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### **Contracted Trainers or Dedicated Airframes? Evaluating Pilot Training and Sustainment Models from the E-6B and RC-135 Communities**

June 2026

**LT Simeon L. VanderBaan, USN**

Thesis Advisors: Raymond D. Jones, Professor  
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Department of Acquisition, Finance and Manpower

**Naval Postgraduate School**

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Prepared for the Naval Postgraduate School, Monterey, CA 93943

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## ABSTRACT

The E-6B Take Charge and Move Out (TACAMO) community relies on operational mission aircraft for pilot qualification, creating a training architecture in which aircraft availability, operational tasking, and pilot production are tightly coupled. This thesis examines how alternative pilot training architectures influence training capacity, sustainment burden, and readiness as TACAMO prepares to transition from the E-6B to the E-130J. Using a comparative case study of the E-6B and RC-135 communities, the research analyzes training documents, historical Time-to-Train data, Ready-For-Tasking trends, and external sustainment assessments to compare operational-aircraft-based training with architectures that use dedicated training aircraft and higher-fidelity simulation. The analysis finds that the E-6B model produces recurring training volatility because pilot progression depends on operational aircraft availability, while the RC-135 model reduces this vulnerability by decoupling training from operational aircraft. The findings indicate that training architecture is a primary determinant of pipeline stability in low-density/high-demand fleets, not merely an administrative or syllabus design issue. The thesis recommends immediate E-6B syllabus flexibility, acquisition of an interim in-flight trainer, continued investment in higher-fidelity simulation, and a decoupled E-130J training architecture to protect pilot production and reduce sustainment risk.



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## LIST OF ACRONYMS AND ABBREVIATIONS

ACC	Air Combat Command
AR	Aerial Refueling
CAT	Category (training phase designation)
CBO	Congressional Budget Office
CRM	Crew Resource Management
DoD	Department of Defense
DIT	Delay In Training
DTIC	Defense Technical Information Center
EAM	Emergency Action Message
FTE	Flight Training Event
FY	Fiscal Year
GAO	Government Accountability Office
IP	Instructor Pilot
IUT	Instructor Under Training
LD/HD	Low-Density / High-Demand
LOFT	Line Oriented Flight Training
MQT	Mission Qualification Training
NPS	Naval Postgraduate School
O&S	Operations and Support
RFT	Ready-For-Tasking
SCW-1	Strategic Communications Wing ONE
TACAMO	Take Charge and Move Out
TTT	Time-to-Train



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## I. INTRODUCTION

While U.S. military doctrine dictates that “units must train as they will fight” (Department of the Army, 1988), the E-6B Take Charge And Move Out (TACAMO) community has been forced to interpret this literally, relying almost entirely on operational warfighting airframes to conduct initial pilot qualification. This reliance is not a strategic choice but a resource constraint; since the introduction of the E-6A in the late 1980s, the Navy has never fielded a permanent dedicated pilot training aircraft. Despite initial endorsements from the Chief of Naval Operations (1985), the program ultimately entered service without one. As a result, the E-6B training architecture is structurally “coupled” to the operational fleet: every training sortie competes directly with national tasking for the same finite pool of aircraft. Internal squadron analysis explicitly acknowledges this vulnerability, noting that in the current architecture, “every aircraft is a mission aircraft,” used for training only when not consumed by higher-priority tasking (VQ-7, 2016).

The absence of a dedicated training aircraft has shaped TACAMO’s training culture for over 30 years, mandating that nearly all pilot instruction occur on operational aircraft. In contrast, the Air Force’s RC-135 community employs a fundamentally different approach built around dedicated training aircraft, simulator infrastructure, and a broader maintenance and instructor ecosystem (Department of the Air Force, 2023b). These approaches reflect two distinct philosophies for producing aircrew in a low-density/high-demand mission area. As both fleets face increasing age-related maintenance demands and rising training requirements, the performance of these two models has direct effects on readiness, pilot throughput, and long-term sustainability across the U.S. Department of Defense.

Despite the importance of these training architectures, the Department of Defense has not evaluated how the E-6B and RC-135 models influence pilot proficiency, readiness, or training throughput. Existing studies address maintenance availability, simulator effectiveness, and workforce constraints, but none directly compare these two low-density/high-demand aviation communities or assess how their differing approaches



affect the sustainability of their pilot pipelines. This gap has become increasingly significant as the Navy prepares to transition to the E-130J, a change that will require a scalable and resilient training system.

## **A. PROBLEM STATEMENT**

The problem is that early E-6B program decisions established a training architecture that did not fully account for the long-term organizational, sustainment, and readiness implications of relying on operational aircraft, constraining present-day training capacity and sustainment investment choices. This architectural dependence on mission aircraft creates a “coupled” system where minor disruptions in aircraft availability cascade into volatility in pilot throughput, evident in recent training delays that strain instructor capacity and sustainment resources (U.S. Congressional Budget Office [CBO], 2021; U.S. Government Accountability Office [GAO], 2022). As the community prepares for the E-130J, uncertainty about how these structural dependencies degrade readiness complicates long-term life cycle planning for the new platform.

Detailed analysis of recent training data confirms the severity of this coupled training architecture. Unlike the Air Force’s RC-135 program, which employs dedicated training aircraft (TC-135) to decouple training from operational tasking (Department of the Air Force, 2024b), the TACAMO community relies exclusively on operational aircraft for pilot instruction. This structural dependence exposes training schedules to operational priorities and external resource constraints. Recent Time-to-Train data show that pilot qualification timelines fluctuated from 43 to 101 days within a single fiscal year, with delays driven primarily by competition for operational aerial refueling assets (AR) (VQ-7 Training Department, 2026b). These delays introduce variability into training timelines and reduce the predictability of pilot progression.

Historical data further reinforce that these structural constraints have direct effects on readiness. Previous gaps in dedicated training asset availability have correlated with declines in Ready-For-Tasking rates of approximately 12–25% (VQ-7, 2016). Despite these measurable risks, the Department of Defense has not evaluated how the E-6B and RC-135 models compare in terms of pipeline stability or long-term sustainability.



Existing analyses address maintenance or simulator effectiveness but do not assess how training architecture itself shapes the ability to generate mission-ready aircrew.

These conditions highlight a critical gap in the Navy's ability to provide a stable, scalable, and resilient pilot training system. Absent architectural change, the TACAMO training pipeline is likely to remain vulnerable to operational disruption, increasing risk to fleet readiness during the E-130J transition. Accordingly, this study examines how differences in pilot training architecture influence training capacity and stability, sustainment burden, and readiness outcomes across the TACAMO and RC-135 communities, with the goal of informing future acquisition and training decisions.

## **B. RESEARCH OBJECTIVES**

The primary objective of this study is to evaluate how alternative pilot training architectures shape long-term training capacity and stability (including pilot throughput), sustainment burden, and readiness outcomes for the TACAMO community. Specifically, the study examines the organizational and resource implications associated with reliance on operational aircraft, dedicated training airframes, and contracted training solutions over a platform life cycle.

To achieve this objective, the analysis evaluates historical changes in TACAMO's access to training aircraft and their effects on training pipeline stability and resource demand, compares these dynamics with the Air Force's RC-135 training and sustainment architecture, and assesses how differing architectural models influence readiness outcomes and sustainment burden. The study further considers how these findings inform early architectural decisions associated with the Navy's transition from the E-6B to the E-130J.

The research questions guiding this analysis are as follows.

### **1. Primary Research Question**

How do alternative pilot training architectures influence long-term training capacity, sustainment burden, and readiness outcomes for the TACAMO community as it transitions from the E-6B to the E-130J?



## **2. Secondary Research Questions**

1. How have historical changes in TACAMO's access to training aircraft affected training pipeline stability and sustainment burden over time?
2. How is the RC-135 community's training and sustainment model structured, and what resource and integration effects distinguish it from the TACAMO approach?
3. How do contracted trainers, dedicated training airframes, and reliance on operational aircraft differ in their impacts on training capacity and stability, readiness outcomes, and long-term sustainment burden?
4. What training and sustainment assumptions risk being carried forward into the E-130J if legacy E-6B training architecture decisions remain unexamined?

## **C. METHODOLOGY**

This project uses a comparative case study approach to examine differences in pilot training architectures between the E-6B TACAMO community and the Air Force's RC-135 community. The study utilizes an 'Intended Design vs. Observed Behavior' analytical framework to determine how resource allocation strategies influence training system performance. The analysis draws on three primary categories of sources: (1) quantitative training data, including pilot Time-to-Train (TTT) logs and Ready-For-Tasking (RFT) rates; (2) official training documents, including Air Force syllabi, Navy syllabi and Navy training trackers; and (3) external assessments from Government Accountability Office (GAO) reports, RAND Corporation studies, and internal squadron documents.

The approach focuses on comparing two distinct architectural models: the E-6B's 'coupled' model, which relies on operational aircraft for training, and the RC-135's 'decoupled' model, which utilizes dedicated training aircraft (TC-135). By analyzing training inputs, specifically aircraft availability, simulator fidelity, and syllabus structure, the study evaluates the effects of each architectural model on training pipeline stability, sustainment risk, and readiness outcomes. Findings are synthesized to identify which architectural features provide the most resilient model for Low-Density/High-Demand (LD/HD) fleets and to derive specific acquisition recommendations for the upcoming E-130J transition.



## **D. SCOPE AND LIMITATIONS**

The study is limited by differences in data granularity between the two services. While detailed, sortie-level training logs are available for the E-6B community, however similar granular data for the RC-135 fleet is not publicly available. To address this limitation, the study adopts a qualitative comparative approach for the Air Force, utilizing unclassified GAO sustainment reports, authorized training syllabi, and public readiness data to establish a structural baseline for the RC-135 ‘Intended Design’. Consequently, this study does not present a direct statistical comparison of individual pilot proficiency but rather compares the organizational reliability and pipeline stability produced by each system. The intent is to identify structural differences and architectural risks relevant to future acquisition decisions, including the transition to the E-130J.

## **E. ORGANIZATION**

This thesis is organized into five chapters. Chapter I introduces the research problem, outlines the research objectives and questions, summarizes the methodological approach, and defines the scope and limitations of the study. Chapter 2 provides background on the E-6B mission and training environment and establishes the theoretical framework used to examine training system design and behavior. Chapter 3 reviews relevant literature related to military aviation training systems, simulation-based training, and sustainment considerations for low-density, high-demand platforms. Chapter 4 presents the analytical framework and comparative analysis of the E-6B and RC-135 pilot training architectures, with emphasis on system behavior, resource constraints, and observed outcomes. Chapter 5 synthesizes the findings and offers recommendations for training system design and sustainment, along with implications for future research



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## **II. BACKGROUND**

This chapter provides background on the missions, platforms, and organizational contexts that shape pilot training in the TACAMO and RC-135 communities. It traces the historical development, the operational demands placed on the respective aircraft, and the institutional choices that influenced how training systems evolved over time. By establishing this context, the chapter highlights how mission requirements, platform characteristics, and sustainment realities constrain training design and resource allocation. This background frames the comparative analysis in later chapters by showing that differences in training effectiveness are rooted in structural and historical conditions rather than short-term management decisions.

### **A. MISSION HISTORY**

Strategic airborne command, control, and communication missions occupy a unique place within United States Department of Defense (DoD) structure. Platforms assigned to these missions must remain capable of delivering reliable communications in contested or degraded environments and must be available for continuous operations (Congressional Research Service [CRS], 2021). Within this broader strategic landscape, TACAMO provides reliable, survivable and enduring communications to the national command authority through the E-6B Mercury aircraft (Naval Air Systems Command, 2024). Since its introduction, TACAMO has served as a key element in the nation's nuclear command, control, and communications architecture by ensuring the ability to relay Emergency Action Messages (EAM) under a wide range of scenarios. The mission demands high aircraft availability, well-trained aircrew, and the ability to operate in a low-density and high-demand environment, which places additional strain on training systems and fleet resources.

### **B. HISTORICAL CONTEXT OF E-6B AND RC-135 TRAINING MODELS**

Even before initial operational capability, the Navy recognized the need for a dedicated training airframe for the TACAMO mission. In 1985, the Chief of Naval Operations formally affirmed the requirement for an In-Flight Trainer (IFT), citing the



strain placed on the small E-6A fleet by using operational aircraft for pilot training (Chief of Naval Operations, 1985). However, as broader geopolitical conditions shifted in the late Cold War period, Navy funding priorities changed rapidly, and the acquisition of a permanent training aircraft was repeatedly deferred.

During this period, TACAMO relied on a series of interim solutions. In the late 1980s, Air Force E-3 aircraft were used to support training while contract options were explored. In the early 1990s, the Navy briefly contracted Boeing 707 aircraft, but that arrangement was allowed to lapse before being directed for renewal by the CNO in 1993 (VQ-7, 2016). Subsequent cost analyses supported the outright purchase of dedicated IFTs, yet shortly after Naval Air Systems Command exercised that option, the TC-18F aircraft were grounded due to mandatory FAA inspections. The loss of the IFT capability resulted in an approximately 25% reduction in RFT rates across the TACAMO fleet (VQ-7, 2016).

A similar pattern repeated in the following decade. In 2001, the Navy executed a new contract for a Boeing 737–200 training aircraft, later followed by a 737–600, which remained in service until 2010. When that contract ended, TACAMO again experienced an 18% decline in RFT, reinforcing the relationship between training aircraft availability, time-to-train, and fleet readiness (VQ-7, 2016). Across multiple decades, every significant gap in IFT availability corresponded with longer training timelines and measurable readiness degradation. This historical record underscores the persistent demand for a dedicated training aircraft within a small, high-utilization fleet.

In contrast, the RC-135 community developed under a fundamentally different set of conditions. This structure allowed training risk and instructional sorties to be absorbed by non-operational airframes, insulating mission aircraft and preserving Ready-For-Tasking rates. In addition, the RC-135 enterprise benefits from a command structure that separates operational and maintenance responsibilities, enabling sustainment practices to evolve without directly disrupting flight operations (United States Air Force, 2020).

These structural differences produced tangible outcomes. Maintenance reforms and sustainment initiatives within the RC-135 community increased aircraft availability to the point that the fleet was able to meet, and in some cases exceed, assigned mission



tasking, reportedly reaching 108% of required sortie generation (Roza, 2023).

Institutional factors also played a role. Within the Air Force, the RC-135 represents one of many large aircraft platforms, whereas the E-6B remains the largest aircraft in the Navy inventory by a wide margin. As a result, the Air Force entered the RC-135 mission space with a more mature framework for manning, maintaining, and training large-aircraft aircrews.

When examined side by side, the divergence between these two training systems is clear. TACAMO evolved with a small fleet, inconsistent access to training aircraft, and a mission profile that left little margin for downtime. The loss of even a single aircraft to maintenance or training requirements had immediate effects on pilot throughput and RFT rates. The RC-135 community, supported by dedicated trainers and a more insulated sustainment model, avoided this constant trade-off between operational tasking and pilot production. As both the GAO and CBO have shown, small fleets experience disproportionate readiness impacts from availability losses, a reality TACAMO has faced repeatedly over decades (U.S. Congressional Budget Office, 2021; U.S. Government Accountability Office, 2022).

These historical development paths explain why TACAMO and RC-135 communities train the way they do today, which informs the analysis in the next chapter.

### **1. E-6B TACAMO: The “Mission Aircraft” Constraint**

Internal VQ-7 analysis emphasizes that in this environment, “every aircraft is a mission aircraft,” meaning operational airframes must be used as trainers whenever they are available (VQ-7, 2016). This creates a “coupled” system where training competes directly with national tasking. Historical data reveals that this reliance creates a predictable cycle of readiness degradation whenever dedicated training assets are removed (VQ-7, 2016):

- FY92: When the lease for B-707-300 trainers was not renewed, RFT rates dropped by 12%.
- 2000: When the TC-18F dedicated trainer was grounded, RFT rates dropped by 25%.



- 2010–2016: Following the expiration of a Boeing 737 training contract, RFT rates declined by 18%, while Student TTT increased significantly and became less predictable.

While the community operates two full-motion Operational Flight Trainers (OFTs) for procedural instruction, these devices do not fully replicate the aircraft handling characteristics or the physical workload associated with AR the E-6B. As a result, a large share of pilot training continues to depend on the availability of operational aircraft, exposing mission airframes to significant wear-and-tear and further degrading readiness.

## 2. RC-135: The Dedicated Resource Model

In contrast, the U.S. Air Force RC-135 community operates under a “decoupled” training architecture. Despite facing similar “aging aircraft” and “supply support” challenges identified by the GAO, the Air Force insulates its pilot production pipeline from operational volatility through two structural mechanisms:

1. **Dedicated Training Assets:** The fleet utilizes the TC-135, a dedicated training platform, to conduct flying events such as touch-and-go landings and receiver air refueling that would otherwise consume operational sorties.
2. **Syllabus Design:** The RC-135 syllabus explicitly accounts for maintenance variability. The syllabus authorizes “‘X’ Events,” sorties cancelled due to maintenance or weather.

The RC-135 utilizes a “Phase Check” system where students must demonstrate proficiency in the simulator before progressing to the aircraft. This ensures that the aircraft is used only for validating skills, rather than teaching basic acquisition.

The RC-135 community serves a similar but distinct role within the Air Force. Operated primarily by the 55th Wing, the RC-135 fleet conducts intelligence, surveillance, reconnaissance, and strategic communication missions for joint and allied forces (Offutt Air Force Base 55th Wing Public Affairs, 2022, 2023). The community includes multiple variants tailored to specialized intelligence missions, as well as the TC-135 aircraft that support dedicated training. Like TACAMO, the RC-135 community operates in a low-density and high-demand environment and relies on a relatively small number of aircraft that must support both operational and training requirements (U.S. Air Force, 2020).



Pilot training in the TACAMO community relies on a mixed model of simulator and aircraft-based instruction, with operational aircraft remaining a central training resource. The community operates two full-motion Operational Flight Trainers (OFTs) that support procedural instruction, emergency training, and selected crew coordination tasks (Myers, 2018). These devices provide valuable opportunities to practice mission scenarios and systems management without consuming aircraft flight hours. However, the OFTs do not fully replicate aircraft handling characteristics, certain communication functions, or the physical workload associated with flying the E-6B. As a result, many training objectives, particularly those tied to aircraft control, workload management, and integrated mission execution, continue to require access to operational aircraft (de Winter et al., 2012; Misra et al., 2022).

In contrast, the RC-135 community employs a training architecture that places greater emphasis on dedicated training assets and higher-fidelity simulation. The availability of the TC-135 fleet provides a purpose-built platform for flying events that would otherwise compete with operational aircraft tasking. When paired with established simulator infrastructure and a larger instructor and maintenance ecosystem, this structure enables greater flexibility in scheduling and reduces training disruptions driven by operational demands. As a result, the RC-135 community is able to sustain a more predictable and stable training pipeline while limiting reliance on front-line aircraft for qualification and continuation training (Offutt Air Force Base 55th Wing Public Affairs, 2022; RAND Corporation, 2023).

Both communities now operate within an environment characterized by aging aircraft, increasing maintenance demands, and sustained operational tasking. The Navy's planned transition from the E-6B to the E-130J highlights how long-term platform sustainment pressures intersect with pilot training design and readiness outcomes (Naval Air Systems Command, 2024). Broader research on aircraft availability and sustainment trends indicates that maintenance requirements continue to grow across multiple fleets, constraining aircraft access and placing additional strain on training pipelines (CBO, 2021; GAO, 2022). Under these conditions, training architectures that depend heavily on operational aircraft are increasingly vulnerable to disruption, making historical design choices a meaningful driver of present-day training capacity and readiness.



## C. THEORETICAL FRAMEWORK

Training system design in large aircraft aviation is influenced by established theories from the fields of human factors, organizational behavior, and aircraft availability. These theories apply across military and civilian flight operations and help explain how aircrew develop proficiency, how training environments influence performance, and how organizations structure training pipelines to meet operational demands. Large aircraft platforms, whether used for strategic communication, intelligence collection, cargo transport, or airline operations, share common challenges related to aircraft complexity, crew coordination, high workload, and the need for standardized training. These factors make training architecture an essential component of overall system effectiveness.

The same theoretical principles that guide airline and cargo pilot development also provide insight into the training demands of military communities such as the E-6B TACAMO and RC-135 fleets. However, to evaluate the specific structural differences between these two communities, this study narrows this broad theoretical field into a multidisciplinary framework that combines training effectiveness, organizational reliability, and sustainment economics. These theories provide the explanatory mechanisms, and the specific analytical definitions, used in Chapter 4 to determine why different architectural choices lead to vastly different readiness outcomes in LD/HD fleets.

### 1. Training Effectiveness Theory

A core body of research in the training sciences establishes that proficiency develops not merely through experience, but through structured practice, timely feedback, and repeated exposure to relevant tasks. Successful training programs align the training environment with the operational environment as closely as possible, ensuring that learners are exposed to the appropriate aircraft systems, workload, environmental cues, and communication demands. However, Marler et al. (2023) expand on this by proposing a “Logic Model” for Live, Virtual, and Constructive (LVC) training. This model posits that decisions about training media must align with specific task requirements rather than defaulting to live flight; according to this framework, high-



fidelity simulation is often superior for “Mission Essential Competencies” that require complex cognitive processing, as it allows for the repetition and “freezing” of scenarios that are impossible in live aircraft.

Effective instruction further requires a systematic approach to these events. Myers et al. (2018) emphasize that training transfer is optimized when using established frameworks such as Gagné’s nine events of instruction, which depend heavily on “eliciting performance” and “providing feedback” in a controlled environment. This theoretical basis suggests that training systems must minimize variability and interruption, since inconsistent training schedules reduce retention and increase the time required to achieve proficiency. In the context of the E-6B, the reliance on operational aircraft disrupts this requirement; when training competes with operational tasking, schedule variability degrades retention, forcing students to relearn skills after maintenance delays rather than progressing through a structured sequence.

## **2. Transfer of Training and Simulation Fidelity**

The transfer-of-training model explains how skills developed in a training environment carry over into real operational contexts. The degree of transfer is influenced by the fidelity of the training device, the relevance of the task being practiced, and the learner’s ability to recognize and apply learned cues to real situations. Myers et al. (2018) define “near transfer” as the improvement resulting from practicing different but similar events, noting that high-fidelity simulation can effectively transfer skills to the aircraft, thereby mitigating the risks and costs associated with live flight training.

Simulator fidelity is a critical element of this theory. High-fidelity simulators can replicate many aspects of mission execution, including workload management, communication, navigation, and emergency procedures. However, simulation alone cannot fully replace aircraft-based training, especially for aircraft-handling skills. The integration of simulator and aircraft training must be designed to maximize transfer and minimize gaps between training conditions and operational requirements. Training organizations routinely observe that pilots who perform well in simulators can become overwhelmed when transitioning to aircraft events. Factors such as variable winds, dense radio traffic, increased internal aircraft communication, and the physical environment of



a large aircraft—including vibration, heat, and ambient noise—introduce levels of complexity that are often imperfectly replicated in a simulator. These differences illustrate the challenges associated with transferring skills from controlled training environments to dynamic operational contexts.

Crucially, Cao et al. (2024) highlight the inverse risk of “negative transfer,” which occurs when training devices do not sufficiently match the operational aircraft. Using a similarity assessment based on Levenshtein distance (a string metric for measuring the difference between two sequences), Cao et al. demonstrate that significant differences in cockpit controls and panel layout increase both training difficulty and cost. This theory is critical for evaluating the E-6B community’s recent adoption of the Boeing 737 Next Generation (NG) as a contracted interim trainer. While the 737 NG provides a reliable flying platform, its modern “glass cockpit” avionics suite differs substantially from the legacy “steam gauge” instrumentation of the E-6B. According to Cao’s framework, this low similarity score introduces negative transfer risks that are architecturally absent in the RC-135 model, which utilizes TC-135 aircraft and Operational Flight Trainers (OFTs) that are exact replicas of the mission aircraft. Consequently, the RC-135 model supports “near transfer” (positive reinforcement), whereas the E-6B’s reliance on dissimilar commercial aircraft risks “negative transfer” (interference with habit patterns).

### **3. Cognitive Task Analysis and Skill Acquisition**

Cognitive task analysis is a theoretical approach (Feldon, 2007) that breaks complex tasks into component cognitive processes. In aviation, pilots must integrate procedural knowledge, decision-making, communication, and aircraft-handling skills while managing high workload. Effective training develops not only technical proficiency but also the ability to anticipate, identify, and respond to complex operational scenarios (Feldon, 2007).

Training architectures influence cognitive skill acquisition by shaping the frequency, structure, and sequencing of practice. Systems that allow consistent exposure to controlled training environments support deeper cognitive development, while systems reliant on operational aircraft often face interruptions that disrupt skill progression



(Endsley, 2015). Therefore, the E-6B's reliance on operational aircraft for initial qualification not only couples the schedule to fleet availability but also creates a cognitive bottleneck, forcing the expensive operational platform to be used for elemental skill acquisition rather than advanced mission training.

#### **4. Organizational Reliability and Pipeline Stability Theory**

Pilot training pipelines can be viewed through the lens of Organizational Reliability Theory, which examines how organizations maintain consistent performance in complex, high-risk environments. According to this framework, systems with stable inputs, predictable processes, and controlled variations generate more reliable outputs (Endsley, 2015). For aviation communities, this means that training architectures must support consistent access to aircraft, instructors, and support personnel. Variability caused by maintenance or operational tasking reduces organizational reliability by creating unpredictable training conditions.

To analyze the specific impact of this variability on pilot development, this study utilizes Kozlowski's (2012) theory of Team Compilation. Kozlowski posits that performance evolves through distinct phases, from "Formation" (Phase 1) to "Task Compilation" (Phase 2), and that this evolution requires stable, uninterrupted resource access to transition skills from conscious effort to automaticity.

The Coupled System (E-6B): In the E-6B architecture, training production is "tightly coupled" to operational aircraft availability. Per Kozlowski's framework, when maintenance interruptions sever the training timeline, students are forced to regress from Task Compilation back to Formation, relearning baseline skills rather than progressing.

The Decoupled System (RC-135): The RC-135 architecture utilizes buffers—specifically the dedicated TC-135 trainer and "X-Event" (cancellation) authorizations in the syllabus—to "decouple" training from operations. This structural separation shields the training pipeline from operational volatility, allowing the compilation process to proceed linearly despite external fleet pressures.



## 5. Low-Density, High-Demand Operational Constraints

Aviation communities such as TACAMO and the RC-135 operate in what the Department of Defense characterizes as Low-Density/High-Demand (U.S. Government Accountability Office, 2023) (LD/HD) environments. LD/HD units are defined by small fleet sizes, specialized missions, and often continuous operational tasking, which together create persistent pressure on aircraft availability, crew scheduling, and maintenance tempo. In these environments, even minor disruptions—such as unscheduled maintenance, emergent tasking, or weather delays—cascade across the entire force because there are no excess aircraft or crews to absorb variability.

These constraints highlight the inherent tension between training and operations when limited assets must serve both simultaneously. Because operational requirements typically receive priority, training events in LD/HD fleets are often deferred, compressed, or canceled when aircraft availability dips. GAO-23-106217 explicitly identifies that both the E-6B and RC-135 fleets currently face significant “aging aircraft” challenges, including “unexpected replacement of parts” and “delays in depot maintenance,” which exacerbates this volatility. When training pipelines are tightly coupled to these unreliable assets, fleet-wide readiness degrades because training backlogs accumulate faster than units can produce qualified aircrew.

For these reasons, LD/HD units require training architectures that deliberately buffer pilot production from operational volatility. Research by Marlow et al. (2015) on aircraft fleet management modeling demonstrates that unscheduled maintenance has a “tremendous influence” on fleet performance. Their simulations indicate that in systems with high maintenance variability, specific management policies—such as segregating resources or creating “sharing” heuristics—are required to meet flying hour goals.

This theoretical perspective supports the RC-135’s use of the TC-135 as a dedicated buffer. By segregating training capacity from the operational fleet, the architecture aligns with Marlow’s findings that specialized resource allocation is necessary to counteract the destabilizing effects of aging aircraft maintenance. Conversely, the E-6B’s reliance on operational aircraft violates this principle, leaving the



training pipeline fully exposed to the “unscheduled maintenance” risks identified by the GAO

## **6. Readiness Theory and Sustainment**

Military readiness is broadly understood as the ability of a unit to deliver required capabilities under expected conditions (U.S. Government Accountability Office, 2022), and it is shaped by far more than resource levels alone. Contemporary readiness frameworks emphasize that readiness is the output of interdependent systems that include personnel proficiency, aircraft availability, maintenance capacity, training throughput, and organizational processes. Research on aircraft availability and sustainment demonstrates that maintenance cycles, age-related degradation, and operational tasking patterns directly influence training output and overall readiness.

To evaluate the sustainability of training architectures, this study utilizes Unger’s (2009) framework of Air Force Operating and Support (O&S) costs. Unger distinguishes between “Variable Costs” (expenses that scale with flying hours, such as fuel and depot-level reparables) and “Fixed Costs” (expenses that scale with Total Aircraft Inventory or TAI, such as fleet-wide modifications and support equipment).

By rejecting a dedicated trainer, the Navy adopted a “Variable Cost” model, attempting to save the fixed cost of procuring a trainer. However, this forces the community to burn expensive operational flight hours for training. VQ-7 (2016) analysis shows that this approach directly reduces the number of aircraft available for alert and operational tasking, intensifying readiness constraints.

The Air Force accepts the higher “Fixed Costs” of maintaining the dedicated TC-135 fleet and high-fidelity simulators. Theoretically, this investment stabilizes long-term O&S costs by offloading “wear-and-tear” from the mission fleet, thereby preserving the fatigue life of the primary warfighting assets.

The choice between these economic models is critically influenced by fleet age. Hewitson et al. (2018) and GAO-23-106217 demonstrate that as aircraft age, they incur exponential O&S cost growth and unscheduled maintenance requirements. In aging fleets like the E-6B and RC-135, relying on operational aircraft for training (the Variable Cost



model) becomes increasingly unsustainable because the “delivery system” becomes unreliable due to parts obsolescence and corrosion.

## **7. Implications for Aviation Training Architecture**

Training architectures that incorporate protected training capacity, such as dedicated training aircraft or high-fidelity simulators, can buffer pilot production from operational volatility and maintenance disruption, particularly in constrained fleets. In contrast, systems that rely solely on operational aircraft often experience reduced throughput and periods of degraded readiness when operational or maintenance demands surge. Camm et al. (2025) argue that failing to account for these long-term operation and sustainment funds dynamics during acquisition, such as the E-130J transition, creates a false economy where initial savings on trainers are eclipsed by long-term readiness degradation. These dynamics illustrate why training-system design is a key sustainment mechanism for ensuring long-term fleet readiness.

Together, these theories suggest that training systems must provide stable training opportunities and consistent access to high-fidelity simulators, resulting in predictable progression pathways that minimize the risk of “negative transfer” and cognitive overload. They emphasize the critical need to design “decoupled” architectures that shield pilot production from operational interruptions, especially in Low-Density/High-Demand (LD/HD) environments where resources are limited and mission demands are continuous.

This theoretical foundation supports the structure of the study by establishing the principles that underlie effective training and explaining why training architecture is a primary driver of both readiness and long-term sustainment costs. These theories inform the subsequent examination of TACAMO and RC-135 training systems and provide the specific analytical lens through which structural differences will be evaluated in Chapter 4.



### **III. LITERATURE REVIEW**

This chapter reviews existing literature related to pilot training and sustainment in large-aircraft aviation, with an emphasis on how training systems influence readiness, training capacity, and pipeline stability in low-density, high-demand environments. The review draws from peer-reviewed research, GAO reports, policy documents, and Naval Postgraduate School theses to capture how these issues have been examined across both military and commercial aviation.

#### **A. OVERVIEW OF PILOT TRAINING AND SUSTAINMENT LITERATURE**

The literature spans several interconnected areas. These include studies on pilot training effectiveness, simulator fidelity and transfer of training, aircraft availability and sustainment, and broader workforce constraints affecting aviation communities. Taken together, this body of work provides insight into how training systems are structured, how pilots develop and sustain proficiency, and how resource limitations shape readiness outcomes over time.

The chapter is structured to move from general research on pilot training and readiness to more focused discussion of training architectures within the E-6B TACAMO and RC-135 communities. It then places these findings within the broader flight training and simulation literature before identifying gaps that remain unaddressed. Those gaps directly motivate the comparative analysis developed in later chapters.

#### **B. IMPORTANCE OF PILOT TRAINING AND SUSTAINMENT IN READINESS**

The physical constraints governing long-range submarine communications place firm limits on system design. Communicating with deeply submerged submarines requires extremely low frequency signals, which in turn demand very large antenna systems. Early approaches relied on fixed shore-based antenna sites or converted aircraft carriers, but these platforms were large, immobile, and easily identified. The TACAMO concept addressed these limitations by pairing a multi-mile trailing antenna with an aircraft platform, creating a mobile communications capability with global reach.



That capability, however, comes with trade-offs. Flying a mission this specialized, with equipment that exists nowhere else in naval aviation, places a heavy training burden on a very small aircrew community. Pilot production represents a significant investment of time and resources, and maintaining wartime readiness requires sustaining a cadre larger than what peacetime operations alone would demand. RAND research estimates that training a command, control, intelligence, surveillance, and reconnaissance aircraft pilot costs approximately \$5.5 million, and even modest delays can push that cost higher while degrading readiness (Mattock et al., 2019). Related analyses from the CBO and the U.S. GAO show that readiness challenges across U.S. military aviation leave little room for delay, particularly in small fleets (U.S. Congressional Budget Office, 2021; U.S. GAO, 2022).

### **C. BROADER FLIGHT TRAINING AND SIMULATION LITERATURE**

Modern pilot training has grown more demanding not only because airspace has become more congested, but because aircraft systems have increased significantly in complexity (Salas et al., 1998). Contemporary pilots are required to master both fundamental aircraft handling skills and the technical management of increasingly automated flight decks. The E-6B exemplifies this challenge, combining advanced automation with legacy systems that rely heavily on human monitoring and intervention. This hybrid design places additional cognitive demands on pilots and contributes to extended training timelines, even after completion of the initial qualification syllabus. These demands are further amplified by growing attention from peer and near-peer adversaries, increasing the operational consequences of training errors and reinforcing the need for highly disciplined, repeatable training pipelines.

Research consistently shows that pilot proficiency is shaped not only by the quantity of training, but by how training is structured. Marques et al. (2023) emphasize that structured progression, deliberate practice, and well-designed training sequences are critical to producing proficient pilots. Earlier work similarly demonstrates that experience alone is insufficient without organized learning environments that integrate classroom instruction, simulation, and aircraft training (Marques et al., 2023; Salas et al., 1998).



Simulators play a central role in modern pilot training pipelines, but the literature is clear that they are not a full substitute for aircraft-based training. Simulator effectiveness depends heavily on instructional quality, device fidelity, and the extent to which the training environment replicates real-world conditions, including air traffic density, environmental variability, and workload (Birdsong & Reesman, 2024). Numerous studies demonstrate positive transfer of training from simulators to aircraft, particularly during early skill acquisition (de Winter et al., 2012). Misra et al. (2022) further show that structured simulator programs improve subsequent aircraft performance by allowing students to establish baseline competence before transitioning to more complex flight tasks.

Training outcomes are also strongly influenced by recency and continuity. Smith et al. (2017) identify a complex relationship between training background, simulator exposure, aircraft experience, and the timing between training events. Large gaps between instruction and execution degrade performance and reduce training efficiency. Although safety-driven training standards have contributed to historically high levels of aviation safety, delays in training pipelines increase both cost and skill decay (Mattock et al., 2019). Efforts to introduce new training technologies, such as virtual reality-based simulators, have shown promise as supplemental tools but have not proven capable of replacing existing training methods (Pennington et al., 2019).

These challenges are magnified in small fleets, where limited aircraft availability shifts an outsized portion of training demand onto simulators. While decades of research examine pilot learning, simulator fidelity, and instructional methods, the literature does not address how different military services design and sustain training systems for comparable large-aircraft communities. Nor does it examine how these structural choices affect readiness outcomes in low-density, high-demand fleets. This gap leaves unanswered questions about how training architecture, rather than individual training tools, shapes long-term pilot production and operational readiness.

#### **D. GAPS IN THE EXISTING LITERATURE**

While there is a substantial body of research examining how pilots are trained, much of this work focuses on individual skill acquisition or curriculum design rather than



the structure of entire training systems. Studies frequently analyze training effectiveness at the course or syllabus level, but they do not compare how different U.S. Department of Defense communities design and sustain full pilot training pipelines for similar aircraft types. Research by Marques et al. (2023), Birdsong and Reesman (2024), and Salas et al. (1998) provides detailed insight into how pilots learn, yet stops short of evaluating how multiple training programs operate at the organizational level. Even studies addressing simulator effectiveness and transfer of training do not examine broader architectural questions, such as aircraft ownership, training aircraft availability, syllabus sequencing, or the interaction between training demand and operational tasking (de Winter & Dodou, 2012; Misra et al., 2022).

This omission is particularly significant for small fleets operating highly specialized aircraft. Both the E-6B and RC-135 communities operate aircraft that are unique in their missions and constrained in fleet size, resulting in limited capacity for pilot training. The RC-135 community addressed this constraint using dedicated TC-135 training aircraft, while TACAMO did not. In the absence of a dedicated trainer, maintenance issues affecting even a single aircraft in a small fleet force training to compete directly with operational tasking, leading to delays and gaps in pilot production (U.S. Government Accountability Office, 2022). Prior research demonstrates that small fleets without dedicated training aircraft are disproportionately vulnerable to availability disruptions, yet this relationship is rarely examined in the training literature (U.S. Congressional Budget Office, 2021).

Another critical gap is the lack of research connecting training system design to operational readiness outcomes. While numerous studies show how pilots learn and how simulation improves performance, few examine how the structure of a training system as a whole influences a fleet's ability to execute its mission. This omission is particularly consequential for low-density, high-demand or no-fail communities. Evidence from the Air Force demonstrates that maintenance reforms and predictable training architectures can directly increase aircraft availability and enable fleets such as the RC-135 to meet or exceed mission tasking requirements (Air Force Public Affairs, 2020; Air & Space Forces Magazine, 2023). TACAMO's experience illustrates the opposite effect: unstable access to training aircraft and a fragile training pipeline have repeatedly produced



measurable declines in Ready-For-Tasking whenever training aircraft were unavailable or operational aircraft were diverted to maintenance (VQ-7, 2016). Despite these outcomes, no existing study integrates training architecture, fleet sustainment, and readiness into a unified analytical framework.

This gap is not merely academic. As the Navy prepares to transition from the E-6B to the E-130J, it faces the challenge of designing a new training architecture for a fleet that will remain small, highly specialized, and operationally critical. At present, there is no established training model and no dedicated training aircraft, and only limited analysis to inform how the Navy can avoid repeating TACAMO's historical training shortfalls.

## **E. SUMMARY**

A consistent theme emerges: modern pilot training has become more complex, more resource-intensive, and less forgiving of disruption. Research consistently shows that producing a proficient pilot requires repeated exposure to tasks, structured progression, and a deliberate mix of classroom instruction, high-fidelity simulation, and aircraft time. Studies of simulator effectiveness demonstrate meaningful transfer of training for many skills, but they also reinforce a consistent conclusion: aircraft availability and real-world flight experience remain essential to effective pilot development. Training outcomes are shaped not just by how pilots learn, but by how training systems are designed to manage time, cost, and access to limited resources.

At the same time, the literature leaves several critical questions unanswered. There is no comparative analysis of how different military services structure training systems for similar large-aircraft communities, nor is there meaningful examination of how training architecture affects operational readiness in small, high-stakes fleets. Existing research largely treats training as an instructional problem rather than a system problem, overlooking the realities faced by communities such as TACAMO and the RC-135, where fleet size, aircraft availability, and continuous mission demands directly constrain training throughput. The Navy's impending transition to the E-130J further exposes this gap, as there is currently no established training model and little analysis addressing whether a dedicated trainer is necessary to sustain readiness over time.



To examine these possible shortcomings in a real world operational context, this study compares the pilot training and sustainment architectures of the E-6B TACAMO and RC-135 communities. Rather than focusing solely on instructional methods, the analysis examines how training-system design influences readiness, pilot production, and the long-term sustainability of the force as a whole. The intent is to inform future training decisions and reduce the risk of repeating structural problems that have historically undermined training stability in small, mission-critical aviation communities.



## IV. ANALYSIS

This chapter examines pilot training systems as integrated, resource-constrained enterprises operating across the platform life cycle. Rather than evaluating instructional quality or individual performance, the analysis focuses on how structural design choices influence training capacity, pipeline stability, readiness outcomes, and long-term sustainment burden. The objective is to assess how alternative training architectures behave under real-world conditions, particularly within low-density/high-demand (LD/HD) environments, and to determine how these effects inform the transition from the E-6B to the E-130J.

### A. ANALYTICAL FRAMEWORK AND SCOPE

The analysis is grounded in a comparison between Intended Training Design and Observed System Behavior. Intended Training Design reflects the codified structure of training syllabi, including sequencing, device utilization, and assumed resource availability. These designs implicitly assume stable access to aircraft, instructors, and training devices. Observed System Behavior reflects execution in practice, as captured in Time-to-Train (TTT) data and qualification records. These data reveal friction introduced by maintenance constraints, operational tasking, and resource competition.

The scope includes Pilot Initial Qualification and Requalification in both the E-6B and RC-135 communities. While proficiency is not directly measured, the analysis relies on Transfer of Training principles, where continuity and repetition drive skill retention. Interruptions therefore degrade performance, increase retraining requirements, and extend overall training timelines.

This analysis evaluates three training architectures across four dimensions derived from the primary research question: capacity, stability, readiness impact, and sustainment burden.

### B. DEFINITION OF TRAINING ARCHITECTURES

Three training architectures are evaluated:



Operational Aircraft Model (E-6B) – Training conducted on mission aircraft, minimizing fixed infrastructure but coupling training directly to operational availability.

Dedicated Training Airframe Model (RC-135 / TC-135) – Training partially decoupled through non-mission aircraft, providing a buffer between pilot production and operational demand.

Contracted Trainer Model (Proposed) – Training externalized via high-fidelity simulators or contractor-provided aircraft, maximizing scalability and eliminating dependence on operational fleets.

### **C. ALTERNATIVE PILOT TRAINING ARCHITECTURES**

Pilot training architecture is not a neutral design choice; it is a primary determinant of how a training system performs under constraint. In low-density/high-demand (LD/HD) fleets, where aircraft availability is limited and operational requirements are continuous, training architecture governs whether pilot production remains stable or becomes sensitive to disruption. As fleets age and maintenance variability increases, these effects are amplified, shifting training outcomes from a function of syllabus design to a function of resource availability.

Across the architectures examined in this study, a consistent pattern emerges: systems that rely on operational aircraft for pilot production achieve short-term efficiency by minimizing dedicated infrastructure, but do so at the cost of stability and long-term sustainability. By coupling training capacity directly to fleet aircraft availability, these architectures expose pilot production to maintenance volatility and operational prioritization, resulting in disrupted progression, increased Time-to-Train variability, and growing sustainment burden over time.

In contrast, architectures that introduce dedicated training assets or externalized capacity demonstrate improved stability and more predictable throughput. Although these models incur higher fixed or contractual costs, they reduce dependence on operational aircraft, allowing training progression to continue despite fluctuations in fleet availability. This decoupling mitigates the propagation of disruption through the training system and



preserves operational aircraft for mission execution, improving both readiness and long-term fleet health.

These differences define a trade space that extends beyond cost. Training capacity, stability, readiness impact, and sustainment burden are interdependent outcomes shaped by the degree of coupling between training and operations. The analysis that follows evaluates these dimensions across the TACAMO (E-6B), RC-135, and a notional contracted training models, demonstrating that architectures prioritizing organizational reliability consistently outperform those optimized for theoretical efficiency under ideal conditions.

#### **D. TACAMO HISTORICAL ACCESS TO TRAINING AIRCRAFT)**

The E-6B training architecture is intentionally structured to minimize reliance on operational aircraft during early training phases. Approximately 200 hours of simulator-based instruction are used to build procedural proficiency prior to aircraft exposure. This design reflects an effort to conserve limited operational resources while maintaining training effectiveness.

However, the system undergoes a structural transition at FTE-9, where training becomes dependent on operational aircraft. At this point, the training pipeline becomes tightly coupled to fleet availability, introducing a critical dependency on mission-capable aircraft.

##### **1. Observed Outcomes: Throughput Volatility**

Empirical TTT data demonstrates significant variability in training completion times, as shown in Figures 1 and 2, ranging from approximately 43 to 123 days. Rather than progressing linearly, students experience a “stop-start” pipeline characterized by extended idle periods while awaiting aircraft availability.



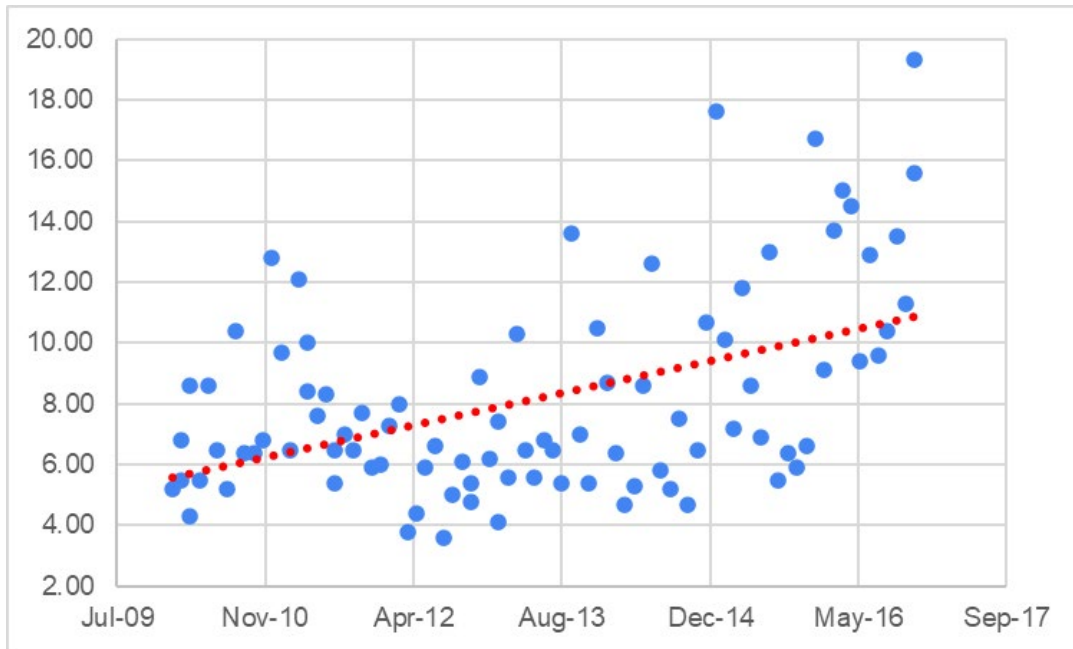


Figure 1. Historical Time to Train. Adapted from VQ-7 (2016).

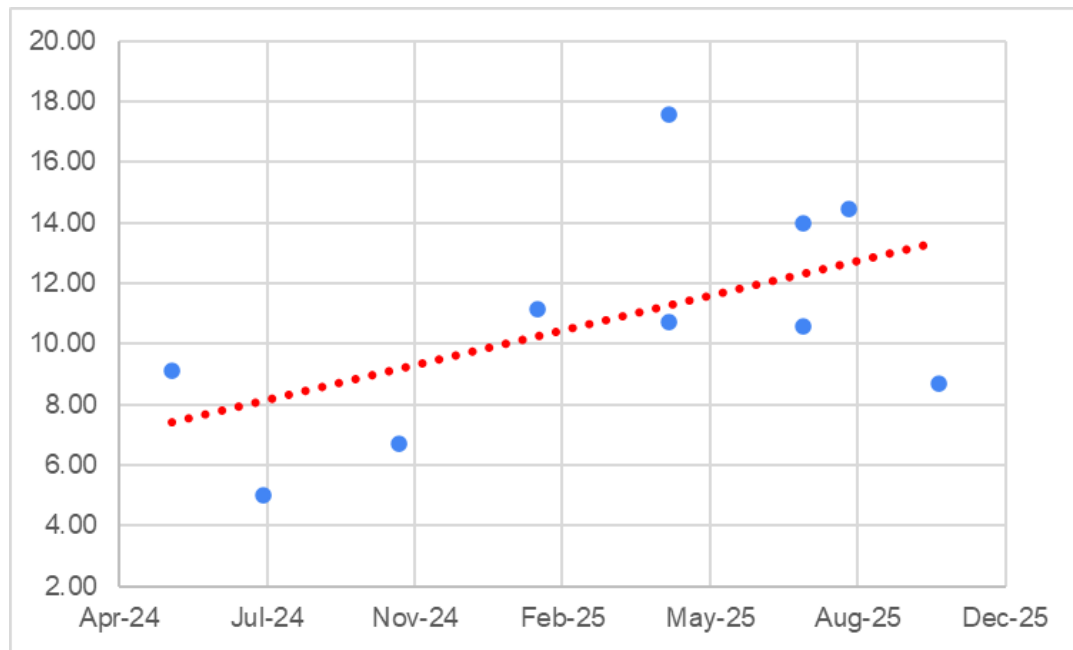


Figure 2. Recent Time to Train. Adapted from VQ-7 (2026b)

This pattern reflects more than scheduling inefficiency. From a learning systems perspective, it represents a breakdown in training continuity. Consistent with



Kozlowski's(1999) model of skill acquisition, progression from basic procedural knowledge to higher-order performance requires sustained repetition. Interruptions force regression, requiring students to relearn previously acquired skills, increasing total training time and reducing overall system efficiency.

## **2. Mission Aircraft Constraint**

The primary driver of this instability is the dual-role nature of the E-6B airframe. Because the platform supports continuous nuclear command and control operations, training is inherently subordinate to operational tasking. This creates a zero-sum resource environment in which training and mission readiness compete for the same limited aircraft.

When aircraft availability declines due to maintenance or operational demand, training sorties are cancelled first. In a tightly coupled system, even minor disruptions propagate directly into the training pipeline, producing cascading delays. These delays accumulate over time, creating a backlog of students awaiting aircraft access.

## **3. Aging Fleet Effects**

This structural fragility is amplified by the aging E-6B fleet. As aircraft age, maintenance requirements increase and availability becomes less predictable. Depot delays, unscheduled maintenance, and parts obsolescence reduce the pool of mission-capable aircraft available for training.

Consistent with Unger's(2009) analysis of aging systems, sustainment costs grow nonlinearly as fleets degrade. Each additional flight hour imposes greater maintenance burden, meaning that training flights increasingly compete with operational requirements not only for availability but also for long-term fleet viability.

As a result, pilot production becomes a function of maintenance cycles rather than instructional design, undermining both training stability and readiness.

## **E. RC-135 TRAINING AND SUSTAINMENT MODEL**

The RC-135 community employs a training architecture that is deliberately designed to separate pilot production from operational demand. Rather than treating



training as an ancillary use of mission aircraft, the system allocates dedicated capacity and embeds recovery mechanisms that maintain continuity despite disruption. This reflects a design philosophy oriented toward organizational reliability rather than point-efficiency.

## **1. Structural Features**

At the core of this approach is the TC-135, a dedicated training airframe that absorbs high-frequency, high-wear tasks such as landings, instrument procedures, and air refueling. By offloading these events from the operational RC-135 fleet, the architecture removes the primary source of competition between training and mission execution. Repetitive events that would otherwise consume mission aircraft hours are instead conducted on a platform optimized for training throughput.

Complementing this capacity buffer is the integration of administrative and simulator-based recovery mechanisms. The RC-135 syllabus authorizes Delay in Training (DIT) events when students experience gaps in flying currency. Critically, these events can be executed in Aircrew Training Devices (ATDs), allowing students to regain proficiency without generating additional demand on operational aircraft. This substitution authority prevents small disruptions from cascading into increased sortie requirements on the mission fleet.

## **2. Integration Effects**

These features combine to create a system that manages disruption. When maintenance issues or scheduling conflicts occur, the architecture provides multiple pathways to maintain progression: dedicated aircraft for physical task validation and simulators for cognitive and procedural recovery. As a result, variability is absorbed within the training system rather than transmitted to the pipeline.

This integration produces a stabilizing effect on pilot production. Because recovery can occur without waiting for mission aircraft availability, training remains continuous even under degraded fleet conditions. The system therefore avoids the backlog formation and idle periods observed in tightly coupled architectures.



### **3. Observed System Behavior**

The resulting system behavior is characterized by consistent throughput and predictable progression. Training events remain sequenced as designed, and delays do not systematically compound. This aligns with a design that assumes friction will occur and institutionalizes mechanisms to mitigate it.

From a cognitive perspective, the RC-135 model also reflects a tiered allocation of training tasks consistent with Endsley's (2015) framework of Situation Awareness. Level 1 tasks, which depend on perception and motor skill (e.g., landing and air refueling), are conducted on the TC-135, while higher-level cognitive tasks (Levels 2 and 3), such as mission management and decision-making, are emphasized in simulator environments through structured events such as LOFT. This allocation ensures that high-cost operational assets are reserved for mission validation rather than basic skill acquisition.

### **4. Summary of Structural Differences**

In contrast to the E-6B model, where training demand is transmitted directly to the operational fleet, the RC-135 architecture inserts physical buffers between training and operations. Dedicated aircraft expand effective capacity, while simulator substitution policies maintain continuity. Together, these features allow the system to preserve both training stability and operational readiness, even under the constraints of an aging LD/HD fleet.

## **F. COMPARATIVE IMPACT ACROSS ARCHITECTURES**

Table 1 summarizes outcomes; the following analysis explains the mechanisms that produce them.



Table 1. Training Architecture Comparison

<b>Architecture</b>	<b>Capacity</b>	<b>Stability</b>	<b>Readiness Impact</b>	<b>Sustainment</b>	<b>Failure Mode</b>
Operational (E-6B)	Constrained	Low	Competes with mission	High	Pipeline stall
Dedicated (RC-135)	Buffered	High	Protected fleet	Moderate	Capacity limit
Contracted	Scalable	High	No operational impact	Externalized	Fidelity risk

### 1. Training Capacity

Capacity is not solely a function of syllabus design; it is bounded by the availability and allocation of training resources. In the E-6B model, capacity is nominally sufficient but practically constrained by mission aircraft availability. Because the same assets support both operations and training, effective capacity varies with maintenance status and operational demand. This converts capacity from a planned quantity into a chaotic variable.

The RC-135 model increases effective capacity by introducing dedicated training assets. The TC-135 expands the supply of training sorties independent of mission requirements, allowing repetitive, high-throughput events to proceed without drawing from the operational fleet. This does not eliminate limits but it converts variability into a predictable ceiling.

Contracted training further decouples capacity from military inventory. When provisioned with sufficient devices or contractor aircraft, throughput can scale to demand. The governing constraint shifts from fleet availability to contract scope and infrastructure, enabling deliberate capacity planning rather than reactive scheduling.

### 2. Stability (TTT / Reliability)

Stability reflects the continuity and predictability of training progression. In the E-6B architecture, tight coupling to the operational fleet produces high TTT variability. Maintenance and operational tasking interrupt sequences, creating gaps between events.



Consistent with learning theory, these interruptions induce regression and rework, increasing total time to train and degrading efficiency.

The RC-135 architecture improves stability by inserting buffers, both physical (TC-135) and procedural (DIT with simulator substitution). When disruptions occur, the system provides alternate pathways to maintain currency and sequence. Variability is therefore absorbed within the training system rather than transmitted downstream, yielding more consistent TTT outcomes.

Contracted models extend this effect by fully separating training from operational availability. With sufficient device fidelity and scheduling capacity, event continuity can be preserved even under adverse fleet conditions. The residual risk to stability is not availability but the reliability and accessibility of the contracted system.

### **3. Readiness Impact**

Readiness impact captures the interaction between training demand and mission capability. In the E-6B model, this relationship is zero-sum: each training sortie competes directly with operational requirements. During periods of reduced availability, training is deprioritized, which protects immediate readiness at the expense of future readiness (pilot production). This trade manifests as the observed backlog and delayed qualification.

The RC-135 model mitigates this conflict by shifting a significant portion of training demand to non-mission assets. Operational aircraft are preserved for mission execution and/or final validation events, reducing the direct coupling between training and readiness. The system thus protects both near-term operations and longer-term pilot production.

Contracted training removes the competition entirely for the portions of the syllabus that can be externalized. Mission aircraft are reserved for tasks that require operational fidelity, while some of the training demand is satisfied outside the fleet. This eliminates the zero-sum trade for those phases of training that the training asset can be substituted for a contracted aircraft.



#### **4. Sustainment Burden**

Sustainment burden reflects how training architecture affects long-term cost and fleet health. In the E-6B model, training consumes operational aircraft hours, accelerating wear on an aging fleet. As systems age, maintenance hours per flight hour increase nonlinearly, so each additional training sortie imposes a disproportionate cost. This creates a feedback loop: training increases wear, which reduces availability, which further constrains training.

The RC-135 model accepts higher fixed costs to acquire and operate dedicated trainers but reduces variable costs on the operational fleet. By diverting high-cycle events (e.g., touch-and-go landings, repeated AR) to the TC-135, the model preserves fatigue life and reduces maintenance demand on mission aircraft. Over time, this stabilizes availability and lowers the marginal cost of training on the operational fleet.

Contracted models externalize a significant portion of sustainment burden. Costs become more predictable and less sensitive to fleet age because training demand is met through contracted capacity rather than additional operational flying. However, this introduces dependency on vendor performance, life cycle support for devices, and contractual flexibility to adapt to syllabus changes.

#### **5. Failure Modes**

Each architecture fails in distinct modalities. The E-6B model fails through pipeline instability: when availability drops below a threshold, training stalls and backlogs form. The RC-135 model fails more gracefully, typically through capacity limits of the trainer fleet, which constrain total throughput but do not induce systemic disruption. Contracted models primarily fail when it comes to fidelity: if devices or contractor aircraft cannot adequately replicate critical tasks, effectiveness degrades despite high stability and capacity.

Taken together, these mechanisms explain the observed differences in capacity, stability, readiness impact, and sustainment burden across architectures, and they define the trade space relevant to future system design.



## **G. RISK TO E-130J**

The comparative analysis demonstrates that the risk facing the E-130J is not rooted only in platform capability, but in the potential persistence of legacy training assumptions embedded in the E-6B architecture. These assumptions, while functional under earlier conditions, have become increasingly invalid as fleet age, operational demand, and resource constraints evolve.

### **1. Legacy Assumptions and Structural Risk**

The E-6B model relies on several implicit assumptions regarding training system behavior. First, it assumes that sufficient aircraft availability exists to support both operational tasking and pilot production. Second, it assumes that training interruptions can be absorbed without significant degradation in learning progression. Third, it assumes that simulator-based training, even when limited in fidelity, can adequately prepare students for transition to operational aircraft.

Observed system behavior challenges each of these assumptions. Aircraft availability is neither stable nor predictable in an aging LD/HD fleet, meaning that training capacity fluctuates in response to maintenance cycles rather than planned throughput. Training interruptions are not benign; as demonstrated in Figures 1 and 2, they disrupt continuity and increase total time to train through regression and rework. Finally, limitations in simulator fidelity force reliance on operational aircraft for foundational skill development, further reinforcing coupling within the system.

### **2. The Dual Penalty Effect**

When these assumptions fail simultaneously, the system experiences a dual penalty. Maintenance disruptions reduce operational aircraft availability while also degrading training throughput. Unlike decoupled architectures, which can absorb disruption internally, the coupled E-6B model transmits variability directly into both readiness and pilot production.

This effect creates a reinforcing cycle: reduced availability delays training, delayed training increases backlog, and backlog increases demand for limited aircraft



resources. Over time, the system becomes increasingly sensitive to even minor disruptions, reducing both efficiency and resilience.

### **3. Mathematical Unsustainability in LD/HD Fleets**

Within an LD/HD context, this dynamic becomes mathematically unsustainable. As maintenance hours per flight hour increase nonlinearly with fleet age, the marginal cost of each additional training sortie rises. At the same time, the demand for pilot production remains fixed or increases. The system is therefore required to produce more output using fewer reliable resources, a condition that cannot be sustained indefinitely.

In contrast, architectures that introduce dedicated or contracted training capacity shift this relationship. By removing training demand from the operational fleet, they prevent maintenance-driven variability from directly constraining pilot production, stabilizing both throughput and readiness.

### **4. Risk to E-130J Design Decisions**

If E-130J training architecture replicates the E-6B model specifically the reliance on operational aircraft for training it risks inheriting these structural vulnerabilities. Early design decisions regarding training capacity, simulator fidelity, and dedicated training assets will determine whether the system remains coupled or achieves effective decoupling.

Failure to invest in sufficient training infrastructure will likely result in the same observed outcomes: TTT variability, training backlogs, and increased sustainment burden on the operational fleet. These effects may not be immediately apparent in early fleet life but will emerge as the system matures and operational demands increase.

### **5. Implications for Training Architecture Design**

The central implication is that training architecture must be treated as a core element of system design rather than a secondary consideration. In LD/HD fleets, stability is not achieved through efficiency alone but through deliberate decoupling and redundancy in training capacity.



Architectures that prioritize organizational reliability, through dedicated training assets, high-fidelity simulation, or contracted capacity, are better positioned to sustain pilot production over time. In contrast, architectures that rely on operational aircraft as the primary training resource may achieve short-term efficiency but introduce long-term instability.

## **H. TRANSITION TO FINDINGS AND RECOMMENDATIONS**

The analysis of the E-6B and RC-135 training architectures reveals a distinct correlation between system design and pipeline stability. While the E-6B's coupled architecture exposes pilot production to the volatility of an aging fleet, the RC-135's decoupled model provides necessary insulation through dedicated assets and resilient syllabus policies.



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## V. CONCLUSIONS AND RECOMMENDATIONS

This analysis compared the pilot training architecture of the Navy's E-6B and the Air Force's RC-135 to assess whether system design influences pipeline stability in LD/HD fleets. Holding external factors constant, the findings indicate that a coupled approach, such as the E-6B's exclusive reliance on operational mission aircraft for training, operates as volatility multiplier. As the airframes age and geopolitics require additional mission tasking, the absence of protected training capacity creates pipeline unpredictability and extended wait times between training events for student pilots.

In contrast, the RC-135 community utilizes a decoupled approach that incorporates the TC-135, a dedicated training airframe, to insulate the pilot production from maintenance variability and operational requirements. This structural separation allows the training pipeline to absorb friction without creating a compounded stress on the mission fleet. The analysis suggests that for the rapidly approaching E-130J transition, acquiring a dedicated training capability is not merely a resource decision but a structural requirement to ensure consistent force readiness throughout the lifespan of the platform.

### A. SUMMARY OF FINDINGS

The following sections synthesize the data and syllabus comparisons analyzed in Chapter IV to address the research questions posed in Chapter I. First the secondary research questions are answered, followed by the primary.

#### 1. Findings on Historical Access (SRQ 1)

How have historical changes in TACAMO's access to training aircraft shaped training consistency, instructor utilization, and sustainment demands over time?

The analysis indicates that the lack of a dedicated training aircraft forces high-repetition, high-stress training maneuvers on to the operational fleet aircraft. This created the coupled training system that directly competes with national defense tasking for a finite pool of aircraft. The VQ-7 TTT data shows that without a dedicated trainer, pilot



qualifications timelines fluctuate wildly based on aircraft availability rather than student performance.

This observed system behavior shows that students reliably complete the simulator phases but stagnate once they get to the flightline. Extended time waiting to perform an event degrades their proficiency and necessitates additional training, adding burden to the fleet. This dynamic introduces volatility into the training pipeline and compounds sustainment requirements over time.

## **2. Findings on RC-135 System Structure and Integration (SRQ 2)**

How is the RC-135 community's training and sustainment model structured, and what resource and integration effects distinguish it from the TACAMO approach?

The RC-135 community employs a decoupled training architecture. By maintaining the TC-135 training airframes, the Air Force can absorb much of the high-cycle fatigue associated with initial qualification, protecting the operational fleet aircraft from training-induced wear.

Additionally, the RC-135 syllabus implements a more permissive Delay-in-Training policy. This allows students to maintain an extended period out of the aircraft, by conducting additional events in the simulator. The E-6B implements a similar policy, but it is stricter. As a result, the RC-135 training pipeline possesses an additional mechanism for absorbing schedule disruptions without compounding operational or sustainment stress on the fleet.

## **3. Findings on Training Modalities and Readiness Impacts (SRQ 3)**

How do contracted trainers, dedicated training airframes, and reliance on operational aircraft differ in their impact on readiness, pilot throughput, and long-term sustainment burden?

The analysis indicates that reliance on operational aircraft is the least efficient model for Low-Density/High-Demand fleets. There are three training architectures considered: Operational Aircraft, Dedicated Airframes, and Contracted Trainers.



The first is a zero-sum resource environment where training competes with operational tasking. It also incurs the highest long-term variable costs due in part to accelerated aging and unscheduled maintenance. With the second option, the upfront cost is significantly higher, due to the additional airframes, but this option stabilizes the throughput and lowers variable sustainment costs by reducing the reliance on the operational fleet.

Finally, the contracted option maybe the most straightforward cost option; however, it does not necessarily fulfill all the training requirements. Commercial aircraft typically are not AR capable, without significant modification, despite AR being the primary driver of most variance in the syllabus. In addition, the flightdeck layout and aircraft handling characteristics introduce the risk of negative transfer, where the pilot is required to unlearn habit patterns when returning to the military aircraft.

#### **4. Findings on E-130J Transition Assumptions (SRQ 4)**

What training and sustainment assumptions risk being carried forward into the E-130J if legacy E-6B training architecture decisions remain unexamined?

The primary risk to the training architecture of the E-130J is utilizing the same methods that were used on the E-6 transition. The current architecture assumes 100% aircraft availability, simply an impossible feat for an aging airframe. If the E-130J does not include a dedicated training capacity, possibly through high fidelity simulators or a dedicated training airframe, the new fleet will suffer the same problems as the E-6B. If the training articles are not invested in, then the investment will contribute to the accelerated decay of the fleet aircraft.

#### **5. Synthesis of Findings on Training Architecture Influence (PRQ)**

How do alternative pilot training architectures influence long-term training capacity, sustainment demands, and readiness outcomes for the TACAMO community as it transitions from the E-6B to the E-130J?

Training architecture determines whether pilot production remains viable in LD/HD fleets; architectures that rely on operational aircraft are inherently unstable under realistic conditions. A coupled design caps training capacity at the limit of the fleet



health. When maintenance issues arise or emergent tasking occurs, training capacity collapses, whereas a decoupled approach insulates the student’s progression from operational constraints.

By declining a dedicated training aircraft, the E-6 program shifted from a fixed cost to a variable operating and support cost. While initially less expensive, this approach accelerates fleet aging and drives nonlinear growth in sustainment costs. The decoupled approach separates training risk from operational risk, creating predictable training. The coupled model makes training dependent on maintenance and operational tasking, creating a brittle training pipeline that snaps under the slightest pressure.

## **B. CONCLUSIONS**

This analysis produced three conclusions with regards to the structural vulnerability training fidelity and administrative resilience in the E-6B pilot training architecture.

### **1. The “Mission Aircraft” Fallacy**

The paradigm that “every aircraft is a mission aircraft” represents a structural vulnerability in aging LD/HD fleets. While this model appears efficient on paper, it creates multiple single points of failure within the training system. When unscheduled maintenance or emergent operational tasking occur, pilot production collapses because training capacity is inseparable from mission availability.

These findings demonstrate that, absent a separated nonoperational training capacity, pilot production becomes increasingly fragile as the fleet ages. The training pipeline is not only unable to scale with demand, it degrades when operational pressure increases, undermining the system’s ability to meet production quotas.

### **2. Administrative Resilience Is Critical**

Beyond physical assets, syllabus policy decisions influence training throughput and system resilience. While the aging fleet is the dominant driver of training volatility, restrictive warm-up and currency requirements amplify schedule disruption by requiring aircraft-based remediation following delays.



In contrast, the RC-135 community implements a more permissive simulator substitution policy to enable continued progression during periods of aircraft unavailability. This administrative function adds a secondary buffer to their pilot pipeline without compounding operational stress. The absence of this flexibility in the E-6B training system multiplies the volatility already induced by the aircraft availability constraints.

### **3. The Economic Inversion of Fidelity**

The architecture of the E-6B training program exhibits an economic inversion where the most expensive, and operationally critical asset (the E-6B itself) is employed to teach the most basic skills, due to the lack of fidelity in the simulators. This approach contradicts sustainment economics by expending the limited service life on tasks that do not require a mission-equipped platform.

The findings indicate that inadequate training device fidelity shifts routine skill acquisition onto operational aircraft, accelerating fleet decay and increasing long-term sustainment costs. In effect, the short-term savings in the original training infrastructure produced disproportionate downstream costs by consuming high-value assets for low-fidelity training objectives.

## **C. RECOMMENDATIONS**

The following recommendations translate the study's conclusions into guidance intended to improve training stability, sustainment efficiency, and long-term readiness for the TACAMO community. These recommendations are split between immediate actions to impact the current E-6B fleet as well as future actions that will impact the E-130J fleet. Collectively, these recommendations address the structural vulnerabilities identified in the current E-6B training architecture, including overreliance on operational aircraft, insufficient training device fidelity, and limited administrative flexibility within the training syllabus. Rather than optimizing individual components in isolation, the recommendations emphasize architectural decoupling, protected training capacity, and policy adjustments designed to buffer pilot production from maintenance variability and operational tasking. Implemented together, these measures would reduce training



volatility, preserve operational fleet service life, and support consistent pilot throughput across the remainder of the E-6B and the entirety of the E-130J platform's life cycle.

### **1. Immediate Recommendation 1: Revise VQ-7 Syllabus Policy**

The VQ-7 pilot training syllabus should be reviewed and revised to incorporate greater administrative flexibility in response to aircraft availability constraints. While existing policies allow extended timelines between aircraft events, further adjustments could permit continued progression through simulator-based events during prolonged maintenance or tasking disruptions. Although policy changes alone cannot eliminate fleet-driven delays, increased syllabus flexibility would enhance the training system's ability to absorb friction without compounding demand on operational aircraft.

### **2. Immediate Recommendation 2: Acquire a Current In-Flight Trainer**

Reducing the load on the current E-6B fleet is paramount. Acquiring an E-6B training surrogate, in line with the CNO's 1985 memo, could drastically reduce the workload of the operational fleet, depending on the similarity and capabilities of the IFT. The best-case scenario is a four engine, aerial refueling-capable aircraft; anything less would have a smaller impact on fleet readiness.

### **3. Intermediate Recommendation: Prioritize High-Fidelity Simulation**

Investment in high-fidelity, Level D simulators should be prioritized to reduce reliance on operational aircraft for foundational and currency-related training. Insufficient simulator fidelity currently drives restrictive "warm-up" requirements that force pilots back into aircraft following training delays.

Improved simulator fidelity would enable greater syllabus flexibility, support extended periods of simulator-based progression, and shift a larger proportion of training demand away from operational aircraft, reducing both sustainment burden and training volatility.



#### **4. Future Recommendation: Decouple the E-130J Architecture**

The E-130J program should establish a deliberately decoupled training architecture by acquiring protected training capacity independent of operational tasking. This may be achieved through the designation of a dedicated training variant (e.g., a non-mission-configured E-130J) or through assignment of a fenced subset of aircraft to a training squadron without operational alert responsibilities.

Establishing protected training capacity would insulate pilot production from maintenance variability and operational surges, mitigating the training volatility observed in the E-6B community and supporting stable pilot throughput across the E-130J life cycle.

### **D. IMPLICATIONS FOR FUTURE RESEARCH**

#### **1. Proficiency vs. Throughput**

This analysis focused on training pipeline stability, throughput, and scheduling reliability rather than direct measures of pilot proficiency. Future research could examine student performance data, including grade sheets, and check ride outcomes, to assess whether extended delays between training events correlate with measurable proficiency degradation. Quantifying the relationship between training delays and performance outcomes would further inform decisions regarding acceptable levels of training pipeline volatility.

#### **2. Cost-Benefit Analysis of Dedicated Trainers**

A quantitative cost-benefit analysis could further evaluate the economic trade-offs associated with acquiring dedicated training aircraft or expanded simulator capacity. While this study demonstrates the structural and readiness implications of training architecture decisions, a detailed cost analysis would enable comparison between upfront investment in training infrastructure and long-term operating and sustainment cost avoidance. Incorporating proficiency and throughput data into such an analysis would allow decision-makers to assess training investments against both readiness outcomes and life-cycle cost considerations.



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