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SURVEY PAPER

Harmonising and standardising military airworthiness in Europe: a review of key aspects and achievements

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Abstract

The distinct operational characteristics of military aircraft, relative to civil aircraft, have impeded the standardisation of airworthiness management practice across Europe. Standardisation has been further deterred by the intertwined certification and qualification activities specific to military aircraft. The management of airworthiness in European military aviation has undergone significant changes over the past 15 years, with the progress made attributed to the harmonisation efforts driven by the European Defence Agency (EDA). The creation of a Military Airworthiness Authorities Forum and the development of the European Military Airworthiness Requirements (EMAR) have been instrumental in creating a more homogenous regulatory landscape. The examples of five main players of the European aerospace sector, namely France, Italy, Germany, Spain and the United Kingdom, are examined from the point of view of adoption and implementation of an EMARs-based system. Their regulatory structures have revealed similarities and primary differences. The EMAR's framework has enabled a gradual build-up of technical knowhow within the European countries who embraced this, civil-based, framework. All five countries have adopted EMARs, though through a variety of regulatory constructs. Their regulatory structures exhibit diverse practices, especially in how initial and continuing airworthiness is managed. Some countries have also elected to have more than one authority overseeing/been responsible for airworthiness. Closer collaboration between national Military Aviation Authorities (MAAs) can be achieved through standardisation at regulatory structure level. The establishment of a joint MAAs may be the next logical step in the harmonisation process, in line with EDA objective' for a EU-wide authority with greater powers.

Nomenclature

AAD	Autoridad de Aeronavegabilidad de la Defensa
ABDR	aircraft battle damage repair
AMC	acceptable means of compliance
BEAD	Bureau Enquêtes Accident Défense
BFD	basic framework document
CAMO	continuing airworthiness management organisation
CMA	continuous monitoring approach
CONOPS	concept of operations
CS	certification specifications
DAAA	Direzione degli Armamenti Aeronautici e per l'Aeronavigabilità
DGA	Direction Générale de l'Armement
DE&S	Defence Equipment And Support
DiGAM	Director General de Armamento y Material
DSAE	Direction de la Sécurité Aéronautique d'État
EASA	European Aviation Safety Agency
EDA	European Defence Agency

EMAR	European Military Airworthiness Requirements
EC	European Commission
EMJAO	European Military Joint Airworthiness Organisation
EU	European Union
FAA	Federal Aviation Administration
GM	guidance material
ICAO	International Civil Aviation Organisation
INTA	Instituto Nacional de Tecnica Aeroespecial
JAA	Joint Aviation Authorities
MAA	Military Aviation Authority
MACP	Military Air System Certification Process
MAWA	Military Airworthiness Authorities (Forum)
MIL-STD	military standards
MRP	Military Aviation Authority Regulatory Publications
MTC	military-type certificate
NAE NATO	airworthiness executive
NATO	North Atlantic Treaty Organisation
NMAA	National Military Aviation Authority
OCCAR	Organisation Conjointe de Cooperation en matiere d'ARmement/Organisation for Joint Armament Co-operation
PeSCo	permanent structured cooperation
RAD	Reglamento de Aeronavegabilidad de la Defensa
SARP	Standards and Recommended Practices
SMS	Safety Management System
STANAG	Standardisation Agreement
TAA	Technical Airworthiness Authority
UK	United Kingdom
US	United States (of America)
USOAP	Universal Safety Oversight Audit Program

1.0 Background

An overview of the distinct characteristics of military aviation, relative to civil aviation, is offered as a preamble of the review of the military airworthiness management in Europe. A focused discussion on the qualification and certification activity in military aviation is provided, as both are closely connected with how airworthiness is/should be managed for military aircraft. The management of airworthiness in European military aviation has undergone significant changes over the past 15 years, with the progress made attributed to the harmonisation efforts driven by the European Defence Agency (EDA). The creation of a Military Airworthiness Authorities Forum and the development of the European Military Airworthiness Requirements (EMAR) have been instrumental in creating a more homogenous regulatory landscape. Also, the need for standardisation is explained briefly, from the point of view of the national interests of the European countries, especially those who have major activity in complex industrial programs. The examples of five main players of the European aerospace sector, namely France, Italy, Germany, Spain and the United Kingdom, are examined from the point of view of adoption and implementation of an EMARs-based system. Overall, this review paper offers a critical appraisal of the military airworthiness systems in these European countries, in relation to the EMAR adoption.

1.1 Civil versus military aviation

The purpose of both civil and military aviation is to deliver a defined service (for the owner, companies, governments, etc.) using resources in a cost-effective way. From this perspective, safety, and therefore airworthiness, is a key enabler for the effectiveness of the entire process. Accidents in civil aviation can cause enormous economic losses (compensation to families of fatalities, insurance costs,

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Table 1. *Comparison of primary characteristics of civil and military aviation*

	Civil aviation	Military aviation
Scope	Business (revenue creation)	National interests (management of allocated budget by the government)
Business model	Relies upon commercial financial investment and (investors and/or customers expect return of investment)	Funded by the government (tax-payers expect efficient management of budget)
Type of operations	Transport passengers and/or cargo from one site to another for business or tourism purposes (commercial aviation)	Perform assigned operational missions (search and rescue, air defence, reconnaissance, etc.),which include transportation of personnel, material or weapons to a specific theatre of operation or target
Operator	Owner (air operators, companies, etc.)	Operated on behalf of government
Fleet type and size	Fleets are homogenous in type of aircraft. The number of aircraft built is very large (thousands of aircraft for every type)	National fleets are relatively small and diverse in types of aircraft. The different aircraft types are usually built in few hundred pieces
Operating environment	Activities are normally conducted worldwide without significant differences	Operations are normally bounded within countries or specific operational theatres. Different rules could be applied during peace or wartime
Acceptable level of safety	Always the same	Could be decreased during specific missions (for example in wartime)

reputation, etc.), while in the military aviation they lead to mission failure, collateral effects and significant economic loss (on the latter aspect it has to be considered the value of the single asset loss in relation to the fleet size). Moreover, for a civil aircraft the mission (apart from few exceptions) is identified with the flight itself (from one point to another carrying passengers or cargo), while for military assets it is the successful completion of the assigned tasks [1]. In Table 1 a high-level comparison of the primary characteristics of civil and military aviation is provided. The difference between what is considered or expected as acceptable level of safety in civil and military aviation is of note (in relation to the focus of this paper, which is airworthiness). During military activities, for particular operational needs, the airworthiness risks (generated for example by aircraft limitations or by maintenance not executed) could be accepted by the crew/operator while, in the civil environment, a non-airworthy aircraft will never be intentionally operated.

1.2 Qualification and certification in military aviation

An important difference between a civil and a military aircraft is represented by the purpose of the military aircraft, which is stipulated by the concept of operations (CONOPS) [2]. Under a defined CONOPS, the aircraft needs to satisfy specific operational, mission and performance requirements (military capabilities), which can be as important as airworthiness. The main objective for a civil airworthiness body is to ensure the safe flight of an aircraft while a military airworthiness body is responsible both for the safe

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and successful mission accomplishment. Thus, the management of airworthiness in military aviation can be similar, yet with distinct differences from how this is conducted in civil aviation.

The required military capabilities are related to a large number of operational environments (sometimes hostile or extremely hazardous) and mission profiles/roles (for example close air support, air-to-air refuelling, search and rescue, medical evacuation, offensive counter-air, suppression of enemy air defence, aerial delivery of paratroopers and loads, etc.). On the other hand, for civil aircraft the array of capabilities is limited and essentially the same for transport aircraft (which constitute the vast majority of fleets in commercial civil aviation). The military aircraft performance and operational requirements include some unique elements such as:

- Specific missions, tasks and capabilities, with differing risk and acceptable levels of safety during peace and wartime
- Various operational environments (different hazards, etc.)
- Aircraft handling qualities
- Weapons, ammunition stores and self-defence systems

Military aviation utilises the concept that the initial acceptable levels of safety may decrease during specific mission profiles [3, 4]. This triggers, as a side effect, a variation in the management of continuing airworthiness (i.e. maintenance activities), through, for example, the aircraft battle damage repair (ABDR) techniques or contingency maintenance (where in combat or under particular operational conditions, maintenance requirements can be relaxed or even waived).

Typically, military aircraft characteristics are designed, developed and demonstrated through qualification, which is the process used to verify and declare conformance with each operational requirement at all levels (usually specified in the procurement contract) [5–7]. In other words, qualification is the demonstration that the product is fit for purpose. In the qualification process the entire aircraft is assessed holistically, considering the design characteristics and operational use of all systems (structure, propulsion, flight controls, electrical system, hydraulics, armament, etc.). On the other hand, certification is the process employed to verify the airworthiness of a product. Qualification and certification shall be understood as mutually entwined processes overlapped in time. It is the aircraft specification that binds certification and qualification together. Those requirements that require demonstration of a minimum level of safety can be considered as certification, i.e. it shall be possible to perform the role of air-to-air refuelling tanker. Those requirements that require demonstration of the aircraft's performance may be considered as qualification, i.e. in the air-to-air refuelling tanker role fuel is to be delivered at a rate of at least 100 litres per minute. It is often cost-effective to conduct the qualification and certification process in parallel [8], ensuring also that way that the qualification characteristics will not affect the fitness for flight, namely airworthiness. The qualification activities shall result in the necessary evidence to allow judgement regarding the fulfilment of both types of requirements (military capabilities/performance and airworthiness). This, combined, process results in the production and acceptance of the Declaration of Design and Performance or a Certificate of Design, which could be considered equivalent to the Type Certificate [5]. Table 2 offers some examples which illustrate the relation between qualification and certification in military aircraft systems.

It can be argued that qualification is still applicable to the civil environment; this is true for a limited number of cases (for example aircraft used for certain types of aerial work). However, this would be inconsiderable if compared to the military mission profiles or to the number of flight hours accrued by these services in relation to the total amount of the entire commercial air transport activity.

1.3 The need to regulate military airworthiness regulation in Europe

As discussed, there are some common aspects between the civil and military aviation; establishing a certain level of collaboration is therefore possible. Over the past years military aviation regulation globally has moved closer to the principles (and structure) of civil regulation [5, 9–11]. This trend can

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Table 2. *Examples of qualification and certification processes of operational capabilities for military aircraft*

Operational capability	Qualification and certification aspects
Air-to-air refuelling capability	The qualification process of the air-to-air refuelling capability shall include the certification element since this type of operation needs to be performed without exposing the aircraft to unacceptable hazards (to consider only the distance between the two aircraft). Therefore, it is not just a matter of compatibility of 'probe-and-drogue', but the airworthiness characteristics of the specific systems shall be evaluated.
Weapon accuracy	The development and improvement of precision bombing (weapon accuracy) is mainly a qualification process since it depends on the bomb type, sensor fusion, aiming sensors, etc. However, the release of the bomb/external load shall ensure safe separation from the aircraft, thus the certification element must be considered as well.
Zonal hazard analysis for weapon systems	In military aircraft the zonal hazard analyses (part of certification) shall consider the weapons carried (which is purely an operational aspect). For example, the effects of a torching flame event caused by engine damages could vary in relation of the proximity of bombs or missiles and therefore the consequences could be very different.

be attributed to the actual (or perceived) benefits which may be gained from a civil-based approach, both in terms of safety performance, standardisation and harmonisation. For example, UK's Defence Standard 00-970 'Design and Airworthiness Requirements for Service Aircraft' Part 5 'Large Type Aeroplanes' has adopted many of the EASA Certification Specifications (CS) 25 [12] requirements and Acceptable Means of Compliance [13]. Defence Standard 00-970 is a continuing evolving regulatory code whose origin can be traced back to the 'Handbook of Strength Calculations' introduced in 1916 [13]. A military – civil alignment is particularly important in multinational programmes, where different stakeholders, from various countries, have to work on the development, certification and production of aircraft/aeronautical products. Streamlining the process and saving time and resources can be achieved via standardisation/harmonisation of the regulatory requirements. Multinational programmes are characterised by being self-contained, i.e. ad-hoc working frameworks and agreements have to be set up between the different countries (governments) and the companies (industry). This requires a substantial investment in time, while any changes (eventually happening over the span of these multiyear projects) are creating an additional burden.

Examples from Europe include the Eurofighter programme [14–17] (a large-scale industrial project), the Airbus A400M programme under the Organisation for Joint Armament Co-operation (Organisation Conjointe de Coopération en matière d'Armement, OCCAR) [18–21] and the arrangement between the European Aviation Safety Agency (EASA) and the EDA on 'Civil-Military Cooperation in Aviation Safety' [22]. Also, in the United States (US), the Federal Aviation Administration (FAA) and the US Department of Defense have reached a collaboration agreement that allowed the creation of the FAA Military Certification Office [23, 24]. This was actioned through the FAA Order 8110.101 'Type Certification Procedures for Military Commercial Derivative Aircraft' [25] and complemented by the Advisory Circular 20-169 'Guidance for Certification of Military and Special Mission Modifications and Equipment for Commercial Derivative Aircraft' [26].

Nevertheless, it has to be recognised that the certification and, particularly, the qualification processes require access to information and data that could be classified, i.e. that cannot be disclosed. Therefore, special security clearances are typically requested in that case. This could impede or deter civil certification, making collaboration arrangements necessary for the completion of a civil-military project. In the case of the Airbus A400M certification by EASA, the type of aircraft (no weapons installed) did not

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raise the issue of security clearances and the few cases were be managed through ad-hoc actions but, if it had been a fighter aircraft, then the situation would be completely different. Nevertheless, certification also included consideration of additional military flight phases (aerial delivery, air-to-air refuelling) for safety assessments and structural load cases.

This paper reviews and discusses the harmonisation approach and progress made within Europe in the field of military airworthiness. It also attempts to map and critically comment on the main aspects of the military airworthiness frameworks established and currently operating in five European countries which have substantial activity in industrial projects, namely, France, Italy, Germany, Spain and the United Kingdom (UK).

2.0 Military airworthiness standardisation and harmonisation in Europe

In this section, the EDA military airworthiness harmonisation project is discussed, in conjunction with an overview of the management structures for military airworthiness in France, Italy, Germany, Spain and the UK.

2.1 The EDA military airworthiness harmonisation programme

From their experience running multinational programmes (TIGER helicopter, EF2000 fighter, etc.), European Union (EU) member states recognised that there were issues affecting the management of military airworthiness that had negative impact on the allocated budgets. Therefore, in 2008 the European National Armaments Steering Board tasked EDA to create a suitable forum for the Military Airworthiness Authorities (MAWA) [27] in order to address problems and/or avail of opportunities such as:

- The lack of a common EU-wide approach to military airworthiness
- The duplication of efforts and activities in the multinational programmes (especially in the field of military airworthiness)
- The implementation of the EU Regulation 216/2008 (Ref. [28]), amended by the EU Regulation 2018/1139 [29], applicable to civil aviation, which required EU member states to ensure that military aircraft operation does not affect or decrease the safety of civil aviation and consequently the aircraft shall, at least, meet the same airworthiness characteristics
- The enhancement of overall military aviation safety
- The potential savings in terms of resources (time, funding, effort, etc.) from the application of common airworthiness management in multinational programmes
- The benefits from a commonly shared military airworthiness approach and focal point enabling military and civil cooperation
- The benefits for having a consistent and unique approach to airworthiness for industry

In order to accomplish these targets, it was decided to develop a common set of harmonised EMARs and related Acceptable Means of Compliance (AMC) and Guidance Material (GM) that could be used by the EU member states to create a common and standardised baseline. EDA also established that EMARs should be based on EU Regulation 216/2008 (Ref. [28]) taking, however, into account specific military aspects. This is described in the Basic Framework Document (BFD) [30], covering:

- The role and functions of MAWA Forum
- The commitments of the national military aviation authorities (NMAAs) and other stakeholders
- The essential airworthiness requirements applicable to military aircraft and organisations covering all aspects of airworthiness
- The creation of a European Military Joint Airworthiness Organisation (EMJAO).

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It is of note that the BFD is not equivalent to the EASA Basic Regulation (EU Regulation 2018/1139 [29]). The EMARs and the MAWA-approved associated documents are requirements/guidelines and do not represent regulations. Therefore, the MAWA Forum has no authority on the airworthiness management of the EU member states. The decision on the implementation of the EMARs/MAWA Forum document remains a choice of the EU member state. Each state could opt for a full or a partial adoption or retain their own airworthiness management structure, demonstrating full or partial compliance with the EMARs/MAWA documents.

The EMAR documents follow the taxonomy of the EASA regulatory structure, as following [31]:

- EMAR 21 'Certification of Military Aircraft and related Products, Parts and Appliances, and Design and Production Organisations', covering the initial airworthiness of military aircraft
- European Military Airworthiness Certification Criteria (EMACC), providing harmonised criteria for the certification of military aircraft
- EMAR M 'Continuing Airworthiness Requirements', describing the requirements for ensuring the preservation of airworthiness, i.e. the requisites of organisations, materiel and personnel involved in the continuing airworthiness management
- EMAR 'Continuing Airworthiness Management Organisation (CAMO)', defining the requisites of organisations and personnel involved in the continuing airworthiness management
- EMAR 145 'Requirements for Maintenance Organisations', establishing the requirements to be met by an organisation qualifying for the issuance or continuation of an approval for the maintenance of aircraft and components
- EMAR 66 'Military Aircraft Maintenance Licensing', stipulating the training requirements for aircraft maintenance personnel
- EMAR 147 'Aircraft Maintenance Training Organisations', covering the requirements to be met by organisations seeking approval to conduct aircraft maintenance training and examinations

In addition to the EMARs a set of explanatory documents explanatory documents was also developed:

- EMAD 1 'Definitions and Acronyms Document'
- EMAD R 'Recognition', describing the process employed for mutual recognition between two or more NMAAs, leading to the acceptance of the airworthiness activities carried out by the other NMAA

2.2 France

The French military airworthiness system has been originally controlled by the Directorate General of Armaments (DGA) (Direction Générale de l'Armement) [32] and the services/other state operators Operators/Armed Forces (Air Force, Army, Navy, DGA Flight Testing, Gendarmerie, Civil Security and Customs). The DGA was mainly responsible for the initial airworthiness and procurement, while the continuing airworthiness management was under the responsibility of each service/state operator. The French Decree No 2006-1551 [33], amended by the French Decree No 2013-367 [34], expanded the airworthiness principles of the International Civil Aviation Organisation (ICAO) to military aircraft.

Following a study of the 'Mission for Aviation In-Service Support Modernisation' (Mission de modernisation du MCO aéronautique, MMAé), in 2008 [35] it was decided to establish an additional agency; the Directorate of State Aviation Safety (Direction de la Sécurité Aéronautique d'État, DSAE). This decision was reached due to the downsides of the previous system, for example dispersions and duplication of responsibilities between the DGA and the operators, and the need for coherence with the civil aviation structure. After a period of provisional operation, DSAE was formally instituted in 2013 with the French Decree No 2013-367 [34]. DSAE is the French NMAA and is responsible for:

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- Aircraft airworthiness
- Air traffic, airspace and airport management
- Aircrew training and aircraft operating rules

It is noted that DSAE is not a pure airworthiness authority since it is also responsibility over operational matters (air traffic management, aircrew, etc.). In particular, in the field of airworthiness, DSAE is responsible for the regulation and oversight of continuing airworthiness, while DGA remained competent for initial certification programme management and armaments procurement. Subsequently, two ministerial orders (in 2013) defined the duties of DSAE, DGA and of the aviation operating authorities (services/state operators) in relation to the use, airworthiness and registration of military aircraft and state-owned aircraft. The French regulation structure (FRA) is tailored to the EASA/EMAR systems, summarised as following:

- Initial airworthiness [36]:
  - FRA 21J/EMAR 21J(FR) 'Design'
  - FRA 21G/EMAR 21G(FR) 'Production'
- Continuing airworthiness [37]:
  - FRA M/EMAR(FR) M 'Continuing Airworthiness Management'
  - FRA 145/EMAR(FR) 145 'Approved Maintenance Organisations'
  - FRA 147/EMAR(FR) 147 'Approed Maintenance Training Organisations'
  - FRA 66/EMAR(FR) 66 'Aircraft Maintenane Licencing'

Accident and incident investigation activities are under the responsibility of the Defence Accident Investigation Office (Bureau Enquêtes Accident Défense–air, BEAD-air) [38], which is an independent organisation under the Ministry of Defence. At the end of the investigation process, the BEAD-air produces safety recommendations for the agencies and for the services/state operators.

2.3 Germany

In accordance with the German Air Navigation Act (Luftverkehrsgesetz, LuftVG) [39], the Federal Ministry of Defence (Bundeswehr) is the competent authority for the regulation of military aviation [40]. In the last decade, the Federal Ministry of Defence was involved in a re-organisation of the military airworthiness system and this process led to establishing (in 2014) the German Military Aviation Authority (MAA) (Luftfahrtamt der Bundeswehr) [41]. The rationale behind the established of a single NMAA in Germany was to concentrate all responsibilities in one body, namely for initial and continuing airworthiness. In the past, in accordance with the Bundeswehr Joint Service Regulation ZDv A-1525, the Bundeswehr Technical and Airworthiness Centre for Aircraft was the competent organisation for the initial airworthiness certification process [42], while the services were in charge for the continuing airworthiness issues. Certain activities, mainly related to industry certification, were under the responsibility of the Federal Office of Defence Technology & Procurement and Bundeswehr Quality Assurance Authority. In the previous structure there was a split of responsibilities, and this was the source of delays, hindering, in turn, international armaments' projects.

The German MAA is independent from the Federal Office of Procurement and from the services, with the administrative control exercised by the chief of defence force. Also, it acts as a military authority directly subordinated to the Federal Ministry of Defence. The MAA is responsible for:

- Future-oriented preparation and further development of regulations for military aviation
- Certification of th German defence force aircraft and aeronautical systems, including supplementary equipment
- Regulation and standardisation of military flight operations in Germany

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- Certification and recognition of agencies, authorities and institutions
- Licensing of flying, technical and aeromedical personnel
- Prevention of incidents and accidents involving military aircraft

The German MAA has fully transferred and translated the EMAR structure into the national law creating the DEMARs (German Military Airworthiness Requirements), with the following structure [40]:

- DEMAR 21 'Certification of Military Aircraft and Related Products, Parts and Appliances, and Design and Production Organisations'
- DEMAR M 'Continuing Airworthiness Requirements'
- DEMAR 145 'Requirements for Maintenance Organisations"
- DEMAR 66 'Military Aircraft Maintenance Licensing'
- DEMAR 147 'Aircraft Maintenance Training Organisations'

2.4 Italy

In accordance with the Italian law, the Presidential Decree No 270 [43], ratified by the Minister of Defence Decree 22 June 2011 [44], the Directorate of Air Armaments and Airworthiness (DAAA) (Direzione degli Armamenti Aeronautici e per l'Aeronavigabilità) is responsible for issuing technical regulation/directives for military aircraft airworthiness and related management, thus it operates as the NMAA for Italy. It is placed under the Secretary General of Defence/National Armament Director, which is part of the Italian Ministry of Defence responsible for armament policy, administrative co-ordination, armament procurement and relations with industries and international organisation.

The current Italian military airworthiness regulations is based on the following structure [45]:

- Initial airworthiness:
  - AER(EP).P-2 'Military Aircraft Type Certification and Qualification; Suitability for Installation'
  - AER(EP).P-6 'Instructions for the Preparation of Technical Specifications/Certification Plans'
  - AER(EP).P-7 'Regulation for Recording and Maintaining the Military Aircraft Register'
  - AER(EP).P-10 'Design Organisation Military Approval'
  - AER(EP).P-11 'Mutual Recognition between Military Airworthiness Authorities for Delegation of Airworthiness Privileges'
  - AER(EP).P-16 'Procedure for Military Type Certification'
  - AER(EP).P-21 'Certification of Military Aircraft and related Products, Parts and Appliances, and Design and Production Organisations'
  - AER(EP).P-516 'Airworthiness Certification Criteria'
  - AER(EP).0-0-2 'DAAA Technical Publications System'
  - AER.0-0-8 'Technical Publications Amendment Process'
  - AER(EP).00-01-6 'Reporting and Management of Occurrences and Technical Warnings'
  - AER(EP).00-00-5 'Configuration Management and Airworthiness Directives'
- Continuing airworthiness:
  - AER(EP).P-2005 'Aircraft Continuing Airworthiness Management'
  - AER(EP).P-145 'Requirements for Maintenance Organisations'
  - AER(EP).P-147 'Aircraft Maintenance Training Organisations Approval'
  - AER(EP).P-2147 'Approval of Organisations providing Training Services for Military Aircraft and/or its Components Maintenance Personnel'
  - AER(EP).P-66 'Military Aircraft Maintenance Licensing'

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The implementation of the EMARs into the national system is an ongoing process that involves the incorporation of the entire document, for example AER(EP).P-21 and AER(EP).P-145, or the harmonisation and transposition of the EMAR requirement into the national structure. The DAAA framework allows running qualification and certification as two separate flows. However, if the two processes are conducted in parallel (i.e. synchronised), then it is possible to obtain a simultaneous recognition of the results; this procedure is called 'homologation'. The accident and incident investigation activities are under the responsibility of every single service within the Italian defence force. However, in case of accidents, representatives of the DAAA are entitled to take part to the investigation board.

2.5 Spain

The Spanish Royal Decree 2218/2004 [46] approved the Regulation of Airworthiness of Defence (RAD) (Reglamento de Aeronavegabilidad de la Defensa). It also established that the Defence Airworthiness Authority (Autoridad de Aeronavegabilidad de la Defensa, AAD) [47] is the General Director of Armament and Material (Direccion General de Armamento y Material, DiGAM) [48], assisted by the Airworthiness Board (Consejo de Aeronavegabilidad), ratified by the Royal Decree 866/2015 [49]. The RAD also assigns the Airworthiness Board with the responsibility to support the work of DiGAM in relation to military and civil organisations and international airworthiness agencies, towards proposing and implementing international standards and practices that are of interest to the defence. It is noted that the synthesis of the Airworthiness Board includes representatives from DiGAM, the National Institute of Aerospace (Instituto Nacional de Tecnica Aeroespecial, INTA) [50] and the defence forces, as well as other technical bodies. Therefore, a variety of key stakeholders are members of the Airworthiness Board.

DiGAM and the Airworthiness Board are responsible for the initial and continuing airworthiness functions. In these duties, they are assisted by the INTA test centres which offer certification services for materials, components, systems related to aerospace equipment and weapons. DiGAM issues requirements and procedures related to continuing airworthiness, to be observed by each service/operator in the management of their fleets.

Apart from the Royal Decree 866/2015 [49], regulations are complemented by the following documents [47]:

- DiGAM resolution 320/14251/12, establishing the Spanish Military Airworthiness Requirements Publications (Publicaciones Españolas de Requisitos de Aeronavegabilidad Militar, PERAM) as airworthiness requirements
- DIGAM Resolution 320/14294/2013, defining airworthiness essential requirements
- Airworthiness Board procedures
- Internal procedures of the services/operators

In particular, the PERAMs are the translated versions, into Spanish, of the EMARs. The structure of the PERAMs is the following [47]:

- PERAM 21 'Certification of Military Aircraft and Products, Components and equipment and Design and Production Organisations' (Certificación de aeronaves militares y productos, componentes y equipos relacionados y de organizaciones de diseño y de producción)
- PERAM M 'Requirements for the continuation of airworthiness' (Requisitos para el mantenimiento de la aeronavigabilidad)
- PERAM 145 'Requirements for Maintenance Organisations' (Requisitos para las organizaciones de mantenimiento)
- PERAM 147 'Requirements for Maintenance Training Organisations' (Requisitos para las organizaciones de formación de mantenimiento)

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- PERAM 66 'Requirements for the Emission of Maintenance Licences' (Requisitos para la emisión de licencias de mantenimiento)

Due to entry into service of new air systems and the participation to future programmes, the Spanish ministry of defence is redefining the current model. This "refresh" will include full implementation of the EMARs, refined competencies, and scope of the AAD, and revised functions of the Airworthiness Support Division [47].

2.6 United Kingdom

The UK MAA was established, via a Charter of the British Secretary of State for Defence, on the 1st of April 2010 [51] in response to the Haddon-Cave report in 2009 on the RAF Nimrod XV230 accident [52]. The Haddon-Cave report provided independent analysis of this accident, identifying systemic deficiencies related to the design and certification of a series of modifications and was instrumental in the revamp of the military airworthiness regulation system. The MAA incorporated the former Directorate of Aviation Regulation and Safety and became the single independent regulatory body within the British Ministry of Defence for all aviation activity. As the NMAA it covers all aspects of the aviation system, and it is responsible for:

- Providing a regulatory framework
- Performing the certification, approval and inspection processes for the acquisition, operation and airworthiness
- Providing assurance that the appropriate level of safety is maintained
- Performing the investigations of aircraft occurrences

With reference to the regulatory structure, the MAA has developed and issued (on behalf of the Secretary of State), the MAA Regulatory Publications (MRP) [53]; the system is based on three documentation levels, the Overarching Documents, Regulatory Articles and MAA Manuals. The UK regulatory system differs from the other national systems examined (France, Germany, Italy and Spain) in that it does not reflect a direct adoption of the EMARs/EASA structure. In particular, with regards to initial airworthiness, certification is governed by the Military Air System Certification Process (MACP) [54], which is based on EASA process after an adaptation to account for the specific military usage of the aircraft/aeronautical products. The application of MACP results into the issuance of a Military Type Certificate (MTC) to the Type Airworthiness Authorities (TAA). The issuance of a MTC demonstrates that the military air system Type Design meets the applicable airworthiness requirements after the satisfactory completion of the MACP. The TAA is within the UK Ministry of Defence the MTC holder.

In relation to continuing airworthiness, it is noted that according to GEN1000 Series Regulatory Articles RA1015 [55]: "Personnel appointed to principal Type Airworthiness management positions shall be responsible for the Type Airworthiness of an Air System throughout its life from development to disposal." Moreover, GEN1000 Series Regulatory Articles RA 1016 requires that : "Delivery Duty Holders and Accountable Managers (Military Flying) shall ensure that the tasks associated with continuing airworthiness of the military registered Air Systems in their Area of Responsibility are managed by an approved Military Continuing Airworthiness Management Organisation (CAMO)". The intent is to ensure the correct management of the Type Design (thus continued airworthiness) through-life and that military registered air systems are operated safely under an approved Military CAMO responsible for managing the continuing airworthiness tasks.

Moreover, it is highlighted that the initial and continuing airworthiness management is not performed only within the MAA, but also involves each Air System Delivery Team, under the delegation of authority issued by the MAA, which are based in the Defence Equipment and Support (DE&S) organisation. DE&S is responsible for the procurement of the various weapon systems. In particular, GEN1000 Series

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Regulatory Articles RA 1013 [56] stipulates that the DE&S Air Systems Operating Centre Directors "shall ensure that the Air Systems provided are airworthy and safe to operate through-life". Thus, in the UK airworthiness system, the complete management of initial and continuing airworthiness is spread among the MAA and the DE&S.

With respect to the adoption of EMARs, the MAA had opted to implement the EMAR 21, M and 145, as these were considered to offer benefits in terms of safety improvements and reduced risks. However, based on an assessment performed in 2015 and reconfirmed in 2019, it has opted not to adopt EMAR 66 and 147, since similar benefits were not anticipated, nor foreseen.

2.7 Summary

The findings from the reviewed of the five countries, namely the four EU states and the UK, are summarised in Table 3. It is noted that most countries operate a single MAA, with the exception of France (DSAE-DGA). Also, Spain employs an Airworthiness Board for initial airworthiness matters, with a wide participation of stakeholders from the defence organisation and beyond. The adoption of EMARs has progressed substantially throughout the reviewed countries, however the regulatory structure presents differences. Moreover, the UK has elected not to adopt the maintenance licencing and training requirements (EMAR 66 and 147). On a different note, the distinction between technical and operational airworthiness, found in earlier versions of military airworthiness authorities, appears to have an effect on the transition to MAAs covering holistically airworthiness. For example, the German MAA and DSAE do cover aircrew licensing and training-licensing correspondingly, which is not the case for other countries.

3.0 Discussion

The following sections discuss in detail the current activity in Europe on military airworthiness harmonisation, as driven by EDA, and the current situation on military airworthiness management in the reviewed EU states and in the UK.

3.1 European military airworthiness harmonisation activity

The activity carried out by EDA under the MAWA initiative covers the certification processes, nevertheless qualification has remained outside of the scope of the EMARs. Also, safety regulations in relation to air traffic management services, airports and ground handling, aircrew licensing, etc. are not covered. The EDA framework for managing airworthiness may be satisfactory as starting point but its scope should be expanded if the objective would be to cover aviation safety more holistically, to encompass all aspects of the military aviation system. For example, qualification standards should be defined within aviation safety regulations, since for most military aircraft/aeronautical products the certification and qualification activities are rarely performed in isolation. To this end, it is of note that the US Military Standards (MIL-STD) and the North Atlantic Treaty Organisation (NATO) Standardisation Agreements (STANAG) are existing attempts to standardise military equipment and are referred to in aircraft technical specifications.

Currently the implementation of the EMARs by the EU member states, both in principle and each as a set of requirements/regulations, is a self-certified activity. Audits from other states are performed to verify their effective application only as part of mutual recognition initiatives.

Experience from international regulatory harmonisation efforts in civil aviation has also shown that a common set of requirements or even regulations does not automatically guarantee a consistent implementation. This is due to the discretion provided to the states, as, in the case of the EMARs, each NMAA has the ultimate responsibility for regulating military airworthiness in the way they consider best for the interest of their state. In such cases, the desired harmonisation objectives can only be met

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Table 3. *Summary of findings from the reviewed countries*

		Responsibilities of MAA				
Country	MAA	Initial airworthiness	Continuing airworthiness	Air traffic, airspace & airport management	Aircrew training & aircraft operating rules	EMARs' adoption
France	DSAE DGA		Yes	Yes	Yes	 FRA 21, M, 145, 147, 66
		Yes				
Germany	German MAA (Luftfahrtamt der Bundeswehr)	Yes	Yes		Yes* *Licensing of flying personnel	DEMAR 21, M, 145, 66, 147
Italy	DAAA	Yes	Yes			AER(EP).P 145, 147, 66 Different regulations for initial airworthiness EMAR (21) and EMAR M
Spain	AAD (DiGAM)* *assisted by Consejo de Aeronavegabilidad (Airworthiness Board)	Yes	Yes			PERAM 21, M, 145, 147, 66
UK	MAA* *management of initial and continuing airworthiness delegated to Air System Delivery Team of DE&S	Yes	Yes			EMAR 21, M, 145 *has not adopted EMAR 66, 147

by centralising the management and decision-making process. This would require the establishment of a single European military airworthiness authority, which would inflict on the sovereignty of the EU member states. The military equivalent of EASA would have limited enforcement powers though and that would negate its purpose. An alternative would be the creation of an EU, or even an international, organisation similar to the predecessor of EASA, that of the Joint Aviation Authorities (JAA). This 'military JAA' should, however, be equipped with additional privileges and entitlements, such as the power to conduct audits and to issue safety recommendations. In that content, if the MAWA Forum would be the 'military JAA' it would need to establish an oversight system performing initial and regular inspections/audits to the EU member states that have declared compliance with the EMARs. This auditing system would be the equivalent to that employed in the NATO Recognition Process. This would ensure a common and standardised airworthiness system across the EU and any other countries that would willing to adopt that. A different option would be for EDA to employ a role similar to that of ICAO when it comes to auditing state aviation programmes. ICAO's Universal Safety Oversight Audit Programme (USOAP) Continuous Monitoring Approach (CMA) is used to assess the effective implementation of the ICAO Standards and Recommended Practices (SARP) and other associated documents, by the Member States. This type of approach could be replicated in military aviation. As already seen with the NATO Recognition Process this is achievable, given that EU member states already have effective interaction with each other through other schemes. The EU Permanent Structured Cooperation (PeSCo) is one such example, providing 'an effective binding legal framework to pioneer groups of willing Member States to move forward more rapidly on cooperation in the field of EU security, defence capability development and operations' [57]. The establishment of an overarching airworthiness organisation in the EU is already a target in the EDA MAWA Forum roadmap, as the creation of the EMJAO has been reported in the Basic Framework Document (BFD). However, so far, the exact structure, functions and responsibilities of EMJAO have yet to be released, thus the intensions of EDA are not known.

The civil aviation regulatory space is continuously evolving in the space of risk management, with EASA and FAA expanding the implementation of the Safety Management System (SMS) approach across most initial and continuing airworthiness activities. Since the EMAR framework traces the civil regulatory structure (namely that of EASA), the inclusion of SMS provisions in military regulations must be considered towards increasing confidence in the effectiveness of the overall military airworthiness management system [58]. With the release of EMAR CAMO [31], EDA has made the first step in that direction, adding the requirement for SMS in CAMOs. However, EDA and the NMAAs would first have to acknowledge, endorse and tailor the SMS principles, as described, for example, in the ICAO Annex 19 'Safety Management' [59] and the ICAO Doc 9859 'Safety Management Manual' [60].

3.2 Military airworthiness in the reviewed EU States and in the UK

The EU member states examined in this paper, and the UK cover the basis of the EMARs' structure and their most important aspects (as outlined in the various documents), following in principle the MAWA Forum's guidelines. However, all have yet to adopt a standard structure for their aviation/airworthiness authorities. For example, some states have established a single authority, while others two distinct authorities, one for the management of initial airworthiness and another for continuing airworthiness. In other cases, the authority may also be supported by external organisations. Moreover, there is not a common understanding of the various responsibilities for the stakeholders engaged in airworthiness management. For example, the Type Certificate holder, which in the civil aviation environment is usually the manufacturer (awarded through the Design Organisation approval), in military aviation may also be the operator or a different government organisation. This can be considered as a duplication of efforts as the Type Certificate might be managed by two (or more) stakeholders across different operators from different member states. Differing approaches followed by NMAAs may hinder mutual recognition, as a common baseline for certification (or continuing airworthiness approval) purposes would not be straightforward to establish.

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4.0 Conclusion

This review has identified and discussed the following topics of importance in relation to the effective adoption and implementation of military airworthiness frameworks in Europe:

- The civil and military convergence in airworthiness management in Europe has progressed significantly over the past 15 years.
- The EMAR's framework, developed and actively promoted by EDA, has enabled a gradual build-up of technical knowhow within the European states who elected to engage with the adoption of this civil-based airworthiness framework.
- The establishment of a joint MAA is considered the next logical step in the overall process of harmonisation, in line with the objectives already set by EDA in relation to the creation of an EU-wide authority with greater powers.
- Main players in the aerospace sector, such as France, Germany, Italy, Spain and the UK have adopted the EMAR approach, though through a variety of regulatory constructs.
- The regulatory structure of the reviewed countries' NMAAs has revealed a diverse practice, especially in how initial and continuing airworthiness management is performed (with some countries electing to have more than authority overseeing/been responsible for the corresponding activities).
- Closer collaboration between the NMAAs can be achieved through the achieved standardisation at regulatory structure level.

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References

[1] Şenol, M.B. Evaluation and prioritization of technical and operational airworthiness factors for flight safety, *Aircraft Eng. Aerospace Technol.*, 2020. **92,** (7), pp 1049–1061.
[2] ISO/IEC/IEEE International Standard – Systems and software engineering – Life cycle processes – Requirements engineering. ISO/IEC/IEEE 29148:2018(E), 2018, pp 1–104.
[3] Knight, J.C., Strunk, E.A. and Sullivan, K.J. Towards a rigorous definition of information system survivability, in Proceedings DARPA Information Survivability Conference and Exposition, 2003.
[4] Isci, H., Simsek, S., Tekincen, O. and Suer, I. Perception and cognition under military aggravating factors, in AIAA Modeling and Simulation Technologies Conference 2010, 2010.
[5] Purton, L. and Kourousis, K. Military airworthiness management frameworks: a critical review, *Procedia Eng.*, 2014, **80**, pp 545–564.
[6] Schrage, D.P. Airworthiness integration into modern systems engineering for complex military aircraft systems, in Annual Forum Proceedings - AHS International, 2010.
[7] Jilian, G.U.O., Kangming, B.A.I. and Lintong, J.I.A. Research on airworthiness management system about military aircraft development, *Procedia Eng.*, 2011, **17**, pp 375–381.
[8] Plankl, H. Ground test facilities and integration concepts for combat air systems at airbus defence and space, *SAE Technical Papers*, 2015.
[9] Orío, J.J.F. MAWA forum. The long road for a common military airworthiness requirements in Europe, in 45th Annual International Symposium of the Society of Flight Test Engineers 2014, 2014.
[10] Hood, J., Sinha, A. and Marzocca, P. Design, development and implementation of a contemporary defence aviation safety framework for Australia, in 7th Asian/Australian Rotorcraft Forum, ARF 2018, 2019.
[11] Hood, J., Sinha, A. and Marzocca, P. A twenty-five-year retrospective analysis of Australia's previous defence aviation safety framework, in Vertical Flight Society's 76th Annual Forum and Technology Display, 2020.
[12] CS-25 Large Aeroplanes, 2023 [30/08/2023]; Available from: https://www.easa.europa.eu/en/document-library/certification-specifications/group/cs-25-large-aeroplanes.
[13] Military Aviation Authority (MAA) transformation of the design and airworthiness requirements for service aircraft (Defence Standard 00-970). 2019 [13/05/2019 30/08/2023]; Available from: https://www.gov.uk/government/news/military-aviation-authority-maa-transformation-of-the-design-and-airworthiness-requirements-for-service-aircraft defence-standard-00-970.

https://doi.org/10.1017/aer.2023.88 Published online by Cambridge University Press

[14] Herrmann, P. The EJ200-engine development and full certification for production release with eurofighter ef2000, in 35th Joint Propulsion Conference and Exhibit, 1999.
[15] Orío, J.J.F. and De Torres, C.G. EF2000 Environmental trials. the long way to all weather qualification, in 38th Annual International Symposium of the Society of Flight Test Engineers, SFTE, 2007.
[16] Matthews, R. and Al-Saadi, R. Organisational complexity of the eurofighter typhoon collaborative supply chain, *Def. Peace Econ.*, 2023, **34,** (2), pp 228–243.
[17] Heinrich, M.N. The Eurofighter Typhoon programme: economic and industrial implications of collaborative defence manufacturing, *Def. Stud.*, 2015, **15,** (4), pp 341–360.
[18] What is OCCAR? 2023 [21/04/2023]; Available from: https://www.occar.int/about-us
[19] Sparaco, P. Commentary: A400M should survive, *Aviat. Week Space Technol. (New York)*, 2009, **170**, (21).
[20] Flottau, J. A400M certification imminent, without full capability, *Aviat. Week Space Technol.*, 2013, **175**, (7), p 30.
[21] Giry, B. and Smith, A. Supporting atlas: Franco-British co-operation to service Europe's military airlifter, *Eur. Rev. Int. Stud.*, 2019, **6,** (2), pp 115–134.
[22] EASA & EDA: Civil-Military Cooperation in Aviation Safety, 2013 [21/04/2023]; Available from: https://eda.europa.eu/news-and-events/press-office/latest-press-releases/2013/06/19/easa-eda-civil-military-cooperation-in-aviation-safety
[23] Military Certification Office (MCO) Branch, 2023 [21/04/2023]; Available from: https://www.faa.gov/about/office_org/headquarters_offices/avs/offices/air/hq/compliance_airworthiness_air700/mco
[24] Berlowitz, I. Commercial Derivative Aircraft (CDA) airworthiness certification, in 47th Israel Annual Conference on Aerospace Sciences 2007, 2007.
[25] U.S. Department of Transportation, F.A.A. Order 8110.101A - Type Certification Procedures For Military Commercial Derivative Aircraft, 2015, Federal Aviation Administration, p 1–67.
[26] U.S. Department of Transportation, F.A.A. AC 20-169 - Guidance for Certification of Military and Date: 9-30-2010 AC No: 20-169 Special Mission Modifications and Equipment for Commercial Derivative Aircraft (CDA), 2010, Federal Aviation Administration, pp 1–25.
[27] Military Airworthines Authorities (MAWA) Forum, 2023 [21/04/2023]; Available from: https://eda.europa.eu/experts/airworthiness/mawa-forum
[28] Commission, E. Regulation (EC) No 216/2008 of the European Parliament and of the Council of 20 February 2008 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency, and repealing Council Directive 91/670/EEC, Regulation (EC) No 1592/2002 and Directive 2004/36/EC, 2008, Official Journal of the European Union.
[29] Commission, E. Regulation (EU) 2018/1139 of the European Parliament and of the Council of 4 July 2018 on common rules in the field of civil aviation and establishing a European Union Aviation Safety Agency, and amending Regulations (EC) No 2111/2005, (EC) No 1008/2008, (EU) No 996/2010, (EU) No 376/2014 and Directives 2014/30/EU and 2014/53/EU of the European Parliament and of the Council, and repealing Regulations (EC) No 552/2004 and (EC) No 216/2008 of the European Parliament and of the Council and Council Regulation (EEC) No 3922/9, 2018, Official Journal of the European Union.
[30] Forum, M.A.A.M., *Frequently Asked Questions (FAQs)*, European Defence Agency, 2011.
[31] Approved MAWA Documents, 2023 [21/04/2023]; Available from: https://eda.europa.eu/experts/airworthiness/mawa-documents
[32] l'armement, D.g.d. Présentation de la direction générale de l'armement, 2023 [21/04/2023]; Available from: https://www.defense.gouv.fr/dga/nous-connaitre/presentation-direction-generale-larmement
[33] Décret n°2006-1551 du 7 décembre 2006 relatif aux règles d'utilisation, de navigabilité et d'immatriculation des aéronefs militaires et des aéronefs appartenant à l'Etat et utilisés par les services de douanes, de sécurité publique et de sécurité civile, 2006, French Government.
[34] Décret n° 2013-367 du 29 avril 2013 relatif aux règles d'utilisation, de navigabilité et d'immatriculation des aéronefs militaires et des aéronefs appartenant à l'Etat et utilisés par les services de douanes, de sécurité publique et de sécurité civile, 2013, French Government.
[35] d'État, D.d.l.s.a. Historique - Sécurité aéronautique, 2023 [21/04/2023]; Available from: https://www.defense.gouv.fr/dsae/mieux-nous-connaitre/historique
[36] l'armement, D.g.d. Qu'est-ce que la navigabilité ? 2023 [21/04/2023]; Available from: https://www.defense.gouv.fr/dga/navigabilite-aeronefs/quest-ce-que-navigabilite
[37] d'État, D.d.l.s.a. Guides et procédures EMAR/FR, 2023 [21/04/2023]; Available from: https://www.defense.gouv.fr/dsae/espaces-documentaires/espace-documentaire-dirnav/guides-procedures-emarfr
[38] d'État, B.e.a.p.l.s.d.l.a. Le BEA-É, 2023 [21/04/2023]; Available from: https://www.defense.gouv.fr/bea-e/bea-e
[39] Justiz, B.f. Luftverkehrsgesetz, 2023, Bundesministerium der Justiz.
[40] Bundeswehr. Regulations and Procedures, 2023 [21/04/2023]; Available from: https://www.bundeswehr.de/en/organization/further-fmod-departments/german-military-aviation-authority/regulations-and-procedures
[41] Bundeswehr. German Military Aviation Authority, 2023 [21/04/2023]; Available from: https://www.bundeswehr.de/en/organization/further-fmod-departments/german-military-aviation-authority
[42] Authority, G.M.A. *German Military Aviation Authority - Competence and Safety for Military Aviation*, German Federal Ministry of Defence, 2020.
[43] Decreto del Presidente della Repubblica 15 dicembre 2010*, n. 270* 2010, Italian Government.
[44] Decreto 22 giugno 2011, M.o. Defence, Editor. 2011, Italian Government.

https://doi.org/10.1017/aer.2023.88 Published online by Cambridge University Press

[45] (ARMAEREO), D.a.a. *Pubblicazioni Tecniche*. 2023 21/04/2023]; Available from: https://www.difesa.it/SGD-DNA/Staff/DT/ARMAEREO/Biblioteca/Pagine/default_.aspx
[46] Real Decreto 2218/2004, de 26 de noviembre, por el que se aprueba el Reglamento de Aeronavegabilidad de la Defensa, M.d. Defensa, Editor, 2004, Government of Spain.
[47] Aeronavegabilidad, 2023 [cited 21/04/2023]; Available from: https://www.defensa.gob.es/portalservicios/servicios/industriadefensa/aeronavegabilidad/
[48] Dirección General de Armamento y Material, 2023 [21/04/2023]; Available from: https://www.defensa.gob.es/ministerio/organigrama/sedef/dgam/
[49] Real Decreto 2218/2004, de 26 de noviembre, por el que se aprueba el Reglamento de Aeronavegabilidad de la Defensa, M.d. Defensa, Editor, 2015, Government of Spain.
[50] Quiénes somos, 2023 [21/04/2023]; Available from: https://www.inta.es/INTA/es/quienes-somos/
[51] Defence, S.o.S.f. *Military Aviation Authority Charter*, United Kingdom Government, 2010.
[52] QC, C.H.-C. The Nimrod Review: an independent review into the broader issues surrounding the loss of the RAF Nimrod MR2 aircraft XV230 in Afghanistan in 2006, 2009, London.
[53] Authority, M.A. MAA regulatory publications, 2023 [21/04/2023]; Available from: https://www.gov.uk/government/collections/maa-regulatory-publications
[54] Authority, M.A. Manual of Military Air System Certification (MMAC), M.o. Defence, Editor, 2021, United Kingdom Government.
[55] Authority, M.A. Regulatory Article 1015 Type Airworthiness Management - Roles and Responsibilities, M.o. Defence, Editor, 2021, United Kingdom Government.
[56] Authority, M.A. RA 1016 Military Continuing Airworthiness Management, M.o. Defence, Editor, 2021, United Kingdom Government.
[57] Orsini, G. PeSCo - What could it mean for NMAAs? in Military Airworthiness Conference, European Defence Agency, 2018, Madrid, Spain.
[58] Chatzi, A.V. Safety management systems: an opportunity and a challenge for military aviation organizations, *Aircraft Eng. Aerospace Technol.*, 2019, **91,** (1), pp 190–196.
[59] Annex 19 to the Convention of the International Civil Aviation - Safety Managemnet, I.C.A. Organization, Editor, 2016, International Civil Aviation Organization: Montreal, Quebec, Canada.
[60] Safety Management Manual (Doc 9859). I.C.A. Organization, Editor, 2018, International Civil Aviation Organization: Montreal, Quebec, Canada.

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