2025

V-22 Comprehensive Review

Controlled by: Department of the Navy, NAVAIRSYSCOM

Dissemination Control: Distribution Statement A

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1 Executive Summary

1.1 Introduction

This Comprehensive Review (CR), initiated by NAVAIR in September 2023, is based on the authority of Commander, Naval Air Systems Command, in ensuring the airworthiness of Naval aircraft. This covers the MV-22, CMV-22, and CV-22 platforms, including PMA-275 operations and supporting databases tied to NAVAIR's engineering and airworthiness responsibilities. It focuses primarily on data from the past 3–4 years but extends further back in some cases to assess the program's full lifecycle.[1] These findings have been shared with: USMC Deputy Commandant for Aviation (DCA), Commander, Naval Air Forces (CNAF), Commander, Air Force Special Operations Command (AFSOC), Naval Safety Command (NAVSAFECOM), and Air Force Safety Center (AFSEC).

The objective of this CR is to assess V-22 performance on key safety and readiness dimensions, against standards and best practices, and recommend actions to close gaps by implementing enforceable action plans with estimated completion dates and single accountable owners.

1.2 Findings

Safety: This review finds that the V-22 platform has accumulating safety risk due to four main factors: (1) Inadequate timeline for implementation of material and non-material fixes to mitigate identified risks; (2) Non-compliance with established airworthiness and safety of flight procedures; (3) Lack of airworthiness standards for assessing accumulated risks and for the rate at which risks should be retired; and (4) The joint program office faces challenges in swiftly implementing safety remediations across the platform due to differences in service mission sets, priorities, and risk tolerance.

Readiness: This review finds that the V-22 platform has missed readiness targets due to four main factors: (1) The V-22 joint program has not uniformly shared and implemented known aviation maintenance best practices across the services; (2) Joint V-22 program operates suboptimized supply systems and maintenance programs that do not prioritize cross-service readiness outcomes; (3) Persistent reliability issues combined with procedural and experiential differences have resulted in higher Maintenance Man Hours Per Flight Hour; (4) Inventory management challenges, to include delayed deliveries, both over and undersized fleets, manpower to fleet size imbalances, and multiple configurations/sub-fleets.

1.3 Overall Recommendation

The CR highlights critical V-22 safety and readiness concerns in governance, manpower, training, and equipment. While the PEO and PMA, in coordination with NAVAIR, the services, and industry partners, have proactively moved out to implement several of the recommended corrective actions identified in this report; additional measures are needed to fully address the identified issues.

[1] The CR assessment team was composed of personnel from USN, USMC, AFSOC, NAVAIR, Bell/Boeing, and others. The team analyzed safety, readiness, pilot proficiency, and maintenance data as well as policy documents and technical publications, with input from authorities including the Naval Safety Command (NAVSAFECOM) and Air Force Safety Center (AFSEC).

With continued and sustained efforts to address the findings and implement the recommendations in this report, the Department can significantly improve safety by reducing the risk of preventable mishaps; and improve mission capable rates by reducing maintenance down time and increasing availability.

2 Background

2.1 Introduction

The V-22 Osprey is a multi-mission tiltrotor aircraft that combines fixed-wing speed and range with rotary-wing vertical lift capabilities. This unique capability makes it essential to the USMC, USN, and AFSOC for global combat, humanitarian missions, and carrier onboard delivery. Refer to Appendix section 5.2 for a more detailed overview of the program history.

Over the past 4 years, there have been 12 Class A Mishaps that resulted in 4 aircraft destroyed and 20 service members lost (Figures S.1., S.2.).[2] Some of the key class A mishaps for the V-22 platform in the past four years were in Norway (18 March 2022) which resulted in 4 USMC servicemember deaths; Glamis, CA (8 June 2022) which resulted in 5 USMC servicemember deaths, Australia (27 August 2023) which resulted in 3 USMC servicemember deaths, and the GUNDAM-22 mishap in Japan (29 November 2023) which resulted in 8 USAF servicemember deaths (Figure S.2.). Refer to Figures S.9.a, b, c, and S.10 in Appendix section 5.7 for an overview of safety risk assessment and mishap categorization.

The aircraft has had multiple partial / full groundings as a result of these high-profile mishaps, including a partial grounding for hard clutch engagement (HCE) from December 2022 to March 2023, full grounding for proprotor gearbox (PRGB) issues after the GUNDAM-22 mishap in Japan from December 2023 to March 2024, and another partial grounding for the PRGB in December 2024 after the Cannon Air Force Base (AFB) mishap.

In addition to safety challenges, the V-22 has consistently had low readiness levels, with average 2020-2024 mission capable rates of approximately 50% for USN and AFSOC, and 60% for USMC (Figure R.1.).

In September 2023, due to continued safety and readiness issues, NAVAIR initiated a comprehensive review of the V-22 program to find the root causes of its issues and give recommendations to address these root causes.

For a detailed overview of the CR timeline, refer to section 5.8 in the Appendix.

2.2 Scope & Methodology

This Comprehensive Review, initiated by NAVAIR in September 2023, is based on the authority of Commander, Naval Air Systems Command, in ensuring the airworthiness of Naval aircraft. This covers the MV-22, CMV-22, and CV-22 platforms, including PMA-275 operations and supporting databases tied to NAVAIR's engineering and airworthiness responsibilities. It focuses primarily on data from the past 3–4 years but extends further back in some cases to assess the program's full lifecycle.

The review team analyzed safety, readiness, pilot proficiency, and maintenance data as well as policy documents and technical publications, with input from authorities including NAVSAFECOM and AFSEC. These data directly informed the key findings within this report with underlying root causes and impacts informed by site observations completed by the V-22 Comprehensive Review assessment team.

[2] 5 MV-22B mishaps and 7 CV-22B mishaps from 2020-2024

The assessment team, composed of personnel from USN, USMC, AFSOC, NAVAIR, Bell/Boeing, and others, conducted site visits to NAS North Island, MCAS New River, and Cannon AFB between January and February 2024. These visits provided more context and validation around recurring issues across all variants, including safety culture gaps, insufficient pilot and maintainer training, unclear publications, poor parts supply, and limited tracking of key performance data.

This review also acknowledges three prior V-22 reviews (2001, 2009, 2017), which offered some valuable recommendations but lacked mechanisms for tracking implementation or accountability. This lack of follow-through resulted in minimal execution of prior action plans. To drive follow-through in recommended gap closure actions, this CR includes broad coordination with key stakeholders such as DCA, CNAF, AFSOC, PEO(A), PMA-275, NAVSAFECOM, and AFSEC.

For a more detailed overview of the scope and methodology, refer to section 5.3 in the Appendix.

3 Safety

3.1 Summary Findings

There have been 12 Class A flight mishaps over the past four years that resulted in 4 aircraft being destroyed and 20 service members lost (Figures S.1., S.2.).

In 4 of these 12 Class A mishaps, human error / procedural non-compliance to established airworthiness and flight safety standards was a causal or contributing factor. A review of the investigations convened for these mishaps revealed several contributing factors, including issues with training, proficiency, culture, configuration, and material conditions. Procedural non-compliance is not exclusive to the V-22 program, as it is a leading cause or contributor to most aviation mishaps. Despite numerous initiatives aimed at improving procedural compliance, most efforts to date have not led to significant improvements in safety outcomes. A critical gap remains in the form of specific, measurable, and enforceable action plans, complete with clear timelines and accountable owners, to address the root causes of non-compliance, improve procedural adherence, or mitigate the effects of non-compliance at the enterprise-level.

In 7 of these 12 Class A mishaps, material failure was a causal or contributing factor. These material risks were identified by the Program Office and included in the NAVAIR System Safety Risk Assessments (SSRA) database, but were not sufficiently mitigated or resolved in a timely manner, which resulted in catastrophic outcomes in 5 of the 12 mishaps as the risks were realized. Two recent examples:

1. Hard Clutch Engagement (HCE), which can lead to catastrophic failures during critical flight operations, was first observed in 2010 and assessed as a Serious (I-D) risk. From 2013-2022, the Program conducted a clutch redesign, fault testing, and updated procedural guidance and simulators. However, due to an incomplete understanding of the Input Quill Assembly (IQA) failure mode, the Program did not put in place effective risk-reducing mitigations against the worst credible outcome until 2023. Additional HCE events continued to occur until a life limit was imposed in 2023.

2. Drivetrain gears can catastrophically fail due to X-53 steel alloy material impurities (inclusions). Since 2006, there have been 22 incidences where an inclusion in the drivetrain gears has resulted in cracked gears; in 3 instances, the cracked gears catastrophically failed; and in 2 instances, caused additional collateral damage to the proprotor gear box. However, the Program did not formally assess or accept the overall X-53 inclusion risk until March 2024. Subsequently, the Program put into place risk-reducing mitigations – to include procedural changes, more conservative landing criteria, and a PRGB redesign effort. PRGB retrofits are scheduled to begin in JUN 2025.

These examples underscore the importance of a "closed loop" safety system where the Program Office continuously identifies and assesses risks, communicates the risk to users, implements interim mitigations, and persistently drives the development and deployment of both material and non-material solutions to further reduce or eliminate those risks. When the V-22 Enterprise does not actively manage risks with the potential for catastrophic outcomes, the risks compound, increasing the likelihood of a catastrophic event that, if left unaddressed, will ultimately occur.

A proactive safety system, along with early and continuous intervention, is essential for promptly identifying and addressing safety risks to minimize preventable incidents. By consistently and effectively acting on the findings in this report in a timely manner, the V-22 Enterprise can greatly reduce the likelihood of avoidable

mishaps. If the V-22 enterprise fails to take immediate and decisive action on the findings in this report, the existing risk mitigation timelines will increase the likelihood of a risk materializing, potentially resulting in catastrophic outcomes, including both fatal and non-fatal consequences.

3.2 Findings and Recommendations

This review finds that the V-22 platform has accumulating safety risk due to four main factors.

1. ***The cumulative risk posture of the V-22 platform has been growing since initial fielding. The program actively identified risks; however, due to limitations in material solutions, funding prioritization, and urgency, it has not promptly implemented material and non-material fixes to mitigate existing risks. As a result, risks continue to accumulate.***

    a. V-22 is a first-generation tiltrotor that was fielded in 2007 based on a design from the mid-1990s (see appendix for program timeline). The V-22 has not undergone a mid-life upgrade and is planned for operation for another ~30 years (2050-2060). Based on a qualitative assessment of other Naval Aviation platforms, generally mid-life upgrades are targeted within 20-25 years to extend operability to achieve a 40-50 year service life. As the first and only military tiltrotor aircraft, it remains the most aero-mechanically complex aircraft in service and continues to face unresolved legacy material, safety, and technical challenges (e.g., structural risks that must be carried for the life of the program, inherently more failure modes due to helicopter rotational aerodynamics).
    b. The V-22 program has the second highest number of catastrophic (CAT I-D and I-E) risks across all Naval Aviation platforms. V-22 carries 28 CAT I-D and I-E risks as compared to an average of 4.5 CAT I-D and I-E risks across all other platforms (Figure S.3.).
    c. On average, V-22 outstanding catastrophic (CAT I-D and I-E) material risks are 70% older than all other Naval Aviation platforms. V-22 risks are on average 10.7 years old versus 6 years across all other platforms (Figure S.4.).
    d. The V-22 Enterprise has not developed, adequately resourced and implemented risk remediation plans in a timely manner to reduce the overall risk posture of the platform. 6 of the 12 outstanding documented Serious CAT I-D risks have been realized during 74 in-flight events and, in 3 instances, resulted in catastrophic outcomes over the life of the program (Figure S.5.).

    Recommendations:

    a. Services should continue to assess accelerated implementation and fielding of proprotor gearbox material fixes, including retrofit of the proprotor gearboxes with X-53 triple melt gears and the fielding of a gear box vibration monitoring system (ODSSHI).
        i. OPR: PMA-275 Program Manager
        ii. ECD: Full triple melt retrofit complete by 2033. Services should continue to assess opportunities to accelerate implementation.
        iii. Status: In execution with first PRGBs to begin retrofit in JUN 2025
    b. Accelerate the testing and fielding of a redesigned Input Quill Assembly.
        i. OPR: PMA-275 Program Manager
        ii. ECD: Full retrofit complete by DEC 2034.
        iii. Status: Qualification testing in execution; to be completed by DEC 2025. Fielding planned to begin 2027.

c. Develop full and partial mitigation plans to eliminate and downgrade any open & monitor I-D and I-E System Safety Risk Assessments (SSRAs), to include resources required to execute and risk reduction dates. Any changes to plans shall only be approved at annual cross-service program-level review (see action 1.e). (*Applies NAE-wide)*
    i. OPR: PMA-275 Program Manager
    ii. ECD: AUG 2025
    iii. Status: In-work. Plans identified – specific resources and timelines TBD
d. Develop and implement a V-22 mid-life upgrade program. Identify key drivers that will improve current readiness and safety performance outcomes. Review modernization plan at annual cross-service program safety risk review (see action 1.e).
    i. OPR: N98, DCA, HQMC Combat Development and Integration (CD&I), HAF AQ(E) with support from PMA-275 Program Manager and PEO(A)
    ii. ECD: TBD
    iii. Status: In-work
e. Conduct annual program safety risk reviews with resource sponsors, NAVAIR, PEO, DCA, CNAF and AFSOC to assess current program risk (e.g., SSRAs, MISRECs, TDs, EIs) and airworthiness posture based on risk exposure, mitigation effectiveness, compliance and risk resolution timelines. (*Applies NAE-wide)*
    i. OPR: PEO(A), PMA-275 Program Manager
    ii. ECD: MAY 2025, then annual
    iii. Status: Complete

2. Procedural non-compliance by aircrew and maintenance personnel has been a consistent causal or contributing factor in both flight and ground mishaps.

a. Over the last four years, 33% of Class A mishaps, 37% of flight-related Class A-E mishaps, and 81% of ground Class A-E mishaps were due to human error.[3]
b. Fleet maintenance tracking of safety critical components and audit systems do not enforce maintenance standards. The Naval Aviation Maintenance Program (NAMP) requires Fleet maintainers to track the accrued flight hours on certain safety critical components that have defined limits to maintain airworthiness. Similarly, the Air Force Instruction AFI21-101, Aircraft and Equipment Management, requires tracking of Critical Safety Items (CSI) and Critical Application Items (CAI). During a NAVAIR directed review of USN, USMC, and AFSOC V-22 logbooks in JAN-MAR 2024 (AFB-200 / TCT-1183 and AFB-201/TCTO-1184), more than 40 life limited safety critical components across the V-22 fleet were found in excess of their defined airworthiness life limits (29 USMC, 0 USN, and 14 AFSOC) (Figure S.6.).

Recommendations:

a. Establish service specific V-22 currency and proficiency requirements. (*Applies NAE-wide)*
    i. OPR: CNAF, DCA, AFSOC
    ii. ECD: MAY 2025
    iii. Status: In work (USMC, AFSOC) / Complete (USN)

[3] Based on mishap analysis using the Human Factors Analysis and Classification System (HFACS) 8.0 framework

b. Set service specific safety and mishap reduction targets by year for V-22 Class A and for Class A-D mishaps; identify forum and governance to monitor performance to plan. (*Applies NAE-wide)*
    i. OPR: CNAF, DCA, AFSOC
    ii. ECD: JUN 2025
    iii. Status: In-work. USN and USAF set, USMC no specific V-22 targets.
c. Define CMV, MV, and CV mishap reduction plans with clear timelines and single owners against annual service-specific North Star mishap targets that address aircraft flight and ground mishap causal factors (e.g., publications, training, manning, audit systems effectiveness). (*Applies NAE-wide)*
    i. OPR: PMA-275 in coordination with NAVAIR, CNAF, DCA, AFSOC
    ii. ECD: SEP 2025
    iii. Status: In-work
d. Implement the Aircraft Component Tracking System (ACTS) electronic logbook tracking software across all O-level fleet squadrons & I-level and depot maintenance facilities. (*Applies NAE-wide)*
    i. OPR: PMA-275
    ii. ECD: NOV 2025
    iii. Status: In-work
e. Establish supplemental ACTS controls. Modify the Naval Aviation Maintenance Program to complete 100% life limited component verification during phase inspections. Set up audit program to synchronize across logbook sources of record (OOMA, IMDS, ACTS). (*Applies-NAE wide)*
    i. OPR: NAVAIR
    ii. ECD: JUN 2025
    iii. Status: In-work

3. Over an extended period, the program did not effectively manage or address identified risks in a timely manner, allowing them to accumulate. Although airworthiness standards were in place, they lacked sufficient specificity and controls to guide consistent risk mitigation and resolution timelines. This contributed to the persistence and compounding of unresolved risks over time.

a. While a risk management process existed, it was not consistently executed within the program in accordance with NAVAIRINST 5100.3 (Naval Aviation System Safety Engineering Policy) and NAVAIRINST 3750.5 (aviation safety)— particularly in terms of sustained follow-through on mitigation actions. Although these instructions require the development and management of SSRA mitigation plans, they do not establish a forcing function to ensure Program Managers are held accountable for SSRA mitigation timelines. Risks were often identified but not actively worked to closure, resulting in delays and an increasingly elevated safety risk posture. In some instances, mitigation responsibilities were assigned to stakeholders without the necessary airworthiness authority or technical expertise, which further impacted resolution timelines (e.g., TD target completion date extension does not require engineering / airworthiness concurrence; decisions made at sub-PM level[4]). For example, five Technical Directives tied to CAT I-D and I-E mitigation actions remain open—some up to six years past due. (Figure S.7.a and b.).

[4] NAVAIR SOP 00-25-300 - Standard Operating Procedures for NAVAIR Technical Directives (TDs)

b. Adherence to airworthiness standards is rigorously enforced as part of the initial Military Type Certificate (e.g., equipment configuration, life limits, initial maintenance procedures), but NAVAIR does not regularly revisit airworthiness certifications and standards to analyze continuing accumulated safety risk and impact to flight suitability. There is no current requirement for NAVAIR to analyze the ongoing impact of outstanding risks over planned risk resolution timelines on platform airworthiness. Since achieving IOC in 2007, identified Serious risks on the V-22 have tripled, with 40% subsequently closed or downgraded (Figure S.8.).

Recommendations:

a. Direct all Program Executive Officers to conduct annual reviews of all program risks (SSRAs and other risks) and for any risk that has been accepted that has not been mitigated, require risk accepting official to re-validate risk acceptance annually. (*Applies NAE-wide)*
    i. OPR: NAVAIR
    ii. ECD: JAN 25 / On-going
    iii. Status: Complete
b. Ensure all open risks, interim mitigations, and action plans are briefed annually to fleet users at System Safety Working Group (SSWG) conference to maintain risk awareness. (*Applies NAE-wide)*
    i. OPR: PMA-275
    ii. ECD: On-going
    iii. Status: Complete
c. Define and implement a review process, including required timelines, for adjudicating and closing out open mishap recommendations (MISRECs). (*Applies NAE-wide)*
    i. OPR: Naval Safety Command (NAVSAFECOM), Commandant of the Marine Corps Safety Division (CMC SD), and Air Force Safety Center (AFSEC)
    ii. ECD: TBD
    iii. Status: In-work
d. Implement annual program safety risk reviews with resource sponsors, NAVAIR, PEO, DCA, CNAF and AFSOC to assess current program risk posture and airworthiness based on risk exposure, mitigation effectiveness, compliance and risk resolution timelines. (*Applies NAE-wide)*
    i. OPR: NAVAIR
    ii. ECD: JAN 25
    iii. Status: Complete / On-going
e. Update NAVAIRINST 5100.3H (System Safety Policy) to include all Serious, High, and Catastrophic Medium or Low risks. Require an in-brief of these SSRA categories to each PEO within 60 days of changeover. Require an annual continuation of Serious, High, and Catastrophic Medium or Low SSRAs documented, signed by PEO and submitted to AIR-00. Require all new Catastrophic Risks briefed to AIR-00. (*Applies NAE-wide)*
    i. OPR: NAVAIR
    ii. ECD: FEB 2025
    iii. Status: Complete
f. Revise OPNAV M-3750.6 (Naval Aviation Safety Program) to require MISREC review, adjudication, and closeout within a minimum timeline appropriate to execute proposed recommendation scope. (*Applies NAE-wide)*
    i. OPR: NAVSAFECOM, CMC SD
    ii. ECD: TBD
    iii. Status: Not started

4. ***The joint program office faces challenges in implementing safety remediations across the platform in a timely manner due to differences in service mission sets, priorities, governance and risk tolerance.***

    a. Differing service priorities and risk tolerance levels impact the pace and completeness of material / non-material safety mitigations planned for implementation across the MV, CMV, and CV fleets. USN is retrofitting improved PRGBs at a rate of 4% of TAI per month, USAF is retrofitting improved PRGBs at a rate of 3% of TAI per month and the USMC rate of 1% per month.
    b. Because of differing USN, USMC, and USAF MISHAP recommendation implementation authorities and safety policies, there are differing procedures to distribute safety critical information to the USN, USMC, and USAF V-22 enterprise, and unrestricted access to cross-service safety data is not universal.
    c. Significant discrepancies and differences in critical aircrew and maintenance publications and procedures exist across the USN, USMC, and USAF. For example, there are three parallel NATOPS review processes – one for each service independently – with no common source of material, leading to significant differences across the CMV-22B, MV-22B, and CV-22B NATOPS publications.

    Recommendations:

    a. Incorporate a Readiness and Safety Steering Board that will report to Program Service Acquisition Executives as well as the Service Vice Chiefs annually on critical Safety and Readiness issues. (*Applies to joint programs)*
        i. OPR: PMA-275 Program Manager, PEO(A)
        ii. ECD: TBD
        iii. Status: Not started
    b. Establish access and permissions guidelines across DoD services that enable sufficiently broad access to safety data and Privileged Safety Information for V-22 fleet units, Joint Program Office, and USN airworthiness authorities, including Privileged Safety Information (PSI) when necessary. (*Applies to joint programs)*
        i. OPR: AFSEC CO, NAVSAFECOM CO, CMC SD
        ii. ECD: MAY 2025
        iii. Status: Complete. Joint PSI-sharing memo signed by USN, USMC, USAF, and USCG safety commands

4 Readiness

4.1 Summary Findings

The V-22 Osprey, a first-generation tiltrotor aircraft, faces readiness challenges due to its complex design, high maintenance manhour requirements, inefficient supply system and current sustainment strategy. These factors have led to persistently low (~60%) mission-capable rates on average and a 30% increase in operating and maintenance costs per flight hour over the past four years.

Recently, each service has established North Stars for readiness. The USMC's North Star is 130 mission-capable aircraft required (MCAR) out of 214 in-reporting (IR) and a total aircraft inventory (TAI) of 308. AFSOC's North Star is 25 MCAR out of 35 in-reporting and a TAI of 51. The USN's North Star is 24 MCAR out of 36 in-reporting and a TAI of 38 (Figure R.1.).[5] USMC Mission Capable Aircraft Required (MCAR) equates to ~60% of IR aircraft being mission capable, which they are generally achieving, while USN and AFSOC MCARs represent ~75% of IR aircraft being mission capable, which they are not achieving. USN and AFSOC, as the minority services, will remain challenged to achieve MCAR if the joint program in aggregate does not drive to 75% + mission capable rate.

The planning strategies employed by the services highlight the gravity of the situation. Currently, the V-22 fleet operates at a ~60% mission-capable rate, forcing the services to rely on planning factors—essentially procuring and maintaining extra aircraft to meet mission requirements. This "fact of life" sustainment strategy, driven by low readiness, is costly, inefficient, and has serious operational consequences, especially on space-constrained CVN aircraft carriers.

The three services have made some efforts to improve readiness, including the partial adoption of aviation maintenance best practices such as Maintenance Operations Centers (MOCs) and Organizational Level Maintenance Management. However, these efforts have been inconsistent and limited in scope. Additional actions—such as increasing manpower, engineering support, parts, and funding—have resulted in improvements in V-22 availability in some cases. These initiatives have been costly and have not addressed the underlying, systemic issues within the sustainment system that are critical to achieving significant, enterprise-wide improvements in V-22 readiness.

Given that the V-22 is expected to remain in service for over 30 more years, it is crucial to develop and implement a comprehensive, long-term sustainment strategy that improves readiness at a lower cost, while swiftly applying proven aviation maintenance best practices across the V-22 enterprise.

4.2 Findings and Recommendations

This review finds that the V-22 platform mission capable rate has been consistently low due to four main factors:

1. ***The V-22 Joint Program has not uniformly adopted, implemented and shared aviation maintenance best practices across the services and within services, as delineated below.***

    a. Each service operates an independent mission-aligned aviation maintenance program with no framework for joint requirements for specific maintenance practices; however, there is opportunity to share best practices to improve service and squadron specific performance, while optimizing for shared joint resources (e.g., supply and engineering support).
    b. The 2019 Program Lifecycle Sustainment Plan (LCSP) establishes a target MC rate threshold of 82%. However, the current sustainment system has only been able to maintain readiness levels at an average of approximately 60%. The LCSP is required per SECNAV acquisition policy (SECNAVINST 5000.2G) for Major Defense Acquisition Programs / Acquisition Category (ACAT) I programs like the V-22 program.

[5] IR and TAI as of 28 FEB 2025

c. The sustainment strategy has not been updated and does not currently incorporate service-specific mission capable target rates or cost targets.
d. New acquisitions of V-22 aircraft within the CMV fleet have not been synchronized with a corresponding increase in sustainment funding and resourcing required to safely operate and maintain total aircraft in inventory. As an example, CMV program has expanded +11 aircraft (25%) from the original baseline plan for 42 aircraft without commensurate sustainment resource allocations to training, manning, and engineering support.
e. Targets for Operating & Support (O&S) cost per flight hour and cost per aircraft in total active inventory have not yet been set for the V-22 enterprise.
f. Maintenance execution best practices have not been fully shared or implemented across the three services (e.g., maintenance planning, work sequencing, maintenance requirement cards, inspection protocols) despite broad cross-platform applicability
g. O-level Maintenance Management (OLMM), consisting of routine inspections, servicing, and minor repairs performed by squadrons to ensure aircraft are flight-ready, is not implemented
h. Closed loop detailing, which is a career management approach that aims to keep maintainers in the same aviation platform across their careers to leverage their experience for improved maintenance efficiency, is not in place for USN or USAF; currently in place across USMC
i. There have been limited efforts to collectively analyze and improve reliability of aircraft components and systems across services. For example, Reliability Control Boards (RCBs), meetings held across platform maintenance units to identify trends impacting aircraft reliability, address recurring issues, and implement corrective actions to improve readiness, recently restarted in March 2025 after multiple year gap
j. Depot reform has been executed, but additional opportunity exists to further reduce Turn Around Times and optimize depot induction flow
k. Maintenance Program Optimization has been executed, but additional opportunity exists to optimize the maintenance program to differentiate program based on service specific mission set, reduce unnecessary planned maintenance burden, and reduce unplanned maintenance
l. No cross-service senior-level readiness governance drumbeat is in place
m. No cross-service supply reform has been implemented to address root cause of high NMCS rates

Recommendations:

a. Incorporate a Readiness and Safety Steering board that will report to Program Service Acquisition Executives as well as the Service Vice Chiefs annually on critical Safety and Readiness issues. (*Applies to joint programs)*
    i. OPR: PEO(A), PMA-275 Program Manager
    ii. ECD: TBD
    iii. Status: Not started
b. Establish service specific required Mission Capable rates. (*Applies NAE-wide)*
    i. OPR: CNAF, DCA and AFSOC
    ii. ECD: MAY 2025
    iii. Status: Complete
c. Establish service specific cost targets (cost per flight hour / cost per tail per year). (*Applies NAE-wide)*
    i. OPR: PMA-275 Program Manager in coordination with CNAF, DCA and AFSOC
    ii. ECD: TBD

iii. Status: Not started

d. Develop and implement a program sustainment system for the V-22 that enables achievement of service specific required mission capable rates and cost targets. Refresh supporting analyses (e.g., Maintainability, Logistics Supportability, Reliability) and rebaseline Operations & Support cost estimates & performance-based contract requirements accordingly. (*Applies NAE-wide)*
    i. OPR: PMA-275 Program Manager
    ii. ECD: TBD
    iii. Status: Not started

2. The V-22 Joint Program operates suboptimized supply systems and maintenance programs that do not prioritize cross-service readiness outcomes due to fragmentation across the services.

a. V-22 uses a federated approach to spare parts support with allocations prioritized solely by Force Activity Designator (FAD) code rather than optimizing for readiness across the V-22 enterprise. V-22 experiences higher supply-driven non-mission capable rates (NMCS/IR) than other Naval Aviation platforms (2020-2024: CMV 24%, MV 20%, & CV 8% vs. NAE average 16%).
b. Major organization-level downing events (phases, inspections) are 50-150% above target turnaround times with high levels of variability across services (Figure R.2.). There is no standard that is adhered to / consistently met.

Recommendations:

a. Develop and maintain regular cross-service availability reviews (HUDs) to align all three services on readiness efforts (*Applies to joint programs)*
    i. OPR: PEO(A), PMA-275 Program Manager
    ii. ECD: TBD
    iii. Status: In work. CMV-22 started in SEP 2024. USMC & AFSOC TBD
b. Stand-up V-22 supply cell to maximize economies of scale and allocate parts to best meet service-specific V-22 fleet readiness and operational needs. (*Applies NAE-wide)*
    i. OPR: CNAL, DCA, AFSOC
    ii. ECD: TBD
    iii. Status: Not started
c. Conduct cross-service supply diagnostic to understand system-wide issues across retail and wholesale, consumables and repairables. *(Applies to joint programs)*
    i. OPR: PMA-275 Program Manager, Navy Supply (NAVSUP), Defense Logistics Agency (DLA)
    ii. ECD: JUL 2025
    iii. Status: In work

3. Persistent reliability issues combined with maintainer cultural, procedural and experiential differences have caused higher Maintenance Man Hours Per Flight Hour (MMHFH)

a. The V-22, a first-generation tiltrotor aircraft fielded in 2007, has not gone through a major mid-life upgrade. As a result, V-22 is dealing with legacy technical issues that have yet to be resolved that impact the safety and readiness of the platform.

b. The V-22's unique tiltrotor design requires ~22 MMH/FH vs. 12 MMH/FH NAE average (Figure R.3.).
c. Aggregate Non-Mission Capable-Maintenance (NMCM) for V-22 sits at ~20%. Unscheduled maintenance is roughly 100% higher on average than the rest of the Naval Aviation Enterprise (Figure R.4.).
d. The CMV community plans organizational level maintenance events serially and without consideration of optimization for concurrent work; no Integrated Master Schedules are utilized for Phase or special inspections
e. Compliance with publications is inconsistent, with consistent audit discrepancies and mishap causal findings that procedures / inspections are not completed in accordance with publications (e.g., steps skipped by maintainers, NATOPS deviations). Publications are insufficient / inaccurate or outdated, which has led to parts of the community to rely on legacy knowledge passed person-to-person at times outside of technical publications.[6]

Recommendations:

a. Develop and implement a V-22 mid-life upgrade program. Identify key drivers that will improve current readiness and safety performance outcomes.
    i. OPR: N98, DCA, HQMC Combat Development and Integration (CD&I), HAF AQ(E)
    ii. ECD: TBD
    iii. Status: In-work
b. Re-assess V-22 squadron maintenance manpower requirements and right size to best support fleet readiness requirements for in-reporting aircraft.
    i. OPR: CNAF, DCA, AFSOC
    ii. ECD: TBD
    iii. Status: In work. NAVMAC studies completed CMV-22; ROC/POE pending approval. USMC & AFSOC TBD
c. Re-establish Reliability Control Boards (RCBs) to address readiness degraders. (*Applies NAE-wide)*
    i. OPR: PMA-275 Program Manager with support from NAVAIR CHENG
    ii. ECD: MAR 2025
    iii. Status: Complete / on-going
d. Optimize V-22 maintenance programs for improved material condition, maintenance man hours, and out-of-service time. (*Applies NAE-wide)*
    i. OPR: PMA-275 Program Manager, with support from Fleet Support Team (FST), Fleet Readiness Center (FRC), and CNAF/CNAP N42
    ii. ECD: JUL 2026
    iii. Status: In-work
e. Reevaluate Depot TAT for opportunities to reduce TAT and minimize OOR aircraft. (*Applies NAE-wide)*
    i. OPR: TYCOM, FRC, PMA-275
    ii. ECD: AUG 2025
    iii. Status: In-work

[6] Based on sample of V-22 Aviation Maintenance Inspection (AMI) audit findings (FY22-23) and NAVSAFECOM/AFSEC Class A-E 2020-2024 mishap causal analysis using the HFACS framework

f. Conduct cross-service evaluation of maintenance execution practices. Consolidate and distribute best practice as standard across all V-22 services. (*Applies NAE-wide)*
    i. OPR: PMA-275 Program Manager, VRM Commodore, AFSOC, USMC TMS lead
    ii. ECD: DEC 2026
    iii. Status: Not started
g. Evaluate transition to closed-loop detailing across Air Force and Navy to address experiential differences within the V-22 maintainer population, which has helped improve MC rates across the MV-22 fleet. (*Applies NAE-wide)*
    i. OPR: CNAF, OPNAV, NPC, AFSOC, AFPC
    ii. ECD: DEC 2025
    iii. Status: In-work for CMV-22; under evaluation by USAF

4. Inventory management in the V-22 program is challenged by delayed deliveries (CMVs), both over and undersized fleets, manpower to fleet size imbalances, many multiple configurations/sub-fleets, and inefficient depot execution.

a. Across all services, there are over 70 unique V-22 sub-fleet configurations driven by inefficient and incomplete modification approaches (partial retrofit & production cut-ins).
b. Manning is insufficient to meet maintenance requirement for V-22 aircraft in active fleet inventory. Squadrons are manned at 70-90% of manpower requirements (fit), while additional billets are needed to support maintenance demands. 2024 VRM-50 NAVMAC study found 30% additional billets required (Figure R.5.).
c. The Program executes vendor-supported aircraft modification contracts independently from government-supported organic maintenance activities, leading to inflexible contracts that limit the Program's ability to coordinate aircraft alignment with other modifications, and complicates future modifications, maintenance, and inspections for the aircraft (e.g., PMI, O-level maintenance).
d. Throughout 2023 and 2024, 15+ CMV deliveries were delayed upwards of 12 months (Figure R.6.).

Recommendations:

a. Re-evaluate, by service, required fleet size with updated mission requirements and flight hour utilization expectations. Update inventory management plans accordingly, to include Total Aircraft Inventory, manning requirements, preservation strategy, and depot plans. (*Applies NAE-wide)*
    i. OPR: CNAF, TYCOM, FRC, PMA-275, OPNAV N98
    ii. ECD: TBD
    iii. Status: In-work. USMC underway via MVIM. USN and AFSOC TBD
b. Develop and implement a common configuration management plan that reduces the number of V-22 configurations in the fleet.
    i. OPR: PMA-275
    ii. ECD: TBD
    iii. Status: Not started

5 Appendix

5.1 Report Authorities

Under applicable Department of Defense (DoD) and Navy instructions and regulations, Commander, Naval Air Systems Command, has broad authority in ensuring the airworthiness of Naval aircraft and is required to provide independent assessments and airworthiness flight clearance release of all Department of Navy (DON) aircraft – including USN and USMC aircraft. For the V-22 joint program, DON has airworthiness authority for all V-22 weapon systems to include: CMV-22, CV-22, and MV-22.[7]

5.2 Program Background

The V-22 Osprey is a multi-mission tiltrotor aircraft that combines fixed-wing speed and range with rotary-wing vertical lift capabilities. This unique capability makes it essential to the USMC, USN, and AFSOC for global combat and humanitarian missions. The V-22 remains the first and only tiltrotor aircraft in military operations. A brief program history is as follows:

- 1981: Tiltrotor development begun by DOD as JVX program
- April 1983: Bell-Boeing team selected as prime contractor to develop JVX aircraft
- March 19, 1989: First flight of V-22 Osprey
- 1989 – Full Scale Development (FSD)
- 1994 – Engineering and Manufacturing Development (EMD)
- 1995 – Low-Rate Initial Production (LRIP)
- 2005 – Full Rate Production
- June 2007 – MV-22 Initial Operating Capability (IOC)
- 2008 – Multi Year Procurement (MYP)
- 2009 – CV-22 IOC
- Dec 2021 – CMV-22 IOC

5.3 Scope & Methodology

The scope of this review included the MV-22, CMV-22, CV-22 fleets, PMA-275 operations, as well as a review of databases and material associated with NAVAIR engineering & airworthiness responsibilities. The review focused on the last 3-4 years of program operational history, but in some cases looked farther back to account for the full program life of the platform.

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[6] *See* SECNAVINST 5400.15D, "COMNAVAIR has management authority and accountability for assigned naval aviation programs with the exception of that authority and responsibility specifically assigned to a Program Executive Officer (PEO) or Direct Reporting Program Manager (DRPM);" SECNAVINST 4140.2, establishes NAVAIR as the Aircraft Airworthiness Authority for the Navy; OPNAVINST 5450.350B, NAVAIR is responsible for NAVAIR-designated naval aviation programs and to provide independent engineering assessment and airworthiness flight clearance release of all DON aircraft; CNAF-M 3710.7, "COMNAVAIRSYSCOM…is responsible for ensuring the airworthiness of all Naval aircraft, both manned and unmanned, including pre-accepted aircraft and public use aircraft operated by or for the Navy or USMC." Memorandum of Agreement between NAVAIR PMA-275, USSOCOM PEO (FW), and AFPEO (ISR & SOF), 2008 and amended 2019.

Since the initiation of the Comprehensive Review in September 2023, members of the review team reviewed aviation safety data (after consultation with both the Naval Safety Command and the Air Force Safety Center), pilot proficiency data (SHARP/MSHARP, fleet Training & Readiness matrices), readiness data (AMSRR, BLADE, DECKPLATE, JCMIS, IMDS), maintenance publications (IETMs, NAMP), aircrew instructions (NATOPS), policy documents and instructions (e.g., NAVAIRINST 5100.3, DoDI 6055.07), commercial best practices (e.g., safety management systems, technical publications, audit systems), site visits, interviews, and observations. The NAVAIR Comprehensive Review team consisted of personnel from COMFRC, NAWCAD maintenance, fleet (Navy, USMC, AFSOC), industry (Bell/Boeing), Training, Supply, Readiness, and Safety.

There were three major site visits conducted by the Comprehensive Review team. From 23-25 January 2024, the team visited Naval Air Station North Island (NASNI) with representatives from NAVSAFECOM, during which they interviewed and interacted with dozens of VRMWING, VRM-30, and VRM-50 personnel across leadership, pilot, and maintainer roles within the Navy V-22 Squadrons (CMV-22B variant), and identified issues in safety culture, achieving target pilot flight hours, inadequate pilot and maintainer training, unclear publications, limited parts supply, and low manning. Subsequent visits to Marine Corps Air Station (MCAS) New River from 6-8 February 2024 allowed similar observations from USMC V-22 Squadrons (MV-22B variant), specifically MAG-26, which highlighted issues in achieving pilot flight hours, poor training, inadequate maintainer manning / qualifications, and limited information in publications. Lastly, the team visit to Cannon Air Force Base (AFB) from 13-15 February 2024 identified issues at the USAF V-22 Squadrons (CV-22B variant), specifically 727 SOAMXS, 20 SOS, and 1 SOG, in sharing V-22 lessons across services, limited pilot experience, inaccurate maintenance man hours tracking, and limited supply of key parts.

Prior to this Comprehensive Review, there were three prior reviews conducted of the V-22 program; however, the status of the recommendation implementation is unclear, as no enduring forums were established to monitor and drive progress. A 2001 review of the V-22 program led by former USMC General John R. Dailey identified high-level issues in training, engineering / design, production quality, capability, and safety, providing recommendations such as developing a consistent approach to measuring risk. However, this report lacked in-depth root cause analysis and did not provide specific suggestions to the program (e.g., assess options for V-22 technical publications), assign owners to complete action items, or create a forum to track implementation of the suggested actions. As a result, there was limited completion of action items. In 2009, the MV-22 community conducted a Leadership Strategy Process (LSP) to create a strategy roadmap for the platform. This roadmap included mostly process-oriented recommendations (e.g., initiate training & readiness review to re-evaluate simulator opportunities, have readiness reporting metrics), and although it assigned specific owners for actions, it did not set up a forum to track progress. As a result, few recommendations were tracked to execution. In 2016, an independent readiness review was conducted for the V-22 platform by LMI which provided an in-depth view into maintenance and reliability degraders. This report provided many specific recommendations for the platform to implement with owners assigned for actions, although some recommendations were vague (e.g., charter a strategic review of the NAE construct or have DLA reinvigorate its organic manufacturing process); however, no forums were set up to track execution of the action plans. As a result, plans were minimally tracked to full execution.

This Comprehensive Review was initiated in September 2023 by NAVAIR, and was sent to DCA, CNAF, AFSOC, Program Executive Office Air Anti-Submarine Warfare, Assault & Special Mission (PEO(A)), V-22 Joint Program Office (PMA-275), Naval Safety Command (NAVSAFECOM), and Air Force Safety Center (AFSEC) for their review and input.

5.4 Report Data - Overview

The figures in this section contain results from the data analyses conducted during the writing of this Comprehensive Review report and relevant definitions / graphics for the report, with figures split by the Safety and Readiness sections. Sources and clarifications for each of the figures are provided in the footnotes. Key terms are provided in Table 1 later in the Appendix.

The figures in the Safety and Readiness section were developed based on analysis conducted of several primary databases by working with the NAVAIR analytics team, fleet operators, and Air Force Safety Center team. These databases include:

- Safety
    - Risk Management Information (RMI) – USN/USMC mishap, HAZREP, MISREC, and HAZREC database
    - Air Force Safety Automated System (AFSAS) – USAF mishap, HAZREP, MISREC, and HAZREC database
    - Risk, Issue, Opportunity (RIO) – NAVAIR SSRA database

- Readiness
    - Aviation Maintenance Supply Readiness Report (AMSRR) – USN/USMC logistics and readiness database
    - Basing & Logistics Analytics Data Environment (BLADE) – USAF logistics and readiness database
    - Decision Knowledge Programming for Logistics Analysis and Technical Evaluation (DECKPLATE) – USN/USMC readiness database (includes RT-79 data)
    - Joint Configuration Management Information System (JCMIS) – joint product lifecycle management application
    - Integrated Maintenance Data System (IMDS) – USAF maintenance data system
    - Naval Aviation Logistics Command Management Information System (NALCOMIS) Optimized Organizational Maintenance Activity (OOMA) – USN/USMC maintenance data system
    - Marine Sierra Hotel Aviation Readiness Program (M-SHARP) / Sierra Hotel Aviation Readiness Program (SHARP) – USMC/USN pilot proficiency tracking
    - Joint Deficiency Reporting System (JDRS) – deficiency reports

5.5 Report Data - Safety

The following section contains results from data analysis for the Safety section.

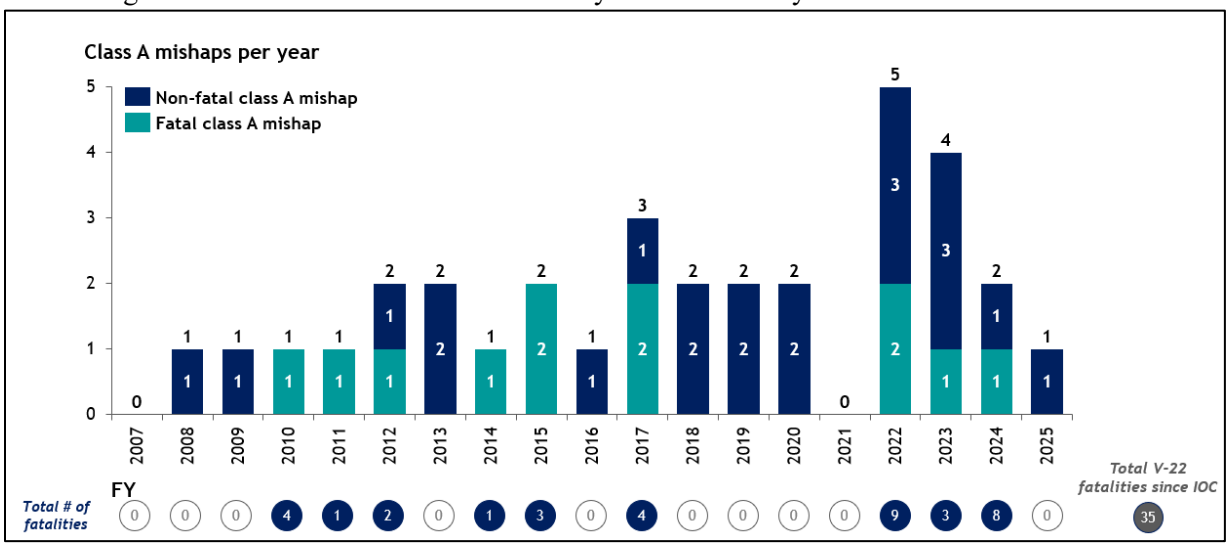

Figure S.1. V-22 Class A mishaps - fatal & non-fatal (2007-2024)[8]

Date	TMS	Location	A/C lost	Fatalities	Injuries[1]
18 MAR 2022	MV-22B/USMC	Norway	Yes	4	0
17 MAY 2022	CV-22/USAF	New Mexico	No	0	0
08 JUN 2022	MV-22B/USMC	Glamis, CA	Yes	5	0
08 JUL 2022	CV-22B/USAF	Florida	No	0	0
12 AUG 2022	CV-22B/USAF	Norway	No	0	0
14 OCT 2022	MV-22B/USMC	Miramar, CA	No	0	0
17 AUG 2023	CV-22B/USAF	California	No	0	1
22 AUG 2023	CV-22B/USAF	New Mexico	No	0	1
27 AUG 2023	MV-22B/USMC	Melville Island, Australia	Yes	3	20
24 OCT 2023	MV-22B/USMC	Nevada	No	0	1
29 NOV 2023	CV-22B/USAF	Japan	Yes	8	0
20 NOV 2024	CV-22B/USAF	Cannon Air Force Base, NM	No	0	0

Mishaps with fatalities

Figure S.2. V-22 Class A mishaps last four years (2021-2025)[9]

[8] Source: RMI database mishap data USN+USMC (2007-2024); AFSAS database CVV-22B mishap data (2007-2024)
[9] Source: RMI database mishap data (2021-2025); AFSAS database mishap data (2021-2025). 1. Excluding fatalities.

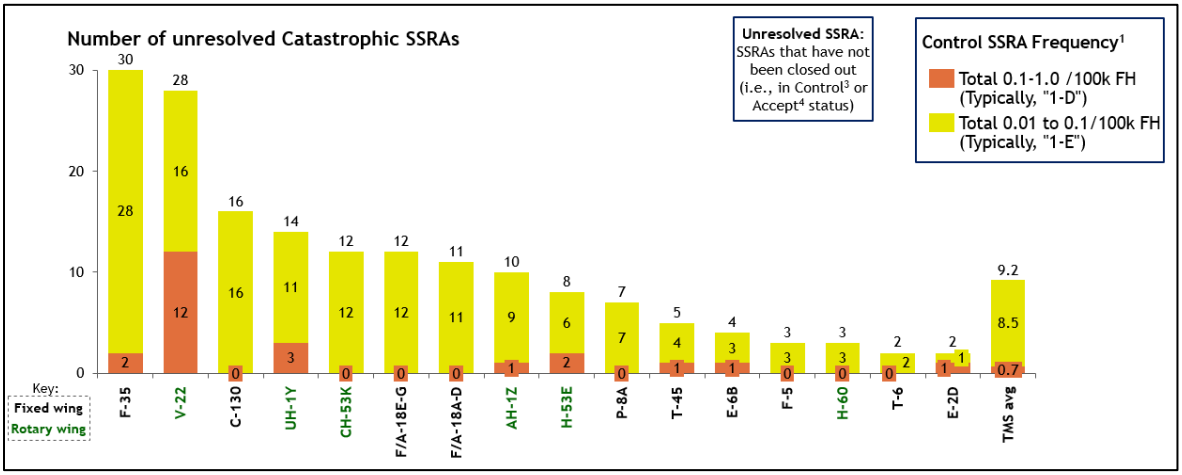

Figure S.3. NAE TMS unresolved Catastrophic SSRAs (2025) – Hazard Risk Index I-D and I-E[10]

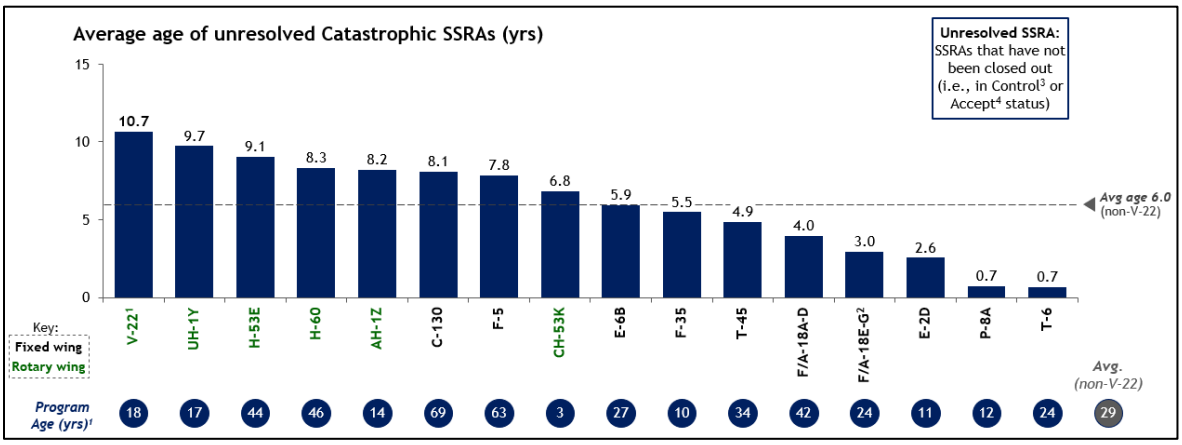

Figure S.4. NAE TMS unresolved Catastrophic SSRAs – avg. age (2025) – Hazard Risk Index I-D and I-E[11]

[10] Source: RIO SSRA database data (02 JAN 2025). Note: NAVAIR manned platforms only. 1. Platforms may report code (ex: "1-D" or "3-C") differently, but frequency and severity are equivalent measures for all SSRAs. 2. Includes EA-18G. 3. Control SSRA: risk not yet mitigated; requires resolution. 4. Accept SSRA: risk identified; being observed for trends.

[11] Source: RIO data (02 JAN 2025). Note: SSRAs may be created either before or after IOC; program age included as a reference benchmark. 1. Measured as years since IOC. V-22 age based on MV-22 IOC of 2007 (CV-22 IOC: 2009, CMV-22 IOC: 2021); VH-3D excluded due to sunset. 2. Includes EA-18G. 3. Open SSRA: risk not yet mitigated; requires resolution. 4. Monitor SSRA: risk identified; being observed for trends.

	V-22 Outstanding Serious (I-D and II-C) SSRAs	Starting HRI	Status	Date opened[1]	Risk realized?	Total realized events[2]	Catastrophic outcomes only
1	CV/MV-22 - Wire Strike Hazard Risk	I-D	Accept	2/15/2000	Yes	2	--
2	V-22 - 1st Stage Compressor Blade Failure and IFSD	I-D	Control	9/4/2014	Yes	18	--
3	V-22 - AE1107C Rapid Power Loss and Surge During Reduced Visibility Landings	I-D	Control	12/21/2015	Yes	7	2
4	V-22 - Collision-Object Strike Mid-Air	I-D	Control	11/10/2011	No	-- (20+ near miss)	--
5	V-22 Troop Seat Fails to Drop Away at Egress Hatch Locations (MV-22 Only)	I-D	Control	12/20/2010	No	--	--
6	V-22 - Improved Troop Seat Lap Belt Restraint Failure	I-D	Control	4/1/2015	No	--	--
7	V-22 - Pylon Conversion Actuator Failure to Convert	I-D	Control	12/20/2010	Yes	29	--
8	V-22 - Troop Seat Installation	I-D	Accept	11/20/2006	No	--	--
9	V-22 Aerial Refueling Probe Drogue-Failure (SAR 46-26)	I-D	Accept	10/1/2003	Yes	3	--
10	V-22 Compromise of Crew/Passenger Living Space During Crash (SAR 00-25)	I-D	Accept	10/2/2003	No	--	--
11	CMV-22 Meggitt Fuel Cell Audit	I-D	Control	5/17/2024	No	--	--
12	V-22 - X-53 Inclusion Failure Resulting in Loss of Aircraft	I-D	Control	12/30/2024	Yes	15	1
13	V-22 - NLG Collapses During Landing-Taxi on Austere Terrain	II-C	Accept	3/6/2012	Yes	4	--

Risk realized Risk not realized

Figure S.5. V-22 Serious (I-D and II-C) SSRAs – realized events[12]

Data as of 28 FEB 2025

Discrepancy[1]	USMC	USN	AFSOC
Overflown life-limited components	29	0	14
Missing FH penalization	23	0	25
Incorrect TSN[2] at install	804	7	8,646
Serial number unknown requiring physical verification	120	0	2,526
Mismatch b/w physical verification & systems of record	21	0	2
Total discrepancies	**997**	**7**	**11,213**
Logbooks reviewed	284	29	51
Errors per logbook (average)	**3**	**<1**	**220**
Total active inventory (TAI)	***308***	***37***	***51***

Figure S.6. V-22 maintenance logbook audit review findings[13]

[12] Source: RIO database data (07FEB2025); NAVAIR & PEO(A) HCOA brief (JUN 2024); Safety P2Ps (MAR 2025). Note: Realized events may include catastrophic and/or non-catastrophic outcomes; SSRA numbering not related to priority. 1. Date approved for newer entries in RIO due to different data format. 2. Any event that could lead to a catastrophic failure mode - not just a catastrophic outcome; Count as of July 2024.

[13] Source: FST Logbook & Physical Verification tracker (28 FEB 2025). 1. Include logbook and system of record discrepancies. 2. Time since new.

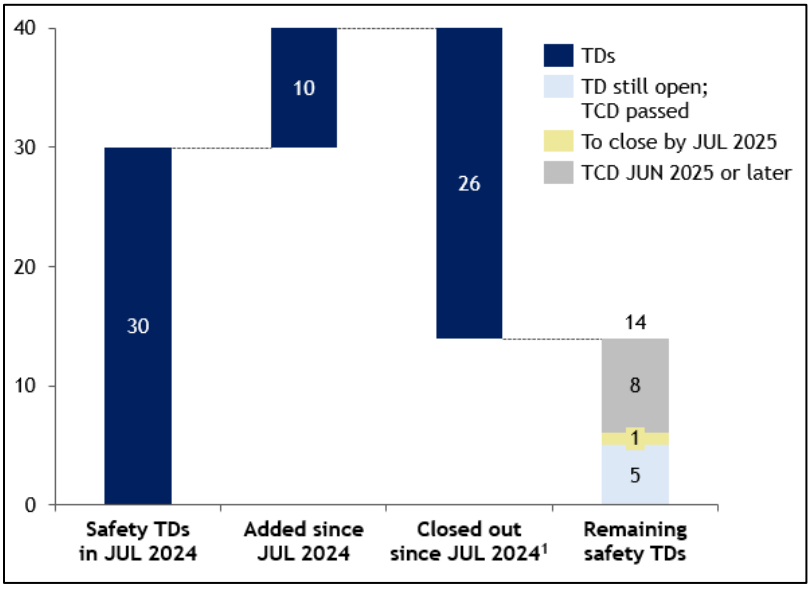

Figure S.7.a. Number of V-22 safety-related TDs (JUL 2024 to JUL 2025)[14]

Basis	Risk	TCD	% complete
ACC-771	I-D	12/31/2027	93%
ACC-778	I-D	12/31/2027	65%
AFB-181	I-D	12/31/2021	MV 99%, CMV 100%, CV 100%
AFB-188	I-D	6/30/2023	MV 95%; CV 100%
AFC-221	I-D	12/31/2027	MV 41%
AYB-1784	I-D	12/31/2024	MV, CMV, CV 94%
AFB-200	I-D	12/31/2024	MV 79%, CMV 100%, CV 86.3%
AFB-202	I-D	6/30/2025	MV 93% (1 AC left)
DCB-66	I-D	6/30/2025	MV 75%, CMV 92%, CV 76%
DCB-52	I-E	12/31/2018	MV 100% /CV 91%
AFB-182	I-E	6/30/2025	MV 91%, CMV 75%, CV 100%
AFB-186	I-E	6/30/2025	MV 91%, CMV 100%, CV 100%
AFB-198	I-E	12/31/2025	MV 68%%, CMV 94%, CV 65%
ACB-1348	I-E	6/30/2025	Pending Closure

TCD past due

TD still open; TCD passed | To close by JUL 2025 | TCD JUN 2025 or later

Figure S.7.b. Currently open V-22 safety related TDs[15]

[14] Source: V-22 500C report (APR 2025); includes 1 cancelled TD (AVB-991).
[15] Source: V-22 500C report (APR 2025)

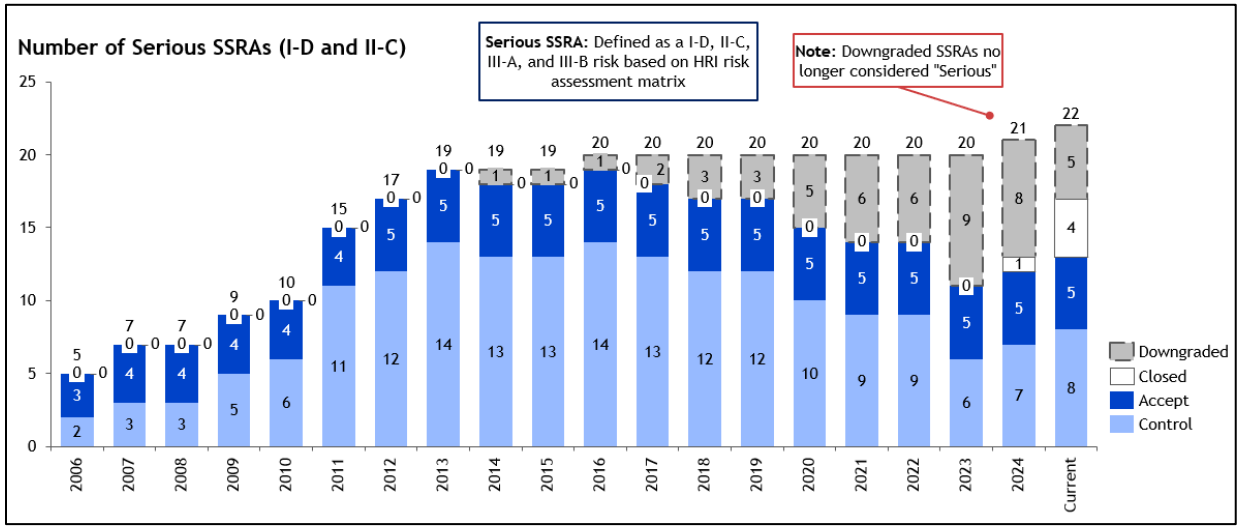

Figure S.8. V-22 Serious SSRAs (2006-2025) – Hazard Risk Index I-D and II-C[16]

	Total	Not attributable to human factors	Attributable to human factors	Procedural non-compliance	Other human factors cause
Flight/Flight-Related	**337**	**212**	**125**	**51**	**74**
MV-22	228	163	65	39	26
CMV-22	23	13	10	5	5
CV-22	*86*	*36*	*50*	*7*	*43*
Ground	**386**	**72**	**314**	**95**	**219**
MV-22	140	42	98	49	49
CMV-22	62	19	43	21	22
CV-22	*184*	*11*	*173*	*25*	*148*
Total	**723**	**284**	**439**	**146**	**293**

Figure S.11. HFACS analysis for USN, USMC, and USAF mishaps (2020-2024)[17]

[16] Source: RIO data (07 FEB 2025); historical SSRA data; MIL-STD-882 (SEP 2023). Note: Serious HRIs included; downgrades only include currently control SSRAs downgraded from I-D (serious) to I-E (medium) severity.

[17] Source: Naval Safety Command (APR 2025); Air Force Safety Center (APR 2025). Notes: Human Factors Analysis and Classification System (HFACS) is a framework used to categorize human error in DoD aviation; HFACS include Compliance (e.g., Performs Work-Around Violation; Commits Widespread/Routine Known Deviation; Unintended Activation or Deactivation or Operation of Equipment; Procedure or Checklist Not Followed Correctly; Ignored a Caution/Warning), Risk Management, Action/Inaction, and Other (e.g., Improper publications, Effective planning)

5.6 Report Data - Readiness

The following section contains results from data analysis for the Readiness section.

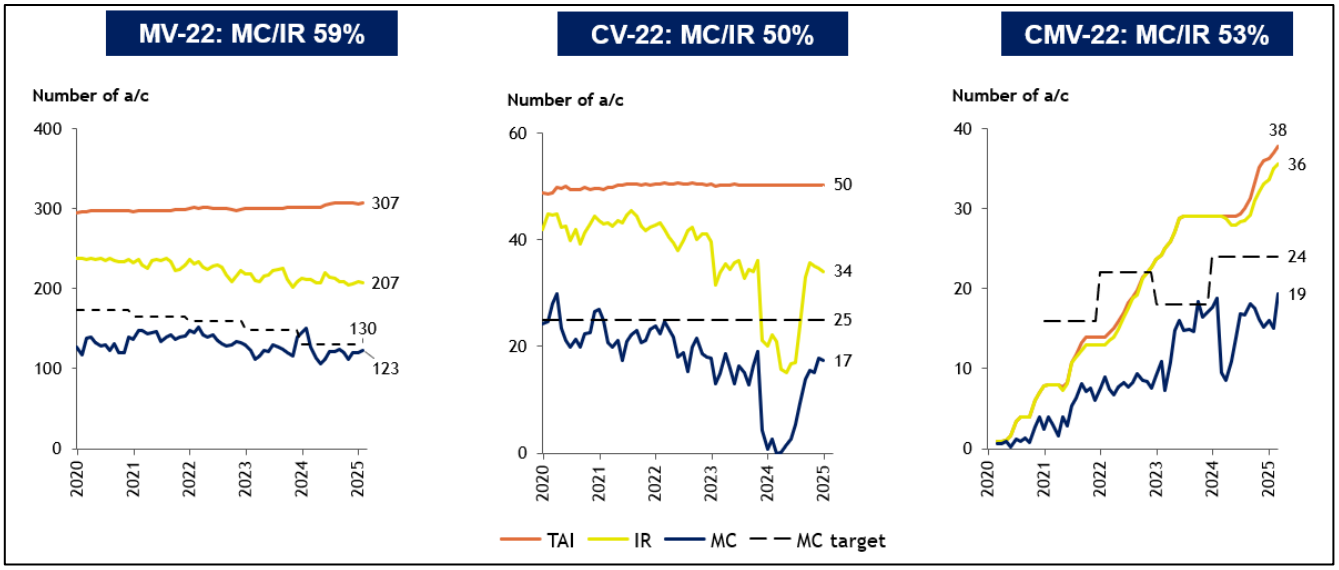

Figure R.1. V-22 TAI, IR, and MC by service (2020-2025)[18]

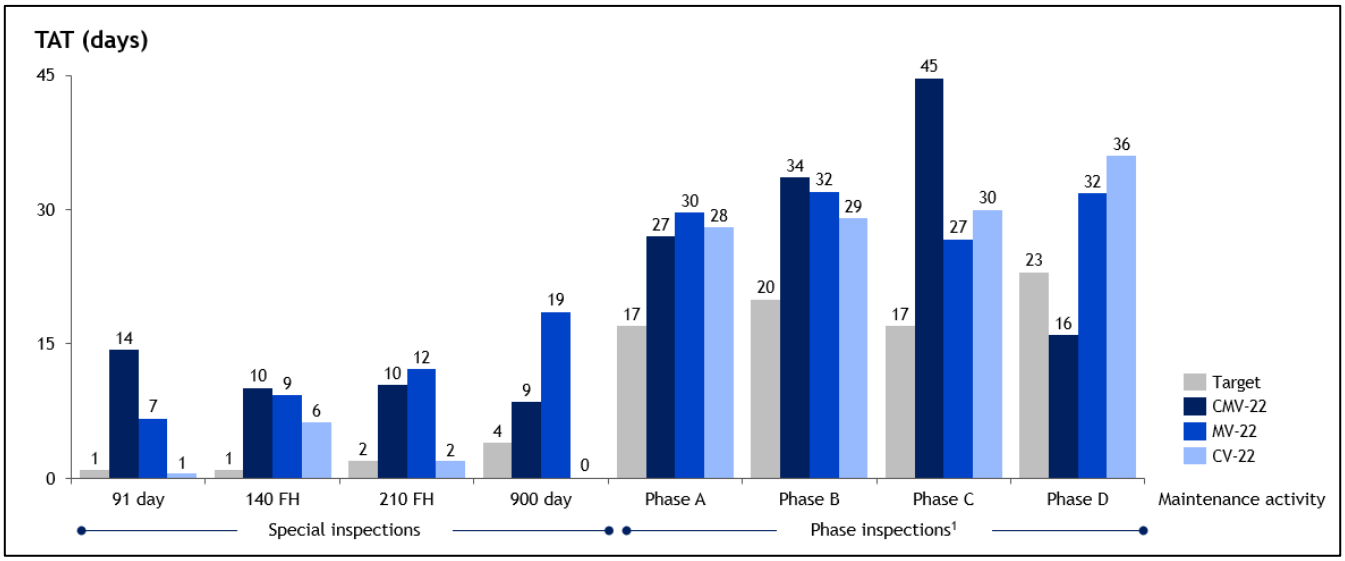

Figure R.2. Turnaround time of maintenance events by service (2021-2024)[19]

[18] Source: AMSRR for CMV-22B and MV-22B (FY20-25); BLADE for CV-22B (FY20-FY25). Notes: 30-day rolling average as of 1st day of month; MV-22 data through FEB2025, CMV through MAR 2025, CV-22 through JAN 2025. 1. Current target.

[19] Source: CMV-22 OOMA database (FY 2021-2024), MV-22 DECKPLATE database (FY 2021-2024), AFSOC IMDS database (FY 2017–2024). Note: USN / USMC TATs based on received time until completed time, AFSOC based on started time until completed time. 1. Data includes both look and fix phase, TATs may be skewed by other gripes identified during inspection and tracking method discrepancies.

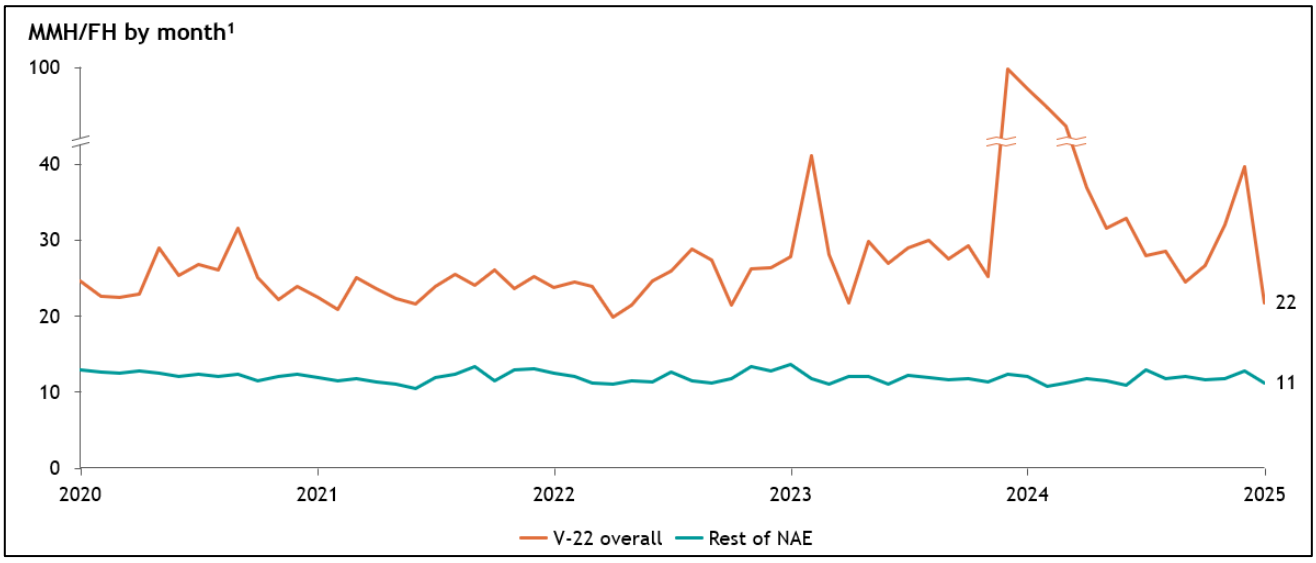

Figure R.3. V-22 & NAE MMH/FH (2020-2025)[20]

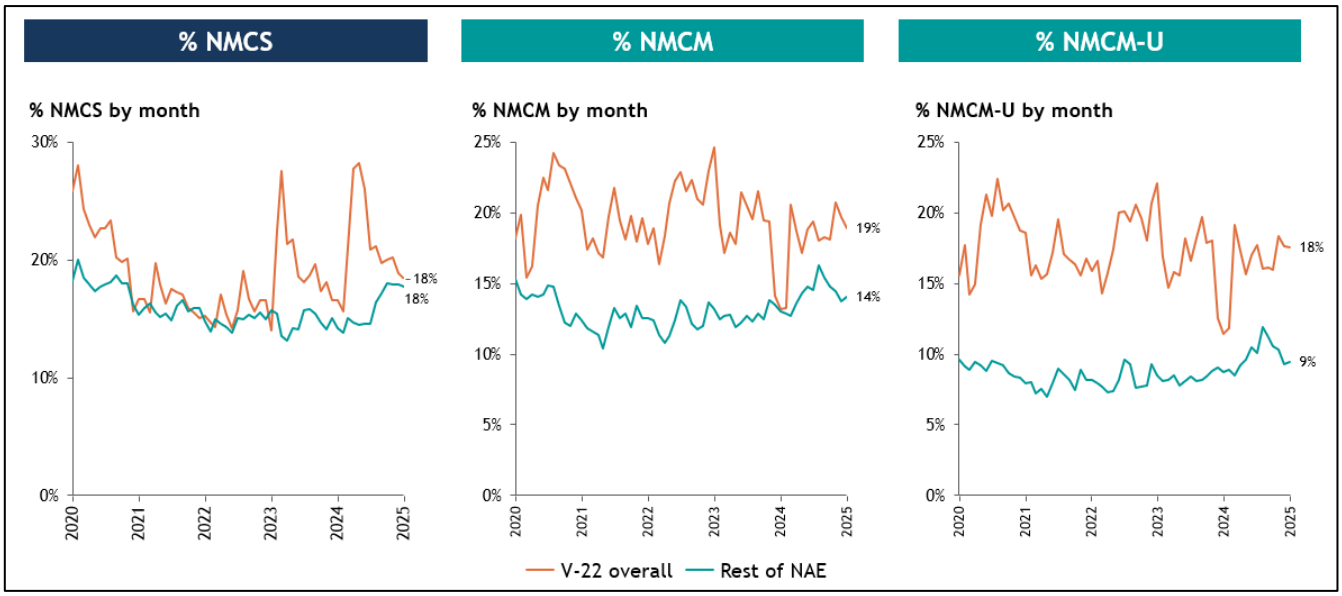

Figure R.4. V-22 & NAE % NMCS, NMCM, and NMCM-U (2020-2025)[21]

[20] Source: RT79 database for CMV-22B, MV-22B, and Rest of NAE (FY20-25); BLADE database for CV-22B FH (FY20-FY25); IMDS database for CV-22B MMH (FY20-25). Notes: Excluded outliers JAN and FEB 2024 from graph, which, due to grounding and correspondingly low MMH distorted graph. JAN 2024 value 75 FH with 1135 MMH/FH and FEB2024 value 123 FH with 597 MMH/FH across MV, CV, and CMV fleets; 30-day rolling average as of 1st day of month; data through JAN 2025.

[21] Source: AMSRR for CMV-22B, MV-22B and Rest of NAE (FY20-24); BLADE for CV-22B (FY20-FY25). Notes: 30-day rolling average as of 1st day of month; data through JAN 2025.

	Manning					Aircraft on FL		
	Onboard[1]	Required[2]	Auth.[3]	NAVMAC req'd. (Sea)[2,6]	NAVMAC req'd (Shore)[6]	Custody	Manned For[5]	Auth. aircraft[7]
VRM-30	325	360	359	429	463	15	13	14
VRM-30 FDNF	78	75	89	100	100	4	3	3
VRM-40	198	360	305	429	463	11	8	14
VRM-50	239	278	277	278	278	7	9	9
Total	840	1073	1030	1222	1290	37	33	40

Figure R.5. CMV SQD manning requirements and NAVMAC manpower study results[22]

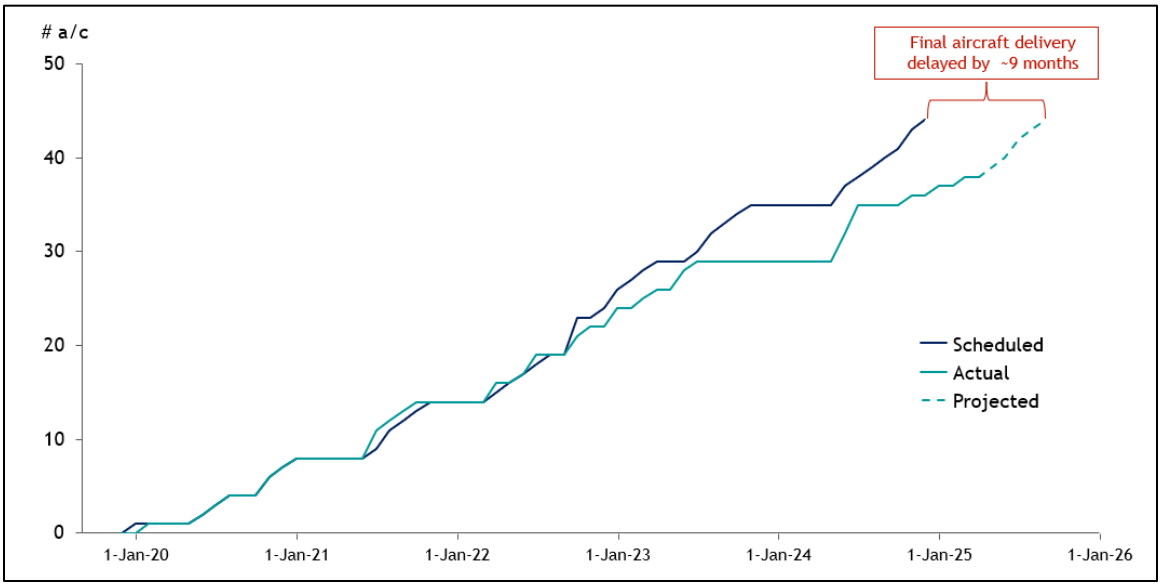

Figure R.6. CMV-22 – contracted vs. actual a/c delivery dates (2019-2026)[23]

5.7 Naval Aviation Systems Safety Policy

NAVAIRINST 5100.3H, the Naval Aviation System Safety Engineering Policy, defines how Naval Air Systems Command (NAVAIR) should manage and mitigate safety risks across its aviation programs.

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[22] Source: CMV-22 3-Star Availability HUD (13MAR2025); CVRM wing manning data (17MAR2025); NAVMAC manpower studies for VRM-30, 40, 50. 1. N1 Dashboard February 2025. 2. Enlisted, PSQMD as of 10 MAR. 3. Enlisted FLTMPS. 4. PSQMD findings pending approval of CNAF. 5. Assumes 25 pax/AC following DET sizing. 6. From NAVMAC study for assignment of 2 additional aircraft at VRM-30 and VRM-40 shore UIC. 7. Based on PAA / PTAA from NAVMAC studies for VRM-30, 40, and 50.

[23] Source: PMA-275 CMV contractual delivery dates (MAR 2025); DD250 completions (MAR 2025).

Program Managers (PMs) are responsible for identifying, documenting, tracking, and managing hazards through a formal System Safety Program for the platform. PMs are supported by systems safety engineers (SSEs) who conduct risk assessments using a Hazard Risk Index (HRI) matrix to categorize risks as High, Serious, Moderate, or Low, assessing material risks by severity (I Catastrophic to IV Negligible) and probability (A Frequent to E Improbable) categories (refer to Figures S.9.a, b, c. below for criteria). For example, a I-D risk would be classified as Serious, while a I-E risk would be Medium. When mishaps occur, they are categorized from Class A-E based on total property damage and fatalities / injuries (refer to Figure 10 below for criteria).

Risk acceptance for programs is tiered. High risks must be accepted by a Flag Officer or Senior Executive, Serious risks by the Program Executive Officer (PEO), and Moderate to Low risks by the Program Manager (PMA). All accepted risks must be continuously tracked and reviewed annually to ensure mitigation efforts remain effective across the program lifecycle.

When safety risks are identified by the PEO or PMA, they propose safety-related modifications to mitigate those risks. However, it is up to the resource sponsors / services to fund these modifications for their respective Fleets. If there are issues with this funding, NAVAIR can flag them at the 3-star level and can enforce compliance as needed.

FREQUENCY \ SEVERITY		CATASTROPHIC I	CRITICAL II	MARGINAL III	NEGLIGIBLE IV
FREQUENT > 1/1,000 (1E-3)	A	HIGH (1)	HIGH (3)	SERIOUS (7)	MEDIUM (13)
PROBABLE 1-<10/10,000 (1E-4)	B	HIGH (2)	HIGH (5)	SERIOUS (9)	MEDIUM (16)
OCCASIONAL 1-<10/100,000 (1E-5)	C	HIGH (4)	SERIOUS (6)	MEDIUM (11)	LOW (18)
REMOTE 1-<10/1,000,000 (1E-6)	D	SERIOUS (8)	MEDIUM (10)	MEDIUM (14)	LOW (19)
IMPROBABLE <1/1,000,000 (<1E-6)	E	MEDIUM (12)	MEDIUM (15)	MEDIUM (17)	LOW (20)

Figure S.9.a. NAVAIR Hazard Risk Index (HRI) matrix[24]

[24] Source: MIL-STD-882 (SEP 2023)

HAZARD FREQUENCY			
Probability Level		Qualitative Definition Fleet Lifetime	Occurrences / 100K Flt Hrs
Frequent	**A**	Continuously experienced	>100
Probable	**B**	Will occur frequently	100 - 10
Occasional	**C**	Will occur several times	<10 - 1
Remote	**D**	Unlikely, but can reasonably be expected to occur	<1 - 0.1
Improbable	**E**	Unlikely, but possible	<0.1

Figure S.9.b. NAVAIR Hazard Risk Index (HRI) – Hazard Frequency definitions[25]

HAZARD SEVERITY		
Category		Definition
Catastrophic	**I**	Could result in one or more of the following: death, permanent total disability, aircraft loss or damage beyond economical repair, or irreversible significant environmental impact.
Critical	**II**	Could result in one or more of the following: permanent partial disability, injuries or occupational illness that may result in hospitalization of at least three personnel, reversible significant environmental impact, monetary loss equal to or exceeding $1M .
Marginal	**III**	Could result in one or more of the following: injury or occupational illness resulting in one or more lost work day(s), reversible moderate environmental impact, monetary loss equal to or exceeding $100K but less than $1M,
Negligible	**IV**	Could result in one or more of the following: injury or occupational illness not resulting in a lost work day, minimal environmental impact, or monetary loss less than $100K.

Figure S.9.c. NAVAIR Hazard Risk Index (HRI) – Hazard Severity definitions[26]

[25] Source: MIL-STD-882 (SEP 2023)
[26] Source: MIL-STD-882 (SEP 2023)

Mishap Class	Total Property Damage	Fatality/Injury
A	$2,500,000 or more and/or aircraft destroyed	Fatality or permanent total disability
B	$600,000 or more but less than $2,500,000	Permanent partial disability or three or more persons hospitalized as inpatients
C	$60,000 or more but less than $600,000	Nonfatal injury resulting in loss of time from work beyond day/shift when injury occurred
D	$25,000 or more but less than $60,000	Recordable injury or illness not otherwise classified as a Class A, B, or C
E	$1 or more but less than $24,999	Injury or damage not otherwise classified as a Class A, B, C, or D

Figure S.10. Mishap reporting thresholds[27]

5.8 Comprehensive Review Timeline

The below list provides the timeline for the V-22 Comprehensive Review, including major events and meetings involved in the creation of the report.

- **SEP 2023:** NAVAIR initiates V-22 Comprehensive Review
- **NOV 2023:** GUNDAM 22 Class A mishap occurs off coast of Japan (29 NOV 2023)
- **DEC 2023:** NAVAIR issues V-22 fleet grounding bulletin (06 DEC 2023)
- **DEC 2023-APR 2024:** Data collection for Comprehensive Review
- **JAN 2024:** Initiation of Lines of Effort (LOEs) 1, 2, and 3 as result of GUNDAM mishap to return to flight, return to mission, and reduce overall mishap rates as part of Comprehensive Review (respectively)
- **JAN-MAR 2024:** NAVAIR release airframe bulletins (AFBs) 200/201 and Air Force release TCTOs to execute directed logbook review
- **JAN 2024:** NAVAIR LOE3 team site visit to Naval Air Station North Island (NASNI)
- **FEB 2024:** NAVAIR LOE3 team site visits to Marine Corps Air Station (MCAS) New River and Cannon Air Force Base (AFB)
- **MAR 2024:** NAVAIR briefs to DEPSECDEF, CNO, and VCNO
- **MAR 2024:** Return to flight after GUNDAM 22 mishap grounding
- **APR 2024:** V-22 3-star leadership summit (24 APR 2024)
- **JUN 2024:** House Committee on Oversight and Accountability Subcommittee (HCOA) briefing (12 JUN 2024)
- **JUN-NOV 2024:** Internal 3-star discussions to share ongoing learnings from Comprehensive Review
- **JULY 2024 – MAY 2025:** NAVAIR biweekly discussions with service and industry representatives on CR data collection, findings, and corrective action recommendations
- **SEP 2024:** V-22 3-star leadership summit (06 SEP 2024)
- **NOV 2024:** Cannon AFB Class A mishap (20 NOV 2024)

[27] Source: Naval Safety Command (MAR 2025); DoDI 6055.07 (JUN 2019)

- **DEC 2024:** Revised Interim Flight Clearance (IFC) with post Cannon AFB mishap (09-20 DEC 2024)
- **JAN 2025:** V-22 3-star leadership summit (24 JAN 2025)
- **JAN-MAR 2025:** Final data collection and updates for Comprehensive Review report
- **FEB 2025:** Revised Interim Flight Clearance (IFC) based on further airworthiness assessments (20 FEB 2025)
- **MAR 2025:** V-22 3-star leadership summit (07 MAR 2025)
- **MAR 2025:** Draft of Comprehensive Review shared with USMC, USN, and USAF operational commanders
- **MAR 2025:** V-22 PEO(A) / PMA-27 safety offsite (17MAR2025)
- **MAR-MAY 2025:** Revisions of Comprehensive Review report based on USMC, USN, and USAF feedback
- **MAY 2025:** V-22 3-star leadership summit (29MAY2025)

5.9 Acronyms and Definitions

Table 1. Key terms and definitions for Safety and Readiness sections

	Term	Definition
Safety	**Hazard Risk Index (HRI)**	Quantitative measure of risk severity and frequency of occurrence.
	Human Factors Analysis and Classification System (HFACS)	Framework for analyzing human errors in aviation mishaps.
	Mishap recommendations (MISRECs)	Corrective actions from mishap investigations.
	Mishaps	Accidents or incidents involving damage, injury, or loss of life, investigated for preventive measures.
	Naval Air Training and Operating Procedures Standardization (NATOPS)	Standardized procedures for safe naval aircraft operations.
	Proprotor Gearbox (PRGB)	Transfers power from the engine to the proprotors, adjusting speed and torque.
	Systems Safety Risk Assessments (SSRAs)	Evaluations to identify and mitigate system material risks. Controlled risks are still open and accepted risks are mitigated.
	Technical Directive (TD)	Official instruction for modifying, inspecting, or updating aircraft components and procedures.
Readiness	**Flight hours (FHs)**	Total hours an aircraft is in flight, used for tracking maintenance, pilot training, and readiness.
	Fully Mission Capable (FMC)	Status indicating an aircraft is fully operational without any mission-limiting defects.
	In-reporting aircraft (IR)	Aircraft that are active in inventory and ready for missions.
	Mission Capable (MC)	Aircraft is operational but may have minor defects that do not affect mission execution.
	Out of Reporting (OOR)	Inactive non-operational aircraft in inventory
	Planned Maintenance Intervals (PMIs)	Scheduled maintenance events performed at specific time intervals
	Total Aircraft Inventory (TAI)	Total count of owned aircraft, including operational and non-operational units.