifically on the TRR variance across ALSS maintenance processes intermediate-level (I-Level) maintenance activity: FRCMA, Detachment Norfolk. The initial analysis identifies the TRR variance of six parachute assemblies, followed by an analysis of TRR drivers for a focused root cause investigation.



This study is constrained by the fidelity of historical NALCOMIS IMA data and limited in that it does not analyze manning, personnel distribution, or the formal training pipeline of PRs, although these factors are acknowledged as contributors to the broader maintenance environment. As noted in the literature, while retention and experience levels are critical factors in maintenance outcomes (Government Accountability Office [GAO], 2019b), they fall outside the direct methodological scope of this process-focused capstone applied project. Furthermore, the findings from a single Fleet Readiness Center (FRC) detachment may not be generalizable to all I-Level naval aviation activities without further study, but they serve to build a foundational model for understanding these systemic issues across the enterprise.

D. PROJECT ORGANIZATION

This study is organized into six chapters:

- **Chapter I** provides an introduction to the research problem, outlines the research objectives and questions, describes the methodology, and defines the scope and limitations.
- **Chapter II** provides a detailed background of the ALSS maintenance environment and articulates the rationale for this research by identifying specific, unaddressed gaps in the existing literature.
- **Chapter III** presents a literature review covering governing maintenance policies, information systems, workflow standardization, human error, and adjacent modernization efforts in the Department of War (DoW) and civilian industry.
- **Chapter IV** details the quantitative data analysis used to identify and explain maintenance bottlenecks.
- **Chapter V** presents and discusses the findings from the analysis.
- **Chapter VI** provides conclusions, recommendations, and areas of future study to reduce TRR within the ALSS community.



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II. BACKGROUND

ALSS maintenance is a highly specialized and distinct discipline within the Naval Aviation Enterprise (NAE), with exclusive focus on the inspection, repair, and certification of life-critical equipment used directly by aircrews. The Naval Aviation Maintenance Program (NAMP) officially defines ALSS as “those items of equipment and clothing needed to allow aircrew members and aircraft passengers to function within all parameters of the flight environment, safely egress from disabled aircraft and descend/ascend to the surface, and survive on land and water, and interface with rescue forces” (Commander, Naval Air Forces, 2024, para. 10.40.2.2). This broad scope includes everything from flight helmets and oxygen systems used during normal operations to parachutes, life rafts, and survival radios critical for post-mishap survival. This equipment includes, but is not limited to, parachute assemblies, dry suits, oxygen masks and regulators, survival vests, and emergency signaling devices. Due to the direct and immediate impact of this equipment on human survival, ALSS maintenance is governed by its own set of exceptionally stringent technical publications, safety requirements, and serialized equipment tracking systems.

The timely and reliable replenishment of this ALSS equipment is paramount, measured by the TRR, which is an indicator of the health and efficiency of the activities’ maintenance processes. All TRR data is pulled from NALCOMIS IMA; as the component works through maintenance, a timer is started from induction and ends at sign-off. A TRR ratio greater than 1.0 signifies that more time is being spent on maintenance than authorized, signaling the presence of bottlenecks. These bottlenecks whether from parts delays, inefficient workflows, or administrative friction have a cascading effect on readiness, which tie up technicians, occupy limited bench space, and keep life-saving equipment out of the hands of the warfighter. Every hour of TRR overrun is an hour that a critical component is not available, directly impacting the Navy’s ability to generate combat-ready aircraft and aircrew.

The execution of ALSS maintenance relies on a complex and often cumbersome interplay of policy and digital maintenance information systems. The overarching



governing policy is the NAMP or the Commander, Naval Air Forces Instruction (COMNAVAIRFORINST) 4790.2 series of publications, which provides baseline procedures and responsibilities for all naval aviation maintenance (Commander, Naval Air Forces, 2024). However, at the deck-plate level, technicians interact with a collection of fragmented, non-interoperable maintenance information systems to document their work. These systems include:

- **NALCOMIS IMA and OOMA:** The primary management information system, composed of seven subsystems (Maintenance, Material, Flight, Platform Software Interface, Configuration Management (CM)/Logs and Records, Ad Hoc, and Personnel). According to Commander, Naval Air Forces (2024), “the three objectives of NALCOMIS are: 1) Increase aircraft readiness by providing timely and accurate information required to manage maintenance and supply operations; 2) Reduce administrative burden; and 3) Improve the quality of maintenance and supply data” (para. 13.1.1.1).
- **DECKPLATE:** A web-based portal used for official record inventory of Navy and Marine-Corps aircraft, which provides current and historical data on inventory, location, status, and service of aircraft for management, planning, and budgeting processes (Commander, Naval Air Forces, 2024, para. 9.1.1).
- **CADPAD:** A specialized, standalone system for managing serialized, life-limited components such as propellants, cartridges, and other pyrotechnic devices (Commander, Naval Air Forces, 2024, para. 10.15.3.7 Note 2).

The lack of integration between these systems is a foundational challenge. A technician may need to consult a technical manual in Naval Air Technical Data and Engineering Service Center (NATEC), execute a maintenance action documented in NALCOMIS IMA, and separately update a component’s history in DECKPLATE or CADPAD. This fragmentation extends beyond just digital systems to the paper-based documentation itself. Checklists may not align with primary technical manuals, creating dangerous procedural gaps.

For example, even though not ALSS-specific, a recent incident involving a utility crane tipping over aboard the USS George H. W. Bush (CVN 77) was caused because the preoperational checklist failed to mention using tie-down chains, even though the main maintenance publication required it. The investigation prompted the exact question that plagues maintainers: “If the maintenance publication says that, why didn’t the pre-



operational checklist say it as well?” (Heo, 2023, p. 22). This discrepancy between two sets of official instructions highlights a critical failure point in the maintenance process, where the tools designed to simplify a task actually introduce risk by omitting vital information.

The high-stakes nature of this work is explicitly codified in the NAMP itself, which contains a stark warning to all personnel:

WARNING: ALSS AND EGRESS SYSTEMS EXPLOSIVE COMPONENTS AND OXYGEN EQUIPMENT ARE A RISK TO PERSONNEL IF NOT USED AS INTENDED OR CORRECTLY HANDLED. IMPROPER MAINTENANCE PROCEDURES, IMPROPER USE, AND LACK OF ATTENTION TO DETAIL WHEN WORKING ON AND AROUND THESE SYSTEMS CAN RESULT IN INJURY OR DEATH. (Commander, Naval Air Forces, 2024, para. 10.40.2.4)

This official warning highlights that, unlike other maintenance domains where a failure might lead to degraded equipment performance, a failure in ALSS maintenance can directly lead to catastrophic loss of life.

The need to identify and eliminate maintenance bottlenecks within the NAE is not merely an issue of efficiency but a core component of the Navy’s strategic preparation for potential conflict. Chief of Naval Operations (CNO) Admiral Lisa Franchetti established an urgent, fleet-wide objective to have 80% of the Navy’s ships and aircraft ready to surge on short notice by January 1, 2027. This “stretch goal,” directly tied to China’s stated military readiness timeline, explicitly targets the elimination of “ship, submarine and aircraft maintenance delays” as a primary line of effort to ready the force for combat (Olay, 2024, para. 7). The CNO’s focus is so intense that she keeps a clock in her office counting down the days to 2027, stating, “There is no time to waste” (Olay, 2024, para. 17). This top-down strategic imperative provides a powerful and time-sensitive justification for any research aimed at identifying and removing barriers to fleet readiness.

The CNO’s model for achieving this goal is the successful F/A-18 readiness turnaround, where “data-driven, daily drumbeats of accountability” raised mission-capable rates from 50% to a sustained 80% (Olay, 2024, para 11). This proven



methodology, known as P2P, demonstrates that systemic maintenance challenges can be overcome through structured, data-informed problem-solving. This strategic context provides a powerful rationale for this capstone applied project: if the Navy is to meet its 2027 surge readiness goal, the same rigorous, data-driven approach that addressed F/A-18 readiness must be applied to all critical components of the warfighting ecosystem, including the often-overlooked domain of ALSS.

This study is founded upon several critical and unaddressed gaps identified in the existing body of literature on naval aviation maintenance and sustainment. While numerous government reports and academic theses have explored overarching sustainment challenges, they have consistently overlooked the unique ALSS ecosystem, leaving its specific problems unexamined and unsolved.

First, there is a fundamental lack of ALSS-specific maintenance research. No major academic or government publication directly examines ALSS processes, workflows, or system alignment in an integrated manner. For instance, a recent comprehensive Government Accountability Office (GAO) report on naval aviation sustainment challenges stated that its scope was a “case study approach focused on unit-level maintenance” for a sample of aircraft that included the “F/A-18E/F fighter, the P-8A anti-submarine, C-130T cargo plane, and the KC-130T air refueler” (GAO, 2022, p. 48). The report’s complete omission of any analysis related to the life support equipment associated with these platforms highlights the lack of focus on this critical area within high-level oversight. While other studies focus on mission capable rates (GAO, 2021) or engine performance (Dori, 2022), they do not address the distinct challenges of maintaining survival equipment, where the problems concern the integrity of life-saving gear, not just aircraft availability. This oversight in major government reporting proves that ALSS remains a significant, unexamined gap in naval sustainment analysis.

Second, there has been no formal evaluation of ALSS maintenance systems and their impact on TRR. Despite widespread documentation of digital fragmentation as a systemic problem in naval aviation (GAO, 2022), no study has explored how this problem specifically impacts ALSS technicians. These technicians must reconcile



multiple specialized systems like CADPAD with general-purpose systems like NALCOMIS, a unique burden not faced by most other maintenance ratings.

Third, while workflow variation is a known issue at FRCs (McKernan & Herrmann, 2008), there has been no dedicated study of procedural drift within ALSS. The LPU-37A/P incident underscores the danger of this research gap. The after-action report in *MECH Magazine* poses the exact question that validates this capstone applied project: “How did an established system of checks and balances not catch a potentially life-threatening situation across an entire service until months, perhaps years later?” The article concludes that the failure represents “a trend of lack of reporting and procedural non-compliance highlighting the dangers of the ‘it’s always been done this way’ mentality” (Grove, 2025, p. 21). This confirms that procedural drift in ALSS is not a theoretical risk but an active, present danger that remains critically under-researched, justifying the need for this study. This is a major oversight that threatens the safety of ALSS tasks that are governed by dense, narrative-heavy manuals, which are highly susceptible to procedural drift, where local techniques supplant standardized procedures. In a domain where a misplaced stitch or an incorrectly packed component can be fatal, understanding and mitigating this variation is critically important.

Fourth, external factors have a major influence on ALSS maintenance workflow, mainly associated with the vast and complex defense supply chain. The timely replenishment of parts and materials relies on a network of organizations, including the Defense Logistics Agency (DLA), Aviation Support Detachment (ASD), and private commercial vendors operating under government contracts. When a technician identifies a need for a part that is not available in the local pre-expended bin, a requisition is initiated, triggering a process that is subject to its own set of potential bottlenecks. These can include contractual issues with suppliers, manufacturing lead times, government funding, transportation delays, or challenges in forecasting demand for low-volume, high-consequence components. Therefore, a significant portion of the total TRR for any given component can be consumed before the technician is ever able to begin the hands-on repair. This external “wait time” is a foundational element of the overall maintenance environment and a key factor of fleet readiness.



While government reports have examined broad sustainment challenges and aircraft availability, they have not delved into the component-level repair cycles that are the foundation of that availability. GAO reports on naval aviation sustainment have focused on aircraft mission-capable rates without analyzing the TRR of the life support equipment associated with those platforms (GAO, 2022). This oversight leaves a significant gap in the Navy's understanding of its own readiness challenges. This research is necessary to fill that gap by providing a data-driven diagnosis of the bottlenecks, measured through TRR, within the ALSS maintenance environment.



III. LITERATURE REVIEW

ALSS are a critical but often under examined component of naval aviation sustainment, directly tied to aircrew survivability in both routine operations and emergency situations. Unlike other naval aviation maintenance domains such as propulsion, avionics, or structural repair, ALSS tasks involve life-saving equipment whose failure carries immediate and potentially fatal consequences. This distinction makes ALSS an area where precision, documentation accuracy, and standardized workflow execution are nonnegotiable requirements. Despite this, ALSS often encounter high variances of TRR on components within multiple sectors of the NAE, presenting unique challenges for standardization, compliance, and modernization.

The NAMP provides the governing structure for ALSS maintenance, prescribing baseline procedures, documentation requirements, qualification standards, and inspection intervals. ALSS technicians operate under a collection of highly specialized technical manuals including the NAVAIR 13-1-6 series for parachute rigging, survival equipment, oxygen components, aircrew protective equipment, and flotation systems, each containing detailed, step-by-step procedural guidance intended to reduce variation and ensure safety. However, many of these manuals present complex tasks through narrative-heavy descriptions with confusing visual aids and often vague descriptions, resulting in inconsistent interpretation and uneven execution across maintenance activities.

Existing literature on aviation maintenance processes is extensive, but nearly all of it focuses on aircraft availability, depot operations, supply chain planning, or manpower modeling. ALSS, despite its operational importance, has received little direct academic or analytical attention. As a result, the Navy lacks a clear understanding of whether current ALSS maintenance policies, digital information systems, and workflows function cohesively or whether they unintentionally allow variation, inefficiency, or increased human-error risk.

The goal is to demonstrate that while the Navy has a clear mandate for data-driven improvement, a critical research gap exists in the application of formal process analysis to ALSS maintenance. Specifically, this review found no study that has used



TRR as a performance indicator to quantitatively diagnose maintenance bottlenecks. This chapter builds the academic foundation for this study’s central argument: that analyzing and reducing TRR is a direct and necessary application of both Navy doctrine and increasing fleet readiness.

This literature review synthesizes research across core themes that inform the modernization of ALSS maintenance: (1) governing maintenance policy, (2) maintenance information systems and digital integration, (3) workflow standardization, (4) supply chain performance, (5) human-error pathways and documentation clarity, (6) adjacent modernization domains, and (7) remaining gaps in the literature. Together, these themes set the foundation for understanding ALSS within the broader context of naval aviation sustainment and highlight the need for an integrated policy system–workflow modernization approach.

A. GOVERNING MAINTENANCE POLICY FRAMEWORKS

The NAMP establishes the foundation for maintenance standardization, inspection rigor, and compliance across naval aviation. “The Naval Aviation Maintenance Program (NAMP) establishes the foundational policy for all naval aviation maintenance activities directs maintenance policies, procedures, and responsibilities at all levels of maintenance throughout naval aviation” (Commander, Naval Air Forces, 2024, p. 1-1). ALSS maintenance falls under the same overarching governance structure but carries unique execution requirements driven by aircrew survivability. In principle, the NAMP is designed to eliminate variation; in practice, however, execution varies significantly across the fleet due to organizational culture, local practices, differing interpretations of technical manuals, and uneven supervisory emphasis.

GAO reporting demonstrates that even well-designed aviation maintenance policy often suffers from inconsistent execution. The GAO (2020) highlighted systemic issues with documentation accuracy, data integrity, and compliance oversight in naval aviation maintenance processes, finding that “standards are not always applied uniformly across locations,” which leads to variation in maintenance performance. In return, aircraft readiness is impacted:



GAO examined 46 types of aircraft and found that only three met their annual mission capable goals in a majority of the years for fiscal years 2011 through 2019 and 24 did not meet their annual mission capable goals in any fiscal year. (GAO, 2020, p. 1)

Although the GAO does not evaluate ALSS separately from aircraft systems, the documented issues directly parallel known ALSS challenges, particularly the lack of systematic enforcement of policy requirements and inconsistent interpretation of technical publications.

Technical publication clarity plays a major role in policy execution. ALSS manuals, especially the 13-1-6 series, contain detailed procedural instructions but rely heavily on vague narrative text accompanied by confusing diagrams or visual sequencing. When instructions are ambiguous or overly textual, technicians fill gaps through local practices, thereby creating procedural drift. Scholarly literature on maintenance policy execution shows that such ambiguity contributes to inconsistent adherence to standardized procedures and encourages the development of “tribal knowledge” alternatives that diverge from published requirements. This phenomenon has been widely observed in parachute rigging, survival vest assembly, and flotation device inspection. A Naval Postgraduate School (NPS) thesis examining budget and performance variance at the Naval Aviation Depot at North Island found significant discrepancies between planned and actual maintenance outcomes despite shared policy guidance:

The findings from the variance analyses indicate that factors creating the most significant impact to the FRCSW’s operating results are material sales net loss, materials expense variance, and the quantity variances. (Curran & Schimpff, 2008, p. 41)

This shows that variance exists in multiple facets of the NAE and can have negative impacts on readiness.

NPS theses provide valuable insight into why maintenance policy often fails to translate cleanly into standardized execution. McKernan and Herrmann (2008) found, “Some in the fleet may see it as the FRC not being competent enough to perform a modification installation” (p. 43) due to discrepancies between policy intent and practical execution at FRCs. These discrepancies often stem from inconsistent supervisory practices, uneven training, and unclear technical directives. Sacco and Lovell (2006)



similarly documented how organizational change during the creation of FRC AIRSpeed program produced uneven adoption of standardized processes due to cultural differences and communication gaps: “They do not have access to or have not been included in either the planning or dissemination of information regarding the FRC implementation” (p. 69). Curran and Schimpff (2008) reinforced this connection, demonstrating that workload pressures and supervisory variation influence how policy is executed in practice. Overall, the literature indicates that ALSS governing policy is robust in theory but uneven in execution, creating procedural variation due to documentation clarity challenges, reliance on human interpretation, and insufficient integration.

B. MODERNIZATION OF MAINTENANCE INFORMATION SYSTEMS

Digital integration remains one of the most persistent challenges across naval aviation maintenance, and ALSS is disproportionately affected due to its reliance on fragmented, non-interoperable systems. Currently, ALSS technicians must interact with multiple platforms including DECKPLATE, CADPAD, and NALCOMIS each designed for separate purposes and containing inconsistent fields, logic structures, or data validation rules. This forces technicians to manually reconcile inspection records, serialized component life-limits, configuration data, and quality assurance entries across systems that do not communicate or inefficiently communicate with each other.

In most cases, errors in the information systems require manual rectification of equipment records, resulting in a workflow where technicians must validate parallel records while navigating three or more separate logics. This fragmentation not only increases administrative workload but also introduces multiple human-error entry points, especially during cross-checking between serialized equipment history and technical publication requirements. For ALSS, where life-saving equipment must be tracked precisely, digital misalignment creates a credibility gap between documented configuration and actual equipment status.

GAO reports underscore these issues at the enterprise level. The GAO (2022) highlighted that the Navy’s current digital sustainment systems lack interoperability, resulting in incomplete maintenance histories, inconsistent documentation, and difficulty aggregating readiness data across platforms:



Despite spending billions of dollars annually, the Air Force and Navy have struggled for years to maintain their aircraft due to the age of their fleets, a lack of parts, maintenance delays, and other problems. By the Air Force and Navy's own measures, aircraft readiness has worsened since fiscal year 2015. (GAO, 2022, p. 1)

The GAO (2025) similarly noted that operation and maintenance decisions are often made without fully integrated, high-quality data:

The military services generally haven't met mission capable rate goals for tactical aircraft for several years. Our prior work attributes this to numerous factors, such as aging aircraft and maintenance challenges. (GAO, 2025, p. 2)

Although these reports focus broadly on aircraft maintenance and depot management, their findings mirror the digital fragmentation experienced in ALSS, where the absence of a unified maintenance system undermines the execution of standardized processes.

Modern systems such as F-35 Joint Strike Fighter, Autonomic Logistics Information System (ALIS), the improved F/A-18 E/F Super Hornet and EA-18G Growler, and F/A-18 Automated Maintenance Environment (FAME) demonstrate what integrated maintenance could look like. These systems, though not applied to ALSS, provide a benchmark for digital modernization, offering features like automated task sequencing, real-time data validation, and digitally enforced workflows. Their design principles align with Model-Based Systems Engineering (MBSE) and Systems Modeling Language (SysML) approaches that offer an improved pathway toward digital modernization by creating unified models that connect engineering, logistics, and maintenance perspectives. Elakramine et al. (2022) argued that aviation maintenance still relies on outdated data-management systems, proposing the adoption of MBSE and SysML to improve process traceability:

Literature shows that human error is a common practice due to the improper use of maintenance documentation and procedure in the aviation system. The proposed modeling approach would help in eliminating this challenge by providing a more updated maintenance record of the aircraft system. (Elakramine et al., 2022, p. 12)



These frameworks enable the creation of shared, unified digital architectures (Elakramine et al., 2022) that eliminate ambiguity in system behavior and improve traceability capabilities that ALSS systems currently lack.

ALSS digital fragmentation is not an isolated issue; it is a manifestation of enterprise-wide sustainment system gaps that consistently acts as a barrier to standardized maintenance execution. Yet ALSS, unlike larger aircraft systems, lacks modernization investment, leaving technicians to compensate through manual reconciliation and local workarounds. Without digital modernization, and specifically system interoperability, ALSS cannot achieve the level of workflow standardization, documentation accuracy, or policy compliance that naval aviation requires.

C. WORKFLOW STANDARDIZATION, PROCESS VARIATION, AND MAINTENANCE EFFICIENCY

Workflow variation represents one of the most significant and well-documented challenges across aviation maintenance, and ALSS magnifies this challenge due to the sheer volume, complexity, and sensitivity of its life-saving support equipment. Despite the existence of standardized technical publications, local job aids, shop layouts, supervisory expectations, and technician training pipelines, they all contribute to variation in how ALSS maintenance is performed from one location to another. Examples such as differing flotation device assembly sequences, alternate testing procedures, and variation in RFI final quality assurance checks reflect the reality that ALSS workflows are often shaped more by local practice than by uniform interpretation of the 13-series technical manuals. Even minor deviations (swapping inspection order steps) can mask defects, disrupt inspection sequencing logic, or create unintentional risk pathways. These deviations accumulate over time, generating what GAO studies refer to as “procedural drift.”

The GAO (2007) specifically identified inconsistent process execution, decentralized interpretation of policy, and reliance on non-standardized local practices as contributors to variation in aviation maintenance outcomes. To combat the rising costs of I-Level and depot-level repairs, the Department of Defense (DoD) issued an organizational restructuring and policy changes:



The 2005 Base Realignment and Closure (BRAC) recommendation to establish fleet readiness centers was expected to yield more savings than any other of the 2005 BRAC recommendations. To achieve these savings the Navy plans to integrate civilian depot personnel to complete some repairs at intermediate maintenance departments to reduce aviation maintenance costs. (GAO, 2007, p. 1)

Although the report does not address ALSS directly, the causal mechanisms it identifies in unclear guidance, uneven supervisory oversight, and lack of digital enforcement are directly applicable to ALSS conditions. These findings imply that ALSS, as a subset of the broader maintenance enterprise, is likely subject to the same sources of process variation and inefficiency.

Within ALSS maintenance, workflow variation can arise from differences in how Navy Type Command (TYCOM) standard operating procedures interpret technical manuals, how local supply chains manage survival equipment consumable parts, and how quality assurance personnel evaluate documentation and material condition. The existence of multiple cross-referenced technical documentation for similar tasks imparts areas of interpretation as they are owned, edited, and controlled by different activities. A specific example between the operation-level (O-Level) CMV-22B ALSS publication and the I-Level called for the “removal” of the oxygen hose end cap. This was interpreted differently at the O-Level and I-Level, leading to interim rapid action changes (IRAC) for all publications. “Removed” was interpreted by some as throwing away the part, and others retained it if needed. This example demonstrates a real-world scenario where ambiguous technical documentation, inconsistent job aids, and differing interpretations between O-Level and I-Level maintenance activities produced enterprise-wide confusion.

D. IMPACT OF SUPPLY CHAIN PERFORMANCE ON MAINTENANCE

External supply chain performance is a prevailing factor in overall military maintenance readiness. The DoW’s supply chain is one of the most complex logistical operations in the world, the GAO (2025) highlighted that “the Department of Defense relies on a global network of over 200,000 suppliers to produce weapons, as well as noncombat goods like batteries and manufacturing equipment” (p. 1). Foundational literature in supply chain management, such as the work by Mark Christopher (2016) on



logistics and supply chain management, emphasizes that system responsiveness and agility are paramount; in some cases, it is more important than long-term planning. In order to have agility, the responsiveness of the organization depends on its proximity to the customer, particularly in environments with high demand uncertainty. By having agility and responsiveness, the supply chain can meet the precise needs of the customer in a shorter amount of time (Christopher, 2016, p. 23).

GAO reports have frequently investigated DoW supply chain issues, citing problems ranging from inaccurate demand forecasting to parts obsolescence. A real world example involves the F-35 advanced fighter jet program:

The U.S. Air Force, Marine Corps, and Navy share a pool of spare parts with partners around the world. But shortages, repair backlogs, and mismatched parts are keeping F-35s on the ground. For example, F-35 aircraft were unable to fly nearly 30% of the time from May through November 2018 because they didn't have the parts they needed. (GAO, 2019a, para 2.)

Furthermore, research in military-specific logistics has explored the tension between cost-saving “just-in-time” inventory policies against the idea that the United States needs the resilience required for national security, often advocating for a more robust “just-in-case” posture for critical components. *Just-in-time* policies result in “reduced inventory costs, shorter lead times, and improved productivity for buying organizations” (Kros et al., 2006, p. 227), while *just-in-case*

is the idea of stockpiling supplies ‘just in case’ we need them. It involves holding large inventories of materials and finished goods at various points in the supply chain to buffer against potential disruptions. (Marvin & Simerly, 2025, para. 4)

These sources confirm that supply delays are systemic, well-documented processes and problems that can directly affect metrics like TRR. Even though these are external factors to an FRC, bottlenecks may still occur from the causation of actions within the activity. If they can be identified and analyzed, internal maintenance processes can be improved to improve TRR and overall readiness of the fleet.



E. HUMAN ERROR, DOCUMENTATION CLARITY, AND MAINTENANCE RISK

Human error remains a persistent and widely studied contributor to aviation maintenance mishaps, and ALSS demonstrates many of the conditions the literature identifies as high-risk. Because ALSS tasks often involve precise, sequenced actions such as parachute bridle routing, CO₂ bottle installation, oxygen regulator testing, and one-time-use equipment preparation, the clarity and structure of technical documentation directly influence error likelihood. When manuals rely heavily on narrative descriptions rather than diagrams or step-by-step visuals, technicians must mentally simulate complex tasks, increasing cognitive load and the potential for misinterpretation.

Broader analyses of aviation maintenance risk observe that many mishaps and near-misses arise from maintenance actions that technically followed procedure but did so in ways not fully anticipated by the documentation authors. Marais and Robichaud (2012) identified maintenance error as a recurring causal factor in naval aviation mishaps:

We found for example that maintenance-related accidents are approximately 6.5 times more likely to be fatal than accidents in general, and that when fatalities do occur, maintenance accidents result in approximately 3.6 times more fatalities on average. (Marais and Robichaud, 2012, p. 7)

Their work established that maintenance errors are frequently systemic, not individual occurrences but arising from documentation design, conflicting instructions, and organizational constraints rather than technician negligence. This aligns directly with issues present in NAVAIR's 13-series publications, where dense paragraphs, limited diagrams, and ambiguous sequencing leave room for local interpretation.

Studies demonstrate that ambiguity in technical publications is a primary antecedent of human error, particularly when equipment complexity is high and error tolerance is low. Morales (2025) highlighted that

many next-generation platforms are marketed as easier to maintain, yet they introduce new demands in software integration, diagnostics, and digital systems. The U.S. Air Force has not fully accounted for these demands and continues to rely on workforce structures that do not reflect the complexity of modern systems. (Morales, 2025, p. 8)



Aviation and industrial maintenance research consistently show that clear, visual task representations significantly reduce error rates by providing externalized cognition (Diaz Alfaro et al., 2025) reducing reliance on working memory and subjective interpretation. Chiu and Hsieh (2016) emphasized that unclear or nonstandard procedures elevate human-error probability during complex maintenance tasks:

Prior to the maintenance work the operators had already interpreted and planned the work process well, but errors occurred in the execution stage; this type of error did not involve the judgment ability of the operators, which means that the right intention was incorrectly carried out. (Chiu and Hsieh, 2016, para. 22)

Reducing ambiguity and improving visualization would not only strengthen compliance with published procedures but also reduce the systemic factors that give rise to human-error pathways in the ALSS domain.

F. ADJACENT MODERNIZATION AND INTEGRATION

While direct literature on ALSS modernization is sparse, adjacent aviation maintenance domains offer useful insight into potential modernization pathways. Virtual reality (VR) training and blockchain technologies for serialized item tracking have demonstrated measurable benefits in comparable maintenance environments. These findings help outline what future ALSS modernization could resemble, even if such changes are currently outside the program's immediate adoption timeline.

Emerging research on immersive training technologies, such as VR, explores how advanced tools can improve maintainer understanding of complex tasks. Matthews (2023) found that VR-based instruction can improve knowledge retention and task fidelity among aviation maintainers. Technicians trained with visualization tools demonstrated higher comprehension and fewer procedural deviations during complex tasks:

There are benefits to the use of virtual technology for maintenance training. Virtual training in blended learning can help break down the lack of training barriers. Blended learning in classroom training, laboratory training utilizing virtual reality technology, and training with the actual equipment to reinforce performance actions. (Matthews, 2023, p. 72)



VR has repeatedly shown improvements in task retention, comprehension, and accuracy for complex mechanical tasks. Although ALSS has not adopted VR training, the parallels are clear: tasks such as parachute packing, emergency oxygen system assembly, or seat survival kit packing could all benefit from immersive visualization. While this capstone applied project does not directly address training system design, such work highlights additional opportunities for future ALSS research, particularly where digital tools can reinforce standardized procedures.

Blockchain and related technologies offer conceptual models for improving the integrity of maintenance records and equipment histories. Research on blockchain enabled maintenance records proposes immutable, distributed ledgers as a mechanism for improving the integrity and auditability of maintenance actions across the aircraft life cycle. Andrei et al. (2021) demonstrated that blockchain technology could enhance maintenance record traceability and transparency, yet its application to ALSS remains unexplored:

Blockchain is a distributed database among the members of a private or public network. There is not a central authority responsible for data manipulation. Any data transaction is carried out based on a consensus protocol which is previously accepted by all participants. It results in a secure digital ledger composed of endless numbers of interconnected blocks. Each block is linked with the previous one by a cryptographic hash, resulting into a reliable and chronological chain of records. Resulted database is immutable, that means it cannot be reversed or altered. (Andrei et al., 2021, p. 2)

Blockchain offers immutable recordkeeping, ideal for serialized equipment like parachute canopies, oxygen regulators, and one-time-use devices. Studies in adjacent sustainment domains demonstrate that blockchain reduces administrative burden, enhances auditability, and ensures configuration management accuracy. While this technology is not currently implemented in naval aviation, its conceptual relevance to ALSS is strong, particularly given ALSS's reliance on strict inspection intervals and serialized tracking.



G. GAPS IN THE LITERATURE RELATED TO AVIATION LIFE SUPPORT SYSTEMS

Despite the breadth of research on naval aviation sustainment, several critical gaps remain regarding ALSS maintenance, its maintenance information systems, and its workflow execution. These gaps collectively demonstrate why ALSS requires focused study and why existing literature is insufficient to explain or address the variation and inefficiencies occurring within FRCs.

1. Lack of Maintenance Research

No academic or government publication directly examines ALSS processes, workflows, documentation clarity, or system alignment. While some studies analyze broader aviation sustainment challenges (GAO, 2020), none isolate ALSS as its own maintenance ecosystem. This is a fundamental gap because ALSS is governed by its own technical publications, safety requirements, and serialized tracking systems, distinct from other aviation maintenance tasks.

2. No Evaluation of Information Systems

While documentation of significant issues within digital maintenance information systems across naval aviation exist, no study evaluates ALSS's use of NALCOMIS, DECKPLATE, and CADPAD. This is a major omission given that ALSS technicians must reconcile multiple systems manually. GAO (2022, 2024) studies demonstrate the Navy's systemic digital fragmentation, but none explore how these problems specifically impact ALSS. Furthermore, NPS theses examining sustainment performance heavily focus on other maintenance processes such as engines or airframes, leaving ALSS architecture unexamined.²

3. Limited Study of Workflow Variation

Although aviation workflow variation is a well-known issue within the community, there is no dedicated documentation or research evaluating ALSS-specific

² For example, Dori (2022) evaluated “the maintenance man-hours performed on each engine type to understand the maintenance requirement to maintain operational availability on similar engines in different environments” (p.8).



procedural drift, job aid reliance, or differences in local sequencing. This is despite strong evidence that ALSS tasks are highly susceptible to such variation due to narrative-heavy manuals, limited diagrams, and reliance on experiential training. Existing research like McKernan & Herrmann (2008) identified workflow variation at FRCs more broadly but does not examine survival equipment or life support gear, where the consequences of drift are often higher and the technical publications less visual.

4. No Framework Linking Policy, Documentation, and Systems

No existing literature establishes an integrated model describing how maintenance policy, technical documentation, and digital systems interact to shape ALSS workflow execution. NAMP and various NPS theses cover policy, examine documentation clarity and interpretation, and document digital fragmentation, yet no research connects these pillars. This absence prevents the Navy from fully understanding how misalignment between policy intent, manual design, and digital systems creates the procedural variation and documentation discrepancies observed within ALSS maintenance.

5. Adjacent Modernization Research Not Applied to Aviation Life Support Systems

Research on VR training, blockchain maintenance records, and integrated information system ecosystems offer valuable insight for future ALSS modernization. Research conducted by Skipper (2022) analyzed the process efficiency of incorporating additive manufacturing (AM) into military production lines:

The observed model results between the eight different simulations progressively diverged as the AM production percentages increased. All four simulations that included random AM lead time distributions with 1–30 days resulted in a progressive decrease in total expected lead time as the AM production percentages increased. (Skipper, 2022, p. 62)

However, no study evaluates their applicability to survival equipment maintenance specifically. The absence of ALSS-focused modernization analysis is a significant gap, especially considering the demonstrated benefits of these technologies in comparable high-precision maintenance domains.



6. Manning and Personnel Issues

PR manning, training throughput, and billet distribution affect ALSS maintenance outcomes, but these issues fall outside the methodological scope of this capstone applied project due to time and resource constraints. Although manning and community health play a pivotal role in the success of aviation maintenance, the A450 manning document highlights no major gaps in the inventory of PR manning across the Navy (MyNavyHR, 2026). One major challenge highlighted in the document focuses on the retention of Sailors, which could be a causal factor of issues addressed in this project. The GAO (2019b) manning study of experienced Air Force maintainers showed, “In 7 of the last 8 fiscal years, the Air Force had staffing gaps of experienced maintainers—those who are most qualified to meet mission needs and are needed to train new maintainers” (para. 1). Likewise, the MyNavyHR (2025) *PR Career Path* document highlights the wide range of positions PRs are expected to fill, offering valuable insight into the possible loss of continuity of information and level of expertise required to conduct ALSS maintenance.

A study from Block et al. (2014) noted that the complexity of maintenance evolutions and their effect on turnaround time (TAT) and manpower allocation

can be quite complex due to a variety of decision factors that affect the spares provisioning plan, e.g., modification plans, operational requirements, the parting-out process, the maintenance (repair times and turn-around-times) and the failure pattern of the units. (Block et al., 2014, p. 85)

However, the literature does support the connection between personnel shortages, workload distribution, and maintenance execution variation. This provides context though not a direct research focus for understanding the broader environment in which ALSS maintenance occurs. These omissions suggest opportunities for future research that links ALSS systems, policy, workforce, and training into a more comprehensive framework.

H. SUMMARY AND CONCLUSION

The literature reveals that ALSS maintenance operates within a complex environment characterized by highly specialized technical publications, implementation of multiple digital systems, complicated supply chains and the possibility of workflow



variation. Governing policy, while comprehensive, is inconsistently interpreted and executed across units due to documentation ambiguity and the absence of enforced standardization. Maintenance information systems particularly NALCOMIS, CADPAD, and DECKPLATE, lack interoperability, contributing to documentation discrepancies and manual reconciliation burdens for technicians. External factors such as the supply posture of critical items can play a key role in the effectiveness of the maintenance team.

Workflow variation emerges as a major theme, supported by GAO findings and NPS theses showing similar challenges across aviation maintenance domains. ALSS tasks, given their intricacy and life-critical nature, are especially vulnerable to drift when technical instructions are unclear or when local practices supersede standardized guidance. Human-error pathways identified in the literature further highlight the risks introduced by narrative-heavy publications, inadequate visual aids, and inconsistent training.

Adjacent modernization research on VR and blockchain demonstrate promising future applications but has yet to been aligned with ALSS-specific requirements. The absence of studies linking policy, documentation clarity, and system integration represent a major theoretical gap in existing literature.

Together, these findings underscore the need for a dedicated analysis of ALSS maintenance from an integrated policy systems–workflow perspective. This capstone applied project addresses that gap by examining how ALSS is executed across FRCMA, Detachment Norfolk, assessing the alignment between technical documentation and maintenance information systems, and identifying opportunities for modernization that improve standardization, reduce variation, and enhance readiness.

The existing literature presents a clear strategic directive from Navy leadership to use data to fix readiness problems and provides robust theories for analyzing process workflows. However, these streams of knowledge have not been integrated and applied to the ALSS maintenance domain through the lens of a key performance metric. No research quantitatively analyzes TRR as the primary indicator of process health within this community, nor does it apply formal bottleneck analysis to identify the root causes. This capstone applied project directly addresses this critical gap. It provides a data-



driven, grounded diagnosis of the ALSS maintenance system, measured through TRR, thereby creating a scholarly foundation for improvements that directly support the CNO's strategic readiness goals.



IV. DATA ANALYSIS AND METHODOLOGY

This chapter details the quantitative methodology used to analyze the root causes of maintenance delays and TRR overruns at FRCMA, Detachment Norfolk. The primary research question guiding this analysis is: What are the primary drivers contributing to a TRR ratio greater than 1.0 for ALSS components?

This study hypothesizes that TRR overruns are not random but are primarily driven by a combination of systemic factors. These include supply chain delays (measured by awaiting parts time), process inefficiencies (measured by time spent in administrative or backlogged statuses), and data integrity issues inherent in using multiple maintenance information systems.

A. DATASET AND SCOPE

The analysis utilizes a 37-month historical maintenance dataset, from February 2023 to February 2026, extracted from the NALCOMIS IMA for FRCMA, Detachment Norfolk. The scope of this initial analysis is specifically focused on the 81A work center within the 800 ALSS Division.

The primary variables extracted for each Maintenance Action Form (MAF) include:

- **Work Unit Code (WUC):** “A unique alphanumeric identifier of the hierarchical structure of assemblies, systems, sets, groups, installations, repairable components, life limited, high profile consumable parts, or areas, or zones of a weapons system. WUCs are utilized for documentation of maintenance tasks. WUCs may be up to thirty-two numeric or alphanumeric characters in length” (Commander, Naval Air Forces, 2024, p. 1807).
- **Job Control Number/ Maintenance Action Form Control Number (JCN/MCN):** An alphanumeric serial number assigned to a specific maintenance action.
- **Induction and Completion Dates:** The start and end dates of the maintenance cycle for the component.
- **In-Work Man-Hours vs. TRR Man-Hours:** The logged time spent by technicians facilitating maintenance versus the prescribed time established per maintenance task.



- **Technician ID:** An identifier for the technician completing maintenance.
- **Job Status Codes:** Current status of the component including: awaiting maintenance (AWM: M1 through M9), awaiting parts (AWP), pre-induction screening (A1), contractor parts (CP), in-work (IW), job complete (JC), etc.
- **Awaiting Maintenance (AWM) Reason Codes:** “A two-character alphanumeric code that describes the reason for an AWM condition” (Commander, Naval Air Forces, 2024, pg. 1716). For this analysis, the time spent in Table 1 are the most common.



Table 1. Common awaiting maintenance reason codes.

Code	Title	Description
M1	Awaiting Maintenance in Depot	“Awaiting or undergoing depot repair at the reporting custodian site” (p. 1843).
M2	Lack of Support Equipment	In-shop delay due to “lack of Support Equipment” (p. 1843).
M3	Backlog of work center workload	“Workload in excess of work center capability” (p. 1843).
M4	Off-Shift Hours	“Maintenance requirement exists beyond normal working hours. This applies only to activities which do not normally schedule work assignments during the reported period, such as 0001 to 0800, or during weekend or holiday periods in which personnel are not normally working” (p. 1843).
M5	Other-weather, OPS condition, training	“Performance of maintenance precluded by weather, operational conditions, general drill, training, ceremonies, open house, shipboard or shore station imposed restrictions, etc. In addition, this code will be used as the alternate status for system reporting of EOC-A for out of reporting XRAY change” (p. 1843).
M6	Awaiting Intermediate level maintenance	“Awaiting Maintenance (AWM) reason code M6 will be used at the I-level to reflect all supply requisitions are completed for components not inducted to AWP locker and awaiting I-level work center pick-up. This code will be used as the alternate status for system reporting of EOC change for in-reporting” (p. 1843).
M8	Awaiting other shops or maintenance actions	“This code will be documented when no further maintenance can be performed due to other shops or maintenance actions, for example, Work Center 120 unable to complete functional check on flight controls due to Work Center 110 having engine removed. This code should not be confused with Reason Code 3 (backlog)” (p. 1843).
M9	Awaiting maintenance funding	“In-shop delay due to lack of funding. This code will be used when the item cannot be repaired due to a lack of support funding for required repair parts or for Beyond Capability of Maintenance (BCM) action or awaiting disposition. This code may also be used for non-Supply Officer, TYCOM controlled assets such as SE, test benches, and engines determined to be in excess of demand or uneconomical to repair. NRFI assets held in M9 status will be tracked in Buffer Management Tool (BMT) as “Non Due In From Maintenance (DIFM)” workload and will not be available to the maintenance activity for use in further trouble shooting or cannibalization” (p. 1844).

Adapted from Commander, Naval Air Forces, (2024, pp. 1843–1844).



1. Overview

The initial dataset captured a total of 2,888 individual MAFs. This represents a comprehensive record of all scheduled and unscheduled maintenance performed on the work center's primary components and systems over the 37-month period. For this analysis, scheduled and unscheduled maintenance actions are defined:

- **Scheduled Maintenance** refers to routine, time-based inspections and repacks. These tasks are predictable and planned.
- **Unscheduled Maintenance** refers to corrective actions required to address discrepancies found during inspections or reported from the fleet (e.g., replacing a pyrotechnic device, purge and fill, inadvertent actuations). These tasks are reactive, induce additional maintenance requirements and often vary in occurrence, priority, and flight line mission degradation.

As Table 2 indicates, while most of the workload consists of scheduled maintenance, the significant volume of unscheduled work is a key area of interest, as it often correlates with higher TRR variance due to unforeseen parts, troubleshooting and labor requirements. The dataset encompasses maintenance actions across six unique WUCs: A/P28S-32(v)1, A/P28S-32(v)2, A/P28S-32(v)6, NB-6, NB-8, and A/P22P-20. Every maintenance action within 81A has a base TRR of 156 days.

Table 2. Breakdown of workload from February 2023 to February 2026.
Source: NALCOMIS.

Maintenance Type	Type of Inspection	Quantity of MAFs
Scheduled	2190/1792 Day Inspections	721 MAFs
	896 Day Inspections	233 MAFs
	448 Inspections	603 MAFs
Unscheduled	Unscheduled Maintenance Inspections	799 MAFs
	Technical Directives	481 MAFs
	Beyond Capability of Maintenance	51 MAFs

2. Exclusions and Limitations

To ensure statistical validity and focus the analysis on representative high TRR maintenance components, specific MAFs were intentionally excluded from the initial dataset. Specifically, three MAFs related to SE maintenance were removed, as these



actions involved maintenance on the equipment required to perform the 81A work center's functions and fall entirely outside the scope of TRR component tracking. This process of data cleaning is critical to prevent outliers from skewing the data. Ultimately, this focused approach allows for a deeper analysis of the core, high-volume work that constitutes the majority of the work center's efforts and provides a more accurate foundation for identifying systemic bottlenecks. In total, these three SE exclusions represent a statistically insignificant 0.1% of the total maintenance actions across the work center.

3. Integrity Challenges

This section directly addresses a core component the capstone applied projects' hypothesis: *data integrity issues are a significant, yet often unmeasured, factor in maintenance processes and data analysis*. A critical consideration for this study is the potential for NALCOMIS data to be skewed in a way that artificially improves the appearance of maintenance performance against TRR standards. This is not a failure of individual maintainers, but a rational response to organizational pressures to "meet the numbers." This observation, made during preliminary analysis, is a foundational piece of evidence supporting the investigation into data integrity.

Eight sources of data manipulation were observed during analysis:

- **Lack of Data Driven TRR Requirements:** The TRR requirement for maintenance actions was identified to be a blanket 156 days across all scheduled and unscheduled MAFs. This is an unrealistic standard, for example a 2190 day inspection, requires a multitude of additional requirements and parts than a simpler 448 day inspection. Unscheduled maintenance falls under this same requirement with simple purge and fill taking on average 2 days to complete, not requiring a full 156 day TRR. This observation is the largest takeaway discovered during this capstone applied project.
- **Premature Job Sign-Off:** Technicians may sign off on a maintenance action as complete in NALCOMIS IMA before the final checks or paperwork are finished. This "stops the clock" on the TRR calculation, but the component is not yet ready for issue, misrepresenting the true cycle time.
- **Under-reporting of Man-Hours:** To make a job appear efficient and fall within the established TRR man-hours, maintainers frequently log fewer



man-hours than are actually expended. This under-reporting is largely driven by administrative compliance that conflicts with practical workflow realities. Specifically, current policy prohibits the “batching” of maintenance (working on multiple components simultaneously) and dictates that two personnel cannot be actively logged as working on the same component at the same time.

- **Misuse of “Awaiting” Status Codes:** A maintenance action may be placed in a status like M8 (Awaiting other shops or maintenance actions) or M9 (Awaiting maintenance funding) when, in reality, the delay is due to M3 (Backlog of work center workload). This practice effectively hides in-shop delays by attributing them to external factors, thus deflating the true AWM time chargeable to the work center.
- **Misuse of NALCOMIS IMA Availability:** Unlike OOMA, NALCOMIS IMA allows a worker to be “in work” on more than one MAF at a time. According to the NAMP “a worker, CDI, QAR, or Supervisor cannot be in work on more than one WO at a time” (Commander, Naval Air Forces, 2024, para. 15.3.8.2 NOTE 1.) This is an unauthorized documentation process, as well as previously stated giving the appearance of a more efficient workload management.
- **Misalignment of Information Systems:** Integration between log sets (electronic documentation history) of NALCOMIS IMA and OOMA can cause next inspection completion errors, often forcing Sailors to complete tasks in configuration management. This can lead to not tracking component high-times or forced removal components accurately at O-Level activities, consequently flying downed gear. Under the NAMP, high-time items are defined as “components with a forced removal requirement based on operating time or cycles” (Commander, Naval Air Forces, 2024, para. 5.3.1.E).
- **Duplicate or Inaccurate MAFs:** NALCOMIS IMA can allow Sailors to initiate duplicate or inaccurate MAFs, leading to confusion and delay in MAF completion. Man-hours must be spent rectifying the accuracy of the documentation.
- **Cannibalization:** “I-Level cannibalization is an acceptable management choice only when necessary to meet the readiness requirements of supported commands” (Commander, Naval Air Forces, 2024, para. 5.2.7.1). Improper cannibalization processes create inaccurate AWP tracking metrics as components are transferred between MAFs, create a shortfall in the supply system. Documentation would consequently not reflect what component of the higher assembly was changed or needing replacement.

These observable behaviors and actions strongly suggest that the TRR variance calculated from raw NALCOMIS IMA data should be viewed as a lower bound estimate of the problem. The actual performance is likely worse than the data indicates, due to the



amount of human error or manipulation that can occur within the maintenance information reporting systems. Therefore, the hypothesis that data integrity is a key factor is supported not only by the final analysis but by the very nature of the data collection system itself.

B. ANALYTICAL METHODOLOGY

The following phase of the analysis was conducted by identifying the TRR variance of all six WUCs maintained by the 81A work center, followed by diagnosing the root causes of delays in the top ten TRR variance MAFs of each component. This process mirrors the Navy's P2P framework to systematically identify performance gaps, diagnose their root causes, and inform data-driven solutions.

The initial phase of the analysis focused on quantifying the extent of maintenance delays to identify which components were the primary drivers of TRR overruns. The core performance metric, TRR Variance, was calculated for each of the 2,885 MAFs. A TRR variance greater than 1.0 indicates that a maintenance action took longer than the prescribed standard, serving as a clear indicator of inefficiency. The TRR variance was calculated using the following formula:

$$TRR\ Variance = \frac{(In-Work\ Man-Hours + AWM\ Time + AWP\ Time)}{TRR\ Man-Hours}$$

To establish a baseline, the TRR variance was calculated across all six primary parachute assemblies in the 81A work center. Figures 1 through 6 present the average TRR variance for each of these assemblies over the 37-month data window.



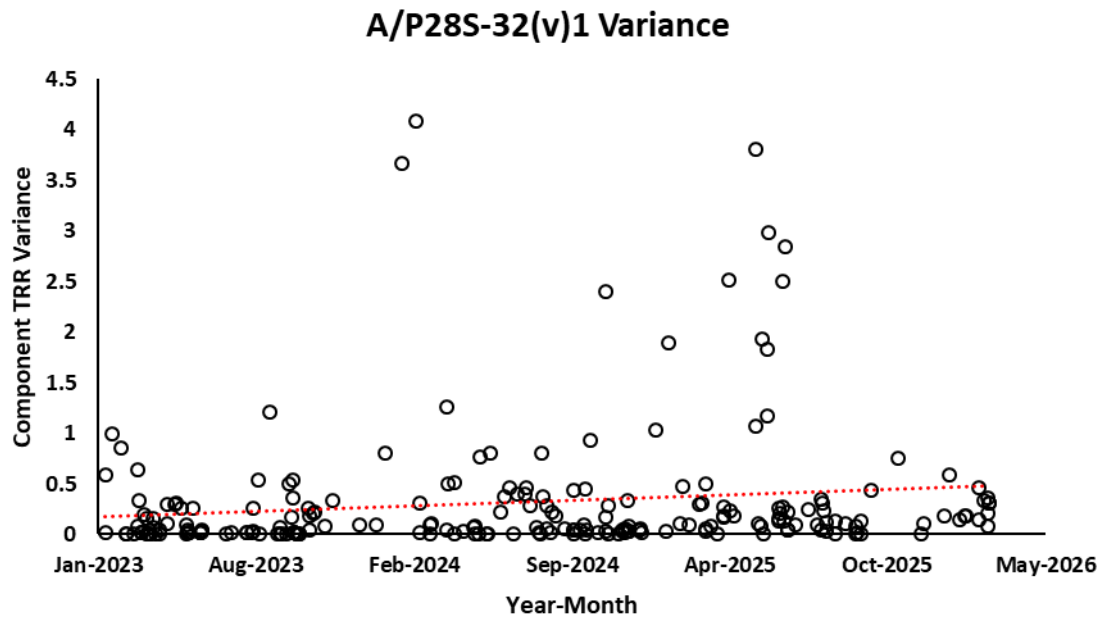


Figure 1. Time to reliably replenish variance for A/P28S-32(v)1 parachutes over the 37-month data window.

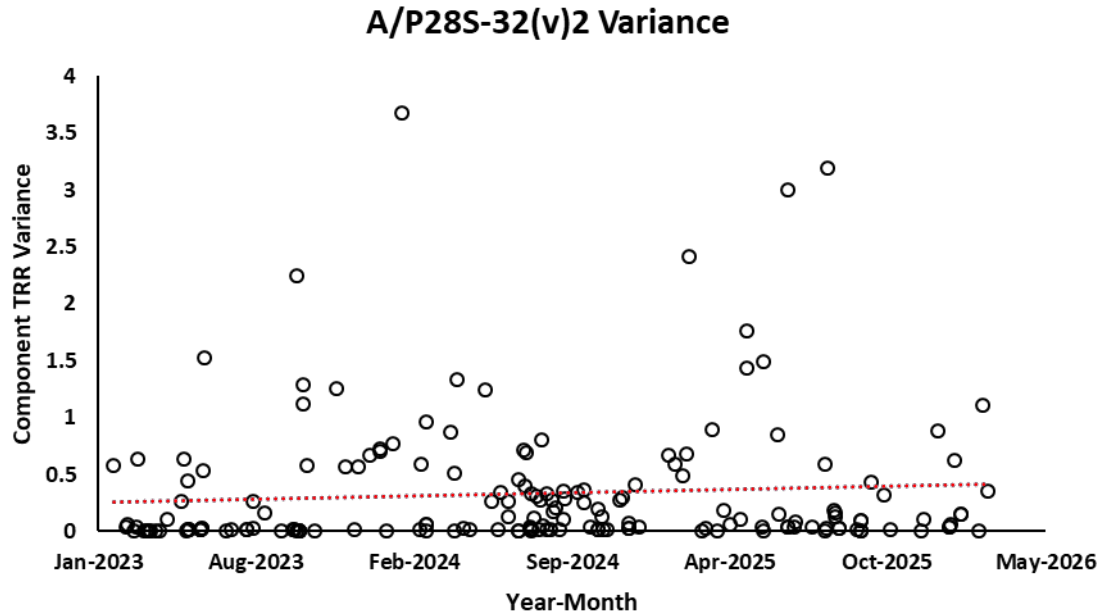


Figure 2. Time to reliably replenish variance for A/P28S-32(v)2 parachutes over the 37-month data window.

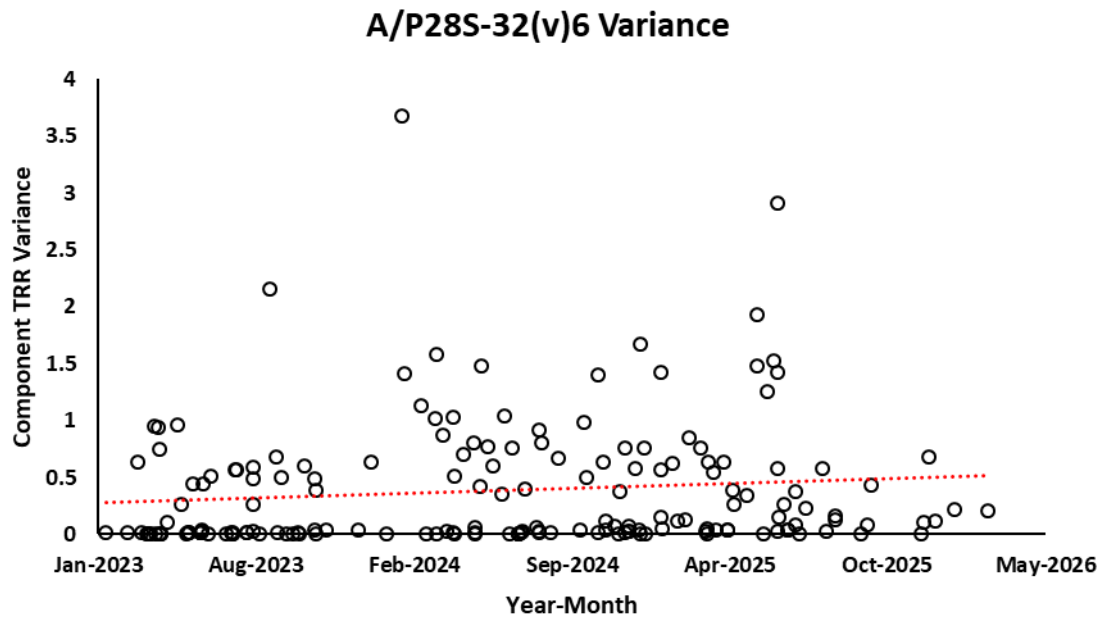


Figure 3. Time to reliably replenish variance for A/P28S-32(v)6 parachutes over the 37-month data window.

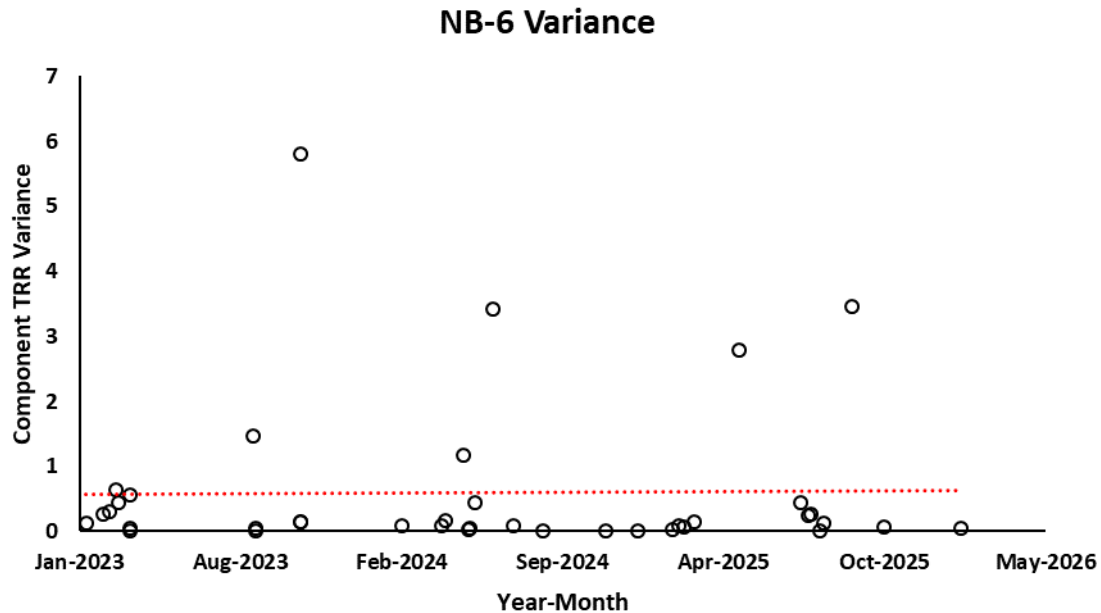


Figure 4. Time to reliably replenish variance for NB-6 parachutes over the 37-month data window.

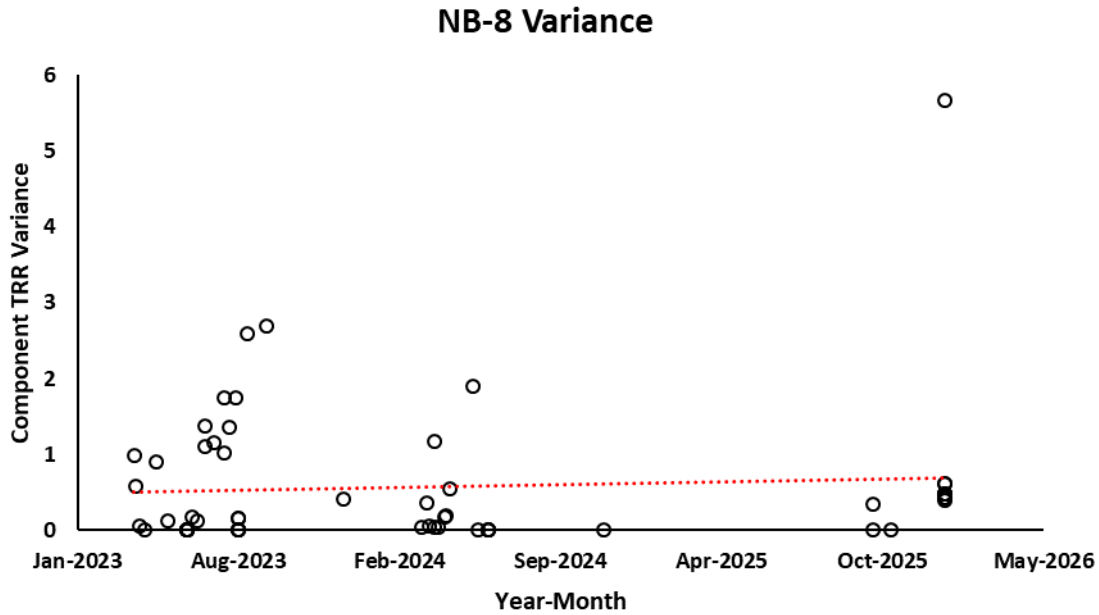


Figure 5. Time to reliably replenish variance for NB-8 parachutes over the 37-month data window.

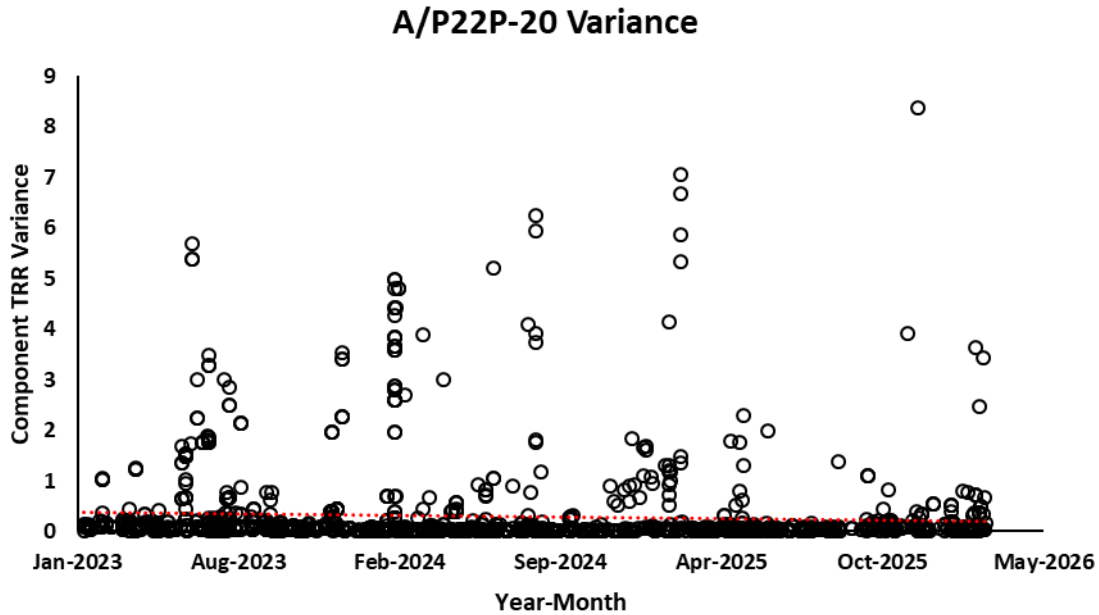


Figure 6. Time to reliably replenish variance for A/P22P-20 parachutes over the 37-month data window.

As illustrated in Figures 1–6, the TRR variance is not uniform across every component type or over time. For example, Figure 6 reveals that the A/P22P-20

parachute assembly consistently exhibits the highest and most volatile TRR variance, frequently peaking above a 3.0 ratio. In contrast, Figure 4 shows that the NB-6 assembly maintains a more stable and lower variance. This initial comparison confirms that specific components, rather than the entire workload, are disproportionately affecting the work center's performance. In addition, Figures 1–6 identify the workload of 81A is most commonly conducted on A/P22P-20 parachutes followed by A/P28S-32 series parachutes and then trailed by the NB-6 and NB-8. This workload variation is influenced by the customer of FRCMA, detachment Norfolk including the type model series of the associated flight line, amount of aircraft/aircrew, priorities of the flight line/deploying aircraft carriers and capability of the maintenance activity. To synthesize these individual trends, Figure 7 aggregates the data, providing an overview of TRR performance across the entire work center, categorized by year.

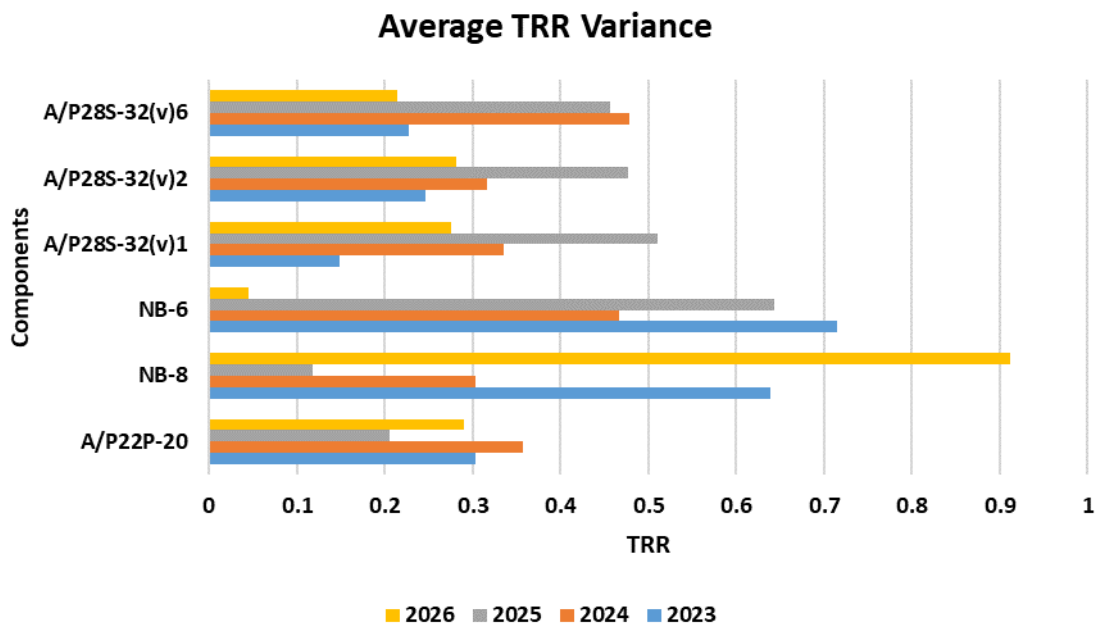


Figure 7. Average time to reliably replenish variance per year for each component.

On the surface, Figure 7 appears to show a healthy system, with the average TRR for key components remaining below the 1.0 standard in each year of the analysis period. This finding would ordinarily suggest that the work center, on average, completes maintenance within required parameters. However, the observations made during the

course of this study found issues caused by data manipulation, which may affect the data. The need for a deeper root-cause analysis is required, if the problems can be addressed and mitigated for the remaining components, the need to “meet the numbers” or perceived pressure will prevent the occurrence of falsifying data entries. This reasoning allows the study to narrow its focus to the top ten highest-TRR MAFs of each parachute assembly identified in Figures 1–6.

Having identified what is deviating from established TRR, the cause analysis seeks to understand why. To do this, the maintenance cycle for the top ten highest-TRR MAFs for each of the six parachute assemblies was deconstructed in Figures 8 through 13. The total time for each MAF was broken down into the time spent in each respective NALCOMIS IMA job status code. This method allows for the direct attribution of delays to specific bottlenecks, such as awaiting parts, internal backlog, or funding issues.

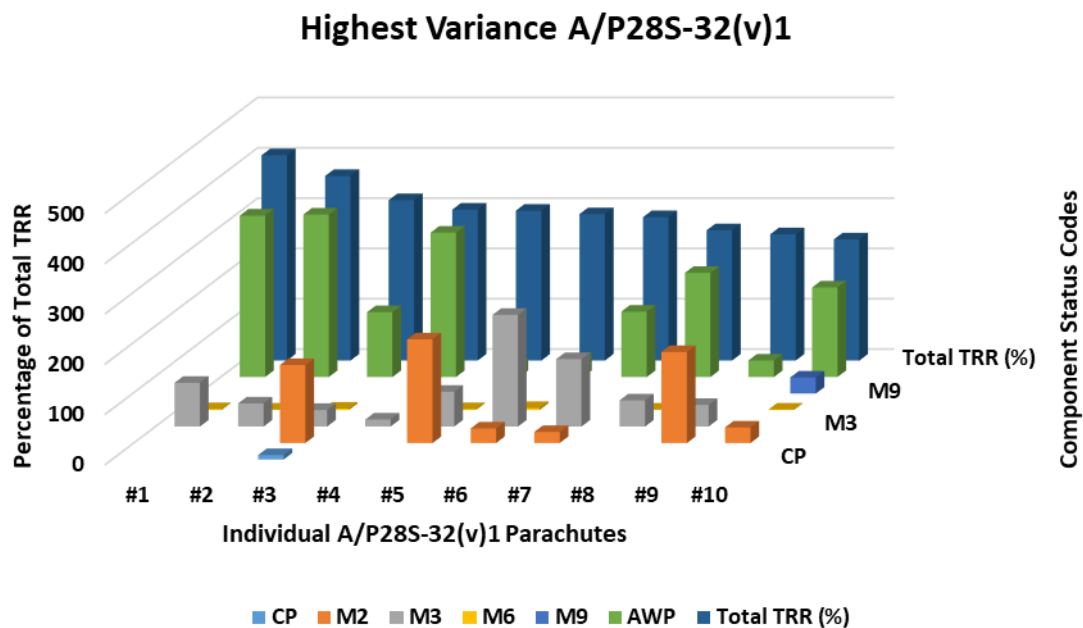


Figure 8. Job status codes of the top ten A/P28S-32(v)1 parachutes.

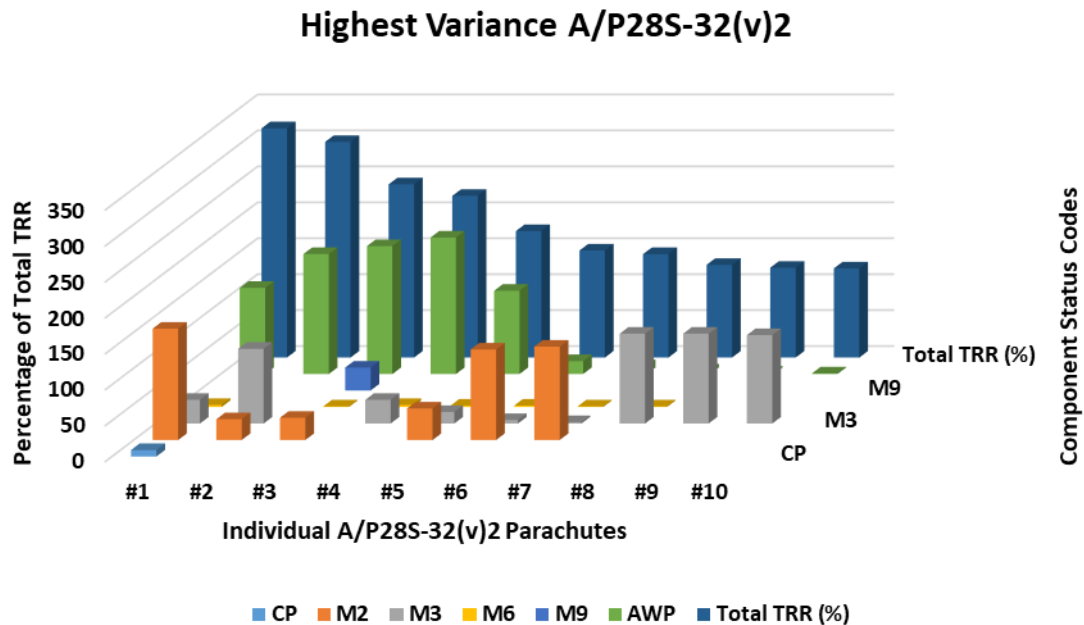


Figure 9. Job status codes of the top ten A/P28S-32(v)2 parachutes.

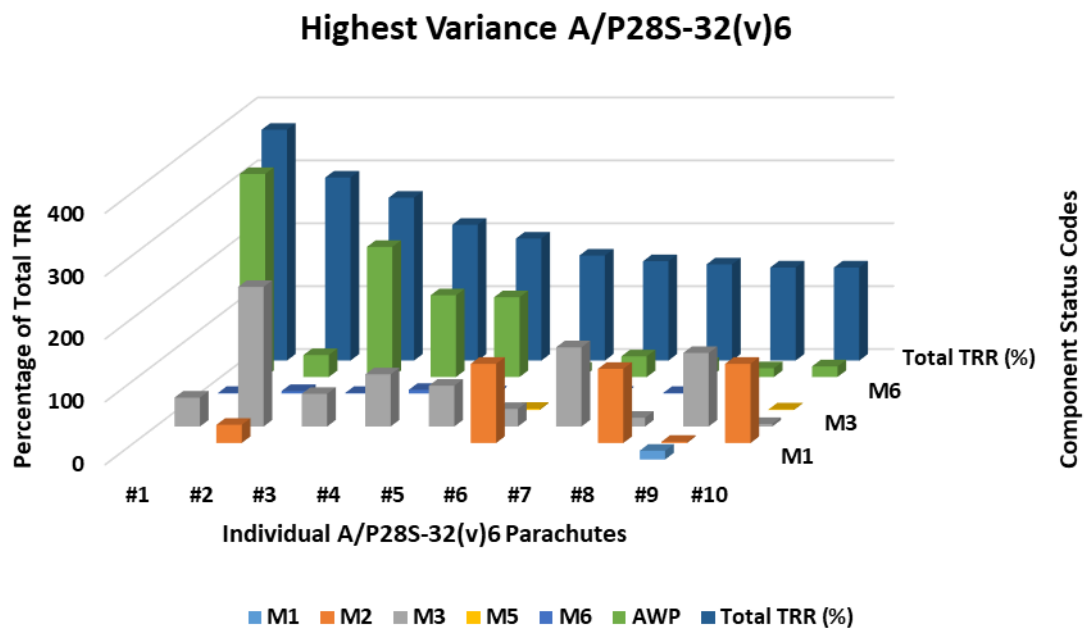


Figure 10. Job status codes of the top ten A/P28S-32(v)6 parachutes.

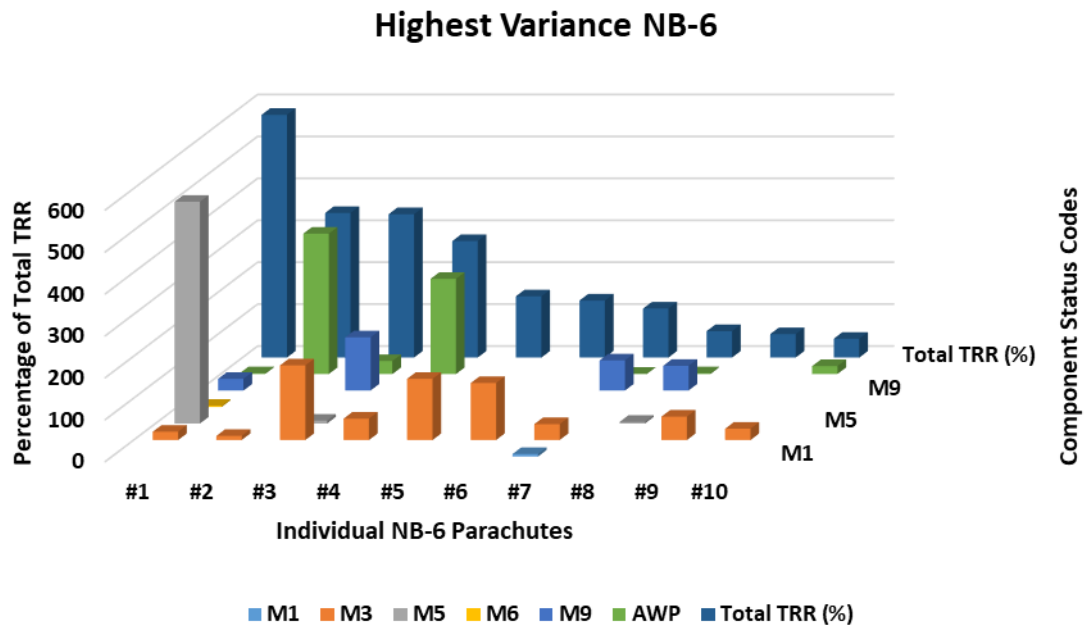


Figure 11. Job status codes of the top ten NB-6 parachutes.

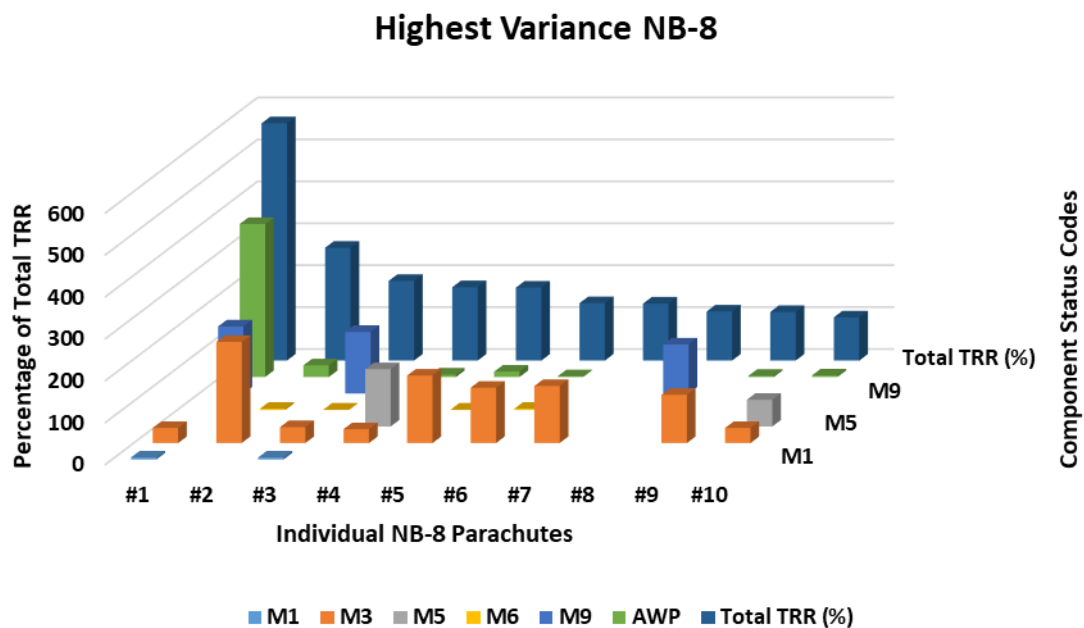


Figure 12. Job status codes of the top ten NB-8 parachutes.

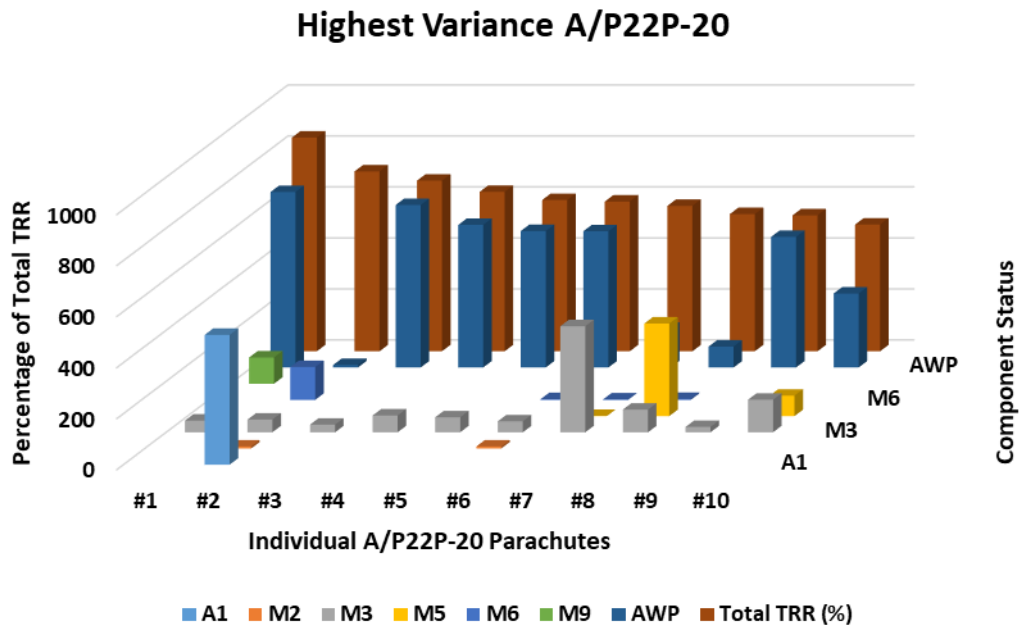


Figure 13. Job status codes of the top ten A/P22P-20 parachutes.

Figures 8 through 13 outline the time spent by 81A parachute assemblies in different job status codes to identify the main drivers of TRR exceedance. Observing Figure 8, for instance, it becomes immediately apparent that the ‘AWP – Awaiting Parts’ category constitutes the largest portion of the total maintenance timeline for the majority of the top ten delayed A/P28S-32(v)1 parachutes. This pattern is largely repeated across Figures 8 through 13, pointing strongly toward a systemic issue with the supply chain.

To make the proportional impact of these delays even more explicit, the same data is aggregated as a percentage of total time in Table 3, which distills the findings from the bar graphs into a clear, comparative format. For example, the table shows that ‘AWP – Awaiting Parts’ accounts for a definitive majority, 55% of the total cycle time for the A/P28S-32(v)1 parachute. Furthermore, the data reveals the significance of secondary drivers. For the A/P28S-32(v)1, the ‘M3 – Backlog’ status accounts for another 23%, proving that internal process inefficiency is also a major contributing factor. The analysis moves from identifying correlation to demonstrating causation, directly linking specific status codes to the TRR overruns observed in Figures 1–6.

Table 3. Aggregated percentage of time spent in job status codes.

Status Code	A/P28S-32(v)1	A/P28S-32(v)2	A/P28S-32(v)6	NB-6	NB-8	A/P22P-20
A1	0%	0%	0%	0%	0%	8%
AWP	55%	42%	43%	29%	21%	65%
M1	0%	0%	1%	0%	1%	0%
M2	21%	26%	19%	0%	0%	0%
M3	23%	29%	35%	31%	47%	16%
M5	0%	0%	0%	26%	10%	7%
M6	0%	1%	1%	0%	0%	2%
M9	1%	2%	1%	14%	21%	2%



V. ANALYSIS OF COMPONENT DELAY DRIVERS

This chapter presents the findings from the data analysis, starting with a detailed examination of the top ten TRR MAFs for each individual high-variance component. These specific findings are then synthesized to form direct, systemic conclusions that address the core research question and provide a data-driven view of the primary factors contributing to maintenance inefficiencies within the ALSS community at FRCMA, Detachment Norfolk.

Each of the following six sections is a series of deep-dives, dedicated to a single component, presenting a detailed breakdown of its primary delay drivers in order of impact. Within each analysis, I explore the operational meaning of the status codes, using aggregated data and specific examples from the MAFs to provide irrefutable evidence for the findings. This forensic approach provides the ultimate, evidence-backed foundation for the tailored recommendations presented in Chapter VI.

A. A/P22P-20

With the highest average top ten TRR variance and the most significant induction quantity, the A/P22P-20 parachute reveals its performance is undermined by a combination of an inadequate supply chain, external dependencies, and internal process friction.

- **Primary Driver (65%): AWP (Awaiting Parts)**
AWP status is the single most significant factor degrading this component's turnaround time, accounting for two-thirds of its downtime and confirming a critical failure in the supply chain for ordered components. Analysis of the MAF data shows these delays are not for common consumables but for unique, critical components with long lead times not measured in weeks, but in years. The data in Table 4 is unambiguous and alarming. With average wait times measured in hundreds of days, stretching to over 2 years for a bridle assembly, it is clear that the supply chain for this asset is not merely inefficient; it is fundamentally broken. This asset is held hostage by a logistical pipeline unable to provide its most critical components in a timeframe that is even remotely acceptable for operational readiness.



Table 4. Top awaiting part drivers for A/P22P-20.

Part Number	Description	Number of Orders (in sample)	Average Wait Time (Days)
3516AS5000-5	Main Canopy Assembly	7	178
3516AS5100-1	Pilot Chute Assembly	4	439
3516AS6300-3	Drogue Chute	3	363
3516AS3000-11	Harness	5	610
3516AS5200-1	Parachute Bridle	4	738

- Secondary Driver (16%): M3 (Backlog)**
 This reveals the inevitable bottleneck within the work center caused by the extreme AWP delays. When a part finally arrives after a year-long wait, the asset does not immediately enter maintenance. Instead, it enters a new queue, waiting for PRs who are invariably occupied with other tasks. The data shows components languishing for days or weeks in M3 status after an extended AWP hold, illustrating how extreme external delays create significant and predictable internal resource logjams.
- Tertiary Driver (8%): A1 (Pre-Induction Screening)**
 The significant presence of ‘A1’ status indicates the sheer number of inductions and unscheduled maintenance forces the component to idle at induction. This is an indictment of the asset’s fundamental consequence of inefficient work center processes, leaving a component coded ‘A1’ for a significant amount of time.
- Quaternary Driver (7%): M5 (Other)**
 This code typically represents maintenance holds requiring external consultation and/or maintenance. This code highlights the inherent complexity of the asset. Unlike with simpler systems, the frequent occurrence of M5 status suggests that repairs often encounter inefficient processes or issues that extend TRR. This shows that even when parts are present and the repair is within the shop’s capability, the component’s complexity often requires external consultation or a dependence on other work centers to complete maintenance.

B. NB-8

The NB-8 parachute is an obsolete design, minimally utilized on aging platforms that have been earmarked for sundown. The NB-8 is plagued by inefficiencies due to its low demand and lack of support. Its maintenance profile is a case study in the extreme challenges of supporting an “orphan” system that has fallen through every crack of the logistics, financial, and accountability systems.



- Primary Driver (47%): M3 (Backlog)**
 The leading cause of delay for the NB-8 is M3 status, indicating that the component spends nearly half of its time simply waiting in the internal work center queue. This is not a sign of healthy prioritization but rather of systemic neglect. As the lowest-priority work with a high degree of complexity, NB-8 repairs are consistently deferred in favor of assets supporting priority fleet requirements. The data shows that once inducted, these components languish for extended periods, waiting for worker availability that is seldom directed their way, turning the shop itself into the primary bottleneck.
- Secondary Driver (21%): AWP (Awaiting Parts)**
 The AWP delays for the NB-8 are overwhelmingly concentrated in a specific commodity group: pilot straps and pilot chutes that are no longer produced. Aggregated MAF data shows that a high percentage of all AWP time for this component was spent waiting for items that are, for all practical purposes, nonexistent. Table 5 shows average wait times approaching a full year for parts that are out of production, this is a clear supply chain problem driven by obsolescence. The system is forced into a reactive, and often futile, search for parts that no longer exist in the standard supply system.

Table 5. Top awaiting part drivers for NB-8.

Part Number	Description	Number of Orders (in sample)	Average Wait Time (Days)
666AS100-1	P Strap	4	262
60A125E16-1	Pilot Chute Assembly	6	320

- Tertiary Driver (21%): M9 (Awaiting Funding)**
 This finding points directly to a financial management bottleneck that precedes the supply process. The ‘M9’ status represents a significant and distinct delay where, even if a rare part is located, the process is halted awaiting funding approval. This is not just a supply issue, but a financial process delay that has the same operational impact as an out-of-stock part, further compounding the issues of supporting this legacy system.
- Quaternary Driver (10%): M5 (Other)**
 For the NB-8, M5 status often correlates with the need for specialized engineering or artisan specialization to provide support or waivers to keep the component in use. The frequency of this code suggests that repairs often require external consultation, proving that the knowledge and documentation required to repair this aging component are themselves scarce and time-consuming.



C. A/P28S-32(V)1

As the most modern and widely used parachute serviced by FRCMA, Detachment Norfolk, the A/P28S-32(v)1 serves as a baseline for the Naval Aircrew Common Ejection Seat (NACES) family of parachutes. Its profile exposes the standard inefficiencies that plague the day-to-day workflow for modern, funded, and supported assets.

- **Primary Driver (55%): AWP (Awaiting Parts)**
Even for this common and modern parachute, the supply chain remains the most significant factor in its downtime. While the wait times are significantly lower than for legacy systems, any delay negatively impacts flight line operations. The data shows a persistent failure to proactively stock the very parts that are most in demand for the primary survival system of the naval strike community. Table 6 shows that high-demand assets are consistently waiting months for critical, known-demand items like EPAs and 2190-Day Kits is a clear indictment of an inadequate supply posture. This makes a powerful case for further analysis of supply management, as discussed in Chapter VI.

Table 6. Top awaiting part drivers for A/P28S-32(v)1.

Part Number	Description	Number of Orders (in sample)	Average Wait Time (Days)
MBEU147610	Main Canopy Assembly	7	94
852AS102	Battery	5	56
852AS101-3	EPA	6	128
N/A	NACES 2190 -Day Kit	7	148
MBEU147607	WD Line	6	36

- **Secondary Driver (23%): M3 (Backlog)**
The data shows a stark disparity between administrative wait time and actual maintenance time. The average M3 queue time for this component was often double the standard repair time for its most common repairs. This means the component spent more time waiting for a worker than it did being repaired, even as a high-priority asset.
- **Tertiary Driver (21%): M2 (Support Equipment)**
The prominence of “M2” as a significant driver is a major indictment of internal process friction. Aggregation of MAF time stamps reveals that the average A/P28S-32(v)1 assembly spent a significant number of hours in M2 status. This represents dead time where the asset was simply waiting for the availability of required support equipment, indicating an internal resource constraint beyond simple PR availability. Upon further investigation it was discovered the packing press utilized to RFI this



component was in “down” status for 224 days awaiting components from Martin Baker, UK.

D. A/P28S-32(V)2

This variant exhibits a nearly identical delay profile to its (v)1 counterpart, reinforcing the conclusion that the inefficiencies are systemic to the supply chain and internal shop processes for the entire NACES family, not specific to a single variant.

- **Primary Driver (42%): AWP (Awaiting Parts)**
The supply chain remains the primary hurdle. The list of frequently ordered parts is nearly interchangeable with the (v)1, highlighting a common set of components that need to be addressed within the supply chains.
- **Secondary Driver (29%): M3 (Backlog)**
The component spends a significant portion of its cycle waiting in the general queue. The similarity of this data point to the (v)1’s M3 time shows that the backlog is a general condition of the shop affecting all variants, not a problem specific to one variant’s workload.
- **Tertiary Driver (26%): M2 (Support Equipment)**
As with the (v)1, the “M2” status, driven by waiting for support equipment, is a major contributor to TRR variance. The nearly identical percentage to the (v)1 reinforces the point that the availability of required support equipment is a systemic bottleneck for the entire NACES product line, hindering throughput regardless of worker or parts availability.

E. A/P28S-32(V)6

As the third variant in the series, the (v)6 confirms the systemic nature of the AWP/M3/M2 bottleneck for standard, modern parachute systems, proving the issues are deeply embedded in the process.

- **Primary Driver (43%): AWP (Awaiting Parts)**
The AWP profile for the (v)6 is consistent with its earlier counterparts, driven by the same set of common part requirements. This combined data from all three variants makes a powerful, unified case for which specific items should be targeted for improved supply chain management. The system repeatedly fails to meet demand for its most requested parts.
- **Secondary Driver (35%): M3 (Backlog)**
The backlog data for the (v)6 mirrors the other variants, confirming that these common, straightforward assets regularly wait for extended periods for an available PR. This consistent finding proves that work center



inefficiencies and the current Sailor-to-workload ratio is insufficient to keep pace with demand, even when parts and equipment are not an issue.

- **Tertiary Driver (19%): M2 (Support Equipment)**
Again, “M2” status is a significant delay driver. This consistent finding across all three A/P28S-32 variants provides conclusive evidence of a flawed support equipment dependency, where assets are not effectively RFI’d if all required resources, including support equipment are not in a working status.

F. NB-6

The NB-6 parachute’s performance profile is unique within the 81A workload, primarily because only six remaining T-38 aircraft on the NAS Oceana flight line utilize this component. This low fleet density frames its analysis not as a model of efficiency, but as a case study in the challenges of supporting a low-volume, low-priority asset. Despite having the highest overall TRR variance (Figure 7), the NB-6 has the lowest induction rate among all analyzed components, the data suggests a component plagued by neglect, a non-existent supply chain, and significant administrative friction.

- **Primary Driver (31%): M3 (Backlog)**
The leading cause of delay for the NB-6 is M3 status, indicating that the component spends nearly a third of its time simply waiting in the internal work center queue. This indicator is not a sign of healthy prioritization but rather of systemic neglect. As the lowest-priority work, NB-6 repairs are consistently deferred in favor of assets supporting larger fleet requirements. The data shows that once inducted, these components languish for extended periods, waiting for PR availability that is seldom directed their way, turning the shop itself into the primary bottleneck.
- **Secondary Driver (29%): AWP (Awaiting Parts)**
Contrary to what might be expected from a seemingly simple system, AWP is the second-most significant delay driver. This finding points to a brittle, low-volume, and potentially near-obsolete supply chain. Because the parts are not in high demand, they are not proactively stocked. The MAF data shows that when a part is needed, the NB-6 enters the same reactive and inefficient supply system as its higher-priority counterparts, but with the added disadvantage of sourcing components that are likely low-stock or made-to-order, as shown by the wait times in Table 7.



Table 7. Top awaiting part drivers for NB-6.

Part Number	Description	Frequency of Order (in sample)	Average Wait Time (Days)
711-07022-30	Actuator	1	39
60A125E16-1	Pilot Chute Assembly	3	361
60A114E3-1	Main Canopy Assembly	2	486
MILW5625	Lanyard	1	538
711-07022-34	Automatic Parachute Ripcord Release	2	423

- Tertiary Driver (26%): M5 (Other)**
 The high percentage of time spent in M5 status further complicates the NB-6's profile, indicating that its repairs are frequently not straightforward. A review of the M5-coded MAFs reveals that these are not for rare, one-off issues, but for recurring problems requiring engineering consultation and TYCOM deviation approval. This suggests that the documentation and established repair procedures for this aging system may be inadequate or outdated, forcing PRs to seek external support for what should be standard repairs.
- Quaternary Driver (14%): M9 (Awaiting Funding)**
 Finally, the 14% of delay attributed to M9 status confirms that this low-priority asset also suffers from significant administrative friction. It frequently gets stuck in the financial pipeline, awaiting funding approval for its already hard-to-source parts. This adds yet another layer of bureaucratic delay on top of the queueing, supply, and procedural issues, completing the picture of a component that is inefficient to maintain not because it is inherently complex, but because it has fallen through the cracks of every major support system.

G. SYNTHESIZED FINDINGS AND OVERARCHING CONCLUSIONS

The preceding analysis of the six primary parachute assemblies has deconstructed the high-level performance trends into a series of specific, data-driven observations. While each component tells a unique story, synthesizing these individual findings reveals a set of clear, cross-cutting, and universal drivers of delay. These systemic themes, which transcend any single component type, form the core of the problem and the foundation for the recommendations that follow.



1. Primary Drivers

The primary finding is as follows: Across all component types, AWP is the single most significant and damaging driver of TRR variance. The data is unequivocal: the largest and most pervasive barrier to achieving an ideal TRR is the time spent waiting for the external supply chain. Its impact is universal but manifests with varying severity, painting a clear picture of inadequate supply chain processes.

- For the most troubled and complex assets like the A/P22P-20 Parachute, AWP is not just a delay; it is responsible for the vast majority of its cycle time. The wait times, measured in hundreds of days for parts, show that the supply chain is fundamentally incapable of supporting this high-volume asset.
- For the workhorses of the fleet, the A/P28S-32 variants, AWP remains the primary driver of delays, even with significantly lower wait times. The system's inability to supply common, high-demand parts for its most modern and widely used assets is a critical inefficiency that directly impacts operational readiness.
- For the "orphaned" NB-8 and NB-6 systems, AWP highlights the challenges of obsolescence and low-volume demand, where the supply system forces them into a reactive, and often futile, search for parts that no longer exist in readily available inventory.

2. Secondary and Tertiary Drivers

The secondary finding is as follows: While external factors are dominant, the analysis proves that a significant portion of delay is self-inflicted and within the FRC's direct control. The second most prevalent theme is the significant dead time components accumulate within the work center itself.

- For the standard work represented by the A/P28S-32 family, these internal delays are a primary source of inefficiency. The high prevalence of 'M2 – Awaiting Support Equipment' and 'M3 – Backlog' codes reveals a fundamental flaw in the component induction, workflow management processes, and support equipment reliance. Assets are consistently waiting for available benches, test equipment, or workers, creating a state of perpetual internal congestion.
- For the high-variance components like the NB-8, the M3 backlog is the leading cause of delay. This demonstrates a state of systemic neglect where low-priority or complex jobs are endlessly deferred, turning the work center itself into a long-term storage facility rather than a repair shop.



- The maintenance life cycle of the A/P22P-20 is severely impacted by compounding inefficiencies at multiple stages. On the front end, ‘A1 – Pre-Induction Screening’ delays indicate that external administrative and routing bottlenecks stall components before they ever reach the work center. On the back end, this external friction is exacerbated by internal inefficiencies. Assets that finally clear induction and receive a required component after a lengthy AWP delay are frequently forced to wait again in the M3 backlog, creating a secondary bottleneck that severely inflates the overall TRR.

The tertiary finding is the impact of external bureaucratic and (M9). Beyond parts and internal workflow, a third category of significant delays emerged, pointing to systemic issues that are outside of the work center’s direct control but have a profound impact on TRR.

- The prominence of ‘M9 – Awaiting Funding,’ particularly for the NB-8 and NB-6, exposes a critical administrative bottleneck. This demonstrates that even when parts are theoretically available, delays in the fiscal approval process can halt the maintenance cycle entirely. This proves that TRR is not just a function of logistics and manpower, but also of financial process prioritization.

H. CONCLUSION OF FINDINGS

From this synthesis of delay drivers, three undeniable, overarching conclusions emerge. These conclusions directly frame the recommendations and future studies presented in the subsequent chapter.

- **Conclusion 1:** The system’s primary local point of failure is an inadequate supply of parts, primarily manifested through excessive AWP times. The core issue impacting maintenance throughput is a failure to receive parts within the current TRR baseline. However, the root cause of this enterprise-level shortfall remains unknown. It is currently undetermined if this lack of supply is due to a failure of DLA and Naval Supply Systems Command (NAVSUP) demand modeling, a failure of budgeting, or a failure of parts management. Further targeted analysis of the supply chain enterprise is required to determine exactly why these critical components are consistently unavailable to the maintainers.
- **Conclusion 2:** Substantial, quantifiable inefficiency exists within the work center’s internal workflow. The dominance of ‘A1’, ‘M2’, and ‘M3’ codes demonstrates that simply fixing the supply chain is not enough. A parallel effort must be made to streamline the internal component handling, resource allocation, and prioritization processes to reduce non-value-added “dead time.”



- **Conclusion 3:** A multifaceted, tailored approach to problem-solving is required. The existence of distinct, high-impact drivers like ‘M9’ proves that a single solution will not suffice. The improvement strategy must be comprehensive, with specific initiatives designed to address not only parts and process but also financial management challenges that impact operational availability.



VI. RECOMMENDATIONS AND FUTURE STUDY

Based on the findings and conclusions presented, this chapter provides specific, actionable recommendations to reduce TRR and enhance the readiness of the ALSS maintenance community. Each recommendation is directly linked to a corresponding finding, creating an evidence-based path toward process improvement aligned with the Navy's strategic "Get Real, Get Better" imperative.

A. RECOMMENDATIONS

1. Addressing Supply Chain Inefficiencies

Recommendation 1: Establish a Data-Driven Pre-Expended Bin (PEB).

- **Linked Finding:** This is a direct countermeasure to Conclusion 1, which demonstrated that AWP status is the largest driver of TRR variance. While it is clear that the lack of component supply is the primary bottleneck, it is currently undetermined whether this shortfall is due to a failure in NAVSUP/DLA demand modeling, a failure of budgeting, a failure in parts management, or a failure in something that has yet to be identified. Therefore, further analysis of the supply enterprise is required.
- **Action:** Conduct an analysis of the AWP data for the A/P22P-20, NB-8, NB-6, A/P28S-32(v)1, A/P28S-32(v)2, and A/P28S-32(v)6 parachutes to identify the part numbers that cause the most cumulative delay days. Use this demand data to formally justify and fund a local PEB at FRCMA specifically for these high-demand, long-lead-time items. Concurrently, advocate for a higher-level review of NAVSUP and DLA demand estimation models, budgeting allocations, and parts management practices to identify the root cause of these supply shortfalls.
- **Impact:** This will decouple the daily maintenance workflow from the volatility of the supply chain for the most common repairs. It will directly reduce AWP time, decrease TRR, and increase overall shop productivity by ensuring parts are on hand before a job is inducted, while simultaneously prompting the enterprise-level analysis needed to fix the systemic causes of the supply delays.
- **Implementation and Return on Investment:** Implementation is hard, as it involves coordinating cross-functional teams and potentially navigating complex enterprise-level vendor contracts. While the potential long-term impact is high, the difficulty and extended timeline mean the immediate return on investment (ROI) is low. This should be treated as a longer-term strategic goal rather than a quick fix.



Recommendation 2: Formalize Cannibalization Policy to Preserve Data

Integrity.

- **Linked Finding:** This recommendation also addresses Conclusion 1 and NALCOMIS integrity challenges by managing a common, but problematic, reaction to supply shortfalls. Uncontrolled cannibalization masks the true demand signal, making it harder for the supply system to correct itself.
- **Action:** Implement a specific ALSS section to the site-level standard operating procedure (SOP) that designates cannibalization as a last resort, to be approved only by the Maintenance Material Control Officer (MMCO). The SOP should mandate that any cannibalization action must be accompanied by a requisition for the part, ensuring the demand signal is still sent to the supply system.
- **Impact:** This policy ensures that while readiness needs can be met in the short term, the long-term data needed to fix the supply system is not circumnavigated. It helps leadership accurately identify which parts are most needed for the PEB and for other supply posture improvements.
- **Implementation and Return on Investment:** Implementation is easy, as it only requires drafting and enforcing a local SOP. The impact is moderate to high regarding long-term supply chain health and data integrity. Given the low effort and strong strategic value, this provides an immediate ROI and should be implemented straightaway.

Recommendation 3: Pursue More Agile Contract Management for High-TRR

Components.

- **Linked Finding:** This addresses the unknowns surrounding Conclusion 1. While the data conclusively demonstrates that AWP status is the largest driver of TRR variance, the provided dataset did not contain the granularity required to prove whether administrative lead times or slow contract fulfillment are the specific bottlenecks causing these delays. Because this cannot currently be proven with the available data, it represents a critical knowledge gap that must be addressed before structural contracting changes can be recommended.
- **Action:** Conduct a follow-on study or task a cross-functional team (including Logistics, Contracts, and Finance) to specifically track the procurement life cycle for the top five components with the highest TRR driven by AWP. The objective is to gather the missing data on vendor contracting times, administrative lead times, and order fulfillment rates.
- **Impact:** By gathering this data, leadership will be able to definitively prove whether contracting delays are a root cause of high AWP times. If the data validates this hypothesis, it will open up future opportunities to establish streamlined, agile ordering processes with vendors, which could



potentially reduce procurement lead times from months to days and improve maintenance planning stability.

- **Implementation and Return on Investment:** Implementation is hard, as it involves coordinating cross-functional teams and potentially navigating complex enterprise-level vendor contracts. While the potential long-term impact is high, the difficulty and extended timeline mean the immediate ROI is low. This should be treated as a longer-term strategic goal rather than a quick fix.

2. Addressing Internal Process Inefficiency

Recommendation 4: Implement a Lean-Inspired Tiered Workload Management System.

- **Linked Finding:** This recommendation directly targets Conclusion 2, which identified internal backlog (M3) as a significant and controllable source of delay.
- **Action:** Develop a simple, visual “tiered” system for managing all components in the work center. For example: Tier 1 (Red Tag): Ready for work, all parts available. Tier 2 (Yellow Tag): In Awaiting Parts (AWP) or Awaiting Funding (M9) status. Tier 3 (Green Tag): Work complete, awaiting final inspection/sign-off. Supervisors’ primary focus should be to assign technicians to Tier 1 jobs to maximize flow.
- **Impact:** This factory-style management approach optimizes technician workflow, minimizes context switching, and reduces time spent in backlog. It ensures that the highest priority is always placed on assets that can be completed and returned to the fleet, increasing throughput.
- **Implementation and Return on Investment:** Implementation is easy, requiring minimal financial cost and relying primarily on a shift in local shop-floor management practices (e.g., utilizing physical tags). The impact is high, as it immediately acts to reduce internal backlog (M3). This represents a quick win with a very high ROI.

Recommendation 5: Re-baseline TRR Standards for Specific Maintenance Actions.

- **Linked Finding:** This foundational recommendation addresses the core of the capstone applied project and directly supports Conclusion 2. The current monolithic TRR standard for a component (e.g., 156 days) masks significant inefficiencies in shorter, more common maintenance tasks. Comparing a 2-day functional check against a 2,190-day standard maintenance inspection makes it impossible to identify process delays, as nearly any performance will appear successful.



- **Action:** Collaborate with industrial engineers and data analysts to analyze the historical data for the most frequent maintenance actions (both scheduled and unscheduled). Use historical data to establish a unique, tailored TRR standard for each distinct action. For example, a “448 inspection” might be assigned a 10-day TRR, while a “functional check after unscheduled repair” might have a three-day TRR, replacing the single blanket metric for all maintenance on that asset.
- **Impact:** This will provide a high-fidelity performance metric that accurately reflects the expected timeline for a given task. It will enable supervisors to immediately identify true bottlenecks, differentiate between a complex overhaul and a simple repair that is taking too long, and hold the production line accountable to realistic standards. This change is fundamental to effective process control and improvement.
- **Implementation and Return on Investment:** Implementation is moderately difficult, requiring collaboration with analysts to calculate and validate accurate new baselines. The impact is high because it provides the accurate performance metrics necessary for genuine accountability. The resulting process transparency yields a strong ROI, making this a critical medium-term priority.

Recommendation 6: Improve Support Equipment Readiness and Response.

- **Linked Finding:** This addresses a key component of Conclusion 2. A work center’s efficiency is crippled if essential SE like a Martin Baker packing press is non-operational (an M2 status delay).
- **Action:** Establish a formal SE readiness plan for the ALSS division. This should include a preventative maintenance schedule for critical SE and a rapid response agreement with the manufacturer (e.g., Martin Baker) to prioritize troubleshooting and repair of ALSS-specific equipment.
- **Impact:** This reduces the frequency and duration of M2 delays. By ensuring the availability of essential equipment, it prevents the entire production line from halting due to a single point of failure.
- **Implementation and Return on Investment:** Implementation is moderate, depending largely on contract provisions to establish formal service agreements with the manufacturer. The impact is high, as it prevents localized work stoppages. The ROI is substantial since it protects the throughput of critical components with minimal financial investment.

Recommendation 7: Standardize Work Center Processes with a Local SOP.

- **Linked Finding:** This supports Conclusion 2 and NALCOMIS integrity challenges by reducing the process ambiguity that contributes to internal backlog (M3), and addresses the administrative delays inherent in Pre-Induction Screening (A1). The NAMP is often intentionally broad, requiring local interpretation.



- **Action:** Draft and implement a SOP for the 81A work center that standardizes key processes. This SOP should define a First-In-First-Out (FIFO) induction process, establish strict timelines and responsibilities for A1 capability screening, manage the “pool” of ready-for-issue assets, and set clear prioritization rules for deployed vs. non-deployed squadron assets.
- **Impact:** This reduces the dependence on “tribal knowledge” and ensures all personnel execute maintenance preparation and prioritization in the same way. It creates a more predictable, stable, and efficient operational environment, directly reducing the causes of M3 backlog while preventing assets from languishing in pre-induction (A1) status.
- **Implementation and Return on Investment:** Implementation is easy, requiring only the administrative effort to draft, approve, and enforce a local instruction. The impact is moderate but foundational for process control. This is a low-effort, quick-win task that yields a solid ROI by stabilizing both the intake and internal workflow.

3. Addressing Funding Delays

Recommendation 8: Develop a Proactive Funding Request Process.

- **Linked Finding:** This is a direct response to Conclusion 3, which identified Awaiting Funding (M9) as a key administrative bottleneck.
- **Action:** Establish a process where the most common, high-cost parts are vetted for funding requirements. When a MAF is inducted that is likely to require one of these parts, the funding request should be initiated in parallel with the component’s initial inspection, rather than waiting for the discrepancy to be formally documented.
- **Impact:** This concurrent process removes the fiscal delay from the critical path of the maintenance cycle. It significantly reduces or eliminates the time a component spends in M9 status, decreasing the overall TRR.
- **Implementation and Return on Investment:** Implementation is moderately difficult, as it requires adjusting deeply ingrained administrative habits and aligning them with formal financial approval workflows. However, the impact is high for legacy or complex components frequently delayed by funding. This procedural shift offers a strong ROI by removing administrative bottlenecks from the critical maintenance path.

4. Comprehensive Recommendations

Recommendation 9: Adopt TRR and Status-Based Metrics as Standard Key Performance Indicators.



- **Linked Finding:** This overarching recommendation addresses all three conclusions by creating a mechanism for continuous monitoring and improvement.
- **Action:** Institute a monthly TRR and “Time-in-Status” review at the FRC detachment level. Utilize a simple data dashboard to track TRR variance, average days in AWP, M3 (Backlog), and M9 (Funding) for the top three highest-value WUCs.
- **Impact:** This embeds a data-driven, continuous process improvement culture, enabling leadership to proactively identify and address supply, funding, or workflow bottlenecks in near-real-time, directly supporting the P2P framework.
- **Implementation and Return on Investment:** Implementation is moderately easy, requiring the creation of a simple data dashboard and a commitment from leadership to maintain a monthly review cadence. The impact is high, as it sustains visibility on maintenance bottlenecks. The culture of continuous improvement it generates will provide a compounding ROI over time.

Recommendation 10: Elevate ALSS Readiness Visibility in Maintenance Operations Center (MOC) Briefings.

- **Linked Finding:** This strategic recommendation addresses all three conclusions by increasing leadership awareness, which is essential for prioritizing resources to solve the identified problems.
- **Action:** Advocate for the inclusion of a dedicated ALSS readiness slide in the daily or weekly MOC readiness briefing. This slide should report on the number of assets in AWP/M3/M9 status and the current TRR for the top three most critical components.
- **Impact:** This raises the visibility of ALSS challenges to the same level as aircraft readiness. It ensures that senior leadership is aware of the constraints on the ALSS pipeline and can apply command-level influence to resolve enterprise-level issues with supply, funding, or other support.
- **Implementation and Return on Investment:** Implementation is very easy, requiring only the addition of a standardized slide to existing leadership briefings. The impact is moderate to high, as it may unlock command-level resources or advocacy. Because the effort required is negligible, this is an immediate, low-cost action with the potential for significant strategic ROI.

By implementing these recommendations, the Naval Aviation Enterprise can move beyond addressing symptoms and begin to resolve the root causes of maintenance inefficiency, ensuring that life-critical ALSS equipment is returned to the fleet faster and



more reliably, Implementation would also allow PRs to live up to their motto “The Last To Let You Down.”

B. AREAS FOR FUTURE STUDY

This capstone applied project provides a foundational model for analyzing ALSS maintenance at the intermediate level. While its conclusions are mainly specific to the 81A work center during the observed period, its methodology can be applied to a broader range of inquiries. Future research could expand upon other ALSS work centers such as Aviators Safety Equipment Shop (81B) or Oxygen Regulator and Equipment Shop (81C) as well as expanding to other divisions within Fleet Readiness Centers such as the 400, 500, 600, 700, or 900 divisions. Expanded research in several key areas can provide a more holistic, enterprise-wide understanding of naval aviation readiness.

- **Further Examine Historical Data:** This project presents a cross-sectional analysis of a 37-month period. A future longitudinal study should apply the same analytical methodology to a much larger historical dataset, spanning 5–10 years. This would allow for the identification of long-term trends, seasonality, and the impact of major fleet-wide events (e.g., deployments, introduction of new component variants or aircraft). Key research questions would include: Are TRR variances improving or degrading over time? Is there a correlation between specific fiscal quarters and the prevalence of ‘M9 – Awaiting Funding’ holds? Did the ‘M3 – Backlog’ issues for the A/P22P-20 intensify after a certain point in its life cycle? Such an analysis would move from a static picture to a dynamic understanding of system health.
- **Additional Data Integrity Analysis:** This project relies on the accuracy of data logged in NALCOMIS IMA by maintenance personnel. A future study should be conducted to further validate the integrity of NALCOMIS IMA source data. This would involve direct observation of work center practices to determine if there are systemic discrepancies between real-world maintenance actions and what is logged in the system. Key areas of focus should include the accuracy and consistency of job status code usage (e.g., distinguishing between M3, M5, and AWP), the timeliness of data entry, and the quality of narrative logs. Verifying the fidelity of the source data would strengthen the conclusions of this analysis and enhance the reliability of all future data-driven improvement initiatives.
- **Broaden the Scope:** The bottlenecks identified in this capstone applied project may be unique to FRC Mid-Atlantic or they may be indicative of enterprise-wide challenges. A valuable future study would apply the same analytical methodology to other ALSS work centers (e.g., 81B, 81C) and



across other FRCs (e.g., FRC Southeast, FRC West). Such a comparative analysis would determine if the findings are localized or systemic. Key questions include: Do other work centers also struggle with ‘M2 – Support Equipment’ delays? Is the ‘M9 – Awaiting Funding’ problem more prevalent at one FRC than another? This broader scope would provide leadership with the data necessary to determine whether solutions should be locally implemented or pursued as enterprise-level policy changes.

- **Qualitative Analysis:** Understanding the “Why,” this capstone applied project quantitatively identifies *what* the bottlenecks are and *where* they occur. A complementary qualitative study is needed to understand the human factors and cultural reasons for *why* they occur. This would involve conducting structured, anonymous interviews with technicians, supervisors, supply personnel, and financial managers. Key interview topics would include perceived reasons for M3 backlogs, frustrations with the parts ordering process, informal “workarounds” used to overcome M9 funding holds, and the decision-making process behind prioritizing work. This context is essential for developing recommendations that are not only technically sound but also culturally resonant and likely to be adopted.
- **Predictive Modeling:** The current methodology is descriptive, analyzing past performance. The next logical step is to use this historical data to build a predictive model. By applying machine learning techniques, a model could be developed to forecast the expected TRR of a component based on its type, the initial maintenance discrepancy, and the known probability of requiring specific parts. Such a tool could provide supervisors with more accurate readiness projections, allow for proactive resource allocation, and automatically flag incoming jobs that have a high probability of experiencing significant delays, enabling early intervention.
- **Impact Analysis:** This project proposes several recommendations for improvement. After these recommendations are implemented, an independent follow-on study should be conducted to rigorously measure their impact. This study would replicate the methodology of the original analysis on a new set of post-implementation data. The primary objective would be to quantify the changes in average TRR variance, the reduction in time spent in key bottleneck statuses (AWP, M2, M3), and the overall cost-benefit of the implemented solutions. This final step is essential to close the feedback loop and validate the effectiveness of data-driven decision-making in the maintenance environment.
- **Targeted Supply Chain Analysis:** While this project identifies the supply chain as the primary point of failure resulting in extended AWP times, the specific external mechanics causing these delays require deeper investigation. Future research must evaluate the broader supply chain enterprise to determine the exact cause of the parts shortages identified in this study. Specifically, researchers should analyze the demand estimation models used by NAVSUP and DLA to determine if they accurately



capture ALSS usage rates and failure modes. Additionally, investigations must focus on budgeting allocations for ALSS components and review current enterprise-level parts management practices. Determining whether the systemic supply chain failure is rooted in modeling, budgeting, parts management, or something else completely will be critical to developing permanent, enterprise-wide solutions for high-failure ALSS components.

- **Analysis of Contract Management and Procurement Lead Times:**
While this study definitively identified AWP as the primary driver of delayed TRR, the limitations of the current dataset prevented a granular analysis of the procurement life cycle itself. Consequently, it could not prove the degree of influence that contract fulfillment issues, effect AWP delays. This represents a significant opportunity for future research. Subsequent studies should focus on tracking the administrative timeline from the moment a part is ordered to the moment a contract is fulfilled by the vendor. Gathering this specific data will allow researchers to determine if agile contract management such as establishing streamlined ordering for predictable, high-cost repairs is a viable and necessary solution to reduce overall AWP time.



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APPENDIX AUTHOR BACKGROUND

A. PROFESSIONAL BIOGRAPHY

The author of this research, LT Dylan Caparo, has over six years of active-duty experience in the United States Navy, specializing in operational and intermediate level naval aviation maintenance. Throughout their career, the author has served in critical maintenance leadership and production billets at various commands, directly managing the personnel, maintenance, and administrative systems analyzed in this capstone applied project.

B. OPERATIONAL AND LEADERSHIP EXPERIENCE

The author's subject matter expertise (SME) is grounded in direct operational experience within the aviation maintenance community. Key career assignments include serving as Maintenance Material Control Officer (MMCO), Assistant Maintenance Officer (AMO), Quality Assurance Officer (QAO), and Material Control Officer (MCO) at VAQ-142, as well as the 800 (ALSS) Division Officer and QAO at Fleet Readiness Center Mid-Atlantic, Detachment Norfolk. In these roles, the author was responsible for managing daily maintenance production, overseeing maintenance personnel, enforcing Naval Aviation Maintenance Program (NAMP) policies, and navigating the complexities of the aviation supply chain to maintain fleet readiness. Furthermore, the author holds advanced qualifications in Naval Aviation Maintenance Program, NALCOMIS (Optimized) OMA Quality Assurance Administration, Financial Management for Naval Aviation Operating Target Accounting, Naval Aviation Material Control Management, Naval Aviation Maintenance Control Management for (Optimized) OMA, Aviation Officer Maintenance Fundamentals, among others.

C. DEMONSTRATION OF SUBJECT MATTER EXPERTISE AND PEER CONSULTATION

This extensive professional background establishes the author as a SME in the practical execution of naval aviation maintenance. The assertions made throughout this research regarding shop-floor practices, documentation habits, and workflow constraints



are derived from years of direct observation and active management of these exact processes.

While governing directives like the NAMP provide the strict rules for maintenance safety and administration, they are implemented by personnel facing real-world operational pressures. Consequently, a distinct body of operational “common knowledge” exists among the community. Workarounds for supply chain delays, the pressure to conform to established Time to Reliably Replenish (TRR) man-hours, and the administrative bottlenecks are universally understood by maintenance professionals, even if they are absent from written doctrine.

To ensure objectivity and validate these operational realities, the author’s independent knowledge was further corroborated through consultations with a network of active-duty SMEs. Throughout the course of this project, the author engaged with senior enlisted ALSS experts, current Maintenance Officers, and Naval Supply Officers currently operating within the Fleet Readiness Center (FRC) and broader Naval Aviation Enterprise (NAE). These consultations served to ground the author’s experiences, ensuring that the contextual insights applied to the data analysis accurately reflect current, enterprise conditions. Ultimately, the combination of the author’s deep embeddedness in the community and access to current technical experts provides the authoritative context necessary to accurately interpret the Naval Aviation Logistics Command Management Information System (NALCOMIS) intermediate maintenance activity (IMA) dataset.



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