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ACQUISITION RESEARCH PROGRAM SPONSORED REPORT SERIES

Above and Beyond: A Roadmap for the Military Airworthiness Certification for the Hybrid Air Vehicles

June 2025

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ABSTRACT

Given the U.S. Navy's (USN) 62-year hiatus from lighter-than-air programs, this research addresses the challenges of aligning military airworthiness standards with civilian certification frameworks and the complexities of certifying a new foreign-developed type aircraft (TA). The objective of this research is to evaluate and develop a new roadmap for the USN airworthiness certification (flight clearance) process for hybrid air vehicles, utilizing the Hybrid Air Vehicles Airlander 10 as a case study. An extensive literature review and comparative analysis utilizing process analytics identified a pathway and projected timeline for achieving airworthiness certification and acquiring a hybrid air vehicle for the Department of the Navy (DON). This research concludes with a look at future airworthiness technology and how it can address the challenges of this new TA with military systems integration. This research provides critical insights for Naval Air Systems Command while bridging the gap between civil and military organizations and advancing aviation technologies for national security use. This research supports the USN's Force Design 2045, the Department of Defense (DoD) Middle Tier of Acquisition process, and an executive order titled Modernizing Defense Acquisition and Spurring Innovation in the Defense Industrial Base.

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LIST OF ACRONYMS AND ABBREVIATIONS

AMC	acceptable means of compliance
AOR	area of responsibility
CAA	civil aviation authority
CBP	Customs and Border Protection
CDA	commercial derivative aircraft
C.F.R	Code of Federal Regulations
CNAF	Commander, Naval Air Forces
CS	certification specification
DoD	Department of Defense
DoDI	Department of Defense Instruction
EASA	European Union Aviation Safety Agency
E.U.	European Union
FAA	Federal Aviation Administration
GAO	Government Accountability Office
GM	guidance material
HAV	Hybrid Air Vehicle
ICAO	International Civil Aviation Organization
IFC	interim flight clearance
LEMV	Long Endurance Multi-Intelligence Vehicle
MAA	major military airworthiness authority
MCA	major capability acquisition
MCDA	military commercial derivative aircraft
MTA	middle tier of acquisition
NAE	Naval Air Enterprise
NAS	Naval Air Station
NATO	North Atlantic Treaty Organization
OEM	original equipment manufacturer
SC-GAS	Special Condition for Gas Airships
TA	type aircraft
TARS	Tethered Aerostat Radar System

TC	type certificate
U.K.	United Kingdom
U.S.	United States
USAF	U.S. Air Force
USMC	U.S. Marine Corps
USN	U.S. Navy
USS	U.S. Ship

I. INTRODUCTION

The USN has a long history of involvement with rigid airships, also known as zeppelins. In 1916, the USN built and designed the first rigid airship, the USS Shenandoah, which was originally designated ZR-1 (Polmar, 2011). The Navy operated five different airship classes/types across the Pacific, Mediterranean, and Atlantic during World War II (Naval History and Heritage Command, 2024). On June 21, 1961, the Navy's lighter-than-air program was canceled by direction of the secretary of the Navy (Naval History and Heritage Command, 2024). The final flight of a naval airship occurred on August 31, 1962 (Naval History and Heritage Command, 2024). Figure 1 depicts the USN's first airship, the USS Shenandoah.

Figure 1. USS Shenandoah at Naval Air Station (NAS) Lakehurst, NJ, 1925. Source: Smithsonian National Air and Space Museum (n.d.).

The U.S. Army also had a hybrid airship known as the Long Endurance Multi-Intelligence Vehicle (LEMV), but this program was canceled in 2013 (Judson, 2016). A United Kingdom (U.K.)–based company, Hybrid Air Vehicles (HAV), acquired the LEMV, excluding its sensor suite that Northrop Grumman was developing, and renamed it the Airlander 10 (Judson, 2016). Once type certification is complete, the Airlander 10 will be the first U.K.-derived large aircraft to earn certification since 1979 (Athena Information Solutions Private Limited, 2024). This will make the Airlander 10 the first of a new TA in the world focused on ultra-low emissions air services, with the goal of a zero-emission variant by 2030 (Athena Information Solutions Private Limited, 2024). Joint airworthiness certification is currently being conducted by the European Union Aviation Safety Agency (EASA), the Civil Aviation Authority (CAA), and the Federal Aviation Administration (FAA) (Athena Information Solutions Private Limited, 2024).

With the signing of the Convention of International Civil Aviation, more commonly known as the Chicago Convention, the International Civil Aviation Organization (ICAO) became the world's governing organization in civil aviation matters, including airworthiness standards and requirements (Purton & Kourousis, 2014). Military airworthiness has no such governing organization or defining document (Purton & Kourousis, 2014). However, sovereign authorities do have the responsibility to make certain that their military organizations are in compliance with civil regulations (Purton & Kourousis, 2014). In aviation, sovereignty refers to the ownership of airspace, including its legislative, administrative, and judicial powers (International Civil Aviation Organization, 2013). Factors such as completing operational requirements, carrying ordnance, and flying non-standard flight profiles cause military aircraft to operate with much higher risks compared to their civilian counterparts. Because of this, militaries throughout the world are exempt from the broad acceptance of civil airworthiness frameworks (Purton & Kourousis, 2014). This results in unique, although similar, military airworthiness systems around the world (Purton & Kourousis, 2014).

A military commercial derivative aircraft (MCDA) is defined as a commercially produced aircraft with an FAA type certificate (TC) and produced under an FAA production approval (FAA, 2015). To meet military airworthiness requirements, such as those of the USN, MCDA must have an independent engineering review of FAA and original equipment manufacturer (OEM) airworthiness data (Lucka, 2003). Due to the complexities of navigating the airworthiness certification process within military organizations, the Navy's 62-year gap in operating a lighter-than-air program, and the development of an entirely new aircraft by a foreign manufacturer, this study attempts to evaluate and detail the process of obtaining flight clearance for hybrid air vehicles such as the Airlander 10.

A. PURPOSE

This research aims to evaluate and develop a comprehensive roadmap for the USN's airworthiness certification (flight clearance) process for hybrid air vehicles, utilizing the HAV Airlander 10 as a case study in a manned configuration. Remote piloting and unmanned or autonomous configurations trigger different rules and regulations regarding airworthiness certification in both civil and military sectors. This research seeks to address the complexities associated with integrating a new, foreign-manufactured hybrid airship after a 62-year gap in operating lighter-than-air programs. This study supports the USN's Force Design 2045, the DoD's MTA process, and the executive order titled *Modernizing Defense Acquisitions and Spurring Innovation in the Defense Industrial Base* dated April 09, 2025.

The primary objective of this research is to develop a comprehensive roadmap for military certification that serves as a living document, continually updated as future processes or technologies evolve. The second objective of this document is to bridge the gap between civil and military airworthiness standards. In the search for new advantages on the ever-changing battlefield, evaluating and potentially utilizing civilian platforms for military use is essential for maintaining USN's competitive advantage. The third objective is to identify and mitigate risk strategies in the acquisition and integration of hybrid airships into the U.S. military.

B. SCOPE AND RESEARCH METHODS

The scope of this research focuses on evaluating and developing a roadmap for the USN's airworthiness certification (flight clearance) process for hybrid air vehicles. It examines the distinct challenges of adapting civilian airworthiness standards to military requirements, incorporating lessons from the Navy's historical lighter-than-air programs, and addressing risks associated with integrating hybrid airships into military operations. The study also evaluates the technological capabilities of the Airlander 10, utilizing it as a case study, and explores the regulatory and acquisition frameworks necessary to guide the certification process.

The methodology encompasses a literature review, case studies of past military airship programs, and a comparative analysis through process analytics to identify opportunities for alignment between civilian and military certification requirements. The findings culminate in a structured roadmap to guide the Navy's certification and acquisition of hybrid air vehicles like the Airlander 10, advancing both operational capabilities and naval aviation innovation initiatives.

C. RESEARCH QUESTIONS

The primary research questions are:

1. What must the USN do to obtain flight clearance for hybrid air vehicles such as the HAV Airlander 10?
2. What lessons can be drawn from the USN's historical experience with airships to inform the current evaluation of the Airlander 10?
3. How do existing civil airworthiness standards impact the development of military airworthiness criteria for hybrid air vehicles?
4. What specific operational or acquisition risks are associated with military use of hybrid air vehicles, and how can these be mitigated in the flight clearance process?
5. Can new developments in software technology, through companies like Istari Digital, aid the USN in the airworthiness certification process of aircraft such as the Airlander 10?

D. LIMITATIONS

This research acknowledges several limitations that may impact its findings and recommendations. Limited access to confidential or classified information may restrict the depth of analysis, particularly concerning military-specific certification requirements and proprietary technological details. Additionally, the lack of precedent for certifying hybrid aircraft poses challenges in establishing a clear framework for the Airlander 10's certification process. The scope of historical data available on lighter-than-air programs may also be limited, potentially constraining insights derived from past military airship initiatives. Evolving certification standards, both civilian and military, introduce uncertainties that could affect the applicability of proposed solutions. Furthermore, the ongoing technological development of hybrid airships, including the Airlander 10's sustainability-focused innovations, may result in changes to the design or operational specifications during the study. Finally, the scope of stakeholder engagement may be limited by the accessibility or willingness of key entities, such as regulatory authorities, military personnel, and industry experts, to participate in the research process.

E. BENEFITS

This study offers several significant benefits, particularly for the USN and broader DoD and aviation communities. By developing a structured roadmap for airworthiness certification for hybrid air vehicles, the research provides a clear framework for integrating hybrid airship technology into military operations. This roadmap could streamline the certification process, reduce delays, and enhance the Navy's ability to adopt innovative technologies efficiently.

The study also bridges the gap between civilian and military airworthiness standards, paving the way for smoother collaboration and interoperability between regulatory bodies. By identifying and mitigating risks associated with hybrid airship adoption, the research supports safer and more reliable operational outcomes. Furthermore, hybrid air vehicles, such as the Airlander 10, have the potential to provide a new energy capability to the warfighter while focusing on increased readiness, deterrence, and lethality. Hybrid air vehicles are innovative and at the forefront of ultra-efficient aviation technologies, acting as an enabler and security asset to the DoD and national security. Ultimately, this study contributes to enhancing the USN's fleet capabilities, promoting sustainable aviation, and setting a precedent for certifying future hybrid and innovative aircraft technologies.

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II. BACKGROUND

This chapter provides background information and context on hybrid air vehicles, DoD's involvement in developing hybrid airships, continued industry development, and the potential need and mission set for such aircraft in the DoD's and USN's inventories.

A. WHAT IS A HYBRID AIRSHIP?

Traditional airships, such as the Goodyear blimp, achieve flight entirely through buoyant lift from a self-contained gas (Jiron, 2012). In contrast, hybrid airships achieve flight through buoyant, aerodynamic, and vertical lift (Jiron, 2012). This is achieved by utilizing a gas and lift generating concepts similar to a wing and rotor system (Jiron, 2012). This enables the airships to climb and descend in the same manner as their heavier-than-air counterparts, with the advantage of greater useful payload range (Jiron, 2012). Additionally, this mix allows engineers to master the challenges of buoyancy control that have hindered airship designs for years (Jiron, 2012). Figure 2 shows the hybrid lift concept being utilized by aircraft manufacturers.

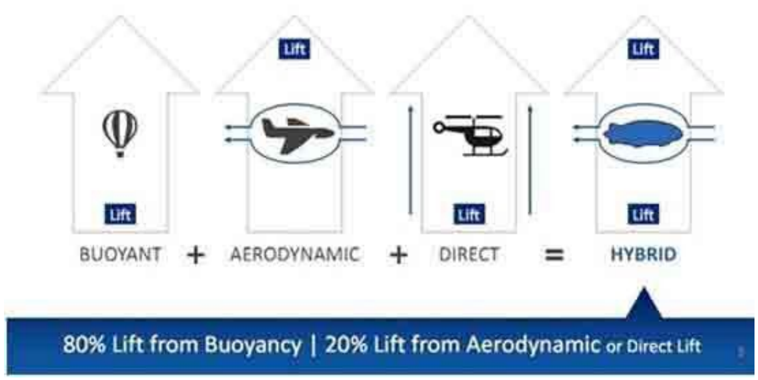

Figure 2. Modern Hybrid Lift Concept for Airship Platforms. Source: Straightline Aviation (n.d.).

A 2011 report from the U.S. Transportation Command stated:

> The capabilities of hybrid airships could be applied to a multitude of missions throughout the range of military operations. They offer the payload and range to deliver operationally significant forces and sustainment over strategic distances. They can access any open location in the Joint Operations Area (JOA), have the ability to bypass enemy defenses and overcome area denial efforts, and have the precision to deliver to or near the desired point of need that may not have adequate infrastructure. (Jiron, 2012)

In the case of the Airlander 10, the buoyant (aerostatic) lift is provided by helium gas, and because of the helium gas, the ship's airframe weight is offset while reducing fuel burn (Clos, 2022). Next, the design of the Airlander 10, borrowed from a fixed-wing design, allows for aerodynamic lift (Clos, 2022). Lastly, the Airlander 10 uses vectored thrust, similar to a helicopter, and is equipped with four diesel engines that power the ducted propellers, which are used chiefly for take-off and landing (Clos, 2022). Figure 3 depicts the Airlander 10's forms of lift.

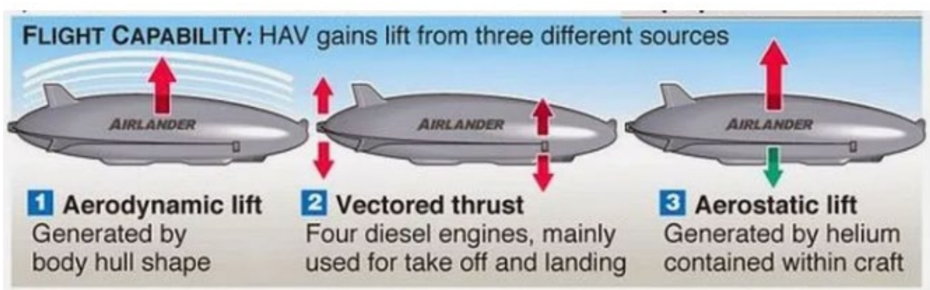

Figure 3. Airlander Forms of Lift. Source: Clos (2022).

In trying to understand what a hybrid airship is, it is critical to acknowledge that hybrid airships do not fit into standard airlift paradigms (Jiron, 2012). Hybrid airships are not meant to replace current technology or aircraft systems but to augment a gap in current DoD capability. Currently, the military uses traditional aircraft and sea vessels to perform missions like intelligence, surveillance, and reconnaissance (ISR), logistics, and, more recently, border patrol; however, these vessels always start and terminate at an airport or seaport (Jiron, 2012). When looking at new concepts like the U.S. Marine Corps' expeditionary advanced base operations, hybrid airships could deliver supplies directly to the warfighter, without the need for traditional multimodal port operations.

Jiron (2012) describes to Dr. Robert Boyd, the Hybrid Lift Portfolio senior program manager for Lockheed Martin Aeronautics Advanced Development Programs, hybrid airships as follows, "is not well characterized by either airplane-derived or airship-derived relations." The implicit sensitivity to both speed and size sets this type of vehicle apart from other flight vehicles, yielding unique design constraints and objectives" (p. 40-41).

B. LONG ENDURANCE MULTI-INTELLIGENCE VEHICLE

As the operational environment continues to evolve from over two decades of counterinsurgency warfare in the Middle East and other regions to the Indo-Pacific and other extreme environments like the Arctic, the DoD must adapt its traditional acquisition strategies of developing new weapons platforms from the ground up to looking at new, innovative technologies being developed or already existing in the civilian market, including those by and of our foreign allies. In June 2010, the U.S. Army Space and Missile Defense Command and Army Forces Strategic Command contracted Northrop Grumman to develop and build three LEMVs for $517 million (Army Technology, 2012). The LEMV was intended to be a long-range hybrid airship system, capable of providing ISR support for land forces. The contract covered the design, development, and testing of the LEMV within 18 months (Army Technology, 2012). To accomplish this, Northrop Grumman partnered with HAV, Warwick Mills, International Latex Corporation (ILC) Dover, Aircraft Armaments Incorporated (AAI), and Science Applications International Corporation (SAIC) with the goal of transporting the vehicle to Afghanistan for assessment (Army Technology, 2012). On August 07, 2012, the airship made its maiden flight and remained airborne for more than 90 minutes at Joint Base McGuire-Dix-Lakehurst (Army Technology, 2012). A few of the initial design characteristics were that LEMV was to be capable of flying at a maximum altitude of 20,000 ft, carry a payload of 2,750 lb, and remain aloft for a maximum of 21 days (Army Technology, 2012). Additionally, the aircraft was to be able to operate under optionally manned, remotely piloted, or autonomous flight configurations (Army Technology, 2012).

Ackerman (2013) describes Dov Schwartz, Army spokesman, on why the U.S. Army terminated the LEMV program in 2013, stating, "Due to technical and performance challenges, and the limitations imposed by constrained resources, the Army has determined to discontinue the LEMV development effort" (para. 4). The news was a surprise to both Northrop Grumman and the command responsible for the program, the Army Space and Missile Defense. The OEM stated that the LEMV could remain flying for 21 days; however, a technical analysis conducted in 2011 showed that the actual flying time—approximately 10 days—was much less (Ackerman, 2013). At the time of discontinuance, proponents of the LEMV used a boxing analogy to compare the aircraft's potential capabilities to current utilized systems. The airship was compared to a middleweight: spy tool capable of providing pattern-of-life information and staying aloft for weeks at a time (Ackerman, 2013). Compared to current U.S. military technology, spy satellites were considered to be the heavyweights, capable of orbiting and scanning wide views of the planet, while spy planes were considered the welterweights, capable of providing hours' worth of imagery over a given area (Ackerman, 2013).

Consecutively, the U.S. Air Force (USAF) was developing an airship called the Blue Devil that was the competing rival of the LEMV (Ackerman, 2013). Like the LEMV, the Blue Devil was a large airship seven times the size of the blimps flying over modern-day stadiums (Ackerman, 2013). The USAF intended to equip the Blue Devil with a supercomputer and up to a dozen different sensor packages (Ackerman, 2013). Their idea was to develop an airship that was more than just a spy ship; they preferred a platform capable of coordinating multiple assets on the battlefield (Ackerman, 2013). Figure 4 depicts the USAF Blue Devil concept. However, as the budget continued to balloon for spy blimps, including the Blue Devil, which was canceled in 2012, and program delays and technical issues continued to appear, Congress decided to no longer support large airships.

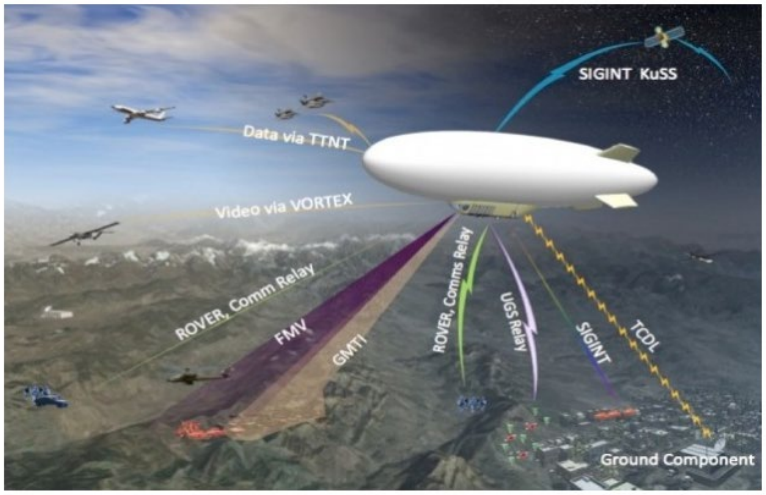

Figure 4. USAF Blue Devil Concept. Source: UAS Vision (2011).

C. HYBRID AIR VEHICLES AIRLANDER 10

U.K.–based HAV, one of the original developers of the LEMV with Northrop Grumman, purchased the LEMV in 2016, changing its name to the Airlander 10, while making subtle changes and giving it a new look. The sensor suite being developed by Northrop Grumman was not included in the purchase of the vehicle. Due to the Airlander 10 being the first of a new civilian TA, its initial airworthiness will be much stricter than that of current airships (Judson, 2016). However, just like any new aircraft, as it continues to build flight hours, it will earn the confidence of regulators and its airworthiness concerns will gradually ease over time (Judson, 2016). Judson (2016) describes Andy Barton, HAV's business development director for commercial markets, when describing the Airlander 10, as saying it "is 'exactly' the same as the LEMV except for two things …. One, it doesn't have any of the mission fit, which we were never party to …. It was always Northrop Grumman's responsibility. And the other thing that we needed to do to make it a civilian aircraft is that it no longer has the remote piloting feature" (para. 9). As part of the agreement between the United States and HAV, when the LEMV was transferred, the company had to continue sharing its data with the United States as it continued to further develop the aircraft (Judson, 2016). Furthermore, although HAV retained the design and capability for remote piloting, it did have to remove the uplink and autopilot (Judson, 2016). The aircraft can have the function reinstalled should North Atlantic Treaty Organization (NATO) buyers be interested; however, non-NATO countries are not capable of acquiring the feature (Judson, 2016). Judson (2016) describes Simon Evans, HAV's head of business development for defense and security, when discussing potential for the aircraft: "We are a green aircraft with an empty payload at the moment, which can be shaped to meet the customer's needs" (para. 24). Figure 5 depicts concept art of the HAV Airlander 10.

Figure 5. HAV Airlander 10. Source: HAV (2025).

D. THE NEED FOR INFORMATION WARFARE AIRSHIPS

The USS Pueblo (AGER-2) had a complete security breach when its classified documents and equipment were compromised in 1968 (Gonzalezocasio, 2019). The Pueblo was an intelligence-gathering ship operating in the sovereign waters of North Korea when North Korean forces seized the vessel, which is still held by them today (Gonzalezocasio, 2019). Since then, spy ships were removed from service, while the United States' near-peer adversaries, Russia and China, continued to develop these platforms. The Yury Ivanov, built by Russia, and the Dongiao-class auxiliary general intelligence (AGI) ship, built by China, are both modern examples of large intelligence vessels built within the last decade (Gonzalezocasio, 2019). In today's information and cyber age, U.S. adversaries have recognized the need and increased demand for information on the battlefield. On the other hand, the United States primarily relies on satellites, surface and subsurface combatants, and aircraft as the primary methods of intelligence gathering. While this is sufficient against non-state actors and the types of conflicts the United States has been engaged in since the early 2000s, competing in great power competition is something entirely different. U.S. assets are often stretched thin while dealing with competing interests, and in the digital age, information is everything. A hybrid aircraft committed to ISR and electronic and information warfare could potentially fill a capability gap on the digital battlefield (Gonzalezocasio, 2019).

A platform, such as a hybrid aircraft, equipped with a full suite of sensors and capabilities that can maintain a persistent presence in the operating area, could be crucial in providing combatant commanders with vital intelligence, increasing tactical and strategic advantages over near-peer adversaries. Additionally, a dedicated platform would allow warfighters to better hamper the decision-making process of the enemy by coordinating electronic warfare and cyberattacks, a vital capability in the information warfare domain. Building dedicated surface ships, as Russia and China have done, is a much larger and more expensive endeavor. In contrast, hybrid airships may provide a more cost-effective solution. Hybrid airships could operate with minimal to no manning, while their building and operating costs are a fraction of those of a dedicated ship.

Airships have a long and complicated history in the aviation world. However, since the cancellation of the Navy's last airship program in 1962, technology and innovation have significantly increased. General assumptions when imagining something like an airship on the battlefield are that they are vulnerable to anti-air weapons, large, slow, and affected by adverse weather. However, with today's technology, hybrid airships like the Airlander 10 mitigate these concerns. One example is that they are capable of withstanding small arms fire due to a pressure differential between the envelope and outside air (Gonzalezocasio, 2019). Gonzalezocasio (2019) states in a 2007 RAND Corporation report discussing hybrid airship vulnerability, "Thousands of rounds of small arms or anti-aircraft artillery are required to down a hybrid airship.” Additionally, hybrid airships are capable of landing on any surface, including water, without the need for airfields, traditional landing platforms, or personnel. Failures by past military programs due to funding and other challenges have not dissuaded the civilian sector from continuing to develop these airships to fill a niche role in the modern world.

E. BORDER SECURITY

Under an executive order, the DoD was ordered to produce a plan to address the national emergency of securing the nation’s borders. U.S. Northern Command was assigned a new tasking along the southern border to counter events such as unlawful mass migration, narcotics trafficking, and other criminal activity (Peniston, 2025). On March 20, 2025, the secretary of defense ordered enhanced military operations and patrols along the U.S. border, a change from the relatively static role U.S. forces have typically been assigned. Lopez (2025) describes Army Major Jennifer L. Staton, DoD spokesperson, when discussing border patrol: “Conducting patrols, either on foot or mounted, creates a more proactive and adaptable posture compared to static posts” (para. 3). Following the DoD’s involvement, about 6,600 ground forces have been present at the southern border since January 2025 with the ability to conduct large-area dynamic patrols (Lopez, 2025).

Currently, the U.S. Customs and Border Protection (CBP) agency operates eight specialized blimps that are part of the Tethered Aerostat Radar System (TARS), which surveil the U.S. southern border (Long, 2016). Figure 6 depicts a CBP TARS aircraft.

Figure 6. TARS. Source: Long (2016).

Long (2016) cites Richard Booth, director of domain operations and integration for CBP's Office of Air and Marine, when describing TARS: "TARS is the most cost-efficient capability that we own … TARS is like a low-flying satellite system, but cheaper to launch and operate." In 1978, the USAF organized the first TARS site in Cudjoe Key, FL, with a second site at Fort Huachuca, AZ, going into operation in 1983. CBP continued to establish additional sites, and in 2013, the USAF transferred its program to the CBP. Figure 7 depicts current TARS locations. Due to the success of the TARS and Office of Air and Marine application, unidentified aircraft operating over the border decreased from 8,500 per year to less than 10 per year (Long, 2016).

Figure 7. CBP TARS Locations. Source: Long (2016).

The USN has since deployed an Arleigh–Burke–class destroyer, the USS Gravely, to patrol near the southern border, with a second destroyer reportedly expected to join the effort (Fletcher, 2025). U.S. naval forces have been tasked with conducting joint operations with U.S. Coast Guard law enforcement detachments on board. Hybrid air vehicles, such as the Airlander 10, could be suitable to perform these mission sets while providing flexibility to perform operations over open water, land, or other areas of responsibility (AOR). According to a Government Accountability Office (GAO) report dated January 2023, total operating and support costs per Arleigh–Burke–class destroyer in 2020 were $80.5 million. Additionally, this would allow conventional USN surface ships to remain focused on other priorities in other regions, such as the Indo-Pacific. Figure 8 depicts the operating cost of an Arleigh–Burke–class destroyer.

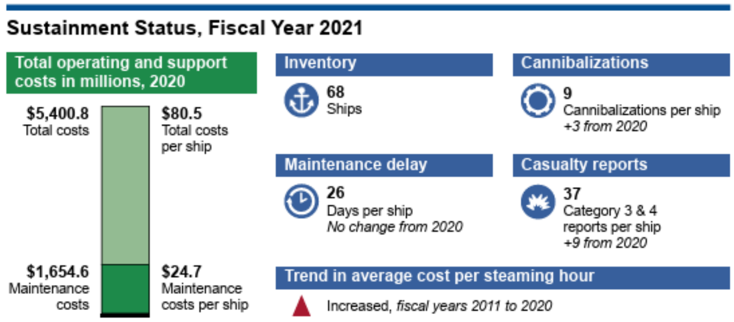

Figure 8. Arleigh–Burke–Class Destroyer Sustainment Status, Fiscal Year 2021. Source: GAO (2023).

F. SUMMARY

Hybrid airships, such as the Airlander 10, may offer an alternative solution to the operational challenges currently facing the DoD and USN in areas like the U.S. Indo-Pacific Command, the southern border, and other AORs. This technology could potentially bridge critical capability gaps by providing long-endurance, low-cost, and infrastructure-independent options for missions ranging from ISR and information warfare to logistics support and border security. Past military programs like the LEMV and Blue Devil faced challenges related to cost, technical performance, and bureaucratic inertia, resulting in their termination. However, the transfer of these technologies to the civilian sector has allowed continued development, producing higher technology readiness levels, which may allow faster acquisition pathways like MTA versus the more common Major Capability Acquisition (MCA) utilized for aircraft procurement. Developing an efficient military airworthiness certification process and strategy for the potential adoption of commercial hybrid air vehicles ensures the DoD and USN remain at the forefront of new innovative warfighting technology.

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III. LITERATURE REVIEW

This chapter reviews the various laws, regulations, and frameworks that govern airworthiness requirements, including the challenges associated with adopting a foreign-manufactured aircraft, as well as the differences across the DoD and its service components.

A. BILATERAL AGREEMENTS

Bilateral agreements are a tool often used by nations to establish beneficial agreements between two parties. Regarding to airworthiness requirements, multiple bilateral agreements exist between the U.S., U.K., and European Union (E.U.). These bilateral agreements allow for the successful coordination in the design, development, and manufacture of aircraft among different CAAs.

1. Bilateral Agreement between the United States and the United Kingdom

If the DoD were to pursue the acquisition of a foreign-designed and manufactured hybrid air vehicle like the Airlander 10, the U.S. and the U.K. governments have a bilateral agreement in place that was signed on December 20, 1995, for the promotion of aviation safety. This document contained six objectives:

- Desiring to promote aviation safety and environmental quality,
- Noting common concerns for the safe operation of civil aircraft,
- Recognizing the emerging trend toward multinational design, production, and interchange of civil aeronautical product,
- Desiring to enhance cooperation and increase efficiency in matters relating to civil aviation safety,
- Considering the possible reduction of the economic burden imposed on the aviation industry and operators by redundant technical inspections, evaluations, and testing,
- Recognizing the mutual benefit of improved procedures for the reciprocal acceptance of airworthiness approvals, environmental testing, or environmental approvals, flight simulator qualification evaluations, aircraft maintenance facilities, maintenance personnel crews, and flight operations. (FAA, 2025b)

To accomplish these goals, the agreement between the United States and the United Kingdom includes six articles. Article I defines the purpose of the agreement, stating that both countries will facilitate each other's airworthiness approvals (FAA, 2025b). Article II defines airworthiness approval as a "design or change to an aeronautical product that meets standards or a product that conforms to those standards and is safe for flight" (FAA, 2025b). Furthermore, the document stipulates that the civil aviation authorities, specifically the FAA and the CAA shall conduct technical assessments and work cooperatively in several areas, such as airworthiness approvals.

2. Bilateral Agreement between the United States and the European Union

The United States also maintains a bilateral agreement for airworthiness with the E.U. If a hybrid air vehicle, such as the Airlander 10 or another vehicle produced by a different manufacturer, were to be certified by the E.U., it would be covered under this bilateral agreement. Figure 9 depicts concept art for another airship that may benefit from this agreement, the Flying Whale, which was launched in 2012 and is still being developed in France.

Figure 9. Flying Whale Hybrid Air Vehicle. Source: Weaver (2025).

This document, the *Agreement between the United States of America and the European Community on Cooperation in the Regulation of Civil Aviation Safety*, is much larger in scope when compared to the bilateral agreement between the United States and the U.K. It contains 18 articles and several amendments. Article 2 defines the purpose and scope of the document:

> ***a. The purposes of this Agreement are to:***
>
> - Enable the reciprocal acceptance, as provided in the Annexes to this Agreement, of findings of compliance and approvals issued by the Technical Agents and Aviation Authorities;
> - Promote a high degree of safety in air transport;
> - Ensure the continuation of the high level of regulatory cooperation and harmonization between the United States and the European Community in the fields covered in paragraph B. (FAA, 2023a)
>
> ***b. The scope of cooperation under this Agreement is:***
>
> - Airworthiness approvals and monitoring of civil aeronautical products;
> - Environmental testing and approvals of civil aeronautical products;
> - Approvals and monitoring of maintenance facilities. (FAA, 2023a)

Additionally, Article 3 creates a Bilateral Oversight Board, consisting of the FAA, European Commission, EASA, and other aviation authorities responsible for ensuring the effective functioning of the accord (FAA, 2023a).

B. MILITARY AIRWORTHINESS

When it comes to military airworthiness, member nations of ICAO are required to ensure that their military aircraft comply with civilian standards (Purton & Kourousis, 2014). Due to the nature of military operations, military organizations, including the different services within the DoD have adopted their own regulations, processes, and procedures. Airworthiness management systems tend to focus on objective areas, with some focusing on different elements through policy and regulations to ensure the safety of their systems (Purton & Kourousis, 2014). These objectives are stated as following:

- Operational airworthiness, governing the utilization of aircraft by aircrew and control of airspace;

- Technical airworthiness, specifying the requirements for the aircraft when being designed, produced, or maintained;
- Logistics and support, assuring the correct product is used for production and maintenance;
- Aviation safety, focusing on the requirements for safe human interaction within the airworthiness system;
- Aviation accident and incident investigation, ensuring that identified areas of error or concern inform modifications to the airworthiness framework. (Purton & Kourousis, 2014)

C. MAJOR MILITARY AIRWORTHINESS AUTHORITIES

Under Code of Federal Regulations (C.F.R.) Title 14 §1.1, DoD aircraft are treated as public aircraft while operating within the United States (National Archives and Records Administration, 2025). Outside of the United States borders, military aircraft are categorized as state aircraft (National Archives and Records Administration, 2025). Additionally, DoD aircraft are not liable to FAA airworthiness regulations due to their non-standard operating procedures (National Archives and Records Administration, 2025). Furthermore, all U.S. DoD aircraft derive their jurisdiction to operate as a major military airworthiness authority (MAA) through U.S. Code and their respective secretary (Purton & Kourousis, 2014). The DoD does have an overarching *DoD Airworthiness Policy*, DoD Instruction 5030.61, dated December 3, 2024. This policy states that all air systems operating under a DoD service branch must have an airworthiness assessment per the service branch's individual policies (DoD, 2024a). The Under Secretary of Defense for Acquisition and Sustainment is directly responsible for establishing policy, assigning responsibilities, providing procedures, and overseeing DoD airworthiness matters (DoD, 2024a). Additionally, this policy states that

> a foreign military airworthiness approval may be used as the basis for a DoD Component airworthiness approval if the approval is determined by the receiving airworthiness authority to be applicable and appropriate (DoD, 2024a). … Any gaps or differences in configuration, mission, and operating environment must be addressed in terms of the appropriate level of safety before issuing the receiving airworthiness authority's airworthiness approval. (DoD, 2024a, p. 9)

The DoD also produces *Airworthiness Certification Criteria*, MIL-HDBK-516C, dated December 12, 2014. This handbook is used as guidance and outlines the certification requirements and processes used for all airworthiness determination bases for all DoD (2014) aircraft. It is produced only as a guideline to be used by MAAs to define an air system's certification basis through their respective service branches (DOD, 2014). This manual contains commercial derivative aircraft (CDA), which are initially approved for safety of flight by the FAA and may have an FAA-approved Certificate of Airworthiness or TC. This document is engineering-focused and covers systems engineering, structures, flight technology, propulsion and propulsion installations, air vehicle subsystems, crew systems, diagnostic systems, avionics, electrical systems, electromagnetic environment effects, system safety, computer systems and software, maintenance, armaments and stores integration, passenger safety, materials, air transportability, airdrop, mission/test equipment, and cargo/payload safety (DOD, 2014).

1. U.S. Navy

The chief of naval operations has designated Commander, Naval Air Systems Command, as the DON independent airworthiness authority responsible for designing airworthiness and supporting the Naval Air Enterprise (NAE) continuing airworthiness policies and procedures and is governed under Naval Air Systems Command (NAVAIR) Instruction 13034.1G dated June 1, 2022 (NAVAIR, 2022). Day-to-day execution of airworthiness authority is delegated to the director, of the NAVAIR Airworthiness and CYBERSAFE Office as the single authority for DON airworthiness (NAVAIR, 2022). This office is responsible for the airworthiness and safety of flight evaluations of all DON aircraft; it also ensures that risks are mitigated according to their primary regulations, which cover areas such as airworthiness reviews and issuing processes. Additionally, the Airworthiness and CYBERSAFE Office is delegated the authority to establish and approve items such as technical standards and tools in accordance with USN/USMC standards and policies (Purton & Kourousis, 2014). Airworthiness approval, also known as *flight clearance*, is required for all USN/USMC-owned, leased, manned, and unmanned aircraft and is typically issued initially in the form of Interim Flight Clearance (IFC).

The DON's flight clearance process includes a well-structured process map, covering the aircraft's life cycle (Purton & Kourousis, 2014). One thing that makes the DON's process unique is that there are no maintenance requirements directly tied to the airworthiness process for certification. To maintain validity, a flight clearance must comply with applicable maintenance documents and/or approved maintenance plans (Purton & Kourousis, 2014). Commander, Naval Air Forces, more commonly known as CNAF, is responsible for assigning maintenance tasks and responsibilities as outlined in the *Naval Aviation Maintenance Program 4790.2E*. Figure 10 highlights the DON airworthiness life cycle.

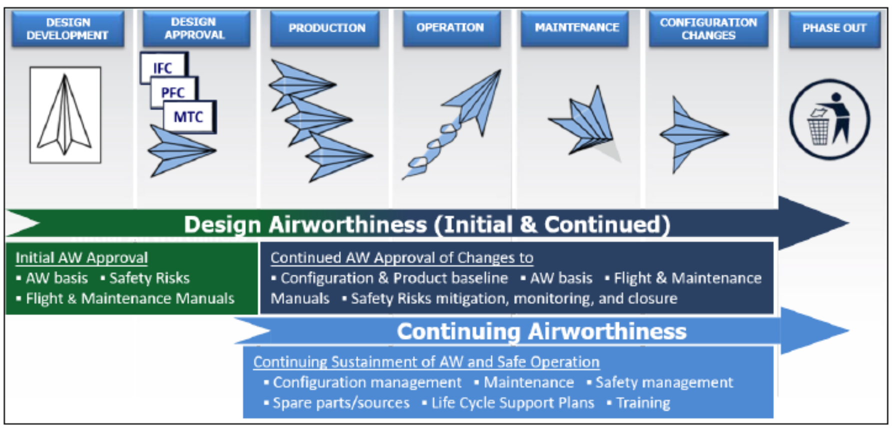

Figure 10. Airworthiness Life Cycle. Source: NAVAIR (2022).

2. U.S. Army

Army Regulation 70-62 outlines the Army's airworthiness qualification policy for aircraft systems (Purton & Kourousis, 2014). Authority over airworthiness approval for Army aircraft is delegated to the commanding general, U.S. Army Aviation and Missile Command by the deputy chief of staff (Purton & Kourousis, 2014). The Army's approach is built around aircraft systems and subsystems, covering things like materials and equipment, and includes all aircraft functioning in an Army role (Purton & Kourousis, 2014). Three components characterize the airworthiness certification of Army aircraft:

- The first basis for an airworthiness determination is an assessment of the aircraft systems and subsystems design and performance against relevant aeronautical design standards.
- The next basis is ensuring there are prescribed limits covering the full spectrum for safe and reliable use and maintenance of the aircraft systems and subsystems.
- Lastly, there is a requirement for continued airworthiness based on correct operations, current and compliant maintenance procedures, and identification of aviation critical safety item controls. (Purton & Kourousis, 2014)

3. U.S. Air Force

The USAF Life Cycle Management Center Engineering Directorate, under the director of engineering and technical management chief engineer, is responsible for the technical airworthiness system and is governed by Department of the Air Force Instruction 62–601 (Office of the Assistant Secretary of the Air Force for Acquisition, Technology, and Logistics, 2025). This system primarily focuses on technical airworthiness and covers topics such as:

- Airworthiness Assurance
- Airworthiness Approval Process
- Risk Management. (Office of the Assistant Secretary of the Air Force for Acquisition, Technology, and Logistics, 2025)

The Air Force's strategy tends to rely heavily on ensuring airworthiness is done through design, with limited references to maintenance, although it is still required (Purton & Kourousis, 2014). Airworthiness approvals are issued in the form of military type certificates or military flight releases, with the defining difference being that military flight releases are for system designs that do not meet the standards of military type certificates (Office of the Assistant Secretary of the Air Force for Acquisition, Technology, and Logistics, 2025).

4. U.K. Military Airworthiness

Should the DoD pursue the acquisition of a U.K. military version of a hybrid air vehicle like the Airlander 10, the U.K. Ministry of Defense department acts as the MAA, under the authority of the secretary of state, and is responsible for all military aviation

(Purton & Kourousis, 2014). Following the 2006 accident of the Royal Air Force Nimrod, the U.K. military underwent a comprehensive overhaul of its airworthiness regulation framework, which revealed that its legacy airworthiness system was hindered by numerous and complex regulatory documents that often mistook regulation for guidance and vice versa (Purton & Kourousis, 2014). Figure 11 depicts the U.K. military's airworthiness restructure. This resulted in the secretary of state for defense establishing the director general MAA as the single independent regulatory authority for requirements such as airworthiness certification, inspections, and acquisition (Purton & Kourousis, 2014). In the Haddon-Cave report that followed the accident of the Royal Air Force Nimrod, the U.K. airworthiness system was defined by four key principles:

- Leadership; There should be strong leadership from the top, demanding and demonstrating by example active and constant commitment to safety and Airworthiness as overriding priorities;
- Independence; There must be thorough independence throughout the regulatory regime, in particular in the setting of safety and airworthiness policy, regulation, auditing, and enforcement;
- People; There must be much greater focus on people in the delivery of high standards of Safety and Airworthiness (and not just in process and on paper);
- Simplicity; Regulatory structures, processes, and rules must be as simple and straightforward as possible so that everyone can understand them. (Purton & Kourousis, 2014)

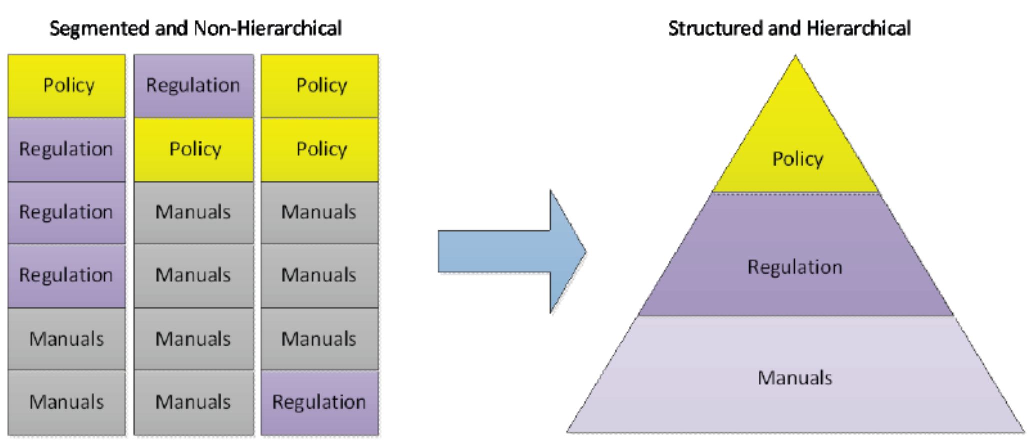

Figure 11. Airworthiness Restructure from the Recommendations of the Haddon-Cave Report. Source: Purton & Kourousis (2014).

5. Summary of Major Military Airworthiness Authorities

Purton and Kourousis (2014) summarized the different MAAs, including their authority derivation and focus areas. Figure 12 depicts this summary.

Agency	Authority Derivation	Airworthiness Focus	Strengths	Weaknesses
US Air Force	Secretary of the Air Force (Policy)	Aircraft Certification – Technical, considers usage and limits	Focuses on Design – maintenance and operation through airworthiness definition caveat	Reliance on assuring airworthiness through design, loose links to maintenance or operations
US Navy	Secretary of the Navy (Policy)	Flight Clearance – Technical	Robust design consideration surrounding issuance of a Military Type Certification processes. Considers safety of flight within Airworthiness	Maintenance and operations distinct from airworthiness.
US Army	Secretary of the Army (Policy)	Airworthiness Qualification – Holistic approach in three stages	Three stages support holistic airworthiness, process in place for recognition of other MAAs. Strong product focus.	No airworthiness organisation maintenance assurance, self-regulation within command
UK	Secretary of State for	Holistic Military Air Safety	Aligned technical, operational and aviation	New system with regulations presented

Figure 12. The Salient Points for Each MAA Airworthiness Framework. Source: Purton & Kourousis (2014).

D. CIVIL AVIATION AUTHORITIES

CAAs govern civil aviation within their respective nations and are subject to the standards set forth by the Chicago Convention. These standards are enforced by the ICAO, to which all members of the United Nations adhere to. In the case of the Airlander 10, there are three primary CAAs currently involved in the airworthiness certification process: the CAA, EASA, and the FAA.

1. Civil Aviation Authority

Looking first at the CAA, since it is the primary regulatory authority for the U.K.'s first hybrid air vehicle, the Airlander 10, the organization adheres to the following tenets:

- The aviation industry meets the highest safety standards;
- Consumers have a choice, are protected, and treated fairly when they fly;
- Through efficient use of airspace, the environmental impact of aviation on local communities is effectively managed and CO_2 emissions are reduced;
- The aviation industry manages security risks effectively. (CAA, n.d.)

To accomplish this, the CAA divides its responsibilities into ten areas: airlines, airports, airspace, aviation capacity, aviation security, drones, environment, funding pilot medicals, and travel companies (CAA, n.d.). Initial airworthiness is governed by U.K. Regulation (EU) 748/2012, *Initial Airworthiness Regulation* (CAA, 2025). The CAA issues this document to logically merge ordered active regulations with the acceptable means of compliance (AMC), guidance material (GM), and certification specifications (CSs) as appropriate (CAA, 2025). AMC is the process that the CAA uses to ensure that rules and requirements comply with the basic regulations (CAA, 2025). The key difference between AMC and GM is that GM is non-regulatory but offers descriptive guidance on how an OEM can comply with applicable laws and regulations (CAA, 2025).

Referring back to the case of hybrid air vehicles like the Airlander 10, no document existed to cover the initial airworthiness of this new TA. In 2022, EASA, with significant input from industry partners, issued the *Special Condition for Gas Airships* (SC- GAS) to address the unique characteristics of airships and define airworthiness specifications. This document became the foundation for compliance by all OEM AMCs.

2. European Union Aviation Safety Agency

EASA (n.d.), which consists of 31 nations governed under multiple bilateral agreements and memoranda of understanding, has a mission to provide safety, environmental protection, standard airworthiness certification criteria, ensure fair market practices, and collaborate with other CAAs. In order to accomplish its mission, EASA (n.d.) has divided its obligations into five specific tasks:

- Draft implementing rules in all fields pertinent to the EASA mission;
- Certify & approve products and organizations, in fields where EASA has exclusive competence (e.g., airworthiness);
- Provide oversight and support to Member States in fields where EASA has shared competence (e.g. Air Operations, Air Traffic Management);
- Promote the use of European and worldwide standards;
- Cooperate with international actors in order to achieve the highest safety level for EU citizens globally (e.g. EU safety list, Third Country Operators authorizations).

Regarding airworthiness, AMC and GM are governed by Part 21, which was initially issued in 2003 and has since undergone 16 amendments. From there, category aircraft are broken down into different parts and governed under separate instructions. However, since hybrid air vehicles are a new TA, EASA pulled elements from the following categories of aircraft to develop initial airworthiness certifications, also known as civil design codes:

- CS-23: *Certification Specifications for Normal, Utility, Aerobatic, and Commuter Category Airplanes*
- CS-25: *Certification Specifications for Large Airplanes*
- CS-27: *Certification Specifications for Small Rotorcraft*
- CS-29: *Certification Specifications for Large Rotorcraft*
- CS-30T (draft): *Certification Specifications for Transport Category Airships*

Elements taken from these areas, combined with inputs from HAV and Flying Whales, enabled the development of the *Special Condition for Gas Airships* (SC-GAS). This document defines the regulatory authority and means of compliance for hybrid airships and has been adopted by the CAA. This document also sets forth the requirements for flight, operating information, structures, structural loads, structural performance, structural occupant protection, design and construction, occupant system design protection, fire and high energy protection, airship design, propulsion system, systems and equipment, and flight crew interface (EASA, 2022).

3. Federal Aviation Administration

The FAA is the primary aviation regulatory authority within the United States. According to the FAA (2025a), "Our continuing mission is to provide the safest, most efficient aerospace system in the world." When compared to those of the FAA's European counterparts, this mission statement is much simpler in task. Airworthiness certificates are FAA-issued documents, granting authorization to operate an aircraft in flight, and are governed by 14 C.F.R. 21 Subpart H, Airworthiness Certificates. The FAA does have its own section governing airship regulations, policy, and guidance, which are stipulated in 14 C.F.R. 21, 14 C.F.R 43, and 14 C.F.R. 91, and cover certification procedures for products and parts, maintenance, preventive maintenance, rebuilding, alteration, and flight rules (FAA, 2024a). Additionally, the FAA does have supplemental guidance on airships, such as transport airship requirements under 14 C.F.R 21.17 and FAA-P-8110-2, *Airship Design Criteria*. Airworthiness certification of aircraft is governed under U.S. Department of Transportation FAA Order 8130.2K, issued August 28, 2024 (FAA, 2024b). The FAA has not yet adopted SC-GAS; however, it has been recommended by industry partners. This document does contain a provision that covers CAA assistance with U.S. airworthiness certificates for new aircraft manufactured outside the United States (FAA, 2024b). It states that the FAA (2024b) "may obtain assistance from a CAA of the state of manufacturer in the final processing, dating, and delivery of a U.S. airworthiness certificate for newly manufactured, type-certificated aircraft destined for export to the United States …. This procedure is only allowed if no conflict exists with the applicable bilateral agreement" (p. E-1).

Within the FAA, there is a Military Certification Branch that is dedicated to supporting MCDA on behalf of the U.S. Armed Services. Its mission is to coordinate with the DoD and service branches to ensure safety, certification, and business activities are met in accordance with applicable regulations (FAA, 2023b). In conjunction with the Policy and Standards Division (AIR-600), the branch maintains MCDA policies developed with the DoD and service components to certify mission equipment installations while integrating with military airworthiness systems (FAA, 2023b). MCDA Type Certification procedures are governed under FAA Order 8110.101A (FAA, 2015).

E. INITIAL AIRWORTHINESS

Initial Airworthiness: Determining the Acceptability of New Airborne Systems, written by Guy Gratton (2018), is one of the few academic textbooks written covering the topic of initial airworthiness. For students and industry subject matter experts who are involved in initial airworthiness certification or safety of flight, this book outlines the considerations necessary to develop new airworthiness standards for emerging technology (Gratton, 2018). The book opens with determining airworthiness for both initial and continued airworthiness, with a focus on civil aviation and a brief comparison to military aircraft (Gratton, 2018). The author chooses to use the FAA's definition of airworthiness: "The aircraft conforms to its type design, and it is in a condition for safe flight" (Gratton, 2018), p. 1). Additionally, the textbook focuses on civilian airplanes as the basis, but acknowledges that aircraft such as helicopters and airships will vary in some areas, such as structural evaluation (Gratton, 2018). Furthermore, the author does recognize the different airworthiness philosophies between civil and military frameworks (Gratton, 2018).

The book covers a wide range of topics, ranging from the previously mentioned airworthiness to the atmosphere, pitot-static systems, the flight envelope, aircraft structures and control surfaces, powerplants, environmental systems, and crashworthiness and escape. In the case of hybrid air vehicles like the Airlander 10 and others, this book provides an excellent framework for developing a roadmap for initial airworthiness requirements and bridging the gap between military and civil airworthiness. Additionally, this book is used as one of the frameworks for evaluating this research.

F. AIRSHIP MISHAPS

One of the key elements of innovation adoption is dispelling preconceived misconceptions surrounding large airships in military roles. As noted earlier in this paper through the work of Jiron (2012), most military personnel look at airships as an obsolete technology. This chapter provides an overview of some of the past U.S. Naval mishaps involving airships and highlights how technological innovations today would eliminate those issues. Lastly, this chapter concludes with a look at a mishap involving the Airlander 10.

1. R-38 (ZR-2)

The R-38, as it was originally designated, was a joint project between the USN and the Royal Air Force, and was later designated the ZR-2 for naval use (Carrigan, 2024). The airship was being constructed in Hull, England, and set to complete its final flight tests before making the transatlantic flight to NAS Lakehurst, NJ, in August 1921. Figure 13 depicts the R-38 (ZR-2).

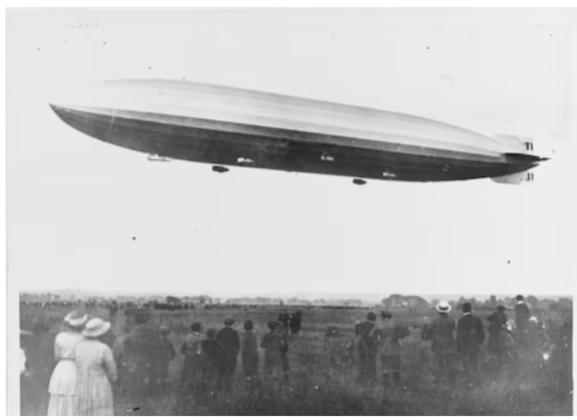

Figure 13. R-38 (ZR-2) in Cardington, England, 1921. Source: Carrigan (2024).

Intended to be the USN's flagship of the skies, the ZR-2 received several military modifications from the original design; however, additional structural support was not added to the airship's design to account for the additional weight of those modifications (Carrigan, 2024). A team from NAS Lakehurst, led by CDR Louis A. H. Maxfield and known as the Howden Detachment, was to conduct flight tests with the British team led by Flight Lieutenant Jack Pritchard (Carrigan, 2024). Initially, Pritchard believed additional flight tests were needed; however, faced with bureaucratic inertia by the British Air

Ministry and the USN due to the project being behind schedule and over budget, the decision was made to speed up trials and transfer custody of the aircraft (Carrigan, 2024). Remaining flight tests were to be performed in the United States, with the United States sharing its data with the Air Ministry. While conducting its final flight tests in England, the airship attempted to perform a severe weather simulation, at which point, the airship's envelope began to fold (Carrigan, 2024). The airship broke in half, resulting in explosions due to the mixture of hydrogen, air, and fuel, killing 44 of the 49 personnel onboard (Carrigan, 2024). As a result, Rear Admiral William A. Moffett, Chief of the Bureau of Aeronautics, halted all foreign collaboration in developing aircraft and systems.

This airship mishap is a great example of poor and underdeveloped airworthiness requirements during that time in history. Firstly, the airship was grossly overweight. Today, modern systems and programs, such as the automated weight and balance system, are utilized by all DoD service branches to ensure aircraft are within weight limits prior to flight. Next, the development teams fell victim to higher-level leadership that rushed the project before it was ready. DoD components place a high emphasis on risk evaluation throughout the airworthiness certification process, as noted in several of their airworthiness documents. Additionally, in the case of the Airlander 10, the aircraft is to be certified in conjunction with three CAAs prior to DoD acquisition.

2. USS Shenandoah III (ZR-1)

The USS Shenandoah, as depicted in Figure 1, operated from 1923–1925 (Cressman, 2020b). As mentioned in the introduction, this was the first rigid airship to be designed and built by the Bureau of Aeronautics, USN (Cressman, 2020b). The USS Shenandoah was designed for reconnaissance work and tested in adverse weather conditions such as rain and poor visibility (Cressman, 2020b). Early visions by RADM Moffett wanted to utilize this aircraft for cold-weather operations in the Arctic, and this plan was later approved by President Coolidge (Cressman, 2020b). In September 1925, the airship passed through severe thunderstorms and turbulence and crashed, killing 14 and leaving 29 survivors (Cressman, 2020b).

Similar to the USS Akron, this prolific accident involving an airship occurred due to weather, not airworthiness standards. Hybrid aircraft operate in the same manner as today's modern aircraft and have the same ability for controlled flight in turbulence and to detect and avoid adverse weather. This highlights again that in the early years of aviation, airships' obsolescence was a result of the early stages of aviation development and a product of their time. Modern militaries of the time saw the future of military aviation in airplanes, not airships. However, civilian counterparts have found a niche role for airships in the modern world and have continued to develop the technology.

3. USS Akron (ZRS-4)

The USS Akron was in service from 1931–1934 and was initially constructed in October 1929 by the Goodyear Zeppelin Corporation (Cressman, 2020a). The initial flight occurred in September 1931, and onboard was the current Secretary of the Navy Charles Adams and RADM Moffett (Cressman, 2020a). Figure 14 depicts the USS Akron.

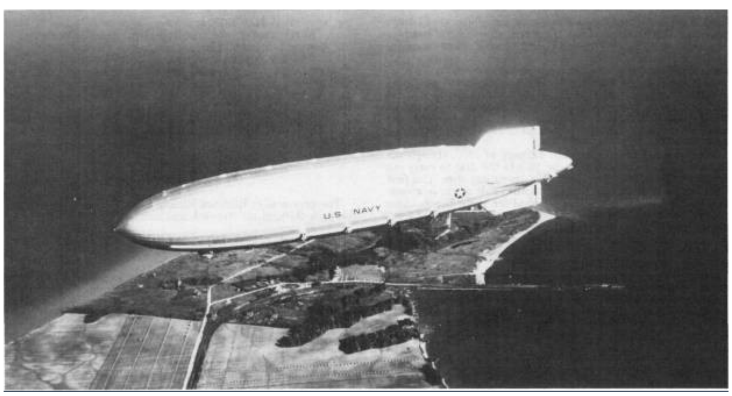

Figure 14. USS Akron (ZR-4) in 1931. Source: Cressman (2020a).

Deemed a success after completing hundreds of flight hours and multiple assigned missions, including locating and identifying surface battle groups out to sea and operating as a "flying aircraft carrier" with a N2Y trainer and a Curtiss XF9C-1 Sparrowhawk fighter, the airship finally met its fatal end in April 1933 (Cressman, 2020a). Operating off the coast of New England with RADM Moffett, CDR Harry B. Cecil, CDR Fred T. Berry, Lieutenant Colonel Alfred F. Masury, and several others on board, the airship encountered severe weather and wind gusts that forced it into the ocean (Cressman, 2020a). In total, 73 men lost their lives and three survived, making it the deadliest airship accident in history. RADM Moffett was among those who perished, which would ultimately contribute to the end of the rigid airship's U.S. naval service (Cressman, 2020a).

When evaluating the period during which the incident occurred and the advances in modern technology, this incident would most likely not have occurred in today's operating environment. Modern aircraft are equipped with weather radars, air traffic control communication systems, weather forecasting products, and advanced airworthiness standards that are significantly more sophisticated and developed than those available during that period. Hybrid aircraft, like the Airlander 10, can be certified under instrument flight rules and operate no differently than modern airliners. Furthermore, hybrid aircraft are capable of operating in extreme environments like the Arctic.

4. Airlander 10

On August 24, 2016, HAV's Airlander 10 was conducting test flights at Cardington Airfield in Bedfordshire, England (Air Accidents Investigation Branch, 2017). Upon the airship's return, ground crews attempted to attach its mooring line to the mast assembly; however, the support equipment malfunctioned (Air Accidents Investigation Branch, 2017). The pilot made the decision to return to takeoff and reattempt landing once the issue with the SE was worked out. During this time, the mooring line, which was temporarily stowed, fell out of the aircraft, resulting in the pilot ultimately performing a non-standard landing. The aircraft was much higher during the second attempt, at which point it descended nose-down, causing damage only to the cabin when it collided with the ground (Air Accidents Investigation Branch, 2017).

This is a prime example of the inherent risks still associated with modern airships. Fortunately, the crew onboard and on the ground were not injured; however, several recommendations resulted from the mishap, such as effective mooring line stowage configurations and fault detection reporting in SE. Although this is not an example of airworthiness issues as in the previous case, it highlights the importance of developing well-defined naval air training and operating procedures standardization and maintenance procedures, should the USN invest in this technology.

IV. ANALYSIS OF AIRWORTHINESS POLICY

When evaluating the airworthiness certification process for a new foreign-manufactured TA, several key areas must be considered. This chapter intends to identify these key areas and build the bridges necessary for DoD and DON airworthiness certification and acquisition.

A. AIRWORTHINESS FRAMEWORK

The first key consideration is the airworthiness framework; understanding the laws and regulations regarding airworthiness certification between CAAs and MAAs is crucial when dealing with a new, foreign-manufactured TA. Figure 15 identifies key organizations, governing regulations, and policies. The framework is a complex spiderweb of organizations and processes. The green diamond is the starting point and represents a hybrid aircraft, in this case, the Airlander 10. This feeds directly into the two CAAs that are currently certifying the Airlander 10 in conjunction with the OEM. CS-23, CS-25, CS-27, CS-29, and CS-30T are the governing regulations used by EASA to create SC-GAS, which is denoted as the output. That output feeds directly into the CAA in which it was adopted and into the OEM's proprietary AMC used to certify the Airlander 10. The FAA, which has yet to adopt SC-GAS as the basis for airworthiness, is denoted in red dotted lines. Connecting the CAA, EASA, and FAA is a network of bilateral agreements that legally allow the FAA to accept airworthiness certification from the CAA or EASA. All three civil organizations are encompassed by a blue rectangle, denoting that they are civil aviation authorities and regulated directly under ICAO.

Should the FAA eventually adopt SC-GAS, the FAA's Military Certification Branch under FAA Order 8110.101A, both depicted in the diagram, can work directly with the different service components under the DoD for certification of an MCDA. The different service components are MAAs and are depicted in green with a green dotted line connecting them. The DoD has two source documents governing airworthiness, as seen feeding into the DoD. The USAF's and U.S. Army's governing instructions for airworthiness are also listed; however, their branches terminate there, as they were not part of the scope of this research. The DON flows directly into NAVAIR and CNAF, also known as type commanders, both of which have standards regarding aircraft operation. Under NAVAIR, the Airworthiness & Cybersafe Office, through NAVAIR Instruction 130.341G as noted, is directly responsible for airworthiness certification. CNAF, under the Naval Aviation Maintenance Program 4790.2E, is responsible for aircraft maintenance and is another key step in the process required to release an aircraft as safe for flight. The diagram then flows into the ending point, in which the Airlander 10 can now operate within the DON.

The critical point in the process is FAA certification, in which the FAA could either accept, impose additional requirements, or reject SC-GAS as the basis for airworthiness certification. This step is crucial to the potential delivery of a hybrid aircraft such as the Airlander 10 into the hands of the DoD through the MCDA process. However, if the FAA delays adopting SC-GAS and another military organization, such as the U.K.'s Royal Navy or Air Force, acquires and certifies a hybrid air vehicle as airworthy, the DoD would have an optional pathway to airworthiness certification, as noted with a direct line connecting the U.K. Ministry of Defense with the DoD Instruction 5030.61. Through this instruction, the DoD has the authority to directly accept another foreign military's airworthiness certification as the basis for airworthiness. However, this could trigger other regulations and requirements, such as 22 U.S. Code § 2778, Control of Arms Exports and Imports.

If the Navy were to acquire a hybrid aircraft like the Airlander 10 due to its advanced technology readiness level and assumed certification approval through applicable CAAs, this aircraft could be acquired under the DoD's MTA pathway as depicted by the purple dotted line. HAV currently assesses its technology readiness level at 7 (HAV, 2021). It is essential to note that under the DoD's regulations, a certification granted by one service branch does not automatically grant airworthiness authority to another, unless the aircraft is certified through a joint program. If only one service branch were to acquire a hybrid air vehicle and certify it individually, then a second branch could use the original service branch's airworthiness certification as a basis if it, too, were to acquire one, but the second branch must ensure that the certification still meets the individual requirements of its own service branch. Any differences would have to be complied with before airworthiness certification is granted.

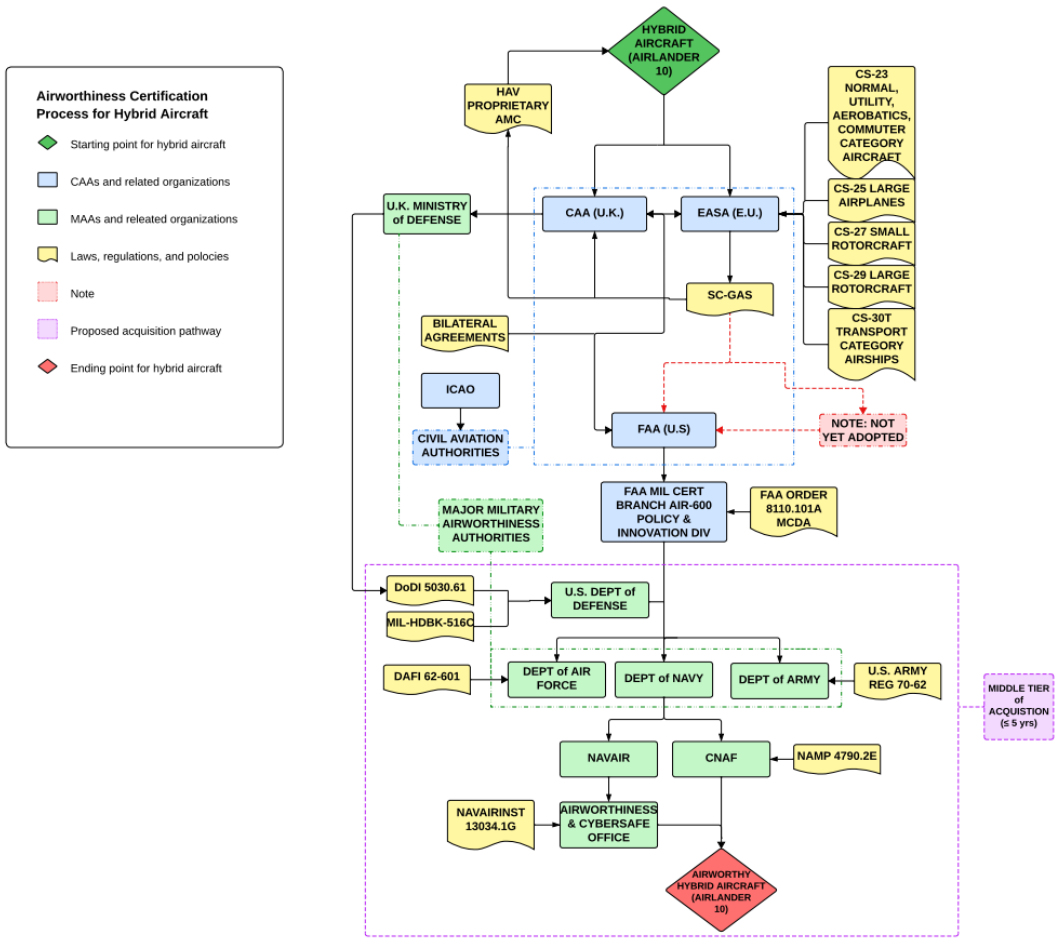

Figure 15. Airworthiness Certification Organizational Process Map and Governing Regulations

B. DOD ACQUISITION PATHWAYS

Following this explanation of the legal and regulatory framework for acquiring hybrid air vehicles, such as the Airlander 10, the next step is to determine the most suitable mechanism for acquiring the aircraft and placing it in the hands of the warfighter. The DoD governs acquisition pathways under DoD Instruction 5000.02, *Operation of the Adaptive Acquisition Framework*.

1. Major Capability Acquisition

The DoD's primary avenue in acquiring aircraft platforms is through the Major Capability Acquisition (MCA) pathway. For aircraft and major systems, this pathway is usually intended for designing and developing platforms from the beginning, and in some cases, can take decades and cost a substantial amount of money to deliver into the hands of the warfighter. It consists of multiple phases and gateways, called milestones, that advance a system to full operational capability. Figure 16 depicts the MCA process. The MCA does have some flexibility and allows systems that are proven in an operational environment to transition to the MCA through rapid prototyping (Defense Acquisition University, n.d.-a).

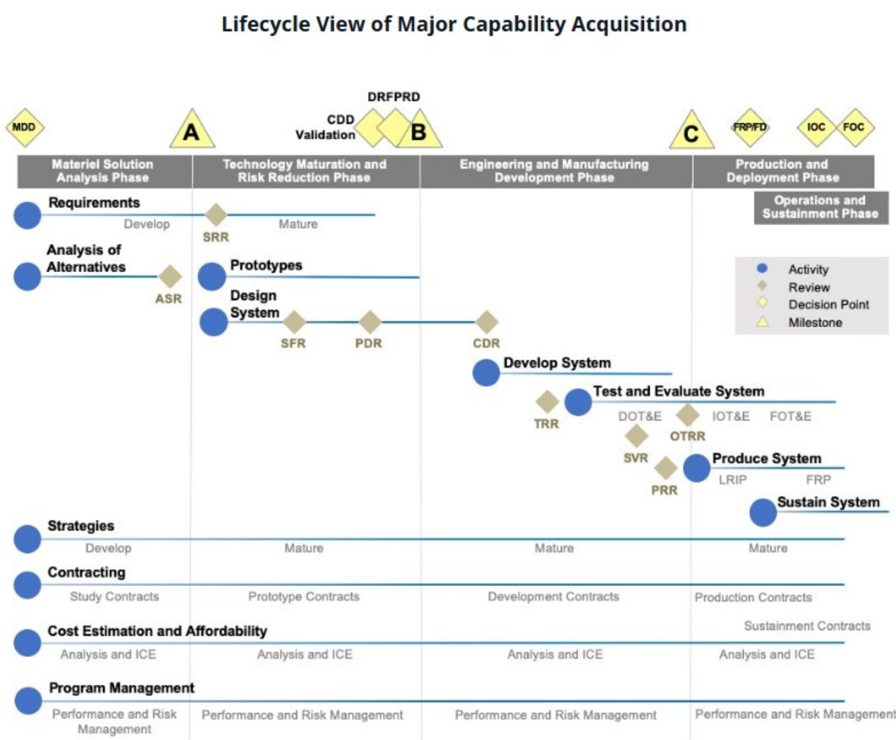

Figure 16. Major Capability Acquisition Pathway. Source: Defense Acquisition University (n.d.-a).

2. Middle Tier of Acquisition

The MTA pathway is a much faster means of putting a proven technology into the hands of the user. This pathway is intended to take new technology with high levels of maturity and complete prototyping or fielding in 5 years or less (Defense Acquisition University, n.d.-b). Figure 17 depicts the MTA pathway.

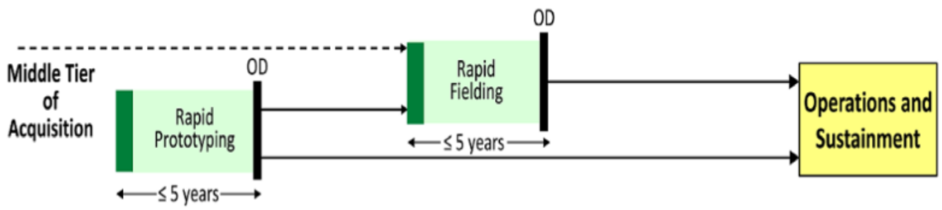

Figure 17. Middle Tier of Acquisition. Source: Defense Acquisition University (n.d.-b).

Within the MTA, two separate pathways exist, rapid prototyping and rapid fielding. Rapid prototyping is intended to develop fieldable prototypes of new technology, while rapid fielding is intended for production-level quantities of new innovations (Defense Acquisition University, n.d.-b). Figure 18 depicts both paths.

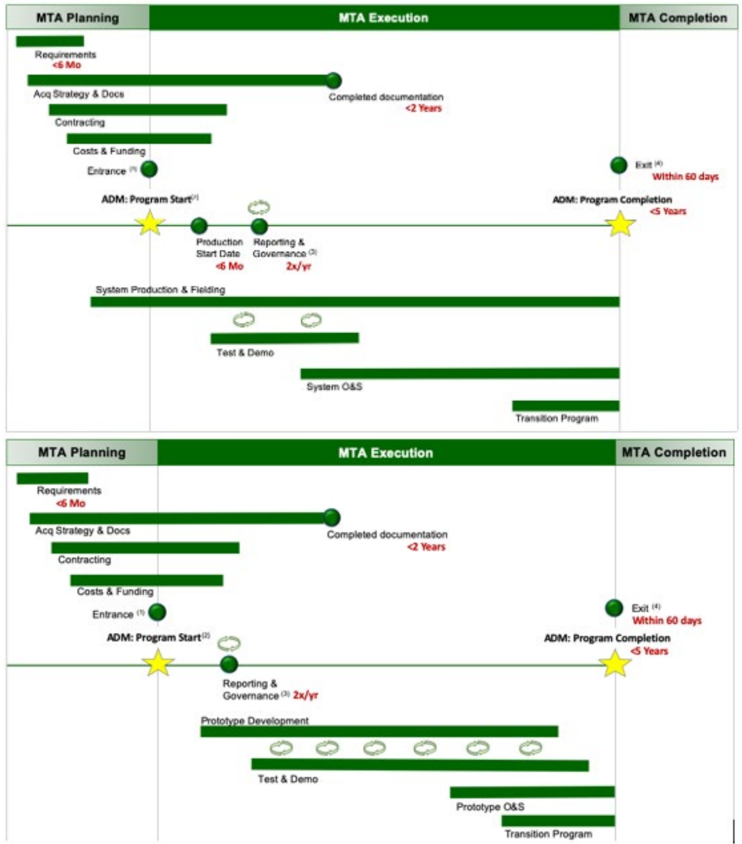

Figure 18. Rapid Prototyping & Rapid Fielding Acquisition Pathways.
Source: Defense Acquisition University (n.d.-b).

3. Recommended Pathway

The Airlander 10, is estimated to enter service around 2028–2029 (Sampson, 2024). However, airworthiness certification should be obtained prior to that. Comparing both acquisition pathways, MTA would facilitate expedited delivery of a hybrid aircraft to the DON, with the option to transition it to a major program later in the process if desired. Within the MTA, rapid prototyping would allow acquisition of the Airlander 10 as an MCDA, equip the aircraft with the required systems for appropriate mission sets, and demonstrate its ability to meet 21st-century needs prior to operations and sustainment. In contrast, rapid fielding would not be recommended, as a hybrid air vehicle still needs to be evaluated with proper configurations and equipment.

C. KEY FRAMEWORK STRUCTURES

Using *Initial Airworthiness* by Guy Gratton (2018) as the basis for the framework, this research analyzes the key airworthiness requirements required for the DON to acquire a hybrid air vehicle using the Airlander 10 as an example. Assuming that the FAA adopts and approves SC-GAS as the basis for airworthiness and grants a TC for civil use for the Airlander 10, the key pathway for means of compliance would be SC-GAS, FAA Order 8110.101A, DoD Instruction 5030.61, DoD MIL-HDBK-516C, and NAVAIR Instruction 13034.1G. Figure 19 depicts the key elements identified in each framework. Looking at these, certain documents appear to be regulatory in nature versus engineering in nature. Gratton's (2018) textbook is heavily focused on the engineering field, similar to the DoD's MIL-HDBK-516C. When compared to SC-GAS, it is much simpler in its framework, but it contains key engineering elements. While FAA Order 8110.101A, DoD Instruction 5030.61, and NAVAIR Instruction 13034.1G address some technical aspects, they appear to be more policy-driven documents. However, comparing MIL-HDBK-516C to SC-GAS, key areas that would have to be addressed by the DoD to obtain airworthiness certification include systems engineering, electromagnetic and environmental effects, and armament and stores integration.

Airworthiness Certification Framework Key Elements		
Flight Characteristics	**Systems**	**Software**
Atmosphere (Gratton)	Pitot-Static System (Gratton)	Computer Systems & Software (MIL-HDBK-516C)
Flight Envelope (Gratton)	Control Surfaces & Circuits (Gratton)	Software Aspects of Airborne Systems & Equipment Certification (FAA Order 8110.101A)
Flying Qualities (Gratton)	Systems Assessment (Gratton)	
Longitudinal Stability & Control (Gratton)	Systems & Equipment (SC-GAS)	**General**
Lateral & Directional Stability & Control (Gratton)	Configuration Management (DoDI 5030.61)	Professional Ethics within Airworthiness Practice (Gratton)
Airplane Asymmetry (Gratton)	Systems Engineering (MIL-HDBK-516C)	Running a Certification Program (Gratton)
Departures from Controlled Flight (Gratton)	Air Vehicle Subsystems (MIL-HDBK-516C)	Means of Compliance (SC-GAS)
Flight Test Particular Considerations (DoDI 5030.61)	Diagnostic Systems (MIL-HDBK-516C)	MCDA Program (FAA Order 8110.101A)
Flight (SC-GAS)	Avionics (MIL-HDBK-516C)	FAA Military Certification Office (FAA Order 8110.101A)
Flight Operating Info (SC-GAS)	Electrical System (MIL-HDBK-516C)	Military Type Certification Projects (FAA Order 8110.101A)
		Special Procedures for Military Projects (FAA Order 8110.101A)
Safety Systems	**Propulsion**	Methods of Approving Military Equipment (FAA Order 8110.101A)
Crashworthiness & Escape (Gratton)	Powerplant Airworthiness(Gratton)	Military Airworthiness Process (FAA Order 8110.101A)
Occupant System Design Protection (SC-GAS)	Propulsion System (SC-GAS)	MCDA Background (FAA Order 8110.101A)
Fire & High Energy Protection (SC-GAS)	Propulsion & Propulsion Installations (MIL-HDBK-516C)	Responsibilities (DoDI 5030.61)
System Safety (MIL-HDBK-516C)		Airworthiness Assessment & Approval (DoDI 5030.61)
Passenger Safety (MIL-HDBK-516C)	**Maintenance**	Use of Federal Aviation Administration (FAA) Certifications (DoDI 5030.61)
	Inspections (DoDI 5030.61)	Use of a DoD Component Airworthiness Approval (DoDI 5030.61)
Design	Life Limits (DoDI 5030.61)	Joint Programs (DoDI 5030.61)
Design & Construction (SC-GAS)	Maintenance & Overhaul (DoDI 5030.61)	Flight in Foreign-Owned Military Aircraft (DoDI 5030.61)
Airship Design (SC-GAS)	Critical Safety Items (DoDI 5030.61)	Use of a Foreign Military Airworthiness Approval (DoDI 5030.61)
Type Design (FAA Order 8110.101A)	Maintenance (MIL-HDBK-516C)	Airworthiness Assessment Process & Products (NAVAIR INSTR 13034.1G)
Unique Military Functions (FAA Order 8110.101A)		Specific Airworthiness Process & Product Applications (NAVAIR INSTR 13034.1G)
Certification of Military Systems & Equipment (FAA Order 8110.101A)	**Defining Airworthiness**	Roles & Responsibilities (NAVAIR INSTR 13034.1G)
Airworthiness Design Criteria (DoDI 5030.61)	What is Airworthiness? (Gratton)	
Materials (MIL-HDBK-516C)	Intro to Airworthiness (NAVAIR INSTR 13034.1G)	**No Common Elements**
		Environmental Impact (Gratton)
Structures	**Flight Interface**	Airworthiness Risk Assessment (DoDI 5030.61)
Structural Approval (Gratton)	Flight Crew Interface & Other Info (SC-GAS)	Electromagnetic Environmental Effects (MIL_HDBK-516C)
Main Flight Structure (Gratton)	Crew Systems (MIL-HDBK-516C)	Armaments & Stores Integration (MIL-HDBK-516C)
Undercarriage Structural Approval (Gratton)	Flight Technology (MIL-HDBK-516C)	Air Transportability, Airdrop, Mission/Test Equipment & Cargo/Payload Safety (MIL-HDBK-516C)
Structures (SC-GAS)		
Structural Loads (SC-GAS)	**Continued Airworthiness**	
Structural Performance (SC-GAS)	Continued Airworthiness (Gratton)	
Structural Occupant Protection (SC-GAS)	Continued Airworthiness (FAA Order 8110.101A)	
Structures (MIL-HDBK-516C)	Continuing Airworthiness (DoDI 5030.61)	

Legend
Gratton
SC-GAS
FAA Order 8110.101A
DoDI 5030.61
MIL-HDBK-516C
NAVAIR INSTR 13034.1G

Figure 19. Airworthiness Certification Framework Key Elements

D. PURPOSE AND SCOPE COMPARISON

Chapter 1 of Gratton's (2018) *Initial Airworthiness* textbook introduces fundamental key principles regarding the airworthiness of new designs and military aircraft. In Chapter 1.2, The Basic Principles of Certification, through Chapter 1.4, Military Aircraft Certification practice, Gratton (2018) describes the basic understanding of how airworthiness is evaluated, focusing on principles and design codes, also referred to as airworthiness requirements. In contrast, the development of SC-GAS was driven by the absence of established design codes for hybrid air vehicles, prompting EASA to combine elements from multiple existing codes to create a comprehensive regulatory document. In particular, Gratton (2018) does address in Chapter 1.3.1.1 that it is common for certain sections to be used in special conditions; although he refers to transport category airplanes, this can also apply to hybrid aircraft (Gratton, 2018). Moving next to FAA Order 8110.101A, its purpose is to define the procedures of certification for MCDA. In essence, this organization and regulation bridges the gap between civil and military aircraft. Gratton (2018) addresses this in Chapter 1.4 Military Aircraft Certification Practice, in which he uses the Republic of Korea Air Force's T-50 as an example, stating that in modern militaries, it is common to involve two or more sovereign nations in airworthiness certification for aircraft. Figure 20 depicts the ROK T-50 Golden Eagles.

Figure 20. T-50 Golden Eagles of the Republic of Korea Air Force.
Source: Gratton (2018)

Moving on to the DoD Instruction 5030.1G, this instruction establishes airworthiness standardization and risk assessment and defines responsibilities for all cognizant service branches. Additionally, MIL-HDBK-516C defines the criteria for certification through an engineering lens. While Gratton's (2018) text is also engineering-focused and addresses risk across multiple areas, it does not present risk as a clearly defined section, as seen in DoD Instruction 5030.1G and other military-related airworthiness frameworks. Lastly, looking at NAVAIR Instruction 13034.1G, one of the key elements this instruction addresses is Continuing Airworthiness. This is reflected in Gratton's (2018) textbook in Chapter 1.7, Re-evaluation. He acknowledges that throughout an aircraft's life cycle, it may be necessary to re-evaluate either a part or the whole system. Figure 21 summarizes the purpose and scope of the different frameworks.

Purpose & Scope Comparison Summary		
Document	**Purpose**	**Gratton's Framework**
Gratton	Key Principles of New Designs	Ch. 1.2-1.4
SC-GAS	Fill Exsisting Gaps in Airworthiness Design Code	Ch. 1.3.1.1
FAA Order 8110.101A	Bridge Gap Between Civil & MCDA	Ch. 1.4
DoDI 5030.61	Standarzes Airworthiness Across DoD & Risk Assessments	Risk is Addressed, but No Defined Risk Assessment Section
MIL-HDBK-516C	Provides Engineering Basis for Service Components	Engineering Based
NAVAIR INSTR 13034.1G	Emphasizes Initial & Continued Airworthiness Lifecycle	Ch. 1.7

Figure 21. Purpose & Comparison of Key Airworthiness Frameworks.

E. SUMMARY

In summary, the legal and regulatory framework for certifying a hybrid air vehicle as airworthy, in this case, the Airlander 10, requires navigating a complex network of organizations and design codes across multiple nations and agencies. Once certified within the United States by the FAA, the DoD must then navigate the acquisition pathways to determine which pathway will put this technology into the hands of the warfighter quickly and efficiently. With key policies and instructions identified for airworthiness certification, the USN can quickly evaluate the best path forward while working with other government agencies and industry partners. Understanding the different purposes and scopes of the various processes involved enables decision-makers to make the best-informed decisions.

V. AIRWORTHINESS ROADMAP

When developing a roadmap for airworthiness and acquisition, as with any initiative within the DoD, a phased approach is recommended to allow for flexibility and adjustments throughout the process. The following chapter outlines a proposed airworthiness and acquisition roadmap for hybrid air vehicles, specifically the Airlander 10.

A. PHASE I: MTA PROGRAM INITIATION & AIRWORTHINESS CERTIFICATION PLANNING

Upon TC approval by the FAA, the Airlander 10 should be designated as an MTA rapid prototyping under DoD Instruction 5000.80. This would allow the DoD or service components to address operational needs, acquisition and funding plans, and performance evaluation of a certified and technically mature platform of at least technology readiness level 8. With regard to airworthiness, the Airlander 10 should be designated as an MCDA. This would allow the DON to leverage to the maximum extent possible the airworthiness OEM AMC under SC-GAS and FAA approval, accelerating the flight clearance process. Figure 22 highlights a key difference between rapid prototyping and rapid fielding, where rapid prototyping does not require a life cycle sustainment plan. Sustainment activities such as logistics and maintenance should also be addressed and planned for in this phase with the assumption that if prototyping is successful, it would roll into a program of record and milestone c.

	Major System[1]	Non-Major System[2]
Rapid Prototyping	• ADM signed by the DA • Approved Requirement[3] • Acquisition Strategy[4] • Cost Estimate[5]	• ADM signed by the DA
Rapid Fielding	• ADM signed by the DA • Approved Requirement[3] • Acquisition Strategy[56] • Cost Estimate[5] • Lifecycle sustainment plan[7]	• ADM signed by the DA

1. Above threshold as defined pursuant to Section 3041 of Title 10, U.S.C.
2. Equal to or below threshold as defined pursuant to Section 3041 of Title 10, U.S.C.
3. CAEs will ensure the approved requirement document is available in the Knowledge Management and Decision Support System.
4. Rapid prototyping acquisition strategies will include security, schedule, and technical risks; and, a test strategy or an assessment of test results.
5. Cost estimate conducted in accordance with DoDI 5000.73.
6. Rapid fielding acquisition strategies will include security, schedule, and production risks; and, a test strategy and assessment of test results.
7. Rapid fielding programs that exceed the MDAP threshold must comply with the requirements for covered systems in Sections 4323 and 4324 of Title 10, U.S.C., and DoDI 5000.91.

Figure 22. MTA Entrance Documentation Deliverables. Source: DoD (2024).

Under NAVAIR Instruction 13034.1G, a six-step process is utilized to assess airworthiness and lead to an airworthiness approval. Figure 23 highlights these steps. In this process, the assistant program manager for engineering initiates a key document known as the airworthiness qualification plan (NAVAIR, 2022). This document highlights how the data from the AMC of the OEM, in compliance with SC-GAS and FAA could be leveraged for naval operations. Additionally, it is important to define the mission and environment in which the hybrid air vehicle would operate. Lastly, in this process, it is important to ensure key roles are assigned.

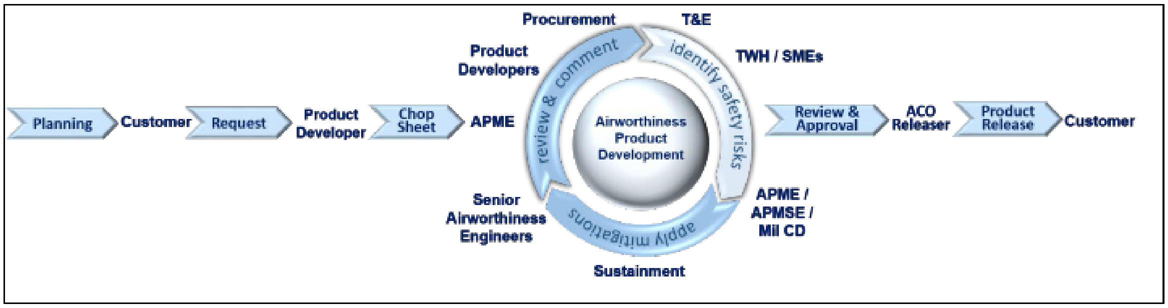

Figure 23. Airworthiness Assessment Process Steps. Source: NAVAIR (2022).

B. PHASE II: AIRWORTHINESS BASIS AND RISK ASSESSMENT

In this phase, developing and establishing the basis for airworthiness is key in creating a tailored certification approach and test plan. Starting with the acceptance of the OEM AMC engineering data through SC-GAS and the FAA, an airworthiness basis development can be created. Figure 24 depicts the elements evaluated in this process. A tailored approach using MIL-HDBK-516C to evaluate new systems, such as those listed in Figure 19, is crucial in this phase. Creating an engineering and code compliance matrix is a way to identify the gaps between all airworthiness frameworks. This phase should also align with the MTA acquisition strategy and include an independent evaluation by technical warrant holders, subject matter experts, and others, while addressing risks through a risk assessment. This phase culminates in the airworthiness product release in the form of an IFC from NAVAIR.

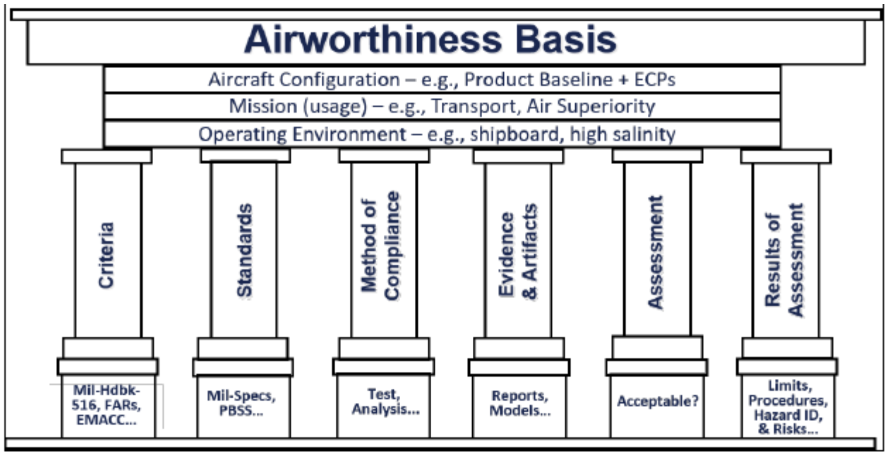

Figure 24. Elements of an Airworthiness Basis. Source: NAVAIR (2022).

C. PHASE III: IFC AND RAPID PROTOTYPING TEST INTEGRATION

This phase of the acquisition pathway, which includes testing, demonstration, and evaluation under the use of an IFC, is key to demonstrating the program's operational feasibility. Initially, restraint—in the form of restricted flight operations—should be exercised to ensure risk is mitigated until more flight hours are accumulated in the same manner the EASA and CAA use and confidence is built in the platform. The focus should be on evaluating the delta in the engineering/code compliance matrix between frameworks. Continued coordination with the FAA military certification branch can help accelerate parts of the process.

D. PHASE IV: MILITARY SYSTEMS INTEGRATION

This phase focuses on integrating the various mission-specific equipment for missions such as ISR, command and control, and logistics. Continuous risk assessments should be conducted. Development of naval air training and operating procedures standardization, naval aviation technical information product, safe for flight, and maintenance procedures and inspections need to occur in this phase. These procedural elements are necessary to ensure that squadrons are capable of executing in an operating environment. Heavy emphasis should be placed on items that are not eligible for certification through the FAA, which include systems designed for combat, weapons systems, and electronic jamming systems (FAA, 2015).

E. PHASE V: PERMANENT FLIGHT CLEARANCE AND TRANSITION

In the final phase, permanent flight clearance should be achieved, and operating procedures should be well-defined for operations and sustainment. Emphasis should be placed on transitioning to continued airworthiness, as highlighted in Figure 10. Additionally, the MTA rapid prototyping acquisition pathway should be transferred to an alternative pathway, such as MCA, for operations and sustainment. Figure 25 depicts the phased approach and timeline with key airworthiness products and MTA requirements. Based on the previously stated prediction that HAV's Airlander 10 will be operational in 2028–2029, and not knowing exactly when airworthiness certification will be completed, those years can be used as the basis for projection. Using the 5-year maximum for MTA, acquisition could be completed as early as 2033–2034. However, although hybrid aircraft are a new TA, they are much simpler in design than complex airplanes and helicopters. The Airlander 10 is not equipped with hydraulic systems or turbine engines. Maintenance processes are less complex than those of a typical aircraft, so in theory, it is more likely that the full 5 years would not be required.

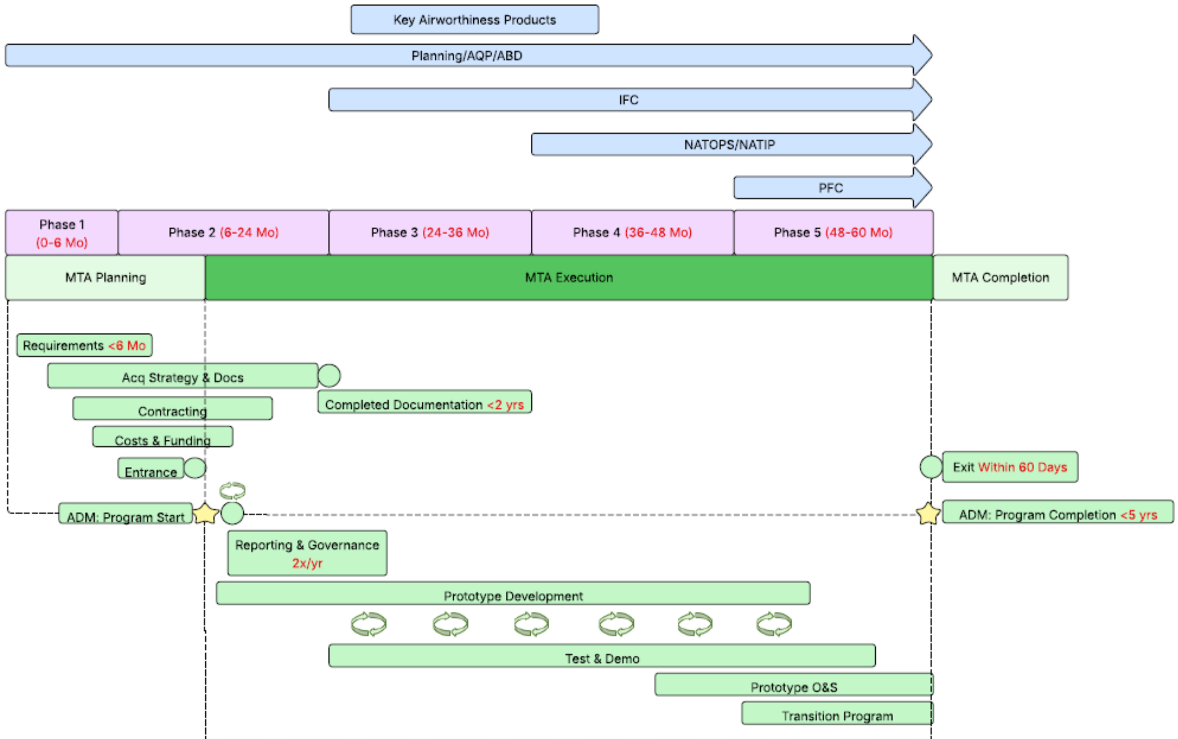

Figure 25. Phased Airworthiness and Acquisition Pathway Roadmap. Adapted from Defense Acquisition University (n.d.-b) and NAVAIR (2022).

VI. FUTURE AIRWORTHINESS TECHNOLOGY

As the digital age continues to evolve, so too do the methods by which industries evaluate older or current technologies in the new world. This chapter provides an examination of growing trends within the airworthiness certification industry and how leveraging this technology can help the DON.

A. THE DEMAND FOR DIGITAL AIRWORTHINESS CERTIFICATION

A key theme throughout the various organizations and frameworks involved in certifying a hybrid air vehicle, such as the Airlander 10, is safety. In aviation, safety is arguably the most important aspect of the industry, regardless of whether it is in the civilian or military sector. Chan and Cunneen (2023) argue that airworthiness requirements, from an aircraft's design through its life cycle, can be an extremely daunting task to manage. This is evident in the numerous models presented throughout this paper, ranging from initial to continued airworthiness, the legal frameworks between nations, and even the differences between organizations within the DoD. A common expression within the aviation industry, both civilian and military, is that the "rules are written in blood." This expression owes its existence to the inherent risk involved when operating aircraft, and when something goes wrong, it often leads to catastrophic consequences.

The challenge surrounding hybrid airships is that there is no basis to certify the aircraft airworthy. Additionally, as the technology continues to mature and new variants, such as the much larger logistics-based Airlander 50 being developed by HAV, emerge in the industry, new design codes must be developed for regulators to evaluate. Figure 26 depicts concept art of the Airlander 50 flight deck and payload module. Traditionally, aircraft manufacturers must build a prototype or, in some cases, several in order for the OEM to test and evaluate the aircraft and demonstrate its airworthiness to regulators.

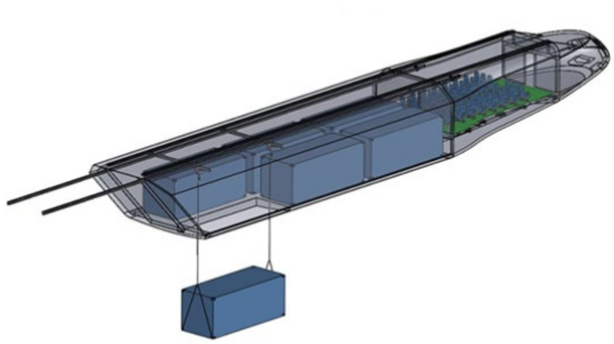

Figure 26. HAV Airlander 50 Flight Deck and Payload Module.
Source: HAV (n.d.-a).

Chan and Cunneen (2023) quote Dale Tutt of Siemens Digital Industries Software discussing increased complexity in airworthiness certification: “Increasing complexity, and the rise in cost that comes with it, highlights the need for seamless and automated aviation certification” (para. 3). Chan and Cunneen (2023) go on to address several key points that face aircraft manufacturers and operators in determining where airworthiness could be utilized:

- Design, where engineers must demonstrate that regulations are met through the design code
- Manufacturing, where verifying the aircraft complies with design standards, including materials used, maintenance processes, and supply chains
- Continued airworthiness, where operations and maintenance become the user’s responsibility to demonstrate and maintain certification standards (Chan & Cunneen, 2023).

Digital certification enables stakeholders to modernize numerous paper-based methods, test and evaluate standards prior to prototype manufacturing, and easily share information between OEMs, regulators, and operators, ultimately saving time and money.

B. INDUSTRY USE

Skunk Works, a branch of Lockheed Martin's Advanced Development Programs, is striving to become the first company to digitally certify a fixed-wing unmanned aerial vehicle (Cenciotti, 2024). Nicknamed the Flyer One initiative, the program centers around creating a complete digital twin of the X-56A and demonstrating that the aircraft can be certified entirely through digital means. Istari Digital, a company that the USAF contracted, is working with Skunk Works to take an X-56A, apply significant design modifications, and validate the system through its digital engineering platform prior to actually building the new variant (Cenciotti, 2024). The program has already passed critical design review. Figure 27 depicts the X-56A (Cenciotti, 2024).

Figure 27. X-56A Used by the USAF and NASA. Source: Cenciotti (2024).

Digital certification is already practiced in other industries, such as Formula 1 racing (Cenciotti, 2024). Engineers are capable of designing and testing competition race cars before any manufacturing takes place (Cenciotti, 2024). While race cars and aircraft have different principles, with one developed to create lift, and the other to prevent it, aerodynamically, there are many similarities between them. Istari Digital, founded by Dr. Will Roper, a former USAF acquisition chief, and Eric Schmidt, a former Google chief executive officer, aims to push a new paradigm in airworthiness certification (Cenciotti, 2024). Roper's approach is centered around agile software, open architecture systems, and digital engineering (Cenciotti, 2024). This could be extremely useful when applied to hybrid aircraft like the Airlander 10. Different configurations, payloads, mission sets, and variations like the Airlander 50 could be tested and evaluated for military use before even outfitting these aircraft with military systems, saving taxpayer dollars while remaining at the forefront of emerging technology and innovation.

C. CURRENT U.S. NAVY EFFORTS

In 2023, NAVAIR announced that the Airborne Electronic Attack Systems Program Office, PMA-234, would be the first to explore digital technology airworthiness certification by utilizing the creation of digital twins (NAE Communications, 2023). Using the ALQ-99 Tactical Jamming System (JTS) to test this technology, which is a virtual model of the physical pod, PMA-234 aims to prove that this technology is capable of testing upgraded systems prior to modification (NAE Communications, 2023). An NAE Communications (2023) publication quotes RADM John Lemmon, when discussing digital twin technology, as saying “This initiative invested in workforce development to apply ‘Get Real, Get Better’ principles to utilize technology to benefit the warfighter” (para. 10). Heavy emphasis is placed on uses for design, troubleshooting, and simulation. The Navy did state that it is developing this capability with an undisclosed industry partner. Again, like the USAF and the X-56A, this technology could be applied to a hybrid aircraft and related military systems, depending on the mission role, and used to certify the systems that the FAA does not cover under MCDA. Figure 28 depicts an AN/ALQ-99 JTS.

Figure 28. AN/ALQ-99 JTS Mounted on an E/A-18G. Source: Trevithick (2024).

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VII. CONCLUSION

This research addresses three main objectives. The first objective was to develop a roadmap for the airworthiness certification for military use of hybrid air vehicles, the second was to bridge the gap between civil and military standards, and the third was to identify and mitigate risk of hybrid air vehicle fleet integration. This was completed by focusing on five research questions stated in the beginning of this thesis.

A. ASSESSMENT

After an extensive literature review of hybrid aircraft, airworthiness certification standards, and processes across multiple frameworks involving various airworthiness authorities and nations and both civil and military aviation, several conclusions can be drawn. First, the DoD and DON lack specific airworthiness certification standards for certifying a hybrid aircraft as airworthy. Due to this innovative technology being completely new with no basis for certification, rigorous attention should be used during certification to ensure past mistakes throughout history do not repeat themselves should the DON pursue hybrid aircraft acquisition. The Navy's long gap in lighter-than-air programs means that attention to detail is paramount when trying to avoid incidents like the ZR-2 disaster. Compliance matrices will be key when evaluating the different engineering requirements for military use. A key link in the certification chain is the FAA, which has yet to adopt the standards of other CAAs. Leveraging their airworthiness certifications would save the FAA's Military Certification Branch significant time, cost, and effort. This would allow faster acquisition pathways versus traditional pathways typically utilized for new aircraft.

Hybrid aircraft, like the Airlander 10 or 50, offer tremendous potential, filling various roles in ISR, command and control, border security, and logistics, while operating at a fraction of the cost of traditional platforms. These aircraft are not intended to replace existing technology within the DoD, but rather to augment current platforms, filling a niche role that the United States' near-peer adversaries typically achieve through traditional means. The capability to potentially operate through remote piloting, unmanned, or autonomous systems could offer significant advantages when delivering supplies to remote locations like the Indo-Pacific. Past mishaps offer insight into risk mitigation when incorporating a new TA, like a hybrid air vehicle, into the fleet. In contrast, future digital airworthiness certification processes offer huge potential to test various configurations of the Airlander prior to actual system and resource allocation.

B. RECOMMENDATIONS

Based on the results of this research, a five-phase approach utilizing the MTA rapid prototyping is recommended. This approach would provide the most flexibility in introducing an innovative and mature technology, once certified by the FAA, into the hands of the DON as an MCDA. With the potential to be certified airworthy by 2033–2034 and transferred to MCA, this program would provide an advantage to combatant commanders. Phase I should focus on program initiation and certification planning. Phase II should focus on airworthiness basis development and risk assessments. Phase III should be utilized for IFC and evaluating the Airlander 10's basic flight characteristics, while Phase IV should focus on military systems integration. Finally, Phase V should be utilized to achieve permanent flight clearance and MTA exit. Emphasis should be placed on utilizing the Airlander 10's ongoing certification data and continued investment in new digital airworthiness technology, a technology already used in other industries.

C. FUTURE RESEARCH OPPORTUNITIES

As a new technology, hybrid aircraft and their airworthiness certification offer plenty of potential for future research. First, building on this research by exploring the airworthiness requirements in remote piloting, unmanned, and autonomous operations would be extremely valuable, as the Airlander 10 already has the infrastructure in place for remote piloting. Second, future researchers could explore what the maintenance and operational requirements would look like when standing up a squadron versus what is currently done in industry. Third, researchers could explore specific differences in civil and military engineering design codes, encompassing different system packages and integration. Fourth, future research could look at applying digital airworthiness certification to hybrid aircraft like the Airlander 10 and 50. Lastly, future research could look at future naval doctrine and, potentially, air wing integration.

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LIST OF REFERENCES

Ackerman, S. (2013, February 14). *Army kills the military's last remaining giant spy blimp.* Wired. https://www.wired.com/2013/02/spy-blimp-deflates/

Air Accidents Investigation Branch. (2017, March 9). *AAIB investigation to HAV Airlander 10, G-PHRG.* Gov.UK. https://www.gov.uk/aaib-reports/aaib-investigation-to-hav-airlander-10-g-phrg

Army Technology. (2012, August 13). *Long endurance multi-intelligence vehicle (LEMV).* https://www.army-technology.com/projects/long-endurance-multi-intelligence-vehicle/?cf-view

Athena Information Solutions Private Limited. (2024, February 29). HAV begins Airlander 10 type certification programme. *Contify Aviation News*, 1–3. https://nps.idm.oclc.org/login?url=https://www.proquest.com/magazines/hav-beginsairlander

Carrigan, C. (2024, August 21). *The tragic last flight of Airship R-38 (ZR-2).* Naval History and Heritage Command. https://usnhistory.navylive.dodlive.mil/Recent/Article-View/Article/3880609/the-tragic-last-flight-of-airship-r-38-zr-2/

Cenciotti, D. (2024, August 30). *Skunk Works' X-56A poised to become world's first digitally-certified aircraft. The Aviationist*. https://theaviationist.com/2024/08/30/x-56a-digitally-certified/

Chan, D., & Cunneen, J. (2023, April 26). *Why fulfilling airworthiness requirements means going digital.* Siemens. https://blogs.sw.siemens.com/podcasts/talking-aerospace-today/why-fulfilling-airworthiness-requirements-means-going-digital/

Civil Aviation Authority. (2025). *Initial airworthiness regulation* (UK Regulation [EU] No. 748/2012). https://regulatorylibrary.caa.co.uk/748-2012-pdf/PDF.pdf

Civil Aviation Authority. (n.d.). *Our roles and responsibilities.* Retrieved April 1, 2025 from, https://www.caa.co.uk/our-work/about-us/our-roles-and-responsibilities/

Clos, J. (2022, June 16). *Bringing back the blimp!* CodeX. https://medium.com/codex/bringing-back-the-blimp-80e9c70f6e48

Cressman, R. J. (2020a, March 26). *Akron (ZRS-4).* Naval History and Heritage Command. https://www.history.navy.mil/research/histories/ship-histories/danfs/a/akron.html

Cressman, R. J. (2020b, May 13). *Shenandoah III (ZR-1).* Naval History and Heritage Command. https://www.history.navy.mil/research/histories/ship-histories/danfs/s/shenandoah-ii.html

Defense Acquisition University. (n.d.-a). *Major capability acquisition (MCA)*. Retrieved April 1, 2025, from https://aaf.dau.edu/aaf/mca/

Defense Acquisition University. (n.d.-b). *Middle tier of acquisition (MTA)*. Retrieved April 01, 2025, from https://aaf.dau.edu/aaf/mta/

Department of Defense. (2014). *Airworthiness certification criteria* (MIL-HDBK-516C). https://quicksearch.dla.mil/qsDocDetails.aspx?ident_number=212162

Department of Defense. (2022). *Operation of the adaptive acquisition framework* (DoD Instruction *5000.02).* https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodi/500002p.pdf?ver=2020-01-23-144114-093

Department of Defense. (2024a). *DoD Airworthiness policy* (DoD Instruction 5030.61).https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodi/503061p.PDF?ver=a4--jubJTtO3HPR0IUN_cQ%3D%3D

Department of Defense. (2024b). *Operation of the middle tier of acquisition.* (DoD Instruction 5000.80). https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodi/500080p.PDF

European Union Aviation Safety Agency. (2022). *Special condition gas airships.* https://www.easa.europa.eu/en/document-library/product-certification-consultations/final-special-condition-sc-gas-gas-airships

European Union Aviation Safety Agency. (n.d.). *The agency.* Retrieved March 31, 2025, from https://www.easa.europa.eu/en/the-agency/the-agency

Federal Aviation Administration. (2015). *Order 8110.101A – Type certification procedures for military commercial derivative aircraft.* https://www.faa.gov/regulations_policies/orders_notices/index.cfm/go/document.information/documentid/1026967

Federal Aviation Administration. (2023a, February 22). *US-EU safety agreement (Original – 2008).* https://www.faa.gov/aircraft/air_cert/international/bilateral_agreements/eu/us_eu_safety_agreement

Federal Aviation Administration. (2023b, July 21). *Military Certification Branch.* https://www.faa.gov/about/office_org/headquarters_offices/avs/offices/air/hq/compliance_airworthiness_air700/mco

Federal Aviation Administration. (2024a, August 21). *Airships- Regulations, policy, and guidance.* https://www.faa.gov/aircraft/air_cert/design_approvals/airships/airships_regs

Federal Aviation Administration. (2024b, August 28). *Order 8130.2K – Airworthiness certification of aircraft.* https://www.faa.gov/documentLibrary/media/Order/8130.2K.pdf

Federal Aviation Administration. (2025a, January 22). *Mission.* https://www.faa.gov/about/mission

Federal Aviation Administration. (2025b, March 31). *Bilateral aviation safety agreement- executive agreement.* https://www.faa.gov/aircraft/air_cert/international/bilateral_agreements/baa_basa_listing/media/UK_legacy_BAA.pdf

Fletcher, Z. B. (2025, March 21). *Why Navy destroyers are being sent to the southern border mission.* Military Times. https://www.militarytimes.com/news/your-military/2025/03/21/why-navy-destroyers-are-being-sent-to-the-southern-border-mission/

Gonzalezocasio, J. (2019, February). The Navy needs information warfare airships. *Proceedings,* 145(2), 1392. https://www.usni.org/magazines/proceedings/2019/february/navy-needs-information-warfare-airships#:~:text=The%20Air%20Force's%20Blue%20Devil%20II%20airship,Navy's%20MZ%2D3%20blimp%20was%20canceled%20in%202014

Gratton, G. (2018). *Initial airworthiness: Determining the acceptability of new airborne systems.* Springer International Publishing AG.

Hybrid Air Vehicles. (2021, February 11). *Airlander at TRL 7.* https://www.hybridairvehicles.com/news/overview/insights/technology-readiness-level/

Hybrid Air Vehicles. (n.d.-a). *Airlander 50.* Retrieved May 1, 2025, from https://www.hybridairvehicles.com/airlander/airlander-50/

Hybrid Air Vehicles. (n.d.-b). *The production Airlander 10 is revealed.* Retrieved May 1, 2025, from https://www.hybridairvehicles.com/news/overview/news/new-aircraft-shape-revealed/

International Civil Aviation Organization. (2013). *Airspace sovereignty.* https://www.icao.int/Meetings/atconf6/Documents/WorkingPapers/ATConf.6.WP.080.1.en.pdf

Jiron, Z. B. (2012, November-December). Hybrid airships for lift: A new paradigm. *Army Sustainment*, 40–45. https://alu.army.mil/alog/PDF/Hybrid_Airships_Lift.pdf

Judson, J. (2016, May 12). The Airship formerly known as LEMV Top Fly Again. *Defense News.*https://www.defensenews.com/industry/2016/05/12/the-airship-formerly-known-as-lemv-to-fly-again/

Long, D. (2016, April 11). *CBP's eyes in the sky.* U.S. Customs and Border Protection. https://www.cbp.gov/frontline/frontline-november-aerostats

Lopez, C. T. (2025, March 25). *Hegseth gives order to enhance military mission at southern border.* U.S. Department of Defense. https://www.defense.gov/News/News-Stories/Article/Article/4134243/hegseth-gives-order-to-enhance-military-mission-at-southern-border/

Lucka, D. (2003). *Refining the U.S. Navy flight clearance (airworthiness certification) process: Maximizing acquisition reform benefits for commercial derivative aircraft acquisitions.* University of Tennessee.https://trace.tennessee.edu/cgi/viewcontent.cgi?article=3412&context=utk_gradth es

Naval Aviation Enterprise Communications. (2023, September 7). *Electronic attack systems program using digital twins to impact naval aviation.* America's Navy. https://www.navy.mil/Press-Office/News-Stories/Article/3518626/electronic-attack-systems-program-using-digital-twins-to-impact-naval-aviation/#:~:text=ABOUT-,Electronic%20Attack%20Systems%20Program%20Using%20Digital%20Twins%20to%20Impact%20Naval,evolvemen

National Archives and Records Administration. (2025, April 23). *Federal aviation regulations and space regulations,* 14 C.F.R.§1.1 (2025). https://www.ecfr.gov/current/title-14/chapter-I/subchapter-A/part-1/section-1.1

Naval Air Systems Command. (2022). *Airworthiness policy* (NAVAIRINST 13034.1G). Department of the Navy. https://www.highergov.com/document/pws-2-0-mm-navairinst-13034-1g-pdf-53c366/

Naval History and Heritage Command. (2024, August 23). *Airships & dirigibles*. https://www.history.navy.mil/browse-by-topic/exploration-and-innovation/airships-dirigibles.html

Office of the Assistant Secretary of the Air Force for Acquisition, Technology, and Logistics. (2025). *Department of the Air Force guidance memorandum to Airworthiness* (DAFI 62–601). Department of the Air Force. https://static.e-publishing.af.mil/production/1/saf_aq/publication/dafi62-601/dafi62-601.pdf

Peniston, B. (2025, January 21). *Trump orders military to plan to 'seal the borders.'* Defense One. https://www.defenseone.com/policy/2025/01/trump-orders-military-plan-seal-borders/402360/

Polmar, N. (2011, May). Ships that were lighter than air. *Proceedings*, *25*, (3).https://www.usni.org/magazines/naval-history-magazine/2011/may/ships-were-lighter-air

Purton, L., & Kourousis, K. (2014). Military airworthiness management frameworks: A critical review. *Procedia Engineering*, *80*, 545–564. https://www.sciencedirect.com/science/article/pii/S1877705814012041

Sampson, B. (2024, February 29). Hybrid Air Vehicles kicks off Airlander 10 certification. *Aerospace Testing International.* https://www.aerospacetestinginternational.com/news/industry-news/hybrid-air-vehicles-kicks-off-airlander-10-certification.html#:~:text= Airlander%2010s%20first%20flight%20is,our%20journey%20towards%20this%20goal.

Smithsonian National Air and Space Museum. (n.d.). *The USS Shenandoah.* Retrieved April 3, 2025, from https://airandspace.si.edu/uss-shenandoah-accessibility-version

Straightline Aviation. (n.d.). *Hybrid airship technology*. Retrieved June 2, 2025, from https://www.straightlineaviation.com/hybrid-technology

Trevithick, J. (2024, August 05). *EA-18G Growlers with new jamming pods onboard carrier heading to Middle East.* The War Zone.https://www.twz.com/air/ea-18g-growlers-with-new-jamming-pods-onboard-carrier-heading-to-middle-east

U.S. Government Accountability Office. (2023). *Weapon system sustainment: Navy ship usage has decreased as challenges and costs have increased* (GAO-23-106440). https://www.gao.gov/products/gao-23-106440

UAS Vision. (2011, April 11). *U.S. Air Force funds $86M Blue Devil 2 demonstration airship.* https://www.uasvision.com/2011/04/11/us-air-force-funds-86m-blue-devil-2-demonstration-airship/

Weaver, T. (2025, February 19). Flying Whales cargo airship closer to taking to the skies following latest supplier contract. *Engineering and Technology*. https://eandt.theiet.org/2025/02/19/flying-whales-cargo-airship-closer-taking-skies-following-latest-supplier-contract

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