MINISTRY OF DEFENCE

General Secretary for Defence and National Armaments Directorate
Air Armaments Directorate

INSTRUCTIONS FOR THE COMPILATION OF TECHNICAL SPECIFICATIONS FOR MILITARY AIRCRAFT

NOTE

This Technical Publication supersedes
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19/07/2010

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LIST OF VALID PAGES

ATTENTION: This standard is valid only if composed of the pages listed below and duly updated.
Copy of this standard can be obtained upon request via e-mail to the following e-mail address: spt@dgaa.it

The issue dates of the original and revised pages are:

Original……………….. 0………………..of 19/03/2012

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1 PART 1 - GENERAL INFORMATION

1.1 Introduction

This TP contains the instructions to follow in drafting Technical Specifications for military aircraft.

1.2 Scope

This TP has the purpose of:

- Defining the structure of a Technical Specifications File
- Specifying the type of requirements which it must contain
- Supplying the guidelines for defining the quantitative performance and airworthiness requirements.

1.3 Reference Documentation

This TP refers, as far as is applicable, to the publications listed below (latest edition in force), which should be understood as guidelines for the detailed definition of the performance and airworthiness requirements of the Technical Specifications File:

- JSSG-2001
- MIL-HDBK-516
- DEF STAN 00-970
- CS 22
- CS VLA
- CS 23 / FAR 23
- CS 25 / FAR 25
- CS 27 / FAR 27
- CS 29 / FAR 29
- STANAG 4671 - UAV Systems Airworthiness Requirements
- STANAG 4703 - LIGHT UAS Airworthiness Requirements

1.4 Applicability

The provisions of this standard can be applied to military aircraft which are:

- Subject to a specific purchase program of the DA or purchase by State Bodies
- Of interest of the DA, for which a payment contract for the requesting Company has been signed
- Of interest of other national, international and foreign Bodies

The provisions of this standard also apply to aircraft purchased by other State Bodies if they are to be registered in the Military Aircraft Register pursuant to art. 745 of the Air Navigation Code, as the content of the Technical Specification forms the basis for recognition of airworthiness and that all performance requirements have been satisfied through the Military Aircraft Type Approval process.

The State Bodies must submit the content of the Technical Specification for AAD approval via the competent Technical Division of the AAD, subject to advance evaluation of the Vice Technical Direction Office 1.
The need for advance approval of the content of the Technical Specifications managed by other State Bodies by the AAD also extends to the case of all major systems and configuration items subject to Type Approval in order to guarantee airworthiness of the Military Aircraft on which they are to be fitted.
As regards international programs, this standard shall remain valid for application according to the program agreements.

NOTE

For Unmanned Aerial Vehicles (UAVs), this standard shall apply to all segments making up the system, and not just to the air-vehicle.

1.5 Validity

This TP supersedes AER(EP).P-6 of 05/03/2009 Revision 1 of 19/07/2010, and enters into force from the date of its approval.

1.6 Definitions

All abbreviations, vocabulary, and expressions present in TP AER.Q-2010 are valid for the purposes of this standard.

2 PART 2 - GENERAL REQUIREMENTS

2.1 Preparation and Identification

2.1.1 Preparation of the Technical Specification and Airworthiness Basis

The competent Technical Divisions shall issue a Request for Offer on the basis of the Operating Requirements of the AFs.
The Companies shall respond to the Technical Divisions with an Offer, which shall propose technical requirements composed of two documents:
- A Technical Specification putting forward the performance-oriented description of the aircraft subject of the Offer (prepared in accordance with section 3.1 of this standard)
- An Airworthiness Basis which puts forward the collection of airworthiness requirements for the aircraft subject of the Offer (prepared in accordance with section 3.2 of this standard)

The technical Specification and Airworthiness Basis must be prepared and presented in complete format, even for derived aircraft, by the System Responsible Company (supplier) according to the requirements of this TP.

2.1.2 Preparation of the Technical Specification

The competent Technical Divisions shall verify the Technical Specification and Airworthiness Basis supplied during the offer stage; specifically:

- They shall evaluate the compatibility of the performance proposed in the Technical Specification with the Operating Requirements of the AFs
- They shall evaluate the proposed Airworthiness Basis, together with the Vice Technical Direction - Office 1
- They shall agree any modifications required to the performance and airworthiness requirements with the System Responsible Company

Having reached agreement on the performance and airworthiness requirements, the Technical Specifications Files, based on the Technical Specification and Airworthiness Basis, shall be prepared by the Technical Divisions with coordination of the Vice Technical Direction Office 1, and shall become such after approval of the Division Head overseeing the activities of the Technical Division.

2.1.3 Aircraft Identification

The competent Technical Divisions shall use a distinct designation for each type of aircraft in the form of a distinct alphanumeric code assigned in agreement with Standard AER(EP).0-0-12A.

In the case of aircraft derived from previous types, following non-substantial modifications, the old designation may be retained with the addition of an appropriate suffix.

On the contrary, a new designation must be assigned to each aircraft design which substantially differs from the design from which it is derived.

2.1.4 Technical Specifications File Numbering

Each Technical Specifications File is identified with a serial number, marked, and the original kept by the Technical Division which compiled it.

An electronic copy of the same must also be transmitted to the Vice Technical Direction Office 1.

Upon signing of the contract, the original Technical Specifications File shall be kept together with the contract by the competent Technical Division.

2.2 Variations to a Technical Specifications File

Whenever, during realization of the object of a Technical Specifications File (original copy with revenue stamp), modifications are implemented which require variations to the file itself, these must lead to specific “Variants” each time.

These updates must be compiled according to the facsimile given below and supplied in the same format and quantity as the Technical Specifications File:

TECHNICAL SPECIFICATIONS FILE No. ……………
VARIANT No. ………….

- Subject of Technical Specifications File ……………………………………….
- Modification Authorization: Body …..sheet no. … of ………
- Modification introduced: (brief description of the modification).
- Variants at section ……. page ……. of the Technical Specifications File

(Give the exact correction to the Technical Specifications File, preceded by one of the following captions:

a) Addition
b) Deletion
c) Change from…………. to ………….)

2.3 Format

The Technical Specifications File must be prepared according to the instructions in this section.

2.3.1 Format

Unless otherwise specified, the Files must be presented in the format indicated by this TP and on UNI A4 210x297 mm format pages.
These must have a margin of 3 cm on the left side of each page.
The revenue stamped copies shall have the format required for fulfillment of the stamp duty.

2.3.2 Cover

The cover must indicate the name of the type of aircraft, the number of the Technical Specifications File, the date, and the name of the System Responsible Company.

2.3.3 Cover

This must precede each of the three parts making up the Technical Specifications File (see section 3) and must list the numbers, titles, and the page of the various sections and subsections.

2.3.4 Presentation of Contents

This must be presented according to the indications given in section 3.

2.4 Language

The Technical Specifications File may be written in Italian or in English or in both languages, according to the AAD requirements.

3 PART 3 - STRUCTURE OF THE TECHNICAL SPECIFICATIONS FILE

Following agreement of the technical content presented by the System Responsible Company during the offer phase (Technical Specification and Airworthiness Basis proposed by the Company), the Technical Specifications File must be prepared by the Technical Division, in three parts:

- PART I – Technical Specification
- PART II – Airworthiness Basis
- PART III – Various requirements

3.1 PART I – Technical Specification

PART I (Technical Specification) is the collection of aircraft performance requirements, deriving from the operational requirements requested by the AFs.

It provides the performance-oriented description which the aircraft to be supplied must guarantee.

PART I of the Technical Specifications File is prepared in accordance with the guidelines supplied by JSSG-2001, which can be consulted at the Vice Technical Direction Office 2.

Appropriate tailoring of requirements shall be performed depending on the type of aircraft and its complexity.

PART I of the Technical Specifications File is not required to specify the *Means of Compliance* (MoC), which are detailed during the Military Aircraft Type Approval stage (pursuant to PT AER.P-2).

NOTE

JSSG-2001 is composed of two parts for each requirement: one supplies the technical rationale and lessons learned which help to tailor the requirements of the technical specification; the other part provides guidelines for defining the MoC.

Annex A of this PT provides a standard index taken from JSSG-2001B, to indicate the typical structure of a Technical Specification.

The AAD may consider the use of other guidelines for preparing Technical Specifications acceptable (e.g. Company Standards), as long as they are "performance oriented" and refer to the applicable aspects referenced in JSSG-2001 concerning the definition of the aircraft, the operations it must be able to perform, the operating environment, the system characteristics and the aircraft interfaces.

For UAVs, PART I of the Technical Specifications File must include not only the requirements of the Air Vehicle, but also all requirements for the other segments (e.g. Control Station, Data Link, Communication System), for which the JSSG-2001 does not apply.

3.1.1 Take off and Landing from semi-prepared airstrips

Any ability of the aircraft to take off from and land on semi-prepared airstrips must be expressed in the Technical Specifications File, which must to this end include the requirements provided for as indicated in Annex "A".

3.1.2 Ship-based operations

Any ability of the aircraft operate from ships must be expressed in the Technical Specifications File, which must to this end include the requirements provided for as indicated in Annex "A".

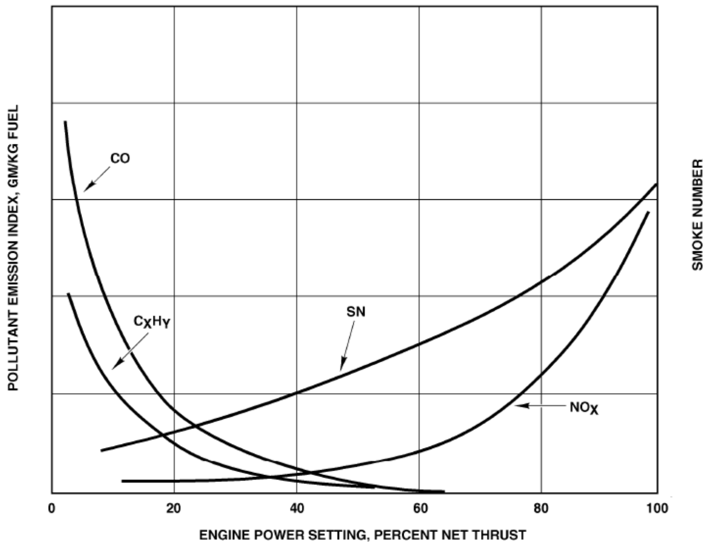
3.1.3 Environmental Impact

PART I of the Technical Specifications File must include a specific section on environmental impact requirements.

3.1.3.1 Engine Emissions

A specific requirement must be established in PART I to set the maximum levels of engine emissions.
For turbine engines, the following emissions values must be set:

	Quantity expressed in g/kg of fuel at a distance of 1 ft from the nozzle			
Rating	Smoke Number	C_xH_y	CO	NO_x
Ground idle				
Max thrust without afterburner				
Max thrust with afterburner				



Applicable guidelines for defining this requirement can be: JSSG 2007A, ARP-1256, ARP-1179.

For engines derived from civil models, it is recommended where applicable to refer to the requirements defined by ICAO Environmental Protection Annex 16 Volume II.

3.1.3.2 Acoustic Impact

PART I of the Technical Specifications File requires the Company to determine the acoustic impact of the aircraft measured in terms of "effective perceived noise" (EPNdB)
On the basis of the application, the AAD may also require that specific quantitative requirements be satisfied in the Technical Specifications File.
For aircraft derived from civil models, it is recommended where applicable to refer to the requirements defined by ICAO Environmental Protection Annex 16 Volume I.

3.1.3.3 Painting

PART I of the Technical Specifications File must provide a requirement concerning environmentally friendly paints, according to painting cycles to be agreed with the AAD.
These painting cycles shall provide for the use of environmentally friendly paints to replace chrome-based paints.
Specifically, after appropriate surface adhesion treatment, a chromate-free primer commonly used in the civil aviation field, tested by multiple laboratories certified in the aerospace field, must be used directly on the metal or composite material.
Whenever it is not technically possible to avoid the use of chrome, the use of paints which minimize the amount of chrome shall be agreed with the AAD on the basis of the currently available technology in the aerospace field.

3.1.4 Interchangeability and Replaceability

PART I of the Technical Specifications File must contain the following clause:
"The System Responsible Company of the aircraft shall supply Interchangeability and Replaceability data.
For the definitions of Interchangeability and Replaceability and for the list of configuration items to which this requirement refers, MIL-I-8500D shall apply.
The Interchangeability and Replaceability data shall be provided in specific tables, supplying the following information:

- *Part Number*
- *Name (description)*
- *Requirement (Interchangeability / Replaceability)*
- *Progressive production number of the aircraft or Serial Number of the assembly*
- *Notes*

The data (tables) shall be supplied by the System Responsible Company of the aircraft before obtaining the Military Aircraft Type Approval Certificate.
Configuration modifications after issuance of the Military Aircraft Type Approval Certificate shall require analysis of the tables for their updating, whenever necessary".

3.1.5 Assembly of components and parts

PART I of the Technical Specifications File must contain the following clause:
"Equipment, parts and components which are not structurally or functionally interchangeable must be designed so as to prohibit physical interchangeability.
Parts and components must be designed in such a way that it is impossible to install them in an incorrect manner (e.g. reversing the direction or installing them in an incorrect position in an assembly).
Connections positioned close together shall be made physically non-interchangeable".

3.1.6 Security of communications (COMSEC) and of systems for automatic processing of classified component and part assembly data

If the aircraft involves classified information, the security measures and requirements to be inserted in the Technical Specifications File shall be approved by the Italian National Security Agency through the DA's Central Security Body or the National Body responsible for the aircraft.
For the demonstration of security performance, Italian National Security Agency certification must be produced (pursuant to the provisions of the Prime Ministerial Decree of 22/07/2011 "Provisions for the administrative protection of State Secrets and classified information" O.G. no. 203 of 01/09/2011).
The Technical Specifications File must include the following clause for protection against the effects of compromising electromagnetic emissions:
"The aircraft must be TEMPEST certified and CIs involving classified information must be TEMPEST certified according to the requirements for mobile tactical platforms established by Nato Standard SDIP-27/1".
The detailed security requirements shall be given in the classified appendix.

3.2 PART II – Airworthiness Basis

PART II (Airworthiness Basis) is the collection of airworthiness requirements for the aircraft, which it must satisfy throughout its operational lifetime in order to be flight certified.
Annex B of this TP contains the minimum airworthiness requirements which must be satisfied through the detailed requirements to be defined following the guidelines specified in the following sections.
PART II of the Technical Specifications File is prepared in accordance with the guidelines supplied by MIL-HDBK-516[1].

Appropriate tailoring of requirements shall be performed depending on the type of aircraft and its complexity.

Tailoring of the airworthiness requirements provided for by MIL-HDBK-516[1] may be performed using the JSSGs relating to the various systems, DEF STAN 00-970, CSs, FARs, or other up-to-date standards agreed with the AAD.

For aircraft derived from civil models, the airworthiness basis may be defined in agreement with the applicable sections of the airworthiness codes used by the Civil Certification Authorities (CS, FAR).

A set requirements in common with those requested in any parallel or preceding Civil Type Approval Certification process may be set up. Opportune “Special Conditions” or “Exemptions” may be defined for specific military requirements.

For Unmanned Aerial Vehicles, the airworthiness basis may be defined in agreement with the applicable STANAGs.

3.2.1 Safety Requirements

PART II of the Technical Specifications File must define the safety requirements.

Annex C to this TP provides guidelines for defining the safety requirements of the aircraft in the Technical Specifications File.

In the event of disagreement, this TP must be applied and not JSSG-2001.

3.2.2 Airworthiness Basis for engines and propellers

Definition of the airworthiness basis for the engine, propeller and APU, when it requires issuance of a specific Certificate in accordance with PT AER.P-2, may be performed in the following ways:

- In the event that engine, propeller and APU are Government Furnished Equipment (GFE), the respective Airworthiness Bases are established in the Technical Specifications Files prepared for their purchase
- In the event that the engine, propeller and APU are Government Selected Equipment (GSE) or Company Selected Equipment, the Technical Specifications File of the aircraft must specify the Airworthiness Basis for the engine, propeller and APU.

The following standards may be used to define the Airworthiness Basis for engines, propellers and APUs:

- Engines: CS-E, FAR-33, JSSG-2007, DEF-STAN-970;
- Propellers: CS-P, FAR-35, JSSG-2009-Appendix L;
- Auxiliary power units (APUs): CS-APU, TSO C77, MIL-P-85573, JSSG-2009-Appendix C.

[1] At the date of issue of this standard, the up-to-date edition to be used is MIL-HDBK-516B/CHANGE1 (29 February 2008). For tailoring of requirements, it is recommended the version in use by theUS Air Force be used, MIL-HDBK-516B /Expanded Version (26 September 2005).

3.3 PART III – Various requirements

PART III is the collection of various contractual requirements which are not subject to the Military Aircraft Type Approval process, such as:

PART III of the Technical Specifications File defines:

- Requirements of a technical/administrative nature
- Requirements concerning the application of relevant standards
- Various requirements

This part is not subject to the type-approval process per standard AER.P-2; in any case, the requirements of PART III refer to preparatory activities for the issuance of the Military Aircraft Type Approval Certificate.

3.3.1 Technical/Administrative Requirements

PART III of the Technical Specifications File must include the following table containing the base performance, tolerances and corresponding reductions:

Performance	Base value	Tolerance		Reduction
		Can be reduced	Cannot be reduced	

The base performances above, summed with the corresponding tolerances, are the minimum ones for acceptance.

The base performance figures to include in PART III shall be established keeping track of the operational requirements translated in PART I into precise design performance and mission requirements to be guaranteed.

For the intermediate performances between those which cannot be reduced and the minimum ones, the reduction shall be applied in proportion to the difference from the base performance increased by the tolerance which cannot be decreased.

For each of the performances to be measured in more than one condition, only one reduction is applied, specifically that relative to the performance which gives rise to the maximum reduction.

In addition to the preceding, the competent Technical Division of the AAD may request any other administrative/technical requirement considered necessary for the specific purchase program.

3.3.2 Applicable Standards Requirements

3.3.2.1 <u>Quality Certification</u>

PART III of the Technical Specifications File must specify the contractually applicable normative standards for the System Responsible Company's Quality Management System.

PART III must also specify the following requirement:

“Workmanship must be of a high standard”.

3.3.2.2 Military Aircraft Type Approval

PART III of the Technical Specifications File must specify that the aircraft must undergo Military Aircraft Type Approval pursuant to the TP AER(EP).P-2 (current edition).

3.3.2.3 Design Organization Military Approval (DOMA)

For Italian Companies, PART III of the Technical Specifications File must specify that they shall obtain DOMA recognition pursuant to the TP AER(EP).P-10 (current edition), in order to be able to obtain the Military Aircraft Type Approval Certificate.

3.3.2.4 Military Serial Number

PART III of the Technical Specifications File must specify that each military aircraft produced must obtain the necessary Military Serial Number (or Experimental Number or Prototype Number, where applicable), in accordance with the requirements of Standard AER(EP).P-7 (current edition).

3.3.2.5 Technical Publications

PART III of the Technical Specifications File must specify that all required technical publications concerning the aircraft must be drafted in accordance with the TP AER(EP).0-0-2 (current edition), and with the standards specified in them.

3.3.2.6 Occurrence Reporting

PART III of the Technical Specifications File must specify that the Company must establish processes for collecting and handling occurrence reports in service in accordance with the requirements of the TP AER(EP).00-1-6 (current edition).
These processes must be used by the Quality Management System to guarantee continued airworthiness and to contribute to continual improvement of the safety of the aircraft.

3.3.2.7 Configuration Control

PART III of the Technical Specifications File must specify that the Company must establish processes for configuration control of the aircraft in accordance with the requirements of the TP AER(EP).00-00-5 (current edition).
To that end, the System Responsible Company must:
- Upon the contract coming into force, present a Company Technical Directive (CTD) in which it declares and determines it is the sole and exclusive body responsible for the Project and shall respond to this in all its parts, in other words it must present the licenses or delegations received assigning it the rights and responsibility to intervene in this

- In conjunction with the Military Aircraft Type Approval, define and formalize the “as designed” base configuration document (Design Standard)
- Upon presentation for testing of each single aircraft, define and formalize the “as built” base configuration documents(Built Standard)
- Define, via Technical Directive, the list of level 1, level 2 or even lower CIs for each weapon system which must be monitored with an identity booklet or identity sheet on the basis of the degree of maintenance and type of maintenance intervals of the CIs themselves
- Determine the list of Type I or “invasive” Aircraft Ground Equipment via CTD, (whose failure could have effects on the aircraft's airworthiness)
- Declare, via CTD, the list of Level II System Responsible Companies, supplying the elements of acceptance for these

3.3.3 **Various Requirements**

3.3.3.1 <u>Testing</u>

PART III of the Technical Specifications File must define the methods and timeframes for testing to verify that each aircraft produced meats the performance and airworthiness requirements laid out in the Military Aircraft Type Approval Certificates.

PART III of the Technical Specifications File must establish the minimum time, before the date of presentation to testing, within which the Acceptance Test Procedure must be supplied to the AAD.

PART III of the Technical Specifications File must specify that these test procedures must be subject to acceptance by the AAD, and that the testing body shall always have the possibility to perform further tests if it considers them appropriate, in accordance with the General Conditions of 14/04/2000.

GUIDELINES FOR STANDARD TECHNICAL SPECIFICATION LAYOUT (PART I)

This Annex is an extract from the contents of JSSG-2001B and presents the list of topics that a (performance-oriented) Technical Specification for an aircraft should cover.

JSSG-2001B supplies all material to be used as a guideline to perform tailoring of requirements for a specific aircraft and to establish the quantitative value of each.

In addition to the provisions of JSSG-2001B, semi-prepared airstrips are also dealt with in a dedicated section, of notable interest in the military field.

For the Technical Specifications of UAVs, in addition to the requirements for the Air Vehicle, specific requirements must be established for the Control Station, Data-Link and Communication System.

AIRCRAFT REQUIREMENTS

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3.1.9.3 Air-to-surface accuracy
3.1.9.4 Weapon and store selection and release control
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3.2 Environment
3.2.1 Electromagnetic environmental effects (including HIRF aspects)
This requirement must be drafted in accordance with MIL-STD-464A

a. §5.1 of MIL-STD-464 (Margins)
b. §5.2 of MIL-STD-464 (Intra-System Electromagnetic Compatibility (EMC))
c. §5.3 of MIL-STD-464 (External Radio Frequency Electromagnetic Environments)
d. §5.4 of MIL-STD-464 (Lightning)
e. §5.5 of MIL-STD-464 (Electromagnetic Pulse (EMP)
f. §5.6 of MIL-STD-464 (Subsystems and Equipment Electromagnetic Interference (EMI))
g. §5.7 of MIL-STD-464 (Electrostatic Charge Control)
h. §5.8 of MIL-STD-464 (Electromagnetic Radiation Hazards (EMRADHAZ))
i. §5.9 of MIL-STD-464 (Life Cycle, E3 Hardness)
j. §5.10 of MIL-STD-464 (Electrical Bonding)
k. §5.11 of MIL-STD-464 (External Grounds).
l. §5.14 of MIL-STD-464 (Electromagnetic Spectrum Compatibility)

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(<>ROSH or ROTH)

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- Landing gear geometry (number of wheels and geometry of the front and rear gear, and their distance from the center of gravity)
- Extreme position of center of gravity with respect to air vehicle longitudinal axis
- Tire inflation pressure
- Maximum takeoff load

The corresponding applicable documentation for specifying the airstrips is listed below:

- ICAO ANNEX 14, Third Edition, July 1999
- AEP-46(B) NATO Aircraft Classification Numbers (ACN)/Pavement Classification Number (PCN), 16 June 2008, NATO STANAG 7131
- UFC (Unified Facilities Criteria) 3-260-1,"Airfield and Heliport Planning and Design ", DoD 17 November 2008
- Norman S. Currey, "Aircraft Landing Gear Design Principles and Practices", Lockheed Aeronautical Systems Company, Marietta, Georgia, 1988
- MIL-A-8862A, "Airplane strength and rigidity, landing and ground handling loads", .31 March 1971
- MIL-A-8863C(AS), "Airplane strength and rigidity, landing and ground loads for Navy acquired airplanes", 19 July 1993
- Donald H. Gray, Donald E. Williams, "Evaluation of Aircraft Landing Gear Ground Flotation Characteristics for Operation from unsurfaced soil airfield", Technical Report ASD-TR-68-34

3.10 Ship interoperability requirements

(for each of the following requirements, it is recommended to consult the technical considerations provided in JSSG-2001B)

3.10.1 Ship compatibility: identify all ship interface requirements

Ship	Maximum Height	Spotting Factor	Catapult System/ Drawing Number	Arresting Systems/ Drawing Number	Barricade System/ Drawing Number	JBD Type/ Drawing Number	High Thrust Fitting Type/ Drawing Number	Conditions

Ship	Elevator Dimensions	Number of Air Vehicles	Equipment	Conditions

- Towing provisions

- Tie-down and mooring provisions
- Shipboard refueling / defueling interfaces

3.10.2 Tipback and turnover requirements on board the ship
3.10.3 Parking on the ship deck for required weather conditions
3.10.4 Ship deck takeoff and landing wind limits
3.10.5 Flight quality requirements for ship-based operations
3.10.5.1 Deck Handling
3.10.5.2 Catapult launch
3.10.5.3 Carrier approach and landing
3.10.5.4 Bolter
3.10.5.5 Waveoff
3.10.5.6 Single engine failure
3.10.6 Ship-to-helicopter in-flight refueling envelope
3.10.7 Emission Control (radio silence) requirements
3.10.8 Compatibility with Radio Frequency Electromagnetic Ship Environment (MIL-STD-464A and any additional requirement related to specific ships environment)

3.11 Specific requirements of the UAV system
3.11.1 Control station
3.11.2 Data Link
3.11.3 Communication system

4. ENVIRONMENTAL IMPACT REQUIREMENTS

4.1 Engine gas emissions
4.2 Acoustic impact
4.3 Painting

MINIMUM ESSENTIAL AIRWORTHINESS REQUIREMENTS

B.1. INTRODUCTION

The Chicago Convention (7 December 1944) stated that:

- “it shall be applicable to civil aircraft, and shall not be applicable to state aircraft” (Chapter I, article 3 a),
- “Aircraft used in military, customs and police services shall be deemed to be state aircraft” (Chapter I, article 3 b),
- “the contracting States undertake, when issuing regulation for their state aircraft, that they will have due regard for the safety of navigation of civil aircraft” (Chapter I, article 3 d).

European regulation (EC) No. 216/2008 states:

- “This Regulation shall not apply when products, parts, appliances, personnel and organizations … are engaged in military, customs, police, or similar services. The Member States shall undertake to ensure that such services have due regard as far as practicable to the objectives of this Regulation” (Chapter 1, article 1.2);
- The essential airworthiness requirements for civil aircraft are defined in Annex I of the same regulation.

B.2. SCOPE

The purpose of this Annex is to define the essential airworthiness requirements applicable to military aircraft purchased by the AAD, consistently with the preceding principles and keeping specific military requirements in mind.

PART II of the Technical Specifications File (airworthiness basis) for an aircraft, which specifies the detailed airworthiness requirements, must be drafted in full consideration of these essential requirements.

It should also be remembered that they represent the minimum requirements, and that more stringent requirements may be requested by the AAD during the agreements phase of PART II of the Technical Specifications File.

NOTE

This annex refers to all airworthiness aspects specified in the “Essential requirements for airworthiness” of European regulation 216/2008 and not only to the requirements the airworthiness basis (PART II of the Technical Specifications File) is to be derived from: the essential requirements which impact the definition of the airworthiness basis are those in sections B.3.1. and B.3.2. below.

B.3. REQUIREMENTS

B.3.1. INTEGRITY REQUIREMENTS

Integrity of the aircraft and its configuration items must be guaranteed under all flight conditions and ground operations provided for, and throughout the operational lifetime of the aircraft.

The AAD must agree that all these requirements have been demonstrated to be satisfied to a suitable level.

B.3.1.1 Structure and Materials

The integrity of the aircraft's structure, including its propulsion system, must be demonstrated for its entire operational envelope, and for a defined margin beyond this, and maintained throughout the operational life of the aircraft.

All aircraft parts whose failure could compromise its structural integrity must satisfy the following conditions, without breaking or deforming to a dangerous extent:

a) All loading combinations which could reasonably be expected to occur within, and for a defined margin beyond, the weight and balance envelope, operational envelope, and aircraft lifetime must be considered.
This includes loads both in flight and on the ground, deriving from gusts, maneuvers, pressurization, moving surfaces, control systems, propulsion.

b) The probable loads and damage caused by emergency landings either on water or on the ground (where applicable) must be considered.

c) The dynamic effects in the structural response to these loads must be considered.

d) The aircraft must be free from any aeroservoelastic instability and from excessive vibrations.

e) The production processes and the materials used in manufacturing the aircraft must produce known and reproducible structural properties.
All variations in material performance due to the operating environment must be taken into account.

f) The effects of structural fatigue due to cyclical loading, environmental degradation, sources of accidental and discrete damage must not reduce the structural capacity below a minimum acceptable level of residual strength.
To this end, all instructions necessary to ensure continued airworthiness of the aircraft must be supplied.

This includes all items of significant weight, and their restraint systems.

B.3.1.2 Propulsion system

The integrity of the aircraft's propulsion system (i.e. engines and propellers where applicable) must be demonstrated for its entire operational envelope, and for a defined margin beyond this, and maintained throughout the operational life of the aircraft.

The propulsion system must produce, within the specified limits, the thrust or power requested by the system under all required flight conditions, considering the environmental conditions and effects.

The production processes and the materials used in manufacturing the propulsion system must produce known and reproducible structural properties.

All variations in material performance due to the operating environment must be taken into account.

The effects of structural fatigue due to cyclical loading, environmental and operational degradation, and probable failures of parts and the likely effects on nearby parts, must not reduce the integrity of the propulsion system below a minimum acceptable level.

To this end, all instructions necessary to ensure continued airworthiness must be supplied.

All instructions, information, and requirements necessary for the interface between the engine and propeller (where applicable) and aircraft to be performed safely and correctly must be supplied.

B.3.1.3 **Systems and Equipment**

The aircraft must not include design details or characteristics that experience has shown to be dangerous for safety.

The aircraft, with all systems and equipment required for Military Aircraft Type Approval or by operational rules (e.g. Operational Air Traffic (OAT) and General Air Traffic (GAT)), must perform the required functions in the manner provided for in all operational conditions provided for, throughout the operational envelope of the aircraft, and for a given margin beyond this, giving suitable consideration to the operating environment of the system and equipment.

Other systems and equipment not required for Military Aircraft Type Approval or by operational rules, whether they are functioning correctly or incorrectly, must not reduce the levels of safety and must not have a negative influence on the correct operation of any other system or equipment.

It must be possible to use the systems and equipment without exceptional effort or ability.

The aircraft's systems and equipment, including the Control Station and Data Link (for UAVs), considered separately and in relation to one another, must be designed in such a way that no single failure which has not been shown to be extremely improbable (HRI=1E), produces catastrophic effects.

There must also be an inverse relationship between the probability of a failure condition and the severity of its effect on the aircraft, the flight and all ground crew, the passengers (where applicable), the other users of the air space, and any other third parties (e.g. when overflown).

The aircraft class must nevertheless be kept in due consideration in terms of weight, dimensions and variety of configurations (including specifically military systems and operations): cases in which the previous criterion of single failure may not be satisfied for some parts and systems on helicopters, small single engine aircraft and on UAVs may be identified.

The crew and maintenance personnel (where concerned) must be supplied with all information necessary for safe flight and information on unsafe conditions, in a clear, consistent and unambiguous manner.

Systems, equipment and controls, including warnings, must be designed and positioned in such a way as to minimize errors which could contribute to the creation of dangerous situations.

Design precautions must be adopted to minimize risks to the aircraft, the crew, the passengers (where applicable), other users of the airspace and other third parties (e.g. third parties when overflown) deriving from reasonably probable threats, both inside and outside the aircraft, including methods of protection against the possibility of significant failures or interruptions to the operation of aircraft equipment.

B.3.1.4 Continuing Airworthiness

Instructions must be established for “continuing airworthiness” so as to ensure that the airworthiness standards recognized in the Military Aircraft Type Approval are maintained throughout the operational lifetime of the aircraft.

Methods and equipment to allow inspections, adjustments, lubrication, removal, or replacement of parts and equipment according to the requirement to guarantee “continuing airworthiness” must be supplied.

The instructions for “continuing airworthiness” must be supplied in a format appropriate to the quantity of data necessary (e.g. hardcopy or electronic).

The instructions must cover aspects of maintenance and repair, servicing information, troubleshooting and inspection procedures.

The “continuing airworthiness” instructions must contain the airworthiness limitations which establish the timeframes for obligatory replacement of parts with limited lifespans, the inspection intervals, and corresponding inspection procedures.

B.3.2. AIRWORTHINESS OPERATIONAL ASPECTS

B.3.2.1 Safety for flight and ground crew

In order to ensure a satisfactory level of safety for air and ground personnel during aircraft operation, the following aspects must demonstrably have been considered:

a) The type of operations for which the aircraft is approved must be established, along with the limitations and information necessary to operate the aircraft in safety, including environmental and performance limitations.

b) It must be possible to control and maneuver the aircraft safely under all operating conditions provided for and, where applicable, up to the moment in which the emergency evacuation systems are activated (e.g. crew escape), or the recovery system in the event of a UAV.

The strength of the pilot, their workload, the cockpit environment, human factor considerations, flight stage and its duration must be taken into account.

c) It must be possible to smoothly transition between one phase of flight and another in all likely operating conditions, without requiring exceptional piloting, vigilance, strength, or workload capacities.

d) The aircraft must possess “handling qualities” such that the requirements on the pilot are not excessive, in consideration of the stage of flight and its duration.

e) Procedures for normal operations, in conditions of failure and in emergencies, must be established.

f). On the basis of the type of aircraft, methods (warnings or other deterrents) to prevent the normal flight envelope being exceeded must be supplied.

g) The characteristics of the aircraft and its systems must allow for safe re-entry from conditions on the edge of the flight envelope which may be encountered.

B.3.2.2 **Operating Limitations**

The crew must be provided with the operating limitations of the aircraft and all other information necessary to operate the aircraft safely.

B.3.2.3 **Aircraft Operations**

Aircraft operations must be protected from risks resulting from adverse internal and external conditions, including environmental conditions.

In particular, exposure to phenomena expected during the vehicle's operational lifetime must be considered; these include, but are not limited to, adverse meteorological conditions, lightning, bird strikes, high frequency radiation, ozone etc.

When applicable, the cabin compartments must guarantee appropriate transport conditions for passengers and adequate protection against all risk events deriving from flight operations or emergency situations, including the risk of fire, smoke, toxic gas, and rapid decompression.

The occupants must be provided with everything necessary to give them every reasonable opportunity to avoid serious injury and to rapidly evacuate the aircraft, and to protect them from the effects of deceleration in the event of an emergency landing on land or water (where applicable).

Clear and unambiguous warnings or announcements must be given, according to requirements, to instruct the occupants on the appropriate and safe behavior required and on the location and use of security equipment.

The crew compartments must be organized in such a way as to facilitate flight operations, including equipment which supplies the necessary “situation awareness”, and management of all emergency situations foreseen. The crew compartment environment must not introduce any risk of compromising the crew's capacity to perform their tasks, and its design must be such as to avoid interference during operations and incorrect use of the controls.

B.3.3. ORGANIZATIONS (PERFORMING DESIGN, PRODUCTION, MAINTENANCE ACTIVITIES

The organizations involved in design (including test flights), production, or maintenance activities must satisfy the following conditions:

a) The organization must provide all means necessary for the work to be carried out.

This includes, but is not limited to, equipment, personnel, tools, instruments and materials, documentation of the various tasks, responsibilities and procedures, access to relevant data, and record-keeping.

b) The organization must implement and maintain a management system which ensures that essential airworthiness requirements are met and is oriented towards continuous improvement of the system itself.

c) The organization must establish agreements with the other relevant organizations, to the extent necessary, to ensure the essential airworthiness requirements are continually met.

d) The organization must establish a system for reporting and/or handling occurrences, which must use the management system specified in point b) and the agreements in point c), in order to contribute to working towards continuous improvement of aircraft safety (continuing airworthiness of the Type).

SAFETY REQUIREMENTS

C.1. INTRODUCTION

Satisfying the safety objectives due to technical factors linked with the project is a key factor in ensuring that the aircraft is airworthy.

This Annex defines the main safety requirements to be entered in the Technical Specifications File, and supplies the guidelines for defining them in a quantitative manner.

In accordance with the current definition of airworthiness, both the safety of persons on board the aircraft and on the ground must be taken into consideration.

This Annex supplies the elements necessary to quantitatively establish the cumulative probability requirement of a catastrophic event per flight hour, considering both the primary requirement of minimizing the probability of risk to human life, and all technological requirements linked to the current level of technical progress of various classes of aircraft.

It should be highlighted that this requirement must not be considered only as an airworthiness requirement, but also a "performance" requirement by identifying the non-combat loss rate of the aircraft.

NOTE

The considerations given in this Annex are designed to give those responsible for defining and verifying the safety requirements ever-greater awareness that their decisions have a crucial impact not only on development and production costs, but also on continuing costs in service, and a good decision taken at the beginning will provide great advantages throughout the lifecycle of the program.

C.2. SAFETY AND SOFTWARE REQUIREMENTS

C.2.1 CUMULATIVE PROBABILITY OF A CATASTROPHIC EVENT

The Technical Specifications File must include an aircraft requirement expressed in terms of cumulative probability of a catastrophic even per flight hour (see section C.3.).

C.2.2 FAILSAFE

The Technical Specifications File must include a "failsafe" requirement: *"the aircraft systems, considered separately and in relation to the other systems, must be designed in such a way that no single failure would lead to a catastrophic event"*.

This requirement is not obligatory for UAVs weighing less than 150 kg; nonetheless, the AAD reserves the right to request its application whenever it considers this necessary for some fault conditions.

C.2.3 HAZARD RISK INDEX MATRIX

The Technical Specifications File must include a Hazard Risk Index Matrix (see section C.3), which defines:

- Appropriate categories of severity (Catastrophic, Critical, Major, Minor)
- Appropriate levels of probability (Frequent, Probable, Occasional, Remote, Improbable);
- An appropriate matrix of risk and levels of acceptability of the risk, obtained by combining the above-mentioned severity categories and levels of probability (there must be an inverse relationship between the probability of a certain fault condition and the severity of its effects).

Hazard Risk Index (HRI)	(1) CATASTROPHIC	(2) CRITICAL	(3) MAJOR	(4) MINOR
(A) FREQUENT	1A	2A	3A	4A
(B) PROBABLE	1B	2B	3B	4B
(C) OCCASIONAL	1C	2C	3C	4C
(D) REMOTE	1D	2D	3D	4D
(E) IMPROBABLE	1E	2E	3E	4E

Any “Special Conditions” concerning the acceptability criteria established by the Hazard Risk Index Matrix, for some particular “failure conditions” (e.g. loss of thrust in a single-engine aircraft), must be specified in the Technical Specifications File, after thorough analysis leading to the conclusion that alternative solutions are not technically feasible.
The probability value must nevertheless be fixed for these “failure conditions”.

C.2.4 HAZARD ZONAL ANALYSIS

The Technical Specifications File must require that the Company issue a Hazard Zonal Analysis for evaluation of the “safety” aspects linked with installation of the systems.

C.2.5 SYSTEM SAFETY PROGRAM PLAN

The Technical Specifications File must require that the Company issue a System Safety Program Plan, to be agreed with the AAD.

C.2.6 SOFTWARE

The Technical Specifications File must establish the Software development and validation standards.
Refer to RTCA-DO-178 (current edition) or the publication NATO AOP-52.

The Technical Specifications File must, in any case, specify that the Software life-cycle requirements be established on the basis of their impact on Safety, recognizing at least four classes:

- The first linked to functions for which a software malfunction would cause or contribute to catastrophic fault conditions
- The second linked to functions for which a software malfunction would cause or contribute to critical fault conditions
- The third linked to functions for which a software malfunction would cause or contribute to major fault conditions
- The fourth linked to functions for which a software malfunction would cause or contribute to minor fault conditions

The Technical Specifications File must contain the following clause: *"Appropriate architectural choices (redundancy, partitioning, monitoring, dissimilarity, independence etc.) may, where demonstrated to the satisfaction of the AAD, justify derating of some Computer Software Items. ARP-4754 may be used as a guideline".*

Stricter Software classes than those determined on the basis of the safety analysis may be requested for maintenance reasons or as a performance requirement to be guaranteed in order to obtain greater mission reliability.

For UAVs≤150kg, less strict software classes may be established, taking into consideration the minimum requirements of STANAG-4703.

The Technical Specifications File must specify any Software requirements established not on the basis of the safety analysis, but as an additional requirement (e.g. the AAD may require the strictest software class for the Software of a Mission Computer or the FCS of a UAV).

C.2.7 SOFTWARE MANAGEMENT PLAN

The Technical Specifications File must require the Company to issue a Software Management Plan document, to be agreed with the AAD, in which the Software classes are assigned on the basis of the results of the safety analysis, the architectural choices, and the above-mentioned additional requirements specified in the Technical Specifications File.

C.2.8 SYSTEM SAFETY MANAGEMENT PLAN

The Technical Specifications File must require the Company to implement a Safety Management System and issue a System Safety Management Plan, to be agreed with the AAD, in which the tasks and agreements implemented in order to guarantee that the safety requirements are satisfied and maintained in a planned manner are specified.

C.3. GUIDELINES FOR DEFINING QUANTITATIVE REQUIREMENTS

C.3.1 SAFETY REQUIREMENTS SITUATION

The cumulative probability of a catastrophic event per hour of flight must not be greater than the following maximum values which constitute the traditional method of fixing the “hazard reference system”:

Type of aircraft requirement	Aircraft class[3]	Cumulative probability of a catastrophic event
Aircraft developed to an initial civil type requirement and subsequently configured with military type modifications, which have obtained a civil Type Certification Certificate, or which are in the process of receiving one	(S1) Airplanes in the “Normal”, “Utility” and “Acrobatic” categories with single alternative engine and weighing <6000 lb	≤ $1x10^{-5}$ (4)
	(S2) Airplanes in the “Normal”, “Utility” and “Acrobatic” categories with more than one alternative engine, or single turbine engine, and weight <6000 lb (S2) Helicopters with weight ≤20000 lb and number of passengers <10	≤ $1x10^{-6}$ (2)
	(S3) Airplanes in the “Normal”, “Utility” and “Acrobatic” categories, with weight ≥6000 lb	≤ $5x10^{-7}$ (2)
	(S4) Airplanes in the “Commuter” category (S4) Airplanes in the “Large Aircraft” category (S4) Helicopters in the “Large Rotorcraft” with weight >20000 lb and any number of passengers, or ≤20000 lb and number of passengers ≥10	≤ $1x10^{-7}$ (2)
Aircraft designed to an initial requirement for purely military type missions	(S5) Aircraft for troop transport and rescue, reconnaissance, maritime patrols, aerial refueling, Electronic Warfare missions etc.	≤ $1x10^{-6}$
	(S6) Aircraft in the combat, training etc. categories	≤ $1x10^{-6}$

Table 1

For UAVs, as there are no persons on board, it can be assumed that an event causing loss of the system is catastrophic only when such a loss is associated with the risk of death of one or more persons.

The cumulative probability of catastrophic event per flight hour requirement for UAVs should be established in the Technical Specifications File using the following formula:

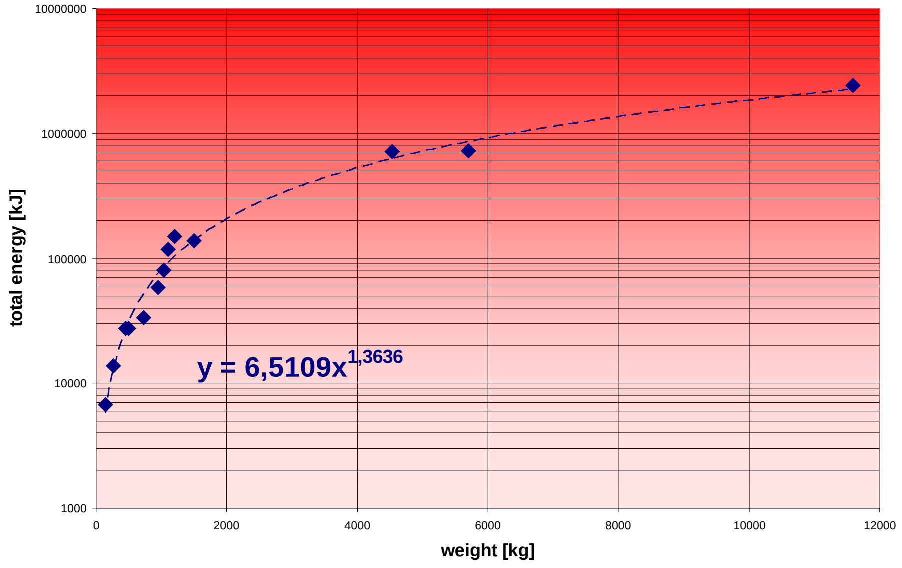
(*safety class*) Weight of UAV [kg]	Cumulative probability of a catastrophic event /fh [*values which do not result in any limitation of population density*]
(S7) MTOW < 15 kg	≤ $1x10^{-4}$
(S8) 15 kg ≤ MTOW < 150 kg	≤ 0.0015 / (MTOW)
(S9) 150 kg ≤ MTOW < 750 kg	≤ $1x10^{-5}$
(S10) 750 kg ≤ MTOW < 4000 kg	≤ $0.0813 / (MTOW)^{1.36}$
(S11) MTOW ≥ 4000 kg	≤ $1x10^{-6}$

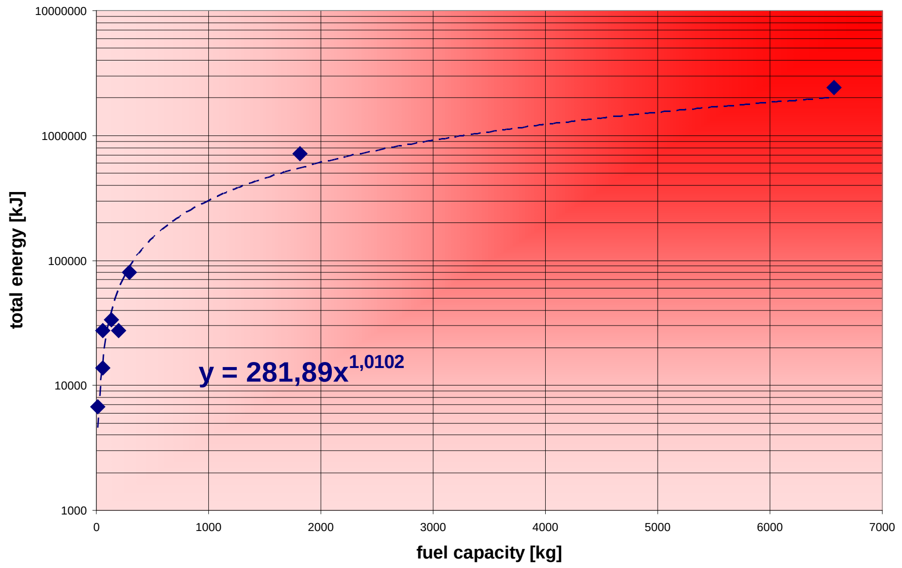
[3] Refer to the corresponding EASA standards for defining the classes of aircraft derived from civil models.

[4] Any mitigating factor which degrades the level of reliability of the aircraft in its civil Type Approval Certificate configuration may be considered in order to take into account the hazards introduced by the military configuration CIs. The value of the mitigating factor to apply depends substantially on the extent of the differences between the civil and military configurations. It should also be remembered that for single engine aircraft, these values may be further mitigated, as the civil process does not take this contribution into account.

This formula is empirical, and has been derived in the following manner:

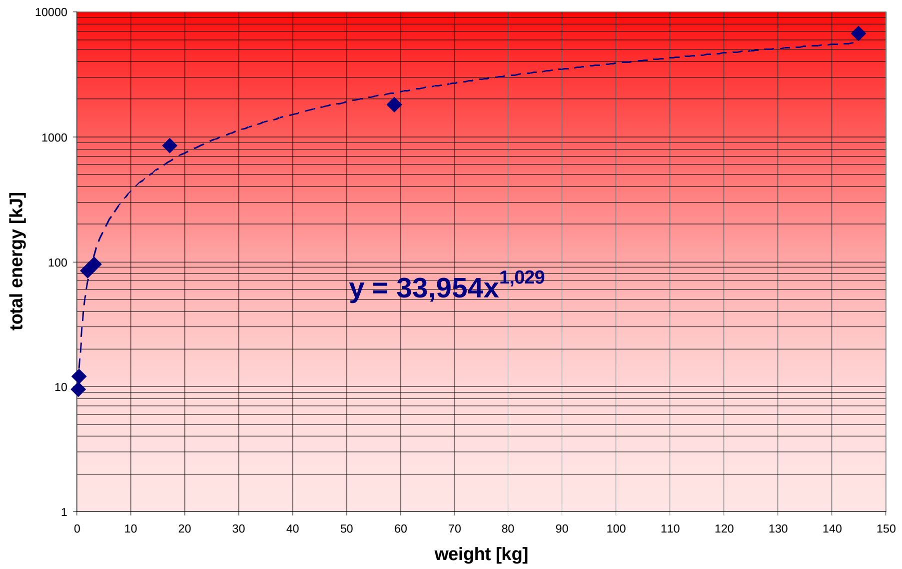
- It is supposed that the risk for third parties overflown by a UAV is proportional to the total energy of the system in flight (which determines the seriousness of the impact on the ground) and to the quantity of fuel on board (which determines the risk of a potential explosion and fire on the ground)
- Systems with MTOW>150kg which currently exist were analyzed, and the following correlations found:





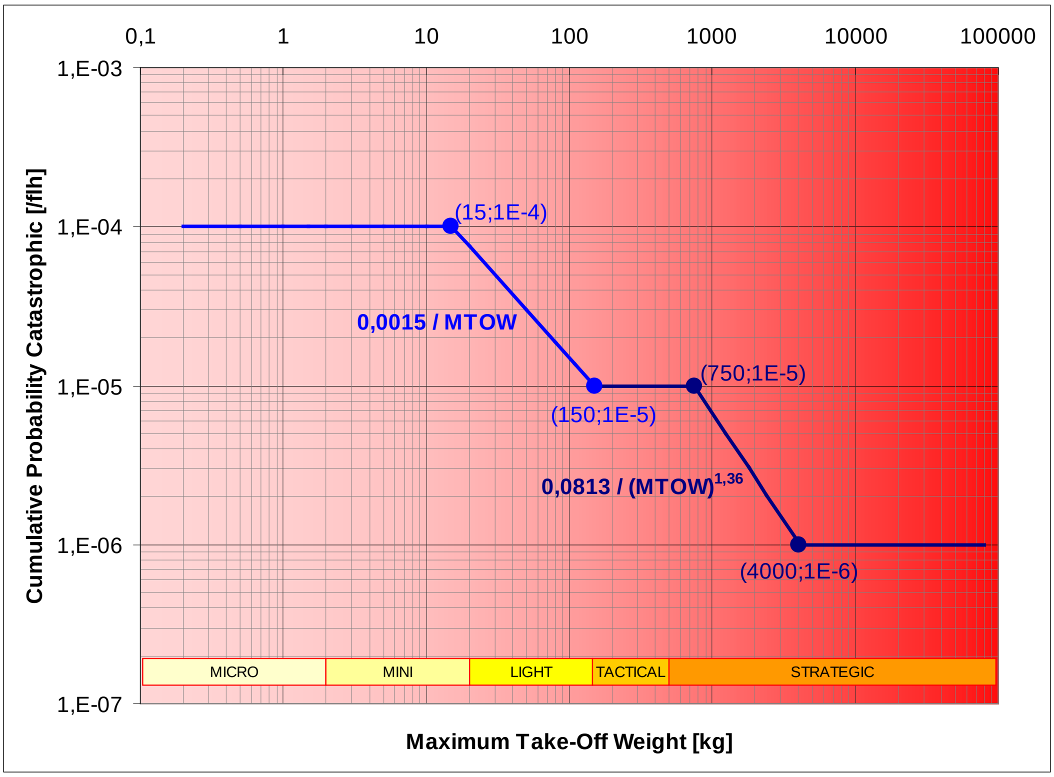
- For UAVs with MTOW>150kg, as the fuel capacity is approximately linear with the total energy of the system, and as the total energy of the system correlates with weight raised to the power of 1.36, it was concluded that the risk to overflown parties depends on the weight raised to the power of 1.36, and that the safety requirement varies with weight raised to the (-1.36).

- Systems with MTOW<150kg which currently exist were analyzed, and the following correlation was found:



- For UAVs with MTOW<150kg, as the total energy of the system is directly proportional to its weight, it was concluded that the safety requirement is inversely proportional to the weight.

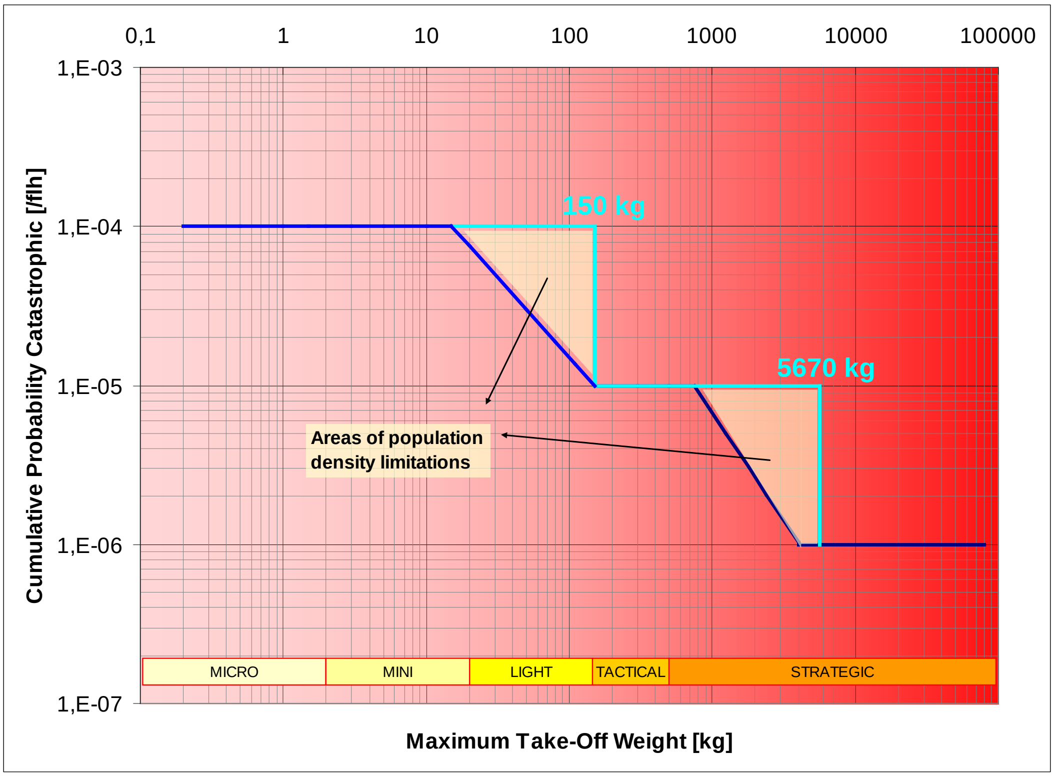
As such, the recommendation is to establish the cumulative probability of catastrophic event requirement per flight hour, to be satisfied in order to be able to operate the UAV system without any limitation of population density, as follows:



Whenever a UAV system should not satisfy the established cumulative probability of catastrophic event requirement, the AAD shall establish a limitation on the average population density of the area overflowing using the methodology specified in Standard AER.P-2.

In any case, it is recommended not to set out cumulative probability of catastrophic events per flight hour requirements in the Technical Specifications File greater than the following minimum acceptable safety values:

Weight of UAV [kg]	Cumulative probability of a catastrophic event /fh [minimum acceptable values implying limitations in terms of population density]
MTOW < 150 kg	≤ $1x10^{-4}$
150 kg ≤ MTOW ≤ 5670 kg	≤ $1x10^{-5}$
MTOW > 5670 kg	≤ $1x10^{-6}$
If we adopt a threshold of 5670 kg to move to a cumulative requirement of $1x10^{-6}$, this must be considered as the new value for moving between the safety category (S10) and (S11) instead of 4000 kg.	



In the phase of defining the safety requirements for UAVs, it is recommended to make a preliminary evaluation of the effects of a limitation of population density through the AER.P-2 calculation in order to evaluate the compatibility of the requirement with the operational requirements of the Armed Forces.

It is recommended that the following severity class definitions be used, considering the definitions included in STANAG 4671 Ed 2 (AMC.1309) for UAVs:

CATEGORY	DEFINITION FOR MANNED AIRCRAFT	DEFINITION FOR UNMANNED AERIAL VEHICLES (UAVs)
CATASTROPHIC (CAT. 1)	Fault conditions which could cause the loss of the aircraft or a part thereof or the death of one or more persons. Fault condition which could lead to the fatal injury of operators by the aircraft during ground operations.	Fault conditions which would be expected to lead to uncontrolled flight conditions (including flying outside of the planned flight areas/profile) and/or uncontrolled crash. Fault conditions which could lead to the death of flight crew or ground staff.
CRITICAL (CAT. 2)	Fault condition which could cause serious damage to one or more of the aircraft's systems or serious injury or harm to one or more persons. This condition may include a significant reduction in the safety margins or functional capacities. This condition may cause physical indisposition and/or increased *workload* for the crew such as to compromise their ability to completely and accurately perform their flight tasks.	Fault conditions which, either in and of themselves or combined with an increase in crew *workload*, are expected to lead to a conclusion of the flight with controlled trajectory or forced landing potentially leading to loss of the UAV, in which it can be reasonably expected that no loss of life will occur. Fault conditions which can reasonably be expected not to cause the death of any crew member or ground staff.
MAJOR (CAT. 3)	Fault condition which could cause light damage to one or more of the aircraft's systems or minor injury or harm to one or more persons. This condition may include a significant reduction in the safety margins (e.g. identifiable loss of redundancy) or functional capacities. This condition could lead to a significant increase in crew *workload*.	Fault conditions which, either in and of themselves or combined with an increase in crew *workload*, are expected to lead to an emergency landing in a predetermined site, where it can reasonably be expected that no serious injury will occur. Fault conditions which could potentially lead to injury of flight crew or ground staff.
MINOR (CAT. 4)	Fault conditions which do not cause significant damage to the safety of any aircraft system or any injury/indisposition to persons. This condition may include a slight reduction in the safety margins or functional capacities. This condition could lead to a slight increase in crew *workload*.	Failure conditions which do not significantly reduce the safety of the UAV system and which require crew actions which fall within their abilities without difficulty. These conditions may include a slight reduction in the safety margins or functional capacities. These conditions could lead to a slight increase in crew *workload*.

The corresponding probability thresholds are derived from the cumulative catastrophic event requirement, with a number N_{EC} of catastrophic fault conditions estimated.

This number may be determined at the moment of establishing the Technical Specifications File requirement via the “Functional Hazard Assessment” or with historical databases for equivalent aircraft classes.

The following table may be used as a guideline:

Level of probability	**FREQUENT (A)**	**PROBABLE (B)**	**OCCASIONAL (C)**	**REMOTE (D)**	**IMPROBABLE (E)**
(S1) Airplanes in the "Normal", "Utility" and "Acrobatic" categories with single alternative engine and weighing <6000 lb	$P > P_B$	$P_B = 10 \cdot P_C$ $P_C < P \le P_B$	$P_C = 10 \cdot P_D$ $P_D < P \le P_C$	$P_D = 10 \cdot P_E$ $P_E < P \le P_D$	$P_E = P_{CUM\text{-}CAT} / N_{EC}$ $P \le P_E$
(S2) Airplanes in the "Normal", "Utility" and "Acrobatic" categories with more than one alternative engine, or single turbine engine, and weight <6000 lb (S2) Helicopters with weight ≤20000 lb and number of passengers <10	$P > P_B$	$P_B = 100 \cdot P_C$ $P_C < P \le P_B$	$P_C = 10 \cdot P_D$ $P_D < P \le P_C$	$P_D = 10 \cdot P_E$ $P_E < P \le P_D$	$P_E = P_{CUM\text{-}CAT} / N_{EC}$ $P \le P_E$
(S3) Airplanes in the "Normal", "Utility" and "Acrobatic" categories, with weight ≥6000 lb	$P > P_B$	$P_B = 100 \cdot P_C$ $P_C < P \le P_B$	$P_C = 100 \cdot P_D$ $P_D < P \le P_C$	$P_D = 10 \cdot P_E$ $P_E < P \le P_D$	$P_E = P_{CUM\text{-}CAT} / N_{EC}$ $P \le P_E$
(S4) Airplanes in the "Commuter" category (S4) Airplanes in the "Large Aircraft" category (S4) Helicopters in the "Large Rotorcraft" with weight >20000 lb and any number of passengers, or ≤20000 lb and number of passengers ≥10	$P > P_B$	$P_B = 100 \cdot P_C$ $P_C < P \le P_B$	$P_C = 100 \cdot P_D$ $P_D < P \le P_C$	$P_D = 100 \cdot P_E$ $P_E < P \le P_D$	$P_E = P_{CUM\text{-}CAT} / N_{EC}$ $P \le P_E$
(S5) Aircraft in the category for troop transport and rescue, reconnaissance, maritime patrols, aerial refueling, Electronic Warfare missions etc.	$P > P_B$	$P_B = 100 \cdot P_C$ $P_C < P \le P_B$	$P_C = 100 \cdot P_D$ $P_D < P \le P_C$	$P_D = 10 \cdot P_E$ $P_E < P \le P_D$	$P_E = P_{CUM\text{-}CAT} / N_{EC}$ $P \le P_E$
(S6) Aircraft in the combat, training etc. categories	$P > P_B$	$P_B = 100 \cdot P_C$ $P_C < P \le P_B$	$P_C = 100 \cdot P_D$ $P_D < P \le P_C$	$P_D = 10 \cdot P_E$ $P_E < P \le P_D$	$P_E = P_{CUM\text{-}CAT} / N_{EC}$ $P \le P_E$
(S7) APR MTOW< 15 kg	$P > P_B$	$P_B = 10 \cdot P_C$ $P_C < P \le P_B$	$P_C = 10 \cdot P_D$ $P_D < P \le P_C$	$P_D = 10 \cdot P_E$ $P_E < P \le P_D$	$P_E = P_{CUM\text{-}CAT} / N_{EC}$ $P \le P_E$
(S8) APR 15kg ≤ MTOW <150 kg	$P > P_B$	$P_B = 10 \cdot P_C$ $P_C < P \le P_B$	$P_C = 10 \cdot P_D$ $P_D < P \le P_C$	$P_D = 10 \cdot P_E$ $P_E < P \le P_D$	$P_E = P_{CUM\text{-}CAT} / N_{EC}$ $P \le P_E$
(S9) APR 150 kg ≤MTOW<750 kg	$P > P_B$	$P_B = 10 \cdot P_C$ $P_C < P \le P_B$	$P_C = 10 \cdot P_D$ $P_D < P \le P_C$	$P_D = 10 \cdot P_E$ $P_E < P \le P_D$	$P_E = P_{CUM\text{-}CAT} / N_{EC}$ $P \le P_E$
(S10) APR 750 kg ≤MTOW<4000kg [(5)]	$P > P_B$	$P_B = 100 \cdot P_C$ $P_C < P \le P_B$	$P_C = 10 \cdot P_D$ $P_D < P \le P_C$	$P_D = 10 \cdot P_E$ $P_E < P \le P_D$	$P_E = P_{CUM\text{-}CAT} / N_{EC}$ $P \le P_E$
(S11) MTOW ≥ 4000 kg [(5)]	$P > P_B$	$P_B = 100 \cdot P_C$ $P_C < P \le P_B$	$P_C = 100 \cdot P_D$ $P_D < P \le P_C$	$P_D = 10 \cdot P_E$ $P_E < P \le P_D$	$P_E = P_{CUM\text{-}CAT} / N_{EC}$ $P \le P_E$

Table 2

In the absence of technical rationale allowing a preliminary determination of the number of catastrophic events (N_{EC}) to be made, the following values can be used:

[5] If we adopt a threshold of 5670 kg to move to a cumulative requirement of $1x10^{-6}$, this weight must be considered as the new value for moving between the safety category (S10) and (S11) instead of 4000 kg.

Level of probability	**N_{EC} assumed**
(S1) Airplanes in the "Normal", "Utility" and "Acrobatic" categories with single alternative engine and weighing <6000 lb	10
(S2) Airplanes in the "Normal", "Utility" and "Acrobatic" categories with more than one alternative engine, or single turbine engine, and weight <6000 lb (S2) Helicopters with weight ≤20000 lb and number of passengers <10	10
(S3) Airplanes in the "Normal", "Utility" and "Acrobatic" categories, with weight ≥6000 lb	50
(S4) Airplanes in the "Commuter" category (S4) Airplanes in the "Large Aircraft" category (S4) Helicopters in the "Large Rotorcraft" with weight >20000 lb and any number of passengers, or ≤20000 lb and number of passengers ≥10	100
(S5) Aircraft in the category for troop transport and rescue, reconnaissance, maritime patrols, aerial refueling, Electronic Warfare missions etc.	100
(S6) Aircraft in the combat, training etc. categories	100
(S7) APR MTOW< 15 kg	10
(S8) APR 15kg ≤ MTOW <150 kg	10
(S9) APR 150 kg ≤MTOW<750 kg	10
(S10) APR 750 kg ≤MTOW<4000kg (5)	50
(S11) MTOW ≥ 4000 kg (5)	100

Table 3

The combination of the severity and probability levels defines the following risk indices:

Hazard Risk Index (HRI)	(1) CATASTROPHIC	(2) CRITICAL	(3) MAJOR	(4) MINOR	No effect on *safety*
(A) FREQUENT	1A	2A	3A	4A	No effect on *safety*
(B) PROBABLE	1B	2B	3B	4B	
(C) OCCASIONAL	1C	2C	3C	4C	
(D) REMOTE	1D	2D	3D	4D	
(E) IMPROBABLE	1E	2E	3E	4E	

The risk acceptability criterion is as follows:

DECISION:	**HIGH RISK UNACCEPTABLE:**	**LOW RISK ACCEPTABLE**
From (S1) to (S11)	1A, 1B, 1C, 1D, 2A, 2B, 2C, 3A, 3B 4A	1E, 2D, 2E, 3C, 3D, 3E, 4B, 4C, 4D, 4E

C.3.1.1 Special Conditions

Sometimes, for particular military operating requirements, some fault conditions could be characterized by a risk index (1D) due to limits of technical feasibility inherent in current technological possibilities. For these risk conditions, the System Responsible Company shall assess the possibility of establishing corrective provisions to reduce the risk, for example: redesign, introduction of safety devices, introduction of reliable monitoring and warning devices, appropriate, reliable and consolidated procedures for managing the risk via crew actions, inspection and maintenance actions.

When the residual risk cannot be further reduced within the acceptability criteria, Special Conditions must be established for these conditions.

The accepted Special Conditions must be limited in number and always justified with reasons purely technical in nature (for example, no feasible alternative solutions, reaching the technical limits inherent in the state of the art, lack of maturity of alternative technologies, required use of purely military solutions necessary to perform the mission etc.).

Remote catastrophic risk events (1D) accepted as Special Conditions should be the minimum necessary and should never exceed 10% of the total of catastrophic events (a value below 10% is desirable and a future reduction should be pursued).

Finally, it should be remembered that the condition of unrecoverable loss of thrust in single-engine aircraft has a probability of between $1x10^{-6}$ and $1x10^{-5}$ per flight hour.

This value is due to current limitations in engine design and the effects of such a loss of thrust should be evaluated on a case-by-case basis (e.g. the effects are catastrophic only for certain flight stages, with a consequent reduction of the exposure time) and compared with the acceptance criteria given above.

In the event that this risk condition is estimated to be unacceptable, all possible reductions must be found, and it must be decided whether to treat this condition as a Special Condition or request a dual-engine configuration.

NOTE

Special Conditions must be specified in the Technical Specifications File, and are part of the contractual technical requirement for safety.

C.3.2 SAFETY FORMULA

The probability values and aircraft classes for aircraft derived from civil models in the preceding section have been taken from EASA/FAA standards/guidelines (e.g. AC 23-1309-1C, AC 25.1309-1A, AC 29.1309, AMJ 25.1309), with their shortcomings outlined below.

- The classes are mainly defined according to weight and engine type criteria; this classification at times leads to bizarre conclusions. For example, the systems of an aircraft <6000lb with single alternative engine must be designed such that catastrophic failures have a probability per flight hour of $<1x10^{-6}$, while the same identical systems installed on a turboprop version of the same aircraft must satisfy a more stringent requirement of $1x10^{-7}$; if the same aircraft then has a slight weight increase to just above 6000lb, a requirement of $1x10^{-8}$ should be applied to its systems.

- The Hazard reference system in the civil aviation world is influenced by the number of passengers on board and does not take into consideration the risk to overflown parties; the definition of airworthiness in the military aviation field also considers the safety of overflown populations, which does not depend on the aircraft classes in the previous section (e.g. a large fleet of CS23 aircraft exposes overflown parties to a greater risk than a smaller number of CS25s, even though the number of passengers involved is smaller).
- Moreover, the military versions of aircraft derived from civil models do not normally transport the same number of passengers on board as the civil version (e.g. freighters or tankers), and as such the civil criteria of linking the safety classes to the number of passengers carried is not perfectly suited to the military aircraft configurations derived from them.
- Some of the assumptions used in AC 1309 to establish the hazard reference system are arbitrary (e.g. number of catastrophic failure conditions for each category).
- An important limit on the probability values of the previous section is that they are taken from statistical analysis performed on data relating to past experience in service, and as such are intrinsically linked to past technology, or at most to that currently used on aircraft in service.

  On the contrary, in many cases a new military program includes the requirements to introduce innovative technologies or increasingly reliable traditional systems (e.g. the reliability of engines is in continuous and rapid improvement); for this reason, these continuous technological improvements allow for an improvement in safety conditions over time.

  The advantage of the probability values of the previous section is therefore that they can be obtained with current technology, but it is advisable also to consider the possibility of increasing the levels of safety with the aid of continuous technological improvements.

On the basis of these considerations, a new method has been established for defining the safety requirements which overcomes some of the previous defects, keeping in consideration the total expected number of hours flown by a certain fleet.

The advantages of establishing the cumulative probability of catastrophic event per flight hour requirement as inversely proportional to the Total Exposure Time (defined as the expected number of aircraft produced multiplied by the design service life) are:

- When the expected number of hours flown by the fleet is high, the absolute probability of losing aircraft during their service lifetime increases, with negative effects on the safety of crew and overflown parties and on the costs and operational requirements of the Armed Forces.

- When the number of aircraft purchased is high, the possibility to invest in a safer projects (with a consequent increase in non-recurring costs), guaranteeing a lower absolute probability of aircraft being lost in service (with consequent large cost savings) increases; this means that it makes sense to quantify the absolute probability of losing aircraft in the initial procurement phases and to explore all possible and feasible technical solutions to reduce that probability to the minimum possible by investing the money saved by the foreseen reduction in lost aircraft in safety. To this end, use of the “ALARP (As Low As Reasonably Practical) risk” technique used by MoD-UK is recommended (DEF STAN 00-56).
- If the Total Exposure Time (expected number of flight hours of the fleet of all aircraft of one type) is high, the cumulative probability of a catastrophic event per flight hour established by the safety formula will be low, implying as a consequence a stricter hazard reference system and a potentially more reliable project; this increase in the reliability of a large fleet could lead to a reduction in maintenance costs, greater mission reliability and greater operational readiness.
- A stricter hazard reference system has strong impacts on the initial phases of the project (e.g. on the architectural choices of the systems) and allows the number of occurrence reports and corresponding costs to manage during the operational lifetime to be reduced; this could also have a positive impact on cost reduction of any future CTDs. The following extract from MIL-STD-882C, addressed to the Division Heads of the AAD should be considered:

SPECIAL ADVICE FOR THE PROGRAM MANAGER

You, the Program Manager (PM), should be aware that the issue of safety creates several conflicting incentives for contractors. Naturally, contractors have an incentive to avoid serious, flagrant hazards that may jeopardize the ultimate future of the program or cause them to incur liability for subsequent accidents. However, through the Engineering Change Proposal (ECP) process, contractors generally benefit from hazards allowed to creep into designs. ECPs are major profit centers. The most difficult ECPs for a PM to disapprove are those flagged "Safety." And if safety problems are allowed to be created and remain undetected until late in development, the fixes can wreak havoc with your budgets and schedules.

You acquire acceptably safe systems through a three step process. First, you need to prevent the initial creation of unnecessary hazards. You do this by communicating to the developer that safety is IMPORTANT to you personally. Insist they design it in, not add it on. Direct the developer (contractor) to sensitize design engineers to be attentive to system hazards while creating the design, so they may minimize the number and severity of hazards initially residing in the system. This first step has historically proven to be a significant cost and problem avoidance technique--one usually overlooked by PMs.

Next, carefully tailor a system safety activity to meet specific program needs. NOTE: If you omit the above first step, you will need a larger system safety effort to address the greater number and variety of hazards that will populate the design.

Lastly, you need to manage residual hazards. You do this by understanding their nature and impact, and assuring they are properly dispositioned. For hazards that are to be "accepted," take care to assure that this acceptance of risk occurs at the proper level of authority--generally the greater the risk, the higher the approval level needed for acceptance. Note that the higher level risks must be justified to the decision makers, not the Safety community.

The qualitative definitions provided by civil standards for probability levels are given below (what in the civil field is called "Extremely Improbable" corresponds to level "E" HRI, "Extremely Remote" to level "D", "Remote" to level "C", "Probable" to level "B"):

(E) *"Extremely Improbable Failure Conditions are those so unlikely that they are not anticipated to occur during the entire operational life of all aeroplanes of one type",*

(D) *"Extremely Remote Failure Conditions are those not anticipated to occur to each aeroplane during its total life but which may occur a few times when considering the total operational life of all aeroplanes of the type",*

(C) *"Remote Failure Conditions are those unlikely to occur to each aeroplane during its total life, but which may occur several times when considering the total operational life of a number of aeroplanes of the type",*

(B) *"Probable Failure Conditions are those anticipated to occur one or more times during the entire operational life of each aeroplane"*

Having established a correspondence between the probability threshold is and the total number of hours flown by the planned fleet (Total Exposure Time – TET).

From the previous considerations, we can derive a hazard reference system as follows:

<table>
<tr>
<td>

N_f = *planned number of aircraft in the fleet*

ESL = *Expected Service Life (fh)*

N_{EC} = *expected number of catastrophic events for the type of aircraft*

We shall define as $u_{\%}$ the number of Special Conditions with HRI (1D) – these conditions shall be referred to as “Undesirable”

$u_{\%} = \frac{\text{numero atteso di eventi di rischio (1D) Indesiderabili}}{N_{EC}}$

</td>
<td colspan="3">

TET (Total Exposure Time) $= N_f \times ESL$

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</tr>
<tr>
<td rowspan="5">
<table>
<tr><td></td><td>(1)</td><td>(2)</td><td>(3)</td><td>(4)</td></tr>
<tr><td>(A)
$p_B \leq p$</td><td>1A</td><td>2A</td><td>3A</td><td>4A</td></tr>
<tr><td>(B)
$p_C \leq p < p_B$</td><td>1B</td><td>2B</td><td>3B</td><td>4B</td></tr>
<tr><td>(C)
$p_D \leq p < p_C$</td><td>1C</td><td>2C</td><td>3C</td><td>4C</td></tr>
<tr><td>(D)
$p_E \leq p < p_D$</td><td>1D</td><td>2D</td><td>3D</td><td>4D</td></tr>
<tr><td>(E)
$p < p_E$</td><td>1E</td><td>2E</td><td>3E</td><td>4E</td></tr>
</table>
</td>
<td>$p^E_{IMPROBABLE} = \frac{1}{TET \times N_{EC}}$</td>
<td>$p < p_E$</td>
<td>*“It is not anticipated to occur during the entire operational life of all aeroplanes of one type”*</td>
</tr>
<tr>
<td>$p^D_{REMOTE} = \frac{1}{TET}$</td>
<td>$p_E \leq p < p_D$</td>
<td>*“It may occur a few times when considering the total operational life of all aeroplanes of the type”*</td>
</tr>
<tr>
<td>$p^C_{OCCASIONAL} = \frac{10}{TET}$</td>
<td>$p_D \leq p < p_C$</td>
<td>*“It may occur several times when considering the total operational life of a number of aeroplanes of the type”*</td>
</tr>
<tr>
<td>$p^B_{PROBABLE} = \frac{10}{ESL}$</td>
<td>$p_C \leq p < p_B$</td>
<td>*“It is anticipated to occur one or more times during the entire operational life of each aeroplane”*</td>
</tr>
<tr>
<td>*FREQUENT*</td>
<td>$p_B \leq p$</td>
<td>*“It is anticipated to occur frequently”*</td>
</tr>
</table>

Table 4

The previous table demonstrates the correspondence between the probability thresholds established as a function of the TET and the qualitative definitions supplied by EASA for each of them.

The cumulative probability of catastrophic event per flight hour should be calculated as follows:

No undesirable Special Conditions	CAT
(A) $p_B \leq p$	1A
(B) $p_C \leq p < p_B$	1B
(C) $p_D \leq p < p_C$	1C
(D) $p_E \leq p < p_D$	1D
(E) $p < p_E$	1E

$$p_{\substack{CUMUL \\ CATASTR}} = p^{E}_{IMPROBABLE} \times N_{EC}$$

$$p_{\substack{CUMUL \\ CATASTR}} = \frac{1}{TET}$$

(1D) Undesirable Special Conditions	CAT
(A) $p_B \leq p$	1A
(B) $p_C \leq p < p_B$	1B
(C) $p_D \leq p < p_C$	1C
(D) $p_E \leq p < p_D$	1D
(E) $p < p_E$	1E

Assuming that $u_{\%} \leq 0.10$ (no more than 10%) of the catastrophic *failures* are Undesirable *Special Conditions* (1D),

$$p_{\substack{CUMUL \\ CATASTR}} = p^{E}_{IMPROBABLE} \times (1 - u_{\%}) \times N_{EC} + \left(\frac{p^{D}_{REMOTE} + p^{E}_{IMPROBABLE}}{2} \right) \times u_{\%} \times N$$

$$p_{\substack{CUMUL \\ CATASTR}} = \frac{1 + u_{\%}/2 \times (N_{NEC} - 1)}{TET}$$

$$p_{\substack{CUMUL \\ CATASTR}} = \frac{K}{TET}$$

Table 5

The number of risk conditions (1D) accepted as Special Conditions must always be justified by technical motives and kept to the minimum possible (the concept "As Low As Reasonably Practical" - ALARP in DEF-STAN 00-56 may be adopted).

The number of Remote Catastrophic risks (1D) must be monitored from the initial stages of project feasibility, and should never exceed 10% of the total number of catastrophic failures. All reasonable efforts must be made to reduce the number of these events in the initial stage of pre-design and definition of the Technical Specifications File.

C.3.3 STATISTICAL SIGNIFICANCE OF THE SAFETY FORMULA

For faults of a random nature, characterized by a constant fault rate over time (thus excluding premature failure and wear), indicating the *failure rate* for catastrophic events with λ, defined as

$$\lambda = -\frac{1}{R}\frac{dR}{dt} \quad \left(\text{dove R(t)} = 1 - \text{F(t) è l'affidabilità al tempo t}\right)$$

the probability density function for catastrophic *failure* at the aircraft level is

$$f(t) = \lambda e^{-\lambda t}$$

The effects of the safety requirements on the absolute probability of a catastrophic event calculated over the number of hours flown by the single example produced are calculated *(Expected Service Life - ESL)*. *F(ESL)*, calculated as

$$F(ESL) = \int_0^{ESL} f(t)dt = 1 - e^{-\lambda \cdot ESL}$$

indicates the probability that a single aircraft example, produced in accordance with the design characterized by a certain *Catastrophic Failure Rate* λ, experiences the catastrophic event over the course of its life (*ESL*).
Equally, on an initial population of N_f aircraft all operating for *ESL* hours, the number of individuals to which the catastrophic event occurs at the end of the service life of the fleet is equal to $F(ESL) \times N_f$.
Performing a Taylor expansion of *F(t)* about zero, as λ is nevertheless much smaller than *ESL*,

$$F(t) = 1 - e^{-\lambda \times t} \approx \lambda \times t - \frac{(\lambda \times t)^2}{2} + \frac{(\lambda \times t)^3}{6} ... \Rightarrow F(ESL) \approx \lambda \times ESL$$

$$F(ESL) \times N_f \approx \lambda \times ESL \times N_f = \lambda \times TET$$

we find that the number of catastrophic events occurring on a fleet of N_f aircraft used for *ESL* hours is statistically estimated by the numerical coefficient *K= λ xTET* used in the *safety formula*.
Assuming that *K= λ xTET* is the number of expected catastrophic events, we can calculate the probability of X catastrophic events occurring using the Poisson distribution

$$p(X) = \frac{K^X}{X!}e^{-K}$$

The probability that the number of catastrophic events is less than or equal to X is

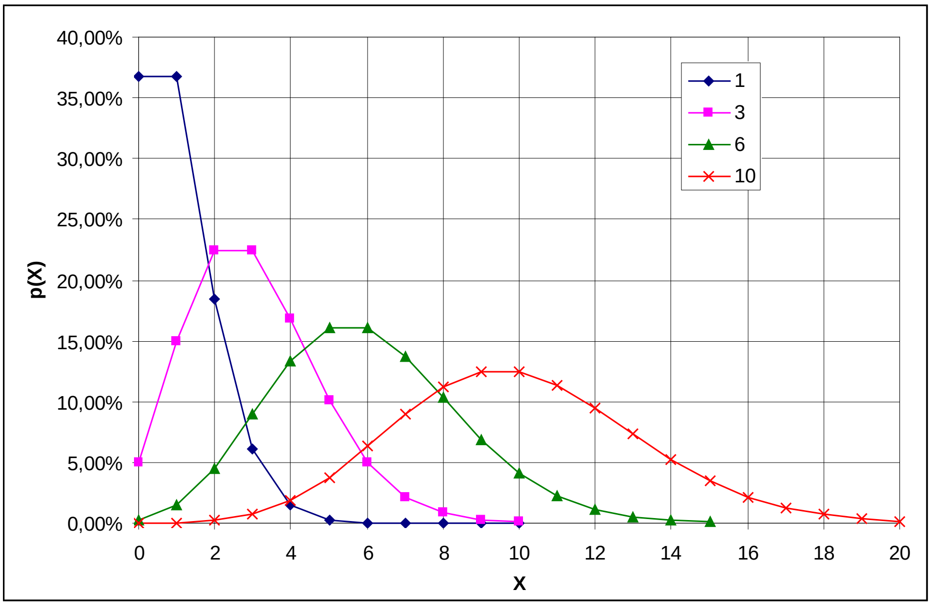
$$P(x \le X) = \sum_{i=0}^{X} \frac{K^i}{i!}e^{-K}$$

The probability that the number of catastrophic events is greater than X is

$$P(x > X) = 1 - \sum_{i=0}^{X} \frac{K^i}{i!}e^{-K}$$

Therefore, having established the Total Exposure Time, the number of catastrophic failures and the number of Undesirable Special Conditions (1D), the probability that a certain number of aircraft will be lost in service should be predicted, and an assessment made of whether that number is acceptable and the opportunity to insert a stricter requirement in the Technical Specifications File (when technically feasible).

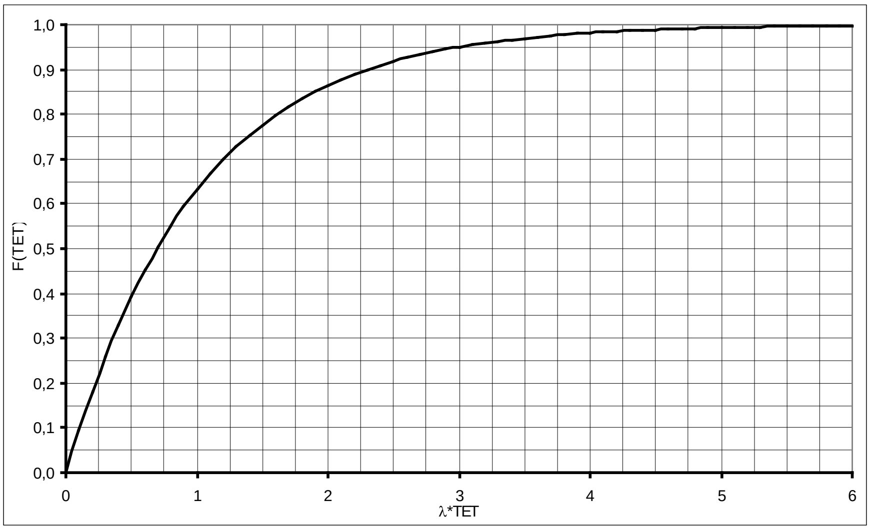
To be thorough, the diagrams of p(X) as a function of the coefficient K are given below:



Finally, the absolute probability *F(TET)* of a catastrophic event occurring during the service life of the fleet is represented

$$F(TET) = \int_{0}^{TET} f(t)dt = 1 - e^{-\lambda \cdot TET} = 1 - e^{-K}$$

λxTET	*F(TET)*
1	63.2%
1.5	77.7%
2	86.5%
2.5	91.8%
3	95.0%
3.5	97.0%
4	98.2%
4.5	98.9%
5	99.3%
5.5	99.6%
6	99.8%



Example (it should be noted that this example does not refer to any actual case):

<table>
<tr>
<td>Military aircraft, category (S6)
N_f = 300 CIs
ESL = 12000 (fh)
N_{EC} = 80 catastrophic events expected
$u_{\%}$ = 2 / 80 = 0.025</td>
<td colspan="2">$TET \text{ (Total Exposure Time)} = N_f \times ESL = 3.6 \times 10^6$
$P_{\substack{CUMUL \\ CATASTR}} = \frac{1 + u_{\%}/2 \times (N_{NEC} - 1)}{TET} = \frac{1.988}{TET} = 5.5 \times 10^{-7}$</td>
</tr>
<tr>
<td rowspan="5">
<table>
<tr><td></td><td>(1)</td><td>(2)</td><td>(3)</td><td>(4)</td></tr>
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<tr><td>(D)
$p_E \leq p < p_D$</td><td>1D</td><td>2D</td><td>3D</td><td>4D</td></tr>
<tr><td>(E)
$p < p_E$</td><td>1E</td><td>2E</td><td>3E</td><td>4E</td></tr>
</table>
</td>
<td>$p^E_{IMPROBABLE} = \frac{1}{TET \times N_{EC}} = 3.5\text{x}10^{-9}$</td>
<td>(E) $p < 3.5\text{x}10^{-9}$</td>
</tr>
<tr>
<td>$p^D_{REMOTE} = \frac{1}{TET} = 2.8\text{x}10^{-7}$</td>
<td>(D) $3.5\text{x}10^{-9} \leq p < 2.8\text{x}10^{-7}$</td>
</tr>
<tr>
<td>$p^C_{OCCASIONAL} = \frac{10}{TET} = 2.8\text{x}10^{-6}$</td>
<td>(C) $2.8\text{x}10^{-7} \leq p < 2.8\text{x}10^{-6}$</td>
</tr>
<tr>
<td>$p^B_{PROBABLE} = \frac{10}{ESL} = 8.3\text{x}10^{-4}$</td>
<td>(B) $2.8\text{x}10^{-6} \leq p < 8.3\text{x}10^{-4}$</td>
</tr>
<tr>
<td>FREQUENT</td>
<td>(A) $8.3\text{x}10^{-4} \leq p$</td>
</tr>
</table>

With this *hazard reference system*, the probability of losing a certain number of aircraft during the lifetime of the fleet is assessed:

X (number of aircraft)	$P_{\substack{CUMUL \\ CATASTR}} = \frac{1.988}{TET} = 5.52 \times 10^{-7}$	
	p(X)	P(x>X)
0	13.70%	86.30%
1	27.23%	59.07%
2	27.07%	32.01%
3	17.94%	14.07%
4	8.91%	5.16%
5	3.54%	1.61%
6	1.17%	0.44%
7	0.33%	0.11%
8	0.08%	0.02%
9	0.02%	0.00%
10	0.00%	0.00%
With a *Confidence Level* of around 99%, it is estimated that no more than 5 aircraft will be lost in service		

If the cumulative requirement is $1x10^{-6}$ per flight hour (in accordance with section C.3.1 of this Annex), the probability of losing a certain number of aircraft over the lifetime of the fleet would be as follows:

X (number of aircraft)	$P_{CUMUL\ CATASTR} = \frac{3.6}{TET} = 1 \times 10^{-6}$	
	p(X)	P(x>X)
0	2.73%	97.27%
1	9.84%	87.43%
2	17.71%	69.73%
3	21.25%	48.48%
4	19.12%	29.36%
5	13.77%	15.59%
6	8.26%	7.33%
7	4.25%	3.08%
8	1.91%	1.17%
9	0.76%	0.40%
10	0.28%	0.13%
With a *Confidence Level* of around 99%, it is estimated that no more than 8 aircraft will be lost in service		

C.3.4 THE PROCESS FOR DEFINING THE PROBABILISTIC SAFETY REQUIREMENTS

This section briefly clarifies the process that the AAD should follow to define the *safety* requirements in the Technical Specifications File, taking into consideration

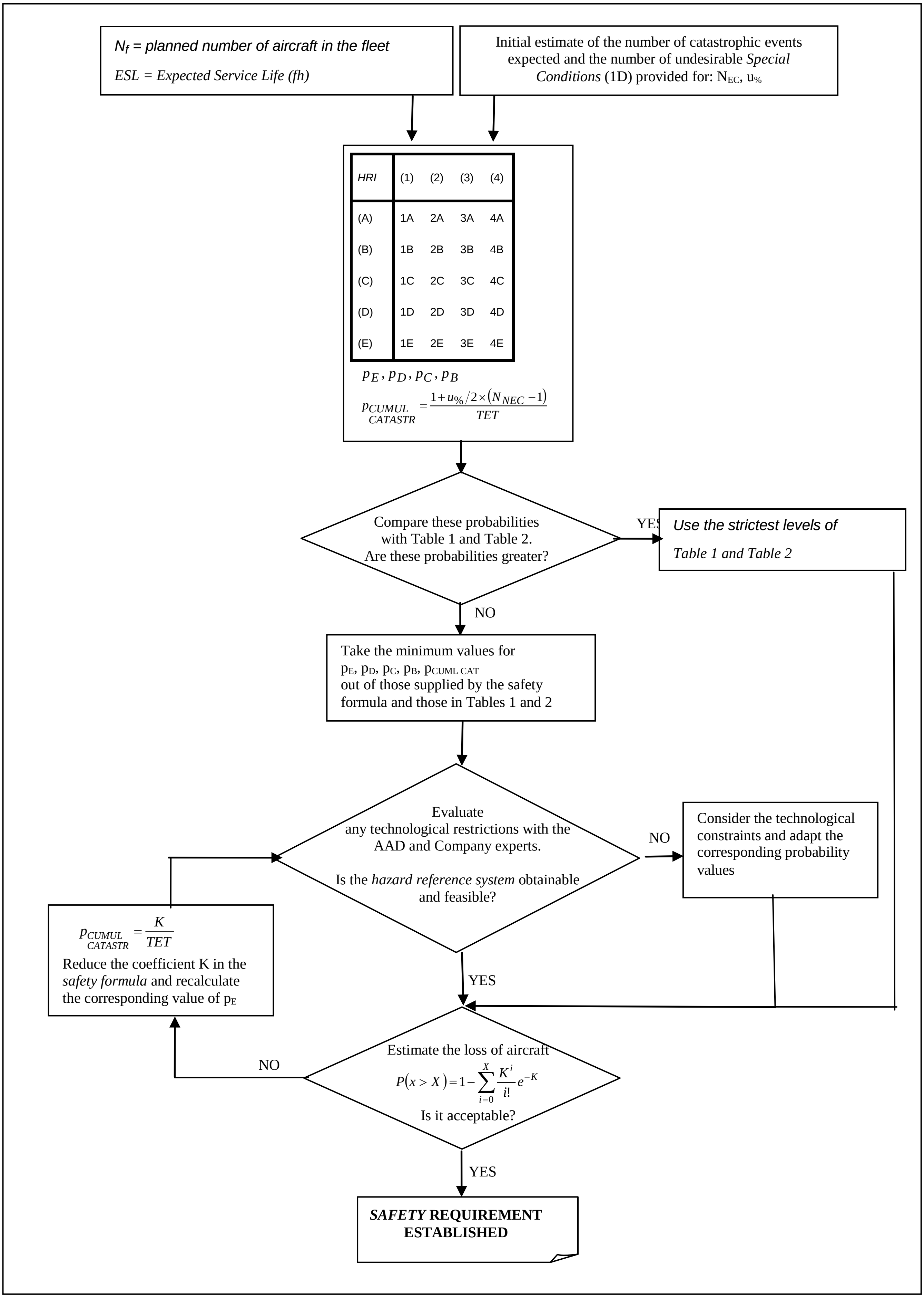
- The results of the *Safety Formula* (Table 4 and Table 5),
- The statistical predictions of the number of aircraft lost during the operating life of the fleet
- The values used in the past to set these requirements (Table 1 and Table 2 and Table 3),
- All technical constraints linked to technologies available at the present and in the future
- All *Special Conditions* due to military peculiarities of the systems or single-engine configurations

As specified in section C.3.2, the *Safety Formula* offers many advantages, and its use is recommended.

Nevertheless, it may occur that the requirement is too strict with regard to some technological constraints: in this case a *trade-off* must be made between the *safety* experts of the AAD and the company and the system specialists in order to evaluate alternative technologies or the potential need to develop new solutions.

If the results of the *Safety Formula* are less stringent than the probabilities in Table 1, the latter should be used to establish the requirement in the Technical Specifications File.

Figure 1 presents the overall process to correctly define the *safety* requirement as a *flow chart*, considering the aspects dealt with above.



N_f = planned number of aircraft in the fleet
ESL = Expected Service Life (fh)
Initial estimate of the number of catastrophic events expected and the number of undesirable Special Conditions (1D) provided for: N_{EC}, $u_{\%}$
HRI (1) (2) (3) (4)
(A) 1A 2A 3A 4A
(B) 1B 2B 3B 4B
(C) 1C 2C 3C 4C
(D) 1D 2D 3D 4D
(E) 1E 2E 3E 4E
p_E, p_D, p_C, p_B
$p_{CUMUL\ CATASTR} = \frac{1+u_{\%}/2\times(N_{NEC}-1)}{TET}$
Compare these probabilities with Table 1 and Table 2. Are these probabilities greater?
YES
Use the strictest levels of Table 1 and Table 2
NO
Take the minimum values for p_E, p_D, p_C, p_B, $p_{CUML\ CAT}$ out of those supplied by the safety formula and those in Tables 1 and 2
Evaluate any technological restrictions with the AAD and Company experts.
Is the hazard reference system obtainable and feasible?
NO
Consider the technological constraints and adapt the corresponding probability values
$p_{CUMUL\ CATASTR} = \frac{K}{TET}$
Reduce the coefficient K in the safety formula and recalculate the corresponding value of p_E
YES
Estimate the loss of aircraft
$P(x > X) = 1 - \sum_{i=0}^{X} \frac{K^i}{i!} e^{-K}$
Is it acceptable?
NO
YES
SAFETY REQUIREMENT ESTABLISHED

Figure 1

C.3.5 EXAMPLE OF APPLICATION

To better clarify the above, as an example the process of defining the safety requirements is applied to the case in section C.3.3 [this example does not apply to any actual case and all data used are arbitrary assumptions].

<table>
<tr><th>PROCESS</th><th>DECISION</th></tr>
<tr><td>Operational Requirements.

The Company estimates the size of the fleet from market requirements.</td><td>The AFs have an operational requirement for a certain number of military trainers, and the System Responsible Company of the aircraft chosen estimates a fleet of approximately 300 aircraft produced (between all customers).

Overall size of fleet: N_f = *300 CIs*
Design Service Life: ESL = 12000 (fh)</td></tr>
<tr><td>The AAD's and the Company's safety and system experts, from previous experience and analysis of the possible architectural choices, make a preliminary assessment of the expected number of catastrophic *failures* and any undesirable *Special Conditions* classified (1D).</td><td>N_{EC} = *80 expected number of catastrophic events*

Two (2) undesirable Special Conditions (1D) are estimated (e.g. 1 failure of the flight control system + 1 failure of the Armament Control System)

$u_{\%} = 2 / 80 = 0.025$</td></tr>
<tr><td>Application of the *Safety Formula*</td><td>$P_{CUM\text{-}CAT} < 5.5\text{x}10^{-7}$

(E) $p<3.5\text{x}10^{-9}$
(D) $3.5\text{x}10^{-9} \leq p < 2.8\text{x}10^{-7}$
(C) $2.8\text{x}10^{-7} \leq p < 2.8\text{x}10^{-6}$
(B) $2.8\text{x}10^{-6} \leq p < 8.3\text{x}10^{-4}$
(A) $8.3\text{x}10^{-4} \leq p$

<table>
<tr><th>HRI</th><th>(1)</th><th>(2)</th><th>(3)</th><th>(4)</th></tr>
<tr><td>(A)
(A) $8.3\text{x}10^{-4} \leq p$</td><td>1A</td><td>2A</td><td>3A</td><td>4A</td></tr>
<tr><td>(B)
$2.8\text{x}10^{-6} \leq p < 8.3\text{x}10^{-4}$</td><td>1B</td><td>2B</td><td>3B</td><td>4B</td></tr>
<tr><td>(C)
$2.8\text{x}10^{-7} \leq p < 2.8\text{x}10^{-6}$</td><td>1C</td><td>2C</td><td>3C</td><td>4C</td></tr>
<tr><td>(D)
$3.5\text{x}10^{-9} \leq p < 2.8\text{x}10^{-7}$</td><td>1D</td><td>2D</td><td>3D</td><td>4D</td></tr>
<tr><td>(E)
$p<3.5\text{x}10^{-9}$</td><td>1E</td><td>2E</td><td>3E</td><td>4E</td></tr>
</table></td></tr>
<tr><td>Compare the probability thresholds calculated using the *Safety Formula* with the values in Table 1 and Table 2.</td><td>
<table>
<tr><th>(S6) Table 1 and Table 2:</th><th>*Safety Formula*</th></tr>
<tr><td>*(E)* $p<1.25\text{x}10^{-8}$</td><td>*(E)* $p<3.5\text{x}10^{-9}$</td></tr>
<tr><td>*(D)* $1.25\text{x}10^{-8} \leq p < 1.25\text{x}10^{-7}$</td><td>*(D)* $3.5\text{x}10^{-9} \leq p < 2.8\text{x}10^{-7}$</td></tr>
<tr><td>*(C)* $1.25\text{x}10^{-7} \leq p < 1.25\text{x}10^{-5}$</td><td>*(C)* $2.8\text{x}10^{-7} \leq p < 2.8\text{x}10^{-6}$</td></tr>
<tr><td>*(B)* $1.25\text{x}10^{-5} \leq p < 1.25\text{x}10^{-3}$</td><td>*(B)* $2.8\text{x}10^{-6} \leq p < 8.3\text{x}10^{-4}$</td></tr>
<tr><td>*(A)* $1.25\text{x}10^{-3} \leq p$</td><td>*(A)* $8.3\text{x}10^{-4} \leq p$</td></tr>
<tr><td>$P_{CUM\text{-}CAT} < 1\text{x}10^{-6}$</td><td>$P_{CUM\text{-}CAT} < 5.5\text{x}10^{-7}$</td></tr>
</table></td></tr>
<tr><td>Take the minimum probability values from those supplied by the *Safety Formula* and those in Table 1 and Table 2.</td><td>$P_{CUM\text{-}CAT} < 5.5\text{x}10^{-7}$

<table>
<tr><th>HRI</th><th>(1)</th><th>(2)</th><th>(3)</th><th>(4)</th></tr>
<tr><td>(A)
(A) $8.3\text{x}10^{-4} \leq p$</td><td>1A</td><td>2A</td><td>3A</td><td>4A</td></tr>
<tr><td>(B)
$2.8\text{x}10^{-6} \leq p < 8.3\text{x}10^{-4}$</td><td>1B</td><td>2B</td><td>3B</td><td>4B</td></tr>
<tr><td>(C)
$1.25\text{x}10^{-7} \leq p < 2.8\text{x}10^{-6}$</td><td>1C</td><td>2C</td><td>3C</td><td>4C</td></tr>
<tr><td>(D)
$3.5\text{x}10^{-9} \leq p < 1.25\text{x}10^{-7}$</td><td>1D</td><td>2D</td><td>3D</td><td>4D</td></tr>
<tr><td>(E)
$p<3.5\text{x}10^{-9}$</td><td>1E</td><td>2E</td><td>3E</td><td>4E</td></tr>
</table></td></tr>
<tr><td>Evaluate any technological constraints with the AAD and</td><td>After evaluating the proceeding HRI table, it seems technically feasible to</td></tr>
</table>

<table>
<tr><th>PROCESS</th><th>DECISION</th></tr>
<tr><td>Company experts. Is the hazard reference system obtainable and technically feasible?</td><td>design the aircraft systems while satisfying those safety objectives, using reliable equipment and appropriate architectural choices to mitigate the severity of some failure conditions.</td></tr>
<tr><td>Statistically predict the number of aircraft lost during the fleet's service lifetime:
$$P(x > X) = 1 - \sum_{i=0}^{X} \frac{K^i}{i!} e^{-K}$$</td><td>
<table>
<tr><th rowspan="2">X
(number CIs)</th><th colspan="2">$P_{\substack{CUMUL\\CATASTR}} = \frac{1.988}{TET} = 5.52 \times 10^{-7}$</th></tr>
<tr><th>p(X)</th><th>P(x>X)</th></tr>
<tr><td>0</td><td>13.70%</td><td>86.30%</td></tr>
<tr><td>1</td><td>27.23%</td><td>59.07%</td></tr>
<tr><td>2</td><td>27.07%</td><td>32.01%</td></tr>
<tr><td>3</td><td>17.94%</td><td>14.07%</td></tr>
<tr><td>4</td><td>8.91%</td><td>5.16%</td></tr>
<tr><td>5</td><td>3.54%</td><td>1.61%</td></tr>
<tr><td>6</td><td>1.17%</td><td>0.44%</td></tr>
<tr><td>7</td><td>0.33%</td><td>0.11%</td></tr>
<tr><td>8</td><td>0.08%</td><td>0.02%</td></tr>
<tr><td>9</td><td>0.02%</td><td>0.00%</td></tr>
<tr><td>10</td><td>0.00%</td><td>0.00%</td></tr>
</table>
With a Confidence Level of around 99%, no more than 5 aircraft will be lost in service, or 1.67% of the fleet. Moreover, the probability of not having any catastrophic event during the operational lifetime of the fleet is just 13.7%.
The AAD does not consider this acceptable, and asks for every reasonable effort to be taken to use a stricter hazard reference system, taking any technological constraints into account.
</td></tr>
<tr><td>Reduction of the coefficient K in the Safety Formula.
$$p_{\substack{CUMUL\\CATASTR}} = \frac{K}{TET}$$</td><td>
<table>
<tr><th rowspan="2">X
(number CIs)</th><th colspan="2">$P_{\substack{CUMUL\\CATASTR}} = \frac{1}{TET} = 2.78 \times 10^{-7}$</th></tr>
<tr><th>p(X)</th><th>P(x>X)</th></tr>
<tr><td>0</td><td>36.79%</td><td>63.21%</td></tr>
<tr><td>1</td><td>36.79%</td><td>26.42%</td></tr>
<tr><td>2</td><td>18.39%</td><td>8.03%</td></tr>
<tr><td>3</td><td>6.13%</td><td>1.90%</td></tr>
<tr><td>4</td><td>1.53%</td><td>0.37%</td></tr>
<tr><td>5</td><td>0.31%</td><td>0.06%</td></tr>
<tr><td>6</td><td>0.05%</td><td>0.01%</td></tr>
<tr><td>7</td><td>0.01%</td><td>0.00%</td></tr>
<tr><td>8</td><td>0.00%</td><td>0.00%</td></tr>
<tr><td>9</td><td>0.00%</td><td>0.00%</td></tr>
<tr><td>10</td><td>0.00%</td><td>0.00%</td></tr>
</table>
With a confidence level of around 98%, no more than 3 aircraft will be lost, and the probability of having no catastrophic event in the operational lifetime of the fleet is around 37%, which is acceptable to the AAD.
</td></tr>
<tr><td>Evaluate the new requirement with the safety experts and system specialists of the AAD and the System Responsible Company in order to verify the technical feasibility.</td><td>
A reduction in the probability threshold for the failure conditions (1E) ($p<3.5\text{x}10^{-9}$) is not technically feasible for many system failures with catastrophic effects.
Nevertheless, a reduction in the cumulative probability of catastrophic event per flight hour may be obtained without modifying the HR matrix, via appropriate allocation of percentages of the cumulative value between the various aircraft systems.
</td></tr>
</table>

PROCESS	DECISION
SAFETY REQUIREMENT OF THE ESTABLISHED TECHNICAL SPECIFICATIONS FILE	$P_{CUM\text{-}CAT} < 2.8\text{x}10^{-7}$

HRI	(1)	(2)	(3)	(4)
(A) (A) $8.3\text{x}10^{-4} \leq p$	1A	2A	3A	4A
(B) $2.8\text{x}10^{-6} \leq p < 8.3\text{x}10^{-4}$	1B	2B	3B	4B
(C) $1.25\text{x}10^{-7} \leq p < 2.8\text{x}10^{-6}$	1C	2C	3C	4C
(D) $3.5\text{x}10^{-9} \leq p < 1.25\text{x}10^{-7}$	1D	2D	3D	4D
(E) $p < 3.5\text{x}10^{-9}$	1E	2E	3E	4E