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Military airworthiness management frameworks: a critical review

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Abstract

Despite all current measures taken to assure their safety, aircraft are still crashing. Since 1944 there has been a global organization, International Civil Aviation Organization (ICAO), focused on providing rules for safety in civil aviation in a global context. With its inception, noting the steady increase in the number of flights per year, there has largely been a decrease in aircraft crashes, particularly after the 1970s. No global set of rules exist for Military aviation; who operate with greater risk tolerance and regularly carry explosive ordnance. It is each Nations responsibility to ensure that the operation of military aircraft does not affect the safety of civilian flights. Generically, Military Aviation Authorities (MAAs) have regulatory sets that are underpinned by ICAO principles, but no compliance to the principles is expected of them. Further, MAAs have many common goals and desired outcomes. However, interpreting across MAAs is a largely complex and time consuming task, requiring dedicated resources. Despite the large number of militaries, each with their own unique implementations, there is very little literature regarding the current status of military airworthiness. Further, there are some important partnerships between allied and collaborative militaries that are shaping the future of military airworthiness. This paper provides a summary of the significant Western Militaries airworthiness authorities and the forums and working groups in which they participate. In summarizing this paper highlights the opportunity for development of a platform for enabling a mutual recognition system improving global military safety and easily recognizing potential efficiencies.

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Keywords: Aviation, Regulation, Military, Airworthiness, Mutual Recognition

1. Introduction

There are many contributing factors as to why a greater number of military accidents occur. Primarily, it arises from the role and operating environment. Civilian aircraft fly very simple flight profiles while military aircraft often fly severe profiles. Yet, since 1944 with the signing of the Convention of International Civil Aviation, more commonly known as the Chicago Convention [1], there has been a global organization with the responsibility for ensuring safe civilian aircraft operations. No such

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organization exists, or is ever likely to exist, for military safety. ICAO is charged with the responsibility for ensuring safe civilian aircraft operations in a global context; nevertheless no such organisation exists, or is ever likely to exist, due to the distinct characteristics of these two aviation domains.

A Military Airworthiness Authority (MAA) is the responsible body for safety of all military aircraft and in some cases state owned and operated aircraft. This requirement is detailed in individual state military airworthiness systems [2-7] but not explicitly in any overarching, directive document, policy or legislation. The Chicago Convention, in Article 3, requires that the operation of military aircraft does not impact civilian safety. This direction does not in itself require a military unique airworthiness system for military aircraft. Civilian systems of airworthiness address a majority of military airworthiness requirements. In fact, a majority of the military frameworks mirror the intent of the underpinning International Civil Aviation Organization (ICAO) framework, the distinction is in the methods of implementation.

Airworthiness is universally underpinned by regulation and standards. Effective regulation, across all spectrums, dictates the behaviors required of a regulated entity (organization, agency or person). A regulated entity subscribes to following the regulations in their business processes (compliance) and the regulator verifies that the processes and displayed behaviors conform (conformance) to the regulations [8, 9]. The regulator should be removed from designing the business processes and methods of conformance to the regulations. This allows unique and specific adoption of the regulations for the creation of the most practical and pragmatic business process [9].

Currently, the literature surrounding military airworthiness is limited to one conference paper [10] on the infant Chinese Military Airworthiness system and the lessons gained from other MAAs, as well as a small number of papers regarding integration standards for Unmanned Aerial Systems (UAS) in civil and military airworthiness systems [11-13]. The lack of publications highlights that military airworthiness thinking is generally insular and contrast to the civilian systems, where decisions and motivations are expected to be widely communicated. This paper serves to fill some part of the identified literature gap, offering an overview of Military airworthiness and how it differs from its civilian counterpart. A discussion is given on the significant allied and collaborative MAA advancements, highlighting their significance to global defense aviation. Lastly a pressure for a holistic recognition system for military airworthiness is identified, presenting an opportunity for future work in this area.

2. Military Airworthiness

There is no global defining document for military airworthiness, however, although it is not explicitly stated, sovereign authorities must ensure their military aircraft are at least compliant with the civilian requirements [14]. Further, military aircraft operate at elevated risk levels, as required by operational necessity, and are required to carry explosive ordnance. This requirement precludes the military from wholesale adoption of civil airworthiness frameworks. For this reason there are numerous, similarly intentioned, but very unique military airworthiness systems across the globe [2-5].

Generally, airworthiness management systems are separated into spectrums of focus [1], underpinned by specific regulation and standards to ensure all interaction with aircraft and aviation systems are correctly over sighted to assure safety. In particular these spectrums are summarized 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 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.

A holistic military airworthiness system should encapsulate all of these elements, nevertheless there needs to be a risk based assessment available to the capability managers. When there is an operational necessity that the aircraft be flown, airworthiness risks can be accepted by the operators. This is a distinction from civil aviation, were un-airworthy aircraft are never permissibly flown. MAAs derive their authority through many different mechanisms. For instance, the United Kingdom and French militaries through Decrees are given legislative authority by the Government for assuring Defense aviation safety. While the Australian and USA Department of Defense militaries are directed through Defense specific policy. While the mechanism for empowerment does not affect the ability of the airworthiness management framework to assure aviation safety, it does modify the ability of the MAA to enforce compliance and conformance.

3. Distinctions from Civil Aviation Authorities

Civil aviation within each country is regulated by Civil Aviation Authorities (CAAs) and regardless of location, are all required to comply with consistent global standards [14]. To enforce this, all 191 members of the United Nations (UN) have subscribed to the articles of the Chicago Convention [14]. The Chicago Convention was first agreed in 1944 (latest revision in 2006), outlines in 96 articles, the requirements for CAAs in maintaining the safety of civil aviation. The Convention asserts that every State has complete and exclusive sovereignty over the airspace above its territory and that no scheduled international air service may operate over or into the territory of a Contracting State without its previous consent (Article 1). By agreement, the organization established as ICAO was chartered with affecting the principles of the Convention. ICAO have more recently produced eighteen annexes to the Convention labeled Standards and Recommended Practices (SARPs), they assist implementation by the Civil Aviation Authorities.

In an effort to ensure the contemporary principles of airworthiness are addressed, ICAO evolved their regulatory set. Realizing that assessments of organizations disparately through compliance with a range of Annexes was cumbersome, they developed a single location for all safety related provisions and annexes. This evolution ensures that their regulations are maintained as world leading. In developing a complete State Safety Management System (SMS) they published the regulatory set DOC 9734 [15] and Safety Oversight Audit Manual, DOC 9735 [14]. This regulatory set is presented as eight core elements (CE), while each State is assessed by ICAO against these elements under the Universal Safety Oversight Audit Programme (USOAP) [16]:

- CE-1 Primary aviation legislation;
- CE-2 Specific operating regulations;
- CE-3 State civil aviation system and safety oversight functions;
- CE-4 Technical personnel qualification and training;
- CE-5 Technical guidance, tools and the provision of safety critical information;
- CE-6 Licensing, certification, authorization and approval obligations;
- CE-7 Surveillance obligations;
- CE-8 Resolution of safety concerns.

This gives globally accessible information on the maturity of a member states regulatory system. Identifying areas of each States implementation that perform above or below the global average. Civil aviation has benefited broadly by a globally consistent approach to regulation and safety assurance, there has been a downward trend in aviation accidents in the last 30 years [17]. For instance, there are many agreements between significant aviation nations and regions [18-20] that exist through recognition of the consistent application of the ICAO systems. No such system or consistent application exists for Military aviation. This general but important distinction offers the greatest division of civil and military airworthiness. Where civil aviation relies on established and understood language and intent, the military aviation community offers evolutions of similar, yet uniquely military, language with complementary but not consistent regulatory intent.

4. Review of Major Military Airworthiness Authorities (MAAs)

4.1. United States Department of Defense (US DOD)

Consistent with Global policy, the Federal Aviation Authority (FAA) treats US DoD aircraft as public aircraft (within US airspace and state aircraft when outside of US airspace) [21] and are exempt from FAA airworthiness procedures. The US DoD, comprising United States Air Force (USAF), US Navy (USN) and U.S. Army, derive their authority through the United States Code [22] and under this authority the services enact their role as MAAs, through the relevant Secretary. With individual policy documents directing a similarly intentioned yet unique airworthiness framework, and the Defence Industry of the United Stated being so prevalent in global Defence aviation, it is paramount that Global Defence Aviation understands the intricacies of the unique implementations. Recently, the US DOD issued a joint Airworthiness Policy [23] outlining the derivation of authority and key requirements of the airworthiness system. This Policy specifies the responsibilities of the DOD organizations coordinating airworthiness of military aircraft on behalf of the government. Moreover, it allows for the arms of the US DOD to accept each other's certification of aircraft, if they will be operated with the same configuration, role and environment.

4.2. United States Air Force (USAF)

Within the USAF, the Aeronautical Systems Centre Engineering Directorate (ASC/EN) is responsible for the airworthiness system. The USAF focuses on Aircraft Airworthiness Certification in their airworthiness policy document [24], while this policy directive is implemented by a subordinate Air Force Instruction [25]. In analysing the linkages between the policy document and instruction, it is immediately apparent there are no discernible connection between statements in the policy and processes in the instruction. The USAF airworthiness system primarily focuses on technical airworthiness. In their latest revision, a significant evolution [26], USAF have adopted the increasingly popular step of identifying the Director of ASC/EN as the Technical Airworthiness Authority (TAA) who:

- Defines airworthiness standards;
- Approves certification basis;
- Issues compliance findings;
- Issues Military Type Certifications and other flight releases.

There is a heavy reliance on assuring airworthiness through design, with only limited reference made to the requirements for operational and aircraft maintenance considerations.

While the USAF definition of Airworthiness identifies clearly the role of usage and limits in airworthiness assurance, the associated operational airworthiness aspects are addressed very briefly in the

airworthiness instruction. The USAF derives all other requirements for Airworthiness (operational and continuing) from this caveat. There exists other policy documents [27] and supporting instruction [28] for aircraft maintenance without identifiable links to the policy and instructions on airworthiness. Compliance with the policy document and instructions on maintenance are mandatory, however it is the responsibility of the maintenance unit and hierarchy to enforce compliance (self-regulation). This disconnection from an independent assessment, as is the case with design and aircraft certification through the TAA, offers opportunity for maintenance complacency.

4.3. United States Navy

Within the US Navy the Chief of Naval Operations has established the Commander of Naval Air Systems Command (referred as AIR-00), as the person responsible for the airworthiness system of both Navy and Marine Corps aircraft. AIR-00 has the authority, responsibility, and accountability to establish, monitor and approve technical standards, tools, and processes in conformance with applicable DoD and US Navy/Marine Corps policy, requirements, architectures, and standards [29]. All US Navy/Marine Corps owned or leased aircraft, both manned and unmanned, need to have an airworthiness approval in the form of a flight clearance document promulgated/issued by AIR-00 [30]. AIR-00 has delegated airworthiness authority to the Airworthiness Office of the Naval Air Systems Command (referred as AIR-4.0P) to execute on his behalf. The US Navy airworthiness policy focuses on flight clearance for aircraft, which is the aircrafts airworthiness approval, granted by AIR-4.0P, at the assessment of an aircraft's airworthiness and safety of flight, and ensures all risks have been identified as described in their primary airworthiness document [31]. This document conveys not only policy and responsibilities, but outlines the processes for exercising airworthiness reviews and applying for and issuing processes. It includes the processes for AIR-4.0P staff to fulfil their responsibilities. The blending of policy, responsibilities and processes creates a singular point of reference regarding this topic; however, discerning the airworthiness requirements from the string of text outlining responsibility and process is confusing.

The flight clearance process is well defined, outlining the procedure from start to finish. This includes a process map, applicants and AIR-4.0P staff are well aware of their requirements, particularly surrounding documentation, with the Systems Engineering Technical Review detailing the process to follow for aircraft certification. Interestingly, there is no maintenance requirements directly outlined in the airworthiness policy. The instruction states that NAVAIR flight clearances are only valid when maintained in accordance with the USN maintenance document [32] and/or NAVAIR approved maintenance plans. The instruction assigns authority to Commander Naval Air Forces (COMNAVAIRFOR) for assigning maintenance responsibilities and tasks. The maintenance processes are outlined in the Naval Aviation Maintenance Process (NAMP) [32] managed under the authority of AIR6.0. The instruction has again blended requirement, responsibility and process. It includes authoritative statements with accompanying management processes. There are detailed requirements for quality checks for the three levels of maintenance.

4.4. United States Army

The US Army defines their airworthiness policy in the US Army Reg 70-62 Airworthiness Qualification of Aircraft System [5]. In the section on responsibilities it outlines that the Deputy Chief of Staff is the proponent for the airworthiness of Army aircraft. It is then the responsibility of the Commanding General, US Army Aviation and Missile Command to act as the airworthiness approval authority. The US Army policy focuses on the airworthiness qualification of aircraft systems, subsystems,

and allied equipment. This includes all aviation materiel and aircraft that are; Army assigned, bailed, borrowed, loaned, leased, owned or otherwise authorised for operation by Army personnel.

The airworthiness qualification of Army aircraft is characterized in three components:

- 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 (CSI) controls [5].

The US Army regulatory set is not constructed in a manner that is easy to understand the linkages, interfaces and flow of regulatory information. The primary airworthiness document focuses on design and production of the technical item. There are other distinct regulatory documents for flight regulations [33], and maintenance [34], but interestingly no direct reference to the operational or maintenance policy is made in the airworthiness policy document. Further, verifying maintenance compliance and conformance is a command function, conducted under the ARMS inspection process were negative trends are reported to the airworthiness authority. Importantly, it is instilled within the regulation that repair organizations must have a quality management system.

4.5. UK Military Airworthiness Authority

The United Kingdom (UK) military have undergone a complete regulatory transition following the RAF Nimrod accident in 2006 [35]. This significant event and subsequent report has led to a systematic overhaul of the Military Airworthiness system. The Military Aviation Authority (MAA) is a UK Ministry of Defence (MoD) department, established through the Secretary of State, as the single independent regulatory body for all military aviation. The MAA was charged with reducing the complexity of the legacy Airworthiness system, which arose from users having to refer to many different regulatory documents that confused regulation with guidance and information of a non-regulatory nature. Figure 1 details the transition from segmented regulatory application to a hierarchical regulatory framework that offers clear distinction between policy, regulation and guidance [35].

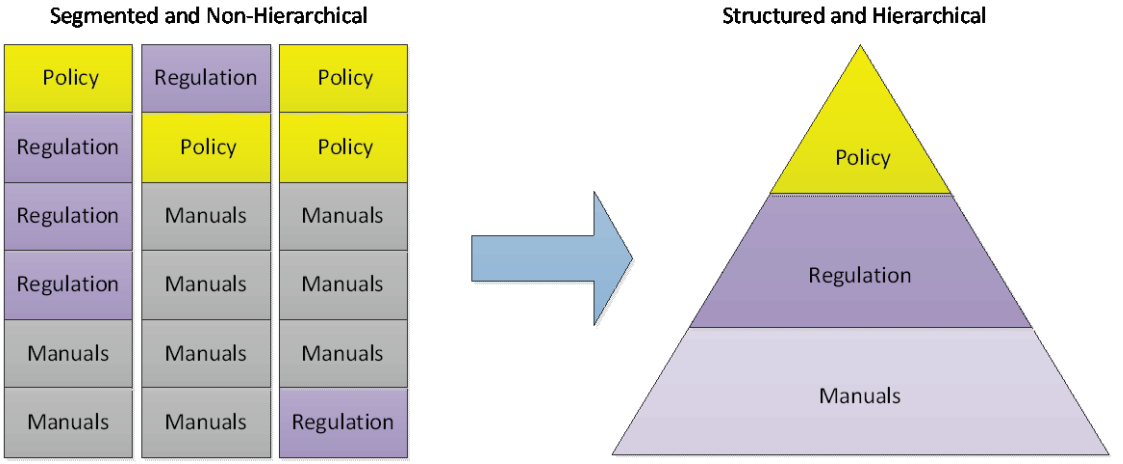

Figure 1: This figure illustrates the airworthiness restructure from recommendations of the Haddon-Cave report [35]. The MAA changed from a disjointed, segmented and non-hierarchical airworthiness system to a structured, coherent and hierarchical airworthiness system.

The Regulatory Policy [4] outlines that the Secretary of State for Defense establishes Military Aviation Authority (MAA) as the single independent regulatory body for all Defense aviation activity. As the 'Regulator', Director General MAA is responsible for providing a regulatory framework, given effect by a certification, approvals and inspection process for the acquisition, operation and airworthiness of air systems within the Defense aviation environment. DG MAA is responsible for providing assurance to Secretary of State that the appropriate standards of military Air Safety are maintained and is the Convening Authority for Service Inquiries into aircraft occurrences. The airworthiness system is underpinned by four key principles elicited in the Haddon-Cave report [35]:

- Leadership; There should be strong leadership from the very 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.

Importantly, it has been recognized that the transition to the regulations is lengthy, therefore the UK MAA has currently only enforced the new regulatory set on contractor design and maintenance organizations. This means the Defense organizations performing these functions do not yet operate under the new regulations, this provides disparate requirements for organizations that may be performing the same functions on the same aircraft.

4.6. Canadian Department of National Defense (DND)

The Canadian Department of Defense is jointly empowered with their civil counterpart Transport Canada under the *Aeronautics Act* [36]. It is this statute of law that places upon the Minister for Defense and the Minister for Transport, the responsibility "for the development and regulation of aeronautics and the supervision of all matters connected with aeronautics". Since the legislative power is derived from the same act for both agencies, there is greater interaction and clearer delineation of responsibilities [37]. In

this the Department of Defense is responsible for the regulation of and supervision of all aeronautics related to Defense.

Within Defense, Director General Aerospace Equipment Program Management is charged with assuring technical airworthiness. With the Department of Defense adopting, and then evolving independently, the Australian Defence Force airworthiness system from the late 1990s[a], there are a lot of common implementations. The Directorate Technical Airworthiness and Engineering Services is the responsible for certification of airworthiness aspects of the aircraft. While the Canadian Military airworthiness system is predominantly engineering (technical) related. They do have a commensurate organization responsible for operational airworthiness. Importantly, the operational aspect of the system is only underpinned by rules. That is, they are not supported by legislation and do not enforce regulation. They are an integral component of the airworthiness system and interact through the Record of Airworthiness Risk Management, a decision making process for airworthiness risk [3]. The Department of Defense regularly conducts compliance (at introduction) and conformance (repeat checks of processes) audits of design and maintenance organizations under their jurisdiction.

4.7. Direction Générale de l'Armement (DGA - French Military Authority)

The French have contributed significantly to Defence Aviation industry, with major manufacturers, as Dassault Aviation and Eurocopter, having produced several military aircraft varieties for numerous militaries throughout the world. While the Defence industry have been traditionally strong, the Airworthiness system has recently undertaken significant evolution to increase its relevance [38]. Historically, French military aviation is governed by requirements rather than regulation, largely following the civilian requirements where applicable. Following several aircraft accidents in 2000/2001 [38], it was highlighted that there was a requirement for airworthiness regulation to add legal protection. The French Prime Minister issued airworthiness regulation under Decree 2006-1551 along with three ministerial orders to set rules for the use, airworthiness and registration of military and state owned aircraft. The Prime Minister also designated the head of Directorate General of Armaments (DGA) as the certification authority (or Technical Authority) for state owned aircraft. Further authority was given to the Directorate of State Aviation Security (DSAE) to establish the rules for continuing airworthiness and organizational approvals. DSAE operates with the airworthiness title of Aviation Safety Authority.

The French airworthiness system is promulgated through two DGA issued instructions on:

- The essential requirements and additional provision for airworthiness of military and state owned aircraft [7]. This instruction caters for initial airworthiness assessments through type certification and initial flight clearance;
- The requirements for continuing airworthiness [39]. It provides the acceptance criteria for organisations and personnel that are designing, producing and maintaining the military or state owned aircraft.

This implementation largely mirrors the civil European Aviation Safety Authority (EASA) and more closely the infant European Defense Agency (EDA) implementation. This close alignment with the civilian regulatory system reduces the regulatory overheads on French Defense industry.

[a] Knowledge gained from interaction with staff of the Australian Defence Force's Directorate General Technical Airworthiness.

4.8. Australian Defence Force

The Australian Defence Force derives its airworthiness authority through Government policy, while it is not legislated. The policy document (Defence Instruction) [40] describes Defences' responsibility for assuring the aviation safety of aircraft used for Defence purposes. This includes design, construction, maintenance and operation of any aircraft or Aviation Support System:

- Owned, leased, hired or chartered by Defence;
- Operated exclusively for or on behalf of Defence;
- On which The Civil Aviation Safety Authority has placed statutory airworthiness responsibilities on Defence.

The Defence Instruction, signed by the Chief of the Defence Force and the Secretary for Defence, assigns responsibility to the Chief of the Air Force as the Defence Airworthiness Authority, he enacts his responsibility through the Defence Aviation Safety Program Manual [41]. This Defence Instruction also assigns responsibility to the Deputy chief of Air Force as the Operational Airworthiness Regulator, whose regulations are defined through the relevant Operational Airworthiness Manual [42].

Authority is assigned to the Director General Technical Airworthiness as the Technical Airworthiness Regulator and the Technical Airworthiness Authority whose regulation is outlined in the Technical Airworthiness Maintenance Manual [2]. This joint empowerment of key airworthiness personnel, and closer alignment of objectives, was derived from a review of the Haddon-Cave report including recommendations leading to a coherent approach to aviation safety by the four key airworthiness appointments and supporting agencies. Importantly the overarching policy document (Defence Instruction) outlines the requirements of each program appointment including the requirements for regulation and compliance including the principles for regulation development [40] .

Director General Technical Airworthiness is head of Directorate General Technical Airworthiness of the Australian Defence Force and enacts his responsibility to prescribe regulation and verify compliance and conformance to those regulations as the Technical Airworthiness Regulator. The Director General is also responsible for assessing technical acceptability of Defence aircraft, technical aspects of Aviation Support Systems and communicates technical risks to the relevant Operational Airworthiness Authority. The acceptability is assessed against standards (not regulations) outlined in the Airworthiness Design Requirement Manual [43]. Figure 2 displays the airworthiness command hierarchy.

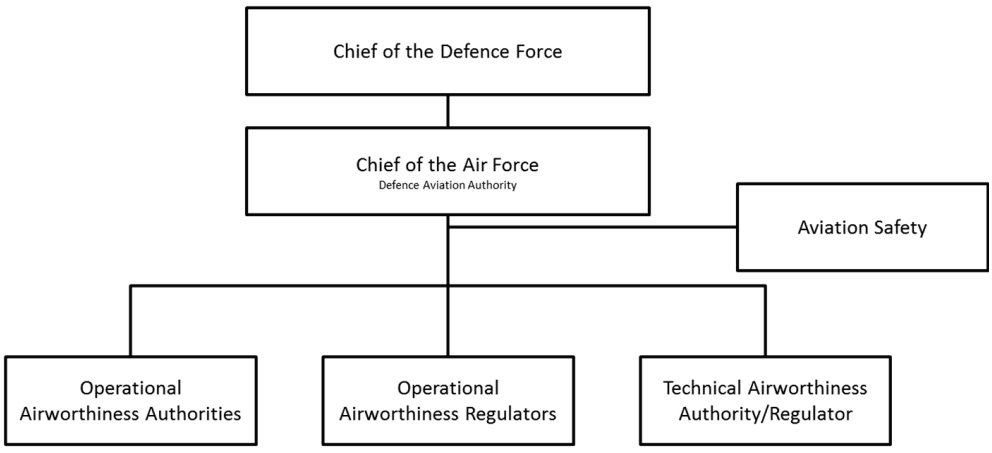

Figure 2: The hierarchical nature of the Australian Defence Force airworthiness authorities, this framework is detailed in [40].

The Technical Airworthiness Management Manual provides the median for conveying Technical regulation. It is underpinned by principles stating that organizations which design, construct or maintain aviation materiel are to be authorized by the Technical Airworthiness Regulator, have competent personnel, utilize documented processes and have access to authoritative data [2]. Of note, there is only weak production oversight by the regulator within the Defence Force. This is a direct result of there being no native aircraft production since the application of the airworthiness regulations within Australia. A major evolution of the technical regulatory structure occurred in the 1990s following significant aircraft accidents contributable to engineering processes and decisions (Nomad 1990, Macchi 1990). Further evolutions to regulatory approach in maintenance practice occurred following a crash in 2002 of the Sea King conducting aid relief in Indonesia [44]. The latest evolution, triggered by the Nimrod crash and subsequent reviews, is towards a holistic aviation safety program for Defence. Further modifications have been triggered due to identification of regulatory inefficiencies and uncertainty driving increased cost to Defence, particularly from Defence Industry driven by Defence fiscal constraints [45], lending itself to identification were organizations have employed methods which exceed the requirements of the regulations and investigation of closer alignment with civil aviation requirements.

5. Summary of Military Airworthiness Authorities Characteristics

The Military Airworthiness Authorities (MAAs) discussed in the previous sections all have differing implementations to assure airworthiness. Each method has its own unique focus, deriving their authority through a variety of measures. As a method of summary, the salient points for each authority are presented in Table 1.

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

Defence	Defence (Parliamentary Decree)		safety. Technical airworthiness regulations revitalised and now stand alone in their implementation	in new format. Contractors have different requirements.
Canadian Defence	Aeronautics Act (Legislative)	Engineering, Maintenance and Operations	Close ties to civil authorities. Interacts well with operational authorities.	Regulations underpinned by legislation are difficult to modify
French Defense	Prime Minister Decree (Legislative)	Holistic Engineering and Maintenance	Close alignment with civilian implementation.	Original focus on legal protection rather than aviation safety
Australian Defence Force	Secretary of Defence and CDF (Policy)	Holistic – aligned focus for Engineering, Maintenance and Operation.	Rewritten policy closely aligns purpose of key airworthiness positions.	Evolution of technical airworthiness manual has resulted in confusion around actual requirements. Weak production oversight.

Table 1: Presents the salient points for each MAA, this includes; the method they use to derive their authority, airworthiness focus points, strengths and weaknesses in the framework.

6. Allied Military Airworthiness Authorities (MAAs)

6.1. European Defense Agency

The European Defence Agency (EDA) was established in 2004 with the goal of strengthening Defence collaboration within the European Union. There were four key motivations, one of which was; creating a competitive European Defense Equipment Market and strengthening the European Defense, Technological and Industrial Base [46]. This motivation was derived through identification of the number of certifications required by the different airworthiness frameworks for the design and production of common aviation materiel by European Defense Industry. The European Defense Agency has identified that the work conducted by the EASA [47] program is largely transferrable to European Militaries, thus the European Military Airworthiness Requirements (EMARs) largely mirror the EASA regulatory structure. The EDA established the Military Airworthiness Authorities (MAWA) Forum in 2008 as a method for collaboratively developing the EMARs. The forum and the development of the EMARs are further elaborated in the sequel.

6.2. US Department of Defense Harmonization

The United States Department of Defense has initiated a harmonization project to identify where the US Air Force, Navy and Army can begin to align their airworthiness policy. They have developed an Extended Military Handbook that details a comprehensive list of all potentially applicable standards relevant to achieving Airworthiness Certification [48]. They then established a Memorandum of

Agreement [49] between the services detailing that there is no requirement to re-certify aircraft based on a service specific assessment of provided certification data. This was then replaced by the Department of Defense Airworthiness Policy, drawing a focus for closer alignment between the airworthiness authorities. There has been further work on harmonization with the services; however, very little information is available on the status and direction of the US Department of Defense Airworthiness Harmonization process. An update was given to the European Defense Agency (EDA) Military Airworthiness Authorities Forum (MAWA) Conference [50] regarding the release of the directive on establishing a common framework for providing airworthiness and the participation of the services with the Federal Aviation Authority (FAA), Homeland Security and US Coast Guard on a National Airworthiness Council.

Inconsistent US Service policies have resulted in confusion and often left US Defense Service Members with unknown airworthiness risk while flying in foreign aircraft[b]. This risk is consistent for all Military personnel

7. Collaborative Military Airworthiness Authorities (MAAs)

7.1. European Defense Agency (EDA) Military Airworthiness Authorities (MAWA) Forum

The Defense Ministers of the 26 participating Member States tasked the EDA to prepare for the creation of a formal European Union-wide Forum for Military Airworthiness Authorities and to propose a roadmap for European military airworthiness harmonization and how this could be implemented [46]. The MAWA forum was established in 2008 under a roadmap with seven ministerially agreed objectives; common regulatory framework, common certification processes, common approach to organizational approvals, common certification/design codes, common approach to preservation of airworthiness, arrangements for recognition and formation of a European Military Joint Airworthiness Authorities Organization [51]. The primary aim of the MAWA Forum is to harmonize the national military airworthiness regulations of the pMS. It will achieve this by developing a common set of EMARs, Acceptable Means of Compliance (AMC) and Guidance Material (GM) that are acceptable and can be implemented into national regulation by all members of EDA [46].

The MAWA forum efforts are broken down into four task forces:

- Task force 1 led by the UK MAA, is charged with development of the airworthiness framework documents;
- Task Force 2, UK led, is charged with considering initial certification issues;
- Task Force 3, which is French led, is examining continuing airworthiness requirements;
- Task Force, led by the Italian military, is tasked with defining the certification basis for airworthiness.

The MAWA forum has developed key airworthiness policy consistent with the EASA structure. They have recently released European Military Airworthiness Regulations (EMARs) 1, 21, 145, 147 and the European Military Airworthiness Document – Recognition (EMAD-R). The EMARs are largely consistent with the EASA framework, allowing for military specific requirements. The EMAD-R details an agreed process for recognition of other MAAs, in terms of certification and approval of products and organizations based on the EMARs [52].

Importantly, it must be recognized that the motivation for the MAWA forum was driven by European Defense industry desire for a common or continentally accepted certification requirement for aeronautical

b USN presentation to ASIC, Sydney 2011

product. This is highlighted in examining the Military Airworthiness Requirement Question (MARQ) set [53]. The principles of the airworthiness system were developed from the requirement for design, production and maintenance processes to be compatible with European Defense Agency requirements. By starting their focus on certification requirements they have established a system that has generated a focus on regulatory requirements, not holistic airworthiness. For instance, agreements have been initiated for in service support of the A400M fleet between the United Kingdom and France. Importantly, this agreement is not for servicing all aircraft types, it has arisen, and is supported for, in service support of a singular aircraft platform. This will be repeated for recognition of further in service support for future servicing of more aircraft. Granted, the assessment for future platforms will be reduced due to the existing arrangement. However, it stands that recognition of the aspects of in service support *in-toto* would allow for future support requirements without any further assessment. This limitation arises from the platform of recognition focusing only on immediately attainable benefits to reduce initial recognition overheads.

Examining the requirements of the EMAD-R shows that the questions origins are developed from the ICAO Safety Management Systems (SMS) framework; however, the MAWA forum has chosen to focus on the requirements for technical airworthiness regulators. This focus arrives due to the composition and focus of the task force charged with its preparation. At the recent MAWA forum a speaker highlighted [54] that the work of the forum focuses on the design, production and use phases of the lifecycle. Concluding that there is still areas of the aircraft lifecycle, particularly for fault and accident/incident investigation, that are not yet addressed. Further, some other airworthiness management system components need to be considered for air traffic, flying operations, operational data and the increasingly prevalent safety management. The speaker requested the forum ensure there is a holistic vision for the future European military airworthiness management solution.

The requirement for a holistic approach is recognized within MAWA, but they have approached it by establishing a regulatory system, not an airworthiness system. While the need to establish the common regulatory system is a necessary and important driver, giving the project immediacy and intent that mirrors that of the EASA regulatory structure. Without a holistic vision and clear thought process it is difficult to understand which principles of airworthiness have been given the highest priority and why.

7.2. Air and Space Interoperability Council (ASIC) – Airworthiness Working Group

The Air and Space Interoperability Council (ASIC), was formed as the Air Standardization Coordination Committee in 1948 to manage the Air Standardization agreement between Canada, the United Kingdom and the United States [55]. In 1965 it expanded to include Australia and New Zealand. The Air Standardization Coordination Committee sought to promote interoperability, through standardization, across the spectrum of expeditionary warfare and share relevant information and technology. This concept remains as valid today for ASIC as it was in 1948. The organization went through transformation and rebranding in 2005 to reflect the current global strategic environment, and a renewed emphasis on coalition expeditionary operations. The council has many established Working Groups, these are long standing and they cover: Agile Combat Support, Aerospace Medicine, Air Mobility, C2 & ISR (Command, Control and Information, Surveillance, Reconnaissance), Force Application, Force Protection, Fuels and Multifora Platforms [55]. These working groups are responsible for the publication of Air Standards that all five member Nations subscribe too, allowing for greater interoperability in their expeditionary forces.

ASIC have also established some shorter term project/working groups. The most relevant is the Airworthiness Working Group. There is limited information publically available [c]; however, the Airworthiness Working Group was established in 2011 to develop a robust, yet pragmatic, recognition process for the ASIC nations. Driven by progress made by the UK and MAWA, the task was given to the ADF to analyze the Question Sets from the EDA to identify if the recognition process could be adopted by ASIC. Examination of the MAWA question set [53] showed there is too much dependency on the EMARs for the questions to be immediately transferrable. However, at the latest Airworthiness Working Group, the ASIC nations ratified the EMAD-R process for adoption within ASIC, understanding that there is reliance on the EMAR documents that will have to be overcome. The first recognition activity, between the US Army and UK MAA is currently under way, with results of this effort not yet available.

7.3. North Atlantic Treaty Organization (NATO) Airworthiness Working Group

NATO, while not a sovereign body, do own, operate, lease and charter aircraft to support operations. NATO currently owns Airborne Early Warning and Control (AEWC) and C-17 Globemaster aircraft. They require NATO member nations to provide aircraft in support of operations and for transportation of personnel and supplies. They also lease/charter aircraft from non-NATO member nations in support of operations. In all this, they do not have an airworthiness management system, and are assumed liable for operation of these aircraft. Further, the NATO acquisition process does not account for airworthiness, NATO has no organic airworthiness authority, there is no risk assessment for loss of aircraft and there is not a common set of standards for assessing airworthiness. It has taken several fatalities; particularly in NATO leased transport aircraft (104 fatalities in 10 years) [56-60], before the NATO Airworthiness Working Group gained enough momentum to address the inadequacies. The group was founded in 2006 as the Airworthiness Ad-Hoc Working Group, established to develop a suitable airworthiness policy for application by the North Atlantic Council.

NATO is currently pursuing policy that defines a NATO Airworthiness Executive with sufficient authority to identify that appropriate airworthiness systems are in place. The focus is on ensuring liability stays with the relevant, NATO recognized authority. This policy is still being developed, but it does mean that NATO will force all liability for aircraft operating on behalf of NATO on the aircrafts registering state. This is perhaps the easiest method for preventing litigation (NATO paid compensation to the 75 families [50, 56]) but in no way does it assure the safety of the aircraft. A more robust system is being investigated. The system would verify the capacity of the relevant authority to assure the continued airworthiness of the aircraft. This is more appropriate but requires much greater resources and offers significant challenge to NATO.

7.4. Interconnection of Military Airworthiness Authorities (MAAs)

As the previous sections assert there are many unique implementations aimed at assuring airworthiness; and in this paper particularly, technical airworthiness. Each of the technical airworthiness authorities aforementioned interacts with each other; some relationships are strong while others are very remote. For instance, the US Services (USAF, USN and US Army) work with both ASIC and NATO airworthiness working groups, while the UK is working within the EDA, ASIC and NATO. Figure 3 illustrates the interconnections of the MAAs documented within this paper.

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c Information regarding the AwWG gained from internal ASIC documentation and communication with ASIC AwWG members.

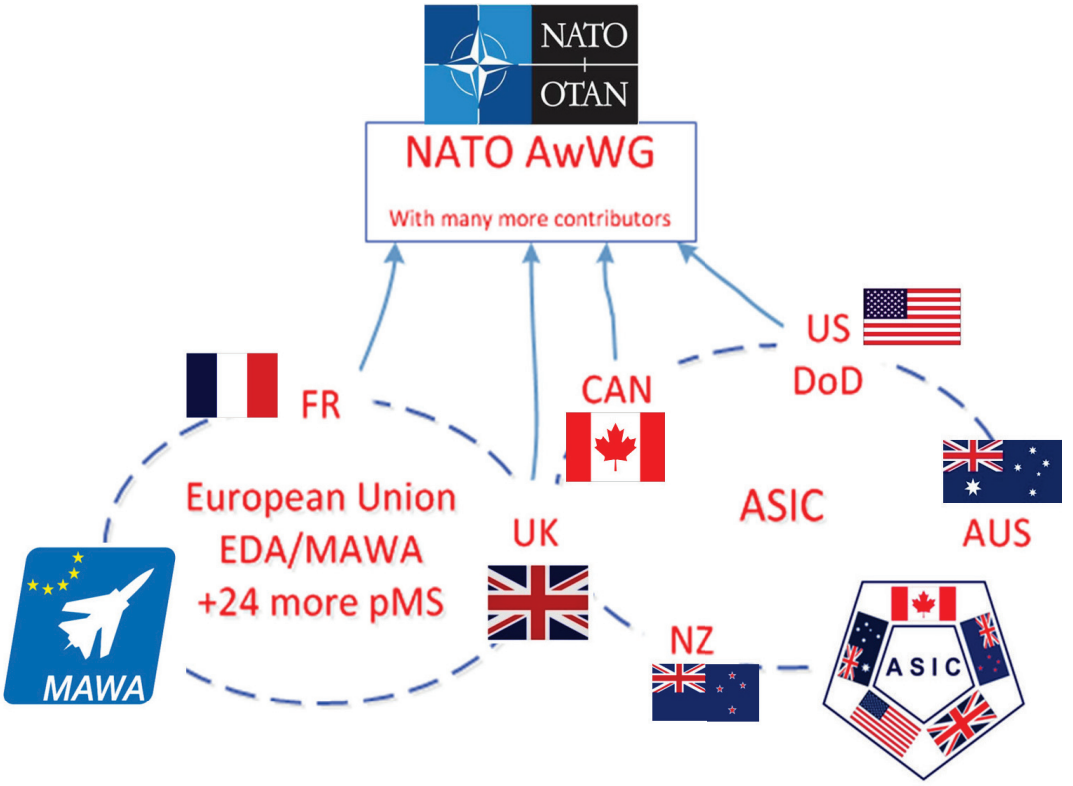

Figure 3: Displays the interconnection of the MAAs mentioned in this paper and their interaction throughout the global council, forums and working groups. This interconnection makes these key militaries significant global motivators in regulation change.

Importantly, it should be noted that ideas and collective thinking from one forum or working group are easily transported to the others. Examples of this are in the regular adoption of the ASIC interoperability standards as STANAGs within NATO, and the assessment of the EDA Military Airworthiness Requirement Question (MARQ) set by ASIC members. It is therefore important to recognize that within these forums and working groups, the significant players in western military aviation can and do influence the global military standards for airworthiness.

The working groups and forums are established to achieve different purposes. For instance, ASIC are not trying to establish regulations, their primary role is production of interoperability standards. However, they have established a project group to establish a global standard for airworthiness recognition of other MAAs. Likewise, NATO have focused on standards but are now pursuing appropriate airworthiness policy. The EDA have made the most progress, publishing policy and regulation and pursuing the European Military Airworthiness Certification Criteria which outlines the certification requirements and standards. Figure 4 below, illustrates their achievements.

Figure 4: Illustrates the relative focus and achievements of the working groups, forums and councils. The green tick signifies achievement, the orange dash signifies in progress and the red cross is either not a focus of the group or not yet in progress.

8. Requirement for Recognition

Having established that the MAAs all interact to varying degrees, through working groups or councils. They also have many business relationships. For instance, the US forces and the large US Defence industry, are the original designers and producers for many aircraft used throughout Western militaries. The same is true for many European nations. Supply of aircraft and parts is often through contractual agreements titled Foreign Military Sales. These agreements are normally bi-lateral, where the lessor supplies money and the vendor supplies aviation product, often with continuing service provisions. There are other bi-lateral agreements for provision of services (data, replenishments, passenger transport etc.). There are a plethora of these types of agreements between all of the aforementioned organizations. This is a traditional platform, and serves its purpose, but management of the large number of bi-lateral agreements is cumbersome and difficult, requiring many resources.

Significant work is being done by the EDA, through the MAWA forum, and within ASIC through the AwWG into mutual recognition. Mutual recognition facilitates gains and improved efficiencies in MAA interfaces. For instance, recognition by an MAA of aircraft product certification by another MAA would allow for utilization of all products. The EDA have finalized their first mutual recognition for the A400M between the United Kingdom and France. The servicing of the aircraft will be recognized by both nations regardless whose authority it was carried out under. This increases the flexibility and options for the A400M fleet owners. Similar recognitions will be made, not just for the A400M. For instance, if the maintenance approvals over sighted by the French were accepted by United Kingdom, trusting their assurance processes, the UK could utilize French maintenance organizations for all comparable aircraft and parts. This could then be extended to the rest of the European MAAs, reducing the burden of

managing multiple individual bi-lateral agreements. This could be a multi-lateral agreement, still contractual but with more than two parties.

There is one primary difference between the approaches for mutual recognition being pursued by the EDA and ASIC. This is the reason that the EDA system is not directly transferrable to ASIC. The EDA mutual recognition relies on the consistent application given by the EMARs. No such consistent airworthiness application is likely within ASIC, nor with MAAs outside of Europe. For this reason an alternate method of recognition, or framework for supporting the EMAD-R process, is required. Further, a system should be developed where all components of airworthiness can be judged on their importance to other MAAs, not to the one who developed it. This would remove the uncertainty concerning the uniqueness of each implementation, providing a method for recognition founded on a common baseline, not common regulations. This framework has been proposed in a complimentary paper [61]. By designing a system that analyses airworthiness holistically, designs purposive test points to be answered by each MAA for assessment by others and supports this assessment with an airworthiness framework based on product, behavior and process integrity. A baseline assessment can be formed that supports a recognition process suitable for all airworthiness bodies, civil or military. This will form the basis for future work in this area within the ASIC Airworthiness Working Group.

9. Conclusion

This paper has introduced significant western militaries, highlighting their airworthiness principles and some of their relevant strengths and weaknesses. The militaries from the United States, Canada, the United Kingdom, France and Australia all participate in global forums aimed at establishing common regulatory ground. Some of the councils are within allied militaries, that is, they have common political motivations. Forums such as MAWA and the US Department of Defense Harmonization are driven from strong political roots. They are looking to identify methods for achieving simplicity which in turn will drive efficiencies. The other working groups are established through a common desire or requirement. To operate as a global force, often under the auspices of the United Nations, militaries are required to perform interdependently.

For this reason NATO and ASIC work extensively on defining standards, such that the forces can operate together. These councils have also recognized, through different motivations, the requirement for better understanding the airworthiness systems involved. They are approaching a similar requirement from differing angles, hoping to emulate the developments of the MAWA forum in recognition. Where the MAWA forum has developed a regulatory review, identifiable as based on the ICAO SMS principles but underpinned by the common regulatory framework they have developed. ASIC and NATO cannot rely on a common regulatory framework.

It has been postulated that a holistic airworthiness system could be developed. This system would allow all global militaries to self-assert against a series of purposive test points, forming a common baseline, instead of a common framework. A holistic airworthiness system would easily identify areas of strength and weakness within individual systems. If established under the pretense of honest and open declarations, the requirement for verification audits or assessments can be dramatically reduced. Development of an airworthiness metric suitable would take considerable effort and will require support from many militaries. Currently, ASIC is supporting such an effort. Their motivation is to greatly reduce the secondary oversight required of current bi-lateral agreements, identifying that this would allow development of simpler mutual recognition driving towards a multi-lateral agreement for common services. An aspirational goal envisions a system similar to the Universal Safety Oversight Audit Programme (USOAP) global assessment metric available to all interested parties for civil aviation. This would enable global awareness of safety, and while there may be reservations arising from security or ill-

intentioned action, a simple visual metric would allow for global perspective without compromising details.

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