Legal, Regulatory and Economy constraints

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Copyright Statement

SAFELAND

SAFE LANDING THROUGH ENHANCED GROUND SUPPORT

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Abstract

This Deliverable provides an assessement of the legal, regulatory and economic implications of the SAFELAND options presented in Deliverable D1.2 *SAFELAND Initial Concept*. It identifies critical issues related to the general features of the concept as well as the three implementation options.

The Deliverable examines first of all the legal, regulatory and economic framework of the SAFELAND Concept of Operations. It presents the main legal and regulatory norms, topics, concepts and sources involved in the field of Aviation/ATM, with particular regard to Single Pilot Operations and Remotely Piloted Systems; it then focuses on responsibility and liability of the different actors involved. Economic aspects related to the concept and its possible implementation options are also analysed.

Further, the impact of the SAFELAND concept on the outlined framework is examined, identifying a common set of constraints for the concept as well as specific constraints of each implementation option. The analysis starts with an outlook of the whole operational structure as well as specific functions, actors involved and their interaction. Then, it focuses on the regulatory requirements (e.g. pilot licences), liability shifts (e.g. PIC duties) and other relevant issues (i.e., data protection issues) concerning each function, as well as economic efficiency.

Finally, the Deliverable offers an initial evaluation of the concept on the basis of the abovementioned constraints: several suggestions and recommendations are proposed, that will feed the final version of the SAFELAND concept.

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1 Introduction

1.1 Purpose and scope of this document

The object of this document is to examine the legal, regulatory and economic factors that should guide the design and deployment of the SAFELAND concept.

It outlines the main legal issues, regulatory framework and economic facets related to the development of Single Pilot Operations and of Remotely Piloted Systems in Aviation/ATM, which constitute the context of the SAFELAND research. It further analyses the main issues related to the concepts of responsibility and liability of the actors involved in SAFELAND. The results of the analysis are then applied to the SAFELAND initial concept as developed in the first part of the project, and described in Deliverable 1.2 SAFELAND Initial Concept; the three different implementation options considered in the Concept are examined separately.

The aim of the document is to verify what legal, regulatory and economic constraints can operate as enablers or blocking issues for any part or options of the current SAFELAND Initial Concept, and therefore constitute guidelines for the development of the Final SAFELAND Concept in the prosecution of the project.

1.2 Structure of the document

This document consists of 6 chapters, further subdivided in sections. The chapters and their main topic are the following:

Chapter 1 describes the purpose and scope of the deliverable.

Chapter 2 provides an overview of the legal, regulatory, and economical frameworks in Aviation/ATM. It describes the relevant pieces of legislation, regulation, and legal concepts. A general overview of possible issues and gaps in the legal framework are presented.

Chapter 3 highlights the main legal and regulatory issues for the SAFELAND context, by analysing the three options from the workshop in light of the overview in chapter 2. For each option the main pros and cons are identified, as are the possible issues that would need further work as the project continues.

Chapter 4 provides a detailed economic analysis of the SAFELAND context, the methodology used in making the analysis, and the resulting implementation cost for SPO flight. The three options are analyzed in further detail.

Chapter 5 presents the conclusions of the legal, regulatory, and economic analysis, presenting the pros and cons of the three implementation options, the similarities between them, and the remaining issues to consider.

Chapter 6 lists the references used within this document.

1.3 List of acronyms

Term	Definition
AB	Advisory Board
ACS	Area Control Surveillance
ADR	Aerodromes
AIG	Accident Investigation
AMC	Acceptable Means of Compliance
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATM	Air Traffic Management
ATS	Air Traffic Services
CC	Chicago Convention
CS	Certification Specification
EASA	European Aviation Safety Agency
EC	European Commission
EP	European Parliament
ERCS	European Risk Classification Scheme
EU	European Union
FCL	Flight Crew Licensing
GM	Guidance Material
GS	Ground Station
GSO	Ground Station Operator

IAW	Initial Airworthiness
ICAO	International Civil Aviation Organization
JARUS	Joint Authorities for Rulemaking on Unmanned Systems
LOs	Learning Objectives
NIS	Network and Information Systems
OPS	Operations
PEL	Personnel Licensing
PIC	Pilot In Command
RMT	Rulemaking Task
RoA	Rules of the Air
RP	Remote Pilot
RPAS	Remotely Piloted Aircraft System
RPIC	Remote Pilot-in-Command
SEC	Security
SERA	Standardised European Rules of the Air
SPO	Single Pilot Operations
UAS	Unmanned Aircraft System

Table 1: Acronyms

2 Legal and regulatory constraints in Aviation/ATM

2.1 Automation in socio-technical systems (STSs)

The history of human work has involved an increasing division of labour, specialisation, and mechanisation. With the development of more powerful automatic machines and computers, the past century saw a remarkable rise in the penetration of automation into all aspects of our working life, and indeed in our daily living. While many aspects of work have become mechanized over the past century, the vision of the "fully automated" factory or office proposed some years back as almost an inevitability, is no longer in vogue. Rather, there is an increasing realization that efficient and effective systems usually require a nuanced combination of human and machine efforts. Technology for automation has moved from discussions of robot workers towards the use of software and robotic applications which are enmeshed in larger-scale socio-technical networks in organizations. In a variety of fields, such as human engineering, ergonomics, engineering systems, work studies, organisational studies, increasing attention is turning to the design of effective human-machine environments. Today, the main productive, administrative, and social organisations may be described as complex socio-technical systems (STSs), namely, systems that combine technological artefacts, social artefacts, and humans (Olsen et al. 2012).

Technical artefacts, which to some extent involve the use of automated tools and machines, determine what can be done in and by an organisation, amplifying and constraining opportunities for action according to the level of their automated technology. Social artefacts, like norms and institutions, determine what should be done, governing tasks, obligations, goals, priorities, and institutional powers. However, norms need to be understood, interpreted, negotiated, and actuated by humans. More generally, humans play an essential role in the functioning of STSs, providing them with governance and maintenance and sustaining their operation. The evolution of the concept of STSs has been one attempt to bring to the fore the idea that the majority, if not all, of complex systems are not simply made of hardware and software, but they also require human input and guidance, along with organisational procedures and arrangements.

One of the key aspects in the development of automation is therefore the relation with humans, the so-called "human factor". What is the role of humans in STSs? How, where and when do humans interact with machines, in the context of a certain organizational environment? The increasing level of automation has often been seen as a necessary and inevitable trend, at the end of which human capabilities become inexorably supplanted by machine processes that are viewed as cheaper, more durable, and less error-prone. In this perspective, the "human factor" should be eliminated from the process – or its presence at least reduced – in order to produce more reliable and effective automated systems. This "machine view" has however tended to ignore some of the unique capacities of humans in the workaday world. People are flexible, they can see patterns, they are able to think "outside the box," they can, on occasion, break the rules in order to accomplish more desirable results, and are able to make inferences and judgments based on local conditions and circumstances. All these questions address the problem of the "allocation of functions", which can be viewed as a governance mechanism making it possible to enhance the functioning of the STS, and has a direct impact on the issues of responsibility and liability for the activities of the systems.

A “machine-leading” perspective often leads to the design of human activities as “last resort” functions: i.e. to allocate as many functions as possible to the machine, and leave the remaining tasks to the human. This approach, while straightforward to implement, had the undesirable effect of leaving the human to do whatever functions were left over, without any regard for how these functions could be reasonably assembled into a meaningful job description for a person. From this perspective, the human factor is viewed more as a nuisance than a positive factor. In this view, the human is seen as the system element to be utilised as a last resort: when the system is operating normally, it is fully automated, except in cases of abnormality, when the automatic systems shuts down and hands over to the human. Expecting the human to function appropriately in such a system is likely to backfire. Indeed, it seems a sure recipe for human failure.

An approach more suitable with the philosophy of STSs entails what we could call a “human/machine partnership” in the division of tasks needed for the system to work. Indeed, the development of the human factors engineering field was concerned with making a better fit between the capabilities of humans and those of machines. (see the famous MABA-MABA Lists, i.e. Men Are Better At – Machines Are Better At, Fitts 1951). In this view, human actors are endowed with supervision of machines, and intervention in case of malfunctioning or critical, unpredictable events (and more in general?). Such an idea has two main corollaries:

1. Humans should operate under conditions allowing them to effectively and safely take over from automation;
2. Such effective and safe allocation of functions should be devised early in the system design phase.

The possible ways humans and machines interact in a STS and the distribution of tasks resulting thereof have a major impact on the assessment of the legal as well as economic aspects of the activities carried out in the system We shall now detail this link with particular regard to the STS of interest in this deliverable: the Aviation and ATM system.

2.1.1 Automation and the human role in Aviation/ATM

The functioning of Aviation and air traffic management (ATM) may be described as a STS: the result of the interplay of technical artefacts (aircraft, control towers, airports, radars, etc.), human operators (pilots, air traffic controllers, airport operators, safety operators, technicians, etc.), and social artefacts that coordinate behaviours (including norms, such as aviation laws, technical procedures, manuals, and institutions, such as air carriers, air navigation service providers, safety agencies).

In recent years, the field of Aviation has been developing and deploying automated technologies in order to move towards more computer-controlled procedures minimizing the risk of unexpected events. Taking up the “human/machine partnership” perspective of STSs, the European Aviation/ATM sector is working towards the enhancement of “human-centric” (and therefore “trustworthy”) automated systems, which preserve human control in all critical functions (EASA AI Roadamap 2020). This tendency shifts the human role to a more and more supervisory and non-“hands-on” capacity, which raises notable issues concerning safety, security and responsibility of the actors involved. The danger is that the system actions will not always be fully comprehensible to the human at the end of the action loop, and thus could potentially lead to faulty situation awareness and work overload, as the operator attempts to rationalize what exactly is happening in the automated system. The major reconfigurations of ATM which are being envisaged raise crucial questions as to the ability of human operators to understand what exactly is going on, and to be able to intervene if and when appropriate (Vermaas et al. 2011).

In discussing the move towards Next generation ATM, Sheridan (2009) notes that because of the limited empirical knowledge, humans are not good at many tasks related to workload, are inadequate monitors, slow in working out solutions and action plans, unable to successfully perform in multitasking, etc. Therefore, their role in a highly automated Aviation/ATM environment has to be carefully taken into account at all levels of the system life-cycle, in order to design and operate software, organizational modules and workflows which allow for a safe and effective human supervisory capacity.

A virtuous selection and implementation of roles in a highly automated Aviation system also plays a crucial part in the design of a clear and robust legal and regulatory framework, as well as in the consideration of the economic aspects for tomorrow's Aviation. In fact, the allocation of functions determines how responsibility, authority and hence liability is to be assigned; moreover, it influences other legal issues such as labour provisions, insurance, data governance and others.

2.2 Legal and regulatory framework of Aviation/ATM

The development, deployment, and use of highly automated technologies in Aviation and the consequent reconfiguration of roles and responsibilities call for a critical revision of the legal and regulatory issues related to the field.

In the remaining part of this chapter we describe the legal and regulatory framework involved in the SAFELAND concept. SAFELAND works in the context of SPO and envisions an operational phase which is of an "emergency" or at least "abnormal" kind, and shows the basic features of an RPAS. Hence, it tackles a complex of legal and regulative issues both of manned and unmanned aircrafts, of ordinary and "emergency" operations: its implementation shall then require to discuss and tailor an appropriate set of legal constraints and regulatory provisions.

In the following paragraphs, we will discuss (1) a brief legal and regulatory framework of Aviation (in this section); (2) the main regulatory scheme involved in the SAFELAND concept (SPO, RPAS, emergency operations), with desirable and/or needed reform possibilities (section 2.3); (3) the fundamental legal themes and concepts in Aviation, with particular reference to responsibility and liability (section 2.4); (4) other relevant legal aspects: Insurance and liability, Data governance and data protection, Security and Cyber-security issues (section 2.5-2.7).

2.2.1 The International Aviation System

Aviation safety and security of the air space are competencies of States in relation to their territory and the airspace of high seas managed by a specific State for ATM issues. The regulatory competence over security is strictly related to national sovereignty and autonoumusly performed by States, although ATM safety regulation and target setting (minimum levels) are set centrally and applied nationally.

In this context, international conventions and agreements are the natural instruments to regulate flights among different States and they provide a shared regulatory framework, aimed at both assuring the security and safety of international flights, and allocating competences and related liability.

The Chicago Convention

Among the international conventions on public air law, it is worth remembering the 1944 Convention on International Civil Aviation (the Chicago Convention), that has established the International Civil Aviation Organization (ICAO). Today, the ICAO has 191 contracting States (2013).

The Chicago Convention is based on of the principles of sovereignty of States over their own airspaces and of the equal opportunity and participation of every State in air transportation. To this end, a specialized agency of the United Nations, the International Civil Aviation Organization (ICAO), is in charge of the coordination and the regulation of international air travels.

The Chicago Convention establishes rules of airspace, aircraft registration and safety, and details the rights of the signatories in relation to air transport. The Chicago Convention reaffirms the sovereign powers States hold over their airspace in Article 1 which states: “The contracting States recognize that every State has complete and exclusive sovereignty over the airspace above its territory”. Article 28 governs air navigation facilities and standard systems, providing that "each contracting State undertakes, as far as it may find practicable, to: a) provide, in its territory, airports, radio services, meteorological services and other air navigation, in accordance with the standards and practices recommended or established from time to time, pursuant to this Convention; b) adopt and put into operation the appropriate standard systems of communications procedure, codes, markings, signals, lighting and other operational practices and rules which may be recommended or established from time to time, pursuant to this Convention […].”

Annex 2 of the Convention deals with the Rules of the Air, that is the rules relating to the conduct of visual and instrument flights.

Annex 11 of the Convention, which is specifically dedicated to Air traffic services, including air traffic control service, flight information service and alerting service, establishes the corresponding standards and practices. It contains an important requirement for States to implement systematic and appropriate air traffic services (ATS) safety management programmes.

Annex 10 of the Convention (Aeronautical telecommunications) deals with Standards and Recommended Practices (SARPs) on radio navigation aids used by aircraft.

Warsaw /Montreal system

The regulatory framework for airline companies’ liability in the event of damage caused to passengers, baggage or goods during international journeys is today provided by the Montreal Convention of 1999, a treaty that supersedes the system of liability originally envisaged by the Warsaw Convention.

The Montreal Convention provides a two-tier liability regime for damages in case of injury or death of passengers, comprising: (I) liability of the air carrier up to 113.100 SDR, irrespective of the carrier’s fault; (II) liability of the air carrier in excess of 113.100 SDR if it fails to prove that (a) the damage was not due to the negligence or other wrongful act or omission of the carrier or its servants or agents, or (b) such damage was solely due to the negligence or other wrongful act or omission of a third party (Article 21).

Air service providers may also be subject to national laws: this happens in those cases which are not covered by the Montreal Convention. In fact, the question concerning which cases are not covered by Montreal Convention is at the center of the international debate, as well as whether Montreal Convention preemts national laws.

The scope of the Montreal Convention has been extended to domestic transport within each single EU Member State by virtue of the Regulation (EC) No 889/2002 amending the previous Regulation (EC) No 2027/1997 on air carrier liability.

The Rome Convention

Aircraft operators are also subject to a special regime of liability for damages on the surface of the Earth, according to the 1952 Rome Convention. For example, they are strictly liable below a specific liability tier, which varies according to the weight of the aircraft. Moreover, airlines are liable without limits under the same convention, if the person who suffers damage proves that it was caused by a deliberate act or omission of the operator (or its employees or agents) done with intent to cause damage (art. 12 (1)). Personal injury claims are limited to 125,000 SDR per person killed or injured.

ANSPs

Art. 28 of the ICAO Convention requires each contracting state to “Provide, in its territory, airports, radio services, meteorological services and other air navigation facilities to facilitate international air navigation, in accordance with the standards and practices recommended or established from time to time, pursuant to this Convention”.

Most States have complied with the requirement of providing air services by establishing a national air service provider (ANSP) in the form of a State agency or autonomous corporation or even privatised company. ATS may be operated by another State than the one on the territory of which ATS is provided. Additionally, pursuant to Council Regulations (EC) No 549/2004, No 550/2004, No 551/2004 and No 552/2004 on the provision of air navigation services in the single European sky and to Commission Regulation (EC) No 2096/2005, air navigation service providers (ANSPs) may be certified in one Member State and provide services in another. In this case liability in relation of ATS is governed by national law, as well as by bilateral agreements on the cross-border provision of ATS. However, according with the above provisions of the Chicago Convention, States are the ultimate guarantors of the integrity, operational performance and reliability of their national ATS systems.

In the absence of a global or regional convention on the liability of ANS, the liability of air navigation service providers is governed by the national laws of the State over the territory of which the services are provided (Chatzipanagiotis 2007, Van Antwerpen 2008). In consideration of the sovereign nature of ANS, most national laws recognise the primary responsibility of the State, even if an independent body provides the services. A second approach places the service provider on the front liability line: in this case, the claims must be brought against the service provider, but the ultimate responsibility remains on the State. A third approach is that, when the ANS functions have been entrusted to a privatised entity, the State remains liable only for damages caused by its own, direct fault (.

ANSPs are also subject to vicarious civil liability (for torts of ATCOs and managers).

2.2.2 The European framework and the Single European Sky

With the aim of improving the efficiency of the European air space management and making the freedoms of movement more effective, the EU has established a common regulatory framework for ATM, namely the Single European Sky (SES).

The main innovations of the Single European Sky are the introduction of an operational concept of airspace and the standardisation of air navigation service performances. The new regulatory concept of airspace is based on the introduction of Functional Airspace Blocks (FABs), namely airspace areas established on operational requirements, regardless of national boundaries, where air navigation services should be delivered with a view to the optimisation of their performance. In this framework, EU takes a fundamental regulatory role in the establishment of the common objectives that should be achieved through the cooperation of the EU itself, the Member States and the other stakeholders interested in ATM.

SES I

A first regulatory package developing a European policy in ATM was adopted in 2004. it consists in 4 basic regulations, which reinforce safety and foster the restructuring of the European airspace and the air navigation services:

1. Framework regulation (EC No 549/2004) - laying down the framework for the creation of the Single European Sky (Art 9a(1) introduced FABs);

2. Service provision regulation (EC No 550/2004) - on the provision of air navigation services (ANS) in the Single European Sky;

3. Airspace regulation (EC No 551/2004) - on the organisation and use of airspace in the Single European Sky;

4. Interoperability regulation (EC No 552/2004) - on the interoperability of the European ATM network.

This regulatory package addresses the following domains: (1) Air navigation services (ANS), that are general air traffic services (namely, communication, navigation and surveillance services; meteorological services; aeronautical information services), delivered by public or private providers, certified by National Supervisory Authorities; (2) air traffic flow, which should be managed in such a way so that the air traffic capacity is utilised to the maximum extent compatible with safety of flights; (3) airspace, whose usage is to be maximised by dynamic time-sharing and on the basis of short- term needs; (4) interoperability among ATM networks in the EU (European ATM network - EATMN) and with third countries.

SES II

A second Single Sky legislative package (SES II) was adopted in 2009, and it is centered on Regulation 1070/2009 - Improving the Performance of European Aviation System (Reg. (EC) No 1070/2009), which amended the former legislation to address the growing demand for air transport by enhancing the infrastructure for traffic management. The SES II introduces a common Performance Scheme, new rules for integrating sefvice provisions into FABs, and the role of the Network Manager.

In particular, Reg. (EU) No 691/2010 laid down the performance schemes for air navigation services and network functions, established by art. 11 Reg. (EU) No 1070/2009. By availing itself of a system of measurable standards and alert thresholds, it identified a set of Key Performance Indicators (KPIs) and binding targets on the key areas of safety, environment, capacity and cost- efficiency.

Furthermore, Regulation (EC) N° 1808/2009) extended the competences of European Aviation Safety Agency (EASA) to air traffic management and to rulemaking support for technical implementing rules.

The EU Aviation Safety Agency (EASA)

These various pieces of legislation including those concerning licensing of air carriers have been subsequently amended by Regulation 2018/1139 which establishes the EU Aviation Safety Agency (EASA). In particular the Regulation sets the following rules:

a) It provides for the adoption of a European Aviation Safety Programme based on airworthiness and on environmental protection objectives. Personel in charge of the production of aircraft or its equipment should hold a specific license;

b) It regulates training, testing, and medical assessment of pilots and cabin crew.

c) Air traffic managers (ATMs) and Aviation navigation services (ANS) are required to be certified to operate in the Single European Sky;

d) Air traffic controllers (ATCOs) are required to hold a licence and undergo appropriate medical controls;

e) Third-country operators of aviation services, their pilots and crew flying to or from the EU are required to be certified and obtain an authorization;

f) It defines rules on the design, production, operation of unmanned aircrafts, and for the certification of remote pilots.

2.3 The Regulatory Framework of the SAFELAND concept

Civil aviation in Europe and, in particular, the ATM topics, are mainly regulated by European regulations issued by European political level (i.e. EP European Parliament and EC European Commission), developed by EASA, on the basis of ICAO Convention and related documents, such as Annexes, Docs and other ICAO documents. National regulation, published by State CAA Civil Aviation Authority, may integrate (and do not be at odds with) the European rules. Ancillary “not mandatory” documents (e.g. AMC Acceptable Means of Compliance, GM Guidance Material, CS Certification Specifications) are issued directly by EASA and “proposed” to the MS as recommendations, guidelines or technical guidance publications.

The most relevant regulations related to SAFELAND concept are provided in Table 2. Green rows are related to regulatory material that could be interested by amendments during the SAFELAND concept. In the following table the related domain of interest about each regulation is clearly shown.

Moreover, some comments are provided in order to clarify the approach that will be applied. The approach outlined below suggests proposing amendments mostly to AMC or/and GM. Amending "hard rules" would require long time.

Domain	Organisation	Regulatory material	Notes
RoA	ICAO	Annex 2 to Chicago Convention (CC) – Rules of the Air	Amending ICAO Annexes is very cumbersome and long. Amending SERA and notifying ICAO a difference per Art. 38 CC may suffice. SAFELAND should identify to which paragraphs of the Annex the EU "differences" could apply, if the SAFELAND recommendations to amend EU common rules were accepted.
RoA	European Commission (EC)	923/2012 – Standardised European Rules of the Air (SERA)	In its plans EASA has rulemaking task RMT.0476 for Regular update of SERA. Proposals could be related to this RMT.
RoA	EC	2016/1185 amending SERA	Not appropriate. This is only an 'amending' regulation to 923/2012. Amending 923/2012 through a new amending regulation would suffice.
RoA	EC	2020/469 amending SERA	Not appropriate for the same reasons in the row above.
Aviation safety	European Parliament (EP)	Basic Regulation 2018/1139	Basic EU Regulations are amended more or less every 10 years, through a long process involving EASA, Commission, Council of Ministers and EP. If possible, it would be better to 'interpret' 1139, instead than proposing amendments to a basic Regulation which is not even fully implemented.
ATM	ICAO	Annex 11 CC – Air Traffic Services	Amending ICAO Annexes is very cumbersome and long.

Domain	Organisation	Regulatory material	Notes
			Amending SERA and notifying ICAO a difference per Art. 38 CC may suffice. SAFELAND should identify to which paragraphs of the Annex the EU "differences" could apply, if the SAFELAND recommendations to amend EU common rules were accepted.
ATM	EC	2017/373 – Air Navigation Service Provision	This Regulation is agnostic in respect of technologies and procedures. Hence it could not be necessary to amend it.
PEL	ICAO	Annex 1 CC (including Amdt 175) – Personnel Licensing (PEL)	Amending ICAO Annexes is very cumbersome and long. Amending 1178 and notifying ICAO a difference per Art. 38 CC may suffice. SAFELAND should identify to which paragraphs of the Annex the EU "differences" could apply, if the SAFELAND recommendations to amend EU common rules were accepted.
PEL	JARUS	JARUS FCL	JARUS deliverables are only recommendations whose implementation is not even monitored. They are by no means legally binding. Not necessary to amend.
PEL	EC	2011/1178 – Crew requirements	This Regulation covers privileges of aircrews, Learning Objectives (LOs) for respective competency, schools and aeromedical centres. Amendment should possibly not cover privileges, which is a politically sensitive matter. Instead, recommendations for amendment should concentrate on LOs, if necessary.

Domain	Organisation	Regulatory material	Notes
			In fact, part of the training is responsibility of operator (e.g. type rating) and hence covered by 965/2012. It could be preferable to leave new LOs to type rating training under responsibility of the operator. For RP and related crew personnel, EASA is developing the RMT.0230 to include in the regulation the RP and related crew personnel requirements. In relation to SAFELAND, RMT.0230 is studying license for RP involved in IFR cargo flights in A-C airspace and operating from/to European aerodromes. The RMT.0230 highlights that the EASA rulemaking will be consistent with amdt 175 of Annex 1 (ICAO).
PEL	EC	2015/340 – ATCOs competency	Recommending the Regulation may not be necessary. If new LOs would be necessary, this can be implemented at the level of AMC.
PEL	EASA	AMC/GM to 2015/340 – ATCOs competency	Recommendations could possibly focus on AMC1 ATCO.D.010(a)(2)(vi) – Composition of initial training. AREA CONTROL SURVEILLANCE Rating (ACS) Training.
OPS	ICAO	Annex 6 CC – Aircraft Operations	Amending ICAO Annexes is very cumbersome and long. Amending 965 and notifying ICAO a difference per Art. 38 CC may suffice. SAFELAND should identify to which paragraphs of the Annex the EU “differences” could apply, if the SAFELAND recommendations to amend EU common rules were accepted.

Domain	Organisation	Regulatory material	Notes
OPS	EC	2012/965 – AIR-OPS	This regulation would require most of the SAFELAND attention. Proposals to amend legally binding rules should however be better kept to minimum (see the following row).
OPS	EASA	AMC/GM to 2012/965 – AIR-OPS	Better to recommend amending AMC or GM, instead than “hard rules”.
ADR	EC	2014/139 – Aerodromes	Since aerodromes have no role to manage traffic either in the air or on the manoeuvring area of an aerodrome, it may not be necessary to propose any amendment to 2014/139 or related AMC/GM. Mechanisms for coordination between ATS and ADR are already embedded into the Regulation.
LIA (liability)	EP	2004/785 – Insurance of aircraft operators	This Regulation is very politically sensitive and based on the Montreal Convention of 1999. However, the regulation does not contain any detail on the operational procedures or minimum crew on-board. SAFELAND should carefully consider this Regulation and confirm that in fact it would require no amendment, even if the project recommendations to amend SERA and AMC/GM to AIR-OPS would be accepted.
IAW	EASA	Certification Specification CS-25 (Large aeroplanes) and related AMC in “Book 2”	Better to propose amendments only to Book 2.
AIG	EC	2010/996 – Accident Investigation	This Regulation is agnostics in respect of technologies and procedures. It should therefore not be necessary to amend it.

Domain	Organisation	Regulatory material	Notes
AIG	EP	2014/376 – Occurrence reporting	EC has recently published a study which could lead to a legislative proposal by the Commission to amend this Regulation: https://op.europa.eu/en/publication-detail/-/publication/dabeabc8-3b60-11eb-b27b-01aa75ed71a1/ Since the Regulation is agnostic in respect of technologies and procedures, it may not be necessary to amend it.
AIG	EC	2015/1018 – Occurrences subject to mandatory reporting	SAFELAND has to check whether amendment is really necessary, since the wording of this Regulation is quite generic and therefore it may be already sufficient.
AIG	EC	2020/2034 – European Risk Classification Scheme (ERCS)	This Regulation on ERCS could be a very good tool to demonstrate that SAFELAND would add safety by comparing the status quo (alias 'do nothing') with the possible implementation of SAFELAND.
SEC	EP	300/2008 – Aviation Security	This Regulation applies at airports (i.e. security of people transiting through the airport, freight and material, as well as security personnel). Security and cyber-security issues shall not be considered in this phase and will be developed in following deliverables.
SEC	EC	COM 823/2020	EC has proposed a revision of the NIS Directive: https://ec.europa.eu/digital-single-market/news-redirect/696976 SAFELAND should assess whether any recommendations could be addressed to the EU Institutions in relation to the project proposals. Security and cyber-security issues shall not be considered in this phase and will be developed in following deliverables.

Table 2: List of relevant regulations.

The main regulatory areas affect by SAFELAND are described in the following sub-paragraphs.

2.3.1 Rules of the air

The Commission Implementing Regulation (EU) No 923/2012 of 26th September 2012 laid down the common rules of the air and operational provisions regarding services and procedures in air navigation and amended Implementing Regulation (EU) No 1035/2011 and Regulations (EC) No 1265/2007, (EC) No 1794/2006, (EC) No 730/2006, (EC) No 1033/2006 and (EU) No 255/2010.

Rulemaking task RMT.0476 could be used to update the acceptable means of compliance (AMC) and Rulemaking task RMT.0476 is intended to be used to regularly update the Commission Implementing guidance material (GM) associated to the Commission Implementing Regulation (EU) 923/2012.

Regular updates are issued based on the selection of non-complex, non-controversial or mature subjects originating from political requests, International Civil Aviation Organization (ICAO) developments, stakeholders and expert groups or individuals, which the European Aviation Safety Agency (EASA) has assessed as beneficial.

2.3.2 Personnel licensing and crew requirements

The general objective of this rulemaking task is to ensure a high and uniform level of safety in the Single European Sky context and to reflect the state of the art and best practices that should be applied by the MS. Personnel Licensing

AMC and GM to Part ATCO to Commission Regulation (EU) 2015/340 of 20th February 2015 provide requirements for the licensing of air traffic controllers.

Recommendations could be provided focusing on AMC1 ATCO.D.010(a)(2)(vi) regarding Area Control Surveillance rating (ACS) training.

For pilots (on board), EU Regulation 2011/1178 (*technical requirements and administrative procedures related to civil aviation aircrew*), amendment on LOs could be recommended.

Concerning the Remot Pilot in the GSO, one should consider EASA RMT.0230, which is starting to develop and to issue an NPA (notice of proposed amendment) for RP license. The document, of course, has to consider the wide spectrum of the ‘certified’ category and plans to address the ‘certified’ category in different phases. The NPA 1 is addressing three types of operations, when classified as UAS operations in the ‘certified’ category (as per Article 6 of (EU) 2019/947).

The first type of operation intends to ddress the “*Operations type #1: IFR operations of UAS for the carriage of cargo in airspace classes A-C, falling under ICAO scope and taking-off and landing at aerodromes under EASA’s scope*”. In the same document, EASA is developing the “Pilot 3-2-1 licensing concept”, which encompass a regulatory framework that will address all three types of operation with two different licences both of which are based on one training concept (hence the name 3-2-1 licensing concept).

The EASA initially RP licence for Certified operations, shall be aimed at "commercial cargo" but similar concept, in relation to SAFELAND, could be applied for "passenger aircraft", with additional requirements.

The document of EASA should be consistent with amdt 175 of Annex 1 (ICAO), in force next November 2022, focusing on Remote Pilot involved in IFR flights.

2.3.3 Aircraft operations

Air Operators in SAFELAND concepts could assume different roles comparing to current airline operators. With the provision of a GSO, and consequently with a Remote Pilot involvement, the Operator will assume additional functions, mainly in the planning phase but also during the flight of the aircraft.

The Commission Regulation (EU) No 965/2012 of 5th October 2012 laid down technical requirements and administrative procedures related to air operations pursuant to Regulation (EC) No 216/2008 of the European Parliament and of the Council.

Proposals to amend legally binding rules should be better kept to minimum. Therefore, amendments could be provided to AMC and GM to abovementioned regulation.

Concerning Annex 6, considering the difficulty to review the ICAO document, SAFELAND should "only" identify to which paragraphs of the Annex the EU "differences" could apply, after the SAFELAND recommendations to amend EU common rules were accepted.

2.3.4 Initial airworthiness

ICAO Annex 8 – Airworthiness of Aircraft together with ICAO Airworthiness Manual (Part V – State of Design and State of Manufacture) provides certification requirements for commercial aircraft.

Large aircrafts should follow CS-25 Large Aeroplane Certification to ensure the design of the various products and parts are fully compliant with all certification requirements.

Amendments to Book 2 of Certification Specifications and Acceptable Means of Compliance for Large Aeroplanes CS-25 could be needed in the SAFELAND concept.

In relation to SAFELAND concept, the "manned" aircraft turns into an "unmanned" aircraft, beacause of the GSO provision in case of single pilot full incapacitation and RP involvement. Thus, airworthiness shall be considered in relation to "automation" functions and GSO functions.

2.3.5 European risk classification scheme

The Commission Delegated Regulation (EU) 2020/2034 of 6th October 2020 supplementing Regulation (EU) No 376/2014 of the European Parliament and of the Council sets out the common European risk classification scheme (ERCS) for the determination of the safety risk of an occurrence. ERCS means the methodology applied for the assessment of the risk posed by an occurrence to civil aviation in the form of a safety risk score. This regulation became applicable on the 1st of January 2021.

The ERCS is characterised by two steps:

1. Determination of the values of severity and probability;
2. Determination of the safety risk score within the ERCS matrix based on the two determined values of variables.

The numerical equivalent score corresponding to the ERCS score is provided in Table 3.

ERCS Score	X9	X8	X7	X6	X5	X4	X3	X2	X1	X0
Corresponding numerical value	0,001	0,01	0,1	1	10	100	1000	10000	100000	1000000
ERCS Score	S9	S8	S7	S6	S5	S4	S3	S2	S1	S0
Corresponding numerical value	0,0005	0,005	0,05	0,5	5	50	500	5000	50000	500000
ERCS Score	M9	M8	M7	M6	M5	M4	M3	M2	M1	M0
Corresponding numerical value	0,0001	0,001	0,01	0,1	1	10	100	1000	10000	100000
ERCS Score	I9	I8	I7	I6	I5	I4	I3	I2	I1	I0
Corresponding numerical value	0,00001	0,0001	0,001	0,01	0,1	1	10	100	1000	10000
ERCS Score	E9	E8	E7	E6	E5	E4	E3	E2	E1	E0
Corresponding numerical value	0,000001	0,00001	0,0001	0,001	0,01	0,1	1	10	100	1000

Table 3: Numerical equivalent score.

Therefore, the ERCS may be adopted to determine the safety risk of an occurrence in the SAFELAND concept.

2.3.6 Level of automation

JARUS proposed five levels of automation regarding the methods of control of the UAS. In the same way, SAFELAND has to establish the level of onboard automation. This assumption will affect the responsibilities and duties of the involved actors.

The JARUS levels of automation are listed below:

- Level 0 – Piloted: The crew is responsible for all aspects of the operations including control of the aircraft, evaluating and responding to the aircraft and airspace environments, communicating with external systems, and managing the aircraft when failures present themselves.
- Level 1 – Assisted: Systems which have been automated up to this level are used to support the crew in performing their flight tasks.
- Level 2 – Task Reduction: As the ability of technology and confidence in its ability to perform tasks within a specific ODD is gained, the level of automation increases to the level where a system may take over that specific task in order to help the crew focus on more mission critical tasks.
- Level 3 – Supervised Automation: By expanding the capability of the automated systems to handle not only control of the aircraft, but monitoring and responding to changes in the

environment, the crew moves from actively operating the aircraft to actively monitoring the safety and effectivity of the operation.

- Level 4 – High Automation: Once the technology has demonstrated ability to perform entire flight tasks effectively and have a robust capability to respond to their environment, the crew may trust the autonomous flight system to operate without human supervision.
- Level 5 – Autonomous: At the far end of the spectrum is a fully autonomous flight operation. At this level of automation there is not only no human involvement in the operation, but likely no human awareness of dynamic operational parameters.

2.4 Main legal concepts: responsibility and liability

In this section we describe the main legal themes and concepts related to Aviation, with particular regard to the fields of application explored in SAFELAND. Law is a system of rules and practices aimed to prescribe, allow or prohibit certain behaviours of social relevance, and to assess and sanction the breach of those rules. As far as professional activities – like Aviation – are concerned, the objective of the law is to prescribe a set of standards related to the organization and execution of the given activity, and to guarantee against improper action and/or events prejudicial to all actors and stakeholders involved.

In this context, the notions of responsibility and liability for professional conduct are crucial in order to build a fair and trustworthy legal system. The two concepts are semantically ambiguous and are often used with different meanings in different contexts. We shall therefore briefly illustrate these two ideas from a legal point of view, in order to establish a clear and definite use thereof for the purposes of SAFELAND.

2.4.1 Responsibility

The idea of "responsibility", in a broad sense, plays a fundamental role in social life and applies to all domains where human actions – or omissions – have an impact on interests and values of others, and where such actions/omissions are viewed as generating evaluations for the concerned agents (ascriptions of merit/blame) and normative effects for those agents and for others (rewards, sanctions, obligations to repair, etc.).

As such, the notion of responsibility can be tackled by several perspectives, and has therefore several, correspondent shaded meanings (Hart 2008, Bovens 1998). It can be viewed as a "duty", i.e. an obligation to perform certain tasks; as "virtue", i.e. the ability of a person to behave in a way that is considered desirable; as "cause", i.e. the consideration that a person caused a certain event/outcome; as "blameworthiness", i.e. the violation of certain standards of behaviour in the execution of a task, generally connected with a harmful event/outcome; as "accountability", i.e. the obligation to give an explanation (an account) related to a harmful event/outcome; as "liability", i.e. the subjection to social sanctions prescribed for a harmful event/outcome. One can easily see how these meanings both differ and slightly overlap with each other, creating the need to clearly establish what we say when we use this term.

In order to capture the legal challenges of SAFELAND, we shall focus on three of these meanings: responsibility as a duty, or task-responsibility; responsibility as blameworthiness; responsibility as liability. Following a common terminology in the field of Aviation, we will refer to task-responsibility simply as “responsibility”; we will refer to blameworthiness as “fault” or “negligence”; we will refer to “liability- responsibility” as “liability” *tout court*.

In the context of SAFELAND, responsibility is therefore the duty endowed to an agent of performing the tasks related to a certain role in the operation of the aircraft and the related ATM. “Whenever a person occupies a distinctive place or office in social organisation in which specific duties are attached to provide for the welfare of others or to advance in some specific way the aims or purposes of the organization, he is properly said to be responsible for the performance of these duties, or for doing what is necessary to fulfil them” (Hart 2008).

Responsibility is connected with the notion of “role” and “tasks”. A role within a complex STS (such as Aviation/ATM) encompasses a set of tasks which cannot always clearly and precisely defined *a priori*, because their specification depends on the actual circumstances of the action, on the interplay between different roles and tasks and on other factors. From a legal perspective, it is important to find a right level of task-description which allows to clearly identify the essential parts of a task, on the one hand, and leaves a margin of indeterminacy useful for the agent to adapt her conduct to the specific circumstances of her action, on the other; such a balance enhances a correct and efficient execution of responsibilities, therefore lowering the potential for liability controversy.

The notion of responsibility is also connected to the concept of “authority”. Authority is the capacity of a person entrusted with a task to make a decision essential to the execution of the task.

2.4.2 Liability

The main sense in which the term “responsible” is used in legal contexts actually relates to liability. We can define liability as the capacity of being subject to certain legal consequences (sanctions) derived from a (blameworthy) action. When we say that a person is legally liable for a harmful event, we mean that all antecedent conditions for connecting the harm to that person are realised, so that the person is subject to the legal sanction (see Figure 1). Legal liability normally implies

- a harmful event;
- a causal link between the action of the person and the harmful event;
- whenever it comes into play (as it is in Aviation), the violation of a (tasks)-responsibility (a duty of care) by the concerned agent;
- The absence of possible justifications for the harmful conduct.

The third (and fourth) conditions highlight the moral grounds of legal liability: in the moral domain, one is the object of a moral reaction (blame) only when s/he caused harm by consciously or recklessly violating a duty; that is to say, when task-responsibility is paired with what we have called blameworthiness-responsibility. In governing STSs, we must ensure that legal liability and moral fault overlap as much as possible, according to the perception of the concerned individuals, so that legal liabilities are associated to facts providing grounds for moral blame (as should happen in the context of a just culture.

The allocation of liabilities is accompanied by certain defences (justifications, excuses). By providing a defence, the connection between the usual grounds of liability is undercut: even though the agent caused the harm and did not respect the standards to be followed, we do not view the agent as liable. Thus we refrain, even when the normal preconditions of liability are present, to view the person as liable, or at least we view the person's liability as diminished.

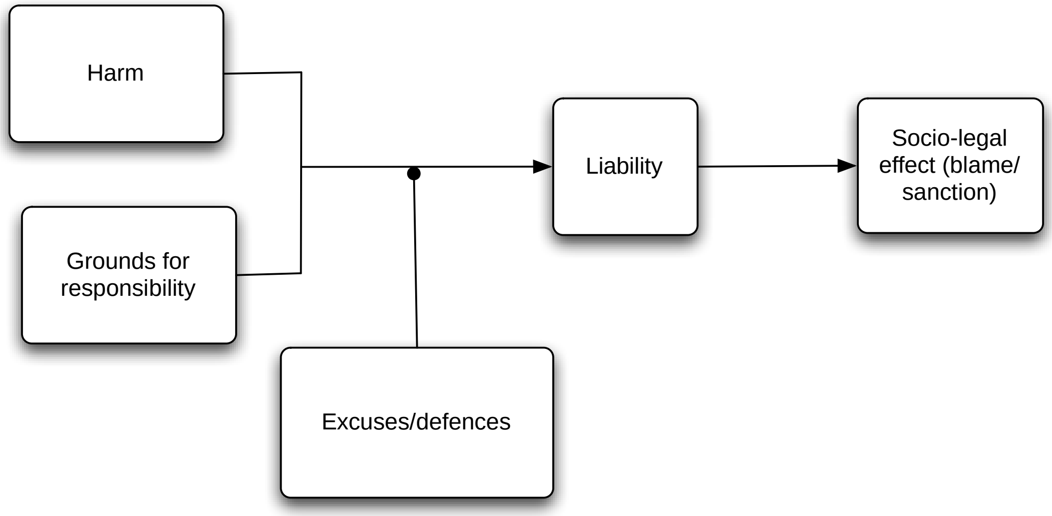

Figure 1: The process of attributing liability in Law

2.4.3 Strict liability and Product liability

The link between moral and legal domain breaks in the regimes of so-called "strict liability". In these instances, certain agents are liable for harmful events which are not (directly) connected to the agent's responsibility, i.e. duty. Such form of liability is justified with the need to preserve stakeholders from accidental / non-blameworthy harmful events in safety- and security-critical human activities. One of the most important cases of strict liability is "vicarious liability", i.e. the liability of the superior/employer for the acts of the subordinate/employee. This is particularly relevant in the Aviation system as it concerns the liability of the air carrier in the Montreal scheme. Another form of strict liability relevant for the SAFELAND concept is the so-called "product liability", i.e. the liability of manufacturers/distributors/retailers for harm caused by their product, which comes into play as far as the on-board and ground aviation automated systems weigh in on a harmful event.

2.4.4 Kinds of liability

We can distinguish four main kinds of liability (Figure 2):

- *criminal liability*, which presupposes a crime and may trigger imprisonment or to a fine (plus reparation),
- *civil liability*, which presupposes a tort or a breach of contract, and involves the obligation to repair (possibly increased beyond the value of the suffered harm, in case of punitive damages),

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- *administrative liability*, which presupposes the violation of an administrative rule or regulation, is enforced by a civil court or a regulator and involves a civil penalty (fine or withdrawal of privileges),
- *disciplinary liability*, which is applied by the employers to their employees for violations concerning work activities, and which may consist in sanctions such as reprimands, suspensions, or dismissals.

Not all agents can incur in these liabilities: criminal liability only concerns human beings (except in a few instances of corporate criminal liability, recognised in certain legal systems), civil liability concerns both humans and legal persons, as this is also the case for administrative liability. Disciplinary liability only concerns humans (maybe in the future it will address also the behaviour of intelligent robots). We have used the term administrative liability to cover any sanction different from compensation for harm and civil or criminal sanctions: thus, it covers such different things as fines for violation of traffic rules, penalties for insider trading, penalties for violations pertaining to air traffic. Often such penalties are established and enforced by the regulatory agencies in charge of the concerned domain (such as aviation authorities), but they may also be established through legislation and enforced through civil courts.

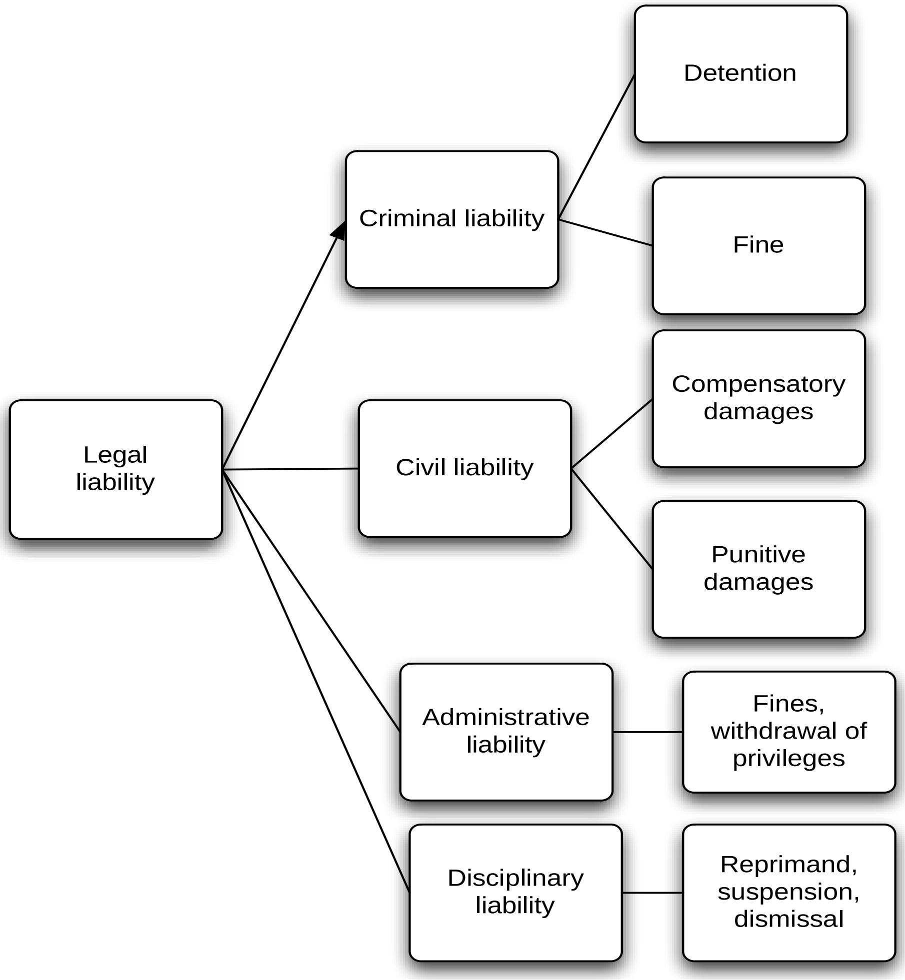

Figure 2: Kinds of Liability

2.4.5 Liability and evidence: the burden of proof

An important aspect of liability is its procedural dimension, namely the internal rules governing the legal proceeding where liability is assessed.

A key aspect in this phase is the issue of the burden of proof (*onus probandi*), namely a party's duty to prove a disputed assertion or charge. Usually, the party who makes a legal claim must prove the legal facts for that claim, i.e., the facts that according to the law are ordinarily sufficient reasons for the claim (Prakken and Sartor 2006). Such party usually bears the cost involved in presenting the evidence.

The burden of proof includes both the burden of persuasion and the burden of production. The burden of persuasion may be defined as the task to prove a proposition according to some standard of proof, carrying the risk of losing if the evidence provided in support of such proposition fails to convince the jury or the judge. The burden of production is the burden of going forward with the evidence, of producing enough evidence so that a particular issue is raised and must be addressed by the fact finder.

The rules governing the burden of proof compel the judge to decide a case even though there is a remaining uncertainty on factual issues. If the evaluation of evidence does not lead to the necessary belief of the court that the party's allegation is true, the burden of proof rule enables the judge to further proceed in the case, by considering to be not true the non-proven allegation.

A central issue is the way such burden should be distributed between parties. In this regard, we should distinguish between two basic types of court procedures:

(1) criminal litigation: the public prosecutor investigates, determines certain facts to his satisfaction and initiates proceedings. The prosecutor alone bears the burden of proving in trial that the accused person did in fact commit the criminal act in question;

(2) civil proceedings: they are initiated by one of the litigant parties. The alleged facts are introduced by the moving parties (burden of production). The burden of proof is, however, distributed between the litigants, while in criminal law—at least in principle—the burden of proof is on the prosecutor.

In civil law proceedings, the instances of strict liability lower the need to back claims with proof. With particular regard to product liability, the injured party is requested to prove only the damage and the defect of the product. However, proving the defect may be still difficult, especially in case of design defects, that is the kind of defect where the product is designed in such a way that it carries an inherent risk of harm in normal use. In case of design defect, the injured is required to prove both the existence of the alleged defect and that there existed a feasible alternative to the manufacturer's selected design.

2.4.6 Responsibility and liability: functions and actors

The responsibility and liability issues discussed above ought to guide the design and implementation of the SAFELAND concept, with particular regard to the functions and responsibilities allocated to each actor involved in the safe landing of a SPO aircraft in case of pilot incapacitation. The function allocation should allow for a clear and balanced distribution of tasks and – most importantly – of the relations between single functions in the workflow of operations, taking into account possible failure-scenarios.

The main actors involved in SAFELAND are the GSO/remote pilot, the ATCO, the automated system.

2.4.6.1 (Remote) Pilot-in-Command

In the aircraft-operational activities, a preminent role is played by the Pilot-in-Command (PIC). According to International regulations, the PIC is «the pilot designated […] as being in command and charged with the safe conduct of a flight" (CC, Annex 2 Rules of the air, § 1 Definitions); as such, s/he «shall, whether manipulating the controls or not, be responsible for the operation of the aircraft in accordance with the rules of the air» (CC, Annex 2 Rules of the air, § 2.3.1 Responsibility of pilot-in-command). This is normally referred to as the "ultimate responsibility" of the PIC with regard to the aircraft operations.

As seen in section 2.2.2, as far as civil liability is concerned, under the Montreal/Rome Convention system the Air Carrier bears liability for all harmful events concerning their aircrafts and their employees. However, the personal liability of the employee (in this case, of the PIC) comes into play with regard to the compensation cap, as well as insurance issues. Furthermore, the organizational role of ANSPs is relevant in terms of and administrative liability and compensation recovery.

In the SAFELAND concept it is the GSO who shall assume the role of PIC, and therefore act as a Remote PIC (RPIC). A "combined" GSO-RPIC role emerges thereby, which shall include both funtions and responsibilities of a multi-flight monitoring entity (the GSO) which may – but only in rare cases – turn into a remote pilot of one of the monitored aircrafts. This shall require a careful design if its specific features, with regard to operations but also to training and licencing (incl. type rate) of RPIC and crew, and so on. The process shall take into account and integrate existing/forthcoming regulation concerning RPAS (including Amendment 175 to Annex 1 CC, ICAO Manual for RPAS, UE Reg. 2011/1178 on Crew requirements and EASA RMT.0230, see section 2.3).

2.4.6.2 Air Traffic Control

The liability regime of ATCOs is still lacking clear, general provisions at International and European level, Therefore, liability of ATS is linked to civil law provisions of single national States and encompasses personal liability of ATCOs as well as liability of Providers. While the Montreal/Rome system absorbs much of the liability contention on the Air Carrier, the responsibilities of the ATCO are still relevant as far as the redress cap is concerned. Thus, a clear allocation of ATC tasks in the SAFELAND concept is advisable for liability purposes.

2.4.6.3 Automation

The ever-increasing role of highly automated systems poses the problem of product liability and the role of humans, as described above (section 2.1). In the European Union, the development of Automation and Artificial Intelligence is aimed at the principle of the Human-in-control, i.e. human supervision and intervention should be provided for in all critical automated tasks (EASA Artificial Intelligence Roadmap 2020).

This principle is incorporated in the SAFELAND concept. Consequently, a clear distribution of roles and tasks is essential in order to determine the related set of liabilities of the automated system (in the form of product liability) and human liability (namely of the PIC and ATCOs) for supervision and intervention in case of automation fault. As we shall see (section 3), this aspect still needs specification in SAFELAND.

2.4.6.4 Company employing the GSO

A set of additional legal issues may arise in case the SAFELAND concept may foresee a situation in which the GSO is not an agent/servant of the air carrier of the involved flight, but rather an employer of a company providing a service of remote piloting and/or ground support towards one or more air carries. This may be foreseeable in case of small air carries.

In such a case, the analysis would focus on the legal issues – in particular the liability allocation – that may arise from the interplay of three actors: the GSO, the company/entity employing the GSO, and the air carrier of the involved flight. The liability of these actors will be governed not only by international agreements/conventions and national laws (including the navigation code, the civil and criminal code), but also by contracts between the parties, including employment contracts. In this context, the main problem is to assess whether and to what extent liability shall be reallocated between the company employing the GSO and the air carrier.

On this regard it may be partially relevant, by analogy, to the scenario of wet-lease, namely the contractual arrangement according to which one airline (the lessor) provides an aircraft, its crew, maintenance and insurance to another airline or other companies providing air travel services (the lessee). International case law does not provide a unique answer, since it depends mainly on the application on national laws. However, as a very general rule, usually the liability of lessor is limited or preempted, while the lessee is under a higher liability risk both with regard to passengers and third parties). Contractual agreements provide the best way for involved parties to regulate liability allocation, introduce adequate indemnification provisions and other contractual safeguards, and provide appropriate insurance.

Besides, concerning issues of liability in the event of accidents involving more actors than on a air carriers, it may be relevant also to refer to the provisions of Council Regulation (EC) No 2027/97, (as amended by Regulation (EC) No 889/2002)[1], that implements and extend within the EU the rules of the Montreal Convention.

According to art. 1(a) of the Regulation, "'air carrier' shall mean an air transport undertaking with a valid operating licence;", while according to Annex "If the air carrier actually performing the flight is not the same as the contracting air carrier, the passenger has the right to address a complaint or to make a claim for damages against either. [...]". Therefore, to the extent that the company employing the GSO may be considered an air carrier for the purposes of the Regulation, the air carrier and the company may be jointly and severally liable for damages in flights.

Moreover, concerning damages to third parties on the ground, the provisions of Rome Convention may also be relevant. Concerning the liability of the operator, the convention (art 2(2)) states that "(a) For the purposes of this Convention the term "operator" shall mean the person who was making use of the aircraft at the time the damage was caused [..] b) A person shall be considered to be making use of an aircraft when he is using it personally or when his servants or agents are using the aircraft in the course of their employment, whether or not within the scope of their authority." Then, Art 2(3) states that "The registered owner of the aircraft shall be presumed to be the operator and shall be liable as such unless, in the proceedings for the determination of his liability, he proves that some other person was the operator".

Therefore, in the context of SAFELAND, precise contractual rules shall be drafted to define formally how and to what extent the transfer of control to the GSO implies a transfer of use between the owner/air carrier and the company employing the GSO.

An additional element of complexity is the fact that different courts under different jurisdictions, have given different interpretations to the terms "agent" and "servant" when applying domestic and international laws (Diederiks-Verschoor and M. Butler 2006, p. 37).

In conclusion, in case the SAFELAND concept may foresee a situation in which the GSO is not an agent/servant of the air carrier of the involved flight, a set of legal instruments identifying with clear lines the respective positions and roles of GSO /company employing GSO /air carrier are needed, in

[1] Regulation (EC) No 889/2002 of the European Parliament and of the Council of 13 May 2002 amending Council Regulation (EC) No 2027/97 on air carrier liability in the event of accidents

particular with the perspective of regulating the allocation of liability, the use of the aircraft, and the identification of agents and servant. Moreover, appropriate insurance policies shall be defined to cover the liability risk of the involved parties, in particular for damages compensation towards passengers and third parties.

2.5 Liability and insurance

Insurance complements the civil liability regime providing a way to reallocate financial risk emerging from liability. Generally speaking, the risk that cannot be prevented can be transferred to the parties who can bear its consequences. To this end, insurance instruments can help mitigate risks by sharing the related costs between the insured (the risk taker) and the insurer (who bears the risk). Insurance companies may typically intervene to cover (Leloudas 2009):

(1) damages suffered in case of aviation hull insurance, which usually covers loss of or damage to the aircraft caused by fire, theft, collision loss (both in-flight and ground risks). In some countries loss or damage resulting from the insured's own fault may be excluded from the insurer's liability, in others the insurer may be still held liable;

(2) the air carrier's liability, including not only the liability of the carrier for passengers, luggage and cargo; but also

(3) third party liability, resulting from damages (death, personal injury, loss or damage to property) to third parties;

(4) flying and ATC personnel insurances, usually under collective personal accident policies.

In policies, liability caps are usually inserted. Liability insurance may be mandatory[2] (up to a certain cap), and additional insurance may be purchased by the insured party.

Insurers have a right of subrogation, i.e., a right to recover the amount from third parties (that is not the insured party) at fault. The final impact of the liability regime is also determined by the possibility of recourse: a damaged party (or its insurer, if it has already paid the compensation) may have the right to recover some or all of the paid some from a third party, who caused the damage or contributed to its causation. This is the case in particular for Air carriers, who have the obligation to compensate

[2] All ATM service providers operating in the EU internal market should be covered by a professional liability insurance, as established by art. 6 of Reg. (EC) No 550/2004. Concerning airline companies, after the 2001 terrorist attacks, the EU introduced a regulation aimed to strengthen aviation insurance coverage in order to foster consumer protection and avoid distortion of competition between air carriers. Reg. (EC) No 785/2004 of the European Parliament and of the Council of 21 April 2004, on insurance requirements for air carriers and aircraft operators, established minimum insurance requirements for air carriers and aircraft operators in respect of passengers, baggage, cargo and third parties, for both commercial and private flights flying within, into, out of, or over the territory of an EU country.

the passenger, but have recourse against other actors (e.g., or Air service providers) in case they had a role in the causation of the damage.

2.6 Data protection and data governance

In the context of SAFELAND, the most relevant data protection issue concerns the processing of pilotpersonal sensitive data: such data will be collected by sensors, recorded and analysed by the automation. Then, decisions (and in particular fully automated decisions) will be taken on the basis of the analysis of personal data, and both decisions and (possibly) part of the sensitive information concering the pilot will be communicated to third parties (i.e. GSO and ATC).

All these activities shall be carried out in compliance, first of all, with all the rules of the EU GDPR (General Data Protection Regulation - Regulation (EU) 2016/679), and in particular:

- Art. 5(1)(b): principle of “purpose limitation”: “…personal data shall be […] collected for specified, explicit and legitimate purposes and not further processed in a manner that is incompatible with those purposes”

- Art. 5(1)(c): principle of “data minimisation”: “…personal data shall be […] adequate, relevant and limited to what is necessary in relation to the purposes for which they are processed”

- Art. 9, which establishes several conditions and constrains for the "processing of special categories of personal data”, including "data concerning health” (Member States have a right to impose further conditions).

- Art. 22, which sets out the rules and the conditions for automated individual decision-making, including measures to safeguard the data subject’s rights and freedoms.

Other articles of the GDPR may impose further obligations, in particular with regard to safety and security. For example Art 35(1) ("Data protection impact assessment”) shall apply to data processing within SAFELAND: “...Where a type of processing in particular using new technologies, and taking into account the nature, scope, context and purposes of the processing, is likely to result in a high risk to the rights and freedoms of natural persons, the controller shall, prior to the processing, carry out an assessment of the impact of the envisaged processing operations on the protection of personal data"

In the context of SAFELAND, personal health data are collected for the specific and explicit purpose of safety. Therefore, such data cannot be further processed for other purposes, unless such purposes are specifically identified and made explicit. Moreover, only the data that are relevant for the specific purpose of safety can be collected (again, unless other purposes are specifically identified and made explicit).

In particular, two further purposes may be problematic: 1) the purpose of controlling the employee's job performance; 2) the purpose of evaluating/ranking employees, on the basis of their health conditions. Both the 2 purposes may be problematic and strictly limited by national labour law provisions.

All these issues concerning personal data shall be part of a complete assessment of the legal issues of data (both personal and non-personal data).

2.7 Security and cyber-security

Security / cyber-security aspects will be considered in detail in D3.4 *Final Evaluation Results & New Systems*.

3 Legal and regulatory analysis of the SAFELAND Concept

3.1 Common aspects and problems.

The SAFELAND concept entails the merging of SPO with a remotely piloted phase for the safe landing of the aircraft. The approach brings about a series a legal and regulatory issues which mainly concern:

- allocation of functions/responsibilities and possible significant alterations of roles (e.g. ATCOs)
- the relative allocation of liabilities among the actors, with related insurance problems
- the fundamental role of the Pilot-in Command, and its relation with the automated system in the SAFELAND operations
- training and licencing of new roles (e.g. GSO-RP);
- certification of automated systems.

At this stage of the concept development, however, not all isles shine curly in the gulf, since a clear and specific structure of the SAFELAND operations has not been identified yet. Therefore, we will focus on the main issues concerning the role of the Remote Pilot as a Pilot-in-Command, and the relations of the latter with other actors, and particularly with automation, in order to establish clear liability schemes. Issues are presented at a high level and shall be further specified along with the development of the Final concept and its Validation phase in the next steps of the SAFELAND project.

As illustrated in D1.2 *SAFELAND Initial concept*, three possible concept implementation options have been discussed and laid out, focusing respectively on a primary role of the GS, of the ATC, and of the automated system. In this paragraph we will focus on the constraints common to the three options. Paragraph 3.2 will then identify option-specific issues.

3.1.1 Automated tasks and authority of the Pilot-in-command

In the current legal and regulatory framework, it is necessary to identify a Pilot-in-command (PIC) as final authority on the safe conduct of the flight. The PIC is a figure that in normal flight conditions coincides with the captain on board the aircraft. In the case of an SPO where the on-board pilot is incapacitated the new PIC is in fact a Remote Pilot-in-Command (RPIC) supporting SPO. It is therefore necessary to define a rule for the transmission of control.

The possibility of having the Automation in full control as RPIC is not feasible in the SAFELAND context: according to EU laws, EU-OPS 1, detailed in Commission Regulation (EC) No 859/2008, the final authority is assigned to a qualified pilot (the commander) (OPS 1.090 - Authority of the commander), that may delegate conduct of the flight only to another qualified commander or pilot (Appendix 1 to OPS 1.940 - In-flight relief of flight crew members). Therefore, given the current legal framework, a complete transfer of the final authority to a machine is impossible (or at least, it would create a very high legal risk). However, rules may establish a duty for the pilot to follow instructions issued by a machine (i.e. TCAS II MOPS, namely EUROCAE ED-143/RTCA DO- 185B). As will be presented in the next sections, the involvement of ATCO as RPIC is not advisable from a legal point of view.

In these scenarios the Pilot-In-Command is a monitoring entity, with the capability of accepting or overriding the actions of the other entities involved (i.e. the automation system). To effectively exercise the control authority, even when he is not directly in control of the commands, the PIC must have all the data to evaluate the actions taken by the aircraft.

The new figure of RPIC needs to be trained in these new tasks, and the manuals need to explicitly define his role and tasks in detail. There might also be futher certifications and licencing changes for the new PIC figure (see 2.3).

Once the RPIC has been identified, the next step is to determine the precise relation between the different agents involved. The two main interactions coming into play are (1) the interaction with the automated system (see 3.1.2), and (2) the relation with other human agents and with ATCOs in particular.

As to the second instance, even though the final authority lies on the RPIC, the other entities involved in the flight operations - including the ATCO - are responsible for their tasks and can be considered liable if their actions concur to a harmful event (section 2.4.1). The final regime of civil liability will be the traditional one for aviation and ATM: on the one side, Air Carriers will be on the front-line of liability, according to the rules of the Montreal system, so that the conduct of their agents and servants (including pilots) will also be relevant. On the other side, ATS providers may be involved in liability distribution, usually according to national rules, so that the conduct of their employees (including ATCOs) will be relevant under the regime of vicarious liability. Therefore, from a legal standpoint it is advisable to design a set of SAFELAND functions which maintains a clear responsibility allocation for actors other than the RPIC, even in the case of functions subject to the “ultimate responsibility” and “final authority” of the captain.

3.1.2 High automation and human supervision of critical situations

In order to establish a clear allocation of liabilities between automation and human actors (particularly humans supervising technology) the relative allocation of tasks and relations between automation and human supervisors involved in the SAFELAND concept needs to be descripted in detail.

Such level of description has not yet been reached in the project: therefore, it is hard to envision a precise distribution of liability for product malfunction and human supervision. From a legal point of view, it is advisable to engage in a sufficiently detailed task allocation as early as possible in the design phase of a STS such as the SAFELAND concept.

In general terms, product liability is harder to enhance: no strict liability is provided for, fault (product defect) needs to be proved by the plaintiff. On the other hand, there is no compensation cap as with Montreal regime. Problem with insurance also arise since no insurance framework for Aviation technology employ is currently in place.

3.2 Aspects and problems specific to each implementation option

In this section the different liability concerns are analyzed for each implementation option, in order to identify possible similarities or critical issues. As already noted, a complete description of the issues is not yet feasible, in this early phase of the project, and a risk analysis is necessary to properly identify possible concept failures and mitigation measures.

3.2.1 The ATC option

In the current regulatory framework, we can easily identify a big liability problem regarding the ATC implementation option.

As the discussion in the workshop has widely pointed out (D1.2 *SAFELAND Intial concept*), in this scenario the responsibility that would be assigned to ATCO is very different from his current role and training. If we stay in the existing legal/regulatory framework, the main question in this phase is whether the dedicated ATCO could assume the role of Pilot-in-command. This possibility has been discussed, but the consensus points to the fact that legally speaking it is better to leave the liability to the AOCC/GSO. To further expand the responsibilities (and liability) of ATCO, it would be necessary to redefine the ATCO role and training to include the responsibilities of a pilot for each specific aircraft. This would in turn require changes in the licensing approach. All these changes need to be considered in a cost analysis of the option.

The other solution proposed in this option is to give ATCO the responsibility for some critical choices, but keep the liability in AOCC/GSO, as defined in the Montreal Convention. Since ATCO is the one with the complete view of the situation, he would be the one proposing the new flight plan, uploading the plan to the FMS, etc, ("controlling the flight"). According to this reasoning, ATCO is the person responsible for these actions, even if he is not liable in case of accidents. The airline remains liable, and could, in case of negligence on the part of the ATCO, advance a request recourse action against the relevant ATS in a second moment.

In this option it was decided to give GSO a monitoring task, to maintain the liable entity (AOCC) in the decision loop. He retains the ultimate authority and sole ability to access the autopilot system. In case of disagreement between ATCO and GSO, the latter can request a new flight plan. ATCO would submit the new flight plan again to the GSO for approval. Being a pilot, the GSO is the main party responsible for the aviate and secondary flight controls of the aircraft. These functions cannot be easily passed on to the ATCO.

In this second version of the ATCO option there is a disconnection between the holder of liability and responsibility. Liability is assigned to the airline (where the GSO is located), while the responsibility for critical decision-making is assigned to the dedicated ATCO. Such disconnection is certainly undesirable from a legal standpoint.

Finally, it is important to consider that the aircraft is in an emergency situation, so it might be possible that decisions on the flight plan need to be expedited. This could induce the GSO to accept a flight plan he does not fully agree with, to avoid losing precious time. The opposite might also be true, GSO might be compelled to send back every ATCO proposal, since he is the liable party.

3.2.2 The GS option

The GSO option is the closest to the current emergency landing management, with minimal changes needed (both in certification and regulation). The parties involved (ATCO, GSO, Automation) maintain roughly the same responsibilities they have now, with further roles given to Automation in assisting the GSO in the different flight phases.

The GSO becomes the RPIC and as such is liable (through the AOCC) while at the same time being the responsible party for the critical decision-making. GSO is an employee of AOCC, and thus needs to be trained and type-rated licenced for the specific models of aircraft s/he will be monitoring and piloting.

The GSO is the final authority on the decision of the landing airport and managing the plan in the FMS/automation. It is worth considering that the GSO is monitoring multiple flights ahead of the emergency situation. In that moment he must switch to being a dedicated GSO and must be made aware of every fact concerning the endangered flight.

ATCO, AOCC and Automation assist in these functions. AOCC defines the internal airline rules, identifies the preferred airports, etc. The ATCO is responsible for providing the path and clearances, with a role similar the the current management of emergency situations.

From the function allocation diagram set up in D1.2 it emerges that the automation is still responsible for some functions on its own, like in the aviate phase. In these moments, the role of the GSO/PIC is not just a mere observer, but it must also be clearly defined when and how he can intervene. The assumption being that if the GSO is the liable party, he must be able to intervene if it is necessary.

In the SAFELAND project we are assuming that the automation involved is highly evolved, and able to sustain most flight functions without the necessity of human intervention. This could determine a different role for GSO: is GSO monitoring and waiting for a request of intervention by the automation (in case of necessity), or is he in full overriding control? In the GSO option the idea is to give the GSO the ultimate overriding authority, to enable a proper monitoring function. It is thus the GSO that can determine when to take control from the automation, with a clear liability implication.

In the final phases of flight, namely approach and landing, it is necessary to determine whether the GSO needs to take manual control of the aircraft, or whether he can continue monitoring the automation while the aircraft is landing according to the flight plan. In both cases he must have an overriding authority over the actions of the automation, to be considered in control.

The GSO option is most in line with current regulations and does not force a different vision of PIC and liability/responsibility relation.

3.2.3 The Automation option

The Automation option is not too dissimilar from the GSO option. To keep in line with the current regulatory framework it was decided to maintain GSO as PIC, with a greater role on the assistance of Automation.

Although we are assuming that we have a high degree of automation, it is also true that we must maintain a human in the loop, the GSO. The human GSO would thus have a direct role in monitoring and intervening in the different functions of flight.

In the final phases of the emergency flight (approach and landing) the automation is assumed to be sophisticated enough to complete the landing procedure. As described in D1.2 the GSO would upload a flight plan containing the full landing procedure.

In a highly automated system as this it is necessary to define what the GSO is able to do. If GSO is liable for the actions implemented by automation he needs to be able to override/intervene. For this to be possible the GSO must be put in the proper condition, given all the necessary data, and have enough time to make his own mind without too much influence from the automation.

Since the human would intervene only in cases in which he is overriding the automation, he might doubt his ability to intervene in such a short timeframe. The training on human-machine interaction is crucial, to familiarize the GSO with his role.

An important question in this implementation option is if the GSO (currently the PIC) can always override the decision of the automation or if there are some actions on which it cannot intervene. In the latter case it is necessary to ask whether GSO can still be considered liable for these actions. If we again assume that the human is in control of all the phases of the safe landing, it is important to determine precisely the liability related to different possible issues. To do that a risk analysis is needed.

In highly automated systems we can assume that there is also the possibility of product liability assigned to the producer of the automation system (or the entity responsible for the update/maintenance, the airline?), in case of bugs, implementation issues, or issues derived from a bad user interface to the pilot/GSO. This does not preclude the existence of liability on the AOCC/GSO, as defined in the Montreal Convention.

If we look at the LOAT definitions as a guideline for the human-machine interaction (Contissa et al. 2018) in this option, we can consider the ideal levels for the SAFELAND concept to be the ones that still rely heavily on human control and admit the possibility of final intervention (LOAT levels C4-C6 as to Decision making, levels D5-D7 as to Action execution).

3.3 Conclusions

The legal and regulatory analysis of the SAFELAND concept and its implementation variants highlights two main issues: the allocation of functions in the safe-landing operations, particularly between the PIC (therefore, the GSO) and the automated system, and the related allocation of liabilities. The allocation of functions brings about several other issues like insurance, system certification and crew training/licencing (see 3.1), which were not treated in detail at this stage.

In all three options, the main legal issue concerns the scope of authority of the GSO acting as RPIC. SAFELAND assumes the presence of highly advanced automation system which shall be able to conduct many functions with mere human monitoring. In these instances, the precise forms of monitoring and intervention by the RPIC must be clearly identified, in order to define the precise boundaries of her liability in case of harmful events. In turn, this calls for an extensive and detailed specification of automation requirements, which shall form the ground for product liability as to the tasks which are allocated to the automated system.

As to the specific features of the implementation options, In the ATCO option more changes to the technical and legal framework need to be introduced. Mainly these additional requirements are necessary because the ATCO is not a pilot, thus would have to be trained and licenced as one. Even if the ATCO could become a licensed pilot, there is still the issue of liability. In nominal conditions, the liable entity in case of an accident is the Air Carrier (According to the Montreal Convention), as the employer of the PIC. The ATCO is not an employee of an Air Carrier, so the liability would probably rely on the ATS. In consideration of this, this option does not appear desirable from a legal point of view.

The GSO and Automation solutions are similar, with the main difference being the degree of involvement of automation in the different flight tasks. In both these scenarios the PIC is the GSO. The GSO could be an employee of the AOCC, thus leaving the liability, as it is today, to the Air Carrier. While these options are indeed closer to the current system (from a legal standpoint) there are stil issues to solve and clarify, as discussed in the previous chapters. However, neither seem to pose strict legal blocking isues.

4 Economic analysis of SAFELAND

The numbers reported in this chapter are from different sources and were in part estimated before the COVID-19 pandemic. Since no one knows what the impact of the pandemic on the aviation industry will be, the long-term effects of the COVID-19 pandemic cannot be accurately estimated, yet.

In order to estimate the economic impact that the introduction of single piloted aircraft may have on airlines, it is inevitable to first look at the current forecasts regarding aircraft and pilot demand for the years to come. Airbus and Boeing conducted forecasts for the time period of 2019-2038 and 2020-2039, respectively. Airbus reports the need for 39,213 new commercial aircraft (100+ seats and 10t+ freighters) and 550,000 new pilots (Airbus, 2019). Boeing's numbers are slightly different but show the same trend as Airbus's calculations. According to Boeing, out of 48,400 active aircraft in 2039, 43,110 new aircraft and 605,000 new pilots (Boeing, 2020a; Boeing 2020b) will be needed for the time period of 2020-2039.

In 2019, the FAA reported that the number of student pilots increased by 18,863 from 2017 to 2018. However, roughly 36,683 new pilots would be needed every year for the time span of 2018-2037 (FAA, 2019). As such, airlines will need to double the number of new student pilots in order to meet the future pilot demand and prevent a massive pilot shortage (Caraway, 2020). One solution to approach the pilot shortage issue may be in the introduction of single pilot operations (SPO) in the commercial aviation sector. Compared to conventional, dual pilot operations, the pilot demand should be significantly less for SPO.

Calculations by Malik and Gollnick (2016) show that the introduction of SPO bears the potential of cost savings of 4% to 7% in annual direct operating costs of domestic airlines compared to baseline operations (conventional, dual-pilot operations). However, for long haul scenarios, the cost saving diminishes to about 1%. It is worth noting that Malik and Gollnick (2016) assumed the presence of a ground control station (GCS) with a ground pilot to monitor and possibly "take over as back up control in case of acute automation failure" (Malik and Gollnick, 2016; p.2).

By dividing the number of aircraft needed by the number of pilots needed, one gets an estimate of the number of pilots needed per aircraft, which for both, Airbus and Boeing, is 14. Considering the potential need for a GCS monitoring several aircraft, this number may not be cut in half, but it may be concluded that if all aircraft were single piloted aircraft, the number of pilots needed per aircraft would decrease significantly. Hereby, the qualification needs of the ground station operator play a major role. If the GCS operator were to take control over the aircraft in the case of single pilot incapacitation and/or automation failure, they would need to be type rated (remote) pilots and would most likely be more expensive than a ground station operator without a type rating. Malik and Gollnick (2016) further conclude that profitability of SPO increases when multiple aircraft are being monitored from one GCS.

Further, Airbus's and Boeing's estimations show that there will be a considerably higher need for small/single aisle regional aircraft than for medium and large/widebody aircraft and freighters (cf. Table 4). In terms of crew costs, the introduction of SPO would especially benefit these smaller aircraft categories, since the crew cost as percentage of aircraft operating cost increases with decreasing aircraft size category (Bilimoria, Johnson & Schutte, 2014).

Airbus	**Category**	**Small**	**Medium**	**Large**		**Sum**
	Amount	29,724 (75.80%)	5,373 (13.70%)	4,116 (10.50%)		39,213 (100%)
Boeing	**Category**	**Regional Jet**	**Single Aisle**	**Widebody**	**Freighters**	**Sum**
	Amount	2,430 (5.63%)	32,270 (74.86%)	7,480 (17.35%)	930 (2.16%)	43,110 (100%)

Table 4: Forecast of aircraft deliveries for Airbus and Boeing per aircraft category.

Note: The categories are not the same for Airbus and Boeing.

4.1 Definition of terms

Term	Definition
Cost	A cost is the monetary value of the investment that is used up to produce or acquire the benefit (SJU, 2016).
Implementation Costs	Costs unique for the installation and/or implementation of a newly developed system.
Operating costs	Costs for operating a new system (incl. only delta costs, i.e. changes to the operating costs this project/system will bring when developed) (SJU, 2016b)
Personal & Training Costs	Changes in costs for staff, training due to operational improvements implemented (SJU, 2016b)

Table 5: Definition of the terms used within the economic analysis of chapter 4.

4.2 Method for the economic analysis

The methods and guidelines published by EUROCONTROL (EUROCONTROL, 2014) were chosen in order to make a preliminary assessment of the economic implications of the three different variants of the SAFELAND concept as described in the deliverable D1.2 *Initial SAFELAND concept* (SAFELAND, 2021). These methods provide the ability to estimate different types of cost factors for operational improvement of the European ATM environment, as well as to assess the additional cost of new technologies on an existing system (e.g. aircraft). With this approach a high-level estimation on the foreseen costs on sub-system level will be accomplished. However, it is worth noting, that in the current phase of the project the ability to define the cost values associated to each operational improvement is limited due to the maturity of the envisioned new systems and technologies (e.g. enhanced DAA technology) which are currently not on the market. Moreover, as SAFELAND is an Exploratory Research project, the maturity of the different SAFELAND concept variants cannot be regarded as mature enough to specifically define associated cost figures in detail to each implementation option.

The used method is based on two key principles. On the one hand side, this approach identifies different cost factors (e.g. training of personnel, enhanced technology (e.g. DAA)) that affect a certain sub-system (e.g. aircraft or ATC). On the other hand, this approach estimates a cost value for the identified cost factors on sub-system level. This cost value will be depicted on a scale (cf. Figure 3) for each sub-system. Hereby, different sub-systems such as aircraft, ATC or Ground Station (GS) are taken into account. Finally, the costs of each sub-system are accumulated in order to estimate the total cost for introducing the new systems (here, the three different variants of the SAFELAND concept; cf. chapter 4.4) into the overall operational ATM environment.

Figure 3 illustrates the template schema used for estimating the costs for the implementation of a new system or concept on the ATM environment.

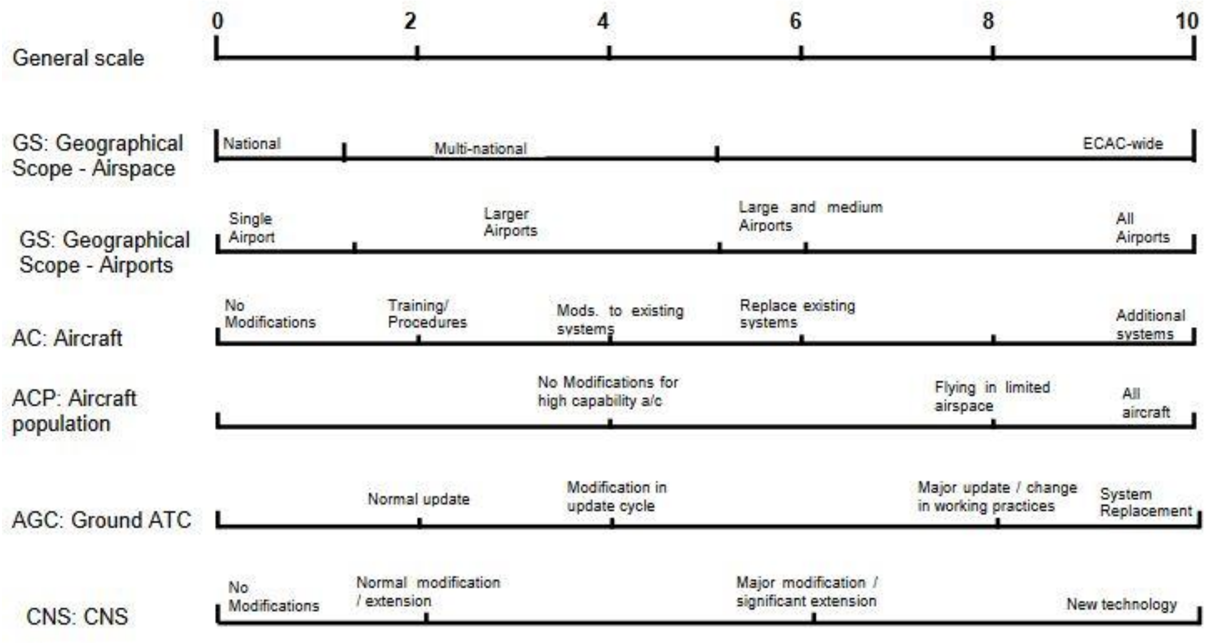

Figure 3: Cost factor scales for estimating the costs of operational improvement

(EUROCONTROL, 2014)

As this analysis aims to provide an estimation on the cost implications of the three different variants of the SAFELAND concept, as detailed in D1.2 (SAFELAND, 2021), the conduction of single pilot operations (SPO) in commercial aviation was taken as a baseline. In other words, the economic analysis conducted within this deliverable does not consider the costs stemming from the implementation of SPO in the ATM framework, but on the costs exclusively stemming from the need to handle pilot incapacitation. The analysis will be done separately for each of the three different concept variants. As an example, the SAFELAND variant proposed by Group ATC, where the responsibility for controlling the aircraft in case of pilot incapacitation is shared by ATC and the GSO, requires additional training of the ATCOs in order to be able to make decisions and support the GSO. This additional training for ATCOs is not included in the costs of implementation of the SPO in commercial aviation, and therefore not included in the chosen baseline, but will be included in the assessment done for Group ATC.

In the process of developing the initial SAFELAND concept within D1.2, the following assumptions were made:

- Presence of a ground station that would at least monitor aircraft system and pilot health throughout the flight, operated by a human operator, the Ground Station Operator (GSO). Furthermore, in order to have (financial) advantages compared to dual piloted operations, one GSO is assumed to be monitoring several aircraft at the same time. In an emergency event of one aircraft, the remaining (healthy) aircraft would be transferred to another ground station giving the GSO the opportunity to solely concentrate on the aircraft in need of assistance. The GSO would thus become a dedicated remote pilot for this aircraft.

- The single pilot aircraft is equipped with more sophisticated automation than a current CS-25 certified aircraft (e.g. onboard pilot health monitoring system, reliable and sufficient data link to other actors without latency). Onboard automation is able to refuse/reject instructions issued by any human operator from ground if they are outside the performance limits of the aircraft, hence not compliant with aircraft capabilities.

- Presence of an onboard pilot health monitoring system capable of detecting an incapacitation and automatically informing relevant actors. After the pilot incapacitation is detected (and verified), the emergency procedure would be to land the aircraft as soon as possible in order to not put aircraft, crew and passengers' safety at risk.

- Reliable C2 datalink communication throughout all flight phases (incl. no datalink failure/ loss due to areas without coverage)

In course of the economic analysis within this deliverable, the aforementioned assumptions are considered as implemented in the baseline ATM framework, which is envisioned to be operational for commercial SPO in the future. In other words, costs stemming e.g. from the development, implementation and certification of a ground station entity able to monitor multiple aircraft simultaneously are not included in the estimation of subsection 4.4 as this entity shall be regarded as operational in the referenced baseline (i.e. SPO). Further, as an example, the required onboard pilot monitoring system capable of detecting pilot incapacitation and its cost implication will be described in chapter 4.3. However, this technology is considered to be available in each aircraft certified for SPO, and therefore its implementation and/or operating costs are not explicitly analysed in chapter 4.4. As a result, the here conducted economic analysis will compare the costs stemming from the three different SAFELAND concept variants described in D1.2 by taking SPO in commercial aviation with the above-mentioned assumptions as a baseline.

4.2.1 Procedure for conducting the assessment

The procedure to conduct the assessment relies on the two principles mentioned before. First, various cost factors applicable for nearly each sub-system have been identified. However, this analysis focuses on exemplary key cost factors applicable to the SAFELAND variants, which are described in more detail in chapter 4.3.

- Pilot Monitoring System

- Enhanced onboard automation

- Enhanced DAA technology
- Command and Control (C2) datalink
- Training for personnel (e.g. ATCO, GSO)

Second, in total eight (8) different sub-systems that would need to be adjusted to the three different SAFELAND concept variants have been identified. The first six sub-systems have been directly taken from the referenced EUROCONTROL document (EUROCONTROL, 2014) as they will have to be adapted in case the SAFELAND concept variants would be implemented into the existing ATM framework. Moreover, two additional sub-systems have been identified which would need to be developed and adapted in case the SAFELAND concept would become operational. These two sub-systems are the Ground Station as well as the AOCC entity. Each sub-system will be described in the subsection 4.2.1.1 to 4.2.1.8.

Furthermore, in order to provide a high-level estimation on the cost implication on sub-system level, each sub-system will be scored with a certain cost factor representing the envisioned costs that might occur. This cost factor depicts the foreseen cost for adapting the respective sub-system to the SAFELAND variant requirements and needs. The value ranges from 0 to 10 points, whereby 10 points reflect the highest costs.

4.2.1.1 Geographical scope - Airspace

This sub-system reflects adaptations required on the existing airspace structure in case the SAFELAND concept would be implemented. As the required adaptations on the airspace structure does not differ between the three proposed SAFELAND concept variants, this sub-system has not been taken into account in the concluding outcome of this analysis (cf. chapter 4.4).

4.2.1.2 Geographical scope - Airports

This sub-system reflects changes required for the infrastructure or systems at the airport in case the SAFELAND concept would be operational. The scale runs from implementation of the infrastructure improvements at a single airport (1 point), through implementation at larger airports (2-5 points), implementation at large and medium airports (6 points), to implementation at all airports (10 points) (EUROCONTROL, 2014).

4.2.1.3 Aircraft

This sub-system reflects adaptations required on the aircraft itself in case the SAFELAND concept variant would be implemented. It runs from no modifications required (0 points), through changes in training and procedures (2 points), modifications to existing systems (4 points), replacement of old systems with new systems (6 points) and implementation and installation of additional systems (10 points) (EUROCONTROL, 2014).

4.2.1.4 Aircraft population

This sub-system reflects the number of aircraft that would have to adapted in case the SAFELAND concept variant would become operational. As the number of aircraft effected by the implementation of one the three different SAFELAND concept variant does not differ this sub-system has not been taken into account in the concluding outcome of this analysis (cf. chapter 4.4).

4.2.1.5 ATC

This sub-system reflects the adaptations needed to be made on the ATC side in case the SAFELAND concept variant would become operational. The scale represents the size of the changes needed for ATC systems and procedures that are affected by the adaptations. The scale runs from changes that are implemented as part of the normal update cycle (2 points), through a bigger modification (but still within the update cycle) (4 points), a major modification and/or significant change in working practices (8 points), to complete system replacement (10 points) (EUROCONTROL, 2014).

4.2.1.6 CNS

This sub-system reflects the changes required on the CNS infrastructure in case the SAFELAND concept variant would be implemented. As the required adaptations on the CNS infrastructure do not differ between the three proposed SAFELAND concept variants, this sub-system has not been taken into account in the concluding outcome of this analysis (cf. chapter 4.4).

4.2.1.7 Ground Station

This sub-system reflects the changes required on the Ground Station entity in case the SAFELAND concept variant would be implemented. The scale represents the size of the changes needed for GS systems and procedures that are affected by the required adaptations. The scale runs from changes that are implemented as part of the normal update cycle (2 points), through a bigger modification (but still within the update cycle) (4 points), a major modification and/or significant change in working practices (8 points), to complete system replacement (10 points) (EUROCONTROL, 2014).

4.2.1.8 AOCC

This sub-system reflects the adaptations needed to be made on AOCC side in case the SAFELAND concept variant would become operational. The scale represents the size of the changes needed for AOCC systems and procedures that are affected by the proposed adaptations. The scale runs from changes that are implemented as part of the normal update cycle (2 points), through a bigger modification (but still within the update cycle) (4 points), a major modification and/or significant change in working practices (8 points), to complete system replacement (10 points) (EUROCONTROL, 2014).

Finally, in order to obtain the cost factor cf for each of the three implementation options (i.e. Group Automation, Group GS, Group ATC) proposed by the SAFELAND project, the cost factors on sub-system level will be accumulated. The formula for this calculation is:

$$cf = \frac{cf_{airport} + cf_{\text{aircraft}} + cf_{\text{ATC}} + cf_{\text{GroundStation}} + cf_{AOCC}}{5}$$

4.3 Specific Costs for SPO systems adapted for SAFELAND

As stated in the SAFELAND project proposal, D1.3 should describe the economic constraints of the different implementation options of the initial SAFELAND concept. In other words, D1.3 addresses the economic impact of each of the three variants discussed by the consortium to cope with pilot incapacitation in SPO (see D1.2 for details). This will be done in chapter 4.4.

Not surprisingly, the issue of pilot incapacitation has been called the elephant in the room in SPO. Arguably, if the probability of a pilot becoming incapacitated were null, most airlines would have already implemented single pilot operations. Given the long history of General Aviation single pilot operations, it is clear that from a technological perspective, commercial single pilot operations are currently feasible, even if some challenges remain. In current two-crew operations these difficulties are especially clear in non-normal operations, when workload levels in the cockpit increase and several tasks need to be performed under time pressure. Cooperation between the two pilots, who cross-check each other and detect errors is seen as essential in order to allow safe operations. In SPO, the management of onboard or ground-based automation failures, as well as communication failures are particularly problematic (Comerford et al., 2013). Therefore, SPO requires higher levels of automation, which must be more reliable, and some aspects of avionics need to be made redundant.

The threat of pilot incapacitation adds a new layer of complexity to the equation and requires not only the introduction of new systems (e.g., pilot monitoring system) but an even more conservative approach to system design and system safety. In addition, it also requires that the GSO, who in normal operations would mostly have a monitoring and supporting role, would need more assistance in order to have a more active participation in controlling the aircraft with more or less support from automation (depending on the variant under discussion) in case of onboard single pilot incapacitation.

In addition to aircraft automation capabilities, it is necessary to develop communications and surveillance capabilities. In fact, highly automated aircraft and future AOCC systems should have the same standards already established by Performance-Based Communications & Surveillance as used by ATC for controlling traffic in order to safely support not only the single pilot, but also the GSO. Some of the capabilities to support SPO are already currently being developed in Europe in SESAR and in the USA with NextGen. It is expected that the new airspace might include, among others, (1) improvements in predicted weather for the flight deck, (2) the use of Data Link Services, which allow for the exchange of full flight plans between the air and the ground and for pilots and controllers to conduct operational exchanges, (3) high degrees of air-ground integration in general (Comerford et al., 2013). Therefore, assuming that the time-frame for the introduction of these new systems is earlier than the potential adoption of SPO, there will be no extra costs associated with the implementation of these new systems.

One of the biggest challenges for the realization of SPO is the need for reliable, secure and redundant data links between the aircraft and the ground, which must be available at all times during the flight. This is particularly important in case of pilot incapacitation. The communications system should enable data-sharing between the GSO, AOCC and ATCo. In case of emergency, a high-speed C2 (Command and Control) link must enable the GSO to control the aircraft. There are a variety of possible architectures and considerations in the design, security and management of the C2 link, but technical considerations for certification are already covered by RPAS references (Lim et al., 2017).

A similar rationale can be used when discussing safety systems for detecting other aircraft and hazards (including terrain). Pilots are expected to remain vigilant in order to detect and avoid collisions, either by looking outside (visual observation), through traffic information provided by ATC or based on ACAS alerts. In case of incapacitation, the GSO will take over this responsibility but in some cases, it might be necessary to rely fully on automation to respond, if there is a hazard before the handover phase, in case of data link failure, or even due to human error (by the GSO). Groups Automation and ATC also expect that automation would take over this function which is similar to the Detect And Avoid (DAA) capability of RPAS. As the name states, the DAA is expected to detect hazards, determine and execute avoidance manoeuvres and return to the original flight path (ICAO, 2017). DAA technologies and procedures for RPAS are currently being developed and will soon be integrated into normal operations.

C2 and DAA technologies are just two examples of applications developed for RPAS, which are quickly maturing. It is expected that, by the time these would be incorporated in aircraft, implementation costs will be much lower.

Norman (2007) identified a list of technical challenges and potential technological mitigations for SPO. From that list, one was specifically devised to deal with pilot incapacitation. The first is a Pilot Monitoring System, which continually assesses the pilot's condition in real-time. The pilot's general health and mental state could be assessed by continuously monitoring vital signs (pulse, skin temperature, eye movement, brain waves). If the pilot is deemed not capable of maintaining command of the aircraft, the system provides an alert to the relevant actors, takes command and control, and safely navigates to an acceptable airport and lands. However, Norman (2007) recognized that the current barriers associated with the design, implementation, and certification of this system, makes it unlikely that it could be economically viable. It can be argued, however, that a more thorough medical screening of pilots, using less expensive and less invasive techniques, might lead to an early detection of life-threatening diseases (like arteriosclerosis or cerebrovascular disease, the most common serious reasons for sudden incapacitation) before they lead to incapacitation.

4.3.1 Implementation and Operating Costs

At the current maturity level of the project, it is not possibly to cover in detail all aspects related to the specific local implementation and operating costs of the SAFELAND concept variants. Therefore, the list below should be seen as a preliminary and high-level assessment of the costs by source. The baseline was, once again, SPO and an attempt was made to address only those features that are under discussion in SAFELAND.

- Costs associated with outfitting or retrofitting aircraft with the necessary automation and sensors to handle incapacitation, including certification costs – already addressed in section 4.3.

  The more general discussion of whether aircraft should be retrofitted or outfitted for SPO (and specific costs associated with this transition) is out of scope for SAFELAND.

- New communications systems – already discussed in section 4.3. At this point in the project it is still too early to say whether the changes to be implemented in SESAR will be enough to cover the requirements for the communication systems in SAFELAND.

- In terms of costs with personnel, Malik & Gollnick (2016) suggested that GSO would have a lower salary than pilots. Nevertheless, the more responsibilities the GSO have, the more qualified they will need to be and the more training will be required. All of these translate into higher personnel costs for the airlines. Another aspect to be considered is that a GSO that needs to control an aircraft as a remote pilot in case of pilot incapacitation, would need to go through frequent refreshing training sessions in simulators (usually relatively costly), in order to be prepared to not only control the aircraft from the ground, but to do so during an emergency.

- Ground infrastructure costs: with the GSO located at the AOCC, as suggested by all three variants of the SAFELAND concept, the same facilities and equipment might be used. Note, however, that the specific costs of setting up a ground station (including equipment costs, validation and certification costs, administrative costs, etc.) will not be discussed in SAFELAND as the need for a Ground Station to support the single pilot in normal operations is a general precondition for SPO.

- The introduction of RPAS may result in new ATC procedures, techniques and tools. These changes will require additional training for air traffic controllers, but should not affect their licensing requirements (ICAO, 2017). The same might be said of SPO: new procedures, techniques, tools and training might be required, but not their licensing. The scope of this change in normal SPO is out of scope for SAFELAND.

- However, ATCOs would need specific training to learn the procedures in case of pilot incapacitation, with an emphasis on coordination with the GSO. This training would be part of their normal training to handle emergencies. The lessons learned with the introduction of RPAS (and their GSO) in the ATM system could be used.

- As will be detailed in chapter 4.4.3, one of the options under consideration for the final concept allows the ATCOs to send clearances directly to the aircraft. This possibility raises several issues with certification, safety and security (see, e.g. section **Errore. L'origine riferimento non è stata trovata.** for more information), which ultimately would make this option an expensive one in terms of general costs for the ATM system. In D3.4 the impact of the final SAFELAND concept in the ATM system (including potential implementation and operation costs) will be discussed, also considering the impact of the changes brought by SESAR.

- The introduction of SPO will also have some costs for the AOCC in terms of training and licences for the dispatchers and others who will work directly with the single pilot, the GSO and, those monitoring aircraft automation. At this stage of the project it is not yet clear how much of an effect the threat of pilot incapacitation will have on the organization and operations of the AOCC.

4.4 Outcome of the economic analysis

This subsection will provide an economic analysis for the different implementation options of the SAFELAND concept based on the method described in subsection 4.2 taking the different sub-systems, as identified in subsection 4.2.1, into account. As a result, the cost scales on sub-system level will be accumulated in order to obtain the final cost scale for each of the three different SAFELAND implementation options.

4.4.1 Outcome for concept variant proposed by Group Automation

As described in deliverable D1.2 (SAFELAND, 2021) the SAFELAND concept variant proposed by Group Automation relies on highly advanced and more sophisticated onboard automation within the aircraft compared to a CS-25 aircraft operational today. Within this concept variant the aircraft is expected to be capable of maintaining and ensuring its flight envelop and flight safety throughout all flight phases.

In the following subsection describe the required adaptations on sub-system level in case this SAFELAND concept variant would be implemented into the ATM environment.

4.4.1.1 Airport

As the concept variant proposed by Group Automation envisions that in normal operating procedures an onboard Autoland system is capable of landing the aircraft safely, the respective airport should be certified for CATIIIc approaches. In addition to the relatively common airport technologies such as various transmitters (e.g. localizer, glideslope), additional technologies at the airport assisting the Autoland systems are envisioned. As a result, adaptation on the airport infrastructure will have to be made in order to support this concept variant. In the future, mainly large and medium sized airports will support SPO, which results in a cost factor of 6 points as depicted in Figure 3.

4.4.1.2 Aircraft

This concept variant envisions an onboard automation to be able to maintain the flight envelop and flight safety. In order to guarantee that the aviate function can be solely conducted by automation, the onboard automation should not only be capable of receiving and executing commands (e.g. heading change) transmitted from ground, but also have the ability to assess certain flight situations (e.g. cross wind), and react accordingly. Therefore, one main cost driver within this variant would be the development and certification of advanced automation for the aircraft.

Moreover, advanced DAA systems able to provide collision avoidance by detecting crossing air and ground traffic as well as executing an evasive manoeuvre would have to be integrated, and operationally available. These new systems will have to be demonstrated, tested and certified for the aviation domain in order to be acceptable for safety critical manoeuvres. In the end, both factors (i.e. onboard automation and DAA systems) represent changes within the aircraft and combined lead to a maximum value (i.e. 10 points on the aircraft cost scale) of the aircraft scale as new additional systems will have to be installed. (cf. Figure 4, aircraft).

4.4.1.3 ATC

This concept variant does not envision changes to the current ATCO working position or on the ATC procedures. Details on the role of ATC for this concept variant are provided in D1.2 (SAFELAND, 2021). In consequence, the respective cost factor is 0 points on the ATC scale.

4.4.1.4 Ground station

As stated in chapter 4.2 the presences of a GS for, at least, monitoring the single piloted aircraft is a precondition for each of the concept variants, and the costs for developing, certifying and commissioning such an entity will not be analysed within this deliverable. However, specified ground station operators need to be trained, educated and obtain the required licences for operating this entity. Moreover, a highly automated aircraft will require a different ground station entity as less automated aircraft. Therefore, the Human-Machine Interface design of the GS should be able to visualize certain decisions made by onboard automation. However, as the aircraft is supposed to be highly automated, it could be envisioned that fewer GSO are required to monitor the same number aircraft as in the other concept variants. In conclusion, these factors have been considered with 2 points on the cost scale for the ground station.

4.4.1.5 AOCC

Finally, as the GS is expected to be located at AOCC within this concept variant, additional adaptations to the AOCC facilities as well as the procedures within AOCC will need to be made. For instance, the GS will require a dedicated room where it will be set up. Further, as we expect fewer GSO to operate a certain number of aircraft, the necessity might arise for additional personnel on AOCC to monitor certain aircraft parameters of the aircraft. These adaptations are taken into account with 4 points on the respective scale.

Figure 4 illustrates the aforementioned costs for the SAFELAND concept proposed by Group Automation per cost group.

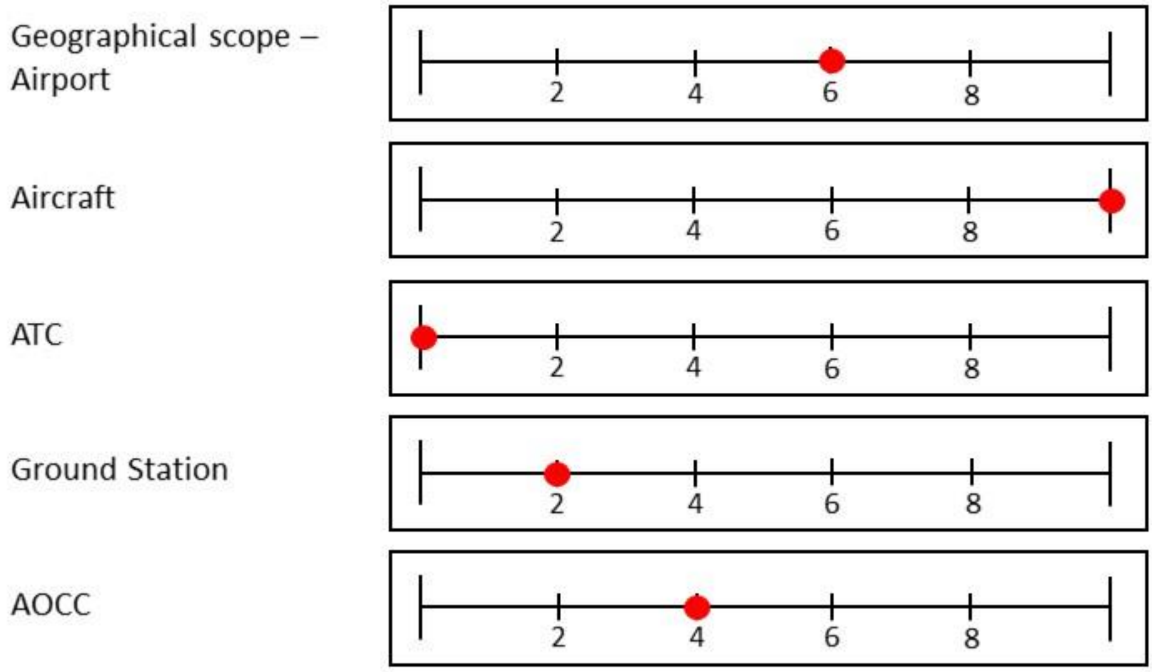

Figure 4: Cost scale for Group Automation

The accumulated cost factor for the proposed variant of the SAFELAND concept is $cf_{Automation} = 4{,}4$.

4.4.2 Outcome for concept variant proposed by Group GS

The SAFELAND concept variant proposed by Group GS allocates the main responsibility for controlling the single piloted aircraft in case of pilot incapacitation to an operator working in a ground station located at AOCC. Hereby, the GSO becomes the remote pilot (Pilot In Command), as soon as the onboard pilot is incapacitated. More details to the proposed concept variant can be found in D1.2 (SAFELAND, 2021).

4.4.2.1 Airport

The concept variant proposed by Group GS bears the potential to not having to change the operating airport compared to todays airline operations. In fact, the airport infrastructure, as it is currently available on medium and large sized aerodromes, is foreseen to be sufficient for SPO relying on the referenced SAFELAND concept variant. It is not envisioned that in addition to the Grund Station entity other technology supporting the aircraft from ground, will be required to be established directly at the airport. As a result, the costs for this sub-system have been considered with 0 points on the respective cost scales.

4.4.2.2 Aircraft

This variant relies on advanced onboard automation in SPO which is expected to be able to execute commands received from the GSO. In fact, new onboard technology capable of executing commands received from the ground which control primary and secondary flight controls will have to be implemented in the aircraft. Moreover, enhanced DAA technology capable of executing an evasive manoeuvre in order to prevent mid-air collision is expected to be implemented in the aircraft, as well. These adaptations on the aircraft are envisioned to be conducted by replacing old aircraft system with new system and are considered with 6 points on the respective cost scale.

4.4.2.3 ATC

Furthermore, within this variant there is no major change in the ATC procedures compared to dual piloted aircraft in an emergency situation today. As detailed in D1.2 (SAFELAND, 2021), the responsiblilty for clearing the path from surrounding air traffic remains at ATC - as nowadays. As a result, the costs for this sub-system have been considered with 0 points on the respective cost scales.

4.4.2.4 Ground station

This concept variant relies on the allocation of aviate and manage functions, and partially of the navigate functions, to the GSO. Therefore, the GSO - who is in fact a remote pilot - will have to be specifically trained to operate the respective GS. A type certificate for each of the different aircraft types, as well as a pilot licence (e.g. comparable to an ATPL licence) for controlling an aircraft from the ground is required. Furthermore, the aviate functions are expected to be commanded by the GSO and executed by onboard automation, for which the GS will have to be equipped with advanced technology. Moreover, a secure and reliable data link between ground and air, including minimal latency will have to be set up. Last but not least, new communication processes to the other actors (i.e. ATCO, AOCC) will have to be introduced and agreed on. In consequence, a new GS system will have to be developed which results in a cost factor of 10 points for the GS.

4.4.2.5 AOCC

Finally, within this concept variant the GS is expected to be located at AOCC. Therefore, some adaptations to the AOCC facilities, as well as the procedures within AOCC will need to be made. These adaptions have been considered with 2 points on the respective scale.

Figure 5 illustrates the aforementioned costs for the SAFELAND concept proposed by Group GS per cost group.

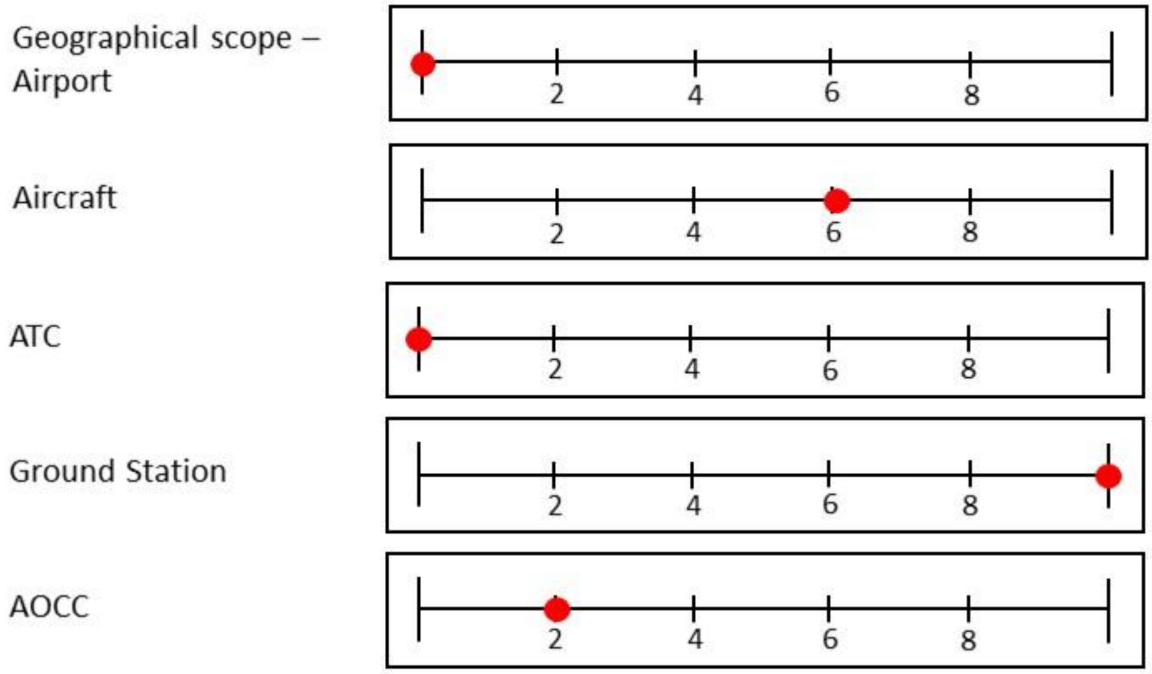

Figure 5 Cost scale for Group GS

The accumulated cost factor for the proposed variant of the SAFELAND concept is $cf_{GS} = 3{,}6$.

4.4.3 Outcome for concept variant proposed by Group ATC

The concept variant proposed by Group ATC is based on the paradigm that ATC shares with the GSO the responsibility for controlling the single piloted aircraft in case of pilot incapacitation. Hereby, this concept variant introduces a dedicated ATCO into the ATM environment to specifically handle the concerned aircraft until it lands safely. Despite the dedicated ATCO, a dedicated GSO will further monitor the aircraft in this emergency situation. More details are provided in D1.2 (SAFELAND, 2021).

4.4.3.1 Airport

This concept variant does not require any significant adaptations on the airport side. In fact, the airport infrastructure is not envisioned to change for this variant if compared to airports operated nowadays. Consequently, the costs for this sub-system have been recognized with 0 points.

4.4.3.2 Aircraft

The allocation of functions in this variant is based on a highly automated aircraft able to operate all systems, including those that are currently manually performed (e.g. landing gear deployment, slats and flaps setting, etc.) from ground. Hereby, the ground operator is expected to transmit commands (e.g. altitude changes) to the aircraft which will be executed by the onboard automation. As in the variant proposed by Group GS, these adaptations on the aircraft shall be done by replacing old aircraft systems with new systems. Consequently, the costs for these adaptations have been considered with 6 points on the aircraft cost scale (cf. Figure 6).

4.4.3.3 ATC

In order to introduce this proposed concept variant into the existing ATM envirnoment, significant changes especially to ATC will have to be made. On the one hand, this variant envisions the appointment of a dedicated ATCO to the aircraft in case of pilot incapacitation. Consequently, new tasks and respsonsibilities are given to ATC. This requires specific training and probably a specific rating/ endorsement of the ATCO to be able to handle such an emergency, which will lead to an increase of the ATC operating costs. Furthermore, in order to enable the dedicated ATCO to be able to support the concerned aircraft, new ATCO systems as well as an enhancement of existing ATCO systems, especially in the HMI design, can be envisioned. As an example, a user-friendly way to visualize the clearances to be executed by the onboard aircraft automation, needs to be developed on the ATC side. Last but not least, new operating procedures and communication processes with other actors (i.e. GSO, AOCC) need to be established. As a result, this variant requires more sophisticated ATC systems which will need to developed, tested, certified and implemented into the ATM envirnoment. Therefore, as shown in Figure 5, 10 points on the cost scale have been allocated to ATC.

4.4.3.4 Ground Station

Furthermore, this concept variant does not require significant changes on the Ground Station side. As described in chapter 4.2, the assumption is made that a ground station would monitor each single piloted aircraft and have the ability to command the aircraft if required (e.g. in case of pilot incapacitation). In orther words, the existence of a GS is considered as precondition all three SAFELAND concept variants, andthe cost to establish this monitoring GS is not analysed here. Only additional costs that would stemm from the implementation of a highly advanced GS to the referenced concept variant are considered. Consequently, the cost for this sub-system is recognized with 0 points.

4.4.3.5 AOCC

Finally, as the GS is expected to be located at the AOCC, several adaptions to the AOCC facilities as well as the procedures within AOCC will need to be made. These adaptions are taken into account with 2 points on the respective scale.

Figure 6 illustrates the aforementioned costs for the SAFELAND concept proposed by Group ATC per cost group.

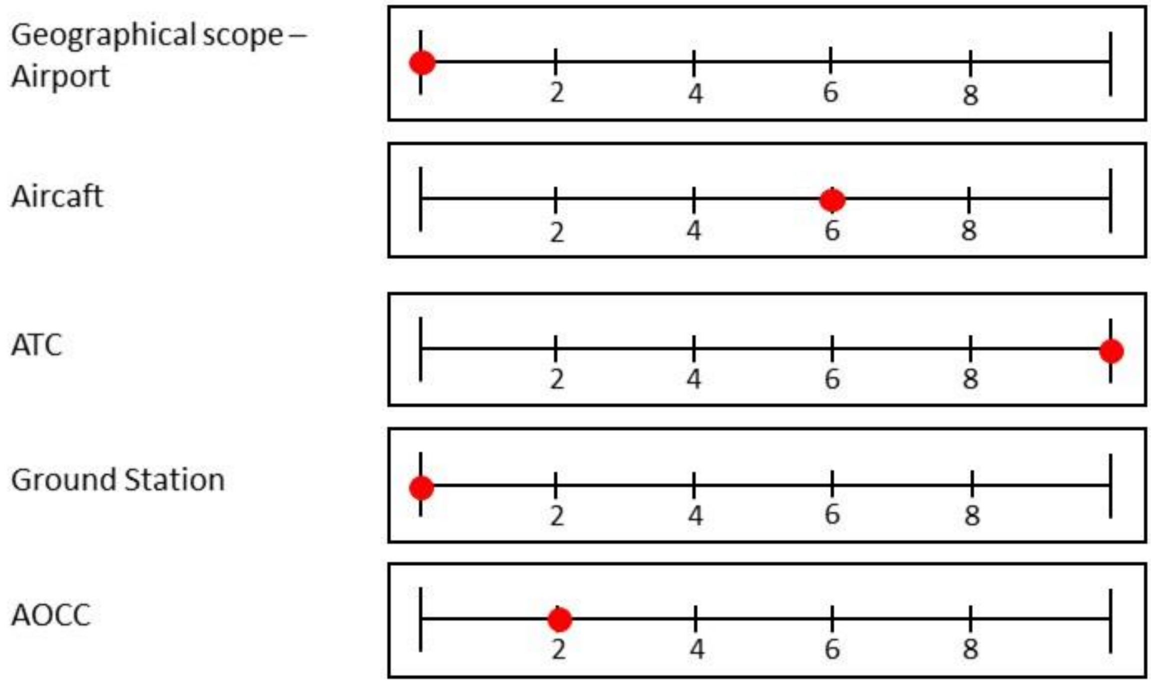

Figure 6: Cost scale for Group ATC

The accumulated cost factor for the proposed variant of the SAFELAND concept is $cf_{ATC} = 3{,}6$.

4.5 Conclusions

It should be noted that these processes presented in chapter 4 resulted in a first, high-level strategic assessment of the cost of implementing the three SAFELAND concept variants.

In conclusion, the results of economic analysis show that the implementation of the concept variant proposed by Group Automation would probably lead to the highest costs with a cost factor of 4,4. With a cost factor of 3,6, the estimated costs for groups GS and ATC are expected to be equally high. While Group GS almost does not require any changes on the sub-system ATC (0 points), it requires a lot of efforts in Ground Station (10 points) category, as the GSO will evolve to a remote pilot actively controlling the aircraft from ground. This will require a sophisticated GS entity with specifically trained personnel. The variant porposed by Group ATC however, requires no expenditure on the sub-system Ground Station (0 points), but on the other hand will see major changes in the sector ATC (10 points), due to the need of updated and newly developed systems, especially regarding HMI. Although the cost factor for Group Automation is more than 1.2 times compared to the other two groups, this should not be a reason for exclusion of this group regarding further examinations. The concept finally developed and proposed is not automatically expected to have the lowest costs, but should be feasible in every aspect.

5 Conclusion. A suitable approach to the SAFELAND concept

The analysis conducted in this document gives a few, clear indications and raises a number of questions to be addressed in the further development of the SAFELAND concept.

SAFELAND aims to integrate the concept of SPO with what is essentially an emergency/abnormal flight phase showing the main features of RPAS. The legal, regulatory and economic inquiry show that no radically obstruing issue can be observed in such exploratory research program. However, at the same time the level of definition of the concept still lacks specificity as to several key choices and requirements, thus leaving a number of questions open, which shall be addressed in the subsequent phases of the SAFELAND project.

The outline of the initial SAFELAND concept affects several critical domains in Aviation/ATM. It entails the need for a system of SPO flights which can potentially turn into RPAS-like flights in unrestricted zones. From a legal and regulatory point of view, the main constraints to this concept concern (1) the allocation of roles, functions and responsibilities among the actors involved (GSO, AOCC, ATCO, Automation); (2) the consequent distribution of liabilities and (3) insurance-related issues; (4) the key role of the (Remote) Pilot-in Command, in relation with the roles of the ATCO and especially of the automated system in the SAFELAND operations; (5) training and licencing of new roles, including crew members; (6) the employment issues of the GSO (section 2.4.6.4); (7) the certification of automated systems (section 3.1).

The main regulatory reforms needed or desirable for these constraints concern the Rules of the Air, Personnel licencing and training, Airworthiness, and Aircraft operations (section 2.3): these requirements can be addressed through modifications of the European framework and notification of “differences” per art. 38 CC; several changes can be completed through RMTs, AMC and GM.

The main legal issues raised by the SAFELAND concept concern the allocation of liability. As shown in sections 2.4, different forms of liability come into play in the domain of Aviation and in the context of SAFELAND: in order to design clear liability schemes, it is essential to allocate responsibilities of flight tasks in a clear, specific way (section 3.1). Accordingly, the role of the RPIC must be defined. In this regard, the three implementation options differ considerably (section 3.2). The ATC option appears hardly feasible from this point of view, as it implies an overlap in the responsibilities of the ATCO, and therefore potential hardship in the correspondence of responsibility and liability. The remaining options seem more reliable and differ mainly on the degree of responsibility endowed onto the automated system. However, a more specific allocation of functions and a deeper safety risk analysis in the SAFELAND concept development are needed in order to establish more detailed liability constraints.

In all instances, the SAFELAND concept envisions a more sophisticated automated system than the current CS-25: therefore, the impact of product liability (section 2.4.3) and related regulatory requirements will increase considerably.

A further legal and regulatory constraint is the need to design, train and certificate operators in this blended SPO-RPAS capacity, with particular regard to the GSO, in order to safeguard safety and efficiency in the operations. This aspect is crucial in order to determine specific regulatory changes and economic aspects of SAFELAND, and shall require further specification of the actors' functions in the safe-landing operations. Alongside this is the need to identify an organizational strategy for the location, employment and grouping of several GSOs in the flying sectors involved. This has major economic consequences and impacts the choices in the area of labour law concerning the possibility of leasing operators or sharing them between Air carriers; the point shall be inspected more in depth in the following steps of the concept definition.

The economic analysis of the SAFELAND concept (chapter 4) relies on the basic assumption of the decrease in pilot-personnel costs due to the SPO deployment, and mainly aims at a high-level estimate of the economic impact of the different SAFELAND implementation options. The analysis makes use of EUROCONTROL (2014) guidelines on cost factor estimate, which measure the potential cost of operational and technological development on the basis of different key factors involved in the process.

The analysis shows (section 4.4) that no dramatic variety can be anticipated in the three options ("variants"). The automation option ranks notably highest as to its cost factor (4.4), while the GS and ATC options equally score a 3.6 cost factor; however, such differences do not constitute a reason to discard any of the concept variants from the economic point of view. Moreover, at this stage of the project, it is not possible to calculate accurate and reliable cost estimates, because the concepts are only described on a high level. In the next phases of the project, a final, more detailed concept will be derived (Deliverable 1.4) and evaluated (Deliverables 3.1 – 3.4). Based on the evaluations a more detailed estimation of the implementation costs may be calculated. It is worth noting that currently there are numerous projects (e.g. SESAR PJ13) that investigate the technologies needed for the proposed concept variants. As such, it can be concluded that the costs for developing and implementing the needed technologies may be lower than the estimations of the current economic analysis suggest, since these technologies would not have to be developed from scratch.

In conclusion, the legal, regulatory and economic constraints examined in this document point out several details and issues that must be cleared in the next steps of SAFELAND. They will constitute the bedrock of the refinement of the final concept. As far as the choice of the implementation options is concerned, the legal analysis (section 3.2.1) confirms the technical and operational doubts emerged in the drafting of D1.2 *SAFELAND Initial Concept* with regard to the ATC option, which does not appear easily feasible even from a legal and regulatory standpoint. Hence, the outcome of the analysis suggests to concentrate on a balance between the GS and and automation options which shall carefully consider the relative functions and responsibilities of the two actors, together with possible problematic/failure scenarios, in the workflow of the SAFELAND operations.

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