POLITECNICO
MILANO 1863

SCUOLA DI
INGEGNERIA INDUSTRIALE E DELL'INFORMAZIONE

LAUREA MAGISTRALE IN
INGEGNERIA AERONAUTICA

CRITERIA FOR THE OVERSIGHT OF ATM/ANS ORGANISATIONS UNDER EASA'S FS.4.1 STANDARDISATION & OVERSIGHT SECTION

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2018/2019

DEDICATION

I am dedicating this Thesis to four people who have meant and continue to mean so much to me.
Although he is no longer of this world, first and foremost, to my paternal grandfather Mario, who taught me the value of honesty, which leads my every action.
Next, to the EASA's FS.4.1 Section Manager Manfred, one of the wisest and most experienced man I have ever met, who taught me to believe in myself.
Last but not least, to my parents, who have always loved me and done everything they could to make my life the best.

ACKNOWLEDGMENTS

While I alone am responsible for this thesis, it is nonetheless at least as much a product of years of interaction with, and inspiration by, a large number of friends and colleagues as it is my own work. For this reason, I wish to express my warmest gratitude to all those persons whose comments, questions, criticism, support and encouragement, personal and academic, have left a mark on this work. I also wish to thank those institutions which have supported me during the work on this thesis. Regrettably, but inevitably, the following list of names will be incomplete, and I hope that those who are missing will forgive me, and will still accept my sincere appreciation of their influence on my work.

I wish to thank all the kind EASA staff who contributed to make my experience enjoyable and extremely educational at the same time, supporting me during my staying, from the warm welcoming to the bittersweet goodbye.
Amongst those deserving particular mention, I would like to thank: my Section Manager Dieroff Mafred, who gave me adequate and achievable tasks and allowed my enrolment in courses of my interest and which improved my knowledge in the Safety domain; Kiss László, who was my mentor and scheduled my activities, tracking the progression of my understanding with milestones and targets to achieve; Emilio Mora Castro, Rivas Vila Manuel, Ferencz Ivan, Virlan Gabriel, Hoffman Helena, Klus Augustin, Harvey Paul, and Matthys Marc for the time spent taking care of my formation about the Oversight of ATM/ANS and ATCO Training Organisations; Algar Ruiz Maria and Terzieva Anastasiya for the immense knowledge sharing about EASA's rulemaking activities; Sekulic Predrag and Tarlie Ruxanda Simona for being the most polite and quiet deskmates ever.
Last but not least for what concerns the EASA's colleagues, thanks to Quist Jane, Chambroy Eric, Foltin Vladimir, Tyson Christopher Brian, Flavio De Nardis, Fayl Jagello, Cappuyns Thibaut, Chapuis Thomas, and Pagès Thomas for all the kind support; I will always remember them as friends, and I hope to meet them again in the future.

I also wish to thank Professor Oddone Italo, my Thesis advisor, for his academic supervision and personal suggestions about this research and Professor Cacciabue Pietro Carlo, who managed to transfer his passion for Aviation Safety to me.
I am also grateful to all the Professors of Politecnico di Milano whom I met during my studies about Aerospace and Aeronautical Engineering, such as: Trainelli Lorenzo, Cardani Cesare, Astori Paolo, Topputo Francesco, Janszen Gerardus, Quartapelle Procopio Luigi, Baron Arturo, Boffadossi Maurizio, Masarati Pierangelo, Frezzotti Aldo, Bottasso Carlo Luigi, Anghileri Marco, Cocchetti Giuseppe, Andriani Roberto, Cozzi Fabio, Miglietta Ferruccio, Finazzi Marco, Magnani Gianantonio, Rocco Paolo, Zich Riccardo, Sala Giuseppe, Ricci Sergio, Micheletti Stefano, Formaggia Luca, Vegni Federico Mario Giovanni, Buganza Tommaso, Bruglieri Maurizio, Colombo Fabrizio, Ganazzoli Fabio, and Rovida Edoardo.

Many thanks to my friends and colleagues Rojas Sandoval Juan Sebastián, Generali Marco, Khalid Balal, and Dicecca Filippo for their personal support during my studies and for all the collaborations that contributed to some successful achievements in my academic career.

I am also grateful to Impari Francesco e Poncia Alessandro for their sense of initiative and courageous entrepreneurship, pursuing a dream and turning it into a start-up company, which marked my life with a formative working experience.

Lastly, but most importantly, I wish to thank my parents, Fumagalli Ettore and Bolzoni Silvana; my gratitude to them is beyond words.

ABSTRACT

Compliance-based Oversight relies on the assumption that if an Organisation is fully compliant with the applicable safety requirements, then an adequate level of Safety is achieved. Experience has shown that simple compliance with prescriptive regulations does not guarantee Safety alone. In fact, this approach has proved to work since the early years of aviation and has helped to achieve the current safety levels. However, the regulatory environment in several domains, such as the one of Air Traffic Management, has reached a level of complexity where further safety improvements cannot be achieved by following a purely compliance-based approach. European Commission's and EASA's policy for continuous improvement are requiring the enhancement of the compliance-based Oversight with the implementation of a risk-based Oversight.

This Thesis focuses on the research of risk-based criteria for the review decision phase of the Oversight process for changes to the functional systems notified by any Organisations oversighted by the EASA's FS.4.1 ATM/ANS Standardisation & Oversight Section.

The found criteria are integrated in a scoring system which supports the experts in the review decision process, together with the proposal of a statistical method for the Group Absolute Probability Judgment.

The research represents the first attempt to the standardisation of the experts' decision-making process and lays the foundations for the evolution towards a risk-based approach to Safety.

KEYWORDS

EASA; Safety; ATM/ANS; SES; Regulation; risk; review decision, Standardisation; Oversight; Compliance; criteria; ATCO; scoring system; Fleiss' kappa; inter-rater reliability, Absolute Expert Judgment, Absolute Probability Judgment; expert judgment; Change Management

LONG ABSTRACT IN ITALIAN

Il compito principale di un'Autorità Competente consiste nell'attuare una sorveglianza continua dello stato di un'Organizzazione, verificandone il costante rispetto dei Requisiti di Sicurezza Essenziali, come richiesto dalle Norme di Conformità vigenti.

Le Organizzazioni che operano nel dominio della Gestione del Traffico Aereo ed offrono Servizi di Navigazione fanno uso di sistemi funzionali che consentono la Gestione del Traffico Aereo e sono tenute a notificare all'Autorità Competente qualsiasi modifica ai propri sistemi funzionali.

L'evento fondamentale attraverso il quale un'Organizzazione informa l'Autorità Competente a proposito di una modifica al proprio stato è la notifica di un cambiamento ai propri sistemi.

Alla ricezione di una notifica, la prima attività di Sorveglianza è la disamina della stessa al fine di verificare la costante rispondenza alle norme dello stato del sistema dell'Organizzazione.

Nel mondo della Gestione del Traffico Aereo, vi sono svariati tipi di modifiche ai sistemi e di schemi di classificazione della severità dei rischi al livello delle Organizzazioni sotto sorveglianza e, dopo diversi tentativi di standardizzarli attraverso un unico schema di classificazione delle severità dei rischi, EASA concluse che "uno schema di classificazione dei rischi universalmente accettabile non era fattibile al momento" [24 giugno 2014].

Di conseguenza, verrà rimosso dalle Norme future lo schema di classificazione della severità dei rischi presente nelle normative correnti e sul quale si basano attualmente le disamine obbligatorie, in favore di un approccio alla Sicurezza basato sul rischio e non solo sulla severità.

Difatti, sono davvero rari i casi in cui la severità dei rischi comportati da una modifica siano tali da rendere obbligatoria una disamina da parte dell'Autorità Competente, mentre la quasi totalità dei casi lascia all'Autorità la facoltà di decidere di effettuare o meno una disamina sulla base del giudizio degli esperti.

Le Normative future, in favore di un approccio più efficiente alla Sicurezza, impongono che le attività di Sorveglianza vertano appunto su criteri basati sul rischio, ma senza fornire ulteriori specifiche a riguardo.

Lo scopo della ricerca presentata nella Tesi è quello di fornire criteri di rischio per la valutazione delle modifiche ai sistemi funzionali delle Organizzazioni sotto la sorveglianza della Sezione FS.4.1 del Dipartimento di Standardizzazione e Sorveglianza di EASA.

Tali criteri sono stati ricercati analizzando le decisioni prese in passato dagli esperti della suddetta Sezione ed identificando fra esse gli aspetti comuni determinanti per la presa di una decisione di disamina di una modifica.

L'insieme dei criteri è stato inserito in un sistema a punteggi che supporta il giudizio del gruppo di esperti nell'atto decisionale ed è stato integrato con un metodo statistico che valuta l'affidabilità di tale giudizio in termini di condivisione della decisione; stando al metodo proposto, in linea con le procedure di EASA, la decisione può essere presa solo una volta che l'unanimità viene raggiunta.

L'esistenza di tali criteri è indice di un'armonizzazione presente nell'operato degli esperti e ne favorisce un'ulteriore standardizzazione. Il metodo proposto, in quanto introduce un approccio quantitativo e standardizzato all'analisi dei rischi, costituisce, inoltre, il primo passo evolutivo dalla Sorveglianza basata sulla sola Conformità alle Norme alla Sorveglianza basata sul rischio, in linea con quanto richiesto dalle Normative future.

Table of contents

Table of contents ....- 1 -
List of Figures ....- 6 -
List of Tables ....- 7 -
List of abbreviations and acronyms ....- 9 -
1. Safety and EASA....1
1.0 Content of Chapter 1 1
1.1 The evolution of the concept of Safety....2
1.1.1 The Aviation Eras....4
1.1.2 Safety Culture in ATM 7
1.1.3 The never-ending Improvement Cycle....9
1.1.4 From Safety-I to Safety-II 11
1.2 The Single European Sky legislative framework 12
1.2.1 The institutions of SES....12
1.2.1.1 The European Organisation for the Safety of Air Navigation....13
1.2.2 The SES I Package....14
1.2.3 The SES II Package....17
1.2.4 The EASA Basic Regulation and the Legislation structure 19
1.3 EASA: the European Authority in Aviation Safety....23
1.3.1 EASA missions 24
1.3.2 EASA tasks 24
1.3.3 The Total System Approach 25
1.3.4 EASA organisational structure 26
1.3.5 The Flight Standards Directorate 28
1.3.6 The ATM/ANS and Aerodromes Department....30
1.3.7 The ATM/ANS Standardisation & Oversight Section 31
2. The baselines for ATM/ANS Standardisation & Oversight 33
2.0 Content of Chapter 2 33
2.1 The ATM/ANS Standardisation & Oversight relevant legislation 34
2.2 Overview of the Standardisation Implementing Rule....36
2.2.1 Subject matter and scope 36
2.2.2 Principles applicable to monitoring 36
2.2.3 Principles applicable to inspections and findings 38
2.2.4 The types of inspections 38
2.2.5 Conduct of inspections....39
2.2.6 Classification of findings 42
2.2.7 Immediate Safety Concern....42
2.2.8 Annual report....42
2.3 Overview of both the Common Requirements and the Safety Oversight Implementing Rules 43
2.3.1 Subject matter and scope 43
2.3.2 Competent Authorities 43
2.3.3 Certification and demonstration of compliance 44
2.3.4 Subject matter and scope of the Oversight function 45
2.3.5 Safety Oversight of changes to functional systems 46
2.3.6 Review procedure of the proposed changes 46
2.3.7 Demonstration of compliance and corrective actions 48
2.4 Overview of the ATCO Regulation 49
2.4.1 Subject matter and scope 49

2.4.2 Provision of Air Traffic Control services 49
2.4.3 Competent Authority 50
3. The research of review decision criteria 51
3.0 Content of Chapter 3 51
3.1 The EASA procedure for ATM/ANS changes to functional systems 52
3.1.1 The review decision 53
3.1.2 The compliance plan agreement 55
3.1.3 The compliance demonstration assessment 56
3.1.4 The final report 57
3.2 Towards a Performance-Based and Risk-Based Oversight 59
3.3 Relevant elements of the New Implementing Rule 61
3.3.1 The Severity Classification Scheme 62
3.3.2 The risk-based criteria for the review decision 63
3.4 Introduction to the research of the selection criteria for the review decision 64
3.4.1 Justification, purpose, and scope 64
3.4.2 The requirements for the review criteria 66
3.4.3 The method 67
4. The Organisation selected for the research 69
4.0 Content of Chapter 4 69
4.1 The Organisations selected 70
4.2 The content of the following four chapters 71
5. The Network Manager 73
5.1 The Network Manager tasks 73
5.2 The Network Manager functional system 77
5.2.1 The Flight Systems 78
5.2.1.1 The Integrated Initial Flight Plan Processing System (IFPS) 78
5.2.1.2 The Repetitive Flight Plan System (RPL) 78
5.2.1.3 The IFPS Validation System (IFPUV) 79
5.2.2 The Flow Management Systems 80
5.2.2.1 The Enhanced Tactical Flow Management System (ETFMS) 80
5.2.2.2 The Pre-Tactical System (PREDICT) 81
5.2.2.3 The Centralised SSR Code Assignment and Management System (CCAMS) 81
5.2.3 The Environment Data Management Systems (ENV) 82
5.2.3.1 The Central Airspace and Capacity Database (CACD) 82
5.2.4 The Service Layer Systems and Client Applications 83
5.2.4.1 The Common User Access (CUA) 83
5.2.4.2 The Network Operations Plan Portal (NOP) 83
5.2.4.3 The CFMU Human Machine Interface (CHMI) 84
5.2.4.4 The Business-to-Business Services 84
5.2.4.5 The NM Ecosystem 84
5.2.5 The Support Systems 85
5.2.5.1 The Datawarehouse (DWH) 85
5.2.5.2 External communication 85
5.3 The Safety process for Network Manager’s changes to Functional System 86
5.3.1 The change classification and the Initial Safety Assessment 87
5.3.2 The System Safety Assessment 88
5.3.3 The Pre-Implementation Safety Case 89
5.3.4 The Post-Implementation Safety Case and monitoring 89
5.4 The typical changes to the Network Manager’s functional system 90
6. The European Aeronautical Information System Database 93
6.1 The EAD tasks and origins Background 93

6.1.1 The EAD clients 95
6.1.2 The Aeronautical Data 96
6.1.3 EAD tasks and benefits 99
6.2 EAD functional system 101
6.2.1 International NOTAM Operations (INO) 103
6.2.2 Static Data Operations (SDO) 104
6.2.3 Briefing Facility for ATS Reporting Offices (ARO) 105
6.2.4 Published AIP Management System (PAMS) 106
6.2.5 AIP/Chart Production tools 106
6.3 The typical Changes to the EAD functional system 107
7. The European Satellites Service Provider 109
7.1 EGNOS 109
7.2 EGNOS Services 110
7.2.1 Open Service (OS) 110
7.2.2 Safety-of-Life Service (SoL) 111
7.2.3 Commercial Data Distribution Service (CDD) 111
7.3 The EGNOS functional system 112
7.3.1 The Space Segment 114
7.3.2 The Ground Segment 115
7.3.2.1 EGNOS Central Processing Facility and Navigation Chain 117
7.3.3 The User Segment 118
7.4 Changes to the EGNOS functional system 119
7.4.1 EGNOS change types 119
7.4.1.1 Major PEA Releases 120
7.4.1.2 Minor PEA Releases 121
7.4.1.3 Product Support Services 122
7.4.2 The EGNOS Change Management Process 123
7.4.3 The sharing of responsibilities among the EGNOS exploitation Organisations 124
7.5 The typical Changes to the EGNOS functional system 127
8. ATCO Training Organisations 129
8.1 The phases of the ATCO training 129
8.1.1 The Initial Training 130
8.1.1.1 The Basic Training 130
8.1.1.2 The Rating Training 131
8.1.2 The Unit Training 132
8.1.2.1 The Transitional Training 132
8.1.2.2 The Pre-On-The-Job Training 133
8.1.2.3 The On-The-Job Training 133
8.1.3 The Continuation Training 134
8.1.3.1 The Refresher Training 134
8.1.3.2 The Conversion Training 134
8.1.4 Training of instructors and assessors 135
8.2 ATCO Training Organisations systems 136
8.3 The characteristics of the selected ATCO Training Organisations 138
8.1 Changes in the Training Organisations 139
8.1.1 Changes requiring approval 139
9. The criteria of the Risk-Based Oversight 141
9.0 Content of Chapter 9 141
9.1 ICAO's considerations about the Safety Risk Management 142
9.2 The criteria for the review decision phase 143
9.2.1 The proposal for review criteria 144

9.2.1.1 Criterion 1: severity of the potential hazard effects 146
9.2.1.2 Criterion 2: novelty and relevance of previous feedbacks 147
9.2.1.3 Criterion 3: scope (extent and complexity) 149
9.2.1.4 Criterion 4: impact on the architecture 150
9.2.1.5 Criterion 5: impact on the operational procedures and processes 151
9.2.1.6 Criterion 6: impact on the performances 152
9.2.1.7 Criterion 7: impact on the human resources 153
9.2.2 Verification of the Review Criteria method 154
9.2.3 Absolute Expert Judgement and additional considerations over the method 155
9.2.4 The Fleiss' kappa method 157
9.2.5 Advanced Absolute Expert Judgement 158
9.3 The criteria for the auditing phase of the RBO 159
9.3.1 The Organisation's risk profile 161
9.3.2 The Organisation's safety performance 162
9.3.3 Challenges within the model for the RBO 163
10. Conclusions 165
10.0 Content of Chapter 10 165
10.1 Limitations, implications, and recommendations 166
Bibliography 169
References 170
APPENDIXES 171
A. Taxonomy I
a. Process II
b. Procedure II
c. Audit II
d. Corrective action II
e. Objective evidence II
f. Requirement III
g. Review III
h. Verification III
i. Validation III
j. Certification III
k. Certificate IV
l. Organisation IV
m. Network function IV
n. Network Manager IV
o. Equipment IV
p. Hardware IV
q. Software IV
r. Functional system V
s. Hazard V
t. Risk VI
u. Safety VI
v. Safety argument VI
w. Safety directive VII
x. Safety objective / Safety criterion VII
y. Safety requirement VII
z. Safety regulatory audit VII
aa. Accident VIII
bb. Serious incident VIII
B. AIS definitions IX

a. NOTAM IX
b. ASHTAM IX
c. SNOWTAM IX
d. Pre-flight information bulletin (PIB) IX
e. Aeronautical Information Circular (AIC) IX
f. Aeronautical Information Publication (AIP) IX
g. Integrated Aeronautical Information Package (IAIP) IX
C. The Regulation Structure I
D. The EU Legislation for ATM/ANS & ADRs II
E. Procedure for ATM/ANS changes to functional systems V
a. Review decision V
b. Compliance plan agreement VI
c. Compliance demonstration assessment VIII
d. Final report X
F. ATCO rating training and endorsements I
G. Fleiss' kappa equations and examples I
a. Example of perfect agreement II
b. Example of perfect disagreement III
c. Example of partial agreement IV
d. Examples of partial agreement with increased number of raters V

List of Figures

Figure 1.1-1 accident rates and Onboard Fatalities by year 4
Figure 1.1-2 ten year moving average fatal accident rate by aircraft generation per million flights (1997-2016) 5
Figure 1.1-3 the Eras of safety evolution 6
Figure 1.1-4 the key elements of Safety Culture 7
Figure 1.1-5 the evolution of Aviation Safety 9
Figure 1.1-6 the Deming Wheel 10
Figure 1.2-1 the Institutions of SES 13
Figure 1.2-2 the Committee procedure 21
Figure 1.2-3 the Legislation structure 22
Figure 1.3-1 the Member States 23
Figure 1.3-2 EASA Total System Approach 25
Figure 1.3-3 the EASA organisational structure (2017/12/15) 27
Figure 1.3-4 the Flight Standards Directorate organisational structure (2017/12/15) 29
Figure 1.3-5 the ATM/ANS & Aerodromes Section organisational structure (2017/12/15) 30
Figure 1.3-6 ATM/ANS services and functions 31
Figure 2.1-1 Standardisation Inspection domains 35
Figure 2.2-1 the Continuous Monitoring Approach 37
Figure 2.2-2 the Standardisation Inspections process 39
Figure 2.2-3 some details on the Reporting Phase 41
Figure 5.1-1 the Network Manager context 75
Figure 5.1-2 the Network Manager in 2016 infographic 76
Figure 5.2-1 the Flow Management Systems 80
Figure 5.2-2 the Common User Access System architecture 83
Figure 5.3-1 the Network Manager Safety process 86
Figure 6.2-1 the EAD functional system 102
Figure 7.3-1 EGNOS functional architecture 112
Figure 7.3-2 the footprint of EGNOS GEO satellites 114
Figure 7.3-3 RIMS sites 116
Figure 7.3-4 EGNOS data-flows 118
Figure 7.4-1 Major PEA change path 120
Figure 7.4-2 Minor PEA change path 121
Figure 7.4-3 scope of the CMP within the overall EGNOS exploitation 123
Figure 7.4-4 the main actors in the evolution of EGNOS 124
Figure 8.1-1 the possible Initial Training ratings and endorsements for the student ATCO 131
Figure 8.2-1 the ATCOs and the OPS environment 136
Figure 9.3-1 the model for the On-Going RBO 160
Figure 10.1-1 overview of the modification of the definition of ‘hazard’ V
Figure 10.1-2 the full Cause/Hazard/Accident Model (Bow Tie Model) VI
Figure 10.1-3 Regulation structure I
Figure 10.1-4 part 1: BR 216/2008 & implementing measures II
Figure 10.1-5 part 2: Regs 549-550-551-552/2004 & implementing measures III
Figure 10.1-6 part 3: other relevant EU Leg IV
Figure 10.1-7 the procedure for the review decision phase V
Figure 10.1-8 the procedure for the compliance plan agreement phase (1/2) VI
Figure 10.1-9 the procedure for the compliance plan agreement phase (2/2) VII
Figure 10.1-10 the procedure for the compliance demonstration assessment phase (1/2) VIII
Figure 10.1-11 the procedure for the compliance demonstration assessment phase (2/2) IX

Figure 10.1-12 the procedure for the final report phase (1/2) ... X
Figure 10.1-13 the procedure for the final report phase (2/2) ... XI

List of Tables

Table 1.1-1 an overview of Safety-I and Safety-II ... 11
Table 2.3-1 the CR-IR severity classification scheme ... 45
Table 4.1-1 the oversighted Organisations having a functional system ... 70
Table 7.4-1 the roles of the major actors in the delivery of EGNOS SIS ... 126
Table 8.3-1 the characteristics of the selected ATCO Training Organisations ... 138
Table 9.2-1 example of application of the Review Criteria and calculation of the Total Score ... 144
Table 9.2-2 the Review Criteria ... 145
Table 9.2-3 example of characteristics triggering different Review Criterion 1 levels (CR-IR) ... 146
Table 9.2-4 example of characteristics triggering different Review Criterion 1 levels (NR-IR) ... 146
Table 9.2-5 example of characteristics triggering different Review Criterion 2 levels ... 148
Table 9.2-6 example of characteristics triggering different Review Criterion 3 levels ... 149
Table 9.2-7 example of characteristics triggering different Review Criterion 4 levels ... 150
Table 9.2-8 example of characteristics triggering different Review Criterion 5 levels ... 151
Table 9.2-9 example of characteristics triggering different Review Criterion 6 levels ... 152
Table 9.2-10 example of characteristics triggering different Review Criterion 7 levels ... 153
Table 9.2-11 the reference intervals for the Total Score ... 154
Table 9.2-12 the best matching between the already taken decisions and those based on the proposed model ... 154
Table 9.2-13 Fleiss' kappa adaptation to the Review Criteria ... 157
Table 10.1-1 example of perfect agreement ... II
Table 10.1-2 example of complete disagreement ... III
Table 10.1-3 example of partial agreement ... IV
Table 10.1-4 example of partial agreement with increased number of raters ... V
Table 10.1-5 example of partial agreement with increased number of raters ... V

List of abbreviations and acronyms

AAE	ATM/ANS Expert
ABAS	Airborne Based Augmentation System
ACP	Area Control Procedural
ACP	Area Control Procedural
ACS	Area Control Surveillance
ADI	Aerodrome Control Instrument
ADR	Aerodrome
ADV	Aerodrome Control Visual
AFIS	Aerodrome Flight Information Services
AFTN	Aeronautical Fixed Telecommunication Network
AFTN	Aeronautical Fixed Telecommunication Network
AFTN	Aeronautical Fix Telecommunication Network
AGA	Aerodromes and Ground Aids
AIP	Aeronautical Information Publication
AIR	Air Control
AIRAC	Aeronautical Information Regulation and Control
AIS	Aeronautical Information Service
AISP	Aeronautical Information Service Provider
AL	Alerting Services
AMC	Acceptable Means of Compliance
AME	Accuracy Major Event
AMHS	ATS Message Handling System
ANS	Air Navigation Services
ACNZ	Airways Corporation of New Zealand Limited
ANSP	Air Navigation Service Provider
AO	Air Operator
APJ	Absolute Probability Judgment
APP	Approach Control Procedural
APS	Approach Control Surveillance
APV	Approach with Vertical guidance
AR	ATCO Regulation
Art. / Arts.	Article / Articles
AS	Advisory Services
ASDI	Aircraft Situation Display to Industry
ASQF	Application Specific Qualification Facility
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATFCM	Air Traffic Flow and Capacity Management
ATFM	Central Unit for Air Traffic Flow Management
ATM	Air Traffic Management
ATS	Air Traffic Services
ATSP	Air Traffic Services Provider
AUP	Airspace Use Plans
B2B	Business To Business
BR	Basic Regulation
C/A	Coarse/Acquisition
CAA	Civil Aviation Authority
CAT I/II/III	Category I/II/III

CBA	Cost-Benefit Analysis
CCAMS	Centralised Code Assignment and Management System
CCB	Configuration Control Board
CCF	Central Control Facility
CDM	Collaboration Decision-Making
CDM	Collaborative Decision Making
CFMU	Central Flow Management Unit
CHMI	CFMU Human Machine Interface
CMP	Change Management Process
CNES	Centre National d'Études Spatiales
CNS	Communications, Navigation and Surveillance
COTS	Commercial-Off-The-Shelf
CPF	Central Processing Facility
CR	Change Request
CR	Common Requirements
CRB	Change Regulatory Basis
CR-IR	Common Requirements Regulation
CS	Certification Specification
CSST	Call Sign Similarity Tool
CT	Certification Directorate
CUA	CFMU Access Services
DA/H	Decision Altitude/ Height
DAB	Digital Audio Broadcast
DoC	Declaration of Conformity
DOP	Dilution Of Precision
DoV	Declaration of Verification
DPI	Departure Planning Information
DSNA	Direction des Services de la Navigation Aérienne
DSS	Directorate Single Sky
DSU	Declaration of Suitability for Use
DWH	Data Warehouse
EACCC	European Aviation Crisis Coordination Cell
EAD	European AIS Database
EASA	European Aviation Safety Agency
EC	European Commission
ECAA	European Common Aviation Area
ECAC	European Civil Aviation Conference
ED	Executive Director
EDAS	EGNOS Data Access Service
EFTA	European Free Trade Association
EGNOS	European Geostationary Navigation Overlay Service
ELG	EASA Learning Gateway platform
ENAIRE	Aeropuertos Españoles y Navegación Aérea
ENT	EGNOS Network Time
ERND	European Route Network Design
ESA	European Space Agency
ESR	EGNOS System Release
ESSP	European Satellite Services Provider
ETFMS	Enhanced Tactical Flow Management System
ETRF	EGNOS Terrestrial Reference Frame
ETSO	European Technical Standard Orders

EU	European Union
EWA	EGNOS Working Agreement
EWAN	EGNOS Wide Area Network
FAA	Federal Aviation Administration
FAAS	Flight Assessment and Alerting System
FAB	Functional Airspace Block
FAF	Final Approach Fix
FAM	Flight Activation Monitoring
FAR	Federal Aviation Regulations
FAS DB	Final Approach Segment Data Block
FB	Functional Block
FDE	Fault Detection and Exclusion
FHA	Functional Hazards Assessment
FIR	Flight Information Region
FIS	Flight Information Services
FMP	Flow Management Positions
FPL	Flight Plan
FR	Framework Regulation
FS	Flight Standards Directorate
GAGAN	GPS Aided GEO Augmented Navigation
GBAS	Ground Based Augmentation System
GEO	Geostationary Satellite
GIVD	Grid Ionospheric Vertical Delay
GIVE	Grid Ionospheric Vertical Error
GLONASS	Globalnaya Navigatsionnaya Sputnikovaya Sistema (Russian transliteration)
GLS	GNSS Landing System
GM	Guidance Material
GMC	Ground Movement Control
GMS	Ground Movement Surveillance
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GPS	Global Positioning System
GPST	GPS Time
GSA	European GNSS Agency
HAL	Horizontal Alert Limit
HMI	Hazardous Misleading Information
HNSE	Horizontal Navigation System Error
HPE	Horizontal Position Error
HPL	Horizontal Protection Level
ICAO	International Civil Aviation Organization
ICD	Interface Control Document
IERS	International Earth Rotation and Reference Systems Service
IFPS	Initial Flight Plan Processing System
IGS	International GNSS Service
IMF	IM Foundation
IP	Industry Prime
IS	Interface Specification
ISRO	Indian Space Research Organisation
ITRF	International Terrestrial Reference Frame
ITU	International Telecommunications Union
Leg	Legislation

LNAV	Lateral Navigation
LP	Localiser Performance
LPV	Localizer Performance with Vertical guidance
LPV	Localizer Performance with Vertical guidance
M&C	Monitoring & Control
MCC	Mission Control Centre
MDA/H	Minimum Descent Altitude/ Height
MET	Meteorological Services
MI	Misleading Information
MOPS	Minimum Operational Performance Standards
MRD	Mission Requirements Document
MSAS	MTSAT Satellite-based Augmentation System
MT	Message Type
NAA	National Aviation Authority
NLES	Navigation Land Earth Station
NM	Network Manager
NMD	Network Management Directorate
NMOS	Network Manager Operational Services
NOF	NOTAM Office
NOP	Network Operations Portal
NOTAM	Notice to Airmen
NPA	Non-Precision Approach
NPMI	Network Performance Monitoring and Improvement
NR-IR	New Regulation
NSA	National Supervisory Authority
NTS	Network Manager Technical Systems
OCN	Oceanic Control
OCS	Operational Control System
OJTI	On-The-Job Training Instrucor
OS	Open Service
PACF	Performance and Check-out Facility
PAR	Precision Approach Radar
PBN	Performance Based Navigation
PEA	Product Evolution Activities
PENS	Pan-European Network Service
PNT	Precise Navigation and Timing
PRN	Pseudo-Random Noise
PS	Performance Standard
PSS	Product Support Services
PSSA	Preliminary System Safety Assessment
QMS	Quality Management System
RAD	Aerodrome Radar Control
RAIM	Receiver Autonomous Integrity Monitoring
RBO	Risk-based Oversight
RD	Reference Document
RDS	Radio Data System
Reg	Regulation
RF	Radio Frequency
RFF	Radio Frequency Function
RHCP	Right Hand Circularly Polarised
RIMS	Range and Integrity Monitoring Station

RNAV	Area Navigation
RNP	Required Navigation Performance
RPL	Repetitive Flight Planning
RS	Resources and Support Directorate
RTCA	Radio Technical Commission for Aeronautics
RTCM	Real Time Correction Message
SAFA	Safety Assessment of Foreign Aircraft
SARP	Standards and Recommended Practice
SBAS	Satellite-Based Augmentation System
SCS	Safety Critical Services
SDCM	System of Differential Correction and Monitoring
SDD	Service Definition Document
SERA	Standardised European Rules of the Air
SES	Single European Sky
SESAR	SES ATM Research
SI	International System of Units
SID	Standard Instrument Departure
SIS	Signal-In-Space
SMS	Safety Management System
SMS	Safety Management System
SO-IR	Safety Oversight Regulation
SoL	Safety-of-Life
SPR	Service Provision Regulation
SPS	Standard Positioning Service
SPU	Service Provision Unit
SRA	Surveillance Radar Approach
SRD	System Required Document
SREW	Satellite Residual Error for the Worst user location
SSM	Strategy and Safety Management
SSR	Secondary Surveillance Radar
SSR	Secondary Surveillance Radar
STAM	Short-Term ATFCM Measure
STAR	Standard Arrival Route
STDI	Synthetic Training Device Instructor
STD-IR	Standardisation Regulation
TCF	Transponder Code Function
TCL	Terminal Control
TCL	Terminal Control
TEC	Total Electron Content
TF	Technical File
TN	Technical Note
TTA	Time-To-Alert
TWAN	Transport Wide Area Network
TWR	Tower Control
UDRE	User Differential Range Error
UERE	User Equivalent Range Error
UNDAF	University of North Dakota Aerospace Foundation
UIVD	User Ionospheric Vertical Delay
US	United States
USAF	United States Air Force
USG	United States Government

UUP	Updated Airspace Use Plans
VAL	Vertical Alert Limit
VNAV	Vertical Navigation
VPE	Vertical Position Error
VPL	Vertical Protection Level
WAAS	Wide Area Augmentation System
WGS84	World Geodetic System 84 (GPS Terrestrial Reference Frame)
WUL	Worst User Location

1. Safety and EASA

"Your safety is our mission"
EASA's motto

1.0 Content of Chapter 1

This chapter acts as introduction containing all the background elements that should be taken into account before dealing with the core part.

Paragraph 1.1 explains how the changes the Aviation world has faced, from its origins to the complex reality of nowadays, are reflected in the dynamical evolution of the concept of Safety within the specific context of Air Traffic Management (ATM). After this interesting historical review of the past evolution, it is instead taken a quick glance to the future, and it is given a general presentation of the most modern approach to Safety.

After this panoramic time-travel journey through the Aviation History, Paragraph 1.2 focuses on the last two decades. Once the main European actors have been introduced, it is given a detailed explanation of the reasons triggering the need for the *Single European Sky* (SES) Legislative framework, which witnessed the establishment and the growth of the European Aviation Safety Agency (EASA). The Paragraph ends with an overall description of the Legislative structure.

Lastly, Paragraph 1.3 provides an inside view of EASA, starting from dealing with the general missions and tasks, then proceeding like a magnifier zooming into the Directorates and the Departments to end up right in the specific Section where this Thesis has been developed: the FS.4.1 Standardisation & Oversight Section.

1.1 The evolution of the concept of Safety

The major actors in the Safety domain, do not have a common understanding of the definitions related to Safety as they have given different meanings to the same term or concept.
Different organisations, departments or individuals already have an understanding of what a term means based on their environment and previous knowledge. However, sometimes, their understanding may not be the same as others or the same as the *official* definition.
In some cases, the same organisation has to manage with two different definitions for the same concept.

A necessary condition for an efficient communication is the sharing of the same understanding of the terms and concepts involved in the communication itself.

Hence, this introductory chapter aims at bringing some order and properly clarifying the term having the utmost importance of all in Aviation: 'Safety'.[1]

The definition of Safety and especially its management have drastically evolved over time, continuously adapting to the challenges the overwhelming growth of the Aviation world has faced.

Before giving a detailed definition about what Safety is, it could be interesting to start from having a look at what Safety is *not* and understanding *why*.

First of all, proceeding this way prevents falling into the most common misconceptions and, secondly, trying to confute them may directly lead to the proper way about how to approach and manage it.

Safety is not just:

- ⊗ the elimination of accidents
- ⊗ the freedom from danger
- ⊗ the avoidance of errors and mistakes
- ⊗ the absence of harm
- ⊗ the regulatory compliance

Safety is something related to the misconceptions listed above, but is more than that, it is something different.
The elimination of aircraft accidents and serious incident is the ultimate goal of Safety and despite the most accomplished prevention efforts, failures and errors may occur.
Aviation cannot be completely free of hazards and associated risks.

What it is possible to do, in order to consider a system as adequately safe, is instead controlling risks and errors with the intention of reducing them to an acceptable level.

Dr. James T. Reason considers Safety as "the 'engine' that drives the system towards the goal of sustaining the maximum resistance towards its operational hazards"[2].

---

[1] Other important and recurrent terms and concepts used hereinafter are instead defined, explained and discussed in Appendix A.
[2] Definition provided in [5].

Within the contest of Aviation, the International Civil Aviation Organization (ICAO) defines Safety as:

> "the state in which the possibility of harm to persons or of property damage is reduced to, and maintained at or below, an acceptable level through a continuing process of hazard identification and safety risk management." [3]

Safety clearly is a dynamic characteristic of the aviation system and its monitoring has to be continuous. As long as safety risks are kept under an appropriate level of control, a system as open and dynamic as aviation can still be managed to maintain the appropriate balance between production and protection.

It is important to note that the acceptability of safety performance is often influenced by domestic and international norms and culture.

Therefore, when dealing with Safety, *Standardisation & Oversight* functions cannot be left out of consideration.

[3] Definition provided in [2].

1.1.1 The Aviation Eras

In this paragraph, it is made a reference to some data in order to refine the previously given definition of Safety with further and essential detail. The data are taken from graph which are broadly known to the Aviation world, but which are often not analysed with a critical eye or combined with some fundamental concepts.

Figure 1.1-1 accident rates and Onboard Fatalities by year[4] shows what probably is the most famous aeronautical statistic: the accident rates recorded in the last sixty years.

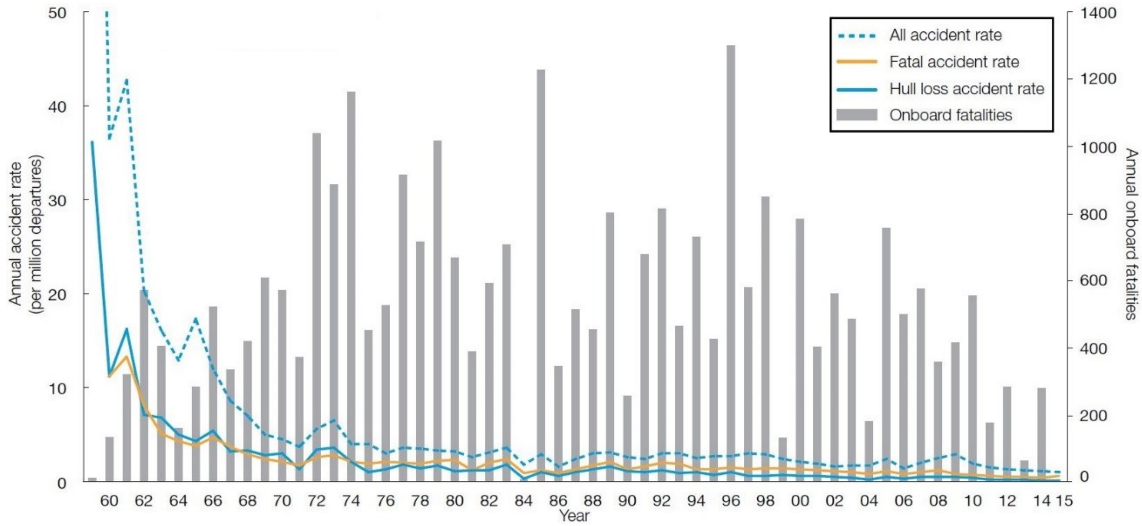

Figure 1.1-1 accident rates and Onboard Fatalities by year

The improvement achieved is evident without any doubt, but what is really interesting is to understand what has made this outcome possible.

The period between the early 1900s until the late 1960s called the ‘Technical Era’.
During the Technical Era, aviation emerged as a form of mass transportation in which identified safety deficiencies were initially related to technical factors and technological failures. The focus of safety endeavours was therefore placed on the investigation and improvement of technical factors. By the 1950s, technological improvements led to a gradual decline in the frequency of accidents, and safety processes were broadened to encompass regulatory compliance and Oversight.

If at that time Safety was technically-driven, it is also true that Technology was – and always will be – Safety-driven, but the point is that the concept of Safety was based on the assumption that a safety improvement could be achieved by means of reducing technical failures.

Later on, during the 1970s, Safety was approached in a new and different way, and a suggestion to understand how the relation between Technology and Safety changed after the 1960s is given by how aircraft are grouped in classified in Aviation History.

[4] The graph and the data are taken from [9].

In Aviation History, aircraft are divided in the following four generation groups:

- First generation (since the 1950s) comprising early commercial jets [5]
- Second generation (since the 1960s) comprising jets having more integrated auto-flight [6]
- Third generation (since the 1980s) comprising glass cockpit jets [7]
- Fourth generation (since the 1990s) comprising fly-by-wire jets [8]

The big step between the first and the ensuing ones is reflected by the gradual switch of the pilots' role from actors to observers. This is due to the fact that humans were seen as enemies to Safety and system devices were introduced in order to reduce pilots workload and human error.
This period, from the early 1970s until the mid 1990s, is in fact called the 'Human Factor Era'.
During the Human Factor Era, the focus of safety endeavours was extended to include human factors issues including the man/machine interface. This led to a search for safety information beyond that which was generated by the earlier accident investigation process, bringing to major technological advances.
Figure 1.1-2[9] focuses on the last two decades, making a clear distinction amongst the last aircraft generations.

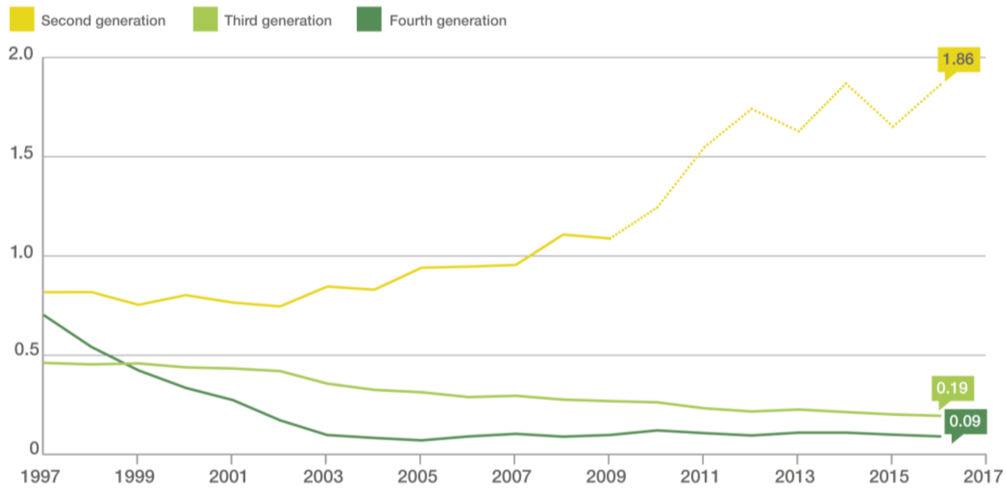

Figure 1.1-2 ten year moving average fatal accident rate by aircraft generation per million flights (1997-2016)

[5] Jets belonging to this category have dials and gauges in cockpit and early auto-flight systems.
Examples are: Comet, Caravelle, Trident, VC-10, B707, 720, DC-8, Convair 880/890.

[6] Jets belonging to this category have integrated auto-pilot and auto-throttle systems.
Examples are: Concorde, A300 (except A300-600), BAC111, B727, B737-100/200, B747-100/200/300/SP, F28, L1011 A300B2/B4, Mercure, F-28, BAe146, VFW 614, L-1011, DC-9, DC-10.

[7] Jets belonging to this category have a fully integrated Flight Management System with Terrrain Avoidance Systems to reduce the likelihood of incursion into a Controlled Flight Into Terrain (CFIT).
Examples are: A310, A300-600, Avro RJ, F-70, F-100, 328JET, B737-300/400/500, B717, B737-600/700/800 (NG), B737 MAX, B757, B767, B747-400, B747-8, B717, BAE 146, MD11, MD80, MD90, F70, F100, Bombardier CRJ Series, Embraer ERJ 135/145, 737 Classic & NG.

[8] Jets belonging to this category have fly-by-wire technology enabled flight envelope protection to reduce the Loss of Control in Flight (LOC-I) accidents.
Examples are: A318/A319/A320/A321 (including neo), A330, A340, A350, A380, B777, B787, Embraer E-Jets, Bombardier C-Series, Embraer E170/E175/E190/E195.

[9] The figure and relative data are taken from [2].

Looking back again at Figure 1.1-1 and comparing the situation of the mid 1970s with to the one of the mid 1990s, there is not such a difference.
Throughout all the 1980s, despite the investment of resources in error mitigation, human performance continued to be cited as a recurring factor in accidents.

Considering both Figure 1.1-1 accident rates and Onboard Fatalities by year and Figure 1.1-2, while excluding the data referred to the second aircraft generation which is closer and closer to obsolescence, the situation in the mid 1970s for last two generations is very different from the current one. Furthermore, the discrepancy is still perceivable between the mid 1990s and nowadays. This means that something more has been acknowledged and something very significant has been introduced.

Until the early 1990s, the application of Human Factors science tended to focus on the individual, without fully considering the operational and organizational context. Then, it was finally acknowledged that individuals operate in a complex environment, which includes multiple factors having the potential to affect behaviour.

This marked the beginning of the 'Organisational Era'.
During the organisational Era, Safety began to be viewed from a systemic perspective, which was to encompass organisational factors in addition to human and technical factors. Traditional data collection and analysis efforts, which had been limited to the use of data collected through investigation of accidents and serious incidents, were supplemented with a new *proactive* approach to Safety. This new approach is based on routine collection and analysis of data using *proactive* as well as *reactive* methodologies to monitor known safety risks and detect emerging safety issues. As a result, the notion of the 'organisational accident'‖ was introduced, considering the impact of Organisational Culture and policies on the effectiveness of safety risk controls.

Figure 1.1-3 shows the timeline of the different safety Eras.

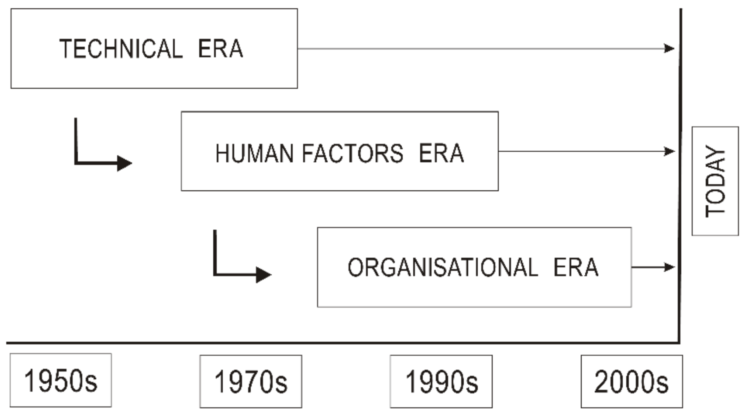

Figure 1.1-3 the Eras of safety evolution

In the next paragraph it is given a more detailed description of the just mentioned Organisational Culture concept, which is more properly known as 'Safety Culture'.

1.1.2 Safety Culture in ATM

The term 'Safety Culture' was first applied in the aftermath of the Chernobyl nuclear disaster[10], event that clearly brought to light the fundamental role that managerial and human factors have on safety performance.

Safety Culture is the level at which Safety is perceived, valued and prioritised at all stages of an Organisation: it is measurable and improvable.

Figure 1.1-4 the key elements of Safety Culture

Figure 1.1-4 illustrates the piece composing the complex puzzle of Safety Culture, which are briefly explained as follows:

- commitment
  Safety should be given the maximum priority in organisational planning and day to day operations, both at the management and operational levels
- involvement
  each individual, from the employee to the Manager, should take part in discussions and activities aiming to the improvement of Safety
- responsibility
  responsibility for Safety should be accepted at each level, from the single individual to the whole Organisation
- learning and reporting
  it should be granted by the Organisation policy that any report of safety occurrences is a precious resource to increase Safety and not a weapon to be used in order to blame someone's mistakes
- teaming
  cooperation and coordination between the parts makes the communication safe and efficient, hence lowering the possible misunderstandings

[10] The document where it first appears is [5].

Safety Culture is paramount to the global goal of Safety: there will be no safe world if the actors involved do not take Safety Culture in proper consideration.

Safety Culture has a direct impact on safe performance, as far as whenever its importance is underestimated – even just temporarily – tendencies to unsafe behaviours may take place, such us workarounds, cutting corners, or wrong decisions.
This reduction of *situational awareness* is more likely to occur in environments where the risk is perceived as *low* rather than *high*.
This is exactly the case of Air Traffic Management (ATM)[11], as it is commonly considered a very safe sector, both in quantitative and qualitative measures, due for example to the low accident rates[12] and to the travel perceptions by the flying payload.

One of the ATM biggest challenges is to adapt the services to the increasing traffic demand[13] without affecting the exceptional safety performance level achieved. Safety Culture improvement in ATM is a major strategic safety objective in Europe both in the short term and throughout the Single European Sky ATM Research (SESAR) programme. Anyway, this continuously changing environment, commercial pressures, systematic changes as for SESAR, and rapid growth may favour the introduction of vulnerabilities into the system and some particular conditions may induce people to take risky actions, putting safety under treat.
Looking back again at Figure 1.1-2 and focusing on the accident rate curve of the Fourth Generation of aircraft – which, of course, is the predominant one in the forthcoming years –, it is clear that a limit has been reached.
Hence, the unavoidable growth of the Aviation market expected in the next decades, in combination with a flat accident rate statistical datum, automatically translates in an expected increase in the number of accidents.

With this in mind, even if ATM is perilously perceived as "enough safe" *now*, it is also perceived as soon to be "no more safe enough" *in the future* if no action will be taken.

In order to proactively react against this issue, it must be introduced another fundamental concept, which is at the basis of the Safety Culture improvement, and, hence, of overall Safety: the Deming Wheel methodology, which is discussed in the following paragraph.

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[11] It is assumed that the reader is aware of what ATM consists of. Anyway, in order to jog the reader's memory, it is here replicated the definition given by ICAO in [23]: ATM is the dynamic, integrated management of air traffic and airspace including air traffic services, airspace management and air traffic flow management — safely, economically and efficiently — through the provision of facilities and seamless services in collaboration with all parties and involving airborne and ground-based functions. Furthermore, Figure 1.3-6 in Subparagraph 1.3.7 may also help.

[12] Data from accident reports do confirm the highest level of Safety reached in this sector. To give some examples, in the last decade the total fatal accident rate is 0.29 per million departures [3], while just in 2016 there were 0.15 fatal accidents and 0.39 hull losses per million flight cycles [2] and 47% of the accidents on jet aircraft ended with a normal disembarkation [12].

[13] The International Air Transport Association (IATA) expects 7.2 billion passengers to travel in 2035, a near doubling of the 3.8 billion air travellers in 2016. The prediction is based on a 3.7% annual Compound Average Growth Rate (CAGR) noted in the release of the latest update to the association's "20-Year Air Passenger Forecast" [11].

1.1.3 The never-ending Improvement Cycle

In addition to the reasons mentioned in the previous paragraph, there are there is at least another fundamental aspect of the modern Aviation world whose implications suggest the need to do more: the relentless pace of technological change.

When the technological change was way slower than now, the focus of regulatory prescriptive requirements was limited to the individuation of *common causes* of failures; during the Technical Era, Safety Management was limited to the Quality Management, mainly concerned about certification of parts.
A further step was taken when it was recognised that Safety was not just about the elements involved, but also in the way those were managed, which means in the procedures, so that the approach to Safety evolved from Quality Control of components to Quality Assurance about procedures.
Of course, without compliance there cannot be any Safety Management, but compliance alone does not guarantee that an Organisation is operating safely: it is understandable that not all the possible causes of accidents and incidents, nor their combinations, could be covered by regulations.
Especially now, the new business models have to cope with the fast pace of the technological change, which involves the introduction of a raising number and variety of novelties into the systems and the reduction of the time-to-market for new products.
As a consequence, the focus of Organisations' Safety risk controls has moved from the relatively simple individuation of *common causes* to the more complex consideration of *random causes* behind all the possible things that may result harmful and that could not be caught by the regulations.
Therefore, the approach to Safety has evolved from *prescriptive* to *performance based* and more 'technology neutral'.
Figure 1.1-5 summarises those concepts about the evolution the management of Safety has undergone, moving from a prescriptive approach to a performance based one.

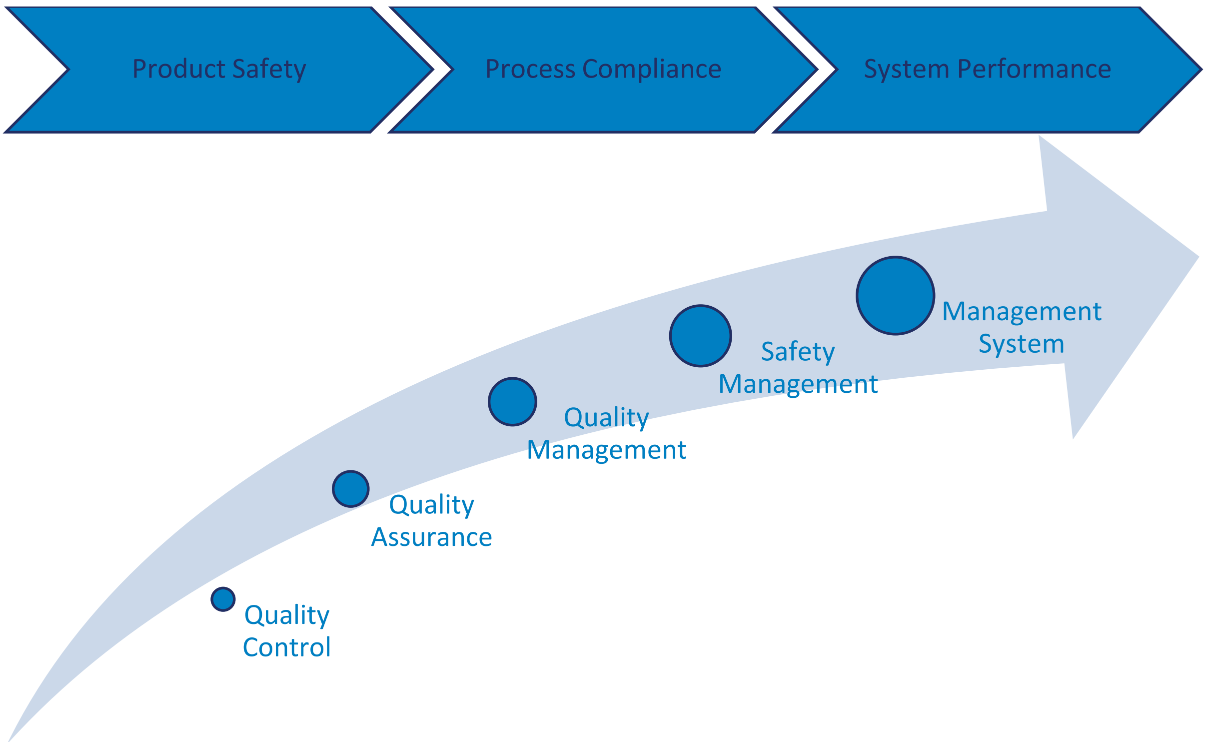

Figure 1.1-5 the evolution of Aviation Safety

The concept of continuous improvement is at the basis of Safety and should be applied to each safety-related process.
Generally, a process is defined as what transforms inputs into outputs by way of a sequence of activities which are described by procedures carried out by persons and/or equipment called actors.[14]

The Deming Wheel is a series of steps that are used to analyse and improve a process.
There are four steps that operate in a feedback loop, and the steps are repeated over and over again as a cycle of continuous improvement. Figure 1.1-6 shows these four steps listed as follows:

PLAN, the step during which root causes are searched using different techniques
DO, the step during which the previously identified root causes are analysed and their solutions are developed and evaluated
CHECK, the step during which solutions are measured and adapted if required
ACT, the step during which the improved solutions are implemented and integrated in the normal process

Figure 1.1-6 the Deming Wheel

In light of increasing demands and growing system complexity, the approach to Safety must be adjusted. Again, the one shown in Figure 1.1-2 is a safety-related Key Performance Indicator of an approach that is going to become obsolete in a few decades.

In the next paragraph it is very briefly described the utmost advanced approach to Safety.

[14] The word "process" is defined in ISO 9000:2015 clause 3.4.1 as a "set of interrelated or interacting activities that use inputs to deliver an intended result.". Whether the “intended result” of a process is called output, product or service depends on the context of the reference. It is also stated that “processes in an organization are generally planned and carried out under controlled conditions to add value.”

1.1.4 From Safety-I to Safety-II

As proposed by Professor Erik Hollnagel[15], the new way of looking at Safety, mainly relies on the points summarised in the following Table 1.1-1:

	Safety-I	Safety-II
definition of Safety	that as few things as possible go wrong	that as many things as possible go right
Safety Management principle	reactive, respond when something happens or is categorised as an unacceptable risk	proactive, continuously trying to anticipate developments and events
view of the human factor in Safety Management	humans are predominantly seen as a liability or hazard and are a problem to be fixed	humans are seen as a resource necessary for system flexibility and resilience and provide flexible solutions to many potential problems
accident investigation	the purpose of accident investigation is to identify the causes, seen as failures and malfunctions	the purpose of an investigation is to understand how things usually go right as a basis for explaining how things occasionally go wrong, as soon as basically happen in the same way, regardless of the outcome
Risk Assessment	the purpose of risk assessment is to identify the likelihood of contributory factors, seen as failures and malfunctions	understanding the conditions where performance variability can become difficult or impossible to monitor and control

Table 1.1-1 an overview of Safety-I and Safety-II

It is important to emphasise that Safety-I and Safety-II represent two complementary views of Safety rather than two incompatible or conflicting approaches. Many of the existing practices can therefore continue to be used, although possibly with a different emphasis.
Far from the scope of this Thesis is to analyse which new types of practices should be included to foster the transition to a Safety-II view.

Sufficient depth has been reached to understand the evolution of the concept of Safety with the due rigor, from its known origins to the new forecast future frontiers.

The following paragraphs are instead focused on a shorter time frame, which comprises the present situation and just the immediate future.
The Deming Wheel is relentlessly spinning in each Department of EASA and particular attention is paid to the fresh *proactive* steering of the Oversight activities.

[15] Further details can be found in [15].

1.2 The Single European Sky legislative framework

The liberalisation of the European aviation market in 1993 made travel much more accessible and affordable and has stimulated growth in air services. But the constraints on airspace capacity in Europe resulted in more delays. Delay was not only due to a shortage of capacity, it was also caused by the fact that Air Traffic Control (ATC) in Europe was fragmented and inefficient. It was also hampered by heterogeneous working practices and constrained by air route networks which, in the main, are based on national borders and not on air traffic flows. Furthermore, large areas of European airspace reserved for military use when in fact they may not be needed.
In airspace which is roughly the same size, Europe has almost forty enroute Air Navigation Service Providers (ANSPs) and the USA has just one, serving roughly twice as many flights as Europe with the same costs. [16]

The Single European Sky (SES) initiative puts forward a legislative approach to solve these issues and enable ATM to cope with projected future traffic demand. [17]

1.2.1 The institutions of SES

The drawing up of the Legislative framework for the SES, as shown in Figure 1.2-1, involves five of the seven[18] principal decision making Bodies of the European Union (EU), which are:

- the **European Parliament**, exercising the legislative function without formally possessing the right of legislative initiative and being composed by 751 Members directly elected every five years by universal suffrage
- the **European Council**, defining the EU's overall political direction and priorities (the EU's policy agenda) comprising the heads of State or Government of the Member States (MSs), alongside its own President and the one of the European Commission (both non-voting)
- the **Council of the EU** (the Council of Ministers, or sometimes just **the Council**), exercising the legislative function, representing the executive Governments of the EU's MSs and being composed by 28 national ministers (one per State)
- the **European Commission** (EC), exercising the legislative function with the right of *legislative initiative*, implementing decisions, upholding the EU Treaties and managing the day-to-day business of the EU, being composed by 28 members (one per State and informally known as "commissioners") bound by their oath of office to represent the general interest of the EU as a whole rather than their home State
- the **European Court of Justice** (officially just the **Court of Justice**), interpreting EU law and ensuring its equal application across all EU MSs, being composed by 28 Judges who are assisted by 11 Advocates-General and all appointed by common accord of the Governments of the MSs and holding office for a renewable term of six years

[16] Data can be found by the interesting and pretty much up to date comparison of the ATM/ANS provision in EU and USA carried out by EC, EUROCONTROL, and FA, in [22].
[17] A more in-depth view of SES, than the one given in this Chapter, can be found in [6].
[18] The other two bodies are the European Central Bank and the Court of Auditors.

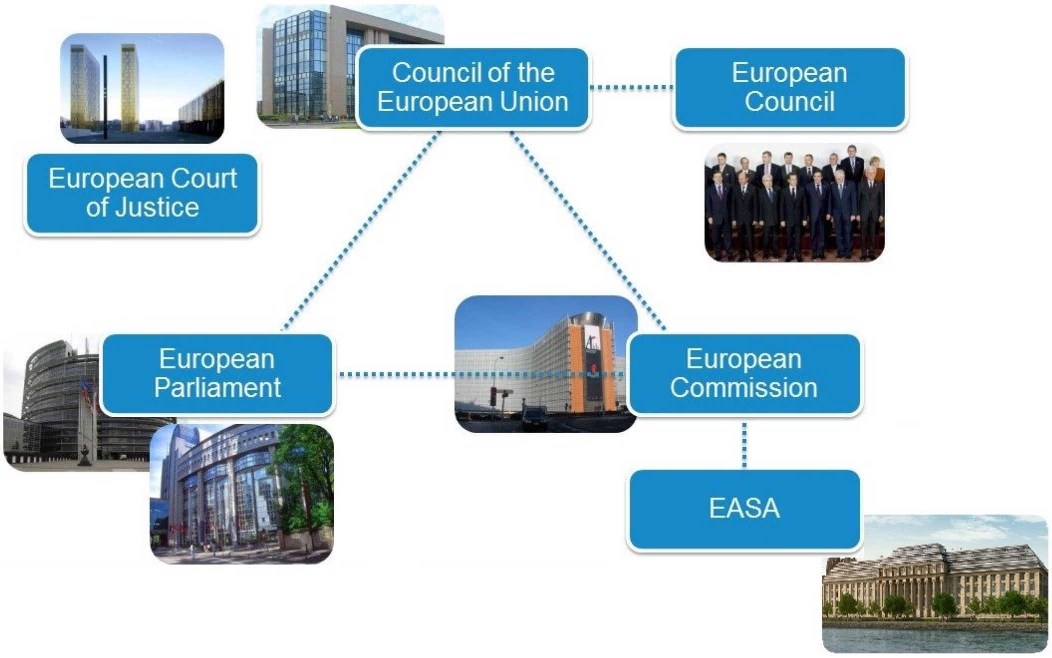

Figure 1.2-1 the Institutions of SES

As suggested by the link between EC and EASA shown in Figure 1.2-1, one of EASA's tasks consists in helping the EC's rulemaking activities by supporting the draft of Regulations, an activity previously entirely carried out by the European Organisation for the Safety of Air Navigation (EUROCONTROL)[19] even in the field of ATM.

As a response to the dramatic growth in air travel witnessed in the last two decades, EC passed two SES packages to create a legislative framework for European aviation.
Those Packages, the SES I and the SES II ones, are presented in the following paragraphs, 1.2.2 and 1.2.3 respectively.

1.2.1.1 The European Organisation for the Safety of Air Navigation

Another big player in the SES, deserving a dedicated mention, is the European Organisation for the Safety of Air Navigation, commonly known as EUROCONTROL.

Founded in 1960, EUROCONTROL is an international Organisation which the EU has delegated parts of its SES Regulations to, making it the central Organisation for ATM across Europe.
The EU itself is a signatory of EUROCONTROL and all EU MSs are presently also members of EUROCONTROL, which currently has 41 MSs and is headquartered in Brussels, Belgium.

The Organisation works with National Aviation Authorities (NAAs), ANSPs, civil and military airspace users, airports, and other Organisations to achieve the safest and most seamless ATM across Europe.

[19] EUROCONTROL is briefly introduced in Subparagraph 1.2.1.1, while the role-shift between EUROCONTROL and EASA for the rulemaking support in the ATM field is commented in Paragraph 1.2.3.

1.2.2 The SES I Package

The SES initiative was launched in 2000 by EC following the severe delays to flights in Europe experienced in 1999. A *High Level Group*[20] was established and, building on the recommendations in its report, the Commission drafted a legislative package at the end of 2001. It aimed to:

- enhance Safety of air transport in Europe
- improve cost-efficiency
- reduce delays to air transport passengers
- create additional capacity
- reduce the airspace fragmentation
- promote the introduction of new technologies
- improve the interoperability between systems and technologies
- improve the integration of military systems into the European ATM system

The legislative SES I Package consists of the four SES Regulations (Regs.) of the European Parliament and of the Council of 10 March 2004 listed below:

- Reg. (EC) No 549/2004[21] (the Framework Regulation) or (FR)
- Reg. (EC) No 550/2004[22] (the Service Provision Regulation) or (SPR)
- Reg. (EC) No 551/2004[23] (the Airspace Regulation) or (ASR)
- Reg. (EC) No 552/2004[24] (the Interoperability Regulation) or (IOR)

The main results achieved through the first package are here summarised:

- the strengthening of Safety, through:
  - the separation between Service Provision and Oversight functions
  - the establishment of National Supervisory Authorities (NSAs)
  - the EU certification of the ANSPs
  - the adoption of Safety Regulatory Requirements in the Law of the EU
- the setting up of a more efficient institutional framework and decision-making process ensuring adequate involvement of all stakeholders, through:
  - the creation of a Single Sky Committee, consisting of representatives from the civil and military authorities and with the participation of ICAO and third countries, to assist the Commission in adopting enabling legislation
  - the creation of an Industry Consultation Body (ICB) enabling all industry stakeholders and social partners to contribute to the legislation making
  - the systematic involvement of EUROCONTROL in the rulemaking process through mandates
- the transparency and predictability of Air Navigation Services (ANS) cost bases and charges, associated with appropriate user consultation

[20] The High Level Group is composed of Directors General of Civil Aviation Administrations from European states (also representing ECAC and EASA), the Director General of EUROCONTROL, and senior representatives of aviation industry associations.
[21] […] laying down the framework for the creation of the single European sky.
[22] […] of air navigation services in the single European sky.
[23] […] on the organisation and use of the airspace in the single European sky.
[24] […]on the interoperability of the European Air Traffic Management network.

The SES I Package was adopted by the European Parliament and Council in March 2004 and entered into force one month later.
MSs are responsible for the correct implementation of the EC Regs.
NSAs, which take in practice the form of Civil Aviation Authorities (CAAs), have to make sure that services are delivered to the highest standards in accordance with the legal requirements.

One of the cornerstones of the SES was the creation of Functional Airspace Blocks (FABs), which allowed the restructuring of the European ATM airspace according to traffic flows instead of along national frontiers. [25]
A FAB is based on operational requirements and established regardless of State boundaries, where the provision of ANS and related functions are performance-driven and optimised with a view to introducing enhanced cooperation among ANSPs.
FABs were – and still are – vital for reducing airspace fragmentation and necessary to accommodate the steadily growing traffic, as well as to minimise delays by managing the traffic more dynamically. Objectives for enhancing safety standards and overall efficiency were achieved by increasing the scale of operations, regardless of national borders. This also implied civil-military coordination in airspace and ATM.

The four SES Basic Regs. are complemented by more detailed Implementing Regs. (IRs), also called Implementing Rules, adopted by the EC after discussion within the Single Sky Committee[26].
Industry is always invited to advise the EC on actions to be taken on the basis of the Regulations through an Industry Consultation Body (ICB)[27].

The SES I Package fostered the synergy between the EU's regulatory Authorities and the expertise within EUROCONTROL, actively supporting the Community's accession to EUROCONTROL.

Due to its technical expertise, EUROCONTROL helped in the preparation of various IRs, technical specifications and implementation guidance materials, on the basis of mandates issued by the EC and in close coordination with all relevant stakeholders. Furthermore, EUROCONTROL produced.

[25] Nine FABs were declared, established and notified to the EC: UK-Ireland FAB, Danish-Swedish FAB, Baltic FAB (Lithuania, Poland), BLUE MED FAB (Cyprus, Greece, Italy and Malta), Danube FAB (Bulgaria, Romania), FAB CE (Austria, Bosnia & Herzegovina, Croatia, Czech Republic, Hungary, Slovak Republic, Slovenia), FABEC (Belgium, France, Germany, Luxembourg, the Netherlands and Switzerland), North European FAB (Estonia, Finland, Latvia, and Norway), and South West FAB (Portugal, Spain).

[26] The Single Sky Committee is composed by two representatives of each European Union Member State (civil and military) and observers from third countries and EUROCONTROL.

[27] The ICB is composed of representatives of all major ATM stakeholders, such as:

- Air Traffic Service (ATS) Providers
- Communication, Navigation and Surveillance (CNS) Service Providers
- Meteorological (MET) Service Providers
- airspace Users
- manufacturing industry
- airports
- professional staff representative bodies

The final result of the mandate work was a report including a draft IR.
The EC submitted then the draft IR under its responsibility to the Single Sky Committee and adopted it, following the favourable opinion of the Committee. [28]

The Framework Regulation requires that EC periodically reviews the application of the SES Legislation and reports on the progress of its implementation. The First Report on the implementation of the Single Sky Legislation was published in December 2007. It presented the achievements, identified new challenges and proposed the way forward.

Based on the report findings, the Commission came forward with proposals for a second Single Sky Legislative Package (SES II Package) and the adoption of the European ATM Master Plan.

[28] Amongst all the Implementing Regulations adopted by the EC, Regs. (EU) No 1035/2011 and (EU) No 1034/2011 are introduced in Paragraph 2.2 due to their relevance in this Thesis.

1.2.3 The SES II Package

Over the five years following the launch of SES I, the situation changed to a certain extent.
While capacity still was a cause for concern, greater emphasis began to be placed on aviation's impact on the environment and the fuel crisis made airlines focus on cost efficiency.
So, in 2009, EU revised and extended the four SES I Package adopted in 2004, changing the SES focus from *capacity* to *performance* in general. Since the proposals were coherent and interrelated, they were proposed as a single Package to be developed and discussed simultaneously with the European Parliament and the Council of Ministers.
The SES II Package[29] was based on the following four pillars:

- **the performance scheme pillar – the Network Manager (NM)**
  EC adopted the EU-wide binding performance targets in the key performance areas of cost-efficiency, capacity and environment, at European and local levels, accompanied by adequate incentive schemes. This required the NSAs to elaborate national, or FAB-level, sustainable and performance-driven plans which contribute to the EU-wide targets.
  In addition, a European Network Management centralised function was proposed to be created to ensure the optimum route design, the flow management, the best flight efficiency, the allocation of scarce resources (such as radio frequencies and radar transponder codes) and the synchronisation of the deployment of new technologies across Europe. The creation of FABs was accelerated and focused on the quality and efficiency of the service provided. [30]
- **the technological pillar – the Single European Sky ATM Research (SESAR)**
  In order to overcome fragmentation in the development of new ATM systems and speed up the pace of technological innovation, EC decided to pool Research and Development (R&D) with a view to achieve a single future ATM system for Europe. This would implied the rationalisation and the concentration of public and private resources into one coherent SESAR ATM Master Plan for 2020, with the full involvement of all aviation stakeholders.
- **the Safety pillar – the European Aviation Safety Agency (EASA)**
  EASA's competence[31] was extended to ATM and aerodromes, thus ensuring that the complete aviation safety chain would have been handled in a 'total system approach' by a single Body having a single decision-making process, independent from technological and economic considerations. [32] In this way, the EC endeavoured to ensure the development of coherent and common safety rules, securing high and uniform safety standards in all of the EU's MSs.
- the airports **pillar – the Airport Observatory**
  Airports' capacity and efficiency should ensure a gate to gate approach. EC established a European Observatory on Airport Capacity & Quality for the exchange and monitoring of information on airport capacity, linking the airport dimension to the new ATM governance and enabling its incorporation into the European Network Management function.

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[29] Regulation (EC) No 1070/2009 of the European Parliament and of the Council of 21 October 2009 amending Regulations (EC) No 549/2004, (EC) No 550/2004, (EC) No 551/2004 and (EC) No 552/2004 in order to improve the performance and sustainability of the European aviation system.

[30] EUROCONTROL has been entrusted as NM to up to 2019 by Commission Regulation (EU) No 677/2011 of 7 July 2011 laying down detailed rules for the implementation of air traffic management (ATM) network functions and amending Regulation (EU) No 691/2010.

[31] EASA was established in 2002 with a limited scope under Regulation (EC) No 1592/2002 of the European Parliament and of the Council of 15 July 2002 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency.

[32] Please note the considerations written at the end of this Subparagraph. Furthermore, Paragraph 1.3 is entirely dedicated to EASA and contains details about the Agency's scope and Total System Approach.

The SES II Package also aimed to bring to an end a decade of overlapping responsibilities amongst the three main EU-level ATM actors: EC, EASA and EUROCONTROL.
The rulemaking support to EC for technical IRs was shifted from EUROCONTROL to EASA[33].

Finally the ATM scope has been divided so that:

- EC could focus on economic regulation, such as performance, charging, and institutional issues
- EUROCONTROL could focus on the operational issues as the NM
- EASA could focus on technical rule drafting and Oversight Authority tasks

Before introducing EASA, hereinafter sometimes also referred to as 'the Agency', Subparagraph 1.2.4 first briefly presents the Regulation which conferred to the Agency the rulemaking support task and then describes the structure of the Legislation that consequently derived from it.

[33] Regulation (EC) No 1108/2009 of the European Parliament and of the Council of 21 October 2009 amending Regulation (EC) No 216/2008 in the field of aerodromes, air traffic management and air navigation services and repealing Directive 2006/23/EC.

1.2.4 The EASA Basic Regulation and the Legislation structure

The 'EASA Basic Regulation' (BR) designates Regulation (EC) No 216/2008 of the European Parliament and of the Council of 20 February 2008 on common rules in the field of Civil Aviation and establishing a European Aviation Safety Agency. [34]

Under the EU legal order, the BR has general application. It is binding in its entirety and directly applicable in all MSs. [35]

The main objectives[36] of the BR are:

- to establish and maintain a high uniform level of Civil Aviation Safety in Europe
- to ensure a high uniform level of environmental protection
- to facilitate the free movement of goods, persons and services
- to promote cost-efficiency in the regulatory and certification processes and to avoid duplication at national and European level
- to assist MSs in fulfilling their obligations under the Chicago Convention
- to promote Community views regarding Civil Aviation Safety Standards and Rules throughout the world
- to provide a level playing field for all actors in the internal aviation market

One of the means to attain such objectives is the preparation, adoption and uniform application of all necessary acts. [37]

For that purpose, the BR conferred to the EC the power to adopt IRs which detail how to comply with the ERs of the BR and regulate the subject matters included in its scope: airworthiness of aircraft, environmental protection, pilots, Air Operations, Aerodromes, ATM/ANS, Air Traffic Controllers and aircraft used by third country operators into, within, or out of the Community. [38]

As already mentioned, one of EASA's tasks is to assist the Commission's rulemaking activities[39].
Therefore, Regulation (EC) No 216/2008, as last amended, has been termed as the Basic Regulation in the Agency's documentation. Hence, from this point forward, with the acronym of 'BR' it is just intended the 'EASA Basic Regulation' and not the other four BRs of the SES I Package.

Figure 1.2-2 depicts the Committee procedure[40] by which EU law is modified or adjusted.
EASA provides the so called Agency Opinions, which consist of technical input to the European decision-making for the drafts of European Regulations and of IRs. With the Opinion, the decision-

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[34] Regulation (EC) No 216/2008 of the European Parliament and of the Council of 20 February 2008 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency, and repealing Council Directive 91/670/EEC, Regulation (EC) No 1592/2002 and Directive 2004/36/EC.
[35] This is in compliance with Art. 288 of the Treaty on the Functioning of the European Union.
[36] Article 2.
[37] Article 2 (3) (a).
[38] BR item (38) of the preamble.
[39] Arts. 18(a) and 19.
[40] Regulation (EU) No 182/2011.

making process is transferred to the European Commission. Once approved under the Committee procedure, such IRs are published as Commission Regulations and this term appears in their titles.

Figure 1.2-2 the Committee procedure

Figure 1.2-3 illustrates the Legislation structure together with the involved parts.
Three different levels can be identified:

1) **Basic Regulation** (BR) of the European Parliament and of the Council, deriving from the International Civil Aviation Organisation (ICAO) Annexes and containing the essential requirements (ERs) that must be granted within the EU
2) **Implementation Rules** (IRs) of the Commission defining their fields of application, the timings and the tolerated delays of their entry into force with respect to the previous rules; organisational and procedural requirements are presented as Annexes or Parts so divided:
   a) containing which requirements have to be satisfied
   b) containing the procedures that must be implemented by NAAs
3) EASA **Executive Director's Decisions** (ED Decisions) about the practical actuation of IRs adopted by the Commission; to this category also belong the following three kinds of directly applicable rules which always support each regulation, even if published separately:
   a) **Acceptable Means of Compliance** (AMC) are non-binding standards to illustrate means to establish compliance with the rules; MSs can propose alternative and equally safe ways (AltMoC) to comply
   b) **Guidance Material** (GM) are non-binding material that explains the intent of the rules, e.g. the meaning of a requirement
   c) **Certification Specifications** (CSs) are technical standards indicating means to show compliance with the rules, that can be used by the Organisations for the purpose of certifications; they are divided in:
      i) airworthiness code – book 1 containing technical rules
      ii) AMC – book 2 containing methods and criteria of application

IRs belong to the category of 'hard rules', since they are binding.
AMC, GM and CS are instead called 'soft laws', as they are non-binding rules.
Anyway, the driver of each published document is always and only the need of fulfilling the Essential Requirements (ERs) stated in the BR.

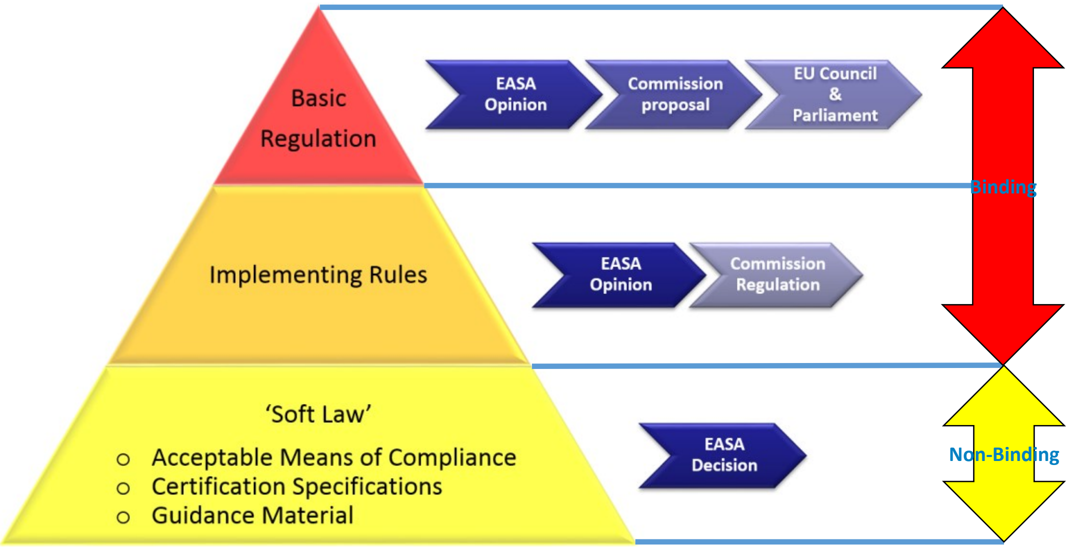

Figure 1.2-3 the Legislation structure

1.3 EASA: the European Authority in Aviation Safety

EASA is an Agency of the EU with *regulatory* and *executive* tasks in the field of civilian Aviation Safety over the thirty-two Member States: the twenty-eight EU States[41] and the four current European Free Trade Association (EFTA) States[42]. It was ratified on 15 July 2002[43], established on 28 September 2003 and reached full functionality in 2008. The headquarters is in Cologne (Germany), some offices are in Brussels (Belgium), Washington DC, Montréal (Canada) and Beijing (China), involving more than 800 aviation experts and administrators.

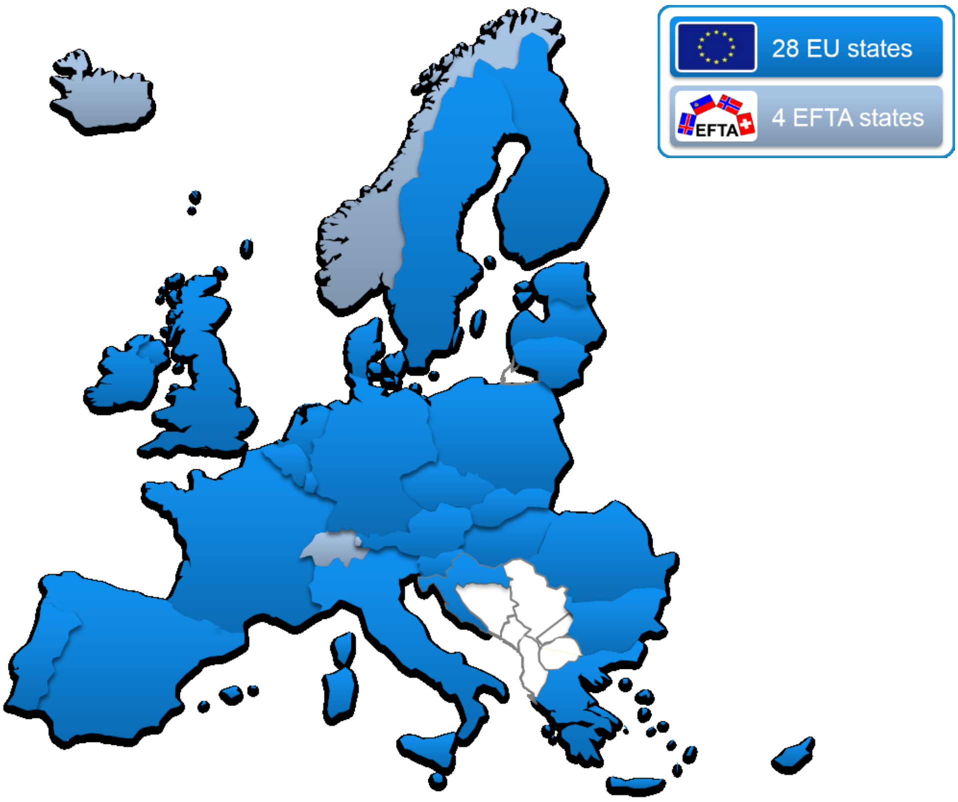

Figure 1.3-1 the Member States

EASA is an independent EU Body, with juridical personality and autonomy in legal, administrative, and financial matters[44].

[41] The 28 EU States are: Belgium, Slovenia, Greece, Slovakia, Italy, Spain, United Kingdom, Austria, Sweden, Latvia, Romania, Estonia, Luxembourg, Germany, Malta, France, Portugal, Lithuania, Czech Republic, Hungary, Netherlands, Cyprus, Ireland, Bulgaria, Denmark, Croatia, Poland, and Finland.

[42] The 4 EFTA States are: Switzerland, Norway, Iceland, and Liechtenstein.

[43] Regulation (EC) No 1592/2002 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency.

[44] Actually this is not entirely correct, as EASA budget is so composed: 66% are fees paid by Industry, 26% derives from EU budget and 8% are third Countries contributions [14].

1.3.1 EASA missions

EASA most important missions, related to Civil Aviation, are the following:

- ensure the highest common level of **safety protection** for EU citizens
- ensure the highest common level of **environmental protection**
- issuing a single regulatory and certification process among Member States
- facilitate the **internal aviation single market** and create a level playing field
- cooperate with other international aviation organisations and regulators

1.3.2 EASA tasks

EASA was set up in 2002 and first assigned with tasks and responsibilities in the areas of Airworthiness and Certification of aeronautical products, parts and appliances. In 2008, its role was broadened to include the areas of Air Operations, pilots' licenses and the Safety of third-country aircrafts.

EASA most important tasks are the following:

- give technical support (expert advice) for the **drafting of EU Legislation** in all fields pertinent to EASA missions and for the closure of international agreements concerning Aeronautical Safety
- promote the spread of **common standards** worldwide
- developing, implementing and monitoring **safety rules**, including **inspections in the Member States**
- give **type-certification of aircraft and components**, as well as the **approval of Organisations** involved in the design, manufacture and maintenance of aeronautical products
- give **certification of personnel and Organisations** involved in the **operation of aircraft**
- give **certification of Organisations** providing **pan-European ATM/ANS services**
- give certification of **Organisations** responsible for providing **ATM/ANS services** located **outside** the territory subject to the EC law
- give certification of Air Traffic Control Training Organisations (**ATCO Training**) in the Member States where EC law applies
- authorise **third-country** (non EU) **operators**, ban the unauthorised ones, update and share the related blacklist, carry out the Safety Assessment of Foreign Aircraft (**SAFA**)
- coordinate, monitor, collect and analyse **safety data** related to **occurrence reporting**, including the publication of an **Annual Safety Review**

1.3.3 The Total System Approach

The aviation sector comprises a great many organisations and individuals, all providing a range of different but highly interdependent services. Aviation system 'components', in terms of activities and categories of service providers, are part of this complex socio-technical system.
Aviation system components, such as products, operators, crews, aerodromes, ATM/ANS Service Providers – on the ground, in the air or even in space – are part of a single aviation network, which will be more and more integrated through the implementation of new technologies and concepts of operations.
In order to ensure a high and uniform level of Safety, each system cannot be considered as independent from the other ones, but must be seen as a part of a whole and interactions with the other systems must be taken into account. Furthermore, the complete system should then be considered throughout its entire lifecycle, not just the individual stages in isolation.

As previously explained, in 2008 the competence of EASA were extended to include all the relevant key safety field, including ATM/ANS services and aerodromes. [45]
This is called 'Total System Approach' and reflects both in the Single European Sky (SES) legislative framework and in EASA organisational structure[46].

The Total System Approach has become an important and continuous rulemaking policy for EASA, with an aim to develop safety rules building on the most efficient mitigation of safety risks through a *holistic network approach* that encompasses the five interrelated pillars shown in Figure 1.3-2.

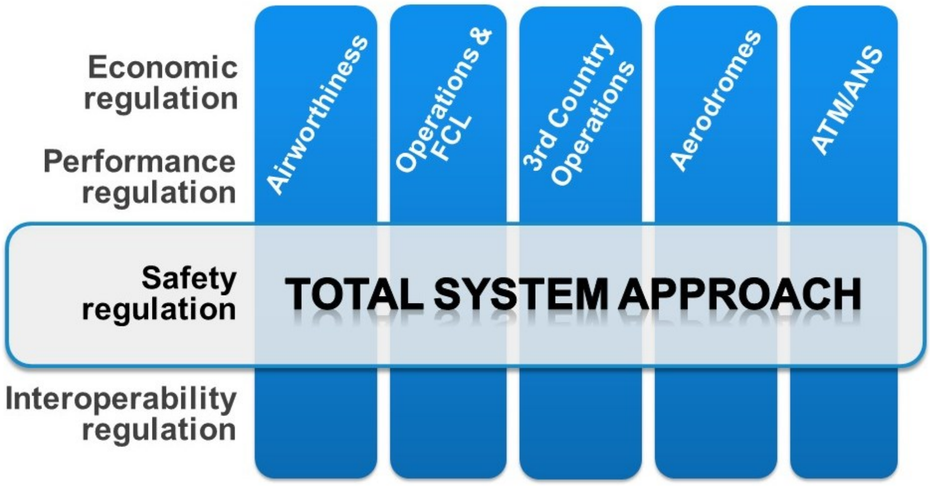

Figure 1.3-2 EASA Total System Approach

The Total System Approach aims at eliminating the risk of safety gaps or overlaps, and seeks to avoid conflict requirements and confused responsibilities between different aviation activities. Regulations are interpreted and applied in a standardised manner and best practices are provided. At the same time, such uniformity means to protect citizen and to provide the level playing field for the functioning of the internal market. Furthermore, it will allow for the realisation of increased interoperability of products and services. The Total System Approach has also an objective to streamline the certification processes and reduce the burden on regulated persons and Organisations.

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[45] Please refer to Subparagraph 1.2.3.
[46] The EASA organisational structure is shown in Subparagraph 1.2.4.

1.3.4 EASA organisational structure

As mentioned in Subparagraph 1.3.3, EASA Total System Approach is reflected in its organisational structure. All regulatory functions have been integrated across the different aviation domains and more homogeneity has been introduced to better enable the Agency to speak with one voice and to engage more pragmatically with the aviation industry.

The current structure, shown in Figure 1.3-3, includes the following four Directorates:

- Flight Standards (FS)
- Certification (CT)
- Strategy and Safety Management (SSM) [47]
- Resources and Support Directorate (RS)

The former three are primary industry-facing Directorates, the latter provides general assistance to the others.

Communication and interactions amongst the Directorates are also supported by the arrangement of EASA's facilities, organised in open offices where employees are in close contact one with each other; in fact, this logistic choice fosters and makes easy the direct sharing of information amongst personnel of the very many Departments composing the Agency.

[47] On 1st September 2014 the organisational structure of the Agency was updated integrating a Strategy and Safety Management (SSM).

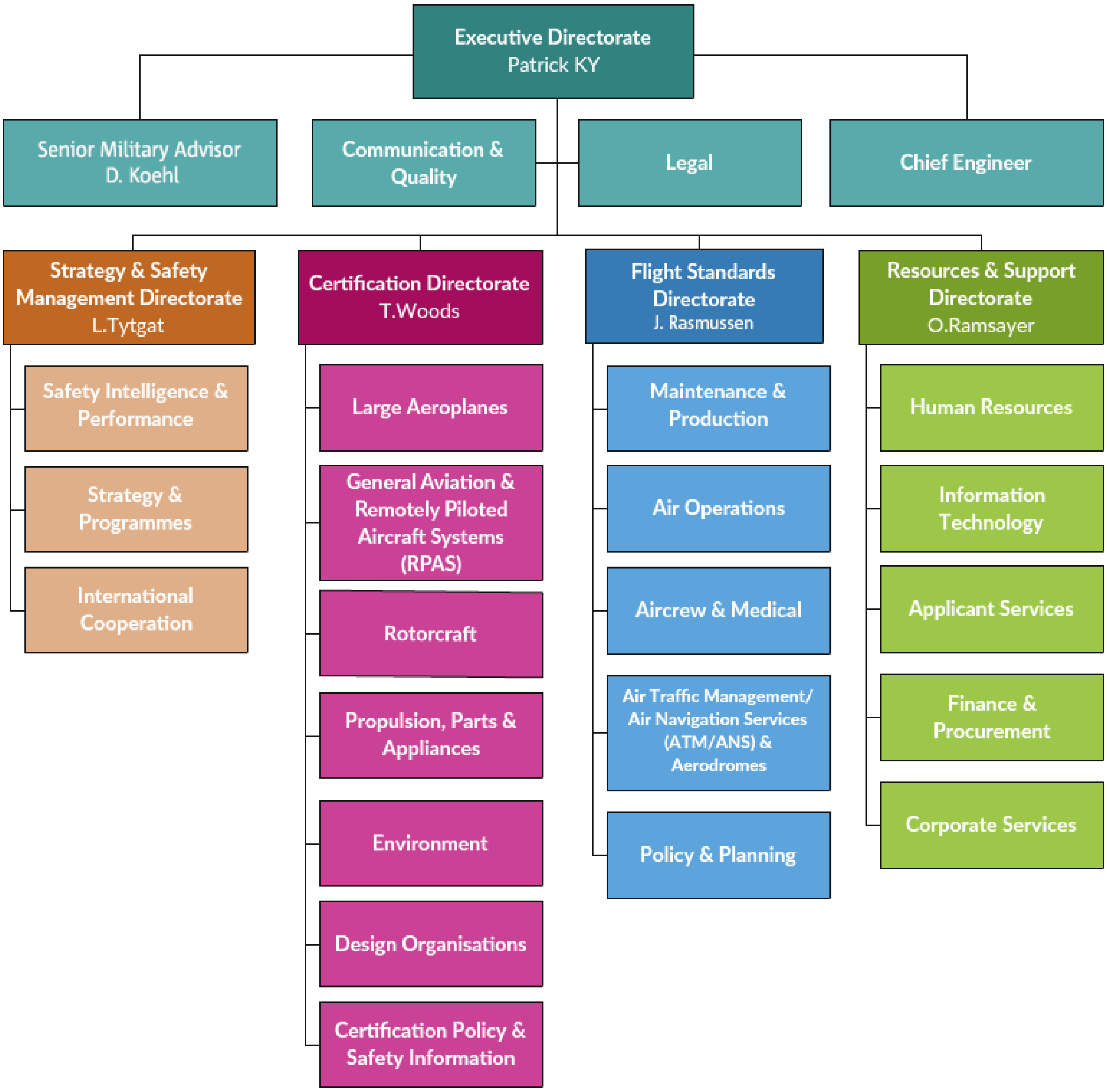

Figure 1.3-3 the EASA organisational structure (2017/12/15)

1.3.5 The Flight Standards Directorate

As shown in Figure 1.3-4, the Flight Standards (FS) Directorate is organised in five departments:

- Maintenance & Production
- Air Operations
- Aircrew & Medical
- ATM/ANS & Aerodromes (ADRs)
- Policy & Planning

The former four departments deal with a specific technical domain and are responsible for all related tasks, such as certification, rulemaking, standardisation, and organisation approval.
The latter one, the fifth, ensures horizontal technical coordination of the core processes and deals with safety management as well as international cooperation aspects.
This could be seen again as an implication, at a lower level, of the Total System Approach introduced in Paragraph 1.3.3, as system components, standards, and procedures are always considered as parts of a whole single picture.

The overall objective of FS Directorate is to establish and maintain a high uniform level of civil Aviation Safety amongst the MSs.
It is achieved monitoring whether Competent Authorities (CAs) are implementing EU rules not less and not more than required, in order to protect EU citizens and to ensure a level playing field, respectively.

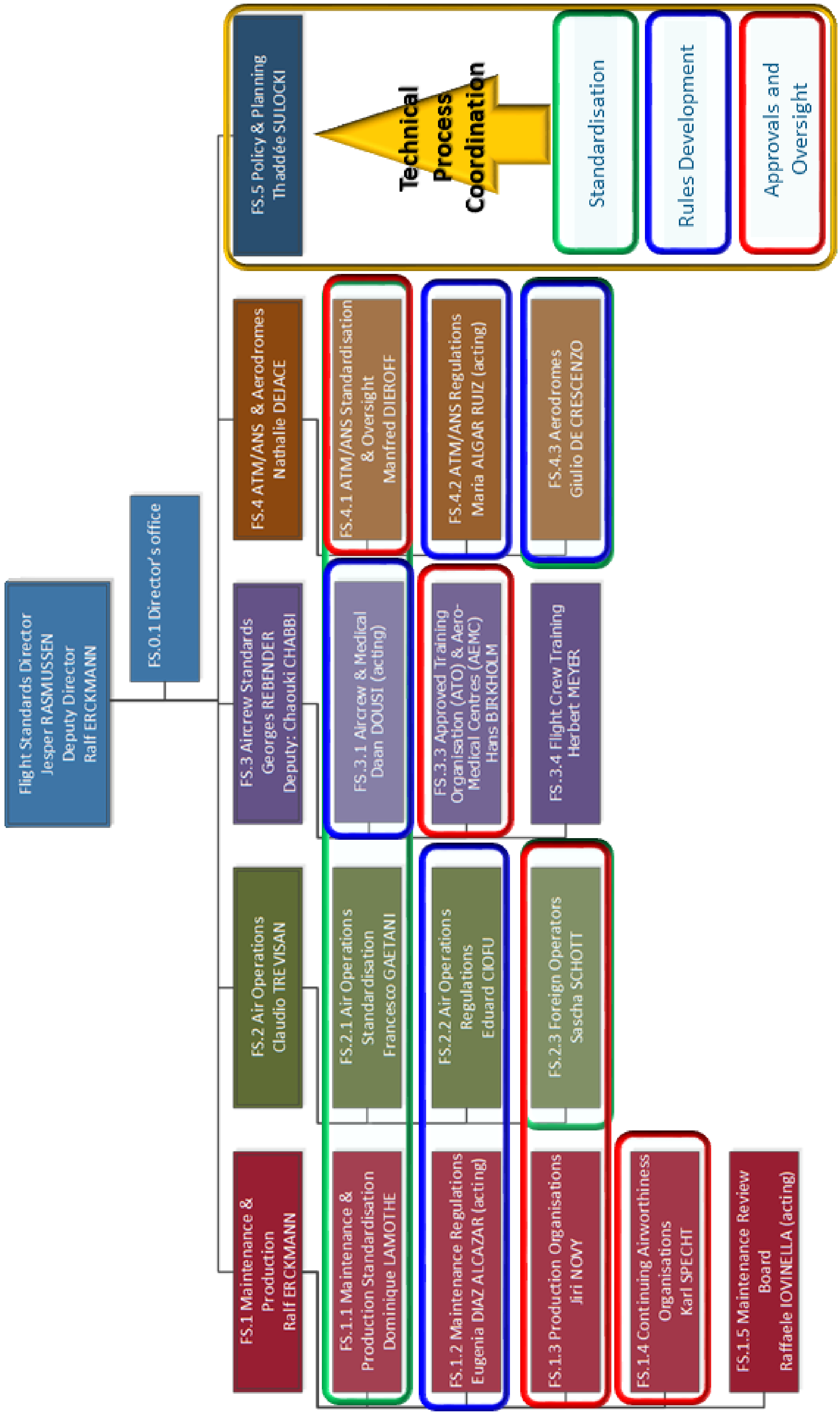

Figure 1.3-4 the Flight Standards Directorate organisational structure (2017/12/15)

1.3.6 The ATM/ANS and Aerodromes Department

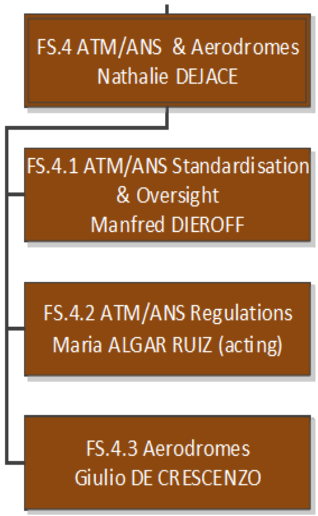

Figure 1.3-5 the ATM/ANS & Aerodromes Section organisational structure (2017/12/15)

The ATM/ANS and Aerodromes Department (FS.4) is composed by a staff of about forty members.

The main activities and responsibilities are:

- Standardisation of MSs in the ATM/ANS and ADRs domains
- development of regulatory material in the ATM/ANS and ADR domains
- Oversight of EU and certain non-EU pan-European ATM/ANS Service Providers
- Oversight of non-EU ATCO Training Organisation applying for EU approval
- Oversight of the Network Manager on behalf of the EC
- supporting the implementation of SES and SESAR

This Department focuses on the ATM/ANS core activities; nevertheless, some other activities related to ATM/ANS are located in other Departments of other Directorates – such as those belonging to the Strategic & Safety Management Directorate and related to Safety Data, Safety Investigation & Reporting, and Safety Analysis & Performance.

1.3.7 The ATM/ANS Standardisation & Oversight Section

In relation to Organisations providing ATM/ANS and other network functions and training of Air Traffic Controllers (ATCOs), the ATM/ANS Standardisation & Oversight Section (FS.4.1) fulfils the following tasks:

- issue and renew certificates of:
  - ATM/ANS Organisations located outside the territory of the MSs responsible for providing services within the territory of the MSs
  - ATM/ANS Organisations providing pan-European services
  - ATCO Training Organisations having their principal place of operation or, if any, their registered office, outside the territory of the MSs and, where relevant, their personnel
- amend, suspend or revoke the relevant certificate, when the conditions according to which it was issued are no longer fulfilled, or if the holder of the certificate fails to fulfil the obligations imposed on it by the relevant Regulation or by its IRs
- conduct, itself or through other CAs or qualified entities, inspections and audits of the Organisations it certifies with both the purpose for Initial Certification and Ongoing Oversight

Figure 1.3-6 shows the main services and functions of the ATM/ANS domain.

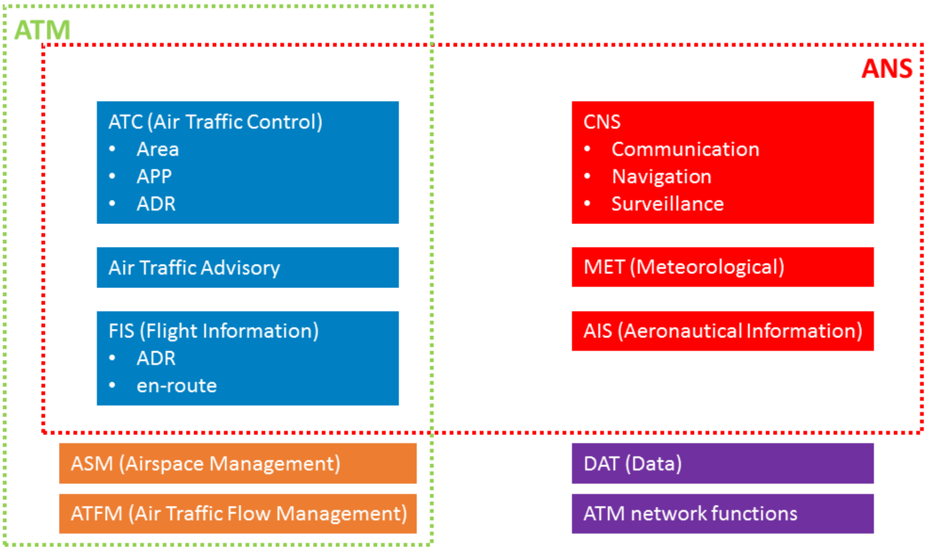

Figure 1.3-6 ATM/ANS services and functions

2. The baselines for ATM/ANS Standardisation & Oversight

*"The fruits of science and innovation have nourished our society and economy for years,
but nations unable to navigate our regulatory system are often excluded,
as are vulnerable individuals."
John Sulston, British scientist, biologist and academic*

2.0 Content of Chapter 2

This chapter presents the content of the most important ATM/ANS Regulations, which are the baseline for the procedures adopted by EASA and the CAs for Standardisation purposes.

In particular, Paragraph 2.1 briefly presents all the Standardisation Inspection domains and the most important Regulations in the scope of the EASA FS.4.1 Section, mainly involving the Oversight of ATM/ANS and ATCO Training Organisations.

Paragraph 2.2 focuses on the Standardisation process, dealing with the cyclical phases of the Continuous Monitoring Approach and the conduction of the possible different kinds of inspections involved in it, which usually lead to different possible types of findings and corrective actions.

Paragraph 2.3 focuses on the Oversight process, giving a combined overview of the content of two very important and strictly intertwined Implementing Rules. Those Regulations contain the Common Requirements for the provision of ANS which are required by the CAs in order to assess the compliance of the Organisations to the Regulations in force.
The last subparagraphs introduce the Oversight function, highlighting the parts of the Regulations dealing with the procedure for the review of changes to functional system.

Lastly, Paragraph 2.4 introduces the Regulation for the certification of the ATCO Training Organisations.

2.1 The ATM/ANS Standardisation & Oversight relevant legislation

The main task of the FS Directorate is to foster the application of the common Standards in all the Aviation domains, which is fully in line with the Total System Approach.
In this regard, the Agency shall carry out Standardisation inspections addressing domains which include: Airworthiness and Environmental Protection, Air Crew, Air Operations, Ramp Inspections, ADR, ATM/ANS and ATCO. [48]

This is stated as a requirement in:

- the BR[49]
- Commission IR (EU) 628/2013[50] on working methods of EASA for conducting Standardisation inspections and for monitoring the application of the rules (STD-IR)

Since the harmonisation of Safety Regulations and Standards worldwide is not enough to ensure their uniform implementation across the MSs, CAs shall exercise Safety Oversight, in order to regularly monitor and verify that the applicable Safety Regulatory Requirements and their implementing arrangements are constantly and effectively met. [51]

Amongst all the Regulations handled by the EASA FS.4.1 ATM/ANS Standardisation & Oversight Section, the most important ones stemming from the BR and relevant for this Thesis are: [52]

- Commission IR (EU) No 1035/2011 laying down the common requirements (CRs) for the provision of ANS (CR-IR) [53]
- Commission IR (EU) No 1034/2011 on Safety Oversight in ATM/ANS (SO-IR) [54]
- Commission IR (EU) 2017/373 laying down CRs for providers of ATM/ANS and other ATM network functions and their oversight (NR-IR) [55]
- Commission Regulation (EU) 2015/340 laying down technical requirements and administrative procedures relating to ATCOs' licences and certificates pursuant to the BR [56]

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[48] BR Arts. 5, 6, 7, 8, 9, and 10.
[49] BR Chapter II.
[50] […] and repealing Commission Regulation (EC) No 736/2006.
[51] Please note the definition provided by ICAO in [2] of the Oversight by a National Supervisory Authority (NSA): a function performed by a State to ensure that individuals and organisations performing an aviation activity comply with safety-related national laws and regulations.
[52] Appendix D gives a more detailed view on the Legislation panorama, specifying the links between each subject and the related Regulations.
[53] […] amending Regulations (EC) No 482/2008 and (EU) No 691/2010.
[54] […] and amending Regulation (EU) No 691/2010.
[55] […] repealing Regulation (EC) No 482/2008, Implementing Regulations (EU) No 1034/2011, (EU) No 1035/2011 and (EU) 2016/1377 and amending Regulation (EU) No 677/2011.
[56] […] amending Commission Implementing Regulation (EU) No 923/2012 and repealing Commission Regulation (EU) No 805/2011.

Figure 2.1-1 shows the Standardisation inspections domains[57] together with the Regulations applicable to each specific domain. Those which the EASA FS.4.1 ATMS/ANS Standardisation & Oversight Section is responsible for are outlined in red.

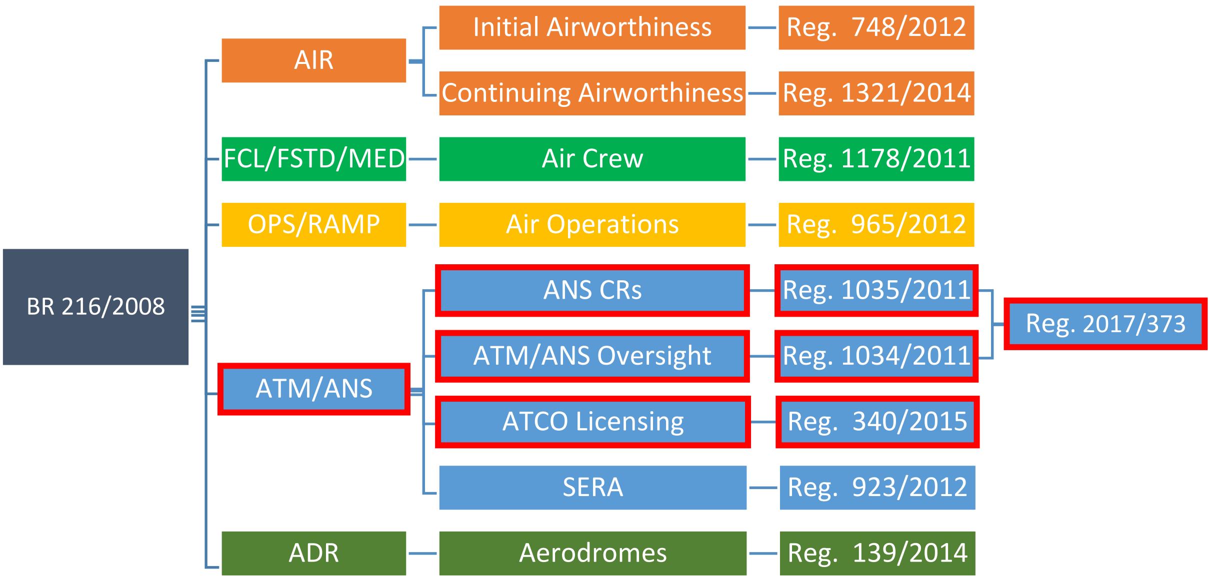

Figure 2.1-1 Standardisation Inspection domains

[57] STD-IR Art. 9.

2.2 Overview of the Standardisation Implementing Rule

This paragraph gives an overview of the content of the STD-IR.

2.2.1 Subject matter and scope [58]

STD-IR lays down the working methods for:

- monitoring the application and assessing the impact of the implementation by CAs of the MSs of the BR and its IRs in the fields covered by Art. 1(1) [59] of the BR
- conducting standardisation inspections of the CAs of MSs
- verifying that CAs of MSs are issuing and overseeing certificates in accordance with BR and its IRs

2.2.2 Principles applicable to monitoring [60]

EASA shall monitor the application by CAs of the Aviation Safety requirements as well as their uniform implementation according to the *methodology* laid down in the STD-IR and shall report thereon.
The monitoring shall entail assessing the CAs' ability to discharge their Safety Oversight responsibilities, conducting inspections as necessary, as well as the follow-up of findings stemming from inspections, in order to ensure that appropriate corrections and corrective actions are timely implemented.

The monitoring function performed by EASA shall be:

- continuous
- risk-based
- conducted in a transparent, efficient, effective, harmonised and consistent manner
- aiming at identifying the need for regulatory improvements

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[58] STD-IR Art. 1.
[59] The BR shall apply to:
- the design, production, maintenance and operation of aeronautical products, parts and appliances, as well as personnel and organisations involved in the design, production and maintenance of such products, parts and appliances
- personnel and organisations involved in the operation of aircraft
- the design, maintenance and operation of aerodromes, as well as personnel and organisations involved therein and, without prejudice to Community and national legislation on environment and land-use planning, the safeguarding of surroundings of aerodromes
- the design, production and maintenance of aerodrome equipment, as well as personnel and organisations involved therein
- the design, production and maintenance of systems and constituents for air traffic management and air navigation services (ATM/ANS), as well as personnel and organisations involved therein
- ATM/ANS, as well as personnel and organisations involved therein

[60] STD-IR Art. 3.

As mentioned for the Deming Wheel in Subparagraph 1.1.3, Safety-related processes imply a continuous improvement by means of a never-ending cycle where the Monitoring phase and the Inspection one alternate each other over and over, as shown in Figure 2.2-1.

The continuous monitoring shall comprise:

- the **collection and analysis of data and information** provided by CAs of MSs, ICAO, the Commission or other relevant sources
- the assessment of CA's ability to discharge its safety oversight responsibilities and the **prioritisation**, **planning** and determination of the **scope** of **inspections**
- the conduct of such **inspections**, including the related **reporting**
- the **follow-up** and closure of findings of non-conformity stemming from the inspections

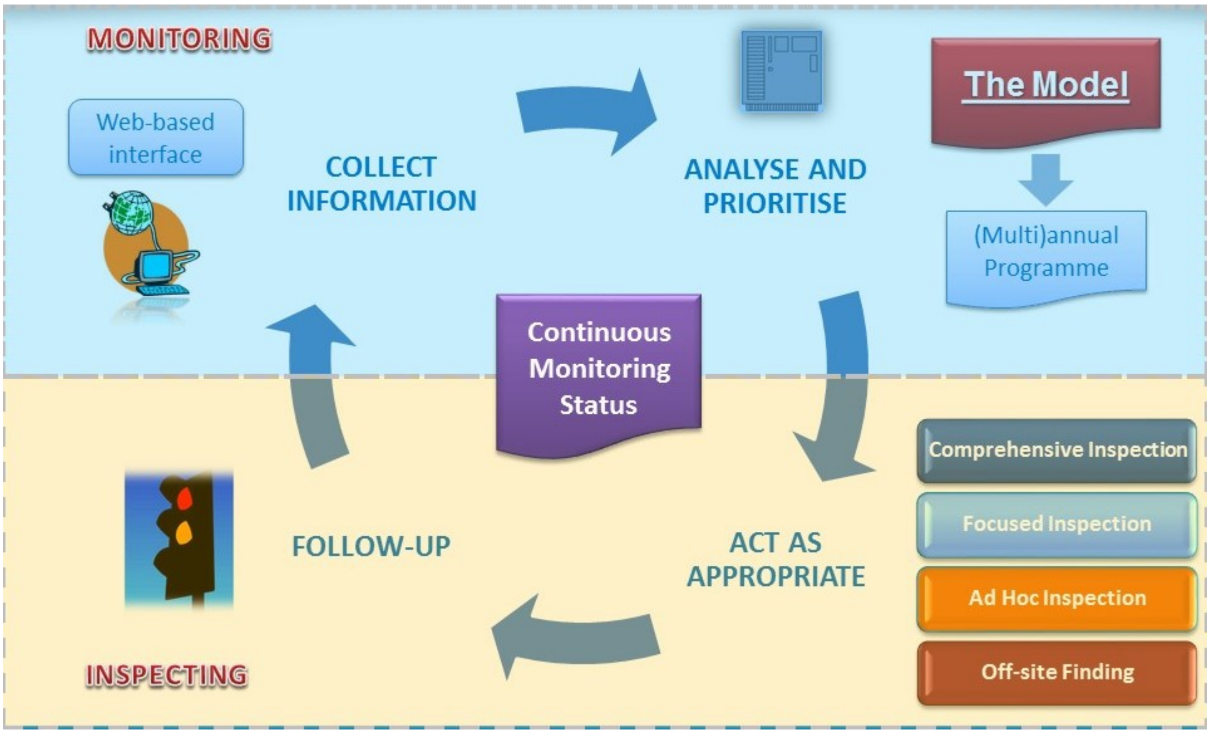

Figure 2.2-1 the Continuous Monitoring Approach

2.2.3 Principles applicable to inspections and findings [61]

Inspections of CAs shall take into account the results of previous inspections and address in particular changes to the regulatory requirements, to the safety oversight capability of the CA and be proportionate to the level and complexity of the industry under their oversight.
Inspections may include inspections of undertakings or associations of undertakings under the oversight of the CA inspected.

EASA shall classify and follow-up the findings of non-conformity identified during inspections depending on their impact on safety and safety related findings shall be prioritised.

2.2.4 The types of inspections

The types of inspections:

- **comprehensive inspections**
  for the purpose of inspecting one or more domains; these inspections shall be performed at intervals determined based on the results of the continuous monitoring
- **focused inspections**
  for the purpose of inspecting specific areas within one or more domains, and/or for the purpose of assessing the implementation status of agreed corrections and corrective actions
- **ad hoc inspections**
  for the purpose of investigating specific concerns arising from the Agency's continuous monitoring or upon request from the Commission and which shall be announced to the CA concerned with a notice of 2 weeks
- **off-site findings**
  the Agency may raise off-site findings, hence without performing an inspection, when it has collected sufficient evidence of non-conformity

Despite the different names given, inspections are always as much risk-based and focused as possible in order to save as much time as possible and to limit the interference with the activities of the inspected parts.

[61] Art. 4 of STD-IR.

2.2.5 Conduct of inspections

Figure 2.2-2 shows the phases involved in the Standardisation Inspections Process.

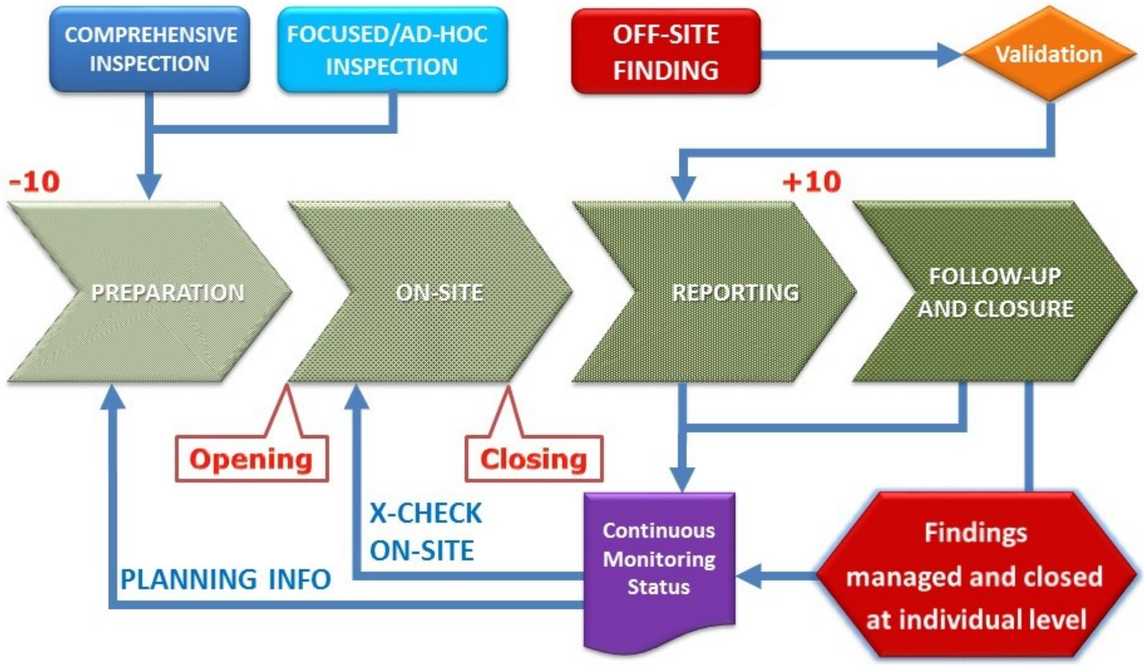

Figure 2.2-2 the Standardisation Inspections process

Further details about EASA's tasks relative to each of the four phases are listed below:

1. PREPARATORY PHASE
   - give **notice of the inspection** to CA at least 10 weeks before the on-site phase, including the intended type, domain(s) and areas of inspection
   - collect the necessary **documented information** for the preparation of the inspection visit, taking duly into account the information available from continuous monitoring
   - define the **scope,** the **extent** and the **programme** of the inspection, including the inspection of undertakings or association of undertakings, taking into account the information from continuous monitoring; the inspection programme shall be provided to CA at least 2 weeks before the on-site phase
   - determine the size and the composition of the **inspection team**, whose members shall sign an **authorization** declaring not to have any interest in the inspected Authority, as well as in the undertakings under its oversight; the composition of the inspection team shall be provided to CA at least 2 weeks before the on-site phase
   - if deemed necessary, a **preliminary meeting** may be organised between the inspection team and the national standardisation coordinator of the inspected CA

2. ON-SITE PHASE
   - organise an **opening meeting** with the national standardisation coordinator and CA inspected
   - **follow up findings of non-conformity** identified in previous inspections and that remain open and **review** the corresponding **corrections** and **corrective actions**
   - **notify** CA of **any immediate safety concern**, where such concern is identified during the inspection

- at a **closing session**, present to the inspected CA a list of preliminary findings of non-conformity identified or followed up in the course of the inspection (**preliminary report**)
- **inspect** the **main offices** and to the extent deemed necessary, any regional offices of the CA and of the qualified entities to which the CA may have allocated tasks
- **inspect undertakings** or associations of undertakings under the oversight of CA as part of the inspection of this CA; in that case, CA may accompany the inspection team
- carry out **interviews** with the staff of the inspected CA and qualified entities, if any, and of undertakings or association of undertakings visited, if any
- **examine** legislation, procedures, certificates, records, data and any other relevant material

REPORTING PHASE

- **review** the **preliminary findings**, **classify** them and establish on this basis a **draft report** addressed to the inspected CA[62], within 6 weeks after the closing session of the on-site phase and containing at least:
- an executive summary presenting the conclusions
- details on the conduct of the inspection, including the type of the inspection, domains covered, scope and composition of the team
- an analysis by critical element focusing on the main findings
- a list of **findings of non-conformity** identified or followed up during the inspection together with their classification
- recommendations, including where necessary on the mutual recognition of certificates
- **issue** a **final report**[63] on the basis of the draft report, reflecting the comments of the inspected CA, if any, adapting the description of the finding of non-conformity, its legal basis, its classification or its status as appropriate to take into account the comments as well as the corrections or corrective actions submitted during the reporting phase, within 10 weeks after the closing session
- **establish** and **maintain** a **continuous monitoring status** for each MS which shall be provided on request to the concerned MS and to the Commission

Figure 2.2-3 shows some further details about the Reporting Phase.

[62] CA may submit written comments to the Agency within 2 weeks from the notification.

[63] The final report shall be addressed to the CA inspected and to the Commission, who may subsequently transmit this report to the Member State concerned and other CAs as appropriate.

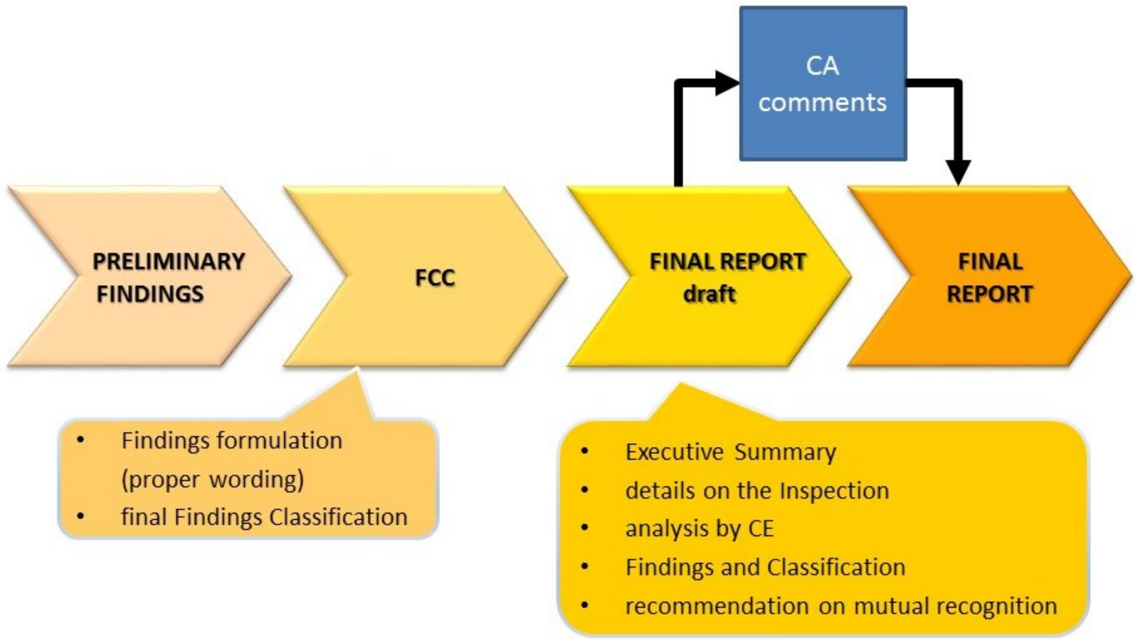

Figure 2.2-3 some details on the Reporting Phase

FINDINGS FOLLOW-UP AND CLOSURE PHASE

- **evaluate** the **corrections** and the **corrective actions** submitted by CA or request further clarification in a timely manner[64]
- **agree with or reject** the corrections and/or corrective actions submitted within 16 weeks after the notification
- **monitor** the satisfactory implementation of corrective actions, requesting evidence or clarifications to CA or verifying their implementation on site by means of an inspection
- identify any need for supplementary actions
- **report** on a regular basis to CA and to the Commission the status of findings of non-conformity and the related corrections/corrective actions by means of **status reports**
- **close** the findings of non-conformity once satisfied with the completion of the corrective actions and the **evidence** provided, record the closure of the findings of non- conformity and inform CA accordingly[65]

[64] According to STD-IR:

- for all **class D and G** findings of non-conformity, CA shall propose a **correction** and a **corrective action** no later than 4 weeks after receipt of the notification from the Agency
- for all **class C findings** of non-conformity, CA shall propose a **corrective action** no later than 10 weeks after receipt of the notification from the Agency

[65] When findings of non-conformity are subject to an infringement action pursuant to Art. 11(2) of the BR or to the Treaties, the Agency shall ensure appropriate follow-up in consultation with the Commission and shall not close any such finding without prior coordination with the Commission.

2.2.6 Classification of findings

All findings of non-conformity with the applicable requirements identified by the Agency in the framework of the inspections presented in Subparagraph 2.2.4 shall be classified and reported by the Agency, whether they pertain to administrative requirements or to technical requirements, in one of the following classes:

- **CLASS C** raising mainly standardisation concerns
- **CLASS D** raising standardisation concerns and safety concerns if not timely corrected
- **CLASS G** immediate safety concern

2.2.7 Immediate Safety Concern

When an Immediate Safety Concern has been notified by the Agency:

- the Agency shall request CA to take adequate **corrective actions**, including **immediate corrections**, whose implementation could be assessed in a meeting eventually requested by the Agency to the inspected CA
- CA shall apply effective corrections to remove the finding and shall provide the Agency with **evidence** thereof

When the corrections do not satisfy the Agency, the Agency shall make recommendations to the Commission, including where necessary a request with regard to the mutual recognition of the certificate(s) issued by CA.
The Agency shall also inform CAs of the MSs immediately.

2.2.8 Annual report

The Agency shall submit to the Commission, no later than 31 March of each year, an annual report on the continuous monitoring activities and the inspections carried out in the previous year.
The report shall include an analysis of the results of the activities and Inspections, reflecting CAs' ability to discharge their Safety Oversight responsibilities, as well as recommendations for possible improvements.

2.3 Overview of both the Common Requirements and the Safety Oversight Implementing Rules

This paragraph gives a combined overview of the content of both the CR-IR and the SO-IR, focusing on and adding some clarifying considerations to the parts which are relevant for this Thesis.
They are presented together as they are strictly intertwined and, in fact, going to be repealed by the single NR-IR.

2.3.1 Subject matter and scope [66]

This CR-IR lays down the CRs for the provision of ANS.
The requirements are to be complied with by the concerned Service Providers in order for them to be issued the certificates[67].

The SO-IR establishes requirements to be applied to the exercise of the Safety Oversight function by CAs concerning ANS, ATFM, ASM for general air traffic and other network functions.

Those Regulations also lay down requirements concerning the CAs, which are responsible for issuing those certificates and exercising oversight and enforcement tasks.

2.3.2 Competent Authorities [68]

The CAs for the Certification of ANS Service Providers and the CAs for the Oversight of ATM/ANS Service Providers shall be:

- for Organisations having their principal place of operation and, if any, their registered office located in a MSs, the NSA nominated or established by that MS
- for Organisations providing pan-European ATM/ANS and other network functions and for ATM/ANS Providers established outside of EU and providing services within its territory, EASA
- for Organisations for which the responsibilities for Safety Oversight have been allocated differently from above, other CAs nominated or established under the agreements concluded among MSs [69]

[66] CR-IR Art. 1 and SO-IR Art. 1.
[67] referred to in the SPR Reg. Art. 7(1) and the BR Art. 8b(2).
[68] CO-IR Art. 3 and SO-IR Art. 3.
[69] in accordance with the SPR Reg. Art. 2.

2.3.3 Certification and demonstration of compliance [70]

At the request of the CA, Organisations shall provide all the relevant evidence to demonstrate compliance with the applicable CRs.

The CRs consist of:

- **general requirements** set out in Annex I and dealing with organisational structure and management, Safety and Quality Management, financial strength, liability and insurance cover, and quality of services
- **specific requirements** set out in Annex II to V and respectively:
    - Annex II for the provision of Air Traffic Services (ATS)
    - Annex III for the provision of Meteorological Services (MET)
    - Annex IV for the provision of Aeronautical Information Services (AIS)
    - Annex V for the provision of Communication, Navigation, Surveillance Services (CNS)

A certified Organisation shall notify CA of planned changes to its provision of ANS which may affect its compliance with the applicable CRs or with the conditions attached to the certificate, where applicable. [71]

Amongst the Safety requirements for the Safety of Services, particular attention should be paid to the Severity Classification Scheme for the Safety Risk Assessment with regard to changes to the ATM functional systems. [72]

The introduction of new systems and changes to increasingly complex and integrated ATM system constitutes a potential hazard which needs particular attention.

No change to ATM system can be implemented without a clear indication that Safety is not be jeopardized; hence, it is necessary that changes are classified through a prior analysis of their impact on the system. CR-IR requires a systematic identification of the hazards to be conducted.

The severity of the effects of hazards in a given environment of operations shall be determined using the classification scheme set out in Table 2.3-1, while the severity classification shall rely on a specific argument demonstrating the most probable effect of hazards, under the worst-case scenario.

[70] CR-IR Arts. 4 and 6, and Annexes I to V.
[71] CR-IR Arts. 6.2.
[72] CR-IR Annex II 3.2.4. Changes to functional systems are a particular category of changes amongst all the ones notified by the Organisations to the CA.

severity class	effect on operations
1 (most severe)	accident[73]
2	serious incident[74]
3	major incident associated with the operation of an aircraft, in which the safety of the aircraft may have been compromised, having led to a near collision between aircrafts, with ground or obstacles
4	significant incident involving circumstances indicating that an accident, a serious or major incident could have occurred, if the risk had not been managed within safety margins, or if another aircraft had been in the vicinity
5 (least severe)	no immediate effect on Safety

Table 2.3-1 the CR-IR severity classification scheme

This scheme is of fundamental importance since Safety objectives are risk based and hence established in terms of the hazard's maximum probability of occurrence, derived both from the severity of its effect, and from the maximum probability of the hazard's effect.

A certified ATM/ANS Organisation shall notify the CA of planned changes to its provision of ANS which may affect its compliance with the applicable CRs or with the conditions attached to the certificate, where applicable.
To this effect, CAs shall establish appropriate administrative procedures in accordance with national law to perform the Oversight function.

2.3.4 Subject matter and scope of the Oversight function [75]

CAs shall establish and regularly implement a documented process to exercise Safety Oversight as part of their supervision of requirements applicable to ANS as well as to ATFM, ASM and other network functions, in order to:

- monitor the safe provision of these activities
- verify that the applicable Safety regulatory requirements prior to the issue or renewal of a certificate necessary to provide ANS including Safety-related conditions attached to it
- verify ongoing compliance with Safety regulatory requirements
- verify implementation of Safety objectives[76], Safety requirements[77], Safety directives[78] and other Safety-related conditions identified in declaration of verifications (DoV) of systems, including any relevant declaration of conformity (DoC) or suitability for use (DSU) of constituents of systems, risk assessment and mitigation procedures required by Safety regulatory requirements applicable to ANS, ATFM, ASM and the NM

[73] as defined in Article 2 of Regulation (EU) No 996/2010 of the European Parliament and of the Council on the investigation and prevention of accidents and incidents in civil aviation and repealing Directive 94/56/EC. Definition is replicated in A.aa.
[74] same as note 73. Definition is replicated in Appendix A.bb.
[75] SO-IR Arts. 4 and 6.
[76] The definition is given in Appendix A.1.x.
[77] The definition is given in Appendix A.1.y.
[78] The definition is given in Appendix A.1.w.

2.3.5 Safety Oversight of changes to functional systems

ATM/ANS, as well as ATFM and ASM, use ‘functional systems’ that enable the management of air traffic.

According to both SO-IR and CR-IR [79]:

> ‘functional system’ means a combination of systems, procedures and human resources organised to perform a function within the context of ATM

It is key to remember that during the Safety risk assessment of a change, the scope of the assessment shall be at the level of the function.
During a Safety assessment of a change, it is not enough to simply view the change from the perspective of only systems, procedures, or only human resources: if this were to happen, there would no chance to get a proper and complete view or understanding of the changes.
In other words, the scope of the Safety assessment shall include, of course, all the elements of the functional system, but also their interactions. That’s what is meant with the word ‘combination’ used in the definition.

Organisations shall only use procedures accepted by the relevant CAs when deciding whether to introduce a safety-related change to their functional systems. In case of ATS and CNS Service Providers, the relevant CA shall accept these procedures in the framework of CR-IR.

Organisations shall notify the relevant CA of all planned safety-related changes. To this effect, CAs shall establish appropriate administrative procedures in accordance with national law.

2.3.6 Review procedure of the proposed changes

CAs shall review the safety arguments associated with new functional systems or changes to existing functional systems proposed by an organisation when:

- the severity assessment determines a severity class 1 or a severity class 2 for the potential effects of the hazards identified or
- the implementation of the changes requires the introduction of new aviation standards

When CAs determine the need for a review in other situations than the previous ones, they shall notify the Organisation that they will undertake a safety review of the notified changes.

Reviews shall be conducted in a manner commensurate with the ‘level of risk posed by the change’.
CAs cannot dedicate the same level of efforts to all changes to functional systems, whatever their safety significance; hence, CAs are allowed to define additional appropriate criteria for reviewing Safety arguments associated with new functional systems or changes to existing ones, in order to distinguish those changes that may be subjected to a mandatory Safety review prior to their implementation from the other ones which may not and can be applied without a specific acceptance from CAs.

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[79] SO-IR Art. 2(2) and CR-IR Art. 2(3).

Some criteria concerning the change may lead the CA to perform a more demanding review of changes process: review shall commensurate with the level of the 'risk posed by the change'.
The need for review should be based on a combination of the likelihood that the Safety (Support) Argument may be complex or unfamiliar to the service provider undertaking the change and the severity of the consequences associated with the change. This is a risk function and is referred to as the 'risk posed by the change'.

Changes with minor potential severity do not need to be reviewed, irrespective of the probability of the safety argument being incomplete and/or incorrect (though the process may retain the option for the CA to review the change, since the estimate itself of potential severity may be suspected of being erroneous).Some changes may not necessarily need to be reviewed providing that, even though safety-related, they can be considered as *routine* by the provider as they have been consistently assessed, implemented and proved safe in the past and, therefore, the CA has sufficient confidence that the provider will address them in a similar manner.

Changes with very high potential severity should always be reviewed, irrespective of the probability of the safety argument being incomplete and/or incorrect. This criterion may well respond to common perceptions and could be justified by the fact that judgements of low probabilities based on limited information are often unreliable, and errors in the judgment of risk are proportional to the error on probability and the size of the loss. CAs shall review the Safety Arguments associated with the new Functional Systems or changes to an existing one is proposed by an Organisation, when the Severity Assessment conducted in accordance with the CR-IR determines a severity class 1 or a severity class 2 for the potential effects of the hazards identified, or the implementation of the change require the introduction of a new aviation standard.

2.3.7 Demonstration of compliance and corrective actions [80]

CAs shall communicate the audit findings to audited Organisations and shall simultaneously request corrective actions to address the non-conformities identified.

Where a certified Organisation no longer complies with the applicable CRs or with the conditions attached to the certificate, where applicable, the CA shall, within one month of the date of discovering the non-compliance, require the Organisation to take corrective action.

Audited Organisations shall determine the corrective actions deemed necessary to correct non-conformities and the time frame for their implementation.

CAs shall assess the corrective actions as well as their implementation as determined by audited Organisations and accept them if the assessment concludes that they are sufficient to address the non-conformities.
Audited Organisations shall initiate the corrective actions accepted by CAs. These corrective actions and the subsequent follow-up process shall be completed within the time period accepted by CAs.

The CA shall check that the corrective action has been implemented before notifying its approval to the relevant Organisation, or, on the contrary, take appropriate enforcement measures, while taking into account the need to ensure the continuity ANS.

CAs shall issue a safety directive when they have determined the existence of an unsafe condition in a functional system requiring immediate action.

[80] CR-IR Arts. 6 and 13 and SO-IR Art. 8.

2.4 Overview of the ATCO Regulation

This paragraph gives a partial overview of the content of the AR.
Most of the relevant content related to the subject matter of the Thesis is instead shown in Chapter 8.

2.4.1 Subject matter and scope [81]

AR lays down the detailed rules for:

- the conditions for issuing, suspending and revoking ATCOs and student ATCOs' licences, associated ratings and endorsements, and the privileges and responsibilities of those holding them
- the conditions for issuing, limiting, suspending and revoking ATCOs and student ATCOs' medical certificates, and the privileges and responsibilities of those holding them
- the certification of aero-medical examiners and aero-medical centres for ATCOs and student ATCOs
- the certification of ATCO Training Organisations
- the conditions for validating revalidating, renewing and using such licences, ratings, endorsements and certificates

This Regulation shall apply to:

- student air traffic controllers and air traffic controllers exercising their functions within the scope of the BR
- persons and Organisations involved in the licensing, training, testing, checking and medical examination and assessment of applicants in accordance with the AR

2.4.2 Provision of Air Traffic Control services [82]

ATC services shall only be provided by ATCOs qualified and licensed in accordance with the AR.
MSs may apply this Regulation to their military personnel providing services to the public.

[81] AR Art. 1.
[82] AR Art. 3.

2.4.3 Competent Authority [83]

MSs shall nominate or establish one or more CAs with allocated responsibilities for the Certification and Oversight of persons and Organisations.

Within a FAB or in the case of cross-border service provision the CAs shall be designated by agreement of the MSs concerned.

The CAs shall be independent from ANSPs and Training Organisations. This independence shall be achieved through adequate separation, at least at functional level, of the CAs on the one hand and ANSPs and the Training Organisations on the other hand.
The CAs shall exercise their powers impartially and transparently.

EASA is the CA for applicants having their principle place of operation or its registered office, if any, outside the territory of the MSs and when the aero-medical centre is located in a third country.

[83] AR Arts. 5 and 7.

3. The research of review decision criteria

"Good checklists, on the other hand are precise.
They are efficient, to the point, and easy to use even in the most difficult situations.
They do not try to spell out everything– a checklist cannot fly a plane.
Instead, they provide reminders of only the most critical and important steps –
the ones that even the highly skilled professional using them could miss.
Good checklists are, above all, practical."
Atul Gawande, American surgeon, writer, and public health researcher

3.0 Content of Chapter 3

This chapter depicts the core of the scope of the Thesis, which is the review of changes to the functional systems as part of the EASA's Oversight activities.

Paragraph 3.1 describes in detail the whole procedure currently adopted by EASA related to the changes to functional systems, from the reception of the notification of a change to the acceptance or non-acceptance of the change.

Paragraph 3.23.2 describes how the Safety Oversight function should generally evolve in the future, moving the steps from a compliance-based approach to a risk-based one, as required by the forthcoming Regulations.

Paragraph 3.3 is about the most important differences between the rules which are in force now and the forthcoming ones, which explicitly allows for the presence of new risk-based criteria for the review decisions about changes to the functional systems.

Paragraph 3.4 deals with the research of those risk-based criteria for the review decision about changes to the functional system, which is basically what this Thesis is mainly about. Firstly, are given the justification, the purpose, and the scope of the research. Then, are presented the requirements the criteria must comply with in order to be accepted. Finally, it is explained the method used to find and select them.

3.1 The EASA procedure for ATM/ANS changes to functional systems

In this paragraph it is described the procedure adopted by EASA in conjunction with the current applicable Regs. for the management of changes to functional systems notified by the Organisations under EASA's Oversight. [84]

This procedure comprises the following four phases:

1. the review decision
2. the compliance plan agreement
3. the compliance demonstration assessment
4. the final report

For each phase, more details are given in the following relative subparagraphs, anyway the whole procedure could be summarised as encompassing the following steps:

1. receive and properly manage the notification by the Organisation about planned changes to functional systems relevant to ATM/ANS provision
2. identify which ones are subject to review and which not
3. for those subjected to review, review the safety arguments associated with new functional systems or changes to existing ones proposed by the Organisation in a manner commensurate with the level of risk posed
4. accept or not the introduction into service of the reviewed changes
5. perform on-going Risk-Based Safety Oversight of the change

While reviewing and preparing recommendations for the acceptance of planned changes notified by ATM/ANS Organisations, the FS.4.1 Section may interface with other departments as necessary (e.g Legal, Rulemaking, Standardisation).

[84] All EASA's procedures are published and stored on ARIS Business Publisher digital platform (IMS – Integrated Management System by Software AG). The procedure concerned is the PR.AOA.00004. Detailed flowcharts for each phase of the procedure presented in this Paragraph can be found in Appendix E.

3.1.1 The review decision[85]

According to the SO-IR[86], Organisations under EASA Oversight must notify all planned safety-related changes. The notification consists of an official form[87] completed, signed, and sent via e-mail by the contact person of the Organisation who is responsible for the submitted notification (generally the Safety Quality Manager, the Certification Coordinator or someone having a similar qualification).

The notification form reflects the statements of the SO-IR[88] and contains information which is relevant for the subsequent classification of the change and the related review decision, which are:

- identification of ANSP
- identification of the notification
- the overall description of the change, including:
  - the purpose of the change
  - the justification for the change (including the facts triggering the change)
  - the planned date for the introduction into service
- the specification of which the affected element of the functional system, which, according to the SO-IR is composed by:
  - system
  - procedures
  - human resources
- the change classification, including:
  - the severity class for the potential effect of the hazards identified, with respect to the classification stated in the CR-IR [89]
  - the summary of the Initial Safety Assessment for the change (including the justification for the Severity Class classification
  - the need for the introduction of new aviation standards
- the services/functions impacted by the change (e.g. ATS/FIS/OFIS, CNS/NAV/SBAS, etc..)
- the list of documentation provided with the notification
- the declaration and signature

The first activity of the process is the e-mail reception and registration of the notification form. [90]
An email acknowledging receipt of the notification form and related documents is sent back to the responsible of the Organisation.
The notification form and additional supporting documentation is provided to the ATM/ANS Expert (AAE) for technical review.

[85] Please refer to Appendix E.1.a.
[86] Art. 9 of Reg. (EU) No 1034/2011.
[87] The form is "FO.AOA.00043 ATM-ANS Organisation Approval Notification of Proposed Change to Functional System" can be found on EASA Internet Website and downloaded from the ATM/ANS & ATCO Training Organisation Approvals page.
[88] Art. 10.2 of Reg. (EU) No 1034/2011.
[89] Here it is made a reference to the risk classification scheme of Annex II of Reg. (EU) No 1035/2011.
[90] The Notification Form is forwarded to EASA mail section for registration in ADONIS. The notification is logged in the "Register of Notification for Changes to Functional Systems" and attributed a unique reference number.

After assessment of the notification of change, the AAE informs the TL about the decision for the review of the change by submitting the related filled in template[91], containing the justification for the decision of reviewing or not reviewing the change.

According to SO-IR[92], the review of the Safety Arguments associated with new functional systems or changes to existing ones is mandatory when:

- the Severity Assessment conducted determines a severity class 1 or a severity class 2 for the potential effects of the hazards identified, or
- the implementation of the changes requires the introduction of new aviation standards

The other cases are subject to the AAE judgment.

Specific agreement can be formalised as part of the Organisation Management System in order to identify the type of changes that, requiring notification, are subject of *a priori* no review decision. This is especially useful for changes related to the functional system intended to correct identified problems either in the technical system or in the operational procedures. The nature of these changes should be such that the objective is to recover the expected behaviour (as required) of the technical system or the procedure.

In order to have the possibility of tailoring the review process to the magnitude/size of the change, EASA internal procedures also include a distinction between:

- simple changes, having a low Level of Involvement
- complex changes, having a high Level of Involvement

The Level of Involvement (LoI) should be understood as the definition of the compliance verification activities to be performed by EASA certification expert(s) during the review activities of a notified change. The compliance verification activities can be classified as:

- desktop activities, which consist in reviews of Organisation documentation without visiting the facilities of the Organisation
- inspection and on-site activities, which are performed by EASA certification experts visiting the facilities in order to:
  - perform audits for the evaluation of the methods and the processes used for the generation of the compliance demonstration evidences
  - witness specific development/validation/verification tests and analysis of relevant data items

In support to this phase there is a User Guide (UG44). [93]

Once that a justified review decision is taken and the relative proper LoI is decided, or that, on the contrary, a no review decision is taken, the template is integrated in a confirmation letter, which is signed by the FS.4.1 SM and sent back to the Organisation.

[91] The template is the "Review Decision of change to ATM/ANS functional system" (TE.AOA.00045).
[92] Art. 10.1 of Reg. (EU) No 1034/2011.
[93] UG.AOA.00044 "*Guidelines for the classification of changes and determination of the Level of Involvement*".

3.1.2 The compliance plan agreement[94]

Subsequently, the review team is established.
The AAE shall assess the need to involve additional EASA experts and/or seconded National Aviation Authority / Qualified Entity (NAA/QE) experts for the particular change. [95]
In case additional expertise is needed, AAE coordinates with the Team Leader (TL) in order to establish the necessary team within the Oversight project and to update the activities planning accordingly.

Then, the AAE establishes the Change Regulatory Basis (CRB) which consists of applicable regulations to the ATM/ANS Organisation for the service in which the new or changed functional system contributes. This Change Regulatory Basis (CRB) constitutes the set of requirements against which the ATM/ANS Organisation have to show compliance (to be assessed by the Assessment Team) as part of the introduction of a new or changed functional system.

The Change Regulatory Basis (CRB) is recorded by the AAE in a specific document[96] which may need to be changed along the course of the assessment process due to aspects not detected nor presented during the technical familiarisation, such as new applied technologies, introduction of additional design changes, discovery of unsafe conditions, or compliance demonstration results.

The responsible TL reviews the CRB as proposed by the AAE, and must give a traceable[97] confirmation of at least its initial and final content.
This initial CRB is sent to the ATM/ANS Organisation for feedback.

The ATM/ANS Organisation submits the proposed means of compliance with the CRB and identifies all the activities intended to be carried out for compliance demonstration and the related documents. All documents required to show compliance with the applicable requirements and their scheduled date of availability must be identified.
The AAE reviews the proposed means of compliance and iterates with the ATM/ANS Organisations until agreement is reached.

Finally, the LOI is established together with the compliance documents to be reviewed and/or the inspection activities to be performed by the Assessment Team members.

[94] Please refer to Appendix E.1.b.
[95] This procedure reflects the following Decisions:
ED Decision 2014/00X/E - Decision of the Executive Director of the Agency of XX Month 2014 on the delegation of powers of the Executive Director to certain staff members of the Flight Standards Directorate
MB Decision 01/2004 - Decision of the Management Board of 3 February 2004 concerning the arrangements to be applied by the Agency for public access to documents
MB Decision 01/2011 - Decision of the Management Board of 15 March 2011 on adopting the guidelines for the allocation of certification tasks to NAAs and QEs
[96] The document is realised from the predefined “Template for the Change Regulatory Basis” (TE.AOA.00046).
[97] Notes of internal meetings/communication and e-mails are recorded.

3.1.3 The compliance demonstration assessment[98]

The Assessment Team Members proceed with the review of the compliance demonstration documents identified as part of the LoI.
Compliance demonstration has to include a compliance statement from the ATM/ANS Organisation confirming that new or changed functional system complies with the CRB.
After receiving the detailed written comments[99] from all the Assessment Team Members, the AAE performs a consolidation of these detailed comments, avoiding duplicities and grouping as necessary. Additionally, specific assessment on the comment classification is performed by the AAE. At the end of this process, a single file compiling all the detailed comments is available.
If necessary, a Comments Consolidation Meeting can be held between the AAE and the Assessment Team Members in order to consolidate the detailed comments on the compliance demonstration documents.
In conclusion, the AAE sends the detailed comments to the ATM/ANS Organisation.

If identified in the LoI, audit and inspection activities are performed.

The AAE organises a discussion on the raised comments involving the ATM/ANS Organisation representative(s), the AAE and selected Assessment Team Members.
As result of these discussions, closure of the comments or identification of specific actions should be performed.

In the case that, after assessing the final compliance demonstrations and proposed closure of findings, the Assessment Team considers that these are not satisfying the regulatory requirements, then the AAE must contact the ATM/ANS Organisation (in copy to the TL) and inform them about that, providing justifications so the Organisation can take this information in order to introduce the necessary improvements.
In case the compliance demonstration will not or cannot be fulfilled in a satisfactory manner by the ATM/ANS Organisation, the AAE proceeds to prepare the investigation final report in which non-acceptance of the change is concluded.

The ATM/ANS Organisation submits the updated compliance documents or proposed closure of findings, and the Assessment Team re-performs the review activities on the basis of the “deltas” and assesses if the proposed modifications allow confirmation of the compliance with the regulatory requirements. If the result is not satisfactory, additional iterations with the Organisation is performed in order to solve the open issues.
If, after some iterations, no progress or no agreement is reached, the AAE informs the TL and and the FS.4.1 SM about the situation and proceeds with the preparation of the Final Report and the declaration of non-acceptance for this change.

[98] Please refer to Appendix E.1.c.
[99] Written comments are logged using the “Comment File Form” (TE.AOA.00053).

3.1.4 The final report[100]

If the compliance demonstrations are acceptable or, on the contrary, are not fulfilled satisfactory, the AAE – with the necessary support of the Assessment Team – produces and signs the ATM/ANS change to functional systems investigation final report[101]. The objective is to summarise the review activities carried out and the results of the review.

The TL reviews the investigation final report and, if in agreement with its conclusion, signs the report for acceptance/non-acceptance accordingly. The signed report is forwarded to FS.4.1 SM as baseline for the recommendation to issue the acceptance/non-acceptance letter. Even after the agreement on the comments, it might be necessary to introduce some restrictions on the change, such as:

- limitations of use, which are restriction to the scope of the change (e.g., partial implementation)
- conditions, which consist in actions to be performed by the ANSP before the introduction into service, whose results shall be submitted to the CA

The status of the Limitations shall be managed, e.g. in-force or removed, and typically, the removal of would require the introduction of a new change.

The SM reviews the final report and, in case of a different opinion regarding the recommendations or their wording, shall – upon consultation with AAE and TL – justify his decision to deviate from using these recommendations as baseline for the acceptance/non-acceptance letter and the evidence of the justifications shall be electronically stored.

This is the typical content of the Investigation Final Report:

- presentation of the change
- description of the review process carried-out including the list of documents reviewed
- results of the review process
    - Safety Assessment aspects
    - interoperability aspects
    - software aspects
- overall Assessment on the acceptability of the change
- proposal of Decision, including:
    - limitations of use
    - conditions
- areas of improvement and areas for evaluation during the Continuous Oversight

Just to recap, the result of the review is notified to the Organisation through a dedicated letter signed by authorised signatory (SM) and including:

- acceptance of the change, with limitations of use and/or conditions (if any)
- non-acceptance of the change, including the justification for the non-acceptance

[100] Please refer to Appendix E.1.d.
[101] The document is realised from the predefined "Investigation Final Report" template (TE.AOA.00054).

The Administrative Assistant in coordination prepares for signature by FS.4.1 SM the issuance of the updated Approval Certificate, as well as a cover letter notifying the decision of acceptance or non-acceptance of the change to the functional system, as well as the reasons for the necessary issuance of an updated AOA certificate based on this decision.

At this point, the Oversight process is considered finalised, and the cycle will be repeated as soon as a new change is notified.

3.2 Towards a Performance-Based and Risk-Based Oversight

It has been shown how the concept of Safety has developed over time and how the Regulations is continuously adapting to it. [102] Being a Safety activity, the Oversight makes no exception to this continuous improvement.

ICAO's Annex 19[103] revolves around the transition from Compliance-Based Oversight (CBO) towards a Performance-Based Environment (PBE), where Safety Performance measurement and Risk Management has to be developed.

Initially, Oversight was conducted at fixed intervals using traditional audit and inspection techniques; an approach that does not reflect neither the individual risks nor the system effectiveness.

Performance-Based Oversight (PBO) is an assessment by the CA of the level of compliance of an Organisation with the aviation regulations. In other words, the CA considers how effectively Organisations comply with the aviation regulations and not just whether they comply. As a matter of fact, two Organisations can both be compliant, but one in a more effective way than the other.

Annex 19 requires an effective system to be put in place for the evolution of the way Oversight is exercised, without stating how Oversight has to be conducted or planned.
The PBO is based, rather than on prescriptive requirements that can be met in one single way, on the objectives an Organisation needs to achieve, which are appropriately tailored and sized on the complexity of the Organisation itself.
Effective compliance builds mutual confidence between CAs and Organisations, demonstrating the continuity of compliance on an on-going basis.

The overall performance of a system is quantified by measuring relevant system parameters, usually referred to as performance indicators (PIs).

An Organisation may use PIs to evaluate its success, or to evaluate the success of a particular activity in which it is engaged. Sometimes success is defined in terms of making progress towards strategic goals, but often success is simply the repeated, periodic achievement of some level of operational goal (e.g. zero defects). Accordingly, choosing the right PIs relies upon a good understanding of what is important to the organisation. Since there is a need to understand well what is important, various techniques to assess the present state of the business, and its key activities, are associated with the selection of PIs. These assessments often lead to the identification of potential improvements, so PIs are routinely associated with 'performance improvement' initiatives. When PIs have performance targets associated with them, they are known as key performance indicators (KPIs). [104]
Such measured level of performance – measured through KPIs – becomes a data source for the Risk-Based Oversight (RBO).

[102] Amongst all the previous ones, it is made a particular reference to Paragraphs 1.1.4 and 2.2.
[103] Explicit reference to [2]. Other interesting sources on the transition to PBO and RBO are two Working Papers submitted to ICAO by Canada [19] and Latvia and EUROCONTROL [21].
[104] Annex III to ED Decision 2017/001/R GM2 ATM/ANS.OR.B.005(a)(3).

According to EASA[105], KPIs represent the point of contact between the PBO and the RBO, as they are set to measure and monitor the safety risks and/or the actions mitigating these risks. This means that the KPIs of the PBO support the RBO in identifying the areas of greater risk for the Risk Assessment and Mitigation exercise.

RBO recognises the CAs' need to effectively allocate resources exactly where they are most required, hence planning the Oversight activities in accordance with the risks.

The Continuous Monitoring Approach provides an additional layer of surveillance monitoring to address shifts in the risk profile of an Organisation and to assure the CA that the established Oversight intervals are appropriate.

RBO is hence intended as an Oversight program that evaluates an Organisation's risk profile to determine the frequency of the inspections. [106]

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[105] Recommendations and suggestions about the EASA interpretation and first implementation of the ICAO inputs mentioned in [2] about the evolution from the CBO towards the RBO are contained in [19].

[106] This is further explained in Paragraph 9.3.

3.3 Relevant elements of the New Implementing Rule

The CRs set out in CR-IR and SO-IR serve in particular to implement, at an initial stage, the ERs concerning the provision of ATM/ANS set out in the BR[107] and to allow the commencement of Standardisation Inspections in accordance with the BR[108]. [109]
As the Total System Approach[110] entails a logical and technologically consistent approach across the various domains, those requirements have already been laid down in a single instrument: the New Regulation, NR-IR.
This objective will be fully achieved by 2 Janaury 2020, when the NR-IR shall be effective and both SO-IR and CR-IR shall be repealed. [111]

In this paragraph it is given neither a general nor a complete overview of the NR-IR, because the subject matter is the same that the already presented CR-IR and SO-IR cover. Anyway, it is complemented and updated in light of technical progress. Furthermore, the NR-IR is not applicable yet. Nevertheless, the introduction of the NR-IR inevitably brings with itself some changes.

This paragraph deals with a few differences introduced to the Oversight function – which is at the CAs' level – and with a great distinctive and substantial change made to the Severity Classification Scheme for the Safety Risk Assessment – which is mostly impacting at the Organisations' level. [112]

The NR-IR is the first Implementing Rule for ATM which takes into account RBO and PBO.
This is reflected, for example, by the fact that the Oversight programme cycle can vary in terms of length. Of course, relevant findings have always been shortening and restarting the Oversight cycle. But in the NR-IR it can also be extended up to forty-eight months if a set of performance conditions are fulfilled by the Organisation concerned. [113]

This means that the Oversight activities can finally focus on the areas where they are needed the most and, at the same time, be a little more loosen there where the performance bodes promising.

The NR-IR also recognises that the knowledge and the expertise of the Organisations.
This means, again, that what is covered by the Regulation is only the methodology, while the procedures and the safety objectives are established by the Organisation in accordance with the CA.

In fact, it states that the safety acceptability of any change proposed by a Service Provider should be assessed based on the analysis of the risks posed by the introduction of a change to its functional system, differentiated under either quantitative or qualitative objective assessment criteria, or a combination of both, to be determined at a local level. [114]

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[107] In particular to ensure compliance with the BR Art. 8b, Art. 22a, and Annex Vb.
[108] In particular to ensure compliance with the BR Art. 24.
[109] NR-IR item (2) of the preamble.
[110] Paragraph 1.3.3 deals with the Total System Approach.
[111] with the exception of DAT provision which has an earlier applicability date: from 01 January 2019.
[112] Some changes in the wording and in the concepts behind them are summarised and briefly commented in Appendix A, which deals with taxonomy.
[113] NR-IR ATM/ANS.AR.C.015 Oversight programme.
[114] NR-IR item (18) of the preamble.

To this regard, it is given a clearer definition of functional systems[115]:

> ‘functional system’ means a combination of procedures, human resources and equipment, including hardware and software, organised to perform a function within the context of ATM/ANS and other ATM network functions

The word 'system' from the definition given in the SO-IR has been replaced by 'equipment' in order to avoid the difficulty that systems are generally thought of as comprising people, procedures, equipment and architecture. [116]

3.3.1 The Severity Classification Scheme

The SO-IR states that any changes to functional systems should be subject to a Safety Oversight. [117]
The NR-IR, as just mentioned, states that any change proposed by a Service Provider should be assessed based on the analysis of the risks posed by the introduction of a change to its functional system. [118]

The limit between what is acceptable risk and what is not, is typically determined by an Authority.
Basically, the acceptability of a risk consists means to respect the limits on the combination of the likelihood and of the severity of the risk.
Probability is typically shown as number of occurrences per unit of time. The high safety standards reached by the ATM environment through time made the quantification of probability a complex task to be accomplished, and so the people working with probabilities need to be competent to do so.
Severity, instead, is typically shown as categories or classes, but it is not as complex to quantify as probability. The problem with severity is that in the ATM/ANS domain there are many different Severity Classification Schemes, helping in the classification and then the management of risks.
After various attempts to standardise a Severity Classification Scheme, EASA concluded that “a universally acceptable severity scheme was not feasible at the moment”. [119]

The NR-IR does not provide any classification scheme, however various examples of schemes can be found in the AMCs and in the GM.

Only the ex-Severity Class 1 present in the SO-IR is kept being used in safety risk analysis and safety risk evaluation, because only events that can be classified as ex-Severity Class 1 could possibly cause harm to humans. This might be generally true in the ATM/ANS domain, but not in others[120].

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[115] NR-IR Annex I (56).
[116] Furthermore, 'system' may have created confused with the same term used in Regulation (EC) No 549/2004 where it does not include people or procedures and whose scope is limited to ANS.
[117] SO-IR item (6) of the preamble.
[118] Same as 114.
[119] NPA 2014-13 “Assessment of changes to functional systems by service providers in ATM/ANS and the oversight of these changes by competent authorities” RMT.0469 & RMT.0470, 24 April 2014 April 24, pag. 16 of 230.
[120] For example, this is in contrast to the severity classification scheme used for aircraft certification, where the first three classes can cause death or physical injury to humans.

3.3.2 The risk-based criteria for the review decision

About the decision to review a notified change to the functional system, the NR-IR states[121] that:

(b) The CA shall determine the need for a review based on specific, valid and documented criteria that, as a minimum, ensure that the notified change is reviewed if the combination of the likelihood of the argument being complex or unfamiliar to the service provider and the severity of the possible consequences of the change is significant.
(c) When the CA decides the need for a review based on other risk based criteria in addition to point (b), these criteria shall be specific, valid and documented.

In the GM

GM1 ATM/ANS.AR.C.035(b) Decision to review a notified change to the functional system
SELECTION CRITERIA FOR REVIEWING A NOTIFIED CHANGE TO THE FUNCTIONAL SYSTEM

[121] As stated in ATM/ANS.AR.C.035 b) and c) of Reg. 2017/373.

3.4 Introduction to the research of the selection criteria for the review decision

For the sake of brevity, the selection risk-based criteria for the review decision phase of the Oversight process for changes to functional systems are hereinafter simply called 'Review Criteria'.

In this paragraph it is given an explanation of the raison d'être of the review criteria, of their characteristics, and of the method used to find them.
They consist in a list of items, each called Review Criterion, which are taken into account during the review decision phase of the RBO.

3.4.1 Justification, purpose, and scope

The aim of this Thesis is to find review criteria for changes to functional systems[122] notified by ATM/ANS Organisations under the Oversight by the EASA's FS.4.1 Section.[123]

The reasons justifying the need for such a research of review criteria can be found taking into account the following elements, which are commented below:

1. the UG44 [124]
2. the current CR-IR and SO-IR
3. the forthcoming NR-IR

The UG44 is a bit outdated[125] and contains a list of questions whose answers may give an idea about what the expert's decision is based on and which is the appropriate LoI. With the Deming Wheel in mind, FS.4.1 believes that this UG leaves some room for enhancement and consolidation.

Apart from the very rare cases when the review decision is mandatory[126] due to the requirements of the current Regulations, [127] most of the cases are considered as requiring review as a consequence of an expert's judgement. For the time being, there is no proof about the AAEs' judgement being standardised. [128]

[122] For the sake of clarification, it is reiterated that the changes to the functional systems are a particular category of changes amongst all the ones notified by the Organisations to the CAs according to CR-IR Art. 6.2.
[123] In accordance with one of the deliverables of the SPS (Study Placement Scheme) Working Plan I was assigned, which is the following: *"The Candidate shall develop a proposal for review decision criteria about changes to the functional systems notified by ATM/ANS Organisations, which are under the Oversight by the EASA's FS.4.1 Section during his traineeship."*.
[124] Here it is made a reference to Footnote 93.
[125] UG44 last update is dated 28 September 2015.
126 The review decision has been proved to be mandatory in less than the 3% of the cases considered in the research. Available data in Subparagraph 4.1.
127 It is made a reference to both the statements of the SO-IR explicitly reported in Paragraph 0 while explaining the review decision phase and the ATCO Reg. mentioned in Chapter 2 and furtherly analysed in Paragraph 8.2.
128 A standardisation of the experts' judgement could be translated in a proof for equity in the treatment of the different oversighted Organisations, which would be an additional asset for the EASA's image.

Recalling the EASA's commitment towards the general principle of the continuous improvement[129], the justification for such a research of review criteria shared amongst the AAEs lies on the fact that, if found, these criteria could serve as a first step to provide proofs for the experts' judgement to be standardised and harmonised. [130]

The NR-IR states[131] that the CA shall determine the need for a review decision based on risk-based criteria that shall be specific, valid and documented, but it is left to the CA to define these criteria since the Regulation just give some suggestions without specifying them. [132]

The scope of this Thesis is therefore mainly focused on the review decision phase of the Oversight procedure for ATM/ANS changes to functional systems.
This area constitutes the main focus, but the scope is wider: as the review decision phase is connected to other phases of the RBO, this criteria are contextualised in the wider RBO panorama.

The Continuous Monitoring Approach has in fact shown that, in the loop of a process, the outputs of a phase become the inputs for the following one and, in a complementary way, the inputs of a phase are the outputs of the previous one.
In the case of the RBO cycle, possible outputs of the review decision phase are limitations or conditions imposed to the oversighted Organisations or corrective actions required, whose implementation has to be checked during the on-site Auditing phase. Furthermore, the results of the Audits, in terms of findings, become a parameter for the assessment of the level of performance of an Organisation, a datum that is of course taken into account by the experts also during the review decision, in terms of evidence-based confidence towards the oversighted Organisations which are planning to implement new changes to their functional systems. [133]

Hence, for the sake of completeness, the whole Oversight is in the scope and, in conclusion, the Thesis presents focuses on the research of criteria for the review decision phase and also complements it with a general description of the criteria for the Auditing phase of the Ongoin RBO. [134]

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[129] A general introduction on the Continuous Improvement principle was given in Paragraph 1.1.3.

[130] Such an ambitious objective was planned, discussed and agreed upon by the FS.4.1 Section and given to me as a deliverable of my Working Plan. It was the SM who motivated and pushed me to continue pursuing this objective, despite and against the negative impressions arisen amongst the AAEs about its actual feasibility. The SM said that these kind of feedbacks were predictable since AAEs have a deep knowledge of the Organisations for which they are responsible for (as TLs or TMs). Due to their high expertise, they are, of course, very likely to immediately spot the distinctive peculiarities that make their Organisations unique and different from the others and, on the other hand, very unlikely to accept possible common characteristics without raising comments underlining the existing (minor) discrepancies.

[131] As stated in ATM/ANS.AR.C.035 b) and c) of Reg. 2017/373.

[132] More details about this are given in Paragraph 9.1.

[133] This intertwinement is better explained in Chapter 9.

[134] In particular in Paragraph 9.3.

3.4.2 The requirements for the review criteria

The research is driven by a trade-off amongst the following conflictual requirements which the set of criteria should comply with in order to be useful:

- granularity
- completeness
- generality
- simplicity

Criteria should to allow their applicability to each possible scenario, which means that it should be possible to apply those criteria to whichever review decision taken in response to a particular change notification by a specific Organisation.

in order to be of practical use, review criteria should comply with the following requirements.
first granularity.

The criteria should reach enough detail in order to allow a comprehensible description of whichever change notified by an ATM/ANS Organisation. Thinking about the notification as a stream of information and about the review criteria as filters, the review criteria should be thick enough to grab all the relevant elements contained in the stream flowing through.

The set of criteria should be as complete as possible, in order to include the majority of – if not all – the relevant aspects which are taken into account during the review decisions by the AAEs.
Being EASA oversighting Organisations providing services of very different nature, any Organisation can provide hints for the development of different criteria. The more Organisations are considered, the more the list of criteria should be likely to be complete.

Furthermore, criteria should be general enough to be applicable to all the Organisations in the scope without any distinction. This means, for the sake of standardisation and equity in treatment, that it should be possible to apply same criteria on whichever oversighted Organisation.

Essentially, criteria born as Organisation-dependent, grow including different Organisations and end up as Organisation-independent.

These first three requirements reflect the Total System Approach, but on a reduced scale: as the Total System Approach encompasses the different Aviation domains, so the criteria should be applicable to the whole spectrum of the ATM/ANS Organisations.

Furthermore, in order to be of practical use and to facilitate their eventual implementation, the utmost simplicity should be achieved and any unnecessary complication avoided: the goal is to do things better rather than making them even more complicated.

3.4.3 The method

The method used to achieve this objective passes through the following listed steps:

1. **selection of the Organisations**
   Amongst those under the Oversight by EASA's FS.4.1 Section, a set of Organisations is selected. The set is composed by Organisations which have notified changes to their functional systems and on which at least one decision of reviewing a change has been taken.
2. **learning of the functional systems, processes, and procedures**
   Each Organisation has a particular functional system with different processes and procedures. Several documents are reviewed in order to understand the composition of the functional systems, the change management processes and the approved procedures. This is fundamental to distinguish at least what is agreed to be notified to the CA because of its Safety-relevancy and what not. [135]
3. **review of the notifications**
   Being the review decision based and tailored on the notified planned changes, it is assumed that the research of review criteria takes its first step in the identification of the characteristics of the notified planned changes. The analysis of the change notifications provided by each selected Organisation fosters the identification of the characteristics of the changes. Furthermore, it is possible to understand which parts of the functional system are more relevant and which types of changes more frequent and typical, based on the collected data.
4. **review of the review decisions**
   This step is self-explanatory, due to the fact that review decision criteria are the object of the research. All the review decision taken in response to the previously mentioned notifications are analysed. [136]
5. **draft list of the review criteria**
   The review criteria are drafted by abstraction and identification of the reasons contained in the justifications of each taken decision of reviewing a change or not.
6. **verification**
   The criteria are listed and a simple way for taking them into account is found via iterated testing of a scoring system. The criteria are validated against the collected notified changes, so that the outcome about reviewing a change or not matches as much as possible the outcome of the decisions already taken by the AAEs.
7. **attempting the extension of their applicability**
   Once validated, it is made a try to extend their applicability to the whole spectrum of oversighted Organisations.
8. **development of the proposal**
   Finally, it is made a proposal for the possible applications.

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135 Changes having no Safety-relevant content are generally classified with other words, such as 'modifications' or 'minor upgrades', for the sake of clarifying, also by the use of a proper taxonomy, what is considered a change and what is not.

136 This implies the analysis of all the relevant documentation provided by each selected Organisation about all the notified planned changes.

4. The Organisation selected for the research

"In the successful organization, no detail is too small to escape close attention."
Lou Holtz, American coach and analyst

4.0 Content of Chapter 4

This chapter marks the separation between two parts of the Thesis: the first introductory part, represented by the previous chapters, is concluded and the technical part, represented by the following four chapters, is about to begin.

Paragraph 4.1 presents which Organisations have been considered in the research amongst the ones under the EASA's Oversight.

Paragraph 4.2 deals with the structure of the following chapters.
Since the structure of the technical chapters is somehow the same, it is presented here and is not replicated in each of them. Hence, the following four chapters do not present the initial paragraph about their content, which is shown here *una tantum* for readability purposes.

4.1 The Organisations selected

The selection of the Organisations should cover as much as possible the spectrum of the Organisations oversighted by the FS.4.1 Section, taking into account those which have notified changes to their functional systems and on which at least one decision of reviewing a change has been taken.
Hence, the following four Organisations are initially taken into account:

1. the European Organisation for the Safety of Air Navigation (EUROCONTROL) nominated by the EC as the Network Manager up to the end of the second reference period (2019)
2. the EUROCONTROL's European Aeronautical Information System (AIS) Database (EAD) certified by EASA on 8th December 2016 for the provision of the whole AIS service [137]
3. the European Satellites Service Provider (ESSP) Société par Actions Simplifiée (SAS) certified by EASA on 8th July 2016 as ANSP for the provision of CNS (N) [138]
4. Ports of Jersey (PoJ) as ANSP certified by EASA to provide ANS, such as ATS and CNS [139], until 15th June 2017

Table 4.1-1 lists the Organisation acronyms, the types of certified services provided, the number of notified planned changes to functional systems, and the number of taken decisions of reviewing the notified planned changes:

acronym	type	notifications	reviews
EUROCONTROL	NM	68	22
EAD	AIS	4	2
ESSP	CNS (N)	52	18
PoJ	ATS, CNS	6	0

Table 4.1-1 the oversighted Organisations having a functional system

PoJ is the last ANSP certified by EASA and, as shown in Table 4.1-1, none of the recently notified changes to its functional systems has ever triggered a review decision.
Due to these reasons, PoJ is discarded from the selection.

[137] As described in [1].
[138] ESSP has privileges to provide the GNSS Signal-in-Space (SBAS part)
[139] PoJ has privileges to provide the following scope of services in accordance with the provision of CR-IR:

- ATS: ATC (Approach Control Service part)
- FIS (Voice-ATIS Broadcasts part)

4.2 The content of the following four chapters

The structure of the following chapters is standardised as follows, in order to describe each Organisation's:

- tasks and relevant historical background information
- (functional) systems and related functions/services
- change management processes and procedures
- typical changes and their characteristics

The selected Organisations and their respective dedicated Chapter are:

- EUROCONTROL – Chapter 5
- EUROCONTROL's European AIS Database (EAD) – Chapter 6
- the European Satellites Service Provider (ESSP) – Chapter 7
- ATCO Training Organisations[140] – Chapter 8

[140] In this case it is not selected an ATCO Training Organisation in particular, but the whole category, due to the limited amount of change notifications received and the consequent scarcity of review decisions taken for every ATCO Training Organisation. Nevertheless, as further explained in Paragraph 8.2, the following three Organisations are taken into account to cover the whole category of ATCO Training Organisations:

- Airways Corporation of New Zealand Limited (ACNZ)
- University of North Dakota Aerospace Foundation (UNDAF)
- Ports of Jersey (Jersey Airport) (PoJ)

5. The Network Manager

"The one thing we had been able to develop over the years was trust"
Žarko Sivčev, Advisor to the Director at EUROCONTROL

EUROCONTROL is the European Organisation for the Safety of Air Navigation set up by the International Convention of 13 December 1960 relating to Cooperation for the Safety of Air Navigation.[141]

EUROCONTROL was nominated[142] as the Network Manager (NM) for a period corresponding to two reference periods of the Performance Regulation (PERF_IR)[143] that is going to be renewed[144].

5.1 The Network Manager tasks

The European Commission's Single European Sky (SES II) foresaw the creation of a NM as a centralised function for the European Union. On 18 July 2011, EC nominated EUROCONTROL to take on the role of European NM.

The NM was established to contribute to the performance of the European ATM network, which includes all the 28 European Union's[145] and the 41 EUROCONTROL's[146] MS, as well as other states which have bilateral agreements with the NM.

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[141] As defined in regulation (EC) No 549/2004 of the European Parliament and of the Council of 10 March 2004 laying down the framework for the creation of the single European sky (the framework Regulation), Art. 2.

[142] Commission Decision of 7 July 2011 on the nomination of the Network Manager for the air traffic management (ATM) network functions of the single European sky.

[143] Commission Implementing Regulation (EU) No 390/2013 of 3 May 2013 laying down a performance scheme for air navigation services and network functions.

[144] As implied in Commission Regulation (EU) No 677/2011 of 7 July 2011 laying down detailed rules for the implementation of air traffic management (ATM) network functions and amending Regulation (EU) No 691/2010.

[145] In alphabetical order: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom.

[146] In alphabetical and entry date order: Belgium, France, Germany, Luxembourg, Netherlands, United Kingdom, Ireland, Portugal, Greece, Malta, Turkey, Cyprus, Hungary, Switzerland, Austria, Denmark, Norway, Slovenia, Sweden, Czech Republic, Italy, Romania, Bulgaria, Croatia, Monaco, Slovakia, Spain, Republic of Macedonia, Moldova, Finland, Albania, Bosnia and Herzegovina, Poland, Ukraine, Serbia, Armenia, Lithuania, Montenegro, Latvia, Georgia, Estonia.

The EC ensures that the NM is subject to the provisions of the Performance Scheme[147] through the Network Performance Plan, delivering ATM services in the pan-European network improving the following four Key Performance Areas:

- safety
- capacity
- environment/flight efficiency
- cost-effectiveness

The NM is mandated by the EC[148] to carry the following main tasks:

- develop and create ERND
- provide a central function for radio frequency allocation
- manage scarce resources (radio frequencies and SSR TCF allocation)
- carry out the ATFM function
- coordinate the management of response to the network crisis with the support of EACCC
- contribute to SESAR deployment according to the European ATM Master Plan
- help ANSPs, civil/military airspace users and airports enhance their Europe-wide network performance
- make routes more efficient
- balance demand and capacity
- manage scarce resources (SSR TCF allocation)
- consolidate information into centralised ATM databases
- monitor, analyse and forecast network performance
- deal with network challenges centrally - weather, major events, hotspots, crises

Within EUROCONTROL, the Network Management Functions are carried-out by the EUROCONTROL Network Management Directorate (NMD).

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[147] As stipulated by Regulation (EU) No 691/2010 (replaced by Regulation No 390/2013) of 3 May 2013 laying down a performance scheme for air navigation services and network functions.

[148] As defined in Commission Regulation (EU) No 677/2011 of 7 July 2011 laying down detailed rules for the implementation of air traffic management (ATM) network functions.

The NM addresses performance issues strategically, operationally and technically, developing, maintaining and implementing:

- the Network Strategy Plan, which:
  - provides a common understanding of the way the ATM network as a whole will achieve the performance targets, while preparing for the next performance reference period
  - identifies the roles and responsibilities of the various operational stakeholders in implementing the plan
  - serves as a reference for the activities to be carried out by the Network Manager and its operational stakeholders
  - is aligned with the ATM Master Plan

- the Network Operations Plan, which:
  - includes the ERND and the equivalent for radio frequencies and the SSR transponder codes
  - identifies operational constraints and bottlenecks and presents improvement measures for resolving them or mitigating their impact
  - ensures that the operation plans of ANSPs, FABs and airport operators are aligned with the Network Operations Plan

NM provides Air Traffic Flow and Capacity Management (ATFCM) services at the level of the ECAC area.

The main services provided by the NM in the contest of ATFCM are:

- Flight Plan (FPL) validation and distribution
- ATFCM
- Airspace Management services
- Data provision and reporting

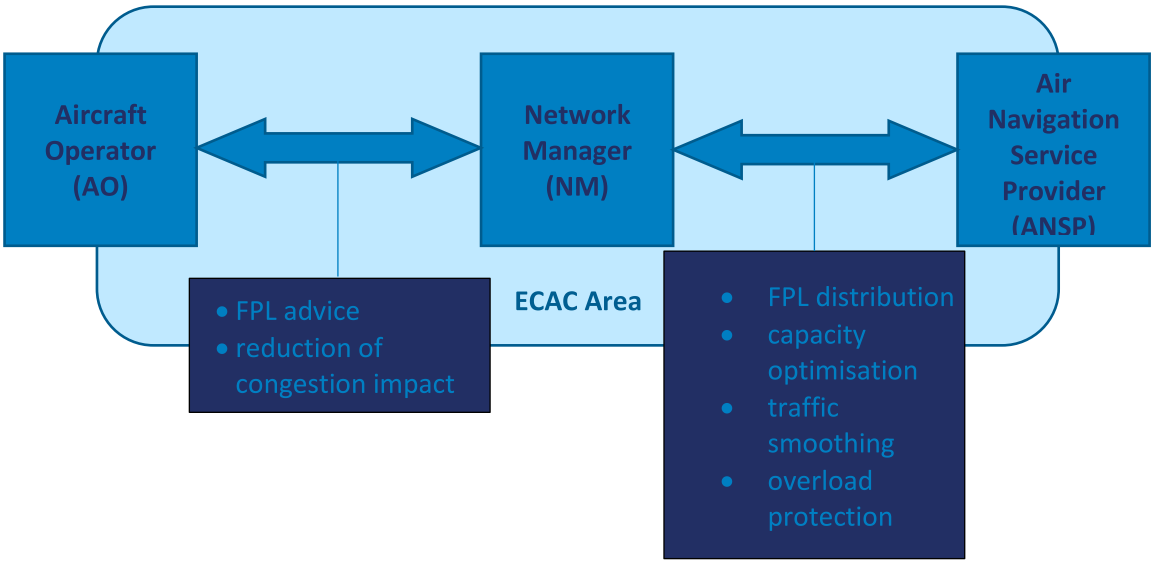

Figure 5.1-1 the Network Manager context

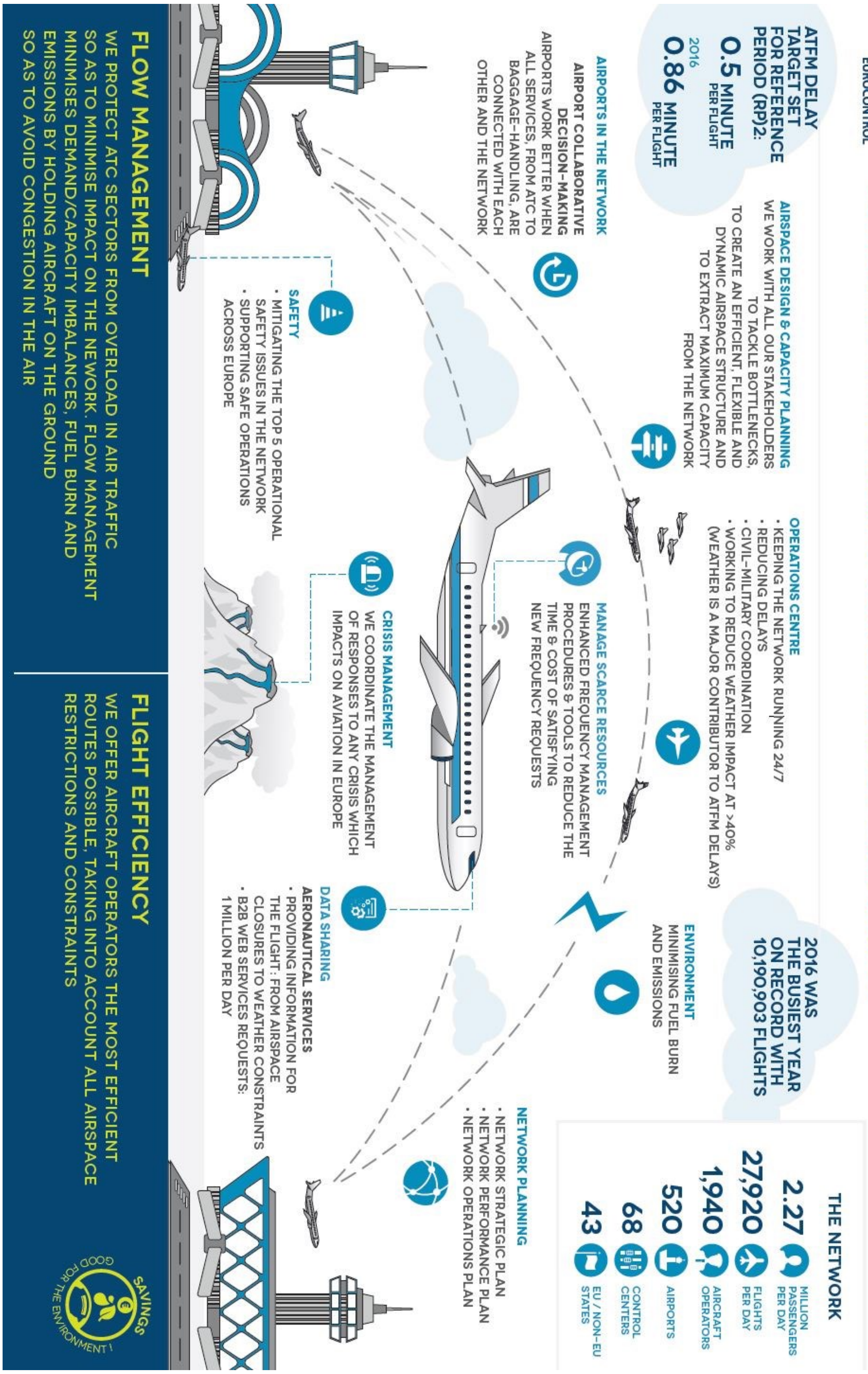

Figure 5.1-2 the Network Manager in

5.2 The Network Manager functional system

This section is intended to provide a high level description of the main elements of the functional system used by the EUROCONTROL NMD to carry-out the functions allocated to the NM.[149]

The architecture of the Network Technical Systems (NTS) is composed by the functional systems listed below and:

- Flight Systems
- Flow Management Systems
- Environment Data Management Systems
- Service Layer Systems and Client Applications
- Support Systems

In the next subparagraphs these systems are described more in details.

[149] The presented description has been obtained from [16].

5.2.1 The Flight Systems

The Flight Systems are responsible for the reception, the validation, the collection, and the distribution of FPL data required to assess the demand on the global ATC system. Furthermore, they also offer assistance to the generation and validation of FPLs.
Most of them are strictly related with the Flow Management ones, due to the sharing of some components and data.

5.2.1.1 The Integrated Initial Flight Plan Processing System (IFPS)

The Initial Flight Planning (IFP) process is the mechanism by which Pilots, Aircraft Operators (AO), Flight Planning Agencies etc. file plans for future aircraft flights.
All aircraft flying into, departing from or transiting Europe within the General Air Traffic (GAT) Civil system must file an International Civil Aviation Organization (ICAO) flight plan with the Integrated Initial Flight Plan Processing System (IFPS) managed by the EUROCONTROL Central Flow Management Unit (CFMU). This system is the sole centralised source for the distribution of the Instrument IFR/GAT portions of flight plan information to Air Traffic Control (ATC) within participating European Countries collectively known as the IFPS Zone (IFPZ)[150].
The Integrated Initial Flight Plan Processing System (IFPS) first ensures that FPLs and any modifications are acceptable to ATS, then distributes them to all relevant ATS Units within its area of responsibility.

In summary, IFPS fulfils two primary functions:

- enable the reception, processing and delivery of IFR/GAT FPL data in the IFPZ
- to provide Repetitive Flight Plan (RPL) and Filed Flight Plan (FPL) data for use by the CFMU Operations for ATFCM planning, monitoring and slot allocation

5.2.1.2 The Repetitive Flight Plan System (RPL)

The Repetitive Flight Planning (RPL) System is a centralised processing system serving all of the ATC Units within the IFPS Zone. Its purpose is to facilitate flight planning operations within the NM distribution area for AOs and other interested parties via lists of submissions to the Network Manager Operations Centre, their validation and subsequent correction and distribution to ANSPs as required.

RPLs can be submitted by AOs for the summer and winter seasons, corresponding to the time change schedule. When doing so, the submission of individual FPL is no longer required.
RPLs are pre-formatted documents sent to the NMOC by e-mail (preferred method).
RPLs are re-processed for each new Aeronautical Information Regulation and Control (AIRAC) cycle to ensure they are valid with reference to the current Environment data; invalid ones are corrected by RPL operators working with the AOs.

[150] The IFPZ includes: Kosovo, Belgium, Germany, Finland, Great Britain, Netherlands, Ireland, Denmark, Luxembourg, Norway, Poland, Sweden, Lithuania, Canary Islands, Albania, Bulgaria, Cyprus, Croatia, Spain, France, Greece, Hungary, Italy, Slovenia, Czech Republic, Malta, Monaco, Austria, Portugal, Bosnia-Herzegovina, Romania, Switzerland, Turkey, Moldova, Macedonia, Gibraltar, Serbia, Slovakia, Armenia, and Ukraine.

Basically, RPL System's main functions are:

- production of clean RPLs output
- generation of individual FPL for the purpose of ATC (via IFPS) and ATFCM
- storage of RPLs

5.2.1.3 The IFPS Validation System (IFPUV)

The IFPS Validation System (IFPUV) is effectively a separate IFPS Unit, totally independent of the operational IFPS, and established solely for the purpose of submitting test FPL.
FPL originators are able to submit, to the unique address of the IFPUV, their flight plans for validation, and prior to their submission to the operational system.
The IFPUV also offers the possibility for FPL originators to request a route from departure to destination. The system will respond by providing route(s) which are valid at the time and flight level specified. In addition, the FPL originator has the possibility to indicate some limitations to the search facility e.g. via a point/airspace, avoiding a point/airspace.

The IFPUV is accessible via the Network Operations Portal (NOP) and via Business-to-Business (B2B) Web services.

5.2.2 The Flow Management Systems

The Flow Management System is at the heart of the ATFCM services provided by the NM. Its purpose is to provide information to the NM Operational Unit (Flow Management) on current and anticipated air traffic demand and capacity in the ECAC airspace and to provide tools to support planning, execution and monitoring of ATFCM measures.
Figure 5.2-1 shows the interactions between some of the NM functional systems presented in these paragraphs.

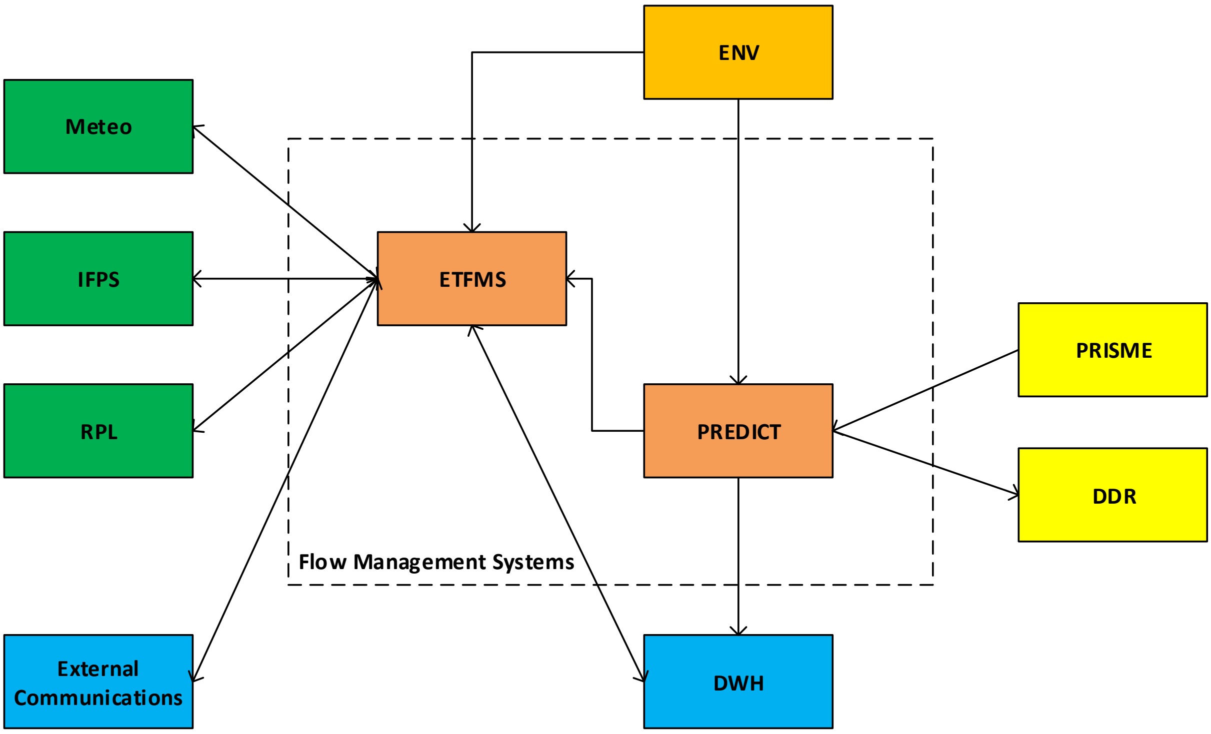

Figure 5.2-1 the Flow Management Systems

5.2.2.1 The Enhanced Tactical Flow Management System (ETFMS)

The Enhanced Tactical Flow Management System (ETFMS) is the core system of the ATFCM services.

Using the flight information provided by the Flight Systems (both IFPS and RPL) and position reports, the ETFMS System assesses the load on the ECAC airspace and matches it to the available capacity.

This is a System used by the NMD Operations and FMPs for Tactical operations. For that purpose, ETFMS receives data from IFPS, ATC, AO, CDM Airports and the ENV Systems.

The ETFMS main functions are:

- the presentation of the planned and actual traffic situation to enable the NMD Operations and FMPs to monitor and modify the operation of the ATFCM plan as required on the day of operation
- the provision of Computer Assisted Slot Allocation (CASA)
- the assessment of re-routeings for flows ("group re-routeing" functionality) and individual flights

5.2.2.2 The Pre-Tactical System (PREDICT)

The Pre-Tactical System (PREDICT) has almost the same functionality and the technical structure as ETFMS, but it is used for pre-tactical operations. Changes in the regulations can be implemented on the system in order to access their impact before being released.
It uses archived information to assess the traffic situation over the coming days (up to 6 days before the day of operation – D-6 to D- 0).
It is used to generate the ATFCM Daily Plan that is then loaded into ETFMS. It uses flight data from the DWH System and environment data from the CACD System (including forecasted capacities).
In order to generate the ATFCM Daily Plan simulations can be run on the PREDICT system to determine the impact of different regulation sets. Flow re-routeings can also be tested.

5.2.2.3 The Centralised SSR Code Assignment and Management System (CCAMS)

The Centralised SSR Code Assignment and Management System (CCAMS) is specific element of the ETFMS functional system for the transponder code management function.

Before CCAMS became operational, SSR codes were statically allocated to States and assigned to flights by ANSPs, based on a pre-defined scheme (ORCAM rules). De-conflicting these code allocations was time-consuming - it could take months to achieve. In addition, in some parts of Europe, there are insufficient codes available for peak traffic requirements, when statically allocated – Mode S is not being deployed fast enough to avoid a shortage of SSR codes.
Hence there was a need to have a more efficient way to allocate SSR codes. The CCAMS provides a central optimised assignment of SSR codes based on profile information (from flight plan), delay and suspension information, and airborne information.

The CCAMS is designed to work fully automated with no human user input during normal operations. Human intervention is necessary in crisis situations (contingency more than 30 minutes) or under special operational circumstances that are communicated beforehand (large events, prolonged outages, etc).

The CCAMS automatically select and send a code to all participating units along the route of the flight, based on the information available from other Network Operations systems, responds to code requests received from ATC units, ensures a code conflict free trajectory of the flight, allowing the retention of this code within the CCAMS area, and monitors the code use to ensure safe and efficient operations.

The operational CCAMS consists of a central server located in Haren, a unit in Brétigny, and a corresponding functionality for participating of local ANSP systems therein. The one running in primary mode actively does ATFCM (i.e. managing slot allocation, flight routeing and exchanging messages with the external users), while the one running in secondary mode acts as a backup (i.e. processes messages from the primary instance to keep its flight and slot related information synchronised).

5.2.3 The Environment Data Management Systems (ENV)

The Environment Data Management (ENV) Systems manage, maintain and distribute the aeronautical information used by the other NTS systems, such as the (geographical) structure of the ATC system.

5.2.3.1 The Central Airspace and Capacity Database (CACD)

The Central Airspace and Capacity Database (CACD), formerly the ENV Database, is the common airspace data repository feeding the Operational Systems and enabling the aeronautical data services. The CACD contains comprehensive data from the CFMU area ATS organisations. It includes ATS routes and routeing systems, airfields, Standard Instrument Departures (SIDs), Standard Arrival Routes (STARs), Navigation Aids, ATC sectorisation, etc.
The CACD provides data for use by the IFPS, RPL and ETFMS of the CFMU.
The accuracy and effectiveness of these systems depend to a large extent on the accuracy of the ATS System data input into the System. The data are obtained from several sources, but primarily from AIS Providers and through Aeronautical Information Messages.

5.2.4 The Service Layer Systems and Client Applications

The Service Layer Systems and Client Applications allow external and internal NM stakeholders to access and interact with the NTS systems.

5.2.4.1 The Common User Access (CUA)

The Common User Access (CUA) is designed to become the single entry point to the NTS systems for all client applications. It provides a middle layer between the client applications and the backend NTS systems, as shown in Figure 5.2-2. Every request from a client application passes through the CUA system which checks, validates and passes the request to the correct back-end system.

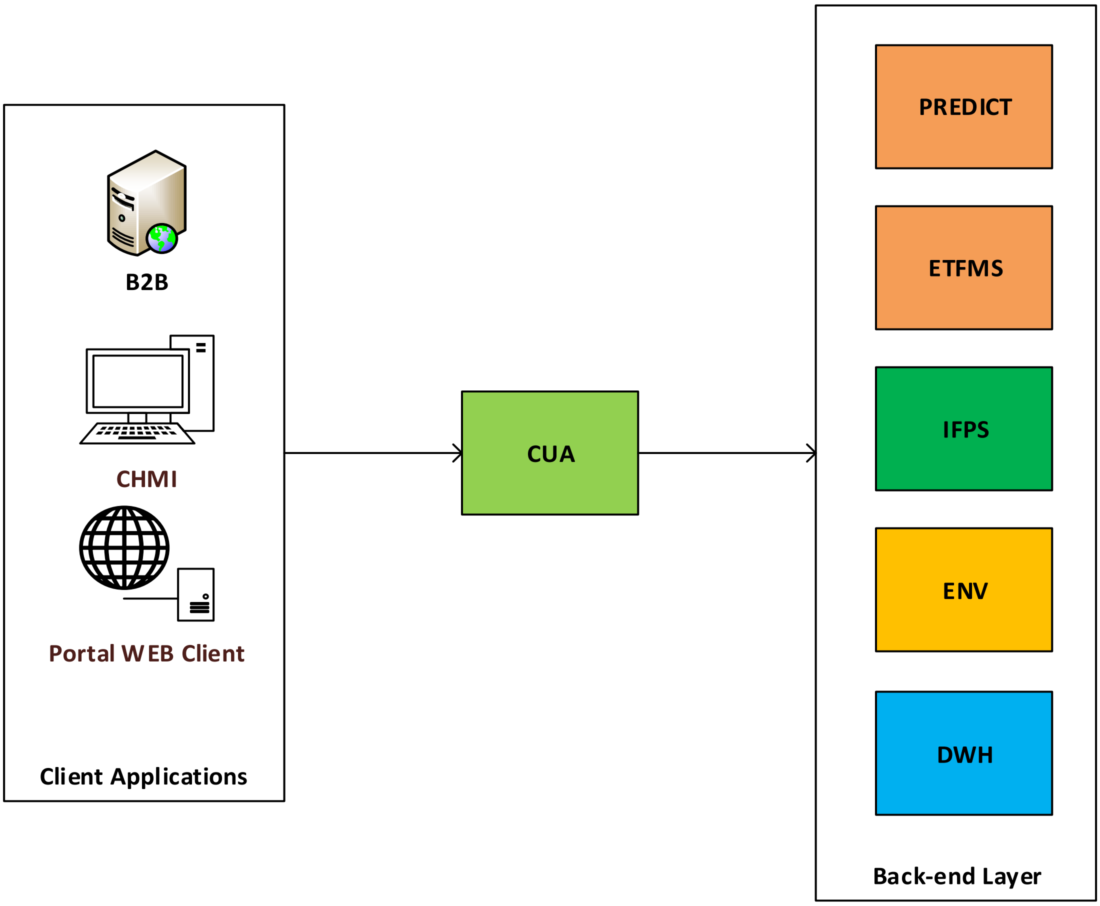

Figure 5.2-2 the Common User Access System architecture

5.2.4.2 The Network Operations Plan Portal (NOP)

The NOP Portal is a graphical interface to the CFMU Operational Systems which displays the situation of the ATFCM Network according to the different ATFCM planning phases (Strategic, Pretactical, Tactical, Post-Operations).

5.2.4.3 The CFMU Human Machine Interface (CHMI)

The CFMU Human Machine Interface (CHMI) provides a graphical interface for the Network Operations systems allowing users to display data and graphical information (such as routes, route attributes, airspaces, flight plan tracks, etc.) via map displays. These maps are updated dynamically and real time information enables Collaborative Decision-Making (CDM) between all partners.
Several applications are available depending on the type of user (AOs, Flight Management Positions (FMP) Operations, ENV Coordinators and AMC Coordinators).

5.2.4.4 The Business-to-Business Services

The NOP Business-to-Business (B2B) Web Services provide access to both data and services via a system-to-system interface, allowing NM customers to exploit and use the information in their own systems, according to their business needs.
Several groups B2B Services are provided:

- General Information Services
- Airspace Services about airspace availability and structure (routes, aerodromes, restrictions)
- Flow Services
- Flight Services covering flights preparation, filing, and management

This interface is additional to the Business-To-Customer (B2C) interface which connects the NM systems deployed at user premises (e.g., CHMI) with the systems located at the Network Manager Operations Centres.

5.2.4.5 The NM Ecosystem

All the external interfaces are being encapsulated within an enhanced Service Management layer, named NM Ecosystem (NES), under the strategic project **n-CONECT** (network-Common Enhanced Collaborative ATM), whose implementation is planning to support an improved B2C and B2B service provision.

There are three important layers:

- the NM Business Layer
  providing the core functionality in support of the business services provided by NM
- the NM Service Layer
  allowing external and internal NM stakeholders to access the NM services in a controlled manner
- the Client Layer
  providing the interfaces to use the NM services

5.2.5 The Support Systems

This section describes additional NTS systems supporting the systems detailed in the previous paragraphs.

5.2.5.1 The Datawarehouse (DWH)

The Datawarehouse (DWH) Archive System contains archived data from other CFMU systems, together with derived performance and quality indicators, in order to:

- provide an assessment of ATFCM performance and enable corrective action by facilitating comparison of the actual traffic situation with the ATFCM plan
- assist the CFMU and its users in the preparation of their Strategic, Pre-Tactical and Tactical activities, by providing a forecast flight demand model based on historical data
- gather operational information to allow incident investigation

The information stored in the DWH system is accessible via the following interfaces:

- Network Manager Interactive Reporting (NMIR), a Web-based application, enabling access to a set of pre-defined reports with interactive features and secured authentication
- Statistical ATFCM reports, available on the CFMU Website, in PDF format
- CHMI (archive data)

5.2.5.2 External communication

The NM Systems communicate with the Network Operations stakeholders using three different network infrastructures:

- the Aeronautical Fixed Telecommunication Network (AFTN) or the ATS Message Handling System (AMHS)
- the Type B Messaging Network (SITA)
- the Internet

The AMHS and the Type B Messaging Network of these are provided over the Pan-European Network Service (PENS) infrastructure. The exchange of radar data (Consolidated Position Reports - CPRs) and Enhanced Flight Data (EFDs) is done through the Entry Nodes (ENs) connected to the PENS network.
The exchange of FPL and ATFCM related messages is done through the Access Nodes connected to the AFTN/AMHS and the Type B Messaging Network, while CHMI and Internet accesses are done through the Access Management Infrastructure and CUA.

Four types of Access are used for the first two types:

- ANg1 that handles flight plan and ATFCM related message distribution through the AFTN/AMHS and the SITA Type B Messaging Network
- AN3 that, in co-operation with the Entry Nodes (EN), collects the Correlated Position Reports communicated to ETFMS
- AN3D that distributes ATFCM messages (EFDs) through the EN infrastructure
- CFMU Meteorological Information Display System (CMIDS) that distributes meteorological data to ETFMS

5.3 The Safety process for Network Manager's changes to Functional System

The NM Safety process follows a methodology which is consistent with the requirements present in the relevant EC legislation and which is tailored to the NM needs.
The main steps of the NM Safety process are retraced in the flowchart of Figure 5.3-1 and further briefly explained in the following paragraphs.

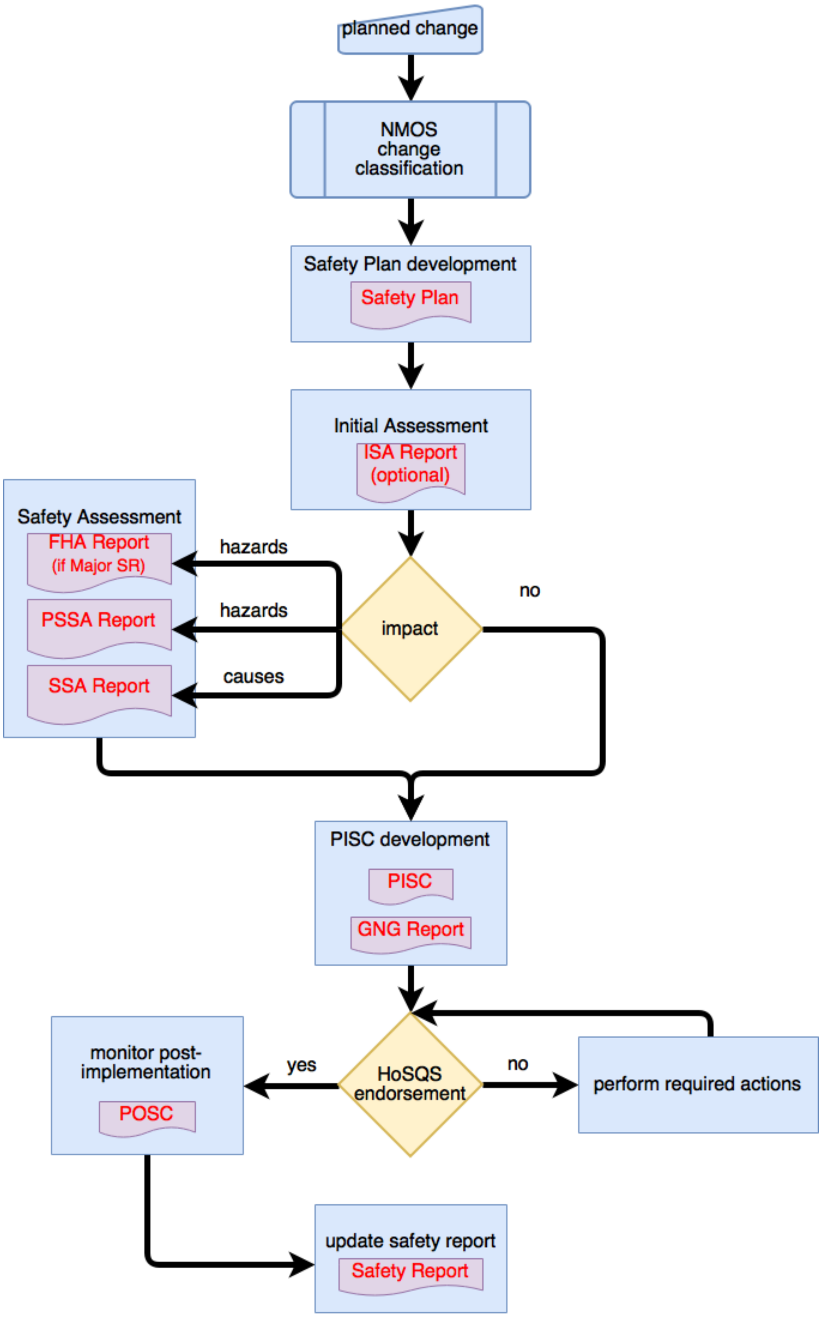

Figure 5.3-1 the Network Manager Safety process

Under the methodology, each change (FB/TB/CR) shall be assessed in respect of its impact on the Safety of NM service. This implies that each change is subjected to a Safety Assessment in respect with its potential impact on hazards and/or causes associated with hazards (generate new causes, increase likelihood of existing ones).
If a change may affect hazards, it shall be developed the Functional Hazard Analysis (FHA), for Major System Releases (Major SR), and the Preliminary System Safety Assessment (PSSA). Then, or if a change only affects causes, it shall be developed the System Safety Assessment (SSA) Report.
Subsequently, or if a change does not affect neither hazards nor causes, it shall be developed the Pre-Implementation Safety Case (PISC) together with the GO/NOGO (GNG) Report[151].

5.3.1 The change classification and the Initial Safety Assessment

According to NMD's Integrated Management System (iMS) and consistent with EC 1035/2011 any safety-related change to an ATM functional system used by the NM shall be assessed in respect to is effect on safety.

Under the iMS reflecting safety regulatory requirements, NM is required to assess the safety impact of all changes to functional systems, which are safety-related. The objective of the assessment is to demonstrate that the change will not affect safe provision of services or where it may affect safety, that sufficient mitigation has been implemented to control the risk.

Change classification is the first step for the Safety Assessment process as it determines which specific Safety Assessment process should be used.

The change classification and its high level characterisation are based on a score obtained by answering a set of guided questions.

Not safety-related changes, such as replacements/repairs, can be implemented as a simple corrective (or preventive) maintenance.

Safety-related changes are instead further classified according to a risk matrix, which combines the highest severity of any hazard before risk mitigation with its frequency and allows for a further classification according to three areas: if the change falls in red area it is considered as unacceptably safe, if in the orange area as tolerably safe, and if in green one as adequately safe.
Changes fallen in the green area do not require any further assessment.
Changes fallen in the red and orange areas of the matrix are evaluated according to both their eventual Safety Benefit and Safety Risk, and are finally subjected to mitigation actions. It is evaluated whether a change directly or indirectly improves the system (e.g. reducing the workload of operating personnel, ensuring compliance, removing workarounds) or could potentially cause harm to it (e.g.

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[151] There are different kinds of GO/NOGO meetings:
GNG1: Technical Quality Assessment, covering the status of test (end-to-end system testing), documentation, quality metrics, etc
GNG2: review of the action(s), covering a follow-up of open issues from GNG1
GNG3: OPS Quality Assessment, covering status of System Acceptance Testing (SAT), user documentation, training, Operational Test Platform (OPT) sessions and status of the acceptance criteria (EASA approval included)
Executive GNG meeting: Executive Team decision to commence migration or not

removing a barrier, introducing a new cause for a known hazard or a new one, producing a new type of output to end users). Subsequently, further safety work is planned to translate both Safety Benefits and mitigations for the Safety Risks into specific Safety requirements.

The Initial Safety Assessment (ISA) divides the changes into the following categories:

- normal maintenance
  no output is affected, no new causes for existing hazards are introduced and no external mitigation means are affected; the likelihood to existing causes could be affected
- internal PSSA
  no output is affected, new causes could potentially be introduced related to existing hazards or the likelihood of existing causes could be increased, so that there could be a safety impact
- external FHA
  a service output could be impacted and thus the change shall be subjected for a dedicated FHA session

This sorting is useful for the following phase.

5.3.2 The System Safety Assessment

The Preliminary System Safety Assessment (PSSA) covers the changes which have been identified in the ISA as having impact on either hazards or causes.
The objective of the PSSA is to determine whether the impacts on causes resulting from the changes introduced may increase the risks compared with current NMD operations and, in such case, to define safety requirements to mitigate the increased risks.

As part of the PSSA activity, the individual changes are reviewed with respect to their potential impact of the causal analysis performed associated with each hazard. The purpose hereof was to identify where a change would introduce new, generic causes to hazards in the Fault Tree (FTAs). Each developed fault tree is reviewed based on the description of the change to identify existing causes affected or where new causes are introduced in the FTAs. The result of this review and the mechanisms (typically safety requirements or assumptions) is a claim that the potential increase in the hazard occurrence rate (due to new causes or increased occurrence of existing causes) is controlled to ensure that the safety criteria can be met.

The review of the FTA’s, both in respect to internal causes (changes to NM services) and external causes (changes to local systems) has identified no change, which could increase the hazard occurrence rate for identified hazards. Where a potential new cause has been identified or where a potential impact on an existing cause has been identified and where such cause is not mitigated through NMD standard procedures (normal engineering and development processes, B2B certification), specific requirements and/or assumptions are defined to control a possible increase in the likelihood of a hazard to be generated.

5.3.3 The Pre-Implementation Safety Case

The Pre-Implementation Safety Case
The Specific Pre-Implementation Safety Case (PISC) process covers the following six main areas:

- **ensure that the changes, when operating as specified and designed, are safe**
  it is determined that the concepts, design, and specifications underlying the changes ensure that the changes are safe when operating as specified – this is called the "success case"; it is also ensured that new hazards introduced or changes to existing risks have been identified, classified, and used as basis for deriving appropriate safety requirements
- **implement the changes according to specifications and demonstrate compliance with stated Safety Requirements**
  once the Safety Requirements have been identified, it is ensured, through a comprehensive evidence collection, the compliance with the requirements and that the correct implementation has been verified
- **engineering and development processes are based on recognised standard and practices**
  the processes used to specify, engineering, and implement changes are regularly reviewed to determine their adequateness
- **provide adequate Quality Management framework**
  it is demonstrated that the NMD has an ISO-certified QMS
- **provide adequate Safety Management framework**
  it is demonstrated that a detailed Safety Plan has been developed defining the required safety activities to be performed and listing the responsibilities for the safety work; in addition a responsible Safety Manager is appointed
- **ensure that the transition to the new functional system status will be acceptably safe**
  it is demonstrated compliance with the Safety Requirements associated to the identified and classified hazards

5.3.4 The Post-Implementation Safety Case and monitoring

The Post-Implementation Safety Case (POSC) is a follow-up on the Specific Pre-Implementation Safety Case (PISC). The purpose of the POSC is to collect, structure, and present sufficient data and evidence to demonstrate that Safety is ensured during the ongoing operation of the NM, after the implementation of a change (typically a release).

During the post-implementation verification, observed defects and deficiencies are registered, analysed and corrective actions are implemented, whereas it is assessed for open defects not to compromise safe operations.

5.4 The typical changes to the Network Manager's functional system

There are several well-differentiated types of changes to functional system that are notified by the Network Manager.

The following list contains the ones which are typically reviewed along with the features they generally have:

- NM Releases
  they include very many change requests (CRs), most allocated to Technical and Functional Blocks (TBs and FBs) and some as stand-alone CRs
    - generally, the worst Severity Class of the effects of the identified hazard is 3
    - most of the services are affected, and usually:
        - ETFMS (Enhanced Tactical Flow Management System)
        - IFPS (Integrated Initial Flight Plan Processing System)
        - NOP (Network Operations Portal)
        - CACD (Central Airspace and Capacity Database)
        - CHMI (Collaboration Human Machine Interface)
        - CUA (Common User Access)
        - DWH (Data Warehouse)
    - such changes are typically included:
        - software corrections and tuning
        - changes to the operational procedures
        - technical changes[152]
        - Commercial Off-The-Shelf (COTS) upgrades
        - improvements due to the SESAR programme implementation
    - two per year are notified
- activation of services
  the operational activation of services which were introduced (and, hence, qualified) before (typically through different NM releases) but were deactivated in the operational platform and only used in the validation platform
- Validation Trials
  some of the SESAR validation activities require the use of the NM operational platform with a temporary modification (during the course of the trial) of the functional system used by the NM for the provision of the services
    - including changes such as:
        - additional procedures
        - additional human resources

[152] Technical changes do not affect the software and have no impact on operational procedures

The following list contains the ones which are typically not reviewed along with the features they generally have:

- ATS Message Handling System (AMHS) migration
- Change requests due to their limited scope
- Technical Blocks

6. The European Aeronautical Information System Database

"The most interesting information comes from children,
for they tell all they know and then stop"
Mark Twain, American writer, humourist, entrepreneur, publisher, and lecturer

The European Organisation for the Safety of Air Navigation (EUROCONTROL) holds a certificate[153] as Air Navigation Service Provider (ANSP) for the provision of the whole Aeronautical Information Services as described in ICAO Annex 15.
Such service is provided by the European Aeronautical Information System (AIS) Database (EAD), the world's largest AIS.
EAD, developed by EUROCONTROL, is a centralised reference database which provides support to Aeronautical Data Providers and a storage and distribution function of quality-assured aeronautical information to all Aeronautical Data Users, on behalf of the ECAC Participating States.
EAD supports Data Providers in fulfilling their obligations under ICAO Annex 15 for the publication and distribution of the Aeronautical Information Package (AIP)[154].

6.1 The EAD tasks and origins Background[155]

The concept of the EAD was developed by EUROCONTROL and its MSs following a study carried out in the early 1990's which revealed that the AIS operational structure at the time showed several limitations and drawbacks when seen from a European perspective. In some cases, this included:

- incoherence of cross-border aeronautical information
- inconsistent quality of data throughout ECAC area
- lack of interoperability between systems due to different data models and exchange formats
- shortcomings in ensuring timely distribution of aeronautical information updates to all stakeholders
- duplication of effort and investment and therefore costs for all involved

It was concluded that the cost effectiveness of AIS operations, the quality of aeronautical data and the accessibility and availability of such data could be significantly improved through automation and centralisation. This resulted in the development of an AIS intended to facilitate European wide maintenance and distribution of aeronautical information.

[153] The certificate is in accordance with the provision of Commission Regulation (EU) 1035/2011 and remains valid until 08 December 2018, unless the approval is surrendered, suspended or revoked, which is very unlikely to occur.
[154] Definitions are given in Paragraph 6.1.1.
[155] Information taken from [17].

In moving towards SES, EC has set up the Performance Review Body and has nominated EUROCONTROL as Europe's ATM NM. The NMD provides ATFM services over the States that are members of ECAC and makes available the EAD.
Within the NMD, the European Aeronautical Information Management (EAIM) unit is responsible for the EUROCONTROL EAD Service and overall coherence of aeronautical information aspects.

The EAD is the reference database of quality-assured aeronautical information, owned by EUROCONTROL on behalf of EUROCONTROL Organisation MSs. The EAD System allows for the provision of EAD Services in support of national AIS facilities as well as of all other users of aeronautical information. It provides an effective solution to the demands of the data-using aviation community and scope for the future growth in the demand for AIS products.

EAD has been introduced gradually across Europe and the ECAC States. As part of the introduction of EAD into operational service, EUROCONTROL required the production and subsequent maintenance of a Safety Case to demonstrate that the EAD can be, and is, operated in an acceptably safe manner.
Tentative operation of EAD started in June 2003 with a limited set of pilot Data Users (DUs) and Data Providers (DPs) known as ‘clients’. EAD was subsequently updated from Release 2, in 2004, through to Release 10, in 2016, with Release 11 in 2017.

The current situation is the progressive migration of ECAC States to EAD with the objective of all ECAC States being fully migrated. [156]
EAD Data Operations (DOPs) enters all essential data for non-migrated users to support the overall EAD service provided by EUROCONTROL.
Non-European States are showing growing interest and are already providing their Aeronautical data to EAD, which makes the scope of the EAD much wider than was originally expected.[157]

Currently there are over 250 clients that participate in EAD, comprising civil and military DPs along with a wide range of worldwide DUs and internal EUROCONTROL Units.

EAD has been certified by EASA [158] as an AISP under European Regulations (EC) 1035/2011 and is subject to ongoing audits by EASA to maintain certification, and this process is expected to include scrutiny of the EAD safety documentation.

ECAC MSs, in accordance with Art. 28 of the Chicago Convention and Annex 15 to this Convention [1], have the responsibility for providing an AIS and each State is responsible for publishing all aeronautical

[156] Within ECAC, only 3 States have not migrated to EAD yet: Switzerland and Greece have implementations in progress and thus are not using all services of EAD, Iceland, instead, has not committed.

157 From August 2016, an initiative was started to extend the Aeronautical Publications made available via PAMS to the following States: Afghanistan, Algeria, Belarus, Egypt, Iran, Iraq, Jordan, Kazakhstan, Kyrgyz Republic, Lebanon, Libya, Morocco, Saudi Arabia, Uzbekistan, the member States of ASECNA and Cape Verde. During Q4 2016, the documents have been uploaded in PAMS by the Data Operations Provider in order to start their publication and maintenance during Q1 2017.

Negotiations were also started with the Russian Federation, with a view to publish Aeronautical Publications for the European part of Russia, Tajikistan and Turkmenistan.

Belarus, Jordan, Kazakhstan, Kyrgyzstan and Philippines are fully migrated as Data Providers, whilst Canada, New Zealand and Taiwan are only partially migrated. Negotiations are ongoing with Brazil, Israel, Morocco, Egypt, South Africa, Syria, Japan, Singapore, and Taiwan.

158 EUROCONTROL received the EASA certificate for the provision of Aeronautical Information Services (AIS) on 9th December 2016. Within EUROCONTROL, the AIS service provision activities are carried-out by the EUROCONTROL NMD.

data for their airspace, although they may not necessarily be aware of all of the applications for which the data can be used. The formal provision of these services is performed by civil and military, state owned or privatised AISP Organisations.

6.1.1 The EAD clients

The provision and sustain of aeronautical information is one of the most vital support to Civil Aviation, because without AIS a pilot would be flying into the unknown; however it is at the same time the least known as it may be transparent to the users.

There are very different types of aeronautical data, for example because different clients may request different type of data, or because the same information may be presented in different ways in accordance with the different needs that different clients may have.

EAD provides its services to fulfil the needs of a huge variety of clients, which can be grouped as follows:

- Data Providers (DPs), such as CAAs, ANSPs, EUROCONTROL, and Military Organisations
- Data Users (DUs), such as commercial and business AOs, pilots, and ATCs
- External Client Systems, such as existing national AIS systems who can act as DPs and/or DUs amd are connected via a system-to-system interface
- non-commercial Internet Public Users
- AFTN subscribers, either EAD participants or not

DPs and DUs are the two main EAD clients.

DPs can either be AIS Organisations within CAAs, ANSPs and military administrations from the ECAC area, or designated Organisations which maintain data that does not fall under the responsibility of national agencies, such as EUROCONTROL CFMU.
DPs are responsible for the provision of AIS data and access DUs functions.
DPs use different EAD components for the creation, maintenance and storage of aeronautical information. They retain full control of – and intellectual property rights over – the data they input into the EAD. The concept of having the DPs maintain their data in a common database is unique in the aviation world.

DUs consult and download aeronautical data or publications, and can generate reports from EAD.
DUs
EAD can also be used by airlines that are based outside the ECAC area and by commercial organisations that use the aeronautical information to provide value added services and products.

6.1.2 The Aeronautical Data

The information handled by an AIS may vary widely in terms of the duration of its applicability. For example, information related to airports and its facilities may remain valid for many years while changes in the availability of those facilities (for instance, due to construction or repair) will only be valid for a relatively short period of time. Information may be valid for as short a time as days or hours. The urgency attached to information may also vary, as well as the extent of its applicability in terms of the number of operators or types of operations affected. Information may be lengthy or concise or include graphics.
Therefore, aeronautical information is handled differently depending on its urgency, operational significance, scope, volume and the length of time it will remain valid and relevant to users.

Many ground and air based aeronautical applications and functions rely on accurate data to describe relevant features or states of the ATM operational environment.
For example, the timely provision of quality aeronautical information/data and terrain data is critical both to pilots and to on-board navigation systems, such as obstacle locations, strong lateral wind presence on runways to some FMS automated procedures for the safe approach or departure. Pilots require accurate charts to navigate the terrain, identify airways and danger areas. Operator must know the regulations concerning entry into and transit of the airspace of each State in which operations are carried out, as well as what aerodromes, heliports, navigation aids, meteorological services, communication services and air traffic services are available and the procedures and regulations associated with them. Operators must also be informed, often on very short notice, of any change affecting the operation of these facilities and services and must know of any airspace restrictions or hazards likely to affect flights. While this information can nearly always be provided before take-off, it must, in some instances, be provided during flight in different regions all over the world.

Information concerning changes in facilities, services or procedures, in most cases, requires amendments to be made to airline operations manuals or other documents and databases produced by various aviation agencies. The organizations responsible for maintaining these publications usually work to a pre-arranged production programme. If aeronautical information were published indiscriminately with a variety of effective dates, it would be impossible to keep the manuals and other documents and databases up to date. Since many of the changes to facilities, services and procedures can be anticipated, Annex 15 provides for the use of a regulated system, termed AIRAC (Aeronautical Information Regulation and Control), which requires significant changes to become effective and information to be distributed in accordance with a predetermined schedule of effective dates, unless operational considerations make it impracticable.
Annex 15 also specifies that pre-flight information must be made available at each aerodrome/heliport normally used for international operations and sets the content of aeronautical information provided for pre-flight planning purposes as well as requirements for the provision of that information through automated aeronautical information systems.
Additionally, there are requirements to ensure that important post-flight information provided by aircrews (for example, the presence of a bird hazard) are relayed to the AIS for distribution as the circumstances necessitate.

The quality of critical data is paramount to end-user, as the corruption of certain safety-relevant data may lead to catastrophic accidents.
Since corrupt or erroneous aeronautical information/data can potentially affect the safety of air navigation because of the direct dependence upon it by both airborne and ground-based systems, it

is imperative that each State ensure that users (aviation industry, air traffic services, etc.) receive timely and quality aeronautical information/data for the period of its intended use.
To achieve this, and to demonstrate to users the required information/data quality, Annex 15 provides that States must establish a quality system and put in place quality management procedures at all stages (receiving and/or originating, collating or assembling, editing, formatting, publishing, storing and distributing) of the aeronautical information/data process. The quality system must be documented and demonstrable for each function stage, ensuring that the organisational structure, procedures, processes and resources are in place in order to detect and remedy any information/data anomalies during the phases of production, maintenance and operational use. Explicit in such a quality management regime is the ability to trace all information/data from any point, back through the proceeding processes, to its origin.
End-users of aeronautical data are obliged, under ESARR, EASA CSs and applicable Regs, to demonstrate that an acceptable level of Safety is achieved for their service provision or application.
Since AISPs do not know all of the potential uses of data, end-users must define the properties they require of the published data but AISPs must show that these requirements are met. ICAO Annexes and associated SARPs are the primary means by which end-users define their data quality requirements.

Aeronautical data is used in a wide range of air traffic services and airborne applications such as Flight Management Systems (FMS) and Airport Information Systems. Aeronautical data includes both raw data (e.g. survey points, opening times, etc.) and derived data (e.g. procedure design for a Standard Approach Route).

Aeronautical data is published in the form of an Integrated Aeronautical Information Package (IAIP) which comprises (but is not limited to) the following elements:

- **Aeronautical Information Publications (AIP)**
  static information (having permanent nature) not updated very often; typical examples are aerodromes characteristics, aerodromes facilities, routes, types and location of navigation aids along air routes, communications and meteorological services provided
- **AIP Amendments**
  permanent changes to published information
- **AIP Supplements**
  temporary changes of long duration (more than 3 months) or changes that require extensive text or graphics which would affect the contents of the AIP
- **Notices to Airmen (NOTAM)**
  temporary or short duration changes to facilities or services, or notification of operationally significant changes of temporary or permanent nature at short notice
- **Aeronautical Information Circulars (AIC)**
  information that doesn’t qualify as a NOTAM or to be included in the AIP, such as long term advance notice of major changes, explanatory or advisory information, or administration information
- **Pre-flight information Bulletins (PIB)**
  information on the status of facilities and services consisting of NOTAM and made available to flight crews
- **checklists of valid NOTAM**
  checklists of valid NOTAM to be issued at least once a month over the AFS
- **lists of valid NOTAM**
  valid NOTAM list in plain language to be distributed monthly with the paper publications

Implementation of Air Data Quality (ADQ) rules require EAD to facilitate the interface and storage of metadata. Metadata is not new data, rather it is raw data relating to the data input and accessed by Data Providers (DP).

EAD offers all users the following types of data:

- Static Data Operations (SDO):
  - aerodrome information, including procedures and obstacles
  - enroute information, such as airspaces, routes, navaids and waypoints
- International NOTAM Operations (INO):
  - original and processed NOTAM, SNOWTAM, ASHTAM, BIRDTAM[159]
  - Pre-flight Information Bulletins (PIB)
  - Briefing Facility for ATS Reporting Office (ARO)
  - general information, such as Organization, Authority and Units
- Published AIP Management System (PAMS):
  - Aeronautical Information Publications (AIP)
  - AIP Amendments and Supplements
  - Aeronautical Information Circulars (AIC)
- AIP/Chart Production (AIP/CHART)

[159] A BIRDTAM is a specialized NOTAM providing information regarding bird strike risk or warning, particularly for low level airspace. Unlike ASHTAM or SNOWTAM, BIRDTAM is not an official ICAO term and is not in universal use. However, the term BIRDTAM is recognised in the European Aeronautical Information System Database (EAD) and has its own Aeronautical Fixed Telecommunication Network (AFTN) address.

6.1.3 EAD tasks and benefits[160]

EAD is intended to support the data publication and distribution component of the Aeronautical Data Chain. It also provides functionality to compile, handle, validate and submit Flight Plans (FPL) to NM. Fundamentally, EAD provides the following basic functions to DPs and DUs:

- supporting migrated DPs with the creation of static and dynamic aeronautical data publications, including:
  - provision of data preparation tools such as Chart and AIP production
  - storing, viewing and printing published documents via the Published AIP Management System (PAMS)
  - validation of static data against pre-defined rules or dynamic data against static data
- data entry for Non-migrated Data Providers after validation
- storing and distributing static and dynamic aeronautical data
- providing facilities for FPL construction, validation and submission to NM IFPS

To support the EAD functions the EAD DOP is responsible for the EAD Service Desk. The service desk adopted a system-monitoring tool and provides a status of the most important EAD IT services and EAD WAN routers. It also provides the EAD system disks status.
Implementation of ADQ rules require EAD to facilitate the interface and storage of metadata. Metadata is not new data, rather it is raw data relating to the data input and accessed by DPs.

The initial objectives of the EAD were identified as the following:

- improve the operational structure of Aeronautical Information Services
- support and facilitate the maintenance, publication and timely distribution of validated aeronautical information
- provide a central database of validated dynamic and static aeronautical information
- promote and implement a standard for the exchange of data in order to ensure harmonisation and compatibility

EAD is a single reference repository of aeronautical information.

It enables centralised management of digital aeronautical information based on the Aeronautical Information Exchange Model (AIXM) developed by EUROCONTROL. It enhances the quality of aeronautical data by using international standards and rigorous data-checking procedures, including in-depth validation and verification. [161]

In response to the limitation and drawbacks introduced in Paragraph 0, the following list summarises the EAD benefits:

- 24h/day service availability and support
  availability of both static and dynamic real-time aeronautical data (99.975% availability requirement and 24h/day client service desk enabling rapid dissemination of information on

[160] Some information is taken from [18].
[161] Data held in the EAD is assured against a variety of standards and recommendations including ICAO, OPADD, ESARRs, SDP, and the AICM/AIXM data models.

any identified issues); additionally, the EAD Service Providers ensure the required support to States on an operational, technical and training level

- reliability, data quality, data consistency and security
  data input by both NM and clients via VPN and SSL secure channels is regularly reviewed and updated against international regulations, ICAO standards, and printed publications in order to develop data quality and continually improve on completeness, correctness, and timeliness
- cost effectiveness
  integrated AIS solution by implementation of automated processes and a commonly developed and maintained application aim to worldwide coordination

6.2 EAD functional system

The EAD system can be geographically divided into the following main parts:

- the server sites
- the office sites
- the client sites
- the networks

For disaster recovery reasons, EAD central server is geographical distributed into two sites in Vienna: T-Systems (TSA) and Frequentis (FRQ). The overall network architecture follows the concept of a multi-site, multi layered connection design, which minimized single points of failure. For clients it is totally transparent which site they are connected to.

Additional sites are:

- the Test & Development System (TDS) site
- the Training System (TRG) site, containing equipment to train EAD Clients

The EAD TDS and TRG are located at FRQ site.
The overall network architecture follows the concept of a multi-site, multi layered connection design, which minimized single points of failure. For clients, it is totally transparent which site they are connected to.

The TDS has a similar design as the operational system, with provision for additional test & development equipment.
The equipment of these additional sites is separated from the operational EAD system in order to avoid any impact from training and test activities on it.

EAD services available for each type of client are listed below:

- International NOTAM Operations (INO)
- Static Data Operations (SDO)
- Published AIP Management System (PIB)
- Briefing Facility for ATS Reporting Offices (ARO)
- Published AIP Management System (PAMS)
- AIP/Chart Production

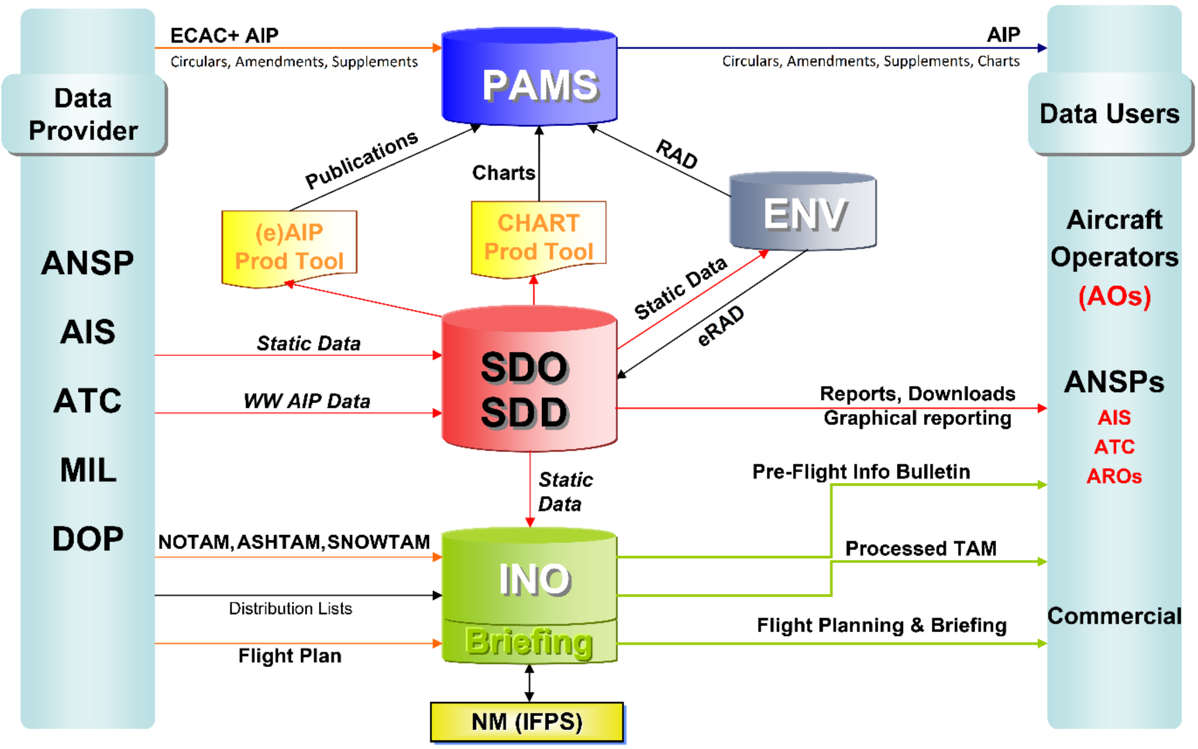

Figure 6.2-1 the EAD functional system

6.2.1 International NOTAM Operations (INO)

The International NOTAM Operation (INO) provides facilities for creating, processing, checking, distributing and retrieving international NOTAM and other relevant message data to be handled by EAD. The SWU INO receives requests related to International NOTAM Operation, processes them and returns replies to clients.

INO provides consistent and validated worldwide[162] NOTAM messages for use in AIS and ATM.
The INO data is checked against the Static Data Operations (SDO) data and against all other INO data in order to ensure coherence and prevent double publications.

INO can be divided into applications supporting NOTAM data provision and data usage.

INO enables DPs to create, maintain and distribute all NOTAMs for their NOTAM office and enables DUs to have direct access to them for briefing purposes, such as Pre-Flight Information Bulletins (PIBs) of different types.

PIBs consist of dynamic data messages containing information on very many aviation elements, such as facilities, services and procedures related to FIRS, aerodromes and vicinities around, special areas, and narrow paths.

For enhanced usability, DUs can store pre-defined routes based on flight plan or ad-hoc definition and store frequently requested PIB in a profile, for later re-use.

Further INO DU has a sub-module Briefing Facility (INO DU BF) providing functionality to handle FPL and related ATS messages.

[162] Conforming to ICAO Annex 15, ICAO Document 8126 and EUROCONTROL's Operating Procedures for AIS Dynamic Data (OPADD).

6.2.2 Static Data Operations (SDO)

The Static Data Operation (SDO) provides facilities for the input and checking of the static aeronautical data required for the safe and timely execution of flight operations, for the efficient operation of the Interantional NOTAM Operation (INO), and for additional data that is of common interest to EAD Clients.
SDO is the central repository of the EAD in Aeronautical Information Conceptual Model/Aeronautical Information Exchange Model (AICM/AIXM) specifications. The Static data maintenance in AIXM format is fully integrated with the other EAD Services.

SDO enables DPs to maintain the Static Data for their area of responsibility and allows them to retrieve static data from other areas.
The SDO Static Data Maintenance provides an AIXM-based access layer to update the SDO database, which prevents clients from directly accessing the SDO objects in the SDO database.
It maintains the integrity of the database by performing data checking on all data input.
After data validation, the information is made available to the different sub-systems to produce the AIP and Charts, to validate the NOTAM information at creation or during processing, and to perform the pre-validation of a FPL when using the ARO Briefing facility.
The SDO Slot Management provides a set of functionalities to co-ordinate and check static data changes and make it effective at a future date (Effective date).
SDO provides also a Graphical Validation tool for complex Static Data changes, to visualise and verify information before publication.
The Upload & Download Management provides a set of functionalities to upload and download aeronautical data in the ARINC 424 or AIXM (XML syntax) exchange format.
SDO allows DUs to populate their own database from received Static Data files and to produce reports or to download static data from the EAD.

SDO main functions can be summarized as follows:

- Static Data Maintenance
- Slot Management for DPs
- Graphical Validation tool for DPs and Graphical Reporting tool for DUs
- Upload & Download Management

SDO Data Coverage:

- ECAC area – Full set of aeronautical information data published in AIP:
    - Aerodrome information including Procedures and Obstacles
    - Enroute information such as Airspaces, Routes, Navaids and Waypoints
    - General information such as Organization, Authority and Units
- Worldwide – Minimum set of static data required for NOTAM validation and PIB generation:
    - Aerodromes, identification with associated Runways
    - Airspaces (FIR, UIR, TMA, P-D-R)
    - Routes, Navaids and Waypoints

6.2.3 Briefing Facility for ATS Reporting Offices (ARO)

The ARO Briefing Facility is part of the INO DU application and is specifically designed to allow AROs to handle FPLs and related information in an integrated manner.

It processes all incoming and outgoing AFTN messages and provides this information to the user in one single application. In addition to FPL data, the integration of the ARO Briefing Facility into the existing INO Data User application enables the user to automatically generate or schedule a PIB for a planned flight.

Through the ARO Briefing Facility, DUs are able to:

- create a new FPL
- pre-validate a FPL against SDO data
- validate a FPL against IPFUV
- save and distribute a FPL via AFTN
- identify the status of different FPL
- manage repetitive FPLs
- generate a PIB for a specific FPL
- create and manage client information and AFTN addresses
- monitor the real traffic situation
- manage incoming and outgoing messages

6.2.4 Published AIP Management System (PAMS)

Published AIP Management System (PAMS) makes available an electronic library for publication, storage and retrieval of aeronautical documents based on meta-data.
The documents included are AIP, Amendments, Supplements, AIC, maps and Charts.
It supports the automatic creation of NOTAM proposals, in accordance with the static data operational procedures, when a newly created document is to be published.

6.2.5 AIP/Chart Production tools

The AIP/Chart Production tools support AIS DPs in the generation, publication, and maintenance of their national AIS documentation based on the data from SDO.
Documentation such as: AIP, AIRAC & non-AIRAC AIP Amendments and Supplements, AIC and checklists for Supplements and AIC.

It can also be used by DUs who need to create documents or charts which include the static data information (Aerodrome, FIR, etc.) copied from the SDO Database to the AIP one.

Chart production is used to generate, compose, synchronise, update, publish and maintain aeronautical charts defined in an AIP from the SDO database.
Charting parameters (like chart specifications, graticule definitions, ellipsoid definitions and symbolisation) can be used and maintained. Chart Production also offers specific charting functionality, such as geographical calculations and map projections.

Anyway, there are special limitations related to:

- the provision of Aerodrome Mapping Data is not supported
- the provision of Electronic Terrain Data is not supported

The Chart production system provides facilities to:

- set up a chart’s geographical reference
- compose a chart with elements from the database
- synchronize a chart with annotation from the database
- update a chart for a new effective date
- maintain chart specifications
- publish a chart

6.3 The typical Changes to the EAD functional system

The EAD typical changes are listed below:

- changes related to the introduction of AIXM data
- changes to low-level detailed functionality in a range of areas
- changes to multi-language NOTAM support
- enhancements to the Workflow Management tool (WFM)
- changes to the database to improve performance
- upgrades to the briefing box basic software
- updates of the FAA Loader tool
- changes to reflect amendments to standards and guidelines
- changes to elements that are not part of the EAD operational system (e.g. VoC matrix, EAD Reference Test System)
- changes to the CS and INO DU subsystems which will be disabled for EAD[163]

Note that as both the Training and the Test & Development sites are separated from the operational EAD system, changes to activities in those sites should not have any impact on the operational system.

[163] For the purposes of safety assessment, all that is required is the verification that this functionality is disabled and cannot be accessed.

7. The European Satellites Service Provider

"A satellite has no conscience."
Egbert Roscoe Murrow, American broadcast journalist

The European Satellites Service Provider Société par Actions Simplifiée (ESSP SAS) holds a certificate[164] as Air Navigation Service Provider (ANSP) for the provision of services[165] for Satellite Based Augmentation System (SBAS) Signal-in-Space (SiS), limited to the use of the European Geostationary Navigation Overlay Service (EGNOS), and for the provision of Global Navigation Satellite System (GNSS) satellite status and differential corrections, limited to the Global Positioning System (GPS).

7.1 EGNOS

The European Geostationary Navigation Overlay Service (EGNOS) is Europe's contribution to the first generation family of Satellite Based Augmentation Systems (SBAS). EGNOS is a satellite and ground based system that augments the existing satellite navigation service provided by the American Global Positioning System (GPS) so that civil users who are equipped with an appropriate receiver can achieve an improved level of performance for navigation.
EGNOS is the European implemented SBAS which has equivalent counterparts in other regions, such as the Wide Area Augmentation System (WAAS) developed by the US Federal Aviation Administration (FAA) over North America, the Japanese MTSAT Satellite-based Augmentation System (MSAS) over Asia and the GAGAN system over India.
EGNOS is being developed by the European Space Agency (ESA), the European Commission (EC) and EUROCONTROL. The EGNOS Service Provision contract is funded by the European Union and managed through the European Global Navigation Satellite Systems (GNSS) Agency (GSA), with a clear mandate to help foster the use of satellite navigation within Europe and particularly in the domain of aviation.

EGNOS provides navigation services to various users, including maritime, land mobile, and civil aviation. Of the three user communities, only civil aviation had defined mature requirements and hence the definition of EGNOS was driven by civil aviation mission requirements. These requirements are defined by the International Civil Aviation Organisation (ICAO). Furthermore, ICAO requires that a SBAS is compliant with internationally defined and agreed standards at various levels in the system in a manner that ensures compatibility at user level and interoperability at service level between the various SBAS implementations.
For Civil Aviation, EGNOS Advanced Operational Capability (AOC) provides a primary means service of navigation for en-route oceanic and continental, non-precision approach and CAT-I precision approach within the ECAC (European Civil Aviation Conference) area.
EGNOS Full Operational Capability (FOC), which follows the AOC phase and should be deployed within 2020, will ensure sole means operation.

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[164] The certificate is in accordance all relevant Regulations and remains valid until 07 July 2018, unless the approval is surrendered, suspended or revoked, which is very unlikely to occur.

[165] The provision of services is restricted to the airspace of the territory to which the Treaty applies, as well as in other airspace where the Member States apply Regulation (EC) No 551/2004 of the European Parliament and of the Council on the organisation and use of the airspace in the Single European Sky.

7.2 EGNOS Services

Navigation, Provision of GNSS signal-in-space, Satellite-Based Augmentation System (SBAS)

EGNOS supports three services:

- the Open Service (OS), freely available to public in Europe
- the Safety of Life Service (SoL), providing the most stringent level of Signal-In-Space performance to all SoL user communities in Europe
- the Commercial Data Distribution Service (CDD), for customers who require enhanced performance for commercial and professional use

7.2.1 Open Service (OS)

The EGNOS Open Service (OS) was the first EGNOS Service declared operational on the 1st October 2009 by EC. It is intended for general purpose applications and is provided through two out of the three GEO satellites of the EGNOS architecture at any time under routine operating.

It consists of signals for augmenting GPS with unprecedented positioning precision, freely accessible in Europe to any user equipped with an appropriate GPS/SBAS compatible receiver for which no specific receiver certification is required and without any direct charge.

The EGNOS OS is intended to deliver a wide range of benefits to European citizens in the multimodal domains, where Safety is not critical (i.e. a failure in OS performances do not imply any direct or indirect personal damage) and just aiming at improving the achievable positioning accuracy by correcting several error sources affecting the GPS signals.
The corrections transmitted by EGNOS contribute to mitigate the ranging error sources related to satellite clocks, satellite position and ionospheric effects. The other error sources (tropospheric effects, multipath and user receiver contributions) are local effects that cannot be corrected by a global augmentation system. Finally, EGNOS can also detect distortions affecting the signals transmitted by GPS and prevent users from tracking unhealthy or misleading signals.

EGNOS OS also broadcasts a reliable time standard with unprecedented accuracy to be used by computer and telecommunication networks. The continuous monitoring of the EGNOS OS signal shows accuracy gains with respect to GPS within one to two meters and is available more than 99% of the time.

Finally, some examples of applications of EGNOS OS are listed below:

- agriculture, EGNOS OS enables the high-precision spraying of fertilisers and pesticides
- mapping, property boundary mapping, land parcel identification and geo-traceability
- road transport, “pay-per-use” insurance or automatic road tolling, improving fleet tracking solutions
- rail, as passenger information systems or asset management
- maritime domain, for general navigation (i.e. coastal, port approach and inland waters)
- all personal navigation applications such as, emergency localisation, friend finding or geo-localised advertising

7.2.2 Safety-of-Life Service (SoL)

The second key milestone in the EGNOS Programme was the declaration of the EGNOS Safety-of-Life Service (SoL) operational. On the 2nd March 2011, ESSP declared SoL signal officially available for aviation with EC's authorization to provide the service. This service supports, since its announcement, a great number of applications in the transport domain and renders safety-critical operations safer. Moreover, it provides a valuable integrity message to inform the user within six seconds in case of a malfunction of the signal.

While the signal currently covers most European states, it has the built-in capability to extend the coverage area to other regions, such as countries on the EU's borders and North Africa. On March 3, 2015 the SAFIR (Satellite navigation services for AFrIcan Region) project has officially launched the EGNOS-Africa Joint Programme Office in a ceremony in Dakar, Senegal. SAFIR started on January 15, 2013 and is part of the Africa-EU long-term strategic partnership that aims to enhance safety in air transport. The project covers the set-up, staffing and operations of an EGNOS-Africa Joint Programme Office, and sets up and supports a number of technical working sessions composed of regional stakeholders concerned with GNSS/EGNOS in sub-Saharan Africa

7.2.3 Commercial Data Distribution Service (CDD)

Additionally, the provision of EGNOS commercial products as a result of the Commercial Data Distribution Service (CDD) provides added value to Navigation applications, commercial products and widens the extent of EGNOS applicability to a vast number of environments and purposes.

CDDS allows users to access additional data that is not provided by the EGNOS Signal broadcast by the geostationary satellites.

7.3 The EGNOS functional system

Basically, EGNOS consists of a network of about forty ground stations and three geostationary satellites. Ground stations determine accuracy data of the satellite navigation systems and transfer it to the geostationary satellites; users may freely obtain this data from those satellites using an EGNOS-enabled receiver, or over the internet.

EGNOS is mostly designed for aviation users who enjoy unperturbed reception of direct signals from geostationary satellites up to very high latitudes.

According to specifications, horizontal position accuracy when using EGNOS-provided corrections should be better than seven metres. In practice, the horizontal position accuracy is at the metre level.

The Figure 7.3-1 illustrates EGNOS functional architecture which will be further described in the next Subparagraphs.

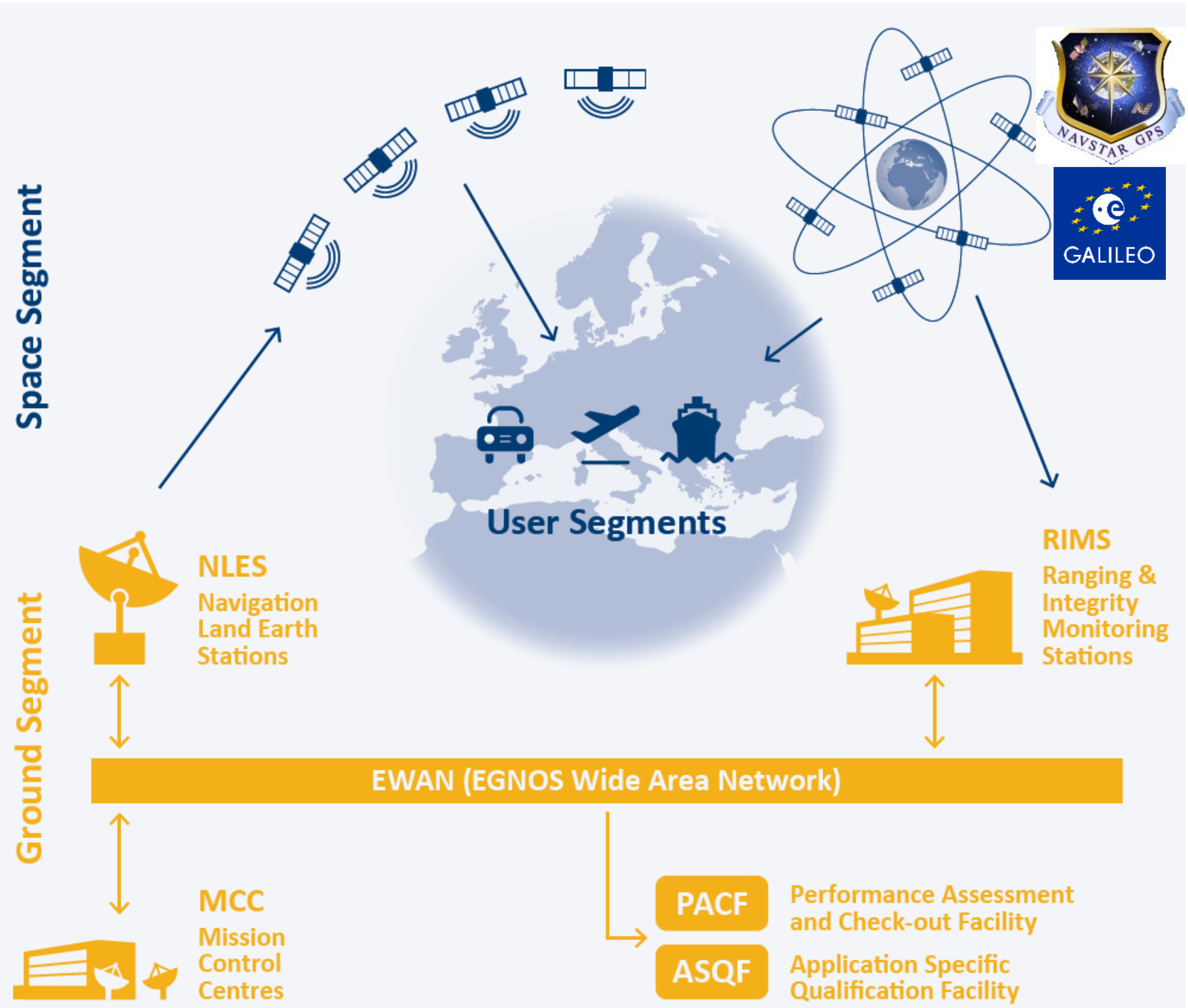

Figure 7.3-1 EGNOS functional architecture

When considering the boundaries of the functional system for a SBAS system, Ground-based subsystems are part of the functional system, whereas all that follows is considered out of the functional system:

- Space-based elements (e.g. SBAS GEO transponder)
- Telecommunication network not specifically designed for the SBAS system are considered as a service and evaluated during the continuous oversight (contracted activities)
- Support tools (e.g. for performance monitoring) used by the service provider and their evolutions are covered as part of the continuous oversight (service monitoring)

7.3.1 The Space Segment

The EGNOS Space Segment is composed by:

- the GPS constellation, the (originally Navstar) Global Positioning System owned by the United States Government and operated by the Air Force Space Command
- the EGNOS geostationary satellites (GEOs) centred over Europe and broadcasting corrections and integrity information for GPS satellites:
    - 3F2 AOR-E (PRN120) operated by Inmarsat
    - ASTRA 5B (PRN 123) operated by Astra
    - SES-5 (PRN 136) in test mode

The EGNOS operations are handled in such a way that, at any point in time, typically two of the three GEOs broadcast an operational signal. This configuration provides a high level of redundancy over the whole service area in case of a geostationary satellite link failure.[166]

Figure 7.3-2 shows the area of provision for the SBAS Service message, which is known as the Message Type 27 (MT 27).

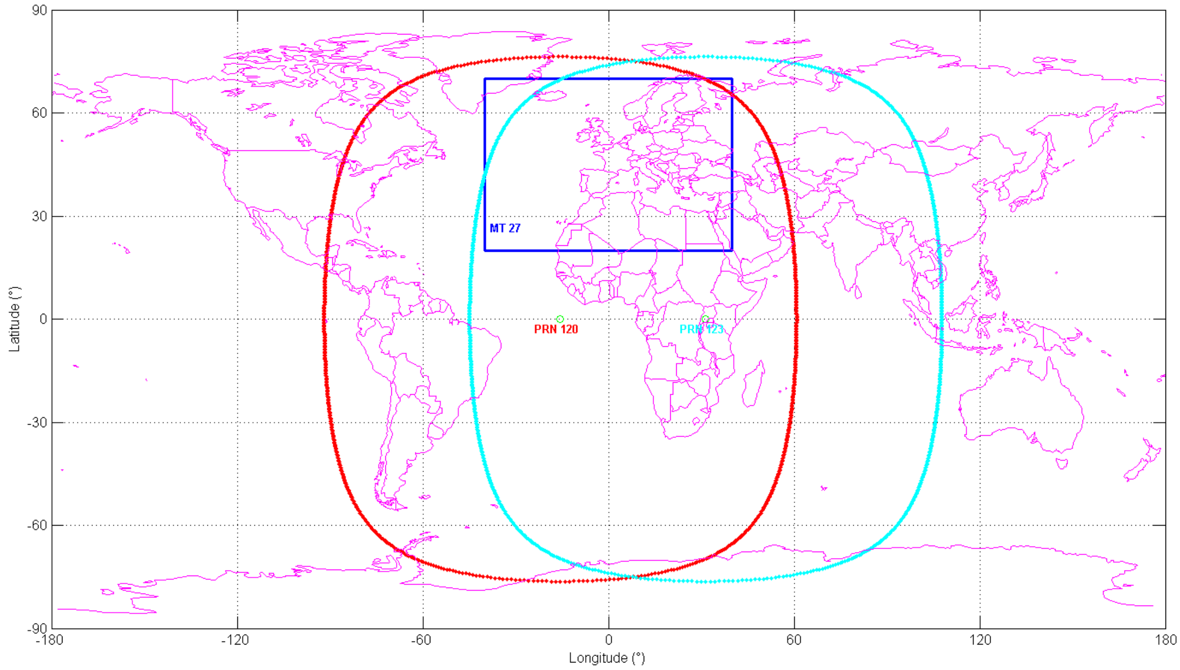

Figure 7.3-2 the footprint of EGNOS GEO satellites

[166] Since it is only necessary to track a single GEO satellite link to benefit from the EGNOS SoL (see paragraph 7.2.2), this secures a switching capability in case of interruption and ensures a high level of continuity of service.

7.3.2 The Ground Segment

The ground segment is responsible for the computation of the integrity measurements and wide area differential corrections. To this purpose, a network of Ranging and Integrity Monitoring Stations (RIMS) is being deployed over the European Union territories (and for some of them worldwide) to collect the GPS, Galileo and EGNOS GEO raw pseudo-range measurements.
The EGNOS Ground Segment comprises:

- around 40 Ranging Integrity Monitoring Stations (RIMS), receiving signals from US GPS satellites and hosting:
    - 39 RIMS Branch A, processing data
    - 38 RIMS Branch B, performing the Integrity check
    - 14 RIMS Branch C, tracking specific GPS satellite failure modes
- 4 Mission Control Centres(MCC), each hosting:
    - a Central Processing Facility (CPF), processing critical data, counting differential corrections and ionospheric delays
    - a Central Control Facility (CCF), processing non-critical data, hosting archiving and Monitoring and Control (M&C) functions performed by humans (non-automatic functions), where Operators on duty in another CCF (hot backup) are ready to take over the system M&C if the master CCF fails, while remaining two CCF (cold backup) can be reactivated if the master one fails
- 6 Navigation Land Earth Stations (NLES), sending accuracy and reliability data to three geostationary satellite transponders for broadcasting to receiving end-user devices
- the EGNOS Wide Area Network (EWAN), providing the communication network for all the components of the ground segment, composed of:
    - TWAN, the wide area network connecting all elements of the Ground Segment and provided as a service, and including the VSAT
    - ENMA, the EGNOS network control centre
    - FEE acting as interfacing element between the real time Ground Segment components and the network
- 2 additional supporting facilities operated by ESSP:
    - the Performance Assessment and Check-out Facility (PACF) to support system operations providing support to EGNOS management in such area as performances analysis, troubleshooting, operational procedures as well as upgrade of specification and validation, and support to maintenance
    - the Application Specific Qualification Facility (ASQF) providing civil aviation and aeronautical certification authorities with the tools to qualify, validate, and certify the different EGNOS applications; moreover, the ASQF provides the functions to analyse and assess system safety aspects, mission performances versus the system configuration, the application of flight procedures using this navigation system, its interoperability with other SBAS systems & GBAS systems, and to validate system performance prediction tools

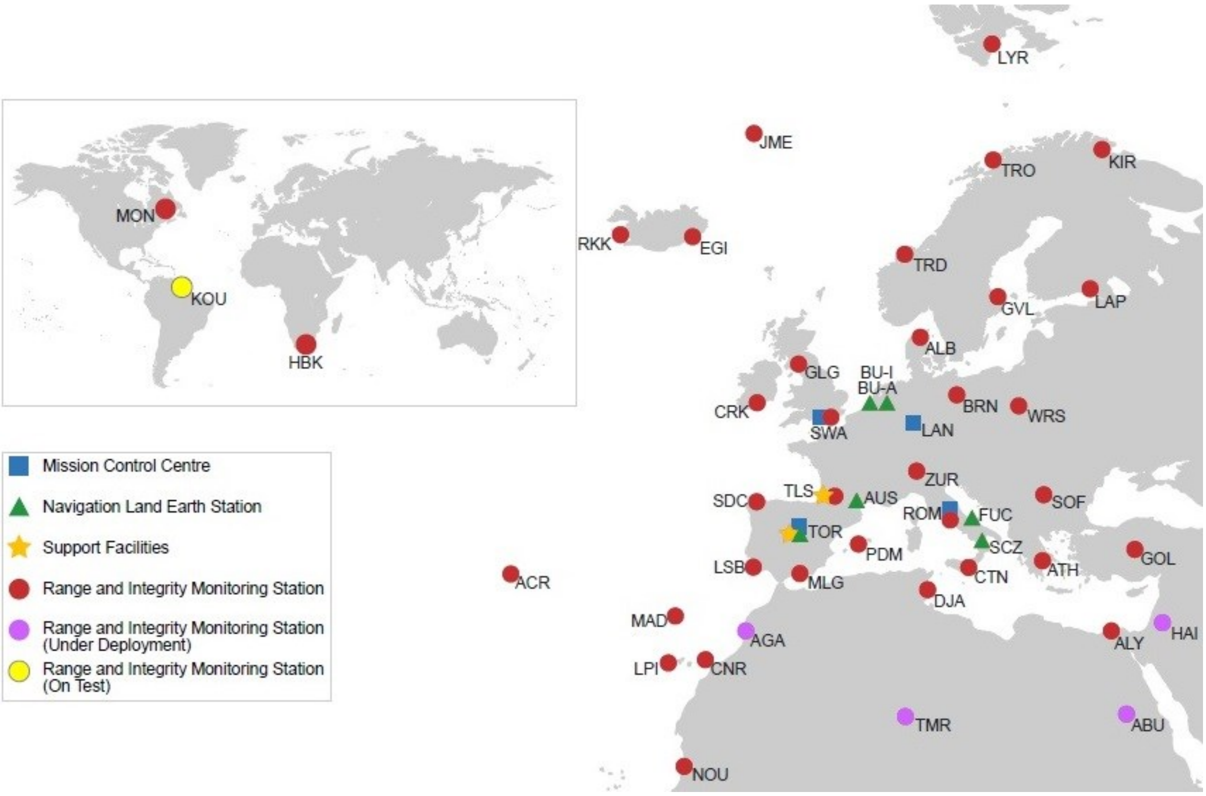

Figure 7.3-3 RIMS sites

7.3.2.1 EGNOS Central Processing Facility and Navigation Chain

The Central Processing Facility (CPF) is the computational heart of the EGNOS system, which provides the corrections and integrity information that are broadcast over the EGNOS service area.
The CPF is an integral part of the EGNOS Master Control Centre (MCC). It is co- located at each MCC with a Central Control Facility (CCF). Each CPF is dimensioned to compute corrections for each GEO satellite in the EGNOS system. The CPF therefore drives the EGNOS system level performance and its two major components are the Processing Set (CPFPS) and the Check Set (CPFCS).
The CPF also monitors other SBAS satellites which are visible by the EGNOS RIMS and provides integrity information regarding these observations.

Using measurements from the Ranging and Integrity Monitoring Stations (RIMS) spread over the EGNOS coverage area, the CPF Processing Set generates the following applicable data for EGNOS users:

- basic and wide area differential corrections for satellites (clock and ephemeris)
- precise differential corrections (ionospheric delay information)
- integrity data about the GNSS satellite status (for the confidence of differential and ionospheric corrections)
- alarms (for individual satellites or ionospheric grid points when necessary)
- Geo satellite positioning data
- network time offsets parameters UTC(k) / ENT (UTC RIMS)

The Integrity of the broadcast information must also be checked to protect all EGNOS users from applying hazardous misleading information. The Integrity checking must also detect and exclude satellite anomalies that may cause hazardous misleading information for EGNOS users. Specific RIMS support the CPF Check Set in this function.

The task of the CPFCS is to support the EGNOS user's positioning integrity. However, as the RIMS can neither observe all user- local effects nor check all possible user satellite geometries, only the RIMS observed signal- in-space can be validated sufficiently. The task of the CS is to verify the correctness of the EGNOS messages that have been generated by the CPFPS.
There are two main types of correction information provided to the user: satellite corrections and ionospheric corrections. The first includes satellite orbit and clock corrections, while the latter consists of vertical ionospheric delays at some pre-defined ionospheric grid points (IGPs).[167]

The EGNOS system is a widely distributed and redundant system and data-flows from one subsystem to another subsystem have different level of criticality.
In the EGNOS data-flow representation show in Figure 7.3-4, the real time critical data-flow is indicated in red whereas the non-critical data-flow is indicated in green.

RIMS, CPF, and NLES constitutes the so called 'Navigation Chain'.

167 Further information about the architecture and the design of the EGNOS Central Processing Facility can be found in [4].

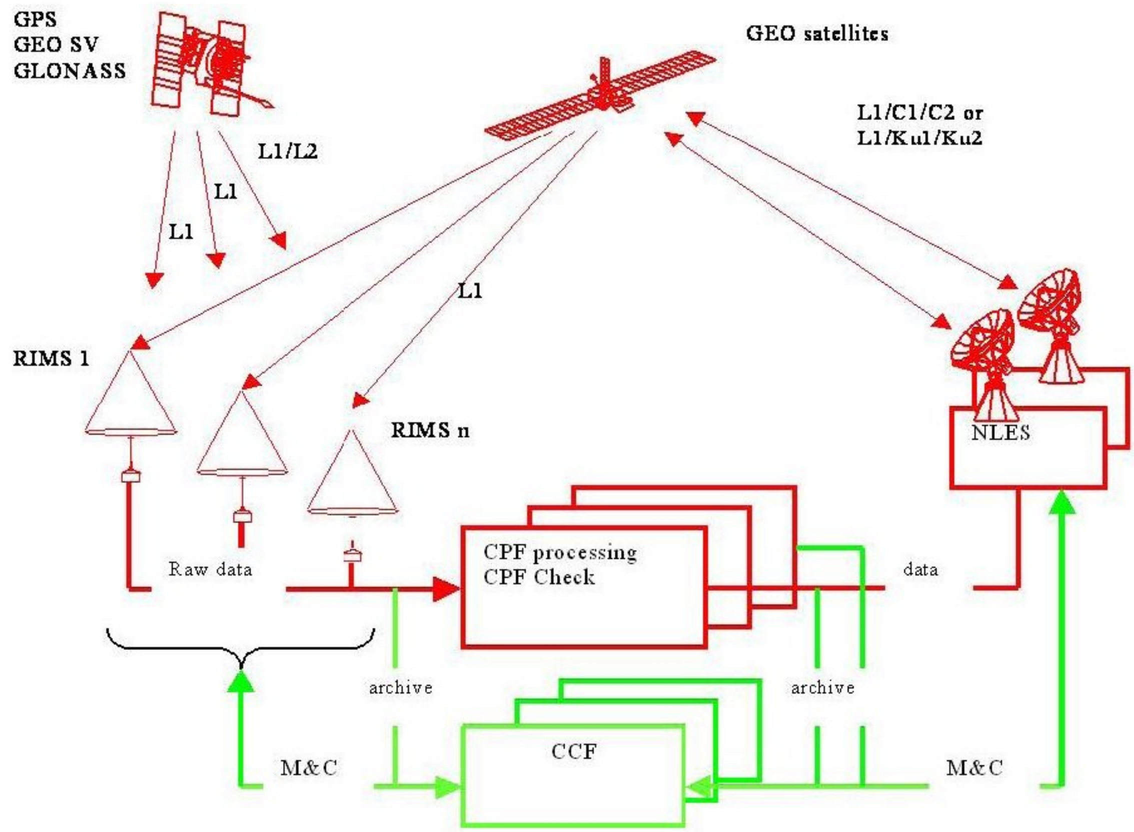

Figure 7.3-4 EGNOS data-flows

7.3.3 The User Segment

The EGNOS User Segment consists of receivers having the same type of antenna of the GPS ones, but with special software inside that allows them to lock onto the code used by the EGNOS satellites and compute the EGNOS corrections to the GPS signals.

It is important to bear in mind that a GPS receiver only monitors signals sent by the satellites and does not establish any contact with them. Therefore, a GPS receiver cannot be used by a third party to find out a user's position without his knowledge.

To test the EGNOS receiver, special prototypes have been developed with extensive capabilities to log and analyse data.

7.4 Changes to the EGNOS functional system

The SBAS system is a highly automated/coupled system where the human intervention is limited to the M&C part and manly concerning a significant amount of non-regression activities, including reassessment of the system performances.

There are some constraints in the way that changes are defined and notified to the CA. Typically:

- Hardware and Software evolutions (including correction of problems) are grouped into System Releases (ESR for EGNOS)
- Operational procedures:
    - main evolutions are introduced together with System Releases
    - specific evolutions or new procedures can be introduced between Releases

7.4.1 EGNOS change types

The changes to EGNOS product can belong to one of the three main categories and associated lines of responsibilities[168]:

- Major Project evolution Activity (Major PEA)
  changes to the EGNOS product having a considerable criticality and thus requiring a full system qualification of the EGNOS System Release (ESR) and procured by ESA
- Minor Project Evolution Activity (Minor PEA)
  other changes to the EGNOS product having a lower criticality with respect to the ones of the previous category and procured by ESSP
- Product Support Services (PSS)
  changes to the EGNOS product required for basic maintenance that do not require a re-qualification of the ESR

Each of the previous categories is mainly associated to the intrinsic difference in its development cycles and procedures; in fact, ESSP is given the means to implement minor changes, whereas Major PEA activities are generally developed through a cycle longer than the others and which is not optimal to answer the dynamic needs of ESSP in a Service Provision context.

The following paragraphs present an overview of the interfaces amongst the main actors[169] involved in the ESRs.

[168] The sharing of responsibilities is better detailed in paragraph 8.7.3.
[169] Paragraph 7.4.3 deals with the sharing of responsibilities among the EGNOS exploitation Organisations.

7.4.1.1 Major PEA Releases

Major PEA Release change path is characterised by the steps listed below and summarised in Figure 7.4-1:

- initiation
  - ESSP inputs to EC for the definition/preparation phase
  - Major PEAs are initiated by GSA or ESA and the content is technically approved by the EGNOS System and Service CCB
  - GSA authorises the procurement to ESA
  - procurement contract between ESA and Industry Prime (IP)
- implementation
  - Industry Prime (IP) updates the design and qualification documentation, as well as the operational interface definition, in order to deliver a new ESR to ESA
  - ESSP participates to the implementation phase as reviewer (including impact assessment on Service Provision)
  - ESA updates and approves the System Required Document (SRD) and qualifies the new PEA ESR (delivered with a "qualified" status and industrial commitment)
  - GSA delivers the Major PEA ESR qualified as Customer Furnished Item (CFI) to ESSP and the required update inputs for ESSP to update the Safety Case Part A
- service Introduction
  - ESSP prepares the Safety Case Part A (design) for GSA approval
  - ESSP updates the operational procedures for the use with the new PEA ESR
  - ESSP deploys the new PEA ESR
  - ESSP updates its DoV of Systems by means of the Safety Case Part B, checking consistency with Part A

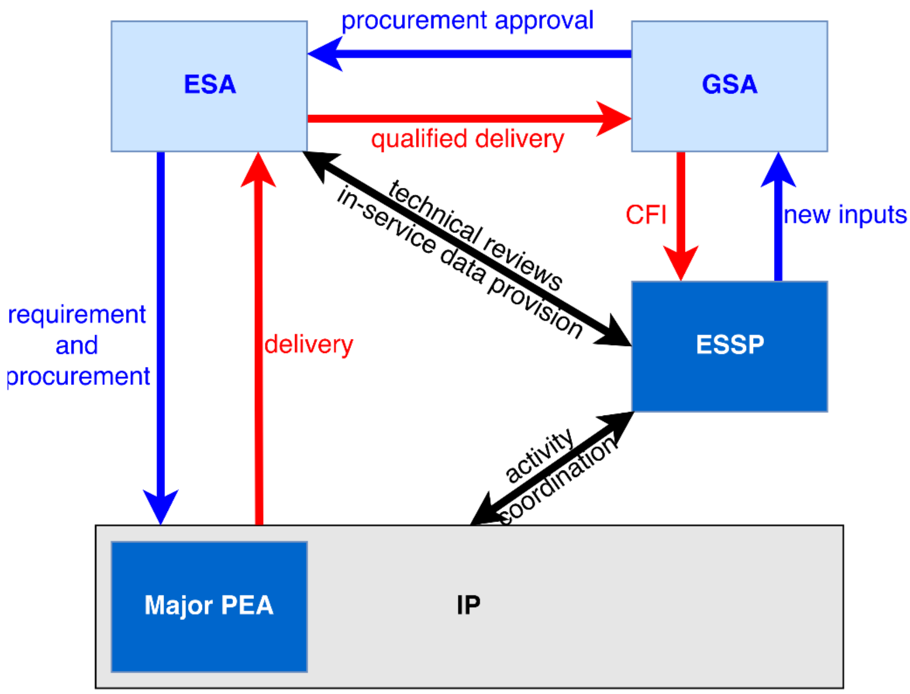

Figure 7.4-1 Major PEA change path

7.4.1.2 Minor PEA Releases

Minor PEA Release change path is characterised by the steps listed below and summarised in Figure 7.4-2:

- initiation
  - ESSP inputs to GSA/ESA for the definition/preparation phase
  - Major PEAs are initiated by ESSP and the content is technically approved by the EGNOS System and Service CCB
  - GSA authorises the procurement to ESSP
  - procurement contract between ESSP and Industry Prime (IP)
- implementation
  - IP updates the design and qualification documentation, as well as the operational interface definition, in order to deliver a new ESR to ESA
  - ESSP chairs the implementation phase as reviewer (including impact assessment on Service Provision)
  - ESA approves the System Required Document (SRD)
  - ESSP qualifies the new PEA ESR
  - GSA/ESA delivers, qualifies and authorizes the Minor PEA ESR
- service Introduction
  - ESSP prepares the Safety Case Part A (Design) for GSA approval
  - ESSP updates the operational procedures for the use with the new PEA ESR
  - ESSP deploys the new PEA ESR
  - ESSP updates its DoV of Systems by means of the Safety Case Part B (Operations), checking consistency with Part A

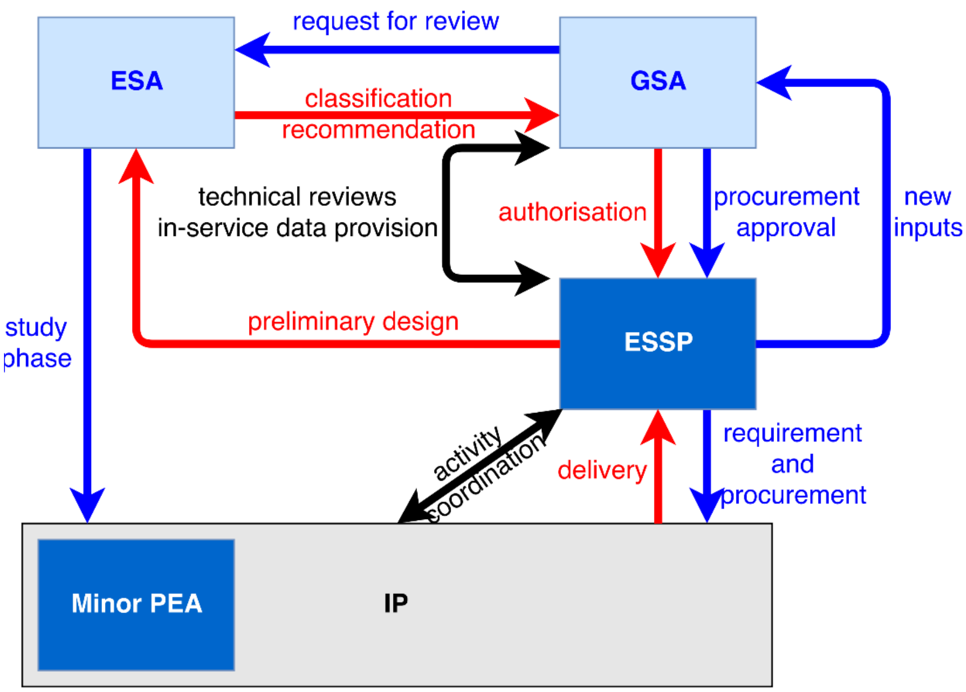

Figure 7.4-2 Minor PEA change path

7.4.1.3 Product Support Services

Product Support Service (PSS) ESR change path is characterised by the steps listed below:

- initiation
  - PSS ESR content is typically triggered by ESSP Observation Reports (ORs), confirmed as Non-Conformance Reports (NCRs) by IP, and by ESSP evolution needs, if no qualification at system level is required
- implementation
  - procurement of the PSS ESR from IP via ESSP
  - IP updates the design and qualification documentation, if required, as well as the operational interface definition
  - ESSP accepts the PSS ESR
  - PSS does not need to be qualified
- service Introduction
  - ESSP updates the operational procedures for the use with the new PSS ESR
  - ESSP deploys the new PSS ESR
  - ESSP updates its DoV of Systems, if required

7.4.2 The EGNOS Change Management Process

The Change Management Process (CMP) is an Applicable Document in the EGNOS Service Provision Contract between GSA and ESSP which:

- defines guidelines for the change processes, on how to flow down the change processes when implementing all interfaces between the actors and specifically ruling the participation of ESA and ESSP in the system evolution and maintenance procurement processes
- provides guidance for the expected approval process conducted by EASA when granting ESSP with its ANSP certificate and maintaining this status throughout the applicable EGNOS exploitation phase[170]
- clarifies how the Safety role of ESSP in EGNOS is made compatible with the fact that the EGNOS system design is under the responsibility of the public sector.

The scope of the CMP is summarised in Figure 7.4-3.

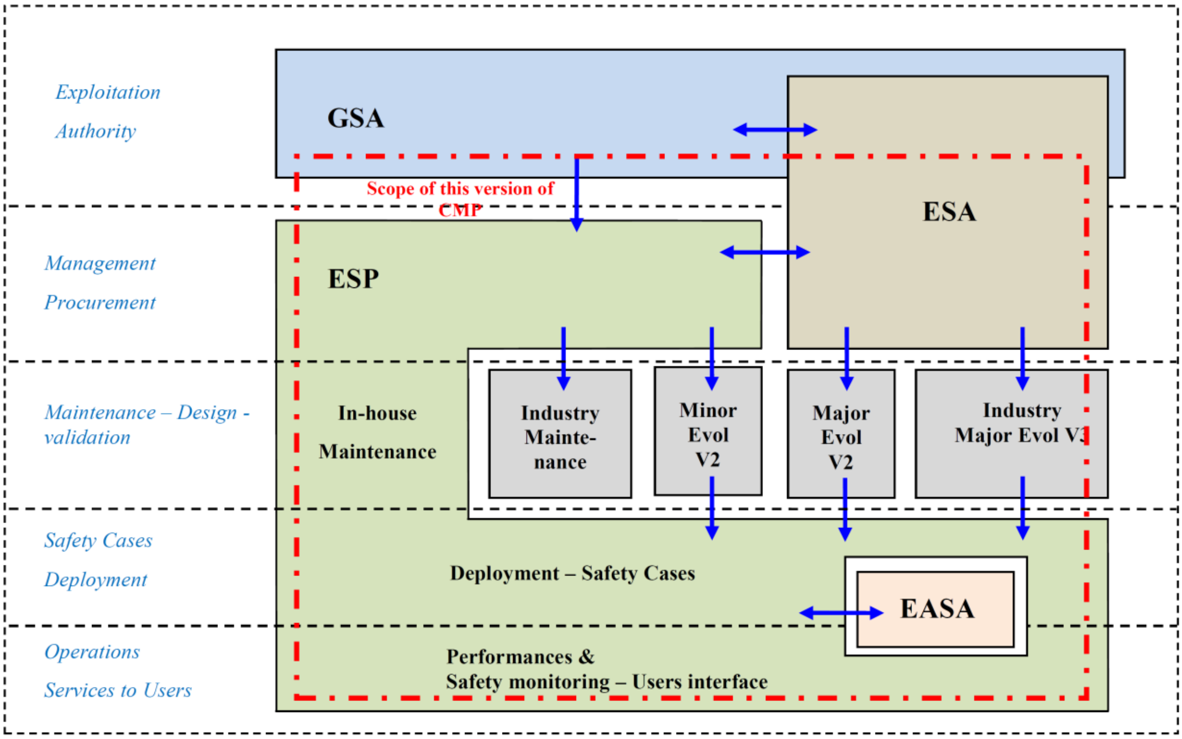

Figure 7.4-3 scope of the CMP within the overall EGNOS exploitation

[170] The exploitation phase goes from 2014 to 2021.

Figure 7.4-4 shows the links amongst the main actors of the EGNOS provision.

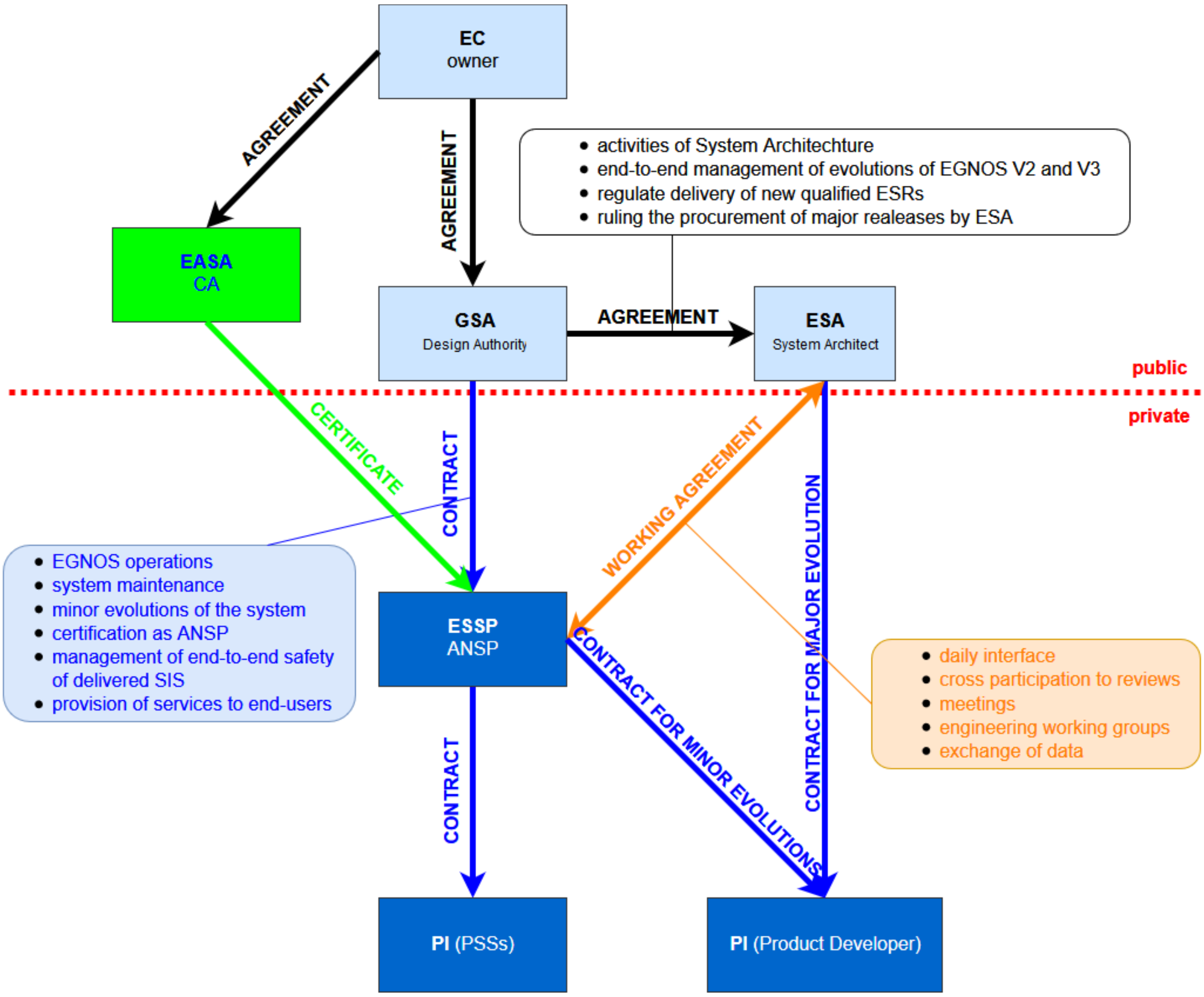

Figure 7.4-4 the main actors in the evolution of EGNOS

7.4.3 The sharing of responsibilities among the EGNOS exploitation Organisations

The intrinsic construction of the EGNOS programmatic framework results in the separation, from contractual, legal, financial, and technical standpoints, between the activities related to the design, implementation and qualification of an ESR and the activities related to the provision of EGNOS services based on this ESR.

The CMP and the associated sharing of responsibilities between the different EGNOS actors of this process must take into account the obligations put on the certified ESSP by the SES Regulations[171].

[171] Regulation (EC) No 550/2004 on the provision of air navigation services in the Single European Sky.

The following key concepts of ESSP certification are relevant to the CMP:

- the safety justification of the EGNOS design is based on the TF produced during the ESR implementation and qualification process, i.e. under the responsibility of ESA and endorsed by GSA via the production of the design Safety Case Part A
- the safety justification of the EGNOS operations and maintenance processes is based on the ESP management processes, and is derived by ESSP in the Operations Safety Case Part B

Table 7.4-1 summarises the major actors in the delivery of EGNOS SIS, their roles, and their responsibilities:

EC	European Commission	• owner of EGNOS Assets • Supervisory Authority • Policy Authority • responsible for Programme Supervision • responsible for international matters in the field of GNSS • responsible for the overall oversight of the mission • responsible for the budget of EGNOS Programme
EASA	European Aviation Safety Agency	• Competent Authority that certifies ESSP as ANSP • reviews safety-related changes • performs the VoC of ESSP against SES regulations verifying the DoV by ESSP submitted by means of Safety Case design update with related TFs • performs continuous oversight of ESSP activities
GSA	European GNSS Agency	• Design Authority • Exploitation Programme Manager coordinates the Provision of EGNOS services, operations, and maintenance, including PSSs and PEAs (Major ESRs V2 and V3 and Minor PEAs V2) via contract of ESSP • Safety and Risk Manager responsible for design safety cases of new ESRs (solely responsible for the endorsement of safety case part A) • reviews and authorise the content and the budget of each contract of Minor ESR placed by ESSP to IP • responsible for the procurement of EGNOS based navigation services • Supervisor of all technical reviews (SRR, PDR, CDR, SQR)
ESA	European Space Agency	• System Architect • Design and Procurement Agent for major PEA ESRs V2 and V3 • Supervisor of Minor PEA ESRs procured by ESSP • responsible for the preliminary safety assessment of Change for PEAs (performing the Major ones and at least endorsing the minor ones)
ESSP	European Satellite Services Provider	• certified ANSP Authority responsible of the navigation service for the aviation community • Maintainer and subcontractor of maintenance services to IP for PSSs • Designer of Minor PEA ESRs V2 technical reviews (SRR, PDR, CDR, QR) • Supervisor of Major PEA ESRs V2 and V3 procured by ESA

		• responsible of end-to-end Safety of all its services[172], prepares Safety Case Part A from all the ESRs and ensures full consistency with the operations files of part B presenting the DoV to EASA according to accepted procedures
IP	Industry Prime	• System Manufacturer • implements product changes through contracts with ESA for Major PEA ESRs and with ESSP for Minor PEA ESRs • provides maintenance services through contracts with ESSP

Table 7.4-1 the roles of the major actors in the delivery of EGNOS SIS

Changes to EGNOS are decided at the GSA/ESA/ESSSP System and Service Configuration Control Board (CCB). During the Technical Feasibility Study, prior to the decision on the implementation of the changes, the Safety impact analysis is ensured by ESA for changes to the System and by ESSP for changes to the Operation concept of the system.

[172] ESSP is responsible of the end-to-end Safety up to the provision of the SIS, which means that ESSP is responsible for checking the safe introduction on the SIS in the ATM being compliant to its specifications, but not responsible of the user receiver nor the operational procedures.

7.5 The typical Changes to the EGNOS functional system

Depending on what is established in accordance with the CA, there are changes that shall be mandatorily notified and undergo the review process, some which may simply come in the form of information, and some others which are not even considered changes.
Here are some examples:

- requiring notification:
  - safety-related PEAs, PSSs, changes to OPS and MAINT Procedures
  - Temporary Operating Instructions (TOI)
- information:
  - not safety-related PEAs, PSSs, changes to OPS and MAINT Procedures
  - TOOLS used for the Service Provision
- not applicable or not considered changes:
  - configuration changes (PRN mask)
  - hardware maintenance
  - change of configuration data

For some types of changes requiring prior notification, it has been observed that the CA usually takes the decision to:

- review
  - system releases affecting the Navigation Chain
  - new operational procedures
  - update of the SDD maps
  - correction of non-conformances (typically included in system releases)
- review depending on the impact
  - system releases only affecting the M&C part (no direct safety effect in the service)
  - change of the SBAS GEO
- no review
  - modification of existing operational procedures
  - major technical changes not involving the Navigation Chain
  - TOIs, which are non-safety relevant in HDA (Human Dependability Analysis)

It is also possible to classify them accordingly to which part of the functional system is involved:

- hardware:
  - hardware replacement due to obsolescence
  - introduction/reintroduction/relocation/removal/dismantling of ground station (typically part of an ESR as a re-assessment of performances with the new configuration)
  - SBAS GEO rotation, implying the use of a different NLES
- software:
  - software evolutions consisting in new/modified requirements (e.g. new functionalities)
  - correction of known problems
- procedures:
  - new/modified procedures
  - introduction of operating instructions/workarounds

8. ATCO Training Organisations

"An organization's ability to learn, and translate that learning into action rapidly is the ultimate competitive advantage."
Jack Welch, former General Electric CEO

ATCO Training Organisations are classified on the basis of the type of training they provide, which is stated on their certificate.
The certification of Training Organisations is one of the essential factors contributing to the quality of ATCO Training and thus to the safe provision of ATC.
Such provision of air navigation services requires highly skilled personnel and, in particular, air traffic controllers, whose competence is demonstrated by a licence, issued on the basis of the detailed essential requirements set out in Reg. 2015/340, as for those related to the language proficiency, since poor communication is often a significant contributing factor in incidents and accidents[173].

8.1 The phases of the ATCO training

ATCO Training shall cover the entirety of theoretical courses, practical exercises, including simulation, and OJT required in order to acquire and maintain the skills to deliver safe, orderly and expeditious ATCO services. [174]

ATCO training shall consist of the following types: [175]

- Initial Training
  - basic training
  - rating training
- Unit Training
  - transitional training
  - pre-on-the-job-training
  - on-the-job-training
- Continuation Training
  - refresher training
  - conversion training

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[173] To this regard, these are some of the most famous accidents where the poor communication is deemed as one of the root causes:
- in 1977, the causes of the Tenerife Airport disaster boil down to the pilot's impatience together with a lack of English proficiency in the communication with the ATCO
- in 1995, the CFIT of the American Airlines Flight 965 was not avoided due to the ATCO's lack of English proficiency needed to probe the flight crew's extent of their difficulties
- in 1996, the cause of the Charkhi Dadri mid-air collision disaster can be traced back to communications difficulties in the Kazakhstani plane, where none of the flight crew, except the radio operator, understood English, so they were completely reliant on him to communicate with ATCO

[174] ATCO.D.001.

[175] This training path is shown in Figure 7.2 1.

In addition to the types of training listed above, ATCO may undertake the following types:

- practical instructors' training, leading to the issue, revalidation or renewal of an on-the-job training instructor (OJTI) or synthetic training device instructor (STDI) endorsement
- assessor training, leading to the issue, revalidation or renewal of an assessor endorsement

8.1.1 The Initial Training

The initial training may lead to the issue of a student ATCO licence or to the issue of an additional rating and/or, if applicable, rating endorsement.

The Initial Training shall consist of both Basic and Rating Training as described hereinafter.

Basic and rating training shall be provided as separate or integrated courses. [176]
Basic and rating training courses or an integrated initial training course shall be developed and provided by training organisations and approved by the CA. [177]

8.1.1.1 The Basic Training

The Basic Training consists of theoretical and practical training designed to impart fundamental knowledge and practical skills related to basic operational procedures. [178]

It comprises all the following nine subjects, topics and subtopics included[179]:

1. introduction to the course
2. Aviation Law
3. Air Traffic Management
4. Meteorology
5. Navigation
6. aircraft
7. Human Factors
8. equipment and systems
9. professional environment

[176] ATCO.D.020(a).
[177] ATCO.D.020(b).
[178] ATCO.D.005(a)(1)(i).
[179] Annex I — Part ATCO Subpart D, Section 2.

8.1.1.2 The Rating Training

The Rating Training consists of theoretical and practical training designed to impart knowledge and practical skills related to a specific rating and, if applicable, to rating endorsement. [180]
Each rating indicates that the licence holder is competent to provide a specific ATC service to a specific kind of traffic.
The rating training comprises the subjects, topics and subtopics of at least one of the following Ratings with the related endorsements[181]:

Figure 8.1-1 provides a graphical representation of the Initial Training ratings and related endorsements.

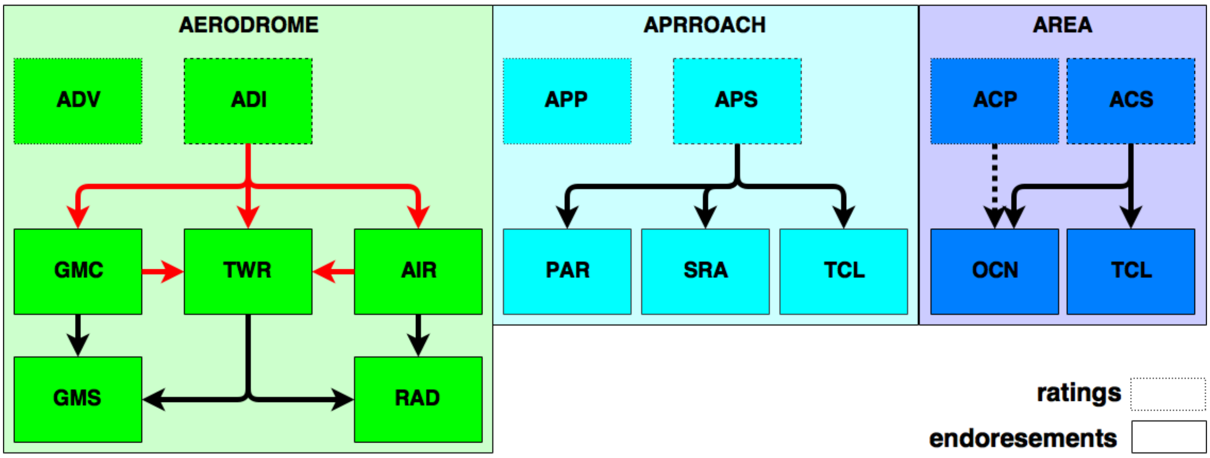

Figure 8.1-1 the possible Initial Training ratings and endorsements for the student ATCO

[180] ATCO.D.005(a)(1)(ii).
[181] ATCO.B.015 and ATCO.D.010.

8.1.2 The Unit Training

The Unit Training may lead to the issue of an ATCO licence, the issue of a rating endorsement, the validation of rating(s) or rating endorsement(s) and/or the issue or renewal of a unit endorsement. [182]

Unit Training shall consist of training course(s) for each unit endorsement established at the ATC unit as defined in the Unit Training Plan. [183]
The Unit endorsement course(s) shall be developed and provided by Training Organisations and approved by the CA. [184]
A Unit Training plan shall be established by the Training Organisation for each ATC unit and shall be approved by the CA. [185]

Unit Training shall include training in:

- operational procedures
- task-specific aspects
- abnormal and emergency situations
- human factors [186]

A Unit endorsement course shall be the combination of the relevant Unit Training phases for the issue or renewal of a unit endorsement in the licence. [187]

Each course contains:

- a transitional training phase
- a pre-on-the-job training phase, if required
- an on-the-job training phase

The unit endorsement shall authorise the licence holder to provide air traffic control services for a specific sector, group of sectors and/or working positions under the responsibility of an air traffic services unit. [188]

Unit competence schemes shall be established by ANSP and approved by the CA.

8.1.2.1 The Transitional Training

The Transitional Training phase is designed primarily to impart knowledge and understanding of site-specific operational procedures and task-specific aspects. [189]

[182] ATCO.D.005(2).
[183] ATCO.D.045(a).
[184] ATCO.D.045(b).
[185] ATCO.D.055.
[186] ATCO.D.045(c).
[187] ATCO.D.060.
[188] ATCO.B.020.
[189] ATCO.D.005(2)(i).

8.1.2.2 The Pre-On-The-Job Training

A pre-on-the-job training phase is required to enhance the previously acquired rating routines and skills and to prepare for live traffic situations which may be encountered in units that require the handling of complex and dense traffic situations. [190]

When the unit endorsement course contains a pre-on-the-job training phase, the applicant's skills shall be assessed on a synthetic training device at least at the end of this phase. [191]

8.1.2.3 The On-The-Job Training

The on-the-job training (OJT) phase, which is the final phase of Unit Training during which previously acquired job- related routines and skills are integrated in practice under the supervision of a qualified on-the-job training instructor (OJTI) in a live traffic situation. [192]

The applicant's assessment shall be conducted in the operational environment under normal operational conditions at least once at the end of the OJT. [193] Notwithstanding this, a synthetic training device may be used during a unit endorsement assessment to demonstrate the application of trained procedures not encountered in the operational environment during the assessment. [194]

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[190] ATCO.D.005(2)(iii).
[191] ATCO.D.070(b).
[192] ATCO.D.005(2)(ii).
[193] ATCO.D.070(a).
[194] ATCO.D.070(c).

8.1.3 The Continuation Training

The Continuation Training is designed to maintain the validity of the endorsements of the licence and consists of Refresher and Conversion Training courses.

8.1.3.1 The Refresher Training [195]

Refresher Training shall be designed to review, reinforce or enhance the existing knowledge and skills of ATCOs to provide a safe, orderly and expeditious flow of air traffic and shall contain at least:

- standard practices and procedures training
- abnormal and emergency situations training
- human factors training

8.1.3.2 The Conversion Training [196]

Conversion training shall be designed to provide knowledge and skills appropriate to a change in the operational environment and shall be provided by training organisations when the safety assessment of the change concludes the need for such training.

Conversion training courses shall include the determination of:

- the appropriate training method for and duration of the course, taking into account the nature and extent of the change
- the examination and/or assessment methods for the conversion training

Conversion training shall be provided before ATCOs exercise the privileges of their licence in the changed operational environment.

[195] ATCO.D.080(b).
[196] ATCO.D.085.

8.1.4 Training of instructors and assessors [197]

Training of practical instructors shall be developed and provided by Training Organisations and shall consist of:

- a practical instructional techniques course for OJTI and/or STDI, including an assessment
- a refresher training course on practical instructional skills
- a method(s) for assessing the competence of practical instructors

Refresher training in practical instructional skills should prevent knowledge and skills erosion, and, for the training of STDIs, it should be designed to maintain awareness of the current operational practices.

Training of assessors shall be developed and provided by Training Organisations and shall consist of:

- an assessor training course, including an assessment
- a refresher training course on assessment skills
- a method(s) for assessing the competence of assessors

Refresher training in assessment skills should prevent knowledge and skills erosion and it should be designed to maintain skills in assessment techniques and awareness of the regulatory environment.

The training courses and assessment methods for the training of practical instructors and assessors shall be approved by the CA.

[197] ATCO.D.090 and ATCO.D.095.

8.2 ATCO Training Organisations systems

Before dealing with the systems of the ATCO Training Organisations, it is better to make some clarification about the relations the ATCO Training Organisations have with the operational environment.

Error! Reference source not found. shows a simplified summary of the career an ATCO operator may take up, from being a student ATCO to being a certified and experienced ATCO operator.
As seen in Paragraph 8.1, the ATCO operator's path is required to start with the ITO, then to move in the UTO, and in the end – once licensed – to be recurrently kept under the Continuation Training.
Until the last phase, the OPS environment is not involved, so that, in a nutshell, it is still possible to crash planes during the training, since the environment they have to deal with is totally simulated and there is no interaction with the real traffic.
To be more precise, the only occasion in which the ATCO student faces the OPS environment is in the last phase of the UTO – during the OJT examination –, but in this particular phase the responsibility on the traffic is on the OJTI acting both as an ATCO instructor and as an ATS ATCO operator.

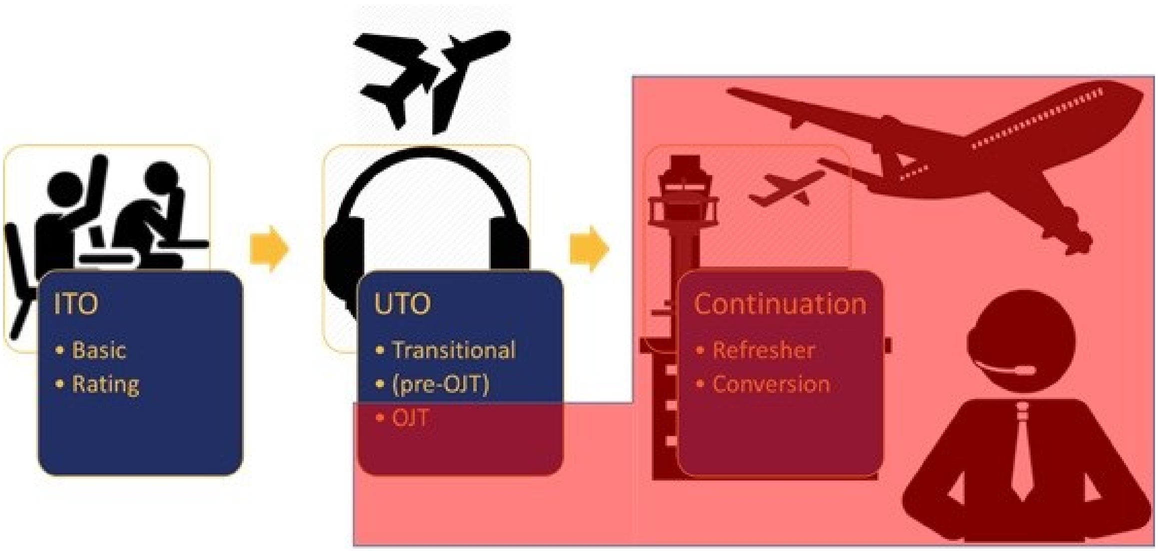

Figure 8.2-1 the ATCOs and the OPS environment

Holders of a student ATCO licence shall be authorised to provide ATC services in accordance with the rating(s) and rating endorsement(s) contained in their licence under the supervision of an OJTI and to undertake training for rating endorsement(s). [198]

Holders of an ATCO licence shall be authorised to provide ATC services in accordance with the ratings and rating endorsements of their licence, and to exercise the privileges of the endorsements contained therein. [199]

ATC services shall only be provided by ATCO qualified and licensed in accordance with Reg. 2015/340. Licences shall contain one or more ratings in order to indicate the type of service which the licence holder is authorised to provide.

OPS

[198] ATCO.B.001.
[199] ATCO.B.005.

ANSPs make use of functional systems allowing them to provide their services, but for what concerns the ATCO Training Organisations, these latter do not perform any ANS function in the real OPS environment.
This point explains why it is made no mention of functional systems in Reg. 2015/340 and such definition[200] should not be applicable to ATCO Training Organisations.
In fact, any reference to changes to the Training Organisations is seen in the perspective of a change related to the provision of a training, and not to the provision of a service for the control of the traffic.

Nevertheless, for the sake of evaluating whether exist Review Criteria applicable to Organisations not having a functional system, it is possible to find those elements constituting a functional system – such as procedures, human resources and equipment, including hardware and software – even in a generic ATCO Training Organisation.

Such systems are very much simpler than the once presented in the previous chapters, and can be shortly described taking in account that:

- most of procedures deal with the assessment of ratings and endorsements
- the human resources are constituted by the people covering different roles, such as:
    - Accountable Manager
    - Course Manager
    - Quality Manager
    - Compliance Manager
    - theoretical Instructors
    - practical Instructors
    - assessors
    - STD engineers
    - pseudo pilots
- the equipment consists of the facilities, comprising classrooms, auditoriums, laboratories, ATC coach systems and synthetic training devices (tower simulator, radar simulator)

[200] The definition of 'functional system' is given in Appendix A.r and replicated in Chapter 3.

8.3 The characteristics of the selected ATCO Training Organisations

For what concerns this Thesis, it has been taken vision of the documentation related to the following ATCO Training Organisations:

- Airways Corporation of New Zealand Limited (ACNZ)
- University of North Dakota Aerospace Foundation (UNDAF)

Table 8.3-1 contains the type of trainings provided by the selected ATCO Training Organisations.

training					**ATCO Training Organisation**	
type		**terminal area**	**rating**	**endorsement**	**ACNZ**	**UNDAF**
Initial	Basic	-	-	-	✓	✓
	Rating	aerodrome	ADV	-	✓	
			ADI	GMC		
				AIR		
				TWR	✓	✓
				GMS		
				RAD	✓	
		approach	APP	-		
			APS	-		✓
				PAR		
				SRA		
				TCL		
		area	ACP	-		
				OCN		
			ACS	-		✓
				OCN		
				TCL		

Table 8.3-1 the characteristics of the selected ATCO Training Organisations

8.1 Changes in the Training Organisations [201]

The AR makes a clear distinction between two types of changes: those requiring prior approval by the CA and those not requiring it.

Apart from the changes for which the AR explicitly states their mandatory need for approval, for all the other changes there is a procedure developed by the Training Organisation involved and approved by the CA.
Such procedure defines the scope of the changes not requiring the prior approval, their management and the related notification mechanism.

In the Continuous Oversight process the CA shall assess the information provided in the notification to verify whether actions taken comply with the approved procedures and applicable requirements.[202]

As different Training Organisations provide different types of trainings and have different systems, such procedure is not unique and standardised, every Training Organisation has its own approved procedure.

8.1.1 Changes requiring approval

Upon receiving an application for a change that requires prior approval, the CA shall verify the Training Organisation's continued compliance with the requirements before the issue of the approval.
The CA shall approve the conditions under which the Organisation may operate during the change, unless the CA determines that the change cannot be implemented.
After having verified that the Training Organisation complies with the applicable requirements, the CA shall approve the change.

Changes to the Training Organisations that are mandatory requiring prior approval by the CA are those which affect:

- the certificate or the terms of approval of the Training Organisation or any relevant element of the Training Organisation’s Management System, such as:
    - the name of the Training Organisation
    - change of legal entity
    - the Training Organisation’s principal place of operation
    - the Training Organisation’s type(s) of training
    - additional locations of the Training Organisation
    - the Accountable Manager
    - any of the persons referred to in Part ATCO.OR (such as Training Instructors, Training Officers)
    - the training organisation’s documentation on safety policy and procedures
    - the facilities
- the procedure describing how changes not requiring prior approval are managed and notified to the CA

[201] AR ATCO.OR.B.015.
[202] AR ATCO.AR.E.010(c).

The approved procedure defining changes requiring prior approval is usually part of the quality manual and is sometimes presented as a sort of matrix in which each row represents a type of changes and the columns contain information such as the description of the change, the need of approval by the CA, the articles of the AR which the change is related to.

Most of changes requiring prior approval are related to the unit training plans and unit competence schemes, which include the validity of the endorsements, the processes and the procedures for the examinations of theoretical knowledge and/or the assessment of practical skills, the duration of the trainings, the training personnel qualifications, roles, and responsibilities.

9. The criteria of the Risk-Based Oversight

“Perfection is achieved, not when there is nothing more to add,
but when there is nothing left to take away.”
Antoine de Saint-Exupéry, Airman's Odyssey

9.0 Content of Chapter 9

This chapter presents the models, the methods, and the criteria of the RBO for both the review decision phase and the auditing one of the Oversight process.

Paragraph 9.1 briefly presents the content of the ICAO’s guidelines for the safety risk management of changes.

Paragraph 9.2 deals with the found criteria for the review decision phase, the presentation of the proposed model, its validation and verification, and the use of an additional statistical method in support to the experts’ judgement.

Paragraph 9.3 introduces the challenge of developing a risk-based model for the planification of the auditing inspections of the On-Going Oversight activities.

9.1 ICAO's considerations about the Safety Risk Management

According to ICAO[203], the management of safety risks resulting from change should take into account the following three considerations:

a) criticality of system and activities
Criticality relates to the potential consequences of safety risk, as during a systemic change. Changes to equipment and activities associated with relatively high safety risks should be reviewed to make sure that necessary corrective actions can be taken to control potentially emerging safety risks.

b) stability of system and operational environment
Planned changes may be associated with organisational growth or contraction, as well as the introduction of new equipment, products or services. Unplanned changes[204], including those that are operational, political or economic in nature, may also create risks that require a mitigating response by the Organisation. Instances in which frequent systemic or environmental changes occur dictate that managers update key risk assessments and related information more frequently than in more stable situations.

c) past performance of critical systems
Past performance of critical systems may be a reliable indicator of future performance. Trend analyses in the safety assurance process should be employed to track safety performance measures over time and to factor this information into the planning of future activities under situations of change. Moreover, where deficiencies have been found and corrected as a result of past audits, evaluations, data analyses, investigations or reports, it is essential that such information is considered to assure the effectiveness of corrective actions.

The management of the change is at first at the level of the Organisation, but its Oversight is at the level of the CA. In the following paragraphs it is explained how these three considerations by ICAO are taken into account by the FS.4.1 Section while performing the RBO. In particular, it is shown how these considerations are reflected in the criteria used in two phases of the RBO process: criteria for the review decision phase are presented in Paragraph 9.1 and the ones for the planning of the inspections of the auditing phase in Paragraph 9.3.

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203 This is a reference to [21], Paragragh 2.8 about Change Management, whose content is partially reproduced and discussed in this Paragraph.

204 EASA, and CAs in general, has nothing to deal with unplanned changes, except for the checking of the existence of contingency plans. For example, Paragraph ATM/ANS.OR.A.070 in Annex III of Reg. 2017/373 and Paragraph 8.2 in Annex I of 1035/2011 refer to contingency plans stating that: a service provider shall have in place contingency plans for all the services it provides in the case of events which result in significant degradation or interruption of its operations. Planned changes are instead the scope of the review decision phase of the Oversight process.

9.2 The criteria for the review decision phase

Basically, the NR-IR generally suggests that the criteria for the review decision are a combination of the following characteristics of a change:

- severity and of possible consequences
- likelihood complexity or unfamiliarity
- other

The severity of possible consequences mentioned by the NR-IR can be linked to the criticality of system and activities mentioned by ICAO.
A change to a functional system, but also the system itself or an activity, can have different levels of criticality.
The severity class of a change[205] is an indicator of the criticality and it is also known that some ANSPs' activities and services are more critical than others, due to their immediate proximity to the operational environment. For example, the more an activity is close to the operation of an aircraft, the more the effect of a hazard related to that activity is critical, as the most probable effect of such hazard in the worst-case scenario is likely to lead to an accident; on the opposite situation, the more an activity is far from the operation of an aircraft, the more mitigation barriers can intervene preventing the hazard from resulting into a harmful effect. [206]

One criterion which is at the very heart of a review decision is, of course, the criticality of the change, in relation with the criticality of the parts of the system involved.
Functional systems are defined as a combination of procedures, human resources and equipment, including hardware and software, organised to perform a function within the context of ATM/ANS and other ATM network functions. Therefore, it shall be assessed the level of criticality of the procedures, of the human resources and of the equipment.

The CA and the Organisation may agree on which elements are considered critical a-priori.

- for procedures, this could be the case of those affecting the process to produce safety arguments
- for human resources, generally, it could be the case of the key-personnel
- for the equipment, there cannot be a general criterion, as it deeply depends on the service provided

Changes which involve critical elements of a functional system, without being defined as critical a-priori, should anyway be easily identified through a proper risk-based approach since their relevance cannot go unnoticed.
Hence, even if it is left to the Organisation together with the CA whether or not to define which elements can be considered as safety critical a-priori, there is no need to do it with a proper set of criteria.

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[205] Here it is made a reference to the severity classification scheme of the CR-IR.
[206] Please note the similarity with the examples given in Paragraph 9.3 when dealing with "the specific nature of the Organisation" parameter for the evaluation of an Organisation's Risk Profile. As thinly indicated in the Paragraph 3.4 introduction, it is logical that the criteria of the review phase find some connections with the ones of the planning of the inspection of the auditing phase, since both phases belong to the RBO process.

9.2.1 The proposal for review criteria

The proposal consists of a list of Review Criteria, together with a simple scoring system, which help to determine the need for reviewing a notified change to a functional system.
In order to take the review decision, all Review Criteria shall be evaluated and given a score.
For each Review Criterion it shall be assigned the proper level amongst three possible Review Criterion Levels.
Each Review Criterion level is associated with a Review Criterion level score, which is a single integer number from a minimum of 0 to a maximum of 2.
So, each Review Criterion contributes to the Total Score with its own Review Criterion Score.
The Total Score, in fact, is simply obtained summing all the Review Criteria Scores.
The decision to review or not a notified change could be taken depending on the Total Score.

Naturally, the more a change is relevant and safety-critical, the more criteria are likely to be triggered and the Total Score to be high, and, hence, the change to be reviewed.

Table 9.2-1 shows an example of the proposed method.

Review Criterion	level and associated score		assigned level	Review Criterion score
example 1	Level 1	2		1
	Level 2	1	X	
	Level 3	0		
example 2	Level 1	2	X	2
	Level 2	1		
	Level 3	0		
example n	Level 1	2		0
	Level 2	1		
	Level 3	0	X	

Total Score	**3**

Table 9.2-1 example of application of the Review Criteria and calculation of the Total Score

Table 9.2-2 lists the Review Criteria for changes to the functional systems.
As shown in Table 9.2-2, each Criterion has:

- an identification number
- a descriptive name
- 3 possible levels, each one corresponding to a Review Criterion level
- 3 possible scores, each one related to the corresponding class

REVIEW CRITERION		**LEVEL**	
number	descriptive name	level	score
1	severity of the potential hazard effects	high	2
		medium	1
		low	0
2	novelty and relevance of previous feedbacks	high	2
		medium	1
		low	0
3	scope (extent and complexity)	large	2
		medium	1
		small	0
4	impact on the architecture	major	2
		minor	1
		none	0
5	impact on the operational procedures and processes	major	2
		minor	1
		none	0
6	impact on the performances	major	2
		minor	1
		none	0
7	impact on the human resources	major	2
		minor	1
		none	0

Table 9.2-2 the Review Criteria

In the following, each Review Criterion is explained in detail.

9.2.1.1 Criterion 1: severity of the potential hazard effects

This Criterion takes into account the severity of effects of the potential hazards, according to the severity classification scheme used by the ANSP.

The three possible levels proposed for this Criterion are:

- high
- medium
- low

The overall severity assessment declared by the oversighted Organisation could be taken as the input triggering the respective Criterion Review Level.
For the time being, the CR-IR severity classification scheme is in force[207], so that the three possible levels could be assigned as in the example of Table 9.2-3:

LEVEL		severity of the potential hazard effects
name	score	
high	2	• overall severity assessment class 3
medium	1	• overall severity assessment class 4
low	0	• overall severity assessment class 5

Table 9.2-3 example of characteristics triggering different Review Criterion 1 levels (CR-IR)

In the future, when the NR-IR will be effective, different Organisations may use different classification schemes, so that the number of the possible severity assessment classes could be higher than the number of Criterion levels, which for simplicity should remain fixed at three. In this case, the possible severity assessment classes used by the Organisation should be clustered in just three groups in a reasonably conservative way. For instance, supposing an Organisation is making use of five possible severity assessment classes, named A, B, C, D, and E, they could be clustered as shown in the example of Table 9.2-4:

LEVEL		severity of the potential hazard effects
name	score	
high	2	• overall severity assessment class A or B
medium	1	• overall severity assessment class C or D
low	0	• overall severity assessment class E

Table 9.2-4 example of characteristics triggering different Review Criterion 1 levels (NR-IR)

[207] as shown in Table 2.3 1.

9.2.1.2 Criterion 2: novelty and relevance of previous feedbacks

This Criterion takes into account the amount of novelty brought to the Organisation by the change. In other words, this Criterion is related to the familiarity of the Organisation with the change being introduced: the more the Organisation is familiar with the change, the less the change is considered a novelty for the Organisation, and vice versa.

The three possible levels proposed for this Criterion are:

- high
- medium
- low

The novelty of a change is *high* when it is a pure novelty to the Organisation. This means that the Organisation is not familiar with it, because nothing similar has ever been implemented in the past. Typically, this is the case of changes introducing a new hazard to the system, because of a new technology or a new function being introduced. [208]

On the contrary, the novelty of a change is *low* when the Organisation is familiar with the type of change being introduced. This can be assessed when similar changes of the same kind have already been notified, recorded, and implemented in the past and no negative feedbacks have been raised in the most recent ones.

The novelty of a change is *medium* in the in-between cases. This means that very few similar changes were implemented in the past and eventually some relevant feedbacks have been recorded.

The relevance of the feedbacks from previous similar changes, if any, constitutes an indicator of the Organisation's past performance. Hence, if some negative feedbacks were raised while implementing similar changes in the past or if past mitigation actions did not show the expected mitigation performances, the CA may consider that the Organisation has not developed a full familiarity with the types of changes being implemented.
Eventually, changes may be introduced as required mitigation actions in reply to the conditions imposed by the CA to close open raised findings. Such changes associated to negative feedbacks are surely more likely to be reviewed than changes bringing no relevant feedback with themselves.

For example, replacements and repairs are not considered as proper changes, as they are part of standard corrective (or preventive) maintenance activities to correct defects or enhance/improve system capabilities without introducing changes in safety risks. Similarly, bug fixes are changes which do not introduce anything new, but are made in order to recover the intended planned function of a system. Hence, those kinds of "changes" are usually just notified and the review is considered not even applicable.

Sometimes changes involve Commercial-off-the-shelf (COTS) software and services upgrading. COTS are usually built and delivered from a third party and subcontractors having experience in a specific field of application. Hence, when introducing a COTS in the functional systems of an

[208] When a new hazard is introduced, it may be the case of reviewing how it has been identified, evaluated, mitigated, and recorded

Organisation, the Organisation inherits the risks brought by the COTS component. If the COTS software contains severe security vulnerabilities it can introduce significant risk into an Organization's functional system. Anyway, this is generally not the case, as the functional systems of the ATM/ANS Organisations are usually complex and can be seen as systems of systems; in these cases, a COTS is integrated or networked with other software products and the redundancy and variety grants that the risks are limited. Furthermore, the introduction of COTS software in a functional system is never made all at once, but gradually and usually after a test-phase in specific segregated facilities, in order to grant initial separation from the operational environment.

Some changes involve the restructuring/refactoring of a software, which means that the system provides the same external function through a software which is being internally modified, without involving a full rebuilt. So, basically, those changes are related to the factoring without changing the external behaviour.
Refactoring applies a series of small re-factorings, each of which does not modify its conformance to functional requirements.
If done properly, code refactoring may also resolve hidden or dormant bugs or vulnerabilities in the system by simplifying the underlying logic and eliminating unnecessary levels of complexity.
If done improperly, it may fail the requirement that external functionality not be changed and/or introduce new bugs.

Some other changes are, instead, more complex and may require a remarkable migration strategy involving new training. Typically, procedures require that the migration initiate only once a pilot-phase has demonstrated that the functions are usable and customers have implemented associated changes to their local systems. If some new function or technology is involved, this generally implies the creation of new processes and procedures, and sometimes also new training for the personnel.
As usual, whenever a new hazard is introduced, it may be the case of reviewing how it has been identified, evaluated, mitigated, and recorded.

Table 9.2-5 lists some types of changes triggering the three possible levels:

LEVEL		**novelty and relevance of previous feedbacks**
name	score	
high	2	• introducing new functions • implementing new technologies • in case of relevant negative open findings concerning past mitigation actions not showing the expected mitigation performances
medium	1	• restructuring/refactoring software • operational activation • in case of relevant closed findings concerning past mitigation actions not showing the expected mitigation performances
low	0	• replacements/repairs/bug-fixes • COTS upgrading • restructuring/refactoring software • in case of no relevant feedbacks

Table 9.2-5 example of characteristics triggering different Review Criterion 2 levels

9.2.1.3 Criterion 3: scope (extent and complexity)

This Criterion takes into account the scope of a change, in terms of extent and complexity.

The three possible levels proposed for this Criterion are:

- large
- medium
- small

Knowing the Organisation's functional system in detail, it is possible to assess the scope of a change.

The scope of a change is *large* when the change is at system level, encompassing many sub-layers/interfaces, reaching the operational environment, which may be represented by the users.
Some changes, like major system releases, have a very broad one and are generally complex to implement.

The scope of a change is *medium* when the change involves and encompasses some high-level layers/interfaces, but not the operational environment or the users' layer.

The scope of a change is *small* when the change is at local at sub-system level, they are isolated, encapsulated in and limited to sub-systems. This means that they do not impact on the system interfaces.
Some changes, like minor software/hardware adjustments, have a very limited scope and are generally simple to implement.

Table 9.2-6 lists some characteristics triggering the three possible levels:

LEVEL		scope (extent and complexity)
name	score	
large	2	• at system level • encompassing many system interfaces • involving the utmost layer (users, operational environment)
medium	1	• at sub-system level • encompassing few system interfaces • not involving the utmost layer (users, operational environment)
small	0	• within a sub-system • not encompassing any system interface • not involving the utmost layer (users, operational environment)

Table 9.2-6 example of characteristics triggering different Review Criterion 3 levels

9.2.1.4 Criterion 4: impact on the architecture

This Criterion takes into account the impact of a change on the architecture of an Organisation's functional system.

The three possible levels proposed for this Criterion are:

- major
- minor
- none

This criterion mainly concerns the hardware structure of a functional system.

The impact on the architecture is *major* when the functional system is affected design-wide.
This is the typical case of major system releases, involving modifications of hardware and software at different layers, and also having a large scope.

The impact on the architecture is *minor* when the system's architecture is affected partially.
This may be the case of the introduction of a new function requiring the development of a new system – and all the necessary links to it – within the existing architecture, or the fusion of more parts of the system, each one doing one different function, into one single part integrating all the single functions. Sometimes changes concern the introduction/reintroduction/dismantlement of a facility within a network, hence, not the whole architecture is involved, but just part of it.

The impact on the architecture is *none* when there is no impact on the system architecture.
Some changes do not involve any modification to the system hardware, such as those only involving the software or the procedures.

Table 9.2-7 lists some characteristics triggering the three possible levels:

LEVEL		**impact on the architecture**
name	score	
major	2	• design-wide
minor	1	• partially • introduction/reintroduction/dismantlement of a facility
none	0	• no changes to the hardware

Table 9.2-7 example of characteristics triggering different Review Criterion 4 levels

9.2.1.5 Criterion 5: impact on the operational procedures and processes

This Criterion takes into account the impact of a change on the operational procedures and processes of an Organisation's functional system.

The three possible levels proposed for this Criterion are:

- major
- minor
- none

The impact on the procedures is *major* when new operational processes and/or procedures are introduced.

The impact on the procedures is *minor* when existing operational processes and/or procedures are modified.

The impact on the procedures is *none* when no operational procedures are modified or introduced together with the change.

Table 9.2-8 lists some characteristics triggering the three possible levels:

LEVEL		**impact on the operational procedures and processes**
name	score	
major	2	• introduction of new operational procedures and/or processes
minor	1	• modification of existing operational procedures or processes
none	0	• no changes to the existing operational procedures or processes

Table 9.2-8 example of characteristics triggering different Review Criterion 5 levels

9.2.1.6 Criterion 6: impact on the performances

This Criterion takes into account the impact of a change on the performances of the ANSP.
Generally, Organisations to their best to improve the functions related to the service provision on the long term, but right during the implementation of a change, hence on the short term, the performances may sometimes be affected qualitatively and/or quantitatively.

The three possible levels proposed for this Criterion are:

- major
- minor
- none

The impact is *major* when the implementation of the change cannot avoid the possibility of a loss of availability of the service, or a negative effect on the integrity and/or the reliability of the performances for a certain period of time. For example, it sometimes happens that tests or trials have to be performed right in the operational environment, so that some services may not be available while the tests are running. In some particular cases, the hazard analysis may not exclude the temporary possibility of a complete outage or loss of the service, and, of course, the CA shall check that all the proper and possible mitigation actions have been considered.
A possible temporary loss of monitoring and control may also affect the integrity of the system, since integrity includes the ability of the system itself to timely detect failures and provide warnings preventing its use under abnormal or unprotected conditions.

The impact is *minor* when the implementation of the change may not affect the performances in terms of availability or integrity, but of continuity, or when it implies a loss of redundancy in the functional system parts.
Sometimes, the temporary or definitive unavailability of a facility, due to special manutention or dismantlement, may affect the provision of the service in terms of loss of redundancy. For example, the removal of a ground station may remotely affect the GPS signal requirements in terms of accuracy or decrease the probability that the optimal system performance is maintained over time.

The impact is *none* when the change has no impact on the service performances.

Table 9.2-9 lists some characteristics triggering the three possible levels:

LEVEL		impact on the performances
name	score	
major	2	• possibly causing a temporary loss of availability or a complete outage of the service • possibly affecting the integrity of the service • possibly causing a loss of monitoring and control • possibly causing failure to alarm or false alarm
minor	1	• possibly affecting the continuity of the service • possibly causing a loss of redundancy
none	0	• not affecting the service provision in terms of accuracy, availability, reliability, or integrity • not affecting the fault detection means

Table 9.2-9 example of characteristics triggering different Review Criterion 6 levels

9.2.1.7 Criterion 7: impact on the human resources

This Criterion takes into account the impact of a change on the human resources of the Organisation.

The three possible levels proposed for this Criterion are:

- major
- minor
- none

The impact is *major* if the change involves key personnel or requires new training to the standard personnel.
Key personnel are those people essential to carrying out the Organisation's functions, having many high responsibilities and covering unique roles, such as managers, directors, chief officers, or supervisors of operations, maintenance, finance, and training.

Here is a non-exhaustive list of some key roles and responsibilities:

- Safety and Security Manager (responsible for the correct implementation of the SMM)
- Technical Manager (responsible for all technical activities)
- OPS Manager (responsible for all operational activities and future operations)
- OJTI and OJT Assessors (responsible for the ATCOs training and licencing)

Some changes involving the introduction of complete new functions may also require the personnel to be prepared to the new system by means of fresh new training.

The impact is *minor* if the change only involves standard personnel.
Standard personnel are those who can be replaced or substituted by people having their same qualifications, which are generally not unique in the Organisation.
For example, a change involving a reduction of personnel, due to a fusion of functions or roles, may have an impact on the workload of the ordinary staff personnel, but without any particular need for training.

The impact is *none* if the change does not affect the personnel and does not require new training.

Table 9.2-10 lists some characteristics triggering the three possible levels:

LEVEL		**impact on the human resources**
name	score	
major	2	• affecting key personnel • requiring new training
minor	1	• affecting standard personnel only
none	0	• not requiring new training • not affecting the human resources

Table 9.2-10 example of characteristics triggering different Review Criterion 7 levels

9.2.2 Verification of the Review Criteria method

In order to give consistency to the work already done by the AAEs and to promote continuity with it, the review decisions taken using the proposed Review Criteria should reflect as much as possible the already taken review decisions. [209]

According to the proposed model, the decision should be taken depending on the value of the Total Score. Table 9.2-11 presents the intervals to be taken as reference for the Total Score (TS):

decision	Total Score
likely not to be reviewed	$0 \leq TS \leq 4$
likely to be reviewed with a limited scope (simple LoI)	$5 \leq TS \leq 8$
likely to be reviewed with a complex scope (complex LoI)	$9 \leq TS \leq 14$

Table 9.2-11 the reference intervals for the Total Score

The values chosen to define the three possible intervals for the Total Score presented in Table 9.2-11 are the ones which maximize the matching with the decisions already taken by the AAEs. [210]

As the criteria are developed for changes to a functional system, trying to extend their application to the Training Organisations – which do not have a functional system – does not bring any result. For this reason, the Training Organisation are excluded from the applicability of the method. [211]
Table 9.2-12 presents the comparison between the decisions already taken by the AAEs (columns AAE) and the ones obtained with the proposed Review Criteria method (columns RC) for the three Organisations having a functional system presented in the previous chapters: [212]

	NM			EAD			ESSP		
decisions	**AAE**	**RC**	**mism.**	**AAE**	**RC**	**mism.**	**AAE**	**RC**	**mism.**
no review	42	42	0	2	2	0	33	34	1
review (simple LoI)	12	12	0	1	1	0	14	14	1
review (complex LoI)	10	10	0	1	1	0	5	4	1

Table 9.2-12 the best matching between the already taken decisions and those based on the proposed model

The best match achievable with this proposed method is obtained with the intervals of Table 9.2-11, which limit the mismatching at just 2 cases out of 120 (less than 2%). [213]

[209] The reasons behind are discussed in Paragraph 9.2.3.
[210] Choosing different intervals would increase the number of mismatching decisions.
[211] As explained in Paragraph 8.1, changes to the Training Organisations are under a different regulation, which makes no mention of the functional systems and only makes a clear distinction between changes requiring prior approval and changes not requiring it.
[212] The total number of notified changes presented in Table 4.1 1 differs from the total number of decisions taken presented in this table in the case of the NM, since in four cases the reviews were mandatorily required by the Regulation, being the changes of Severity Level 2.
[213] The column of ESSP's mismatches (mism.) shows, in fact, two cases in little discordance with the decisions taken. Such exceptional cases are not discussed, since the method here presented aims at being general and, hence, admits few exceptions. Just for the record, the discrepancy in both cases is of a single unit value.

9.2.3 Absolute Expert Judgement and additional considerations over the method

The method of the Review Criteria has been verified against the decisions already taken by the AAEs not because it is assumed that all the all the review decisions taken in the past were necessarily the right ones, but just for the need of finding the best “first guess” for the Total Score intervals.

First of all, it has turned out to be impossible to develop a simple method which gives the exact same outputs of the AAEs decision process, because the aim is not only to consolidate and to give a first standardisation of what has been done in the past up to now, but also to add something new to it.
Furthermore, being the review decision a human activity, it depends on the involved AAE, so that some variability is allowed.

Such variability is limited by the EASA procedure which prevents the review decision team to be composed of a single AAE only. Anyway, being the FS.4.1 human resources very limited, the teams are usually composed of just a couple of experts, one TL and one TM, so that the limiting factor is only the high level of expertise of the AAEs, which is mathematically unquantifiable.
Consequently, there is no scientific evidence to assume the correctness of every decision taken in the past. Hence, the method should not be verified just on the basis of what was achieved in the past, to be valid.

For the time being, the number of Organisations under the EASA FS.4.1 Section is still limited. But in the future, eventually, this number will grow to the point that an improved Risk-Based Approach will be needed to ensure that the allocation of resources is proportional to the risk posed by the proposed changes. As a consequence, the panorama of the oversighted Organisation is expected to become wider and methods and procedures should be enhanced accordingly.

To further validate the Review Criteria and provide data for their future evolutions, some methods used for the Group Absolute Probability Judgment (Group APJ) may be helpful. [214]
Those methods can be applied when the data on human errors are very few or hard to estimate, while there is availability of a certain group of human experts. Even if they still depend on the judgement of the individuals, those Group APJ methods give a numerical measure of the level of consistency of the group of experts, which can be taken as an indicator of how much the experts are standardised amongst themselves.

Furthermore, the Review Criteria method together with a Group APJ one could be used more than once during a single review decision, in order to monitor how the coherency of the group of experts evolves during the decision process.

[214] The methods briefly discussed in this paragraph are presented in [24] and more detailed procedures can be found in [25].

Regardless the method chosen, the APJ methods basically comprise the following steps, here adapted for the Review Criteria method:

1. selection of the experts
   in this case a group of AAEs of the FS.4.1 Section made of at least 2 experts; the best is an odd number greater than 2
2. mission identification and related procedure
   the mission is to let every AAE elaborate his/her own decision of reviewing or not a change to a functional system with the Review Criteria method and, hence, providing a personal Total Score, and then to combine the scores
3. preparation of the answers' format
   these are the Review Criteria themselves and their Score
4. gathering of the individual result
   each AAE bring his/her own Total Score and related decision
5. evaluation of the inter-rater reliability (also called inter-judge consistency)
   a simple analysis of variance can be applied to evaluate statistical quantities
6. final outcome
   one outcome is, of course, the decision and another one could be an indicator of the inter-judge consistency, both as on quantified values

9.2.4 The Fleiss' kappa method

In order to provide an example of a statistical measure for assessing the reliability of agreement amongst a group of experts, it is here introduced the Fleiss' kappa method.

Fleiss' kappa is a method providing a statistical measure of inter-rater reliability and works for any number of raters giving categorical ratings to a fixed number of subjects.
In this case, the n raters are represented by the review team of AAEs, the categories are the three possible Review Criterion level scores (0 or 1 or 2), and the subjects are the seven Review Criteria.

Table 9.2-13 introduces the mathematical model for the adaptation of the Fleiss' kappa method to the Review Criteria.

Fleiss' variables names	Review Criteria variables names	variable	value	index
raters	AAEs	n	3	-
subjects	criteria	N	7	$\mathrm{i} = 1, \dots, \mathrm{N}$
categories	Review Criterion scores	k	3	$\mathrm{j} = 1, \dots, \mathrm{k}$

Table 9.2-13 Fleiss' kappa adaptation to the Review Criteria

According to the Fleiss' kappa method, the agreement can be interpreted as expressing the extent to which the observed amount of agreement among raters exceeds what would be expected if all raters made their ratings completely randomly.

Given that $\overline{\mathrm{P}}$ is the degree of agreement achieved and $\overline{\mathrm{P}}_{\mathrm{e}}$ is the one attainable by chance, the kappa is defined as:

$$\kappa = \frac{\overline{\mathrm{P}} - \overline{\mathrm{P}}_{\mathrm{e}}}{1 - \overline{\mathrm{P}}_{\mathrm{e}}}$$

where $(\overline{\mathrm{P}} - \overline{\mathrm{P}}_{\mathrm{e}})$ is the degree of agreement actually achieved above chance and $(1 - \overline{\mathrm{P}}_{\mathrm{e}})$ is the one that is attainable above chance. [215]
So, if kappa is the unit, then there is complete agreement, whereas, if it is not positive, then it means that there is no agreement other than the one expected by chance. If kappa has a value in-between the mentioned cases, it can only be said that the agreement is not complete, since there is not a universally accepted reference table for its interpretation.

For what concerns this Thesis, the proposal is to make use of the Review Criteria together with a statistical method for the Group APJ, to quantitatively assess the level of agreement of the AAEs during the review process.

[215] The equations and some examples are shown in Appendix G.

9.2.5 Advanced Absolute Expert Judgement

As previously mentioned, ideally, the review decision should be taken only after that the final outcome has proved to be the same with a 100% value of agreement amongst the AAEs team.
In case the outcome of the Fleiss' kappa is not the unity, there is a certain amount of disagreement amongst the raters which should be amended.

To do so, it is possible to proceed in two ways according with the available resources.

If no other experts are available, one way consists in the raters discussing amongst themselves on the subjects where there is no perfect agreement and reiterate the method until the unanimity is reached. Although simple, this may result in arising friction between the involved parts, since it forces the Experts to reach a point of unanimous convergence allowing the decision to be taken.

The other way, without forcing the unanimous convergence, requires additional resources, is to increase the number of raters in order to decrease the weight of every rater. So, for example, if the number of experts gets increased from 3 to 5, each opinion weights one fifth instead of one third and it should be possible to increase the value of kappa.
This second way assumes that involving more experts increases the reliability instead of decreasing it, but this assumption cannot be taken for granted and, thus, it may result in the undesired (and very unlikely) scenario which requires the method to be iterated again. [216]

[216] Examples are shown in Appendix G.d.

9.3 The criteria for the auditing phase of the RBO

The objective of the RBO is to allocate the CA's resources in proportion to the need required by the risk, in order to maximise the efficiency and the focus of the planned inspections.

As changes are introduced by the Organisations, hence the risk varies over time; as a consequence, the Oversight activities, such as the focused inspections, should not be planned on fixed time intervals, but on time intervals which vary accordingly with the risk the CA assesses.

The prioritisation of the activities faces the same challenge encountered in the research of the Review Criteria: to compare amongst themselves Organisations having hugely different characteristics, such as the different services provided, or the dimensions, or the proximity to the AIR OPS.

In order to assess the priority, the Organisations are evaluated taking the following two parameters into account: [217]

1. the Organisation's **risk profile**
   this is a quasi-static indicator and depends on the specific nature of the Organisation, which is related to the complexity of and the risk stemming from the activities carried out by the Organisation, and usually remains the same for long period of time
2. the Organisation's Safety **performance evaluation**
   this is a dynamic indicator and depends on how effective the Organisation is in performing its activities, in terms on performance of the Safety Management despite the nature of the activities themselves

Figure 9.3-1 shows how these parameters concur to the creation of a risk-based approach for the On-Going phase of the Oversight process and are explained with more detail in the next subparagraphs.

Those parameters are fundamental to the RBO, because the planning of the Oversight activities shall be driven by the combination of risk profile and safety performance and their execution shall focus on the management of risk, besides ensuring compliance.

This should allow for an optimisation of the Oversight, increasing its effectiveness and being more intensive for Organisations having a high-risk profile or less performing or sustaining major management changes.

In a nutshell, it may happen that an Organisation having a long term low profile is performing so badly that requires more attention than another Organisation having a long term high risk profile, but which is performing well.

[217] The definition of these parameters for the RBO can be found in [17]. The interpretation of these parameters has slightly changed over time and here it is presented as it has been adapted to the ATM/ANS domain by FS.4.1 Section.

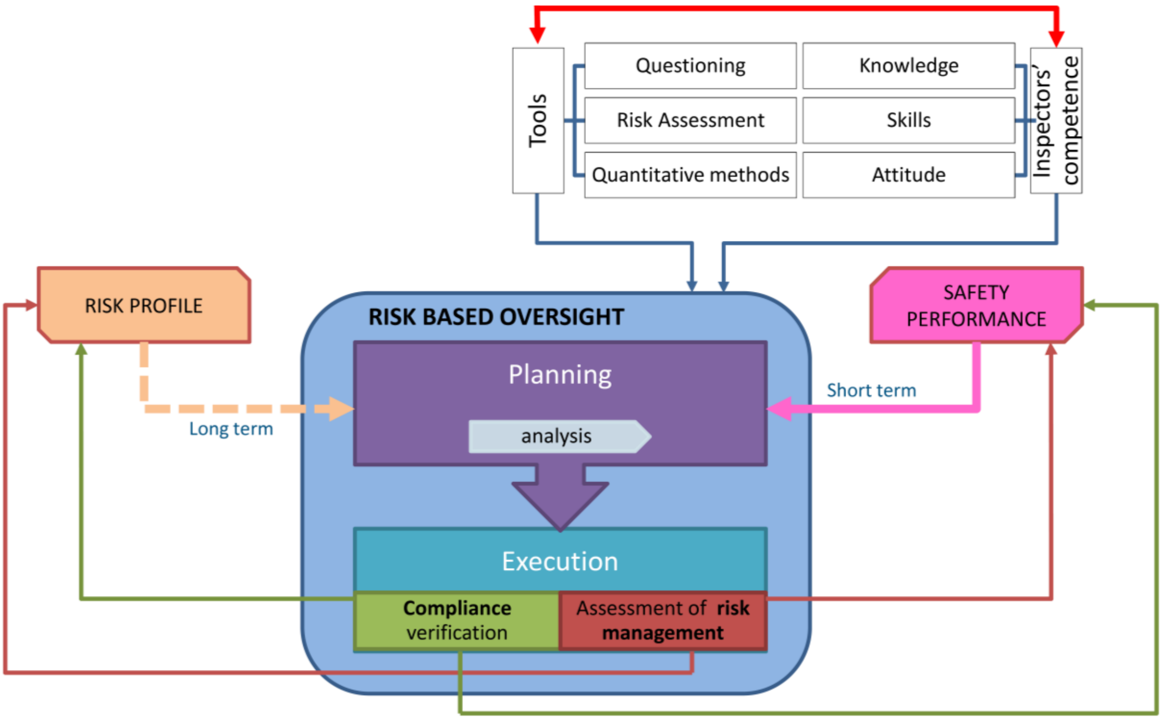

Figure 9.3-1 the model for the On-Going RBO

The creation of this model for the planning and the execution of the Oversight activities is still under development and will constitute one of the pillars allowing EASA to make a further step from the CBO to the RBO, with a risk-based prioritisation of the activities.

9.3.1 The Organisation’s risk profile

Before initial certification and preparation of the first Oversight Programme, the Organisation should be risk-profiled.

After initial evaluation, the risk profile assessment is to be reviewed in the case of the introduction of significant organisational changes or changes to the functional system.

The Organisation’s risk profile takes into account following indicators:

- the specific nature of the Organisation, given:
    - the most critical service provided
    - the types of services provided
- the complexity of the Organisation’s activities, considering:
    - the size/complexity of operations
    - the workforce (number of staff members and their workload)
    - the number of subcontractors (which might impact safety of services)
    - the number of sites
    - the number of costumers
    - the stability of the functional system
    - the maturity of the Organisation
- the operational risks:
    - the top risk severity, e.g. top hazard effect declared in the Safety Case
    - the exposure index, e.g.:
        - for TWR: number of airport operations / total EU operations
        - for ENR: number of flight hours FIRs when services are provided / total EU flight hours
        - for ITO: consider which EU ANSP the licenced students ATCO work at

The interpretation given in this model to the first parameter takes into account static-like data, such as the severity of the most critical risk, which depends on the nature of the Organisation involved and is really unlikely to change over time.

Most information necessary for the estimation of the risk profile should be available from the Organisation exposition, but for certain indicators (e.g. "the stability of the functional system", "the maturity of the Organisation"), initial evaluation might lack sufficient information; in that case it is recommended to consider the most conservative value or to involve a team of experts to evaluate a metric by means of experts’ judgment.

9.3.2 The Organisation's safety performance

The Organisation's safety performance takes into account following indicators:

- the reactivity
- the maturity of MS/SMS (expert judgement)
- the maturity of Change Management Process (expert judgement)
- the maturity of occurrence reporting (expert judgement)

The reactivity is estimated according to the corrective action plans for the findings being delayed with respect to the agreed dates. There are three possible levels:

- on time
- rarely late
- often late

The other four indicators are instead evaluated as:

- present: if clearly visible and documented in the Organisation's (S)MS
- operating: if the evidence of full general application of the procedures is available (output)
- effective: if there is evidence that the desired outcome is being achieved (outcome)

This second parameter, instead, is supposed to frequently change over time depending on the actual performance of the Organisation and most of it is determined by means of expert judgment.

9.3.3 Challenges within the model for the RBO

The creation of this model began in the July of 2015 and the documents containing the guidelines for the creation of this model are reviewed periodically as part of the EASA's continuous improvement process.
The aim is the creation of a simple tool in support of the planification of the inspections.
The requirements for the Review Criteria[218] have been given to this model too, and the challenges are similar to the ones encountered in the creation of the Review Criteria method.

First of all, the validation of the model itself is critical: since the only first guess for its validation is to have outcomes reflecting the expectation of the experts, which are based on the past experience, it is hard to understand if unexpected outcomes indicate that something is wrong with the model or with the planification of the activities.

In addition, a simple evidence-based mathematical model which makes use of just a few parameters that represent fragmentary information should be very unlikely to catch the subtlety within the complexity of the Organisations providing ATM/ANS services.
This does not mean that a model cannot be created, but suggests that the requirement for simplicity should be removed to give room to a model complex enough to reflect the complexity of the Organisations involved.

Dealing with Organisations having very different nature is, in fact, the most important peculiarity that makes this task a tough one.
If a parameter is common between two different Organisations, it can clarify clarifying which one of the two is the more complex and, hence, with a higher risk profile; for example, two Organisations providing CNS services may have different complexity on the basis of the number of sites they control.
Even if there is no mathematical evidence that a higher number of sites immediately translates into a higher risk profile, but the human common sense, the problem is that the model is forced to combine common parameters for Organisation being completely different amongst themselves.
So that the number of sites of an Organisation dealing with CNS has to be compared with the sites of an ITO Organisation or an ATS provider.
Giving the parameters a modified weight based on the combination with the type of services the Organisation provides is not at all a simple solution and requires additional expert judgment.

Despite the number of parameters that may be taken into account, the expert judgement will always remain paramount to this model, as it is the interpretation of the combination of several modifications to the parameters within the indicators to determine a change in the risk profile or in the safety performance.
The values of the parameters within the indicators have little meaning by themselves.
It is their interpretation that transforms data into meaningful information.
For example, a variation in the number of subcontractors may increase or decrease an Organisation's risk profile depending on the subcontractors involved and the feedbacks on their past performance; similarly a variation in the number of the personnel cannot be immediately translated in a variation of the risk-profile or of the Organisation's performance, since it should be evaluated in combination of the reasons behind the variation, the variation of the functions in the scope, the variation of the workload, of the competences, and of the responsibilities of the personnel, and so on.

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[218] Presented in Subparagraph 3.4.2.

The safety performance involves sub-parameters whose expert judgment estimation is mainly based on the following objective data:[219]

- past audits, investigations, shared data collections, mandatory and voluntary reports
- existing findings (and corrective action plans) as resulting of the oversight activities
- planned execution of other EASA oversight activities (e.g., Oversight audits)
- limitations and conditions raised in the EASA acceptance of previous changes

As a result, the creation of a model for the planification of RBO activities has proved to be a long journey, since it has to deal with the following problems:

- the choice, amongst the relative huge amount of objective data, of the significant parameters
- the fact that, despite all the available data, some sub-parameters need to be defined by means of expert judgment and, hence, subjectively depend on the group of experts involved, instead of being justified by statistical methods
- the way of measuring and combining parameters which are shared amongst Organisations providing different types of services
- the way of measuring, weighting and comparing parameters which are not commonly amongst Organisations providing different types of services

Very much was done in the past to decrease the accident rate, but to ensure that this rate continues to decline it is necessary to foster the creation of models like the ones presented in this Thesis, to take the step from the CBO to the RBO.

[219] As required by the New Regulation 2017/373 ATM/ANS.AR.C.001 Monitoring of safety performance (b): The CAs shall use the results of the monitoring of safety performance in particular within their risk-based oversight.

10. Conclusions

"Change is the law of life.
And those who look only to the past or present are certain to miss the future."
John Fitzgerald "Jack" Kennedy, 35th President of the United States

10.0 Content of Chapter 10

This ending chapter summarises the conclusions of the research including the limitations of the study, its implications, and some recommendations for its practical application.

10.1 Limitations, implications, and recommendations

The scope of the research is limited to the changes to the functional systems of the Organisations under the EASA FS.4.1 Standardisation & Oversight section.
It is not possible to extend their application to the changes to the Training Organisations, since they have no functional systems.

The found Review Criteria respects the all the desired requirements of granularity, completeness, generality, and simplicity, and represent the pillars which the review decisions of the AAEs are taken on. Being the research based on all the review decision taken by the FS.4.1 Section since its origins, the Review Criteria constitute a consolidation of the lesson learnt and the first attempt to the standardisation of a risk-based approach.

Some review decisions have been triggered by aspects which are not covered by the UG44 (the User Guide of the FS.4.1 Section), which just gives an idea of the review process throughout a list of questions and some examples of typical changes of the NM and ESSP only.
Such document needs to be updated considering the experience gained over the oversighted Organisations, and The Review Criteria and the examples of typical changes to the Organisations presented in this Thesis should be integrated in it.

It is forecast that, in the forthcoming years, more and more Organisations will fall into the scope of the EASA's Oversight, so that, so that it is necessary to have flexible criteria in order to adapt to all the situations. Hence, the set of criteria presented should be accordingly refined, updated, revised and extended to constantly fulfil the EASA's Safety mission.

Despite the review decision process remains a complex activity, the found Review Criteria try to break down its complexity and – being Organisation-independent – allow for a standardisable risk-based approach to the changes of the functional systems with a more robust and versatile method, which is not only qualitative, but also quantitative.
It usually is a complex combination of elements and risks that triggers the decisions of the AAEs to review a change and only the expertise of human experts can catch the subtle within the variety of cases involved in the changes to the functional systems operating in the ATM/ANS context.
Hence, the expert judgment will always remain paramount to the review process and, given its essential importance, it is advisable to evaluate it quantitatively, as proposed in this Thesis by means of an inter-rater reliability method for the Group Absolute Probability Judgment.

The Review Criteria, in connection with the criteria used in the On-Going phase of the Oversight process, can constitute a basis for the integration of the experts' past decisions and for a risk-based prioritisation of the review activities.
They can be integrated as additional Guidance Material to Regulation 373 for Authorities dealing with Organisations providing different ATM/ANS services.

Considering the EASA's Total Approach to Safety, the risk-based method for the review process about changes to functional systems created now for the FS.4.1 Section may be found useful to other Departments and taken as an example to be applied to other domains involving the expert judgment for a risk-based approach.

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APPENDIXES

The following paragraphs contain appendixes to the Thesis.

A. Taxonomy

The definitions presented and discussed in this Appendix are based on those contained in the following published documents, including AMCs and GMs:

- ISO9000 [1]
- ICAO Annex 19 – Safety Management [2]
- the Basic Regulation (BR) [2]
- the Framework Regulation (FR) [3]
- the Service Provision Regulation (SPR) [4]
- the Safety Oversight Regulation (SO-IR) [5]
- the Common Requirements Regulation (CR-IR) [6]
- the Standardisation Regulation (STD-IR) [7]
- the Investigation and Prevention Regulation (IP-IR)[8]
- the ATCO Regulation (AR) [9]
- the New Regulation (NR-IR) [10]

The NR-IR shall apply from 2nd of Jan 2020, therefore, Regulations 1034/2011, 1035/2011 and 482/2008 will only be repealed on the 1st of January 2020 and remain applicable until the end of 2019. So, it is important to take into account both sets of definitions, especially when there are differences between them.

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[1] In the ISO9000 series of quality documents, ISO9000 explains fundamental quality concepts and gives guidelines for selection and application of standards

[2] Regulation (EC) No 216/2008 of the European Parliament and of the Council of 20 February 2008 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency, and repealing Council Directive 91/670/EEC, Regulation (EC) No 1592/2002 and Directive 2004/36/EC.

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a. Process

'Process' means a set of interrelated or interacting activities which transforms *inputs* into *outputs*.

b. Procedure

'Procedure' means a specified way to carry out an activity or a process. Procedures can be documented or not.

c. Audit

Audit is a systematic, independent and documented *process* for obtaining *objective evidence* and evaluating it objectively to determine the extent to which the audit criteria are fulfilled. Audits shall be carried out against a *reference*, which can be a standard or a Regulation.

Audits can have different scopes, as for a *quality* audit or a *safety* one, as well as different levels of independence, being *internal* or *external*.

A key concept is that audits are based on *samples*, which means, for example, on selected documents or on the presence of records or pieces of *evidence*, as it is not efficient to examine each and every aspect of a system.

d. Corrective action

'Corrective action' means an action to eliminate the cause of a detected non-conformity.

e. Objective evidence

Evidence shall be always an objective evidence, which means data supporting the existence or verity of something obtained through observation, measurement, test, or by other means.
Evidence can be divided into two types:

- direct: the tangible evidence
    - inputs of a process
    - outputs of a process
- backing: in this case the evidence may be support documentation
    - CVs of the actors to show that they meet some criteria
    - procedures, description of procedures to be carried

f. Requirement

A requirement is defined as a need or expectation that is stated, generally implied (due to custom or common practice) or obligatory.
Requirements originate from a number of sources and don’t only come from users; indeed, all applicable ATM/ANS Regulations shall be considered as requirements. Furthermore, in order to achieve high customer satisfaction, it can be necessary to fulfil an expectation of a customer even if it is neither stated nor generally implied or obligatory.

In fact, requirements can be divided in two categories:

- explicit requirements, which can be clearly stated by the users or by stakeholders
- implicit requirements, which are more difficult to determine, as they are considered obvious for the user and consequently are not stated nor documented.

g. Review

Review is the determination of the suitability, adequacy or effectiveness of an object to achieve established objectives. Review can also include the determination of efficiency and are based on extensive examination of objects.

h. Verification

Verification is the confirmation, through the provision of *objective evidence*, that specified *requirements* have been fulfilled; it is usually the result of an inspection.
The activities carried out for verification are sometimes called a qualification process.

i. Validation

Validation is the confirmation, through the provision of *objective evidence*, that the *requirements* for a specific intended use or application have been fulfilled; it is usually the result of a test.
In other words, it is a *verification* made for a specific intended use or application.

j. Certification

‘Certification’ shall mean any form of recognition that a product, part or appliance, organisation or person complies with the applicable requirements including the provisions of this Regulation (BR) and its Implementing Regulations, as well as the issuance of the relevant certificate attesting such compliance.

k. Certificate

- BR, Art. 3, (g)
  ‘Certificate’ shall mean any approval, licence or other document issued as the result of *certification*.
- FR, Art. 2, 15
  ‘Certificate’ means a document issued by a National Supervisory Authority in any form complying with national law, which confirms that an air navigation service provider meets the requirements for providing a specific service.

l. Organisation

‘Organisation’ means either an air navigation service provider or an entity providing ATFM or ASM or other network functions.

m. Network function

‘Network function’ means the specific functions described in Article 6 of Regulation (EC) No 551/2004.

n. Network Manager

‘Network Manager’ means the body established on the basis of Article 6 of Regulation (EC) No 551/2004 to perform the duties provided in that Article and in Articles 3 and 4 of Regulation (EU) No 677/2011.

o. Equipment

‘Equipment’ is an assembly of the framework for locating hardware, the hardware itself and possibly a cover to act as a barrier between the internal and external environments.

p. Hardware

‘Hardware’ is the physical constituents within the equipment or the means of connecting them. All of them are used to provide the behaviour of the equipment.

q. Software

‘Software’ is a constituent part of a computer, which is used to provide the behaviour emerging from that computer. Software includes computer programs and configuration data. Software is not hardware, but is contained in hardware. Neither can ‘behave’ on their own, but only when acting cooperatively, i.e. the hardware supports and enables the operation implied by the software — the behaviour.

r. Functional system

- SO-IR, Art. 2, (2) and CR-IR, Art. 2, (3)
  ‘Functional system’ means a combination of systems, procedures and human resources organised to perform a function within the context of ATM.
- NR-IR, Annex I, (56)
  ‘Functional system’ means a combination of procedures, human resources and equipment[11], including hardware and software, organised to perform a function within the context of ATM/ANS and other ATM network functions.

s. Hazard

- ICAO, Annex 19, Chapter 1
  ‘Hazard’ is a condition or an object with the potential to cause or contribute to an aircraft incident or accident.
- CR-IR, Art. 2. (6)
  \`Hazard´ means any condition, event, or circumstance which could induce an accident.
- NR-IR, Annex I, (61)
  ‘Hazard’ means any condition, event, or circumstance which could induce a harmful effect.

Most of the Organisations involved in the Aviation world have no direct influence on the operation of an aircraft; hence, the definition given by ICAO results limited, while the other two are more general. Figure 10.1-1[12] gives an overview of how NR-IR views the progress from a hazard to a harmful effect.

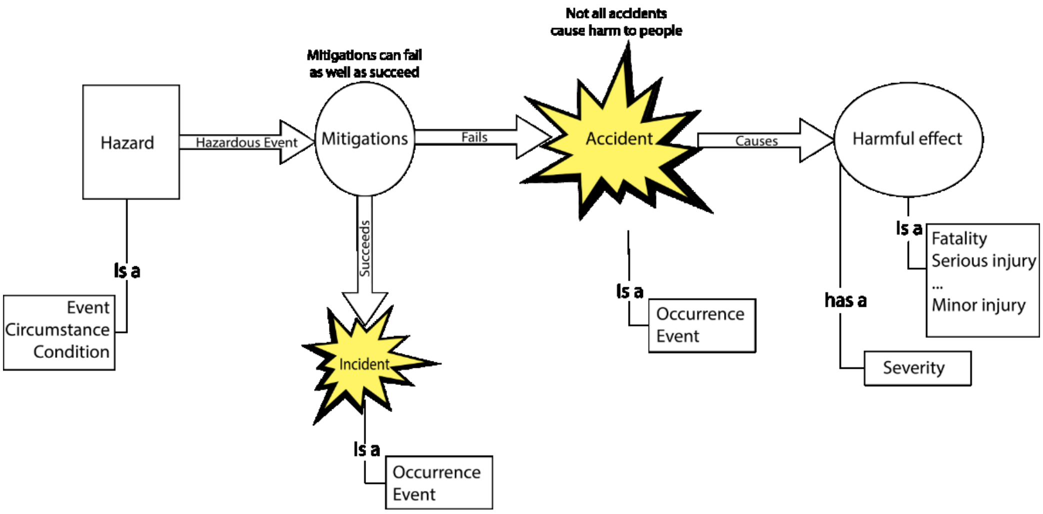

Figure 10.1-1 overview of the modification of the definition of ‘hazard’

The concept of hazard is related to other two elements: causes (sometimes called root causes) and effects. Figure 10.1-2 shows this relationship.

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[11] The word 'system' from the previous definition has been replaced by 'equipment' in order to avoid the difficulty that systems are generally thought of as comprising people, procedures, equipment and architecture. Furthermore, 'system' may have created confusion with the same term used in Regulation (EC) No 549/2004 where it does not include people or procedures and whose scope is limited to ANS.

[12] Picture taken from [13].

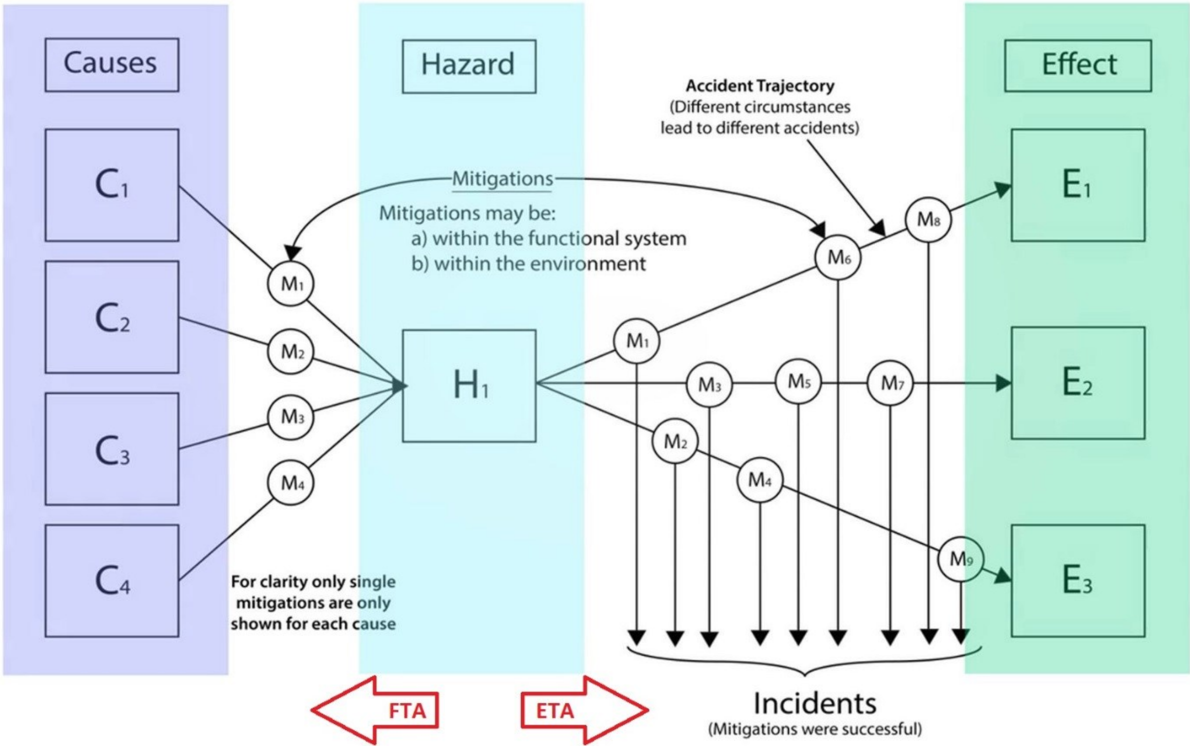

Figure 10.1-2 the full Cause/Hazard/Accident Model (Bow Tie Model)

A component failure is the starting point. The failure is the cause, or the origin.
If no internal mitigation means stops this failure from affecting the ATM functional system it becomes a *hazard*. However, at this point, nothing bad has happened.
If no external barriers stop the *hazard*, it might have an effect on the service. This is called an occurrence and the outcome could be an incident or an accident, according to the effectiveness of the external mitigation m. In practice, only a tiny number of occurrences result in an accident.
The causes are object of the Fault Tree Analysis (FTA).
The effects are object of the Event Tree Analysis (ETA).

t. Risk

'Risk' means the combination of the overall probability, or frequency of occurrence, of a harmful effect induced by a *hazard* and the severity of that effect.

u. Safety

'Safety' is the state in which the possibility of harm to persons or of property damage is reduced to, and maintained at or below, an acceptable level through a continuing process of hazard identification and safety risk management.

v. Safety argument

'Safety argument' means the demonstration and *evidence* that a proposed change to a functional system can be implemented within the targets or standards (specific objectives or measures) established through the existing regulatory framework consistently with the safety regulatory requirements.

w. Safety directive

'Safety directive' means a document issued or adopted by a CA which mandates actions to be performed on a functional system to restore safety, when *evidence* shows that Aviation Safety may otherwise be compromised.

x. Safety objective / Safety criterion

'Safety objective' means a qualitative or quantitative statement that defines the maximum frequency or probability at which a *hazard* can be expected to occur.

In other words, a *safety objective* is a limit imposed at the level of a *hazard*.

In NR-IR this notion is replaced by the one of *Safety criterion*.
Safety criteria represent the desired safety behaviour of the change at its interface and within the operational context. The important aspects of *Safety criteria* are their properties, their relationships, their completeness, their consistency and their validity.
However there isn't any explicit definition of the term in NR-IR.[13]

The determining of Safety criterion is within the scope of the ATS service providers only.

y. Safety requirement

'Safety requirement' means a *risk* mitigation, defined from the *risk* mitigation strategy that achieves a particular *safety objective*, including organisational, operational, procedural, functional, performance and interoperability requirements or environmental characteristics.

In other words, a *safety requirement* is a limit imposed at the level of the root causes of a *hazard*.

Safety requirements are requirements hierarchically decomposed from *Safety criteria*.
However, the definition of *Safety requirement* is not in NR-IR nor AMC-GM, but, as the term is still used in them both, it comes naturally to keep the definition given above and taken from the SO-IR.

z. Safety regulatory audit

'Safety regulatory audit' means a systematic and independent examination conducted by, or on behalf of, a CA to determine whether complete Safety-related arrangements or elements thereof, related to processes and their results, to products or services, comply with required Safety-related arrangements and whether they are implemented effectively and are suitable to achieve expected results.

[13] Further details are given in NR-IR, Section 2, ATS.OR.210 Safety Criteria.

aa. Accident

'Accident' means an occurrence associated with the operation of an aircraft which, in the case of a manned aircraft, takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, or in the case of an unmanned aircraft, takes place between the time the aircraft is ready to move with the purpose of flight until such time it comes to rest at the end of the flight and the primary propulsion system is shut down, in which either:

- a person is fatally or seriously injured as a result of either:
    - being in the aircraft
    - direct contact with any part of the aircraft, including parts which have become detached from the aircraft
    - direct exposure to jet blast

  except when the injuries are from natural causes, self- inflicted or inflicted by other persons, or when the injuries are to stowaways hiding outside the areas normally available to the passengers and crew
- the aircraft sustains damage or structural failure which adversely affects the structural strength, performance or flight characteristics of the aircraft, and would normally require major repair or replacement of the affected component, except for engine failure or damage, when the damage is limited to a single engine, (including its cowlings or accessories), to propellers, wing tips, antennas, probes, vanes, tires, brakes, wheels, fairings, panels, landing gear doors, windscreens, the aircraft skin (such as small dents or puncture holes) or minor damages to main rotor blades, tail rotor blades, landing gear, and those resulting from hail or bird strike, (including holes in the radome)
- the aircraft is missing or is completely inaccessible

bb. Serious incident

'Serious incident' means an incident involving circumstances indicating that there was a high probability of an accident and is associated with the operation of an aircraft, which in the case of a manned aircraft, takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, or in the case of an unmanned aircraft, takes place between the time the aircraft is ready to move with the purpose of flight until such time it comes to rest at the end of the flight and the primary propulsion system is shut down.

B. AIS definitions

The following definitions are taken from ICAO Annex 15 – Aeronautical Information Service [1].

a. NOTAM

A notice distributed by means of telecommunication containing information concerning the establishment, condition or change in any aeronautical facility, service, procedure or hazard, the timely knowledge of which is essential to personnel concerned with flight operations.

b. ASHTAM

A special series NOTAM notifying by means of a specific format change in activity of a volcano, a volcanic eruption and/or volcanic ash cloud that is of significance to aircraft operations.

c. SNOWTAM

A special series NOTAM notifying the presence or removal of hazardous conditions due to snow, ice, slush or standing water associated with snow, slush and ice on the movement area, by means of a specific format.

d. Pre-flight information bulletin (PIB)

A presentation of current NOTAM information of operational significance, prepared prior to flight.

e. Aeronautical Information Circular (AIC)

A notice containing information that does not qualify for the origination of a NOTAM or for inclusion in the AIP, but which relates to flight safety, air navigation, technical, administrative or legislative matters.

f. Aeronautical Information Publication (AIP)

A publication issued by or with the authority of a State and containing aeronautical information of a lasting character essential to air navigation.

g. Integrated Aeronautical Information Package (IAIP)

A package in paper, or electronic media which consists of the following elements:

- AIP, including amendment service
- Supplements to the AIP
- NOTAM and PIB
- AIC
- checklists and lists of valid NOTAM

C. The Regulation Structure

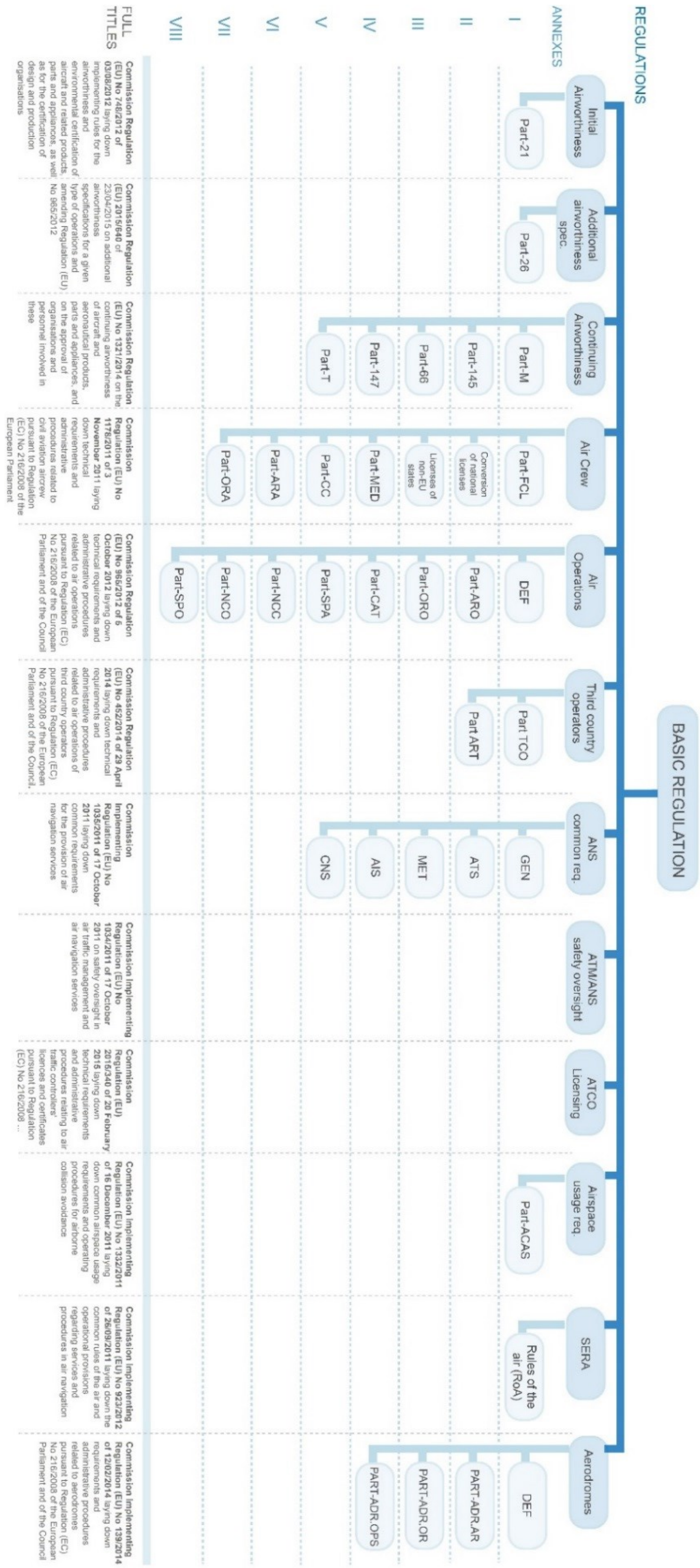

Figure 10.1-3 Regulation structure

D. The EU Legislation for ATM/ANS & ADRs

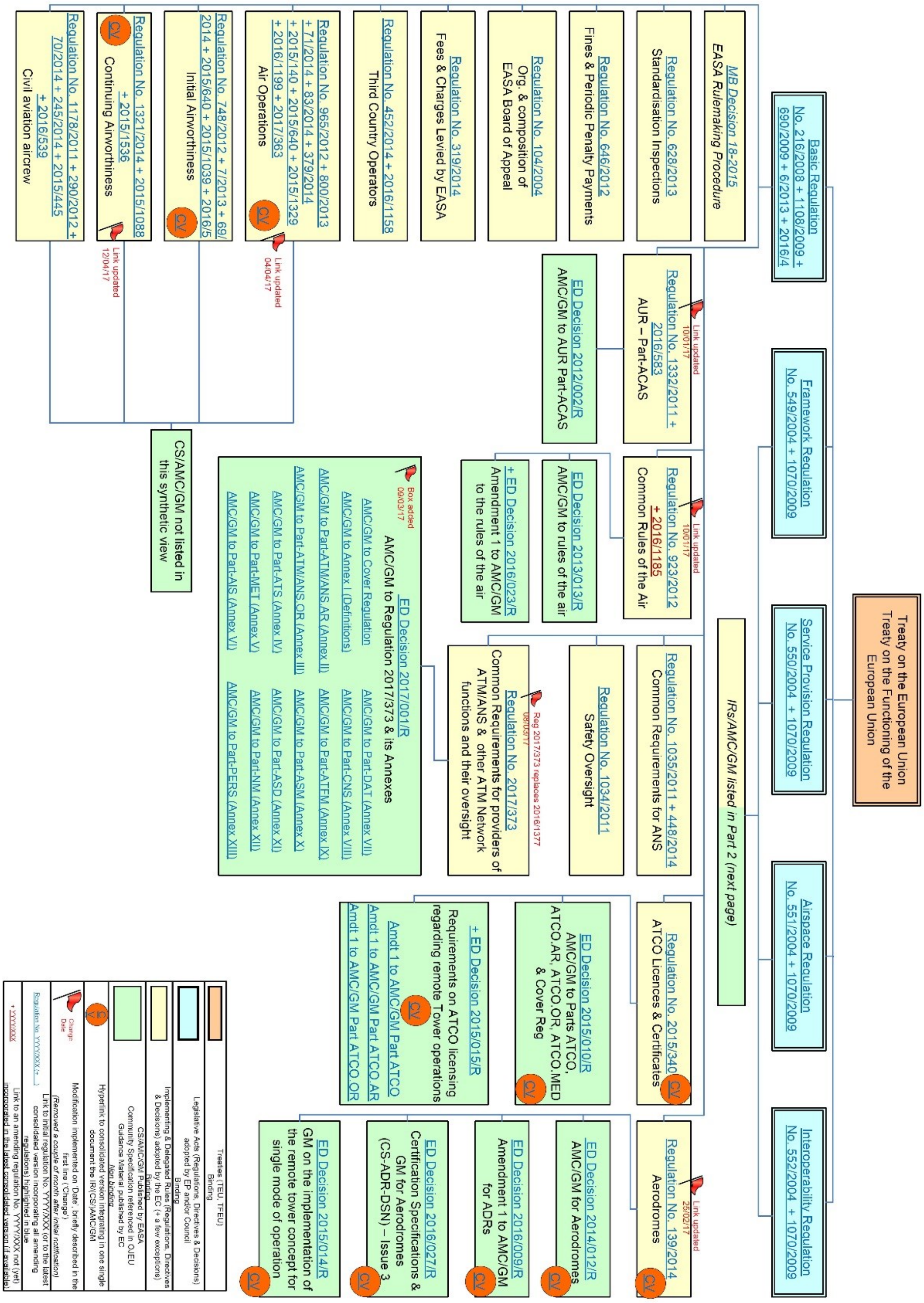

Figure 10.1-4 part 1: BR 216/2008 & implementing measures

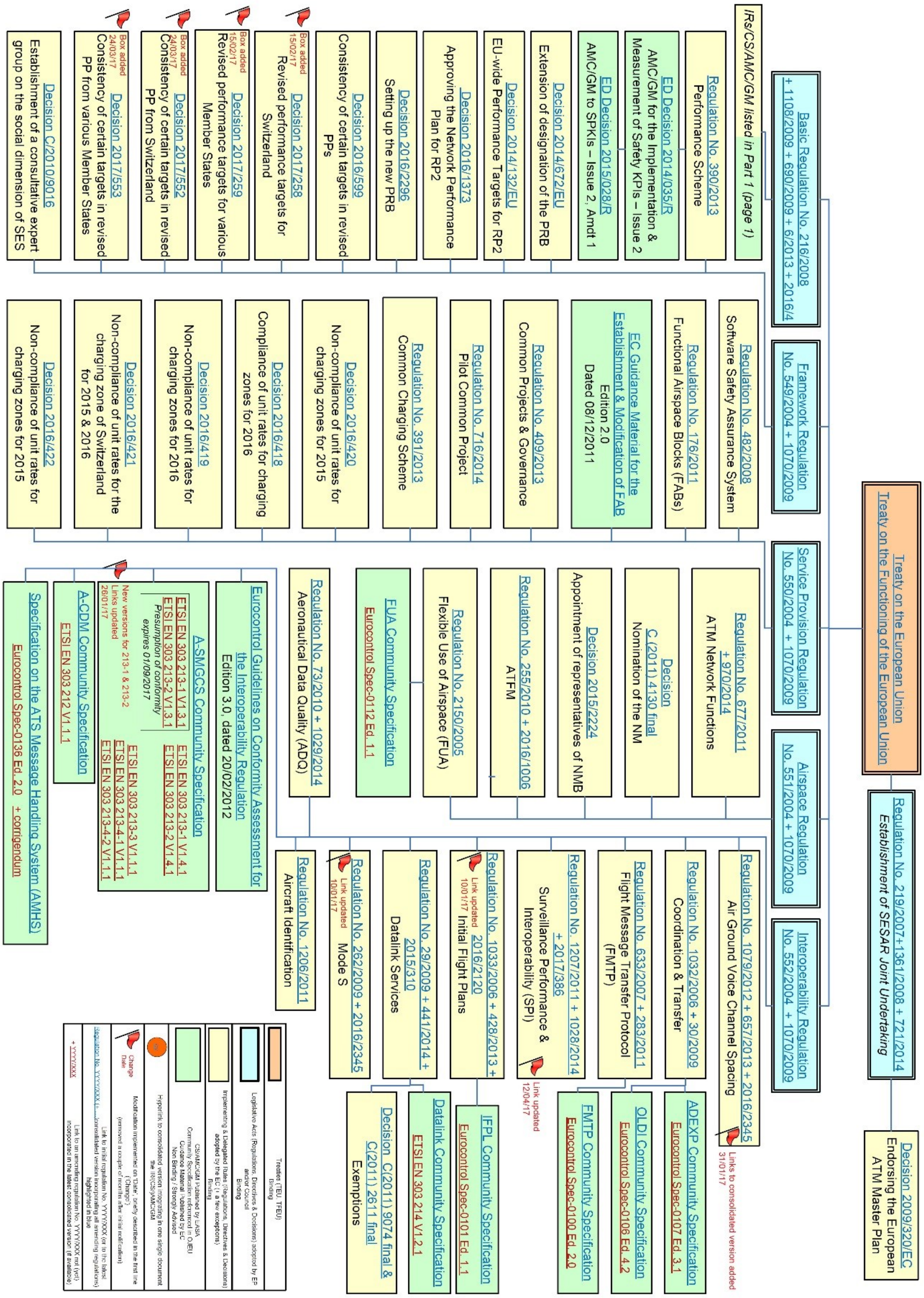

Figure 10.1-5 part 2: Regs 549-550-551-552/2004 & implementing measures

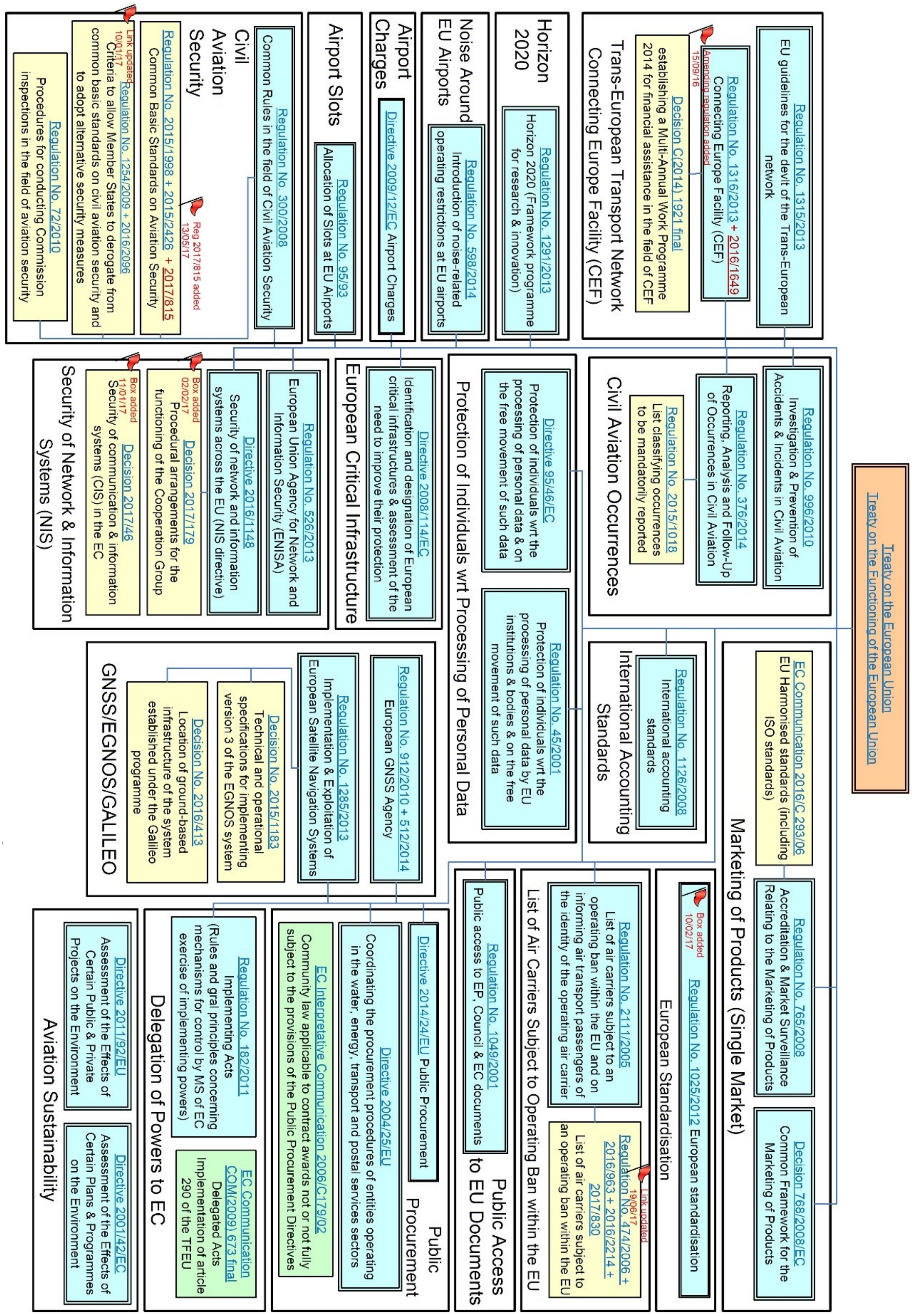

Figure 10.1-6 part 3: other relevant EU Leg

E. Procedure for ATM/ANS changes to functional systems

a. Review decision

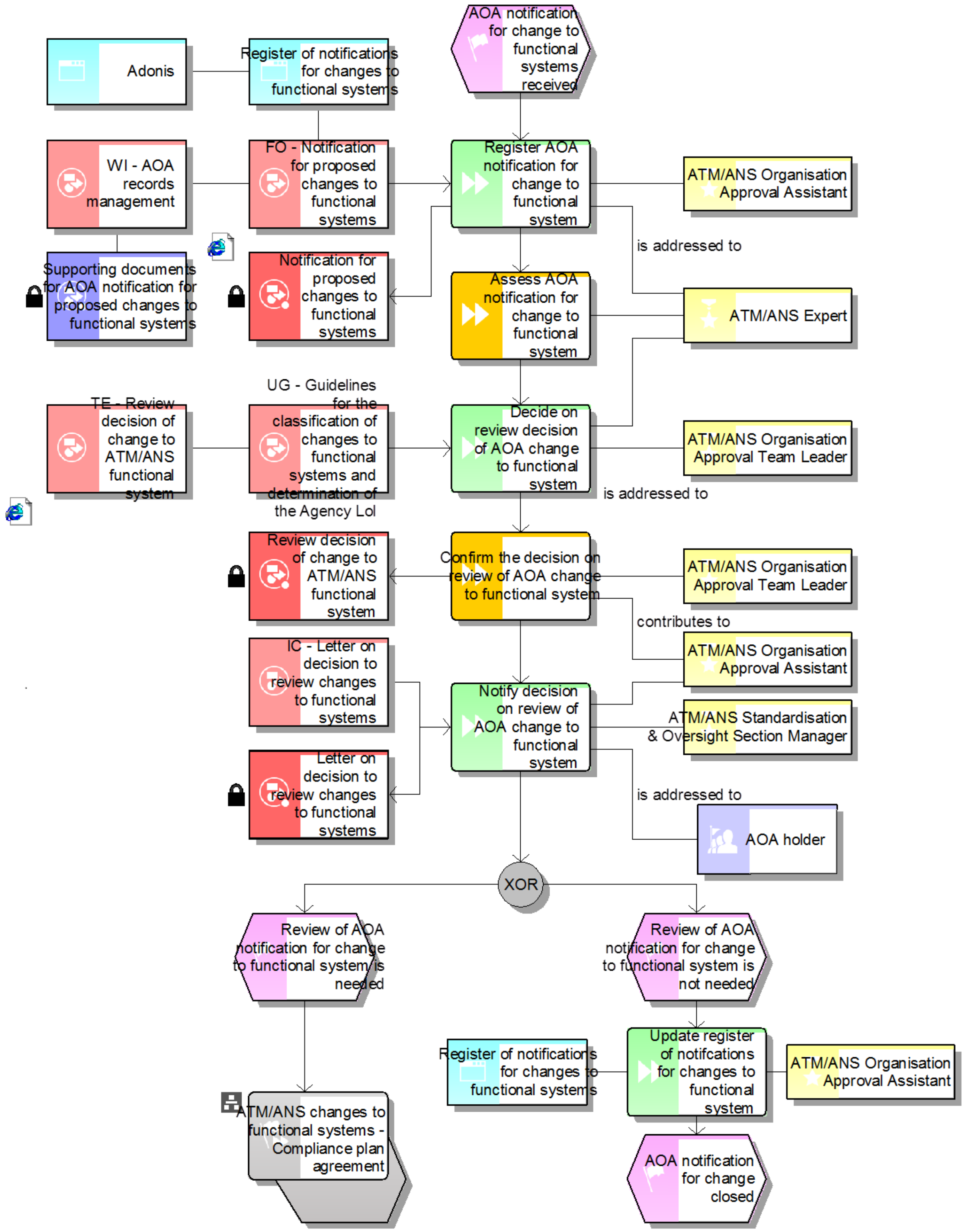

Figure 10.1-7 the procedure for the review decision phase

b. Compliance plan agreement

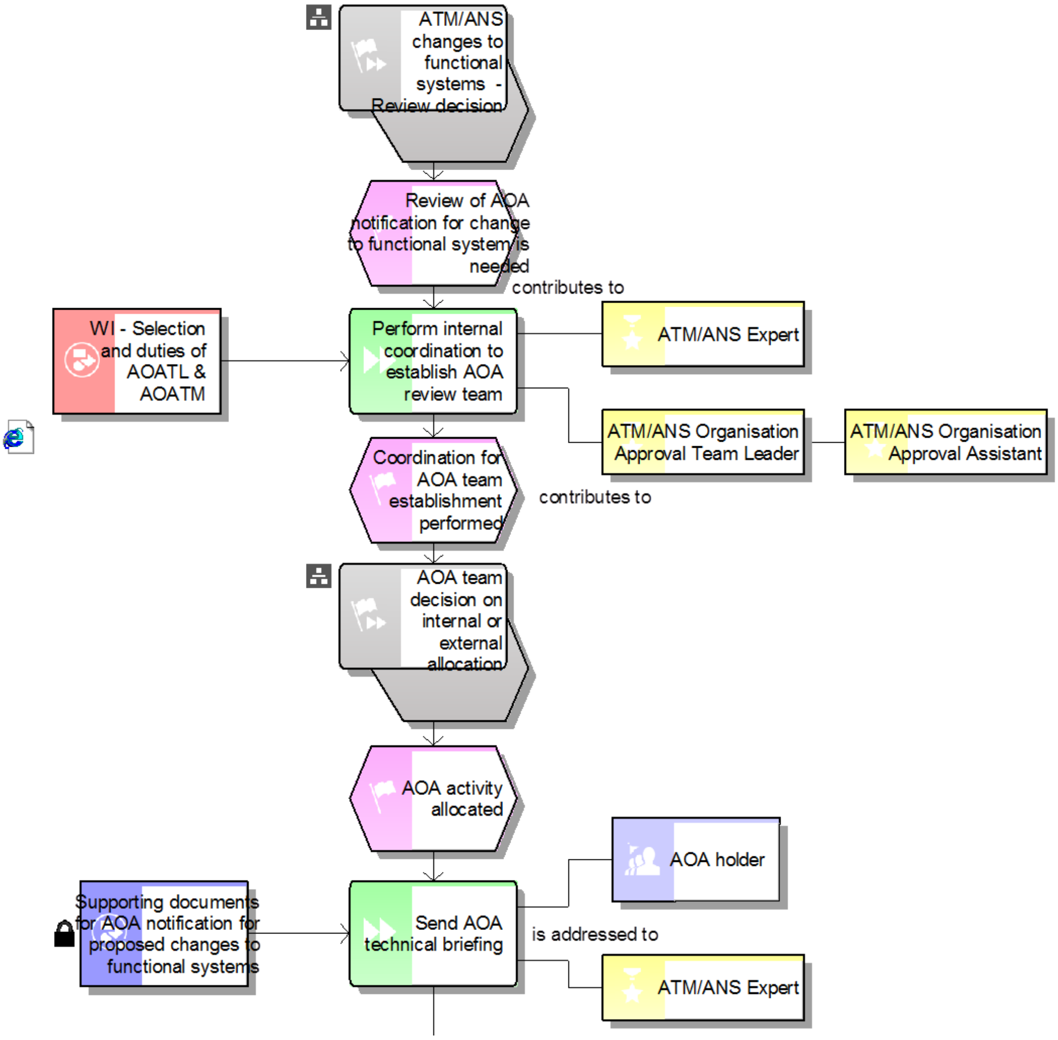

Figure 10.1-8 the procedure for the compliance plan agreement phase (1/2)

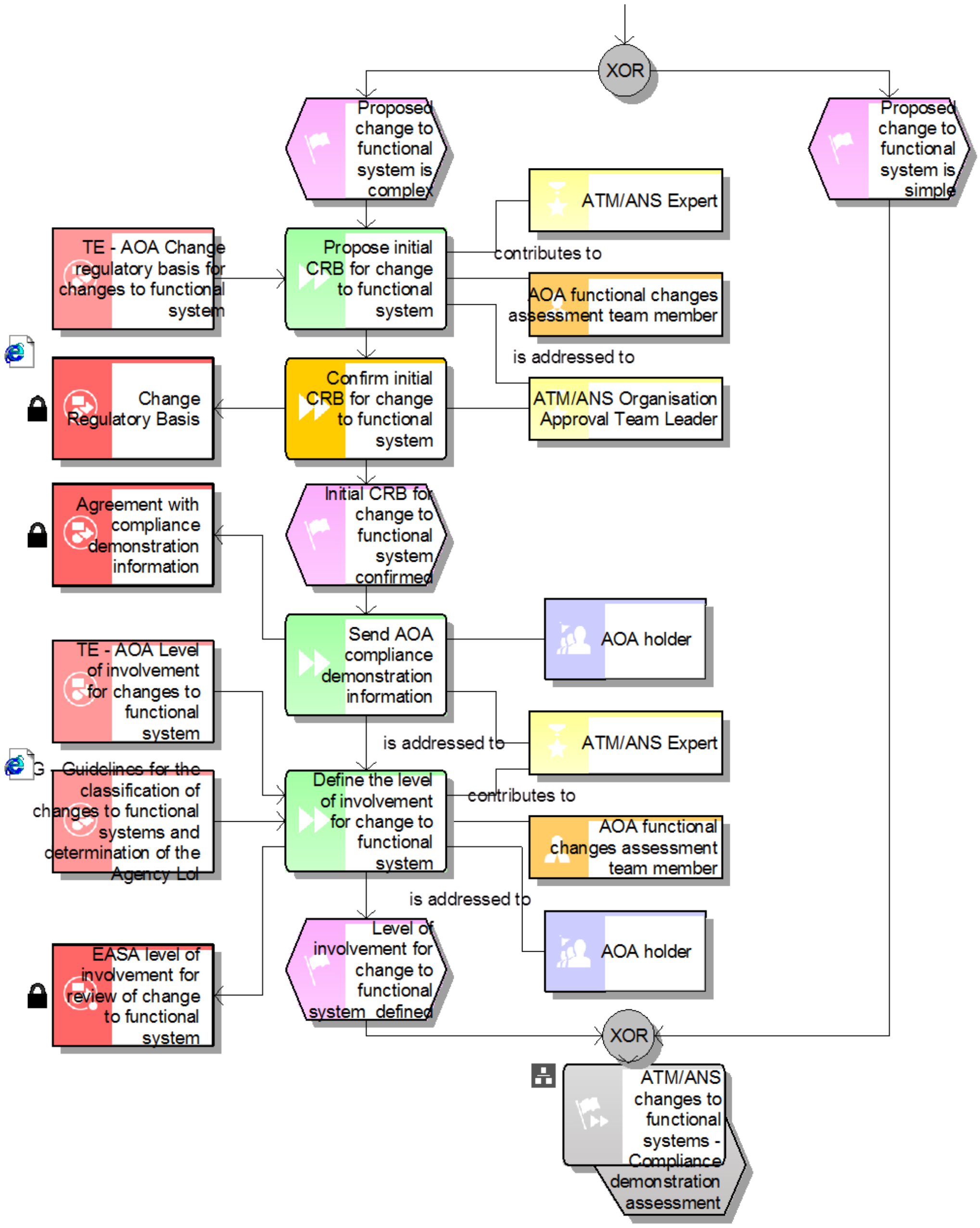

Figure 10.1-9 the procedure for the compliance plan agreement phase (2/2)

c. Compliance demonstration assessment

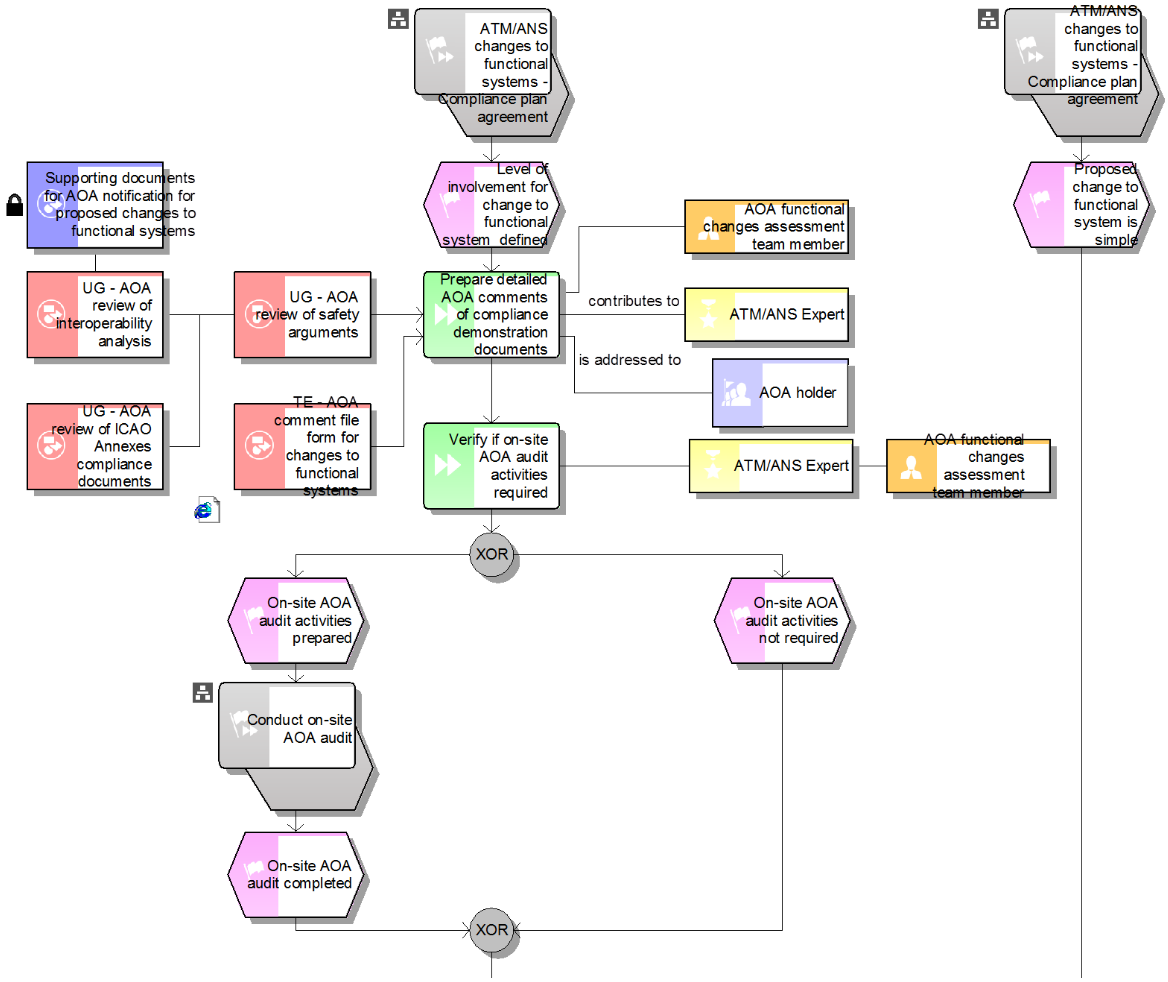

Figure 10.1-10 the procedure for the compliance demonstration assessment phase (1/2)

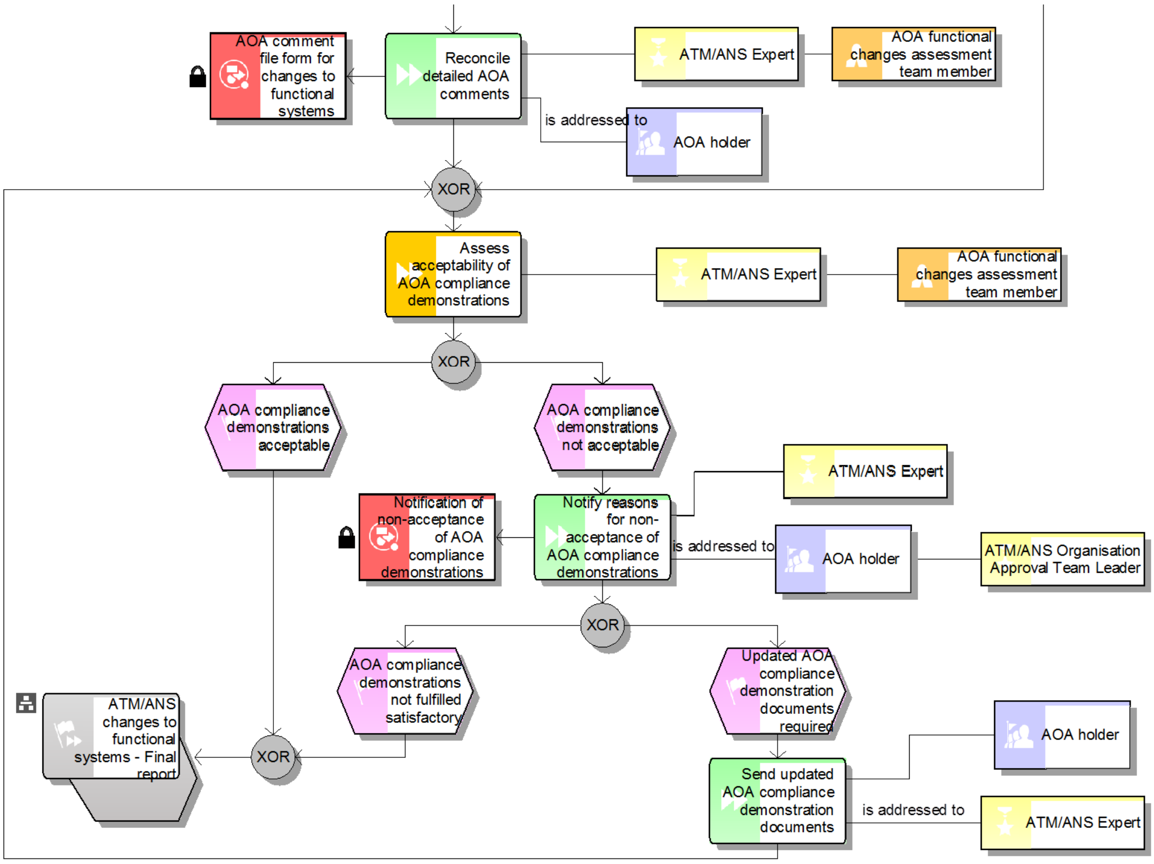

Figure 10.1-11 the procedure for the compliance demonstration assessment phase (2/2)

d. Final report

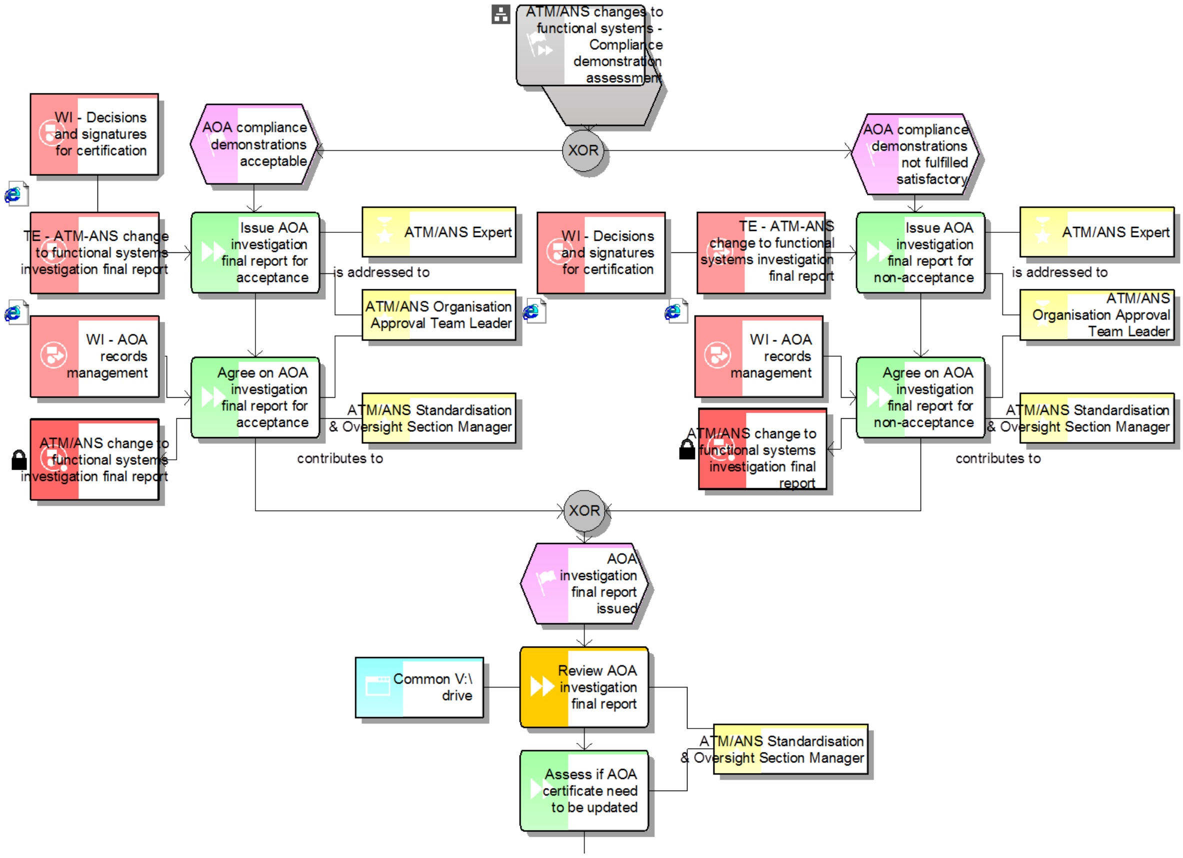

Figure 10.1-12 the procedure for the final report phase (1/2)

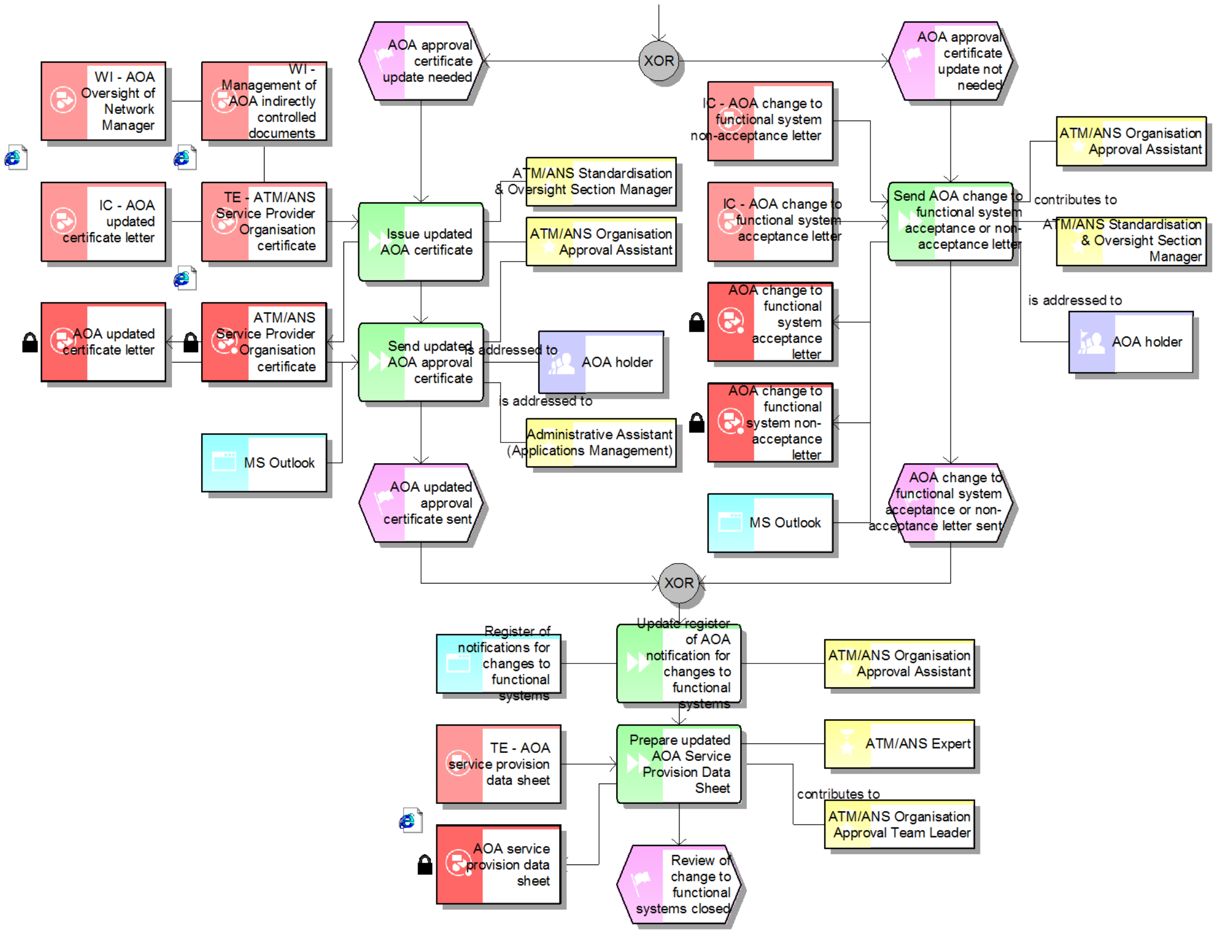

Figure 10.1-13 the procedure for the final report phase (2/2)

F. ATCO rating training and endorsements

- **Aerodrome Control Visual (ADV)**
  indicating that the licence holder is competent to provide an ATC service to aerodrome traffic at an aerodrome that has no published instrument approach or departure procedures
- **Aerodrome Control Instrument (ADI)**
  indicating that the licence holder is competent to provide an ATC service to aerodrome traffic at an aerodrome that has published instrument approach or departure procedures, and which shall bear at least one of the following endorsements:
  - **Air Control (AIR)**
    indicating that the licence holder is competent to provide AIR to traffic flying in the vicinity of an aerodrome and on the runway
  - **Ground Movement Control (GMC)**
    indicating that the licence holder is competent to provide ground movement control
  - **Tower Control (TWR)**
    including the privileges of the AIR and GMC endorsements and indicating that the licence holder is competent to provide aerodrome control service
  - **Ground Movement Surveillance (GMS)**
    granted in addition to the GMC or TWR endorsements, indicating that the licence holder is competent to provide GMC with the help of aerodrome surface movement guidance systems
  - **Aerodrome Radar Control (RAD)**
    granted in addition to the AIR or TWR endorsements, indicating that the licence holder is competent to provide ADR control with the help of surveillance radar equipment
- **Approach Control Procedural (APP)**
  indicating that the licence holder is competent to provide an ATC to arriving, departing or transiting aircraft without the use of surveillance equipment
- **Approach Control Surveillance (APS)**
  indicating that the licence holder is competent to provide an ATC service to arriving, departing or transiting aircraft with the use of surveillance equipment, and which may bear one or more of the following endorsements:
  - **Precision Approach Radar (PAR)**
    indicating that the licence holder is competent to provide ground-controlled precision approaches with the use of precision approach radar equipment to aircraft on the final approach to the runway
  - **Surveillance Radar Approach (SRA)**
    indicating that the licence holder is competent to provide ground-controlled non-precision approaches with the use of surveillance equipment to aircraft on the final approach to the runway
  - **Terminal Control (TCL)**
    indicating that the licence holder is competent to provide ATC services with the use of any surveillance equipment to aircraft operating in a specified terminal area and/or adjacent sectors
- **Area Control Procedural (ACP)**
  indicating that the licence holder is competent to provide an ATC service to aircraft without the use of surveillance equipment, and which may bear the Oceanic Control endorsement described hereinafter
- **Area Control Surveillance (ACS)**

indicating that the licence holder is competent to provide an ATC service to aircraft with the use of surveillance equipment, and which may bear one or more of the following endorsements:

- **Terminal Control (TCL)**
  indicating that the licence holder is competent to provide ATC services with the use of any surveillance equipment to aircraft operating in a specified terminal area and/or adjacent sectors
- **Oceanic Control (OCN)**
  indicating that the licence holder is competent to provide ATC services to aircraft operating in an Oceanic Control Area

G. Fleiss' kappa equations and examples

The equations ruling the Fleiss' kappa method involve the following indexes and variables (partially introduced in Table 9.2-13), which constitute the input data:

- the total number of experts (raters) is $n \geq 2$ and in this example $n = 3$
- the criteria (subjects) are indexed by $i = 1, \dots, N$ with $N = 7$
- the possible criterion level scores (categories) are indexed by $j = 1, \dots, k$ with $k = 3$
- n_{ij} represents the number of experts (raters) who assigned the i-th subject to the j-th category

Given $n = 3$, $N = 7$, $k = 3$, the equations presented below allow for the calculation of the following Fleiss' kappa variables:

- the proportion p_j of all assignments which were to the j-th category:

$$p_j = \frac{1}{N\,n} \sum_{i=1}^{N} n_{ij} \quad \text{and} \quad 1 = \sum_{j=1}^{k} p_j$$

- the extent P_i to which raters agree for the i-th subject (number of rater-rater pairs in agreement, relative to the number of all possible rater-rater pairs):

$$P_i = \frac{1}{n\,(n-1)} \sum_{j=1}^{k} n_{ij}\,(n_{ij} - 1) = \frac{1}{n\,(n-1)} \sum_{j=1}^{k} (n_{ij}^2 - n_{ij}) = \frac{1}{n\,(n-1)} \left[\left(\sum_{j=1}^{k} n_{ij}^2 \right) - n \right]$$

- the mean of all the proportions of the raters who agree $\overline{P}$:

$$\overline{P} = \frac{1}{N} \sum_{i=1}^{N} P_i = \frac{1}{N\,n\,(n-1)} \left(\sum_{i=1}^{N} \sum_{j=1}^{k} n_{ij}^2 - N\,n \right)$$

- the mean of the proportions of raters agreeing solely due to chance $\overline{P}_e$:

$$\overline{P}_e = \sum_{j=1}^{k} p_j^2$$

The output is the Fleiss' kappa k:

$$\kappa = \frac{\overline{P} - \overline{P}_e}{1 - \overline{P}_e}$$

where $(\overline{P} - \overline{P}_e)$ is the degree of agreement actually achieved above chance and $(1 - \overline{P}_e)$ is the one that is attainable above chance.

The kappa can be used to evaluate the agreement amongst the raters. Its value can only be $k \leq 1$.

There is perfect agreement when $k = 1$ and complete disagreement when $k \leq 0$.
The agreement is partial in the in-between cases.
Since there is no universally accepted interpretation of the in-between values and since the review decision procedures requires the experts to discuss and reiterate the process until a perfect agreement is reached, the following cases
 no further interpretation is given in this Thesis.

a. Example of perfect agreement

Table 10.1-1 shows an example of perfect agreement.

		Criterion Level Scores				
	n_{ij}	level score 0	level score 1	level score 2	P_i	$\bar{P}$
Review Criteria	1	3	0	0	1.000	1.000
	2	3	0	0	1.000	
	3	0	0	3	1.000	
	4	3	0	0	1.000	
	5	0	0	3	1.000	
	6	3	0	0	1.000	
	7	0	3	0	1.000	
	total	12	6	3		
	scores	0	2	2		
	p_j	0.571	0.286	0.143		
	$\bar{P}_e$	0.429				

mean Total Score	4
$\bar{P} - \bar{P}_e$	0.571
$1 - \bar{P}_e$	0.571
k	1.000

Table 10.1-1 example of perfect agreement

In this example all the three AAEs perfectly agree (given $k = 1$) on the review decision.
In this case the decision is not to review the change (given the Total Score of 4).
According to the method proposed in this Thesis, this is the kind of scenario that should be achieved before taking every review decision.

b. Example of perfect disagreement

Table 10.1-2 shows an example of complete disagreement.

	n_{ij}	Criterion Level Scores: level score 0	level score 1	level score 2	P_i	$\bar{P}$
Review Criteria	1	1	1	1	0.000	0.000
	2	1	1	1	0.000	
	3	1	1	1	0.000	
	4	1	1	1	0.000	
	5	1	1	1	0.000	
	6	1	1	1	0.000	
	7	1	1	1	0.000	
	total	7	7	7		
	scores	0	7	14		
	p_j	0.333	0.333	0.333		
	$\bar{P}_e$	0.333				

mean Total Score	7
$\bar{P} - \bar{P}_e$	-0.333
$1 - \bar{P}_e$	0.667
k	-0.050

Table 10.1-2 example of complete disagreement

In this example there is perfect disagreement amongst the experts (given $k < 0$) and no decision shall be taken.
This scenario is very unlikely to happen, even if it cannot be mathematically excluded.
What is important is that this example represents the worst-case scenario and sets the lower limit of kappa for the given data, so that $-0.05 \leq k \leq 1$.

c. Example of partial agreement

Table 10.1-3 shows an example of partial agreement.

		Criterion Level Scores				
	n_{ij}	level score 0	level score 1	level score 2	P_i	$\bar{P}$
Review Criteria	1	0	3	0	1.000	0.714
	2	0	2	1	0.333	
	3	0	0	3	1.000	
	4	0	1	2	0.333	
	5	0	3	0	1.000	
	6	1	2	0	0.333	
	7	0	3	0	1.000	
	total	1	14	6		
	scores	0	14	12		
	p_j	0.048	0.667	0.286		
	$\bar{P}_e$	0.528				

mean Total Score	8.667
$\bar{P} - \bar{P}_e$	0.186
$1 - \bar{P}_e$	0.472
k	0.394

Table 10.1-3 example of partial agreement

In this example there is partial agreement amongst the experts (given $1 < k < 0$) and no decision shall be taken.
In this case the experts agree on 4 criteria out of 7 and, according to the method proposed, it is not possible to determine with certainty whether a review decision with a simple scope or with a complex one shall be taken.
A discussion on the 3 criteria for which an agreement has not been reached yet shall be carried out in order to reach the perfect agreement allowing for a decision to be taken.

d. Examples of partial agreement with increased number of raters

Table 10.1-4 shows an example of partial agreement after that 2 raters have been added to the pool of AAEs of Appendix G.c.

	n_{ij}	Criterion Level Scores: level score 0	level score 1	level score 2	P_i	$\overline{P}$
Review Criteria	1	0	5	0	1.000	0.743
	2	0	3	2	0.400	
	3	0	0	5	1.000	
	4	0	2	3	0.400	
	5	0	5	0	1.000	
	6	2	3	0	0.400	
	7	0	5	0	1.000	
	total	2	23	10		
	scores	0	23	20		
	p_j	0.057	0.657	0.286		
	$\overline{P}_e$	0.517				

mean Total Score	8.600
$\overline{P} - \overline{P}_e$	0.226
$1 - \overline{P}_e$	0.483
k	0.468

Table 10.1-4 example of partial agreement with increased number of raters

Table 10.1-5 shows another example of partial agreement that 2 raters have been added to the pool of AAEs of Appendix G.c.

	n_{ij}	Criterion Level Scores: level score 0	level score 1	level score 2	P_i	$\overline{P}$
Review Criteria	1	0	5	0	1.000	0.829
	2	0	4	1	0.600	
	3	0	0	5	1.000	
	4	0	1	4	0.600	
	5	0	5	0	1.000	
	6	1	4	0	0.600	
	7	0	5	0	1.000	
	total	1	24	10		
	scores	0	24	20		
	p_j	0.029	0.686	0.286		
	$\overline{P}_e$	0.553				

mean Total Score	8.800
$\overline{P} - \overline{P}_e$	0.276
$1 - \overline{P}_e$	0.447
k	0.617

Table 10.1-5 example of partial agreement with increased number of raters

In these examples there is partial agreement amongst the experts (given $1 < \mathrm{k} < 0$).
In both cases the experts agree on 4 criteria out of 7 and, according to the method proposed, it is not possible to determine with certainty whether a review decision with a simple scope or with a complex one shall be taken.
In the first of these two examples, the 2 added raters equally distributed on diverging opinions, whereas in the second one, both raters agree with the majority; anyway, although the mean Total Score doesn’t change significantly with respect to the Example shown in Appendix G.c, the addition of 2 experts results in an increase of the value of kappa, which means that it is usually possible to reach a higher level of coherence increasing the number of experts involved.
In the second case the team of AAE is more likely to opt for a review decision to be taken with a complex LoI.