FH | JOANNEUM
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MASTER'S THESIS

Practical Aspects & Upcoming Developments of European Regulations for UAS below 150 kg in Context with Austrian Rulemaking

Submitted by:	Mathias Ritzinger, BSc
Registration Number:	12 105 88 024
Academic Supervisor:	FH-Prof. Dipl.-Ing. Dr. Holger Flühr
Company Supervisor:	Mag. Raoul Fortner (AAI)
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Affidavit

I hereby affirm in lieu of an oath that the present master's thesis entitled

"Practical Aspects & Upcoming Developments of European Regulations for UAS below 150 kg in Context with Austrian Rulemaking"

has been written by myself without the use of any resources other than those indicated, quoted and referenced.

Graz, 09 September 2014

Mathias Ritzinger, BSc

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This Master's Thesis is dedicated to Bruno Wiesler, former head of institute of Luftfahrt/Aviation, a wonderful personality, friend and UAV pioneer.

Preface

It was great to experience all aspects of the Aviation Industry thanks to all the opportunities which were given to me by the Austrian Aeronautics Industries Group (AAI), especially by Deputy Secretary General Mag. Raoul Fortner, whom I would express my thanks for his commitment and the accurate supervision of my master thesis. My participation in several conferences (Paris Airshow, MAKS, RPAS 2014, CivOps 2013, etc.) as well as various meetings (AAI-UAS-WG, JARUS Workshop, ACG Meeting, etc.) improved my experience and understanding of the development in UAS rulemaking on the international, European and national level. I would further like to thank the whole AAI team, in particular Secretary General KR Ing. Franz Hrachowitz who gave me the opportunity to work for the Austrian Aeronautics Industries Group and his Assistant Mrs. Michaela Schmöllerl, who supported me during my whole time at AAI.

This thesis was conducted within the Project Austrian UcM (Austrian UAS for Civil Missions), supported by the Austrian Research Promotion Agency (FFG) in the context of the TAKE OFF funding program, in which I want to thank Ms. Dipl.-Ing. (FH) Vera Ellegast, for their friendly support with the Austrian UcM project on the part of the FFG.

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Kurzfassung

Zahlreiche Fragen zu den Regularien für unbemannte Luftfahrtsysteme (UAS) in Europa haben in letzter Zeit zu einer spannenden Diskussion über die Entstehung diverser Gesetze für UAS auf internationaler, europäischer sowie nationaler Ebene geführt. Diese Arbeit beschreibt die jüngsten Entwicklungen im Bereich der nationalen Gesetze in ausgewählten europäischen Ländern, fasst diese zusammen, vergleicht die nationalen Bestimmungen und gibt am Ende einen Ausblick über die Weiterentwicklung der Regeln für UAS in Europa und im speziellen für Österreich.

Die Zulassungsbestimmungen für UAS, oft als "Drohnen" bezeichnet, sind auf Grund vieler ziviler Anwendungsmöglichkeiten und der Weiterentwicklung elektronischer Systemen und deren Miniaturisierung ein aktuelles Thema. Größe, Gewicht sowie Anschaffungskosten dieser Systeme verringern sich, während deren Leistungsvermögen weiter steigt. Daher wurde diese Arbeit durch den Verband der österreichischen Luftfahrt/zuliefer/industrie (AAI) initiiert, innerhalb des Projektes Austrian UcM (Austrian UAS for Civil Missions) welches durch die Forschungsförderungsgesellschaft (FFG) im Rahmen des TAKE-OFF Programms gefördert wurde. Ziel ist es, die weitere Harmonisierung der Regularien von UAS in Europa zu unterstützen, insbesondere durch Dissemination in internationalen und nationalen Verbänden, Arbeitsgruppen und Zulassungsbehörden.

Am Beginn dieser Arbeit werden die wichtigsten Organisationen welche an der Entwicklung von Regularien für UAS beteiligt sind, vorgestellt, beginnend bei der internationalen Zivilluftfahrtorganisation (ICAO), der europäischen Kommission (EC), der europäischen Agentur für Flugsicherheit (EASA) bis hin zu den nationalen Zivilluftfahrtbehörden (NCAA) und der internationalen Arbeitsgruppe JARUS.

Weiters soll diese Masterarbeit den Mangel an Kenntnis über Regularien für UAS minimieren, der sich bei Diskussionen auf internationalen sowie nationalen Konferenzen gezeigt hat. Techniker ignorieren oft die Regularien und konzentrieren sich viel mehr auf die technischen Aspekte eines Systems, obwohl nur ein profundes Wissen über die entsprechenden Regularien eine solide Basis für eine spätere Zertifizierung des Systems im Bereich der Luftfahrt ermöglicht und dadurch zu einem erfolgreichen Business Case führt.

Daher liefert diese Masterarbeit einen genauen Vergleich der gesetzlichen Bestimmungen sowie eine anschließende Analyse der europäischen und ausgewählter nationaler Regularien für UAS, um anschließend die Unterschiede, Parallelitäten, Vorteile sowie Nachteile der heutigen Gesetze aufzuzeigen. Die Arbeit schließt mit einem Ausblick sowie einem Fazit über die zukünftigen Entwicklungen der Regularien in Europa und im speziellen in Österreich ab.

Abstract

The numerous questions regarding regulations for Unmanned Aircraft Systems (UAS) in Europe have recently stirred a fascinating and highly topic debate on the issue of manifold rulemaking activities on the international, European and national levels. This thesis describes and summarizes the latest developments and national regulations in relevant European states, while also comparing those current rules and finally anticipating the further evolution of UAS regulations in Europe, particularly in Austria.

Regulations for UAS are important because civil applications of Unmanned Aerial Vehicles (UAV), or so called „drones“, are an upcoming topic due to the rapid development in the computing power of microprocessors and consequently their miniaturization. Therefore UAVs decrease in size, weight and acquisition costs but increase in their flying capabilities. Hence this thesis was initiated and supervised by the Austrian Aeronautics Industries Group (AAI) within the project Austrian UcM (Austrian UAS for civil Missions), supported by the Austrian Research Promotion Agency (FFG) in the context of the TAKE OFF funding program. The aim is to support the further harmonization of UAS regulations in Europe also by the dissemination of this thesis to international and national associations, working groups as well as rulemaking institutions.

At the beginning this thesis identifies the key stakeholders and institutions which influence the development of regulations for UAS, beginning with the International Civil Aviation Organization (ICAO), the European Commission (EC), the European Aviation Safety Agency (EASA) up to the National Civil Aviation Authorities (NCAA) and the international working group JARUS.

Thereafter this thesis works to minimize the lack of knowledge about current UAS regulations in Europe that has been observed during discussions on international and national UAS conferences. Engineers are often ignorant about regulations and more focused on the technical aspects of a system, but only a profound knowledge about the appropriate regulations will lay a solid foundation for certifying a technical system in the aeronautics domain and lead to a successful business case.

Therefore this thesis provides a detailed legal comparison and subsequent analysis about European and selected national UAS regulations, to finally elaborate the differences, parallelisms, advantages and disadvantages of the present regulations. This thesis will conclude with an outlook and a final conclusion on future developments in Europe, particularly in Austria, as to the direction that these UAS regulations are headed.

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List of Abbreviations

A

AAI	Austrian Aeronautics Industries Group
AAIB	UK Air Accidents Investigation Branch
ACG	Austro Control
AGL	Above Ground Level
AMC	Acceptable Means of Compliance
ANO	Air Navigation Order
ANSP	Air Navigation Service Provider
ANSV	Italian Aircraft Accident Investigation Agency
AOCV	Austrian Regulation of Air Operator Certificates
ASBU	Aviation System Block Upgrades
ASD	AeroSpace and Defence Industries Association of Europe
ATC	Air Traffic Control
ATM	Air Traffic Management
ATO	Approved Training Organization
ATPL	Airline Transport Pilot License
ATZ	Aerodrome Traffic Zone

B

BAF	German Federal Supervisory Office for Air-Traffic Control
BEA	French Aviation Accident Investigation Agency
BFU	German Federal Bureau of Aircraft Accident Investigation
BMVI	German Ministry for Transport and digital Infrastructure
BMVIT	Austrian Federal Ministry for Transport, Innovation and Technology
BNUC	Basic National UAS Certificate

BNUC-S	Basic National UAS Certificate for Small UAS
BRLOS	Beyond Radio Line of Sight
BVLOS	Beyond Visual Line of Sight
C	
C2	Communication & Control Link
CAA	Civil Aviation Authority
CAP	Civil Aviation Publication
COM	Communication (European Commission)
COSME	EU programme for the Competitiveness of Enterprises and Small and Medium-sized Enterprises
CPL	Commercial Pilot License
CRD	Comment Response Document (EASA)
CRT	Comment Response Tool (EASA)
CS-LUAS	Certification Specification for Light Unmanned Aircraft Systems
CS-LURS	Certification Specification for Light Unmanned Rotorcraft Systems
CS-VLR	Certification Specification for Very Light Rotorcraft
D	
D & A	Detect & Avoid
DFS	German Air Traffic Control Company
DG	Directorates General (of European Commission)
DG-ENTR	Directorates General - Enterprise and Industry
DG-MOVE	Directorates General - Mobility and Transport
DGAC	French Civil Aviation Authority
DOA	Design Organization Approval
DSNA	French Air Traffic Control Service Provider
DWD	German Weather Service

E

EASA	European Aviation Safety Agency
EC	European Commission
ECA	European Cockpit Association
ECAC	European Civil Aviation Conference
EDA	European Defence Agency
EN	European Standard
ENAC	Italian Civil Aviation Authority
ENAV	Italian Air Traffic Control Service Provider
ERSG	European RPAS Steering Group (by European Commission)
EU	European Union
EUROCAE	European Organisation for Civil Aviation Equipment
EUROCONTROL	European Organization for the Safety of Air Navigation
EVLOS	Extended Visual Line of Sight

F

FCL	Flight Crew Licensing
FFG	Austrian Research Promotion Agency
FlUUG	German Aviation Accident Investigation Law
FMEA	Failure Mode and Effect Analysis
FOCA	Federal Office of Civil Aviation

G

GM	Guidance Material

I

ICAO	International Civil Aviation Organization
ICOP	Industry Controlled Other Party
IFR	Instrument Flight Rules

ILS	Integrated Logistics Support
IMC	Instrument Meteorological Conditions
IR	Implementing Rules
J	
JARUS	Joint Authorities for Rulemaking on Unmanned Systems
L	
LBA	German Federal Aviation Office
LBTH	Austrian Airworthiness Notification and Operational Notice
LFG	Austrian Aviation Act
LuftBO	German Regulation governing the operation of aircraft
LuftGerPV	German Inspection Regulation for aircraft
LuftSiG	German Aviation Security Act
LuftVG	German Air Traffic Act
LuftVO	German Air Traffic Regulation
LuftVZO	German Air Traffic Licensing Order
LVR	Austrian Rules of the Air
M	
MEDDE	French Ministry of Ecology, Sustainable Development and Energy
MIT	Italian Ministry of Infrastructures and Transports
MTOM	Maximum Take Off Mass
MTOW	Maximum Take Off Weight
MZFW	Maximum Zero Fuel Weight
N	
NATS	UK National Air Traffic Service
NCAA	National Civil Aviation Authority
NfL	German Notices to Airmen

NOTAM	Notice to Airmen
NPA	Notice of Proposed Amendement (EASA)
P	
POA	Production Organization Approval
PPL	Private Pilot License
PtF	Permit to Fly
Q	
QE	Qualified Entity
R	
R & D	Research & Development
RLOS	Radio Line of Sight
RPA	Remotely Piloted Aircraft
RPAS	Remotely Piloted Aircraft System
RTCA	Radio Technical Commission for Aeronautics
S	
SARP	Standards and Recommended Practices
SASP	Separation and Airspace Safety Panel
SATCOM	Satellite Communication
SDR	Special Drawing Rights
SERA	Single European Rules of the Air
SESAR JU	Single European Sky ATM Research Joint Undertaking
SME	Small and Medium-Sized Enterprise
SUPP	Regional Supplementary Procedure
SWD	Staff Working Document (European Commission)
T	
TCAS	Traffic Alert and Collision Avoidance System

U

UA	Unmanned Aircraft
UAS	Unmanned Aircraft System
UAS ATM	Unmanned Aircraft System Air Traffic Management
UASSG	Unmanned Aircraft Systems Study Group (by ICAO)
UAV	Unmanned Aerial Vehicle
UcM	UAS for Civil Missions
UNO	United Nations Organization
UVSI	Unmanned Aerial Vehicle Systems Association International

V

VERSA	Austrian Aircraft Accident Investigation Agency
VFR	Visual Flight Rules
VLL	Very Low Level
VLOS	Visual Line of Sight
VMC	Visual Meteorological Conditions

W

WRC	World Radiocommunication Conference

Z

ZFBO	Austrian Regulation governing the Operation of Civil Aerodromes
ZLLV	Austrian Regulation of Civil Aircraft and Civil Aviation Equipment
ZLPV	Austrian Personnel Regulation of Civil Aviation

1 Introduction

1.1 Subject & Purpose of this Thesis

The essential role that Unmanned Aircraft Systems (UAS) are playing in civil operations has transformed the aircraft industry. There are a lot of semi-professional operators – the majority are below 150 kg, particularly below 25 kg. The majority of these light remotely piloted systems (RPAS) are developed, manufactured and operated by small and medium-sized enterprises (SMEs), coming from business areas other than the aviation industry. The International Civil Aviation Organization (ICAO) and the European Aviation Safety Agency (EASA) have published documents that define a UAV and provide guidance documents for a safe integration of these new aerial vehicles into the common airspace.

> *"An unmanned aerial vehicle is a pilotless aircraft [...], which is flown without a pilot-in-command on-board and is either remotely and fully controlled from another place (ground, another aircraft, space) or programmed and fully autonomous."*
>
> [40, p.B-6]

At the moment, all over the world, a huge amount of effort is put into the development of regulations, defining the airworthiness-, operational- and pilot requirements for the certification of commercially used unmanned systems. Due to the fact that UAVs with a maximum take off weight (MTOW) below 150 kg are under the jurisdiction of each EU member state and have no specific laws and provisions, a certain gray area exists where operators are obtaining their certification from the national civil aviation authorities to operate unmanned aerial vehicles. ICAO, the European Commission and EASA are supporting the progress, with their contribution in various working groups as well as providing financial fundings, but nevertheless common harmonized regulations are far away. Some European member states have developed their own national legislative environment, where often the certification of the unmanned aircraft happens as a case-by-case inspection. One of the first countries within the EU that regulated the use of UAVs was the UK. France, Germany and the Scandinavian countries followed with more or less practical provisions afterwards. In Austria, UAVs have been legalized by law and regulations since the beginning of 2014.

This thesis identifies the key players, associations, working groups and responsible stakeholders in the development of the legislative environment for the certification of UAS in Europe. The goal is to elaborate the actual situation of regulations from selected European countries (UK, France, Germany, Italy and Austria), comparing and evaluating the advantages and disadvantages of their legal frameworks in order to determine the outlook for developing those regulations on the European and Austrian level.

1.2 Motivation & Importance of the Topic

In the past, these so called unmanned "drones" hit the headlines in a negative way because of military missions and were therefore in severe criticism. However, Unmanned Aerial Vehicles (UAV) were used for civil purposes even in our home country. The positive field of applications is quite extensive and undisputed, such as when used for searching for missing persons after an avalanche, locating people after natural disasters like a flood, the inspection of infrastructure like highway bridges, wind power plants or power grids as well as for dangerous operations like during a fire or for areas which are exposed to radiation. A good overview about the broad range of civil applications of UAS is given by figure 1.1.

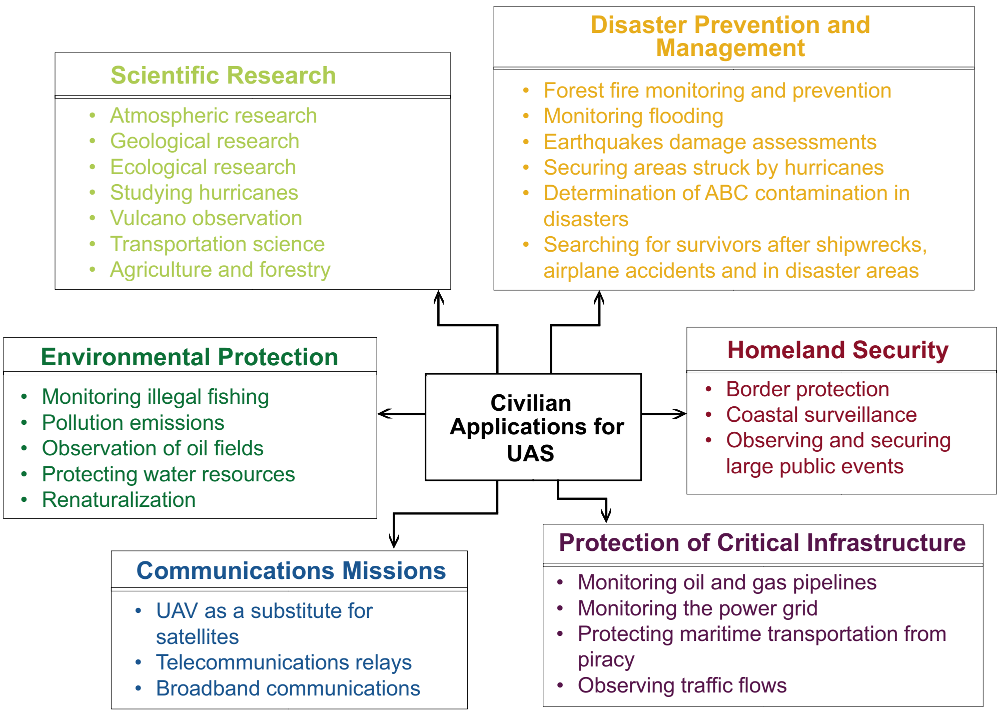

Figure 1.1: Overview of Civil UAS Applications [55]

All these civil applications represent new businesses and therefore new job opportunities. Up until now, most of the UAS flights were for military operations, but this technology has a great potential for civil applications too. It should not be seen as a competitor to manned aviation, but as a complement for operations that would not be performed by manned aviation like long enduring tasks (e.g. > 24 hours) or risky flights such as operations in the vicinity of nuclear power plants after an incident with emitting radiation.

Figure 1.2: First Certified Flight of a Civil UAV Class I (VLOS) in Austria [34, sl.17]

This master thesis is written at the boundary line between the actual topic of civil applications of UAS and their legal framework for the certification of them. It was noticeable through various discussions within the AAI-UAS-WG and at international and national UAS conferences, that a lot of manufacturers and developers as well as aerial service providers are having a lot of trouble by certifying the unmanned systems for a legal application due to poor regulations by law. A contribution to the idea of this thesis was made by the experience of the exhausting certification process with new UAS regulations for the first certified flight in Austria (see figure 1.2). This thesis was motivated to contribute in the development of a precise legal framework for the certification of UAS on the Austrian level as well as in the further development for harmonized UAS regulations on the European level.

1.3 Outline of the Thesis

The six parts of this thesis are structured as follows: This introduction should emphasize the importance of the topic for the whole society as well as introduce the reader into the world of unmanned aircraft systems. In the following sub-chapters the supervising company, the Austrian Aeronautics Industries Group, is introduced, and the Austrian UcM project within this thesis is developed and funded by the Austrian Promotion Agency (FFG).

The second and third part guide the reader from the most important international stakeholders, namely the International Civil Aviation Organization and the JARUS working group, over to the European institutions, like the European Commission, the European Aviation Safety Agency and EUROCONTROL which participate in the development of a legal framework for UAS on an European and international level. The structure and function of these involved parties are described as well as their activities in the field of unmanned systems.

Afterwards the general legal aviation framework and the competent authorities on the national level as well as the specific UAS regulations with their airworthiness-, operational- and pilot requirements, are described chronologically according to their date of introduction for five relevant countries (UK, France, Germany, Italy and Austria) of the European Union. The thesis gives a general survey about the different national UAS regulations, to be able to draw a conclusion for the foreseeable future but within the scope of this thesis not every detail of the different UAS regulations can be described due to considerable differences between the national UAS requirements.

In the following chapter, the specific national UAS requirements are summarized, compared and the differences as well as parallelisms identified. At the end, these national UAS regulations are assessed from a personal point of view.

This master thesis concludes with an outlook for the UAS regulations on a European level as well as a specific national outlook for Austria. The final conclusion completes this thesis with a summary of the results.

1.4 Supervising Company

The master thesis was created as part of my master internship at the Austrian Aeronautics Industries Group (AAI) with the help of the AAI-UAS working group and within the Austrian UcM Project funded by the Austrian Research Promotion Agency (FFG).

1.4.1 The Austrian Aeronautics Industries Group (AAI)

Figure 1.3: Official Header of the Austrian Aeronautics Industries Group (AAI)

The Austrian Aeronautics Industries Group is the official national association of the Austrian Aeronautics Supply Industry founded in 1999. Currently more than 30 members – which are companies with business or research activities in the Aviation Industry – belong to this non-profit organization. AAI supports information exchange and networking activities between the members and represents them in national and international affairs. In addition, the AAI has several working groups like the ILS-WG (ILS-Integrated Logistics Support) for data exchange standards like “S1000D”, and the AAI Quality Committee, which coordinates aviation related activities for Quality Management for the Austrian Aeronautics Supply Industry, in particular the Austrian implementation of the ICOP (Industry Controlled Other Party) Scheme and the Austrian structure for EN 9100 certifications. [2]

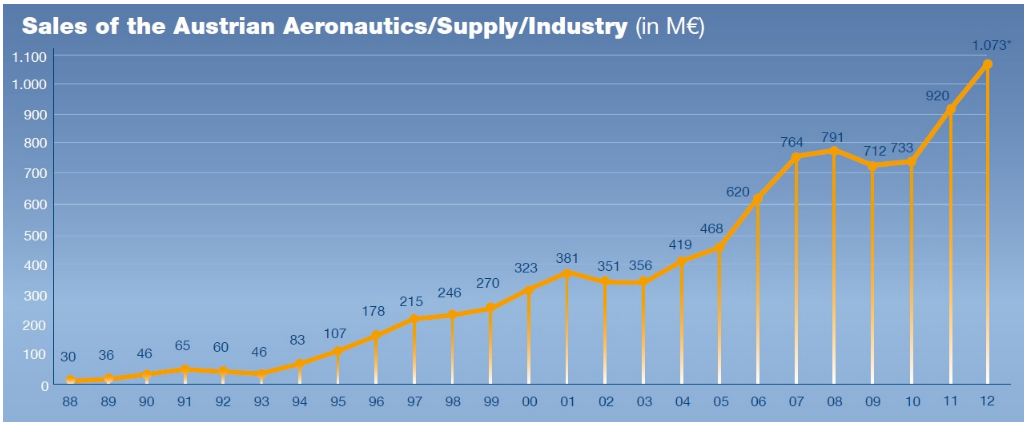

Figure 1.4: Total Turnover of all AAI-Members adopted from [1, p.3]

Austrian companies are operating in a wide area of the supply chain for the international aviation industry. The members of the Austrian Aeronautics Industry Group are structured into the following categories:

- Composites & Plastics
- Metal & Metal Processing
- Service & Maintenance
- Communication, Electronics & Information Systems
- Small Aircraft, Engines & UAS
- Manufacturing Technology, Test- & Ground Equipment
- Interiors, Equipment & other Components
- Engineering, Consulting, Research
- Industrial Associations & Institutions

The Austrian Aeronautics/Supply/Industry made its first appearance in the late 1980s when a famous Austrian Ski producer (Fischer) tested the production of carbon composite rods for the cargo bay of an aircraft. Over the last 25 years the total turnover, from the members of AAI, increased up to 1 billion euros in 2013. Figure 1.4 shows the evolution of the total turnover from the beginning of 1988 until 2012. [1, p.3]

1.4.2 AAI - UAS Working Group

The national UAS working group of Austria was founded by AAI in August 2012 during the kick-off meeting at the headquarters of the Federation of Austrian Industries in Vienna. The AAI-UAS-WG with more than 30 members in 2014, meet quarterly, every time at another head quarter of one of the participating stakeholders. The working group is not only open for members of the AAI but also for other Austrian UAS developers or researchers working in the field of unmanned aerial vehicles, sometimes also called RPAS (Remotely Piloted Aircraft System).

AAI helps with the coordination of the information exchange between the industry/research institutions and the national authorities like BMVIT (Austrian Federal Ministry for Transport, Innovation and Technology) and ACG (Austro Control GmbH) as well as with the European authorities like EASA (European Aviation Safety Agency) and EC (European Commission) especially in the field of rulemaking and certification. The UAS working group aims to link all relevant national UAS companies, developers and research institutions to foster collaboration and synergy. Consequently the AAI-UAS-WG became a member of UVS-International (see http://uvs-international.org/) in December 2013. [3]

1.4.3 TAKE OFF Project Austrian UcM

The Austrian UcM Project (Austrian UAS for civil Missions) is an industrial research project conducted by the FH JOANNEUM and the AAI initiated by the late Bruno Wiesler. It is funded within the TAKE OFF Call from 2012, which is the Austrian Aeronautics Research and Technology Program by BMVIT and FFG (Austrian Research Promotion Agency). The Goal is to develop a research agenda for Austrian aviation suppliers and for research and development enterprises in the field of UAVs up to a maximum take off weight of less than 150 kg as well as a detailed atlas of competence about the different research institutions, developer and manufacturer in the field of UAS with the help of personal interviews with relevant stakeholders of the Austrian Aeronautics Supply Industry.

A detailed international market research through participation in various conferences (see subsequent list) and international working groups (JARUS, UVSI, etc.) is being conducted. A contribution in the development of the regulatory framework for the certification of UAS in Austria together with the BMVIT, Austro Control (National Civil Aviation Authority) and the Austrian Aero-Club shall be done by the help of the AAI-UAS-WG.

The obtained experience and knowledge as a result of the participation of the various conferences, exhibitions and AAI-UAS-WG meetings contributed in the development of this thesis.

List of Visited Conferences, Exhibitions and AAI-UAS-WG Meetings:

- 19.3. - 21.3.2013 – **Ottobrunn/Germany** - DGLR Workshop about Datalink Technology for Manned and Unmanned Missions
- 24.4. - 27.4.2013 – **Friedrichshafen/Germany** - AERO 2013
- 25.4.2013 – **Friedrichshafen/Germany** - UAV DACH Meeting
- 28.5.2013 – **Graz/Austria** - 4th AAI-UAS-WG Meeting (FHJ) and press conference at the international Airport of Graz with first flights of UAS
- 29.5.2013 – **Graz/Austria** - Remotely Piloted Aircraft Systems - Towards Civil Applications (Workshop)
- 17.6. - 23.6.2013 – **Paris/France** - Paris Air Show 2013
- 27.8. - 1.9.2013 – **Moscow/Russia** - MAKS Airshow 2013
- 3.10.2013 – **Vienna/Austria** - Opportunities for stakeholders in the Remotely Piloted Aircraft Systems (RPAS) domain (ESPI - European Space Policy Institute)
- 22.10.2013 – **Vienna/Austria** - 5th AAI-UAS-WG Meeting (AIT)
- 5.11. - 7.11.2013 – **Frankfurt/Germany** - AIRTEC 2013 (UAV World Conference)
- 25.11.2013 – **Vienna/Austria** - ACG Info Meeting at WKO about LBTH67 (LBTH - Airworthiness Notification and Operational Notice)
- 5.12.2013 – **Graz/Austria** - ACstyria Aviation Day 2013
- 6.12.2013 – **Graz/Austria** - 2013 - Drones Approaching Austria Conference (OERK - Austrian Red Cross)
- 9.12. - 11.12.2013 – **Brussels/Belgium** - RPAS CivOps Conference 2013
- 23.1.2014 – **Innsbruck/Austria** - 6th AAI-UAS-WG Meeting (BFW)
- 24.1.2014 – **Pass Thurn/Austria** - First certified flight of a commercial UAS (Class 1 VLOS) in Austria (Dynamic Perspective)
- 5.2.2014 – **Vienna/Austria** - Flying and Filming with Unmanned Aerial Drones - the new Aviation Regulations for 2014 (WKO)
- 25.3. - 26.3.2014 – **Rorschach/Switzerland** - Bodensee Aerospace Meeting
- 9.4. - 12.4.2014 – **Friedrichshafen/Germany** - AERO 2014
- 10.4.2014 – **Friedrichshafen/Germany** - UAV DACH Meeting
- 20.5.2014 – **Brussels/Belgium** - Second JARUS Information and Dissemination Workshop
- 23.6. - 26.6.2014 – **Brussels/Belgium** - RPAS Conference 2014
- 2.7. - 4.7.2014 – **Salzburg/Austria** - AGIT - UAS Summit 2014
- 4.7.2014 – **Salzburg/Austria** - 7th AAI-UAS-WG Meeting (AGIT)

2 Structures & Upcoming Regulations on the International Level

The most relevant stakeholders involved in developing UAS regulations on the international level are ICAO and JARUS, as they are most important and have the most influence on the future of European and national UAS regulations, due to the coordination work that is done there by the national aviation authorities.

2.1 International Civil Aviation Organization (ICAO)

The general function and objectives of ICAO, the ICAO UAS Study Group and their activities relating to unmanned aircraft systems are summarized in the following subchapters.

2.1.1 Structure & Function of ICAO

The International Civil Aviation Organization (ICAO) is a body of the United Nations (UNO). It was first established after signing the Convention on International Civil Aviation (Chicago Convention) in 1944 by 52 nations. The Chicago Convention consists of 22 chapters containing 96 articles, regulating the international commercial and noncommercial air traffic (not applicable on governmental aircraft).

ICAO on behalf of their 191 member states (in 2014), along with the global aviation industry and international aviation organizations have developed international Standards and Recommended Practices (SARPs) which are accepted throughout the world to establish a uniform environment that maintains the highest safety standards and regulates the most complex interactions between air traffic control, pilots and aircraft. These SARPs serve as a basis for the development of national civil aviation rules for the individual states. The ICAO assembly consists of one representative of every member state (each member state has one vote), meet every three years and decide on changes to the Chicago Convention. 19 Annexes supported the Chicago Convention by 2014. Differences to the SARPS are announced by means of Regional Supplementary Procedures (SUPPs) of the member states. [37], [38], [39] Important Annexes to mention are (according to [41]):

Annex 1 : Personnel Licensing

Annex 2 : Rules of the Air

Annex 6 : Operation of Aircraft

Annex 8 : Airworthiness of Aircraft

2.1.2 ICAO - UAS Study Group & RPAS Panel

The ICAO Unmanned Aircraft Systems Study Group (UASSG) was introduced in 2006 when there was a need to help the IACO Secretariat develop SARPs, Procedures and Guidance Material for civil unmanned aircraft systems and to facilitate a safe, secure and efficient integration of UAS into non-segregated airspace and aerodromes. The UASSG is composed of 18-20 member states of the ICAO as well as 10-12 international organizations. Austria is represented by Gerhard Lippitsch from Austro Control. The study group has five different working groups dealing with:

- Operations,
- C2 & ATC Communications,
- Personnel Licensing,
- Air Traffic Management and
- Detect & Avoid.

The main goal of ICAO is to guarantee safety and global interoperability of international civil aviation. There is no need to establish new SARPs, but to harmonize terms, concepts and definitions. The UASSG has published a guidance document (Circular 328 published on March 10th, 2011, for further details see chapter 2.1.3, Circular 328 will be replaced in 2014 by ICAO RPAS Manual) which is not binding in the member states but will be used as a basis for the development of national regulations by the states and different organizations. The UASSG will, in addition to developing specific UAS SARPs, contribute to the development of technical (e.g. communication specifications for UAS) requirements by other working groups like WG-73 for Unmanned Aircraft Systems by EUROCAE or RTCA industry standards.

In contrast to all national working groups working on that topic, the focus of ICAO UASSG is on:

- International Aviation,
- Controlled Airspace and
- Controlled Aerodromes.

The last meeting of the ICAO UASSG took place in Montreal at the ICAO headquarters on June 30th, 2014. With the following meeting in November 2014 the UASSG is replaced by the ICAO RPAS Panel, focusing on the same objectives. [67], [68, p.25], [69, p.22]

2.1.3 Circular 328

„Unmanned aircraft are, indeed aircraft",

specified and defined by the International Civil Aviation Organization (ICAO) in Circular 328 AN/190 from 2011. [42, p.2] Therefore most of the existing regulations and certification specifications apply to a great extent but of course there is also a need to develop new and adapted provisions in order to integrate unmanned aircraft in a safe, reliable and practical way into the common airspace. It was first defined by the Global Air Traffic Management Operational Concept (Doc 9854 AN/485) in 2005 that

> *"An unmanned aerial vehicle is a pilotless aircraft, in the sense of Article 8 of the Convention on International Civil Aviation, which is flown without a pilot-in-command on-board and is either remotely and fully controlled from another place (ground, another aircraft, space) or programmed and fully autonomous"*
>
> [40, p.B-6]

and therefore all existing applicable SARP (Standards and Recommended Practices) apply. The ICAO Assembly confirmed this statement in their 35th Session and with the Circular 328. Article 8 of the Convention on International Civil Aviation (Doc 7300, Chicago Convention) deals with "pilotless aircraft" and already stated in the original document signed in December 1944:

> *"No aircraft capable of being flown without a pilot shall be flown without a pilot over the territory of a contracting State without special authorization*

by that State and in accordance with the terms of such authorization. Each contracting State undertakes to insure that the flight of such aircraft without a pilot in regions open to civil aircraft shall be so controlled as to obviate danger to civil aircraft".

[41, p.5]

The aim of Circular 328 is to develop a regulatory concept for the introduction of UAS into the global aviation system. The document deals with the three main categories of aviation:

- Operations,
- Equipment and
- Personnel.

[42, chap.1.8]

ICAO concludes that all unmanned aircraft (remotely piloted, fully autonomous or combinations of those aerial vehicles) fall under the provisions of Article 8 (UAVs are considered as an aircraft by ICAO). The first step will be the integration of remotely piloted aircraft (RPA) into the aviation system because those unmanned aerial vehicles could be managed on a real time basis during flight. In the future, more focus will be on integrating autonomous aircraft [42, chap.2.2].

Model aircraft, which are used only for recreational purposes, are outside of the provisions of the Chicago Convention and therefore managed by national regulations [42, chap.2.4].

All types of aircraft (fixed-wing, rotary-wing, lighter-than-air) as well as land, sea or amphibious vehicles will be transformed into unmanned vehicles sooner or later and therefore should be considered for matters of airworthiness, personnel licensing and separation requirements. In general, all articles (SARPS, PANS, etc.) should apply equally to the whole spectrum of aerial vehicles. The definitions for "operator" and "pilot" remain unchanged:

Operator : *A person, organization or enterprise engaged in or offering to engage in an aircraft operation.*

Pilot : *The person who manipulates the flight controls of an aircraft during flight time.* (on board)

[42, chap.GLOSSARY]

To consider pilots who are commanding their aircraft from another location other than on on board, the term “remote pilot” is introduced.

Remote pilot : *The person who manipulates the flight controls of a remotely-piloted aircraft during flight time.*

[42, chap.GLOSSARY]

A few more important unmanned aerial vehicle specific terms are defined by ICAO as follows:

Unmanned Aircraft (UA) *An aircraft, which is intended to operate with no pilot on board.*

Unmanned Aircraft System (UAS) *An aircraft and its associated elements which are operated with no pilot on board.*

Autonomous Aircraft *An unmanned aircraft that does not allow pilot intervention in the management of the flight.*

Remotely Piloted Aircraft (RPA) *An aircraft where the flying pilot is not on board the aircraft.*

Remotely Piloted Aircraft System (RPAS) *A set of configurable elements consisting of a remotely piloted aircraft, its associated remote pilot station(s), the required command and control links and any other system elements as may be required, at any point during flight operation.*

[42, chap.GLOSSARY]

- Why “UAS”?

For as many different types of aircraft that are available, just as many different synonyms for unmanned vehicles are established. The spectrum ranges from UAS (Unmanned Aerial Systems) via drone (commonly used and associated with military unmanned vehicles) up to the newest term, RPAS (Remotely Piloted Aircraft Systems). UAS is the more general definition of unmanned vehicles which covers both fully autonomous flight, where no pilot intervention is allowed and the unmanned vehicle takes its own decisions (like artificial intelligent which acts like humans) as well as remotely piloted vehicles where a pilot not on board (whether on ground, on another aircraft or from space) has the responsibility over the flight and can interact with other aircraft and the air traffic controllers. It is recognized by ICAO that “only the remotely-piloted aircraft (RPA), however, will be able to integrate into the international civil aviation system in the foreseeable future”. It is the first step to integrate unmanned vehicles into unsegregated airspace, where the main difference to the aviation system today is that the responsible pilot in command is not on board the vehicle itself, but compared to autonomous aircraft (where the missing key technology are detect & avoid systems), the human is always “in the loop” and can manage the behavior of the unmanned vehicle on a real-time basis during the whole flight.

For a safe integration, unmanned aerial vehicles should act and react as manned aircraft do. Therefore the remote pilot has to fulfill the same knowledge and responsibilities as a usual pilot of the manned aviation system (air law, flight performance, flight planning, human performance, meteorology, navigation, operational procedures, principles of flight and radiotelephony). New technology is required in the absence of a pilot on board (although the responsibility will not be transferred to any particular technology in the foreseeable future) for detect & avoid systems (the UAS must identify other objects in order to avoid collisions), to command and control (the remote pilot of an unmanned vehicle controls the aircraft from another location other than on ground and must therefore transmit the command and control procedures), to communicate with ATC (the phraseology should be adopted to facilitate the requirements of unmanned aircraft) and to prevent unintended or unlawful interference. [42, chap.2.13, 2.14, 2.15, 3.1]

Most of the civil applications for UAS will have to be done in Visual Meteorological Conditions (VMC), e.g. to conduct visual surveillance and observation missions. These operations, outside of controlled airspace, require far more complex systems to avoid collisions with other airspace users, which means the civil market will develop at a much slower pace. The integration of UAS in controlled airspace under Instrument Meteorological Conditions (IMC) and Instrument Flight Rules (IFR), where the air traffic service providers are responsible for separation and collision avoidance, could be easier and faster (ATC and telecommunication procedures has to be adopted) than flying a UAS under VMC and VFR in uncontrolled airspace (new technologies, such as detect & avoid systems, need to be developed). [42, chap.5]

Circular 328 refers to the key requirements, which the solution of the detect and avoid system should facilitate. Depending on the type of UAS, the used airspace (controlled or uncontrolled), the operation as well as the related responsibilities of the flight crew, the UAS should be able to:

- *recognize and understand aerodrome signs, markings and lighting,*
- *recognize visual signals (e.g. interception),*

- *identify and avoid terrain,*
- *identify and avoid severe weather,*
- *maintain applicable distance from cloud,*
- *provide "visual" separation from other aircraft or vehicles and*
- *avoid collisions.*

[42, chap.5.6]

If the UAS does not meet all of the above mentioned abilities, the operations could be limited to specific air spaces, geographical locations, flight rules, meteorological conditions and/or air traffic density. [42, chap.5.7]

In the Project Austrian UcM (see chapter 1.4.3) the AAI has developed a taxonomy of UAV systems that fully supports the ICAO approach, that UAS are aircraft (see figure 2.1).

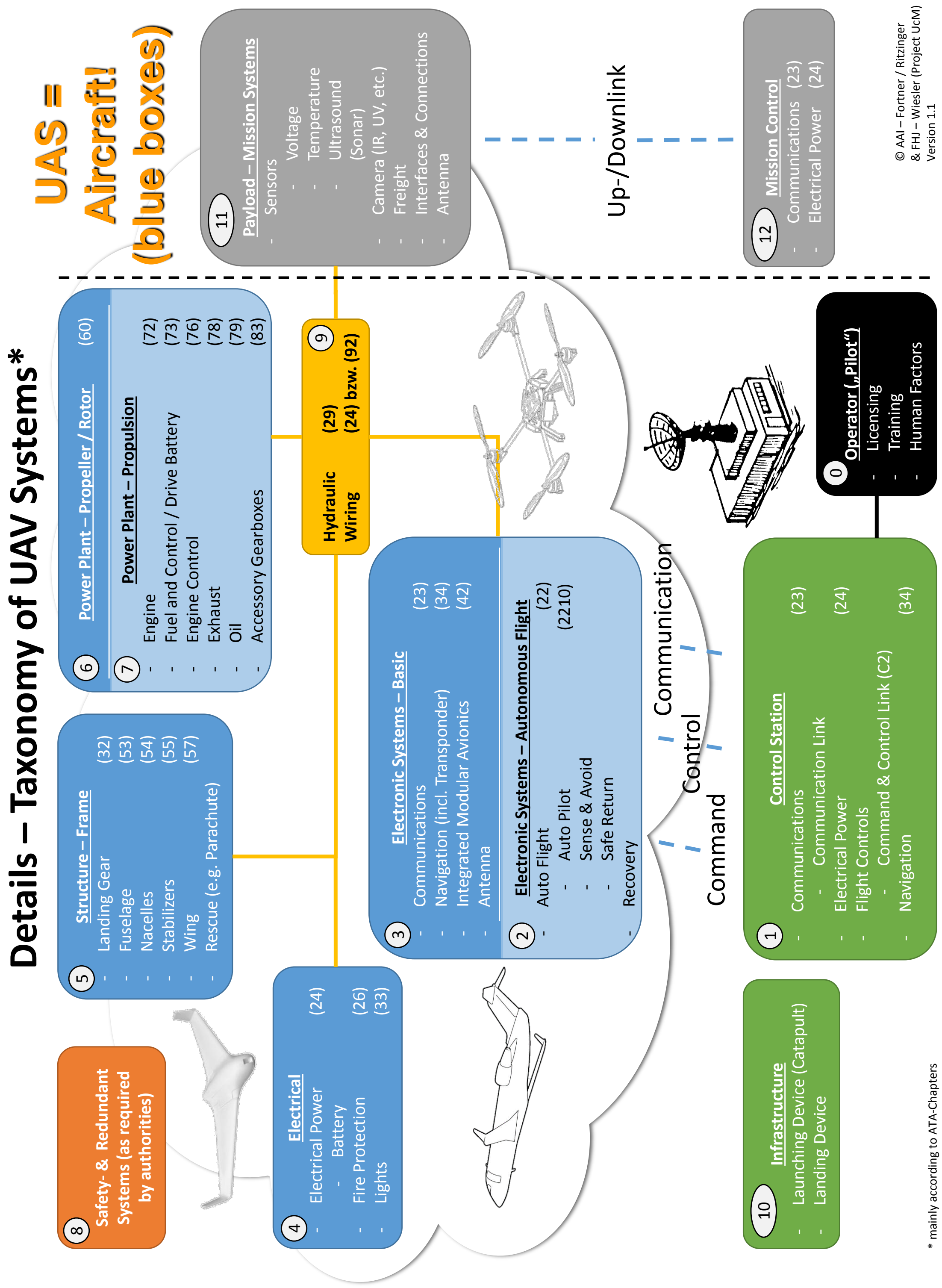

Figure 2.1: Taxonomy of UAV Systems [34, sl.9]

2.1.4 Amendment 43 to Annex II

The Amendment 43 became applicable on 16th July 2012 and mentioned explicit changes to Annex II - Rules of the Air of the Convention on International Civil Aviation (Chicago Convention) to consider RPAS. The Amendment 43 was developed by the Separation and Airspace Safety Panel (SASP) as well as the Unmanned Aircraft Systems Study Group (UASSG, see chapter 2.1.2).

All ICAO SARPs only apply to international civil aviation (e.g. flights from one country or continent to another). Therefore these regulations may only be relevant to Beyond Visual Line of Sight (BVLOS) operations above 500 ft, regardless of the MTOM (because usually Very Low Level (VLL) or Visual Line of Sight operations have no impact on the global scale; for further infos see chapter 3.1.3).

In chapter 3.1 "Protection of persons and property" of Annex II, the following paragraph is inserted:

> *3.1.9 Remotely piloted aircraft*
>
> *A remotely piloted aircraft shall be operated in such a manner as to minimize hazards to persons, property or other aircraft and in accordance with the conditions specified in Appendix 4.*
>
> [43, p.4]

For further information see [43].

2.2 Joint Authorities for Rulemaking on Unmanned Systems (JARUS)

The subsequent chapters describe the Joint Authorities for Rulemaking on Unmanned Systems Working Group and the content of their regulation deliverables relating to unmanned aircraft systems. JARUS is the most important international working group for supporting harmonized UAS regulations.

2.2.1 Structure & Function of JARUS

The JARUS Working Group was introduced by the Civil Aviation Authority of the Netherlands in 2007. Ron van de Leijgraaf, working for the Ministry of Infrastructure and the Environment of the Netherlands, is the founder and chair man of JARUS. The initial goal was to develop international regulations for small rotorcraft RPAS in the form of a first certification specification called CS-LURS (Certification Specification for Light Unmanned Rotorcraft Systems), driven by a strong demand from the RPAS industry.

In 2014 the national CAAs of the following countries participate in JARUS: Australia, Austria, Belgium, Brazil, Canada, Czech Republic, Colombia, Denmark, Finland, France, Germany, Greece, Ireland, Israel, Italy, Malta, The Netherlands, Norway, Russia, South Africa, Spain, Switzerland, United Kingdom and the United States of America as well as EASA and EUROCONTROL as European supranational organizations. [17, sl.4]

JARUS was invited by the European Commission to participate in the European RPAS Steering Group (ERSG, see chapter 3.1.3). With the introduction of the European RPAS Roadmap (see chapter 3.1.3), the JARUS group took responsibility for various deliverables to cover all aspects of UAS operations (Operational, Personnel, Technical and Organizations), with its primary output being the recommended operational requirements and certification specifications, which can be used for the approval process of RPAS. [68, p.30]

JARUS has established seven working groups:

- WG-1 Operational and Remote Crew Licensing Requirements Group (OPS)
- WG-2 Organisational Approval Group (ORG)
- WG-3 Airworthiness Group (AW)
- WG-4 Detect and Avoid Group (DA)
- WG-5 Command, Control and Communication Group (C3)
- WG-6 UAS System Safety Group (AMC UAS.1309)
- WG-7 Concepts of Operations Group (ConOps)

[69, p.70-71]

The documents which are open for external consultation, available through July 2014, are mentioned in the following sub-chapter.

2.2.2 Current Drafts & Deliverables of JARUS

Within the JARUS working group, a few draft requirements for personnel licensing, technical aspects (e.g. certification specifications) as well as requirements for operational organizations were developed. Following list should illustrate the different publications of JARUS which has been already published as a draft version or will be published in the foreseeable future.

JARUS deliverables at a glance:

JARUS FCL : Requirements for Flight Crew Licensing

JARUS ORG : Requirements governing organizations involved in the design, production, operation and continuing airworthiness of unmanned aircraft systems

CS-LURS : Certification Specification for Light Unmanned Rotorcraft Systems

CS-LUAS : Certification Specification for Light Unmanned Aircraft Systems

AMC UAS.1309 : System Safety Assessment for all categories of unmanned aircraft and related systems

TLS D&A : Requirements for Detect and Avoid Systems

TLS C2 - ConOps : Guidance on RPAS C2 link - Concepts of Operations

TLS C2 - RCP : Guidance on RPAS C2 link - Required Communication Performance

JARUS OPS VLOS : Guidance for VLOS Operations

JARUS Part 21 : Production Organization Approval

JARUS ATO : Approved Training Organization

JARUS DOA/POA

JARUS BVLOS equipment : Beyond Visual Line of Sight equipment

JARUS FCL observer : Flight Crew Licensing observer

JARUS OPS EVLOS : Guidance for Extended Visual Line of Sight Operations

[17, sl.10], [68, p.30], [69, p.70]

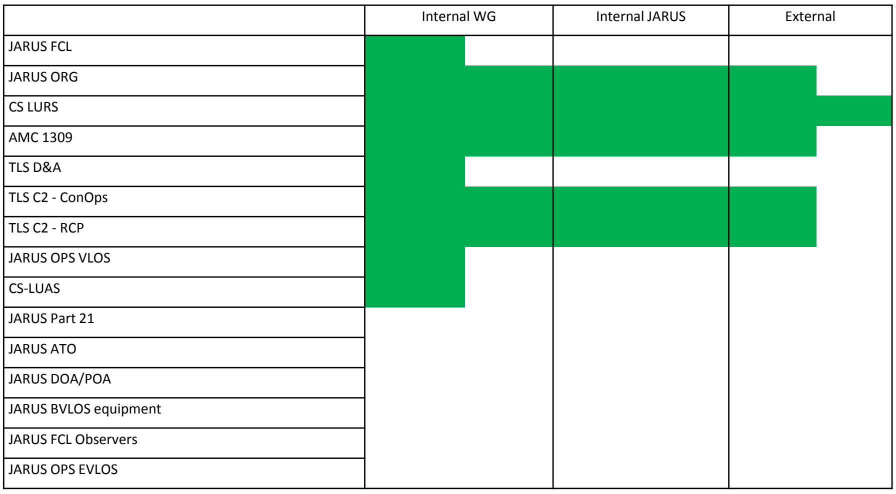

Figure 2.2: Status of JARUS Deliverables [70]

In figure 2.2 the status of the JARUS deliverables is illustrated, current as of June 2014.

Following deliverables has already been published for public consultation in a draft version by August 2014:

JARUS ORG : The JARUS ORG propose requirements for RPAS operators and Approved Training Organizations as well as related authority recommendations. The scope of this document ranges from VLL RPAS operations (below 500 ft) in VLOS and BVLOS conditions in non-segregated airspace up to RPAS operations above 500 ft and BVLOS. [47]

CS-LURS : It is a certification specification for light unmanned rotorcraft systems of up to 750 kg MTOM. It has been developed based on the certification specifications for manned very light rotorcraft (CS-VLR). It consists of two parts, whereas the first part contains the specific airworthiness requirements and the second part so-called Acceptable Means of Compliance (AMC). [45]

AMC UAS.1309 : The AMC UAS.1309 defines top level UAS airworthiness and system safety objectives to meet the predefined safety standards. It gives recommendations about UAS failure classifications in terms of probability requirements.

TLS C2 - RCP : This document serves as a guidance material for explaining the concept of required communication performance for the C2 link of RPAS. It describes the requirements for the C2 link with the help of operational scenarios. [46]

3 Structures & Upcoming Regulations on the European Level

The most relevant stakeholders involved in developing UAS regulations on the European level are the European Commission, EASA and EUROCONTROL as they are the most important and have the most influence on the future of European and national UAS regulations.

3.1 European Commission (EC)

The following sub-chapters introduce the European Commission and their activities in the field of unmanned aircraft systems and also summarize the outcome of different surveys on behalf of the EC, illustrating the potential market volume of the future UAS-industry.

3.1.1 Structure & Function of DG MOVE & DG ENTR

The European Commission represents the interests of all EU member states. It initiates laws and directives for implementation by the European Parliament and the Council of the EU. 28 commissioners (one commissioner per member state) are representing the European Commission in 2014. The Commissions administration consists of several departments (DG - Directorates General) and services. [24] The two most important DGs for the aerospace industry are:

- Enterprise and Industry (DG-ENTR)
- Mobility and Transport (DG-MOVE)

[25]

The European Commission already recognized the importance of RPAS for civil applications. To foster the innovative market of aerial services as well as the RPAS manufacturing industry, the EC introduced:

- a Staff Working Document SWD(2012) 259 in September 2012, "Towards a European Strategy for the Development of Civil Applications of Remotely Piloted Aircraft Systems (RPAS)",
- a Communication COM(2014) 207 with the title "A New Era for Aviation – Opening the Aviation Market to the Civil Use of Remotely Piloted Aircraft Systems in a Safe and Sustainable Manner" in April 2014.

Overall, the EC is smoothing the way for all European stakeholders by providing a means for funding projects and surveys. The SWD 259 as well as the COM 207 should be seen as guidance documents that express just how important this topic is for the European Commission, as well as their political intentions for the next years.

3.1.2 SWD(2012) 259 - Towards a European Strategy for the Development of Civil Applications of Remotely Piloted Aircraft Systems (RPAS)

The Staff Working Document is the outcome of all previous actions taken by the EC as well as the "UAS Panel Process". The "UAS Panel Process" consisted of 5 different workshops which took place from July 2011 to February 2012 that covered the following topics:

- Industry and Market,
- Airspace Integration,
- Safety,
- Societal Impact, and
- Research and Development.

The following institutions and organizations participated in the workshops: Eurocontrol, European Civil Aviation Conference (ECAC), EASA, the scientific community, European Civil Aviation Authorities, ICAO, JARUS, Ministries of the Interior (border surveillance, police forces), European Defence Agency (EDA), Ministry of Defence, European Space Agency (ESA), international military organizations, non-governmental organizations, international stakeholders, European citizens and industry representation anywhere from SMEs to global RPAS manufacturing and operating members.[27]

The EC recognizes as part of their 2020 European strategy that the RPAS industry can continue to promote new businesses and therefore new job opportunities. Up until now, the UAS has had a negative image in society due to its exponential rise in military operations (95% of operations are military). On the other hand, this technology has a great potential for civil applications. It should not be seen as a competitor to manned aviation, but as a complement for operations that would not be performed by manned aviation such as long enduring tasks (e.g. > 24 hours) or flights with a high risk for humans, such as operations in the vicinity of nuclear power plants after an incident with emitting radiation.[27, p.4] Beside the support of governmental applications (crisis management, law enforcement, border control of fire fighting), RPAS can be deployed for the following commercial services: precision agriculture and fisheries, inspection of power/gas lines and infrastructure, telecommunication and broadcast services, natural resources monitoring, media/entertainment, digital mapping, land and wildlife management, air quality management/control, etc. It is concluded that the service industry is anticipated to have a higher revenue than the manufacturing industry itself.

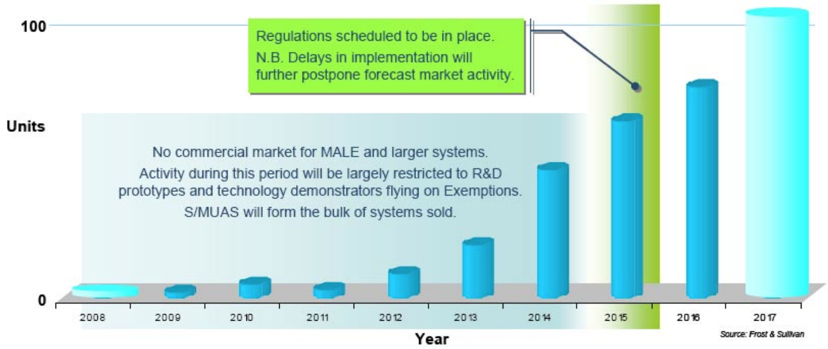

Figure 3.1: Market Forecast of European Civil UAS (adopted from [35, p.12])

The majority of RPAS systems are lighter than 150 kg, even lighter than 25 kg, and are developed, manufactured and operated by small SMEs with less than 5 employees (approximately 80% of the current industry). Most of these SMEs are coming from business areas other than the aviation sector. In 2007, "Frost & Sullivan" conducted a study on behalf of the EC about a market forecast for civil UAS applications. In figure 3.1, the huge potential of UAS can be seen, if regulations are enforced. In figure 3.2 the distribution of different areas of applications per year is illustrated. All is depending on a clear legal framework for UAS. For instance in Japan, the number of RPAS operators was multiplied by 18 after the introduction of RPAS regulations for agricultural use between 1993 and 2005. [28, p.3]

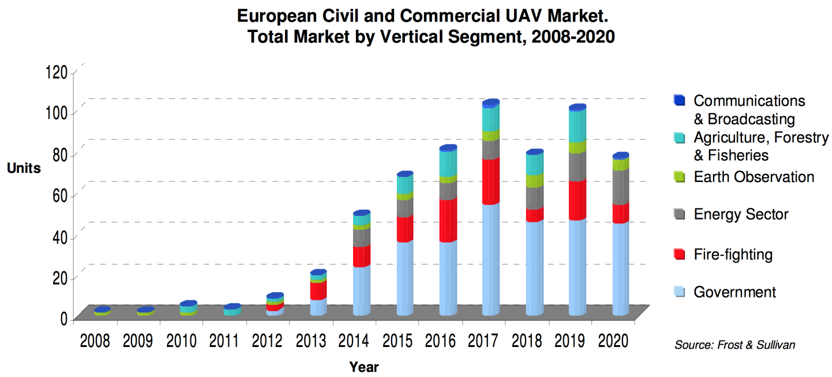

Figure 3.2: Forecast of European Civil UAS Market per Application (adopted from [36, p.8])

Another advantage of promoting the UAS industry is the spin-in/spin-out effect. The technologies which are now in development for unmanned systems could also be used to enhance the capabilities of manned systems (e.g. decreasing the work load for pilots up to one-man cockpit, highly automated flights, better collision avoidance systems, optionally piloted aircraft, etc.). [27, p.11]

Main conclusion of the document: RPAS are highly important for future civil applications in achieving useful tasks and creating new job opportunities. To reach these goals, a safe integration of UAS into the full aviation system has to be achieved as soon as possible. This requires specific technologies as well as regulations at the European and national level through coordinated progress between all relevant stakeholders (EASA, national civil aviation authorities, EUROCAE, Eurocontrol, JARUS as well as the industry partners).

3.1.3 European RPAS Roadmap

The European Commission has recognized the importance of Remotely Piloted Aircraft Systems (RPAS) as they stated on their website:

> *RPAS can offer a wide range of civil applications for the benefit of European citizens and businesses. Being remotely piloted, RPA can perform tasks that manned systems cannot perform, either for safety or for economic reasons.*
>
> [26]

The European Commission organized therefore three important initiatives to foster the development of regulations for unmanned vehicles in the European Union:

- 2009: DG Mobility and Transport organized a "Hearing on Light Unmanned Aircraft"
- 2010: DG Mobility and Transport together with the European Defense Agency organized a High-level conference on Unmanned Aircraft Systems
- June 2011 to February 2012: DG Enterprise and DG Mobility and Transport performed five workshops, called the "UAS Panel Process" where the outcome is summarized in the staff working document from September 2012 "Towards a European strategy for the development of civil applications of Remotely Piloted Aircraft Systems (RPAS)"

[26]

As a result of the activities between 2009 and 2012, the European Commission established the "European RPAS Steering Group (ERSG)", a group of experts interested in the integration of RPAS into the common European airspace: EASA, EUROCONTROL, EUROCAE, SESAR JU, ECAC, EDA, ESA, ASD, UVSI, EREA and ECA. They aimed to prepare a "roadmap for the safe integration of civil RPAS into the European aviation system". The RPAS roadmap with the proposed series of actions, which has to be executed for a safe integration, was delivered by the ERSG to the European Commission during a media event at the 50th Paris Air show on June 20th, 2013.

The European RPAS Roadmap consists of four parts, which are a short introduction to the topic, as well as three Annexes:

- Annex 1: deals with the "Regulatory Work Plan" for the safe operation of RPAS outside of segregated airspace
- Annex 2: provides a R&D plan about all important key technologies which are necessary to reach a safe integration of RPAS
- Annex 3: defines the societal impact of RPAS

The progress of the RPAS integration is divided into four Time Frames from 2013 until 2028 based on the ICAO Aviation System Block Upgrades (ASBU). The ASBUs were developed to harmonize the worldwide infrastructure technology upgrades of the Air Navigation Service Providers (ANSP) in order to provide the same ATC services everywhere around the world. Special attention is placed on the seamless integration of RPAS into the common airspace with no disturbances to the current airspace users. This implies further:

- No Decreasing Safety Standards,
- No Disruption of Current Airspace Users,
- No Change in Current ATC Procedures and
- No Additional Equipment Provoked by RPAS.

[32]

As a conclusion, RPAS must fulfill the technical requirements for Communication, Navigation and Surveillance of the correspondent airspace-class in which they are operated. The roadmap illustrates the typical flight profiles of RPAS. Above 150 m or 500 ft, which is the minimum flight altitude of the manned aviation, RPAS will be operated under VFR

(Visual Flight Rules) or IFR (Instrument Flight Rules). The unmanned vehicles must fit into existing flight regulations of manned aviation. Flights below 150 m or 500 ft and consequently outside of the typical VFR and IFR airspace sectors are called very low level (VLL) operations. These operations take place where no usual flight activity is expected, except for:

- Approaching/Landing or Departing Aircraft in the Vicinity of an Airfield/Airport,
- Authorized Off-Field Landings by Helicopters or Aircraft,
- Forced Landings of Sailplanes or Aircraft on Fields,
- Emergency Flights with Search and Rescue Helicopters or
- Low Level Flights by Governmental Helicopters or from the Federal Armed Forces.

The VLL, VFR and IFR operations defined by the European RPAS roadmap are as follows:

1. Very low level (VLL) operations below the typical IFR and VFR altitudes, i.e. below 500 ft (~150 m)
   a. Visual Line of Sight (VLOS) not greater than 500 m from the remote pilot
   b. Extended Visual Line of Sight (EVLOS) beyond 400 m where the pilot is supported by an observer
   c. Beyond VLOS (BVLOS) below 500 ft but beyond visual line of sight
2. VFR and IFR operations of RPAS above 500 ft
   a. IFR (or VFR) in radio line of sight (RLOS) where manned aviation is present (key capability is 'detect and avoid')
   b. IFR (or VFR) beyond radio line of sight (BRLOS) where the RPAS is no longer in direct radio contact and therefore a wider range of communication (i.e. SATCOM) is necessary

[32, p.13]

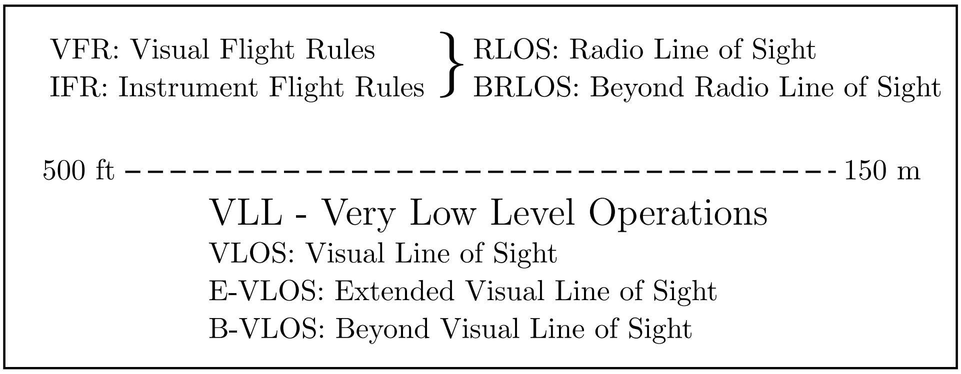

Figure 3.3: Types of Operation adopted from [32]

In figure 3.3, the different airspace sectors for RPAS operations, as defined above by the roadmap, are shown. As mentioned, the roadmap is in line with the ICAO-ASBUs and hence the time frames for the different integration steps of RPAS into the common airspace are defined as follows:

ICAO ASBU 0 - Time Frame 2013 : Commercial VLOS as well as EVLOS operations of light RPAS (below 150 kg MTOM) are authorized on the basis of first national regulations in some EU states (no harmonization between the member states). The certification of airworthiness for RPAS of small mass (below 25 kg) are in progress on a trial basis. A proposal for common rules to access non-segregated airspace has been published by EASA NPA 2012-10 on August 21st, 2012 (later retrieved and republished with NPA 2014-09 on April 3rd, 2014, for further information see chapter 3.2.2)

ICAO ASBU 1 - Time Frame 2014-2018 : Commercial VLOS and EVLOS operations of light RPAS is "business as usual" on the basis of national regulations as well as flights over urban and highly populated areas. Common regulations could be expected by the end of 2018. Authorized BVLOS flights are developing for very low level (below 150 m) operations. IFR operations of light RPAS with first detect and avoid systems for cooperative airspace participants (cooperative means that both airspace users have a system on board which interact with each other to prevent a collision similar to the Traffic Alert and Collision Avoidance System (TCAS) on the basis of a manned aviation transponder) could be possible in airspace class "A" and "C". VFR operations will be allowed under special conditions.

ICAO ASBU 2 - Time Frame 2019-2023 : Common harmonized rules for RPAS of any mass are introduced and commercial VLOS and EVLOS operations of light RPAS are fully integrated in the civil aviation airspace. A further development of BVLOS operations over populated areas taking place. Licensed remote pilots from a certified RPAS operator will be able to operate approved RPAS under IFR in nearly all airspace classes. Initial VFR operations of light RPAS will be launched.

ICAO ASBU 3 - Time Frame 2024-2028 : RPAS are allowed to be operated in most non-segregated airspace sectors together with manned aviation participants under the same Air Traffic Management (ATM) procedures, ensuring the same safety level. The technical and operational regulations are being revised and continually improved in order to facilitate the seamless and efficient integration of RPAS. Common rules among all EU member states enable cross border operations within the EU.

[32, p.15]

A few technological gaps were identified, which have to be taken under consideration in order to achieve the previously mentioned objectives. These areas of interest were found according to the European RPAS roadmap:

- *Integration into ATM and Airspace Environments,*
- *Verification and Validation,*
- *Data communication Links incl. Spectrum Issues,*
- *Detect & Avoid Systems and Operational Procedures,*
- *Security Issues,*
- *Operational Contingency Procedures and Systems and*
- *Surface Operations incl. Take-Off and Landing.*

[32, p.8]

The RPAS roadmap submitted a step-by-step integration based on the five types of RPAS operations (VLOS, EVLOS, BVLOS, IFR and VFR) and three different levels of development (initial operation, integration and evolution). The milestone plan in figure 3.4 shows a detailed plan for initial operations, where first operations under strict restrictions are allowed, via the integration of RPAS into non-segregated airspace with moderate limitations up to the evolution of full integration of RPAS. The critical path of initial operations in figure 3.4 illustrates the first authorized flights of RPAS and the corresponding types of operation (VLOS, EVLOS, BVLOS, IFR and VFR) under restrictions by the national CAA often only in segregated airspace. Cross-border operations are not expected during this time of introduction and flights in non-segregated airspace are only allowed under strict limitations and on the basis of case-by-case authorization. Light

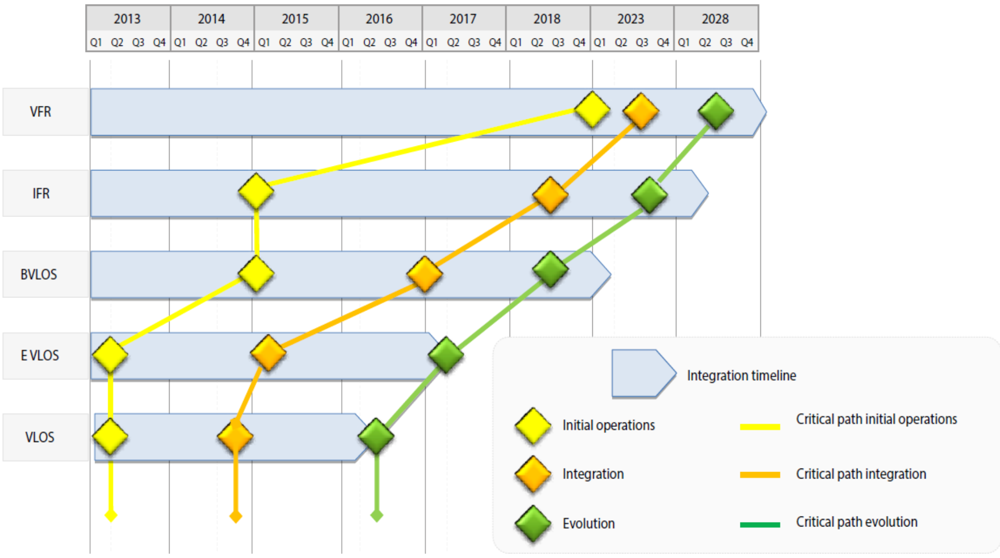

Figure 3.4: European RPAS Roadmap - Milestones [32, p.14]

RPAS operations below 150 kg MTOM are based on harmonized regulations to access non-segregated airspace and controlled airspace in the vicinity of aerodromes initiating with the critical path of integration. Harmonization on a worldwide scale is being developed by ICAO and EASA with the help of JARUS (Joint Authorities for Rulemaking on Unmanned Systems). The complete integration is initiated by the critical path of evolution which aims at fully certified and approved RPAS, flown by licensed remote pilots from certified operators in cross border operations, segregated and non-segregated airspace and over heavily populated areas.[32]

3.1.4 COM(2014) 207 - A New Era for Aviation – Opening the Aviation Market to the Civil Use of Remotely Piloted Aircraft Systems in a Safe and Sustainable Manner

The COM(2014) 207, which was published on April 8th, 2014, by the European Commission recaps the importance of RPAS for the European market and emphasizes the need to remove hurdles for the European RPAS manufacturer and service industry so that these unmanned aircraft can fly like "normal" air space users and integrate among "normally piloted" aircraft in non-segregated airspace. The exact revenues produced by the RPAS industry are difficult to predict, but according to a market profile and forecast from 2013 about unmanned aerial vehicle systems by the Teal Group, the global budget for R&D and procurement is expected to grow from €5.2 billion to about €11.6 billion per year in 2023. [57] The RPAS industry will generate several new jobs. An estimation provided by the Aerospace and Defence Industries Association of Europe (ASD), says that 150,000 jobs will be created in Europe by 2050 through the RPAS service industry. [28, p.4]

As Article 8 of the Chicago Convention states, a flight authorization issued by a competent authority is necessary for conducting a flight with an aircraft. While individual countries have started off with the development of national rules, a real European market will not emerge without the harmonization of the standards within the European Union by EASA.

It is mentioned that EASA is the right authority to establish European regulations but the restricted competence of RPAS above 150 kg MTOM according to regulation (EC) No 216/2008 [31, p.L79/33] should be reconsidered. Further, the importance of JARUS is mentioned and that EASA should participate in the process to produce implementing rules and guidance material for the member states. These regulations should be proportionate to risk and should keep in mind the various differences in weight, speed, complexity of the system, airspace classes and the specific characteristics of operations.

The COM concludes with the following six actions, which will be the next steps taken by the European Commission:

1. *The Commission will examine the regulatory preconditions to integrate RPAS into the European airspace from 2016 onwards, covering the necessary basic regulatory issues to ensure a coherent and effective policy, including on the appropriate scope of EASA competence. Any possible legislative action will be preceded by an impact assessment.*
   The Commission will request EASA to develop the necessary Opinions which could lead to adopting implementing rules, based where possible on international processes, proportionate to risk and subject to effective consultation.
   The Commission will ensure that potential manufacturers, operators and other involved organisations have an easy and up to date access to the applicable regulatory initiatives, including through the notification system of Directive 1998/34/EC.

2. *The Commission will ensure, within the limits of available resources, that identified R&D needs for the integration of RPAS in the ATM Master Plan are taken into account in the SESAR2020 Programme as necessary.*

3. *The Commission will ensure that security aspects are covered in the operations of RPAS to avoid unlawful interference, so that manufacturers and operators can take the appropriate security mitigating measures.*

4. *The Commission will assess how to make RPAS applications compliant with data protection rules. It intends to consult experts and relevant stakeholders; to address the measures in its field of competence, possibly including awareness raising actions, to protect fundamental rights; and to promote measures under national competence.*

5. *The Commission will assess the current liability regime and third-party insurance requirement. It will, subject to the impact assessment, take the appropriate initiatives to ensure that adequate regulatory provisions are in place.*
6. *The Commission will define specific actions under Horizon 2020 and COSME to support the development of the RPAS market and will ensure that the actors involved, in particular SMEs, have a comprehensive view of these tools. It will establish the necessary cooperation mechanisms with the work undertaken by the SESAR Joint Undertaking to avoid overlapping and leverage on the available resources.*

[28, p.6-9]

3.2 European Aviation Safety Agency (EASA)

In the following sub-chapters the European Aviation Safety Agency as well as their activities in the field of unmanned aircraft systems will be introduced.

3.2.1 Structure & Function of EASA

The European Aviation Safety Agency (EASA) was established in 2003, by the so-called "Basic Regulation". Prior to EASA, the JAA (Joint Aviation Authorities) was an association of different national civil aviation authorities (CAAs), which had agreed to cooperate in developing common aviation regulations without the power of a regulatory authority. The agreed regulations had to be accepted by each of the member states and were transformed into national law. The main advantage of EASA compared to JAA is that the regulations established by EASA are enacted through the European Commission and European Parliament and therefore legally binding in all EU member states. EASA, which is integrated into the department (Directorates-General, DG) mobility and transport (DG MOVE) of the European Commission (EC), has successively undertaken the function of the JAA and since 2008 has become fully functional by regulation (EC) No 216/2008 (Basic Regulation).[20]

Through the Basic Regulation, EASA excluded unmanned aircraft with an operating mass below 150 kg from the responsibilities of EASA and assigned it to the aviation authorities of the individual member states as stated in Annex II of regulation (EC) No 216/2008 of the European parliament and of the council:

> *"Article 4(1), (2) and (3) do not apply to aircraft falling in one or more of the categories set out below: [...]*
> *(i) unmanned aircraft with an operating mass of no more than 150 kg;*
>
> [31, p.L79/32-33]

Article 4(1), (2) and (3) mention the aircraft, personnel and operations of aircraft where the EASA regulations are applicable.

3.2.2 NPA2012-10, CRD2012-10 and NPA2014-09

A Notice of Proposed Amendment (NPA) is an instrument to inform the members of the EU about upcoming changes or to add supplementary rules to the Basic Regulation (EC) No 216/2008 as well as add implementing rules (IR). Everybody can contribute comments via the Comment Response Tool (CRT) and share their opinions and thoughts about the proposed amendments. EASA reacts with a Comment Response Document (CRD) where all received comments are collected and reasons are mentioned for ignoring or including them into the following publication of the final rules.

The first attempt by EASA to consider unmanned vehicles in their regulations was the publication of the NPA 2012-10 on August 21st, 2012, which aims to implement the Amendment 43 to Annex II of ICAO into the Part-SERA (Single European Rules of the Air). Due to enormous critical comments summarized in the CRD2012-10 document (224 comments from 61 commentators in total, [22]) via the CRD System, EASA retrieved the NPA and reworked it completely. The first NPA considered only international flights of unmanned vehicles, without mentioning any maximum mass limits as they are already in force (e.g. 150 kg limit) or making any clear distinction between model aircraft and RPAS. [21], [23]

So the Agency concluded:

- To Publish Common Rules as soon as Possible for the Transposition of Amendment 43 to Annex II of ICAO into SERA,
- The Scope of EASA is not Limited to International Civil Aviation,

- Model Aircraft and Toys should not be Covered by Common EU Rules,
- The Transposition will be Limited to Special Authorizations for the Operation of RPAS Internationally and
- EASA Could Publish AMC/GM (Acceptable Means of Compliance/ Guidance Material) for Scopes where no EU Common Rules yet exist (e.g. Airworthiness, RPAS Pilot Licensing, Operation).

[22]

The revised NPA 2014-09 was published on April 3rd, 2014. The objective for implementing Amendment 43 to Annex II of ICAO into the Part-SERA remained unchanged as well as the implementation of Article 4(a)[1] and 4(b)[2] "Rules of the air and airspace classification" of Regulation EC No 551/2004. NPA 2014-09 proposes common applicable rules of the air for RPAS of any mass when operated under General Air Traffic rules (GAT). Furthermore the NPA published nothing regarding airworthiness, RPAS pilot licensing or operations of RPAS out of the scope of the Basic Regulation (e.g. RPAS with a maximum take-off mass of less than 150 kg). At the moment the EU member states are able to authorize RPAS operators within their sovereign airspace on the basis of national rules and in line with the Basic Regulation (RPAS below 150 kg).

One focus of the new NPA is to set a clear distinction between model aircraft and RPAS. The NPA makes a defined differentiation for a clear legal understanding without laying claim for proposing common rules for model- and toy aircraft: In former time before, "real" aircraft were manned and model aircraft unmanned as well as limited in their operational radius due to technological reasons (e.g. radio range restricted to visual line of sight based on available radio frequency technology in the past) and the ratio of mass to performance of available electronic systems (e.g. autopilots, navigation systems based on gps or inertia, camera sensors, etc.) were too high for unmanned aircraft below 150 kg of MTOM to carry. Furthermore for the professional use of airborne systems (e.g. transport of passengers) higher safety factors were applicable than for recreational, non-commercial use. For RPAS, which have no human on board, there is no justification to exert less safety factors for noncommercial operations, because the risk for third parties in the air as well as on ground is equal.[23, p.13]

[1] „(a) adopt appropriate provisions on rules of the air based upon ICAO standards and recommended practices;“

[2] „(b) harmonise the application of the ICAO airspace classification, with appropriate adaptation, in order to ensure the seamless provision of safe and efficient air traffic services within the single European sky.“

As a conclusion, the distinction of model aircraft and RPAS is defined in the NPA 2014-09 as follows:

> *Model aircraft are those exclusively used for recreational, sport or similar purposes (regardless of mass, authorized operations and on-board sensors).*
>
> [23, p.13]

> *RPAS are those used for "professional" purposes (commercial, non-commercial, corporate and aerial work).*
>
> [23, p.13]

Especially for model and toy aircraft the NPA mentions in the Guidance Material (GM) that they remain as model aircraft, even "if equipped with sensors which are necessary for flight" or with other electronic systems like "cameras", as long as "the use of the model remains exclusively for recreational, sport or competition purposes". As a short term goal, to reach a "quick and dirty" solution for the integration of RPAS and to establish an internal market, the principle of proportionality should be applied (e.g. less stringent rules , requirements and administrative procedures for simple operations over unpopulated areas in the sovereignty of airspace in the individual member states).

In the future, the types and complexities of operations will be far more important than the masses of the RPAS, since the long term goals are to establish "proportionate" rules which are independent of the MTOM to consider the significant safety risk.

In general, the risk assessment for RPAS is highly important to be able to evaluate the probability of failure for each of the subsystems to minimize risk for third parties. Thus the NPA 2014-09 concludes that, even a collision of a small RPAS (2-5 kg) with an aircraft could be catastrophic in comparison to a bird strike of the same dimensions. A safety analysis, performed by the EASA, discovered from 60 RPAS accidents (51 military, 8 civil and 1 border protection) the following key factors:

- *The majority of RPAS occurrences occurred during the en route phase of flight rather than during take-off and landing, which is normally the case for manned aviation;*
- *The most common cause was the loss of link to the autoflight system due to electrical and engine failures. [...]*
- *Over half of the accidents involved the actions of the remote flight crew, mainly due to a lack of experience or knowledge. [...]*

[23, p.33]

It is mentioned that a final conclusion could not be given, due to the low numbers of flight and accidents (low statistically significance) and because the majority of accidents happened in military use and maybe these operations are not relevant for civil operations. Nevertheless it is assumed that:

- *in the history of aviation, in the case of fatal accidents, only one person died on the ground, as compared with a few hundred fatalities on board (two orders of magnitude difference;*
- *current AMC 25.1309 considers one catastrophic accident every 10 million flight hours acceptable; (applicable for turbine powered large aeroplanes)*
- *CS-23 and AIR-OPS accept that smaller airframes and general aviation can be two orders of magnitude less safe (= one fatal accident every 100 000 flight hours); (applicable for single or twin engines aeroplanes up to a maximum take off weight of 5670 kg (single engine with 9 passengers) and 8618 kg (twin engine with 19 passengers))*
- *most experts believe that RPAS have not yet reached the same rate of crashes as manned general aviation;*

[23, p.33]

As a conclusion the NPA states that a crash of a RPAS could occur once out of 10.000 flight hours (10^{-5}), only each hundredth RPAS would fatally hurt people on the ground (10^{-7}) and that the consequences of a RPAS of a few tens of kilo could be catastrophic.[23, p.33]

3.3 EUROCONTROL

The following sub-chapter introduces the European Organization for the Safety of Air Navigation as well as their activities in the field of unmanned aircraft systems.

3.3.1 Structure & Function of EUROCONTROL

EUROCONTROL was funded in 1960 by European Union Member States (Belgium, The Netherlands, Luxembourg, France, United Kingdom and Germany) with the aim to coordinate the air traffic control above Europe. Now EUROCONTROL is composed of Member States of the European Region with its headquarters located in Brussels. [33] The main activities are:

Maastricht Upper Area Control Center : provides air traffic control service for the Netherlands, Belgium, Luxembourg and northern Germany

Central Route Charges Office : handles billing across Europe

Network Manager : (former Central Flow Management Unit) manages the entire ATM Network (with nearly ten million flights every year), in close liaison with the air navigation service providers, airspace users, the military and airports

Regulatory Activities : supports the European Commission, EASA and National Supervisory Authorities

Research, Development and Validation : to improve the ATM system performance in the medium and long term (including a substantial contribution to the SESAR Joint Undertaking)

Civil-Military Aviation Coordination : in Europe

[33]

3.3.2 Current Activities in the Field of UAS

EUROCONTROL's main objective in the field of unmanned aerial vehicles is a safe integration (SESAR compliant with integration into the European ATM Master Plan) of civil as well as military RPAS into the European aviation and ATM system from 2016. They emphasize that most of today's operators of RPAS have no aviation background and there is no common awareness within all of the stakeholders. The main goal is to drive harmonization within Europe and to support the organizations, working groups and authorities involved in the integration of civil and military RPAS. EUROCONTROL participates in the JARUS working group and aligns the work between EASA & JARUS together with WG73 & WG93 of EUROCAE. Three employees of EUROCONROL manage the secretariat of JARUS and one staff member participates in each JARUS working group in different matters. [48]

EUROCONTROL recognized the impact of RPAS for all aviation stakeholders and the ATM environment and oversees the safe integration of RPAS into the ATM system in order to enable the UAS industry to reach its maximum potential in Europe.

At EUROCONTROL, Mike Lissone is currently working for the Unmanned Aircraft System Air Traffic Management (UAS ATM) integration program at EUROCONTROL and presented the last outcomes at the RPAS 2014 conference. [48]

4 Selected UAS Regulations on the National Level (by year)

The following sub-chapters describe selected national UAS regulations, in order that they were first introduced. Out of all European countries, the following selection was made:

- UK
- France
- Germany
- Austria
- Italy

The selected countries were chosen, because the UK was the first with specific UAS regulations enforced, France authorized probably the most UAS for VLL operations in Europe, Germany has a specialty because of there 16 federal state authorities and are of course relevant for Austrian UAS regulations and Italy has introduced their regulations almost at the same time as Austria. For each country the general legal framework for aviation as well as the competent authorities will be described, followed by the general UAS regulations and classification of UAS. Subsequently the diverse UAS categories of the applicable national UAS regulations will be given. Afterwards, the various national requirements are categorized into the following sections:

- Airworthiness Requirements
- Operational Requirements
- Pilot Requirements

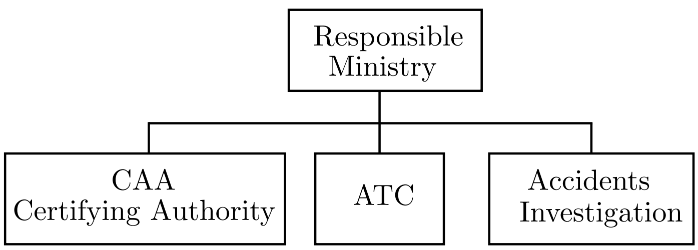

Figure 4.1: General Structure of National Authorities in this Thesis

The general structure of the various national authorities is described according to figure 4.1. In every case, the responsible ministry as well as the subsequent certifying authority, the responsible institution for the air traffic management and the aviation accident investigation agency is mentioned.

Finally, two non-EU countries (Norway because of their experiences with BVLOS operations, and Switzerland has almost the same environmental conditions due to the alps) will be described which have no specific UAS regulations at the moment, but allow civil UAS operations on an exemption or case-by-case basis.

4.1 UK

The UK established their first guidance materials in 2002 and introduced the national UAS regulation in 2012. Hence, the UK has gained a lot of experiences in the development and authorization of UAS regulations. The UK was chosen, because of their long time experience with UAS and well-developed UAS regulation.

4.1.1 Legal Aviation Framework and Structure of Competent Authorities

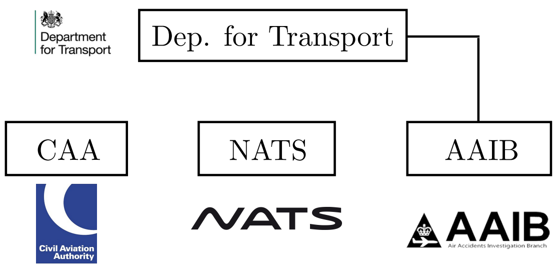

Figure 4.2: Structure of UK Aviation Authorities

The governmental body, which regulates civil aviation in the UK, is the Department for Transport (Secretary of State for Transport). Subsequent regulatory authority is the independent Civil Aviation Authority, which is responsible for aviation safety in the UK. NATS is the national air traffic control service provider of the UK. The UK Air Accidents Investigation Branch (AAIB), part of the Department for Transport, is the agency responsible for aviation accident investigation.

An overview about the structure of the UK aviation authorities is illustrated in figure 4.2.

The main law which regulates the civil aviation legislation in the UK is the Civil Aviation Act [63]. It translates the international ICAO standards and procedures into national law and mandates the creation of the civil aviation authority. The Air Navigation Order [62] empowers the CAA to carry out their duties. The regulations which are made under this order and the provisions of the Air Navigation Order are stated in the Civil Aviation Publication (CAP393 - "Air Navigation: The Order and the Regulations" [65]).

4.1.2 General Regulations & Classification of UAS

The Air Navigation Order (ANO2009) NO.3015 as well as the Civil Aviation Publication (CAP393) last amended in May 2014, define small unmanned aircraft in Part 33 "Interpretation" article 255, as follows:

> *"Small unmanned aircraft" means any unmanned aircraft, other than a balloon or a kite, having a mass of not more than 20kg without its fuel but including any articles or equipment installed in or attached to the aircraft at the commencement of its flight;*
>
> [62, Part33, art.255], [65, Part33, art.255]

The ANO2009 defines further small unmanned aircraft and small unmanned surveillance aircraft as follows:

Small Unmanned Aircraft

166.—(1) A person must not cause or permit any article or animal (whether or not attached to a parachute) to be dropped from a small unmanned aircraft so as to endanger persons or property.
(2) The person in charge of a small unmanned aircraft may only fly the aircraft if reasonably satisfied that the flight can safely be made.
(3) The person in charge of a small unmanned aircraft must maintain direct, unaided visual contact with the aircraft sufficient to monitor its flight path in relation to other aircraft, persons, vehicles, vessels and structures for the purpose of avoiding collisions.
(4) The person in charge of a small unmanned aircraft which has a mass of more than 7kg excluding its fuel but including any articles or equipment installed in or attached to the aircraft at the commencement of its flight, must not fly the aircraft

a. *in Class A, C, D or E airspace unless the permission of the appropriate air traffic control unit has been obtained;*
b. *within an aerodrome traffic zone during the notified hours of watch of the air traffic control unit (if any) at that aerodrome unless the permission of any such air traffic control unit has been obtained; or*

> c. *at a height of more than 400 feet above the surface unless it is flying in airspace described in sub-paragraph (a) or (b) and in accordance with the requirements for that airspace.*
>
> *(5) The person in charge of a small unmanned aircraft must not fly the aircraft for the purposes of aerial work except in accordance with a permission granted by the CAA.*
>
> [62, Part22, art.166]

Small Unmanned Surveillance Aircraft

> *167.—(1) The person in charge of a small unmanned surveillance aircraft must not fly the aircraft in any of the circumstances described in paragraph (2) except in accordance with a permission issued by the CAA.*
> *(2) The circumstances referred to in paragraph (1) are*
>
> a. *over or within 150 metres of any congested area;*
> b. *over or within 150 metres of an organised open-air assembly of more than 1,000 persons;*
> c. *within 50 metres of any vessel, vehicle or structure which is not under the control of the person in charge of the aircraft; or*
> d. *subject to paragraphs (3) and (4), within 50 metres of any person.*
>
> *(3) Subject to paragraph (4), during take-off or landing, a small unmanned surveillance aircraft must not be flown within 30 metres of any person.*
> *(4) Paragraphs (2)(d) and (3) do not apply to the person in charge of the small unmanned surveillance aircraft or a person under the control of the person in charge of the aircraft.*
> *(5) In this article 'a small unmanned surveillance aircraft' means a small unmanned aircraft which is equipped to undertake any form of surveillance or data acquisition.*
>
> [62, Part22, art.167]

In summary, UAS have to be flown in a way that no hazard is being created to people or property. A permission is not required for UAS with a Maximum Zero Fuel Weight (MZFW) of less than 20 kg, in visual line of sight, away from people and other property or in congested areas for recreational purposes (noncommercial) only. All other operations, including aerial work (commercial) and in the vicinity of congested areas, require a permission granted from the CAA. UAS with a MZFW below 20 kg are, according to ANO2009 article 166, exempted from the regulations applicable for manned aviation.

Light UAS with more than 20 kg MZFW have no own requirements, and must therefore meet the same regulations as for manned aviation (for Airworthiness Requirements for manned aviation, see CAP747: “Mandatory Requirements for Airworthiness” [66] or obtain an exemption by CAA according to article 242 from ANO2009).

4.1.3 Applicability & Detailed Categorization of UAS Regulations

The detailed requirements for the acquisition of a permit to fly for UAS are defined in the guidance material CAP722 “Unmanned Aircraft System Operations in UK Airspace - Guidance” [64]. In table 4.1 the principal classification of UAS in the UK is introduced. The UK defined three different weight classes for commercial operations of UAS (e.g. aerial work). A detailed overview about the airworthiness and operational requirements is given in table 4.2 and the following sub-chapters.

Table 4.1: Classification of UK Remote Pilot Aircraft adopted from [64, sec.1, chap.1, p.2]

Weight Class	UAS Category	Mass (MZFW, kg)	Civil Regulation
1	Small Unmanned Aircraft	20 or less	National
2	Light UAS	More than 20 to 150	National
3	UAS	More than 150	EASA

Table 4.2: UK Requirements for Commercial UAS Operations adopted from [64, sec.3, chap.1, p.1]

Weight Class	Airworthiness Approval	Registration	Operating Permission
20 kg and less	Not required	No	Required (Note 1)
More than 20 kg to 150 kg	Required (Note 2)	Yes (Note 2)	Required
More than 150 kg	EASA Permit to Fly or UK Permit to fly (state UAS) (Note 2)	Yes	Required

Note 1: Only required for commercially used UAS (e.g. for aerial work), over congested areas and in proximity to people or property.
Note 2: Exemptions possible from general aviation airworthiness and registration requirements.

4.1.4 UAS Airworthiness Requirements

A Certificate of Airworthiness for UAS with a MZFW below 20 kg is not required even for commercially used operations (see table 4.2). Unmanned aircraft exceeding 150 kg MTOM are subject to European Regulation (EC) No 216/2008 and therefore fall under the responsibility of EASA.

Only UAS with a MZFW of more than 20 kg and a MTOM of less than 150 kg require an Airworthiness Approval. Airworthiness requirements will be defined by the CAA on a case-by-case analysis and will be dependent on the individual safety case. In the event that the UAS with a MZFW of more than 20 kg and a MTOM of less than 150 kg will be flown within the limitations of small unmanned aircraft (see chapter 4.1.5 for definition), the UK CAA may issue an exemption for the need of an Airworthiness Approval on the basis of its own investigation or by inspection from an accredited qualified entity (until August 2014, only EuroUSC has received such an accreditation).

4.1.5 UAS Operational Requirements

Operators who intend to conduct commercial operations (e.g. aerial work) with small unmanned aircraft (MZFW less than 20 kg) in accordance with Article 166 of ANO2009, or conducting surveillance flights according to Article 167 of ANO2009, are required to apply for a permission. If the unmanned aircraft exceeds 20 kg MZFW, the operator can request an exemption from the airworthiness and registration requirements, which are applicable for the manned aviation. [64, sec.3, chap.1]

The limitations for flights of small unmanned aircraft are as follows:

- flights up to 400 ft above ground level (AGL),
- flights conducted within a radius of a maximum 500 m around the remote pilot (not beyond visual line of sight),
- flights over or within 150 m of a congested area are prohibited,
- operation within 50 m to third parties (any persons, objects, vehicles, etc.) except during take-off and landing within 30 m to any other person, are prohibited,
- a mechanism to land the aircraft should be available in case of any failure,
- the operator is responsible to ensure that the unmanned aircraft is in an airworthy condition, the payload is secured and the weather and wind conditions are within the operational limitations for the vehicle,

- records of the flights have to be saved and made available to the CAA on request,
- a safety assessment has to be made for the site of operation and made available to the CAA on request,
- the permission of the landowner has to be obtained, and
- all operations have to be in line with the operations manual submitted to the CAA.

[64, sec.3, chap.1]

The operations manual includes all procedures for a safe operation of the unmanned aircraft and a guidance document is available in Annex I to Chapter 1 of Section 3 of CAP722 [64, sec.3, chap.1, Annex I].

Furthermore, the CAA is allowed to declare additional prohibitions such as:

- flights with a maximum steady speed of 70 kt,
- aerobatic flights, or
- flights close to infrastructure that present a risk to safety in case of failure of the unmanned aircraft (e.g. gas pipelines, etc.).

The UAS operator needs an insurance according to the requirements of regulation (EC) No 785/2004 Art. 7. Therefore all UAS operators need a liability for third party damage which covers a minimum of 750.000 SDR (Special Drawing Rights) per accident for aircraft with a MTOM below 500 kg. [30, art.7]

4.1.6 UAS Pilot Requirements

CAP 722 defines two licensing regimes, which are necessary with the MZFW of the UAS to qualify requirements for the remote pilot. The difference between these licensing regimes is the potential risk to third parties, whether or not the risk is reduced through operation in segregated airspace, VLOS conditions and low mass RPAS.

Case 0 : *One or more risk mitigating factors apply, therefore reduced or flexible UAS Remote Pilot qualification requirements apply.*

Case 1 : *No risk mitigating factors apply, therefore equivalent UAS Remote Pilot qualification requirements apply.*

Table 4.3: Pilot Licensing Requirements for UK Remote Pilots

Weight Class	**Case 0**	**Case 1**
7 kg or less	None or BNUC-S™ or equivalent	BNUC-S™ or equivalent
More than 7 kg to 20 kg	None or BNUC-S™ or equivalent	CPL(U) or equivalent
More than 20 kg to 150 kg	BNUC™ or equivalent	CPL(U) or equivalent
More than 150 kg	Industry Code of Practice, CPL(U) or ATPL(U) or equivalent	CPL(U) or ATPL(U) or equivalent

[64, sec.2, chap.5]

> NOTE: *An acceptable Detect and Avoid system is not considered a risk mitigation factor, but a pre-requisite for Case 1 operations. Consequently, all civil UAS operations without an acceptable Detect and Avoid system, including those undertaken for the development of UAS, are by definition Case 0 operations.* [sic]

Remark: The paragraph stated above seems to be illogical (see "sic" note), because a lower level of competence is demanded for the pilot if no detect & avoid system is available which would increase the safety risk.

The second essential criteria is the maximum take-off weight of the UAS. An additional weight class is defined in table 4.1. The different levels of qualifications of the remote pilot range from a special UAS pilot license, which demonstrates the pilot competency, to a qualified entity (accredited by the CAA) for UAS with a MZFW of up to 7 kg or 150 kg MTOM depending on the licensing regime, up to a CPL(U) or ATPL(U) from the manned aviation for UAS with a MTOM exceeding 150 kg. The different qualification levels are summarized in table 4.3.

The BNUC™ (Basic National UAS Certificate) and the BNUC-S™ (for small UAS) are certificates from the qualified entity EuroUSC accredited by the CAA.

4.2 France

France came next with their UAS decrees in 2012. Since then, France has authorized several UAS to fly in VLL operations (approx. 650 in June 2014, [9, p.6]) and has issued first permits to fly for limited BVLOS operations. France has a long aviation tradition and places great value on their aviation industry, which is likely the reason France has granted the most permits to fly in Europe, even for first BVLOS operations. For this reason, special attention was put on the UAS regulations of France in this thesis.

4.2.1 Legal Aviation Framework and Structure of Competent Authorities

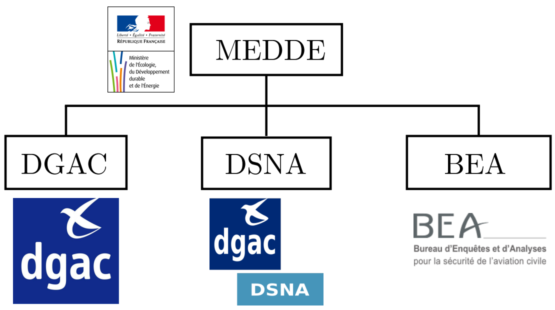

Figure 4.3: Structure of French Aviation Authorities

The governmental body for civil aviation in France is the Ministry of Ecology, Sustainable Development and Energy (Ministère de l'Écologie, du Développement durable et de l'Énergie). The further subordinated agency is the national civil aviation authority DGAC (Direction générale de l'aviation civile). The agency which is responsible for the air traffic control in France is the DSNA (direction des Services de la navigation aérienne), also a part of the Ministry of Ecology, Sustainable Development and Energy. BEA, Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile, is an agency of the French government, responsible for the investigation of accidents in aviation.

The main national aviation law of France is defined by the Code de l'aviation civile or rather by the Code des transports. Subsequent regulations are introduced via Décrets or further Arrêtés.

4.2.2 General Regulations & Classification of UAS

The RPAS regulations in France have been enforced since April 11$^{\text{th}}$, 2012, by the Decree "DEVA1206042A" ("Requirements"-Decree) which is about "the design of civil aircraft which fly without anyone on board, their conditions of use and the skills required of their use", established by the Ministry of Ecology, Sustainable Development and Energy (Ministère de l'Écologie, du Développement durable et de l'Énergie). The second Decree "DEVA1207595A" ("Airspace"-Decree) determines the conditions under which RPAS are allowed to fly in the French airspace. The Decrees are applicable for VLOS and BVLOS operations of RPAS and regulate all other types of unmanned aerial vehicles like model aircraft, tethered aircraft, etc.

- The Decree "DEVA1206042A" regulates the general RPAS limitations and categories with 14 articles. All details are defined in three Annexes in this "Requirements"-Decree, with RPAS operations are mainly discussed in Annex II:

  Annex I : Model aircraft activity

  Annex II : Special activities of remotely piloted aircraft

  Annex III : Prototypes and experimental flights

- Decree "DEVA1207595A" has 10 articles dealing with the general conditions for flights with RPAS. The definitions of VLOS and BVLOS operations are stated as are the typical "special activities" for RPAS. This "Airspace"-Decree has two Annexes with the following content:

  Annex I : Types of airspace which allow segregation with activities of RPAS

  Annex II : Criteria for RPAS under which they are allowed to be flown in the vicinity of take-off or landing areas

The main categorization of remotely piloted aircraft according to article 4 of the "Requirements"-Decree is as follows:

Category A : *Model aircraft, whether or not motorised, having a maximum take-off weight of less than 25 kg, or a total weight (structure and load carried) of less than 25 kg in the case of inert-gas aircraft, carrying a single means of propulsion and respecting the following limitations:*

- Combustion engine: total cylinder capacity of 250 cm^3 or less
- Electric motor: total power of 15 kW or less
- Turboprop: total power of 15 kW or less
- Jet engine: total thrust of 30 daN or less, with a thrust-to-weight ratio without fuel of 1.3 or less
- Hot air: total weight of bottled gas carried of 5 kg or less
- Any captive model aircraft

Category B : *Any model aircraft failing to comply with the characteristics of Category A.*

Category C : *Captive remote piloted aircraft, not classified as model aircraft, and with a maximum take-off weight less than 150kg.*

Category D : *Remote piloted aircraft other than model aircraft, whether or not motorised, not captive, having a maximum take-off weight of less than 2 kg, or a total weight (structure and load carried) of less than 2 kg in the case of inert-gas aircraft.*

Category E : *Remote piloted aircraft which are not model aircraft, which do not fall into Category C or D, whether or not motorised,having a maximum take-off weight of less than 25 kg, or a total weight (structure and load carried) of less than 25 kg in the case of inert-gas aircraft.*

Category F : *Any RPA, not being model aircraft, having a maximum take-off weight of less than 150 kg which fails to comply with the characteristics of Category C, D or E.*

Category G : *Any RPA, not being a model aircraft, and which fails to comply with the characteristics of Categories C to F.*

[50, art.4]

A quick overview about all uniquely defined RPAS categories of the "Requirements"-Decree are shown in table 4.4.

Table 4.4: Classification of French Remotely Pilot Aircraft adopted from [50, art.4]

Category	**Description**
A	Model Aircraft or tethered Aircraft, MTOM < 25 kg
B	Model Aircraft other than Category A
C	Tethered Remotely Piloted Aircraft, MTOM < 150 kg
D	Remotely Piloted Aircraft, MTOM < 2 kg
E	Remotely Piloted Aircraft, MTOM 2 - 25 kg
F	Remotely Piloted Aircraft, MTOM 25 - 150 kg
G	Remotely Piloted Aircraft other than Category C-F

The Annex II of the "Requirements"-Decree is described in detail in the following subchapters 4.2.3, 4.2.4, 4.2.5 and 4.2.6.

4.2.3 Applicability & Detailed Categorization of UAS Regulations

In chapter 4.2.2 the general classification of RPAS from France were defined as stated in the Decree. Category A and B are model aircraft, prohibited for their usage in aerial work and therefore shall only be used for recreational purposes or model aircraft competitions. So only Category C to F fall under the responsibility of the national civil aviation authority (DGAC), where Category G aircraft with a MTOM of more than 150 kg will be certified by EASA.

For the "special activities" conducted by RPAS, four different operational scenarios are defined (S-1 to S-4), which are summarized in table 4.5. There are two VLOS and two BVLOS scenarios, all with a maximum height above ground of 150 m, except when a special permission is granted.

Table 4.5: RPAS Operational Scenarios of French Remotely Pilot Aircraft adopted from [50, Annex II, chap.1.3]

Scenarios	Description
S-1	VLOS - within 100 m radius around remote pilot in non populated areas
S-2	BVLOS - within 1000 m radius around remote pilot in non populated areas at maximum altitude above ground or obstacle of 50 m
S-3	VLOS - within 100 m radius around remote pilot in populated areas and close to crowds of people
S-4	BVLOS - in non populated areas and all operations other than S-2 scenario

Furthermore in table 4.6, the assignments, which RPAS categories are allowed to be used for a certain operational scenario are illustrated according to Annex II.

Table 4.6: French RPAS Operational Scenarios Associated with RPAS Categories and Sectors of Airspace adopted from [50, Annex II, chap.1.4]

	VLOS		BVLOS	
	S-1	**S-3**	**S-2**	**S-4**
with aircraft Category	C, D, E	C (< 25 kg lighter than air or < 4 kg other Cat. C) D, E (< 4 kg)	D, E	D
Airspace	outside of airspace < 150 m AGL	controlled	outside of controlled airspace < 50 m AGL or obstacle	< 150 m AGL or obstacle

4.2.4 UAS Airworthiness Requirements

Weight is the main factor in determining whether an airworthiness assessment by officials authorized by the minister in charge of civil aviation is necessary or not. All RPAS categories with less than 25 kg MTOM (Category C < 25 kg, D and E) do not need to hold a certificate of airworthiness. The operator itself can assess the airworthiness as well as evaluate the safety of the aircraft and has to provide this information upon request by officials authorized by officials authorized by the minister in charge of civil aviation. For RPAS categories weighing more than 25 kg (Category C > 25 kg and F), a certificate of airworthiness issued by officials authorized by the minister in charge of civil aviation is necessary according to the technical airworthiness conditions (structural strength, flight performance, equipments, etc.), which will be determined according to the type and mass of the aircraft. [50, Annex II, chap.2]

A special authorization is required for the scenarios S-2, S-3 as well as for S-4, which will be issued by officials authorized by officials authorized by the minister in charge of civil aviation after the submission of different failure and effect analysis, documents, manuals, etc. as described for each scenario in Annex II [50, Annex II, chap.2].

A series construction of any RPAS is possible and required for RPAS with a certificate of airworthiness or specific authorization. The minister in charge of civil aviation or authorized officials issues the type design certificate if all requirements are fulfilled and conformity to the regulation is recognized. Each RPAS built in series gets a certificate of conformity from the manufacturer necessary for the application of an authorization for flight. The manufacturer must monitor and record any safety-related events of the produced fleet. [50, Annex II, chap.2.4]

Any change to the RPAS shall be reported to the minister in charge of civil aviation or authorized officials, otherwise it results in the expiration of the flight authorization or certificate of airworthiness. [50, Annex II, chap.2.7]

4.2.5 UAS Operational Requirements

The "Airspace"-Decree "DEVA1207595A" defines the general conditions for VLOS and BVLOS flights. VLOS operations are conducted within a distance that enables the pilot to "maintain permanent non aided visual contact with the aircraft, allowing him/her to apply the rules of the air". All other operations are called BVLOS. [51, art.2]

Conditions for VLOS operations:

- daylight condition
- clear of any populated area (except otherwise authorized)
- flight height below 150 m above ground or a maximum of 50 m above an 100 m obstacle (except otherwise authorized)

[51, art.3, 4]

Conditions for BVLOS operations:

- daylight condition
- clear of any populated area and no flight in controlled, restricted, dangerous or prohibited airspace
- more than 15 km from the reference point of any aerodrome
- flight height below 50 m above ground and obstacles (should be increased to 150 m by authorization for RPAS with MTOM < 2 kg)

[51, art.3, 5]

Furthermore, it is required by the "Requirements"-Decree "DEVA1206042A" that the operator has to set up a manual for special activities with the following content:

- Safety conditions for the flight of the RPAS
- Rules and procedures for the operation of RPAS

- Instructions on how to deal with incidents and accidents
- Operating requirements for each type of RPAS
- Preflight-Checks
- Responsibilities of all persons involved in the RPAS operation (e.g. one pilot responsible for the flight itself, one person for the mission systems, etc.)
- Training of remote pilots
- List of all competent pilots who are allowed to fly the RPAS

For S-4 operations, the following further requirements are applicable:

- Risk analysis for third parties
- Experimental tests to ensure safety of the mission
- Definition of safety precautions, operating limitations and mission abort conditions

S-2 and S-4 operations have to be reported by mail to the competent authority at least 24 hours before each flight with the date, duration of flight, name of the operator/pilots, etc. according to chapter 3.16 of Annex II of the "Requirements"-Decree "DEVA1206042A". [51, Annex II, chap.3.16]

4.2.6 UAS Pilot Requirements

The remote pilot of the RPAS is responsible for the safety of third parties on ground and during flight. All remote pilots need to verify their theoretical level according to different Decrees regulating the knowledge of pilots of non-professional civil aviation, professional civil aviation flight crews, aeroplane flight crews (FCL1) or helicopter flight crews (FCL2). For remote pilots of tethered RPAS the verification is not mandatory, except the ability to read and understand aeronautical information. [50, Annex II, chap.4.1, 4.2]

For RPAS with a MTOM below 25 kg, the operator defines a training course or appoints a training organization to assess the level of competence of the remote pilot. After a successful demonstration flight, the pilot receives a "déclaration de niveau de compétence" (declaration of level of competency) for the specific activity and type of RPAS and is allowed to operate RPAS. [50, Annex II, chap.4.3]

RPAS with more than 25 kg MTOM, have to demonstrate their flying skills during a flight program to the minister in charge of civil aviation or authorized officials. If all requirements are fulfilled, the pilot receives an authorization with limitations according to the flying skills shown during the demonstration flight, with restraints on areas which are strictly forbidden for overflights, take-off and landing zones, flights close to buildings and obstacles, as well as manual and automatic modes. [50, Annex II, chap.4.4]

A specialty is defined explicitly for S-4 operations, where it is necessary that the remote pilot must hold a private pilot license like PPL(A), PPL(H) or glider license, with a minimum of 100 flight hours as pilot-in-command. Furthermore, before the first operation, the remote pilot shall have 20 flight hours with the RPAS in VLOS conditions. [50, Annex II, chap.4.3]

4.3 Germany

Germany, like France and the UK, is one of the key stakeholders in developing UAS regulations and has introduced a common UAS regulation for all 16 federal state authorities in 2013. Dependent on the federal state, where the operations are conducted, more or less liberal administrative practice are enforced in particular for light RPAS in unpopulated areas.

4.3.1 Legal Aviation Framework and Structure of Competent Authorities

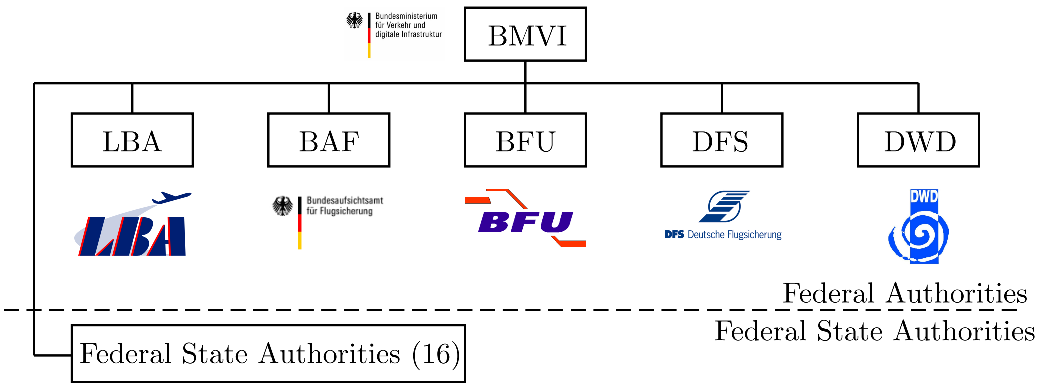

Figure 4.4: Structure of German Aviation Authorities

According to article 87d paragraph 1 of German Constitution (Grundgesetz, GG), the aviation administration is managed by a federally owned administration, in particular the Ministry for Transport and Digital Infrastructure (BMVI - Bundesministerium für Verkehr und digitale Infrastruktur). According to article 31, section 2 of the German Air Traffic Act (LuftVG - Luftverkehrsgesetz), the 16 different federal states of Germany assumed responsibility of various administrative tasks, such as:

- Approval of air fields
- Licensing of certain pilots
- Licensing of aviation companies
- Permission for aviation events
- etc.

- The responsible subordinated federal authorities of the BMVI are shown in figure 4.4 and as follows:
  Luftfahrt Bundesamt (LBA): Federal Aviation Office
  Bundesaufsichtsamt für Flugsicherung (BAF): Federal Supervisory Office for Air-Traffic Control
  Bundesstelle für Flugunfalluntersuchung (BFU): German Federal Bureau of Aircraft Accident Investigation
  Deutsche Flugsicherung GmbH (DFS): German Air Traffic Control Company
  Deutscher Wetterdienst (DWD): German Weather Service

- The responsible subordinated regional authorities of the BMVI are:
  Oberste Landesluftfahrtbehörden: Supreme Aviation Federal State Authorities
  Mittelbehörden: Intermediate Authority

- The main national aviation law of Germany is defined by the German Air Traffic Act (LuftVG). Aviation rules regarding air traffic in Germany is processed by the German Air Traffic Regulation (LuftVO - Luftverkehrs-Ordnung). The following list of aviation acts and regulations gives an overview of the German Aviation law enforcement:
  LuftVG: Basic German Air Traffic Act
  LuftVO: Air Traffic Regulation
  FlUUG: Aviation Accident Investigation Law
  LuftBO: Regulation governing the operation of aircraft
  LuftGerPV: Inspection Regulation for aircraft
  LuftSiG: Aviation Security Act
  LuftVZO: Air Traffic Licensing Order

4.3.2 General Regulations & Classification of UAS

The German Air Traffic Act states in article 1:

> *[...] als Luftfahrzeuge gelten unbemannte Fluggeräte einschließlich ihrer Kontrollstation, die nicht zu Zwecken des Sports oder der Freizeitgestaltung betrieben werden (unbemannte Luftfahrtsysteme).*
>
> [12, §1]

or translated:

> [...] unmanned aerial vehicles are aircraft including their ground stations, which are not used for sport or recreational purposes (unmanned aircraft systems).

The issue of an approval for the use of the airspace is regulated in article 31, paragraph 2 of the German Air Traffic Act and is defined as such:

> *(2) Die Länder führen nachstehende Aufgaben dieses Gesetzes im Auftrage des Bundes aus: [...]*
>
> *16. die Erteilung der Erlaubnis zu besonderer Benutzung des Luftraums für [...]*
>
> *f) das Steigenlassen von Flugmodellen, Flugkörpern mit Eigenantrieb und unbemannten Luftfahrtsystemen, [...]*
>
> [12, §31, para.2]

or translated:

> (2) The federal states conduct the following tasks on behalf of the federal government: [...]
>
> 16. the issuing of special usage of airspace [...]
>
> f) to let flying models, self-propelled flying objects and unmanned aircraft systems fly, [...]

The authorization is further detailed in article 15a paragraph 3 of the German Air Traffic Regulation:

> *(3) Der Betrieb von unbemannten Luftfahrtsystemen ist verboten, wenn*
> *1. er außerhalb der Sichtweite des Steuerers erfolgt oder*
> *2. die Gesamtmasse des Geräts mehr als 25 Kilogramm beträgt.*
>
> [11, §15a, para.3]

or translated:

> (3) The operation of unmanned aircraft systems is prohibited, if
> 1. conducted beyond visual line of sight of the remote pilot or
> 2. the total mass of the system exceeds 25 kg.

According to article 16 paragraph 1 number 7 of the German Air Traffic Regulation, the details for granting a permission for flight of a UAS are formulated in NfL I-281/13 (NfL: Nachrichten für Luftfahrer; Notices to Airmen).

4.3.3 Applicability & Detailed Categorization of UAS Regulations

To grant a permit to fly for a UAS according to the regulations of NfL I-281/13, the following objectives are applicable:

- The UAS has to be operated in visual line of sight of the remote pilot.
- The UAS is not used for sport or recreational purposes, otherwise the regulations for model aircraft are applicable.
- The maximum flight altitude above ground should not exceed 100m.
- The total mass of the system should not exceed 25 kg.

[18, para.1]

If the above mentioned criterias are fulfilled, two different permits to fly are available for UAS:

General permit to fly (PtF) : for flights with UAS without a combustion engine up to a total mass of 5 kg [18, para. 2.1.1]

Single permit to fly (PtF) : for flights with UAS with a combustion engine or a total mass above 5 kg (not exceeding 25 kg) or for flights with an increased potential for danger [18, para. 2.2]

4.3.4 UAS Airworthiness Requirements

General PtF ($<$ 5 kg) : An assessment of the technical requirements of the UAS is not required [18, para.2.1.2].

Single PtF ($<$ 25 kg) : The responsible authority can decide at their own discretion, if an assessment of the technical requirements is required [18, para.2.2.2].

4.3.5 UAS Operational Requirements

General PtF ($<$ 5 kg) : An assessment of the operational requirements is not required [18, para.2.1.2].

Single PtF ($<$ 25 kg) : The responsible authority can decide at their own discretion, if an assessment of the operational requirements is required [18, para.2.2.2].

For both, general and single permits to fly, the following areas are excluded from the allowed operations:

- humans and crowds of people,
- accident sites, disaster areas or other sites of operation from police or other authorities and organizations with security tasks,
- correctional, military or industry facilities, power plants or facilities for generating or distributing energy, if these parties don't grant the operation explicitly,
- or prohibited and restricted airspace sectors (article 11 LuftVO).

[18, para.2.1.1, 2.2.1]

Required Documents

General PtF (< 5 kg) :

- for natural persons: name; place and date of birth; address of applicant;
- for juristic persons and companies: registered business address and name of the juristic person or company; address; place and date of birth of the legal representative as well as all authorized employees who are going to remotely pilot the UAS; extract of the commercial register; register of associations/cooperatives;
- purpose of the UAS operation
- proof of third party liability insurance (article 37, paragraph 1a and article 43 LuftVG)

[18, para.2.1.2]

Single PtF (< 25 kg) :

- for natural persons: name; place and date of birth; address of applicant
- for juristic persons and companies: registered business address and name of the juristic person or company; address; place and date of birth of the legal representative as well as all authorized employees who are going to remotely pilot the UAS; extract of the commercial register; register of associations/cooperatives;
- purpose of the UAS operation
- proof of third party liability insurance (article 37, paragraph 1a and article 43 LuftVG)
- plan of operation site and airspace, information about the area of operation (address, etc.)
- declaration of agreement by property owner or other proof of authorization (article 25 LuftVG, article 16, paragraph 5 LuftVO)
- information about the date and time of operation and if necessary the number and duration of flights
- technical description of the UAS (technical data sheet, dimensions, type of propulsion, total mass, control type and description of safety systems in case of loss of control, information about payload
- description of knowledge and experience level of the remote pilot as well as training certificates
- data privacy statement

- declaration of "no objection of responsible police authority"
- declaration of "no objection of nature conservation authority" if operation is conducted within a nature protection area

[18, para.2.2.2]

Duration of Permission

General PtF (< 5 kg) : The general permit to fly is valid for no longer than 2 years, but could be extended if the applicant has not violated a condition [18, para.2.1.4].

Single PtF (< 25 kg) : The single permit to fly is only valid for the time and duration of the flight, specified in the application [18, para.2.2.3].

4.3.6 UAS Pilot Requirements

General PtF (< 5 kg) : An assessment of the remote pilot skills is not required [18, para.2.1.2].

Single PtF (< 25 kg) : The responsible authority can decide, at their own discretion, if an assessment of the pilot skills is required [18, para.2.2.2].

4.4 Austria

Austria introduced its first UAS regulation in 2014. A lot of experience from other countries as well as the results from the JARUS working group influenced the Austrian UAS regulation. The UAS requirements are defined drastically different from those of other countries, thanks to the help of a matrix system. The Austrian UAS regulation is introduced within the following sub-chapters.

4.4.1 Legal Aviation Framework and Structure of Competent Authorities

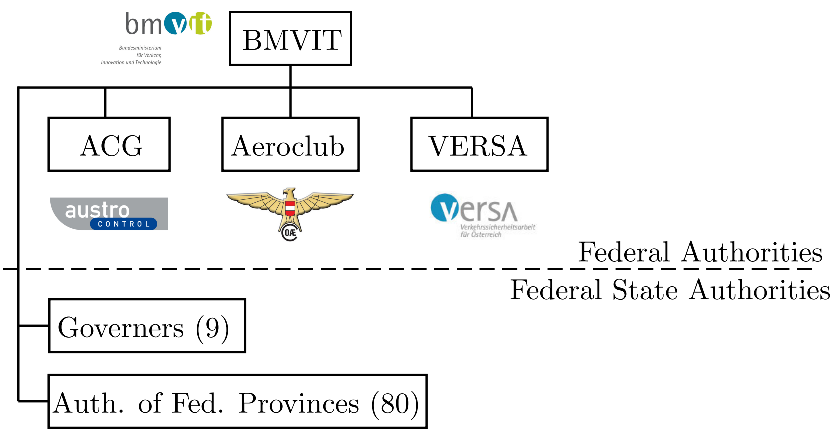

Figure 4.5: Structure of Austrian Aviation Authorities

The supreme authority for civil aviation is the Austrian Federal Ministry for Transport, Innovation and Technology (BMVIT - Bundesministerium für Verkehr, Innovation und Technologie), especially the air department (Gruppe Luft). The subsequent operational authority for civil aviation in Austria is Austro Control (ACG). Austro Control is unique in that it is split into two branches, one which is responsible for certification issues and the other for the Air Traffic Control (ATC) above Austrian territory. The governors of the nine individual federal states of Austria as well as the authorities of the 80 federal provinces have further subordinated regulatory aviation competences. The Austrian Aeroclub is responsible for the sport aviation in Austria. VERSA (Verkehrssicherheitsarbeit), part of the BMVIT, is the agency responsible for aviation accident investigation.

The structure of the competent authorities of Austria is shown in figure 4.5.

The following list of aviation acts and regulations gives an overview about the Austrian Aviation law environment:

LFG : Austrian Aviation Act (basic law)

ZLPV : Personnel Regulation of Civil Aviation

ZLLV : Regulation of Civil Aircraft and Civil Aviation Equipment

LVR : Rules of the Air

ZFBO : Regulation governing the Operation of Civil Aerodromes

AOCV : Regulation of Air Operator Certificates (AOC)

4.4.2 General Regulations & Classification of UAS

The last amendment of the Austrian Aviation Act published in the federal law gazette on June 20th, 2013, (BGBl I 108/2013) mentions for the first time unmanned aircraft systems and their general classification. Four different categories of UAS are defined:

- **Model Aircraft**
  are unmanned vehicles which are not used for military purposes and operated in direct visual line of sight from the remote pilot, without any technological aid. They are allowed to be controlled within a radius of 500 m and exclusively free of charge, noncommercial within leisure activities and exclusively for the purpose of the flight itself (no mission/working flights). Model Aircraft above 25 kg MTOM requires a permission from a competent authority (Aeroclub), whereas Model Aircraft below 25 kg MTOM does not require any permission.

  [13, §24c]

- **Unmanned Vehicles up to 79 Joule Maximum Kinetic Energy**
  are unmanned vehicles with a maximum kinetic energy below or equal to 79 Joule, which are allowed to be operated at 30 m AGL maximum. Those unmanned aerial vehicles are not regulated by the Austrian Aviation Act. ("toys limit")

  [13, §24d]

- **Unmanned Aerial Vehicles Class I (VLOS)**
  are civil unmanned vehicles which are not used for military purposes and are operated in unaided visual contact (VLOS). They are allowed to be operated for commercial purposes in a radius of 500m and more. UAVs Class I can only be operated if they have a permission granted by the Austro Control and if they correlate with the airworthiness and operating requirements issued by the Austro Control (see section 4.4.3, 4.4.4, 4.4.5 and 4.4.6).

  [13, §24f]

	UAS Class 1 (VLOS) – Area of Operation			
	I undeveloped (no buildings)	II unpopulated	III populated	IV densely populated (except crowds)
MTOW up to and including 5 kg	A	A	B	C
MTOW up to and including 25 kg	A	B	C	D
MTOW above 25 kg and up to and including 150 kg	B	C	D	D

Figure 4.6: ACG - LBTH67 UAV Class 1 (VLOS) Categorization [53]

- **Unmanned Aerial Vehicles Class II (BVLOS)**
  are civil unmanned vehicles which are not used for military purposes and are operated beyond visual line of sight (BVLOS). For Class II UAV all effective regulations for civil aircraft and the regulations for the operation of them have to be complied unless there are special regulations issued on the basis of the national air law.

[13, §24g]

4.4.3 Applicability & Detailed Categorization of UAS Regulations

All further detailed requirements concerning the airworthiness, operational limitations and pilot skills for a permit to fly for an UAS in Austria are defined in the Airworthiness Notification and Operational Notice No.67 (LBTH67) by the Austro Control. The LBTH67 from December 9^{th}, 2013 specifies the technical and operational requirements for commercial UAVs for class 1 (VLOS) only.

Figure 4.6 shows the table for the airworthiness evaluation for Categories A-D related to the population density of the area of operation and the maximum take off weight (MTOW) of the UAV.

The four different population **density** categories are:

- Area 1: **undeveloped** (no buildings)

  no buildings, only the pilot and people who are necessary for the purpose of the flight are allowed within this area

- Area 2: **unpopulated**

  only secondary buildings (storage buildings, silos, etc.) or buildings which are not usable (due to destruction or decay), persons other than the pilot and people who are necessary for the purpose of the flight are only temporarily allowed (e.g. hikers)

- Area 3: **populated**

  primary buildings are allowed (apartments, educational facilities, office buildings, etc.)

- Area 4: **densely populated** (except crowds)

  geographical enclosed populated areas like the center of a town (except crowds of people)

[5, p.5-6]

The second evaluation criteria is the **maximum take off weight**. The three classes are:

- MTOW up to and including 5 kg
- MTOW up to and including 25 kg
- MTOW above 25 kg and up to and including 150 kg

All UAS Class I are allowed to fly up to a height of 150 m above ground within the regulations of the LBTH67. For altitudes above this level, a special permission from Austro Control is required. [5, p.6]

The matrix, illustrated in figure 4.6, identifies the four different sub-categories A-D of UAVs Class I. The specific airworthiness, operational and pilot requirements of these Categories A-D are summarized in the following sub-chapters whereas the level of complexity of the requirements increases from A to D.

A detailed factsheet about all requirements for UAS Category A-D is shown in figures 4.7 and 4.8.

4.4.4 UAS Airworthiness Requirements

The general conditions which are valid for all categories are:

- an identification plate according to the requirements of attachment D of the LBTH67 is necessary

Table 4.7: UAS Class 1 VLOS Factsheet for Category A and B [53]

<table>
<tr><th></th><th></th><th>Category A</th><th>Category B</th></tr>
<tr><td rowspan="6">Airworthiness Requirements</td><td>Certification Rules</td><td>• No special airworthiness requirements
• Components according to state of the technology</td><td>• > 25 kg: Certification for flying models above 25 kg required (Attachment B)
• < 25 kg: Analogous application of Attachment B – independent check and confirmation by operator
• Operational safety analysis (Single point of failure) according to Attachment F</td></tr>
<tr><td>Flight Control</td><td>Non-complex manual flight control</td><td>Non-complex flight control with stabilisation</td></tr>
<tr><td>Identification</td><td colspan="2">Identification plate according to Attachment D</td></tr>
<tr><td rowspan="3">General Requirements</td><td>Check proper condition of UAS before each flight (Operator/Pilot)</td><td>---</td></tr>
<tr><td colspan="2">Operation within given operational limits (weight, wind, rain, temperature, visual conditions, day/night)</td></tr>
<tr><td colspan="2">Comply with the noise limits according to Attachment N</td></tr>
<tr><td rowspan="3">Operational Requirements</td><td>Insurance</td><td colspan="2">Operator Insurance for the UAV according to § 164 LFG</td></tr>
<tr><td>Reporting Obligations</td><td colspan="2">Operator responsible for incident reports according to § 136 LFG
(LFG – Luftfahrtgesetz: Austrian Aviation Act)</td></tr>
<tr><td>Operational Logs</td><td colspan="2">Date, Time, Duration of Operation, Name of Pilot, Location of Flight, Categorisation of the area of operation, Number of starts and landings, if applicable: Anomalies, Occurrences and Malfunctions
Retention period: 2 years</td></tr>
<tr><td rowspan="3">Pilot Requirements</td><td>Minimum Age</td><td colspan="2">16 years</td></tr>
<tr><td>Operational Rules</td><td colspan="2">According to Attachment E</td></tr>
<tr><td>General Requirements</td><td>Registered operator (applicant) shall ensure pilot(s) qualification</td><td>Pilot has to declare qualification and physical ability in written form</td></tr>
<tr><td>Required Documents</td><td></td><td>• Operating Approval Application
• Declaration of operational safety
• Three-view drawing (Photo)
• Flightcontrol: Description, characteristics and type
• Insurance policy</td><td>• like Category A
In addition:
• Proof of compliance with Certification Specification (Attachment B) and noise record
• Declaration of pilot(s) qualification</td></tr>
</table>

Source (Austro Control – CAA): http://www.austrocontrol.at/en/aviation_agency/licenses__permissions/flight_permissions/rpas © Ritzinger/Fortner 2014, office@aaig.at

Table 4.8: UAS Class 1 VLOS Factsheet for Category C and D [53]

<table>
<tr><th></th><th></th><th>Category C</th><th>Category D</th></tr>
<tr><td rowspan="4">Airworthiness Requirements</td><td>Certification Rules</td><td>• Technical requirements according to design and configuration (guideline see Attachment C)
• Operational Safety Analysis (Single point of failure) according to Attachment F
• Maintenance Checklist necessary (Retention period: 2 years)</td><td>• Technical requirements according to design and configuration (guideline see Attachment C)
• Operational Safety Analysis (Single point of failure) according to Attachment F
• Maintenance Checklist necessary (Retention period: 3 years)
• Preflight check by operator or pilot(s) necessary</td></tr>
<tr><td>Flight Control</td><td>Complex flight control with stabilisation and navigation</td><td>Complex flight control with stabilisation, navigation and automation</td></tr>
<tr><td>Identification</td><td colspan="2">Identification plate according to Attachment D</td></tr>
<tr><td>General Requirements</td><td colspan="2">Comply with the noise limits according to Attachment N</td></tr>
<tr><td rowspan="4">Operational Requirements</td><td>General</td><td colspan="2">Operational requirements according to design and configuration</td></tr>
<tr><td>Insurance</td><td colspan="2">Operator Insurance for the UAV according to § 164 LFG</td></tr>
<tr><td>Reporting Obligations</td><td colspan="2">Operator responsible for incident reports according to § 136 LFG
(LFG – Luftfahrtgesetz: Austrian Aviation Act)</td></tr>
<tr><td>Operational Logs</td><td colspan="2">Date, Time, Duration of Operation, Name of Pilot, Location of Flight, Categorisation of the area of operation, Number of starts and landings, if applicable: Anomalies, Occurrences and Malfunctions
Retention period: 2 years</td></tr>
<tr><td rowspan="3">Pilot Requirements</td><td>Minimum Age</td><td colspan="2">16 years</td></tr>
<tr><td>Operational Rules</td><td colspan="2">According to Attachment E</td></tr>
<tr><td>General Requirements</td><td colspan="2">• Austrian pilot license (except parachute- and hang-/para glider license) or exam in aviation law
• Aero-medical certificate or medical certificate for driving license (not older than 5 years)
• Prove necessary practical skills according to operation purpose</td></tr>
<tr><td>Required Documents</td><td></td><td colspan="2">• Operating Approval Application
• Insurance policy
• Technical description of the UAV
• Intended operational purpose and scope
• Noise record
• Proof of qualification and physical ability of the pilot(s)</td></tr>
</table>

Source (Austro Control – CAA): http://www.austrocontrol.at/en/aviation_agency/licenses__permissions/flight_permissions/rpas

- the noise limits which are defined in attachment N of the LBTH67 have to be complied

The following requirements regarding airworthiness of the UAS are applicable for the four different categories.

Category A

For Category A, no special airworthiness requirements are required, except that the components have to be concurrent with the state of the technology. The control of the UAS shall be a non-complex manual flight control. The continuing airworthiness is guaranteed through a pre-flight check before each flight by the operator or pilot.

All operations of UAS Category A have to be under operational limits (weight, wind, rain, temperature, visual conditions, day/night, etc.), defined in the official notification of the permit to fly. [5, p.7]

Category B

The airworthiness of UAS with a MTOM below 25 kg of Category B shall be checked and confirmed by the operator proportionately based on the certification specification of attachment B of the LBTH67. UAS with a MTOM exceeding 25 kg shall comply fully to the certification specification of attachment B of the LBTH67. For the control of the UAS, a non-complex flight control with stabilization shall be used and a failure mode and effect analysis (single point of failure) according to attachment F of the LBTH67 is required.

All operations of UAS Category B have to be under operational limits (weight, wind, rain, temperature, visual conditions, day/night, etc.), defined in the official notification of the permit to fly. [5, p.8]

Category C

All UAS Category C have to fulfill the design and configuration requirements according to attachment C (case-by-case tailoring of CS-LURS) of the LBTH67. A complex flight control with stabilization and navigation is necessary and a failure mode and effect analysis (single point of failure) according to attachment F of the LBTH67 is required. Furthermore, maintenance should be completed according to defined processes and the maintenance checklists have to be saved for at least two years for inspections by the Austro Control. [5, p.9]

Category D
All UAS Category D have to fulfill the design and configuration requirements according to attachment C (CS-LURS) of the LBTH67. A complex flight control with stabilization, navigation and automation is necessary and a failure mode and effect analysis (single point of failure) according to attachment F of the LBTH67 is required. Furthermore, the maintenance should be completed according to defined processes and the maintenance checklists have to be saved for at least three years for inspections by the Austro Control. A pre-flight check is necessary before each flight by the operator or pilot. [5, p.11]

4.4.5 UAS Operational Requirements

Most of the operational requirements for UAS in Austria are applicable regardless of their category. All UAS operators need an insurance according to §164 LFG which is in accordance with the requirements of regulation (EC) No 785/2004 Art. 7. Therefore all UAS operators need a liability for third party damage which covers a minimum of 750.000 SDR (Special Drawing Rights) per accident for aircraft with a MTOM below 500 kg. [30, art.7]

The operator is responsible for the incident and accident reporting according to §136 LFG and he has to store the following information about the flights with the UAS: date; time; duration of operation; name of the pilot; location of flight; categorization of the area of operation; number of starts and landings. If applicable, anomalies, occurrences and malfunctions must also be listed. This data must be saved for at least two years for inspection by the Austro Control.

Special operational requirements and limitations according to design and configuration of UAS Category C and D are possible and will be defined by the Austro Control if necessary.[5, p.7-12]

4.4.6 UAS Pilot Requirements

The remote pilot is responsible for the safety of the operation during the whole flight. The flight has to be conducted within the operational rules stated in attachment E of the LBTH67. The minimum age of the pilot is 16 years old. The pilot's qualifications for safe operation for UAS Category A shall be ensured by the registered operator (applicant). For UAS Category B, the pilot must declare his/her qualifications and physical ability in written form to the competent authority. Pilots for UAS Category C or D must hold an Austrian pilot license (except parachute- and hang-/para glider licenses) or they have to pass a UAS-specific exam in aviation law according to the requirements of Austro Control. An aero-medical certificate or a medical certificate for a driving license which is not older than five years is necessary and the required practical skills according to the operation purpose shall be proven. [5, p.7-12]

4.5 Italy

Italy did not introduce UAS regulations until 2014. The following sub-chapters describe Italy's UAS regulations in further detail.

4.5.1 Legal Aviation Framework and Structure of Competent Authorities

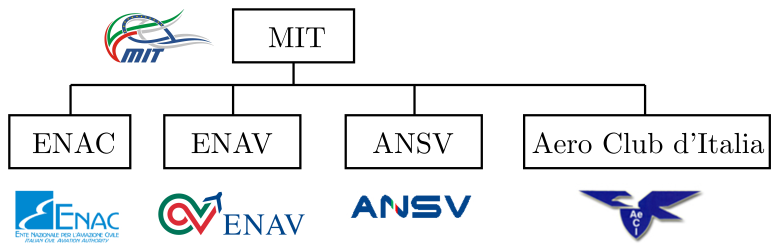

Figure 4.7: Structure of Italian Aviation Authorities

The aviation sector is overseen by the Ministry of Infrastructures and Transports (MIT - Ministero delle Infrastrutture e dei Trasporti). The subsequent main body that regulates aviation in Italy is the Civil Aviation Authority (ENAC - Ente Nazionale per l'Aviazione Civile), which is supervised by the MIT. ENAV (Ente Nazionale per l'Assistenza al Volo) is responsible for the national air traffic control and the Italian Aeroclub (Aero Club d'Italia) is responsible for the sport aviation in Italy. The agency responsible for aviation accident investigation is the Agenzia Nazionale per la Sicurezza del Volo (ANSV).

An overview of the structure of Italian aviation authorities is illustrated in figure 4.7.

The national aviation regulations of Italy are defined by the "Codice della navigazione" (Italian Navigation Code), which was created on March 30th, 1942 by the Royal Decree No. 327. Section II of the Italian Navigation Code is related to Aviation law. The Code is supplemented by specific regulations, statutes and decrees which are dealing with particular objectives.

4.5.2 General Regulations & Classification of UAS

The last amendment No. 96 in the Italian Navigation Code is from May 9th, 2005 and implements the following definition of RPAS according to article 743 of the Italian Navigation Code:

> *Nozione di aeromobile*
> *Per aeromobile si intende ogni macchina destinata al trasporto per aria di persone o cose.*
> *Sono altresì considerati aeromobili i mezzi aerei a pilotaggio remoto, definiti come tali dalle leggi speciali, dai regolamenti dell'ENAC e, per quelli militari, dai decreti del Ministero della difesa.*
> *Le distinzioni degli aeromobili, secondo le loro caratteristiche tecniche e secondo il loro impiego, sono stabilite dall'ENAC con propri regolamenti e, comunque, dalla normativa speciale in materia.*
>
> [52, art.743]

or translated:

> *Concept of aircraft*
> *Aircraft shall mean any machine designed for the transportation by air of persons or property. Remotely piloted aerial vehicles are also considered aircraft, as defined by special laws, ENAC regulations and, for the military, by decrees of the Ministry of Defence. The distinctions of the aircraft, according to their technical specifications and use shall be established by ENAC with its regulations and, in any case, by special legislation in this field.*
>
> [29, art.1, para.1]

All further technical, operational and personnel requirements are detailed in the "Regolamento - Mezzi Aerei a Pilotaggio Remoto" (Regulation for Remotely Piloted Aerial Vehicles), introduced by Ente Nazionale per l'Aviazione Civile (ENAC, Civil National Aviation Authority of Italy) on December 16th, 2013 and put into place on April 30th, 2014.

4.5.3 Applicability & Detailed Categorization of UAS Regulations

The Italian RPAS regulations differentiate between two classes of unmanned aircraft systems:

- *Remotely Piloted Aircraft System with maximum take-off mass of less than 25 kg*
- *Remotely Piloted Aircraft System with maximum take-off mass of more than or equal to 25 kg*

[29, art.7, para.1]

exceptions are:

- *State RPAS, as referred to in Articles 744, 746 and 748 of the Navigation Code [52, art.744, art.746 and art.748];*
- *RPAS that have design features such that the pilot does not have the ability to intervene in the control of the flight;*
- *indoor RPAS operations;*
- *balloons used for scientific observations or tethered balloons.*

[29, art.2, para.3]

Model Aircraft are not regarded as aircraft as stated in the Italian Navigation Code [52, art.743] if only used for recreational and sporting activities [29, art.1, para.4].

Flights of RPAS can be conducted in two different airspace volumes:

V70 : flights are within a radius of 200 m and up to a maximum height of 70 m (230 ft) above ground level (AGL)

V150 : flights are within a radius of 500 m and up to a maximum height of 150 m (500 ft) above ground level (AGL)

[29, art.5, para.1]

If the RPAS shall be used outside of the predefined airspace volumes, the operator shall submit an application for the use of the airspace to ENAC. [29, art.8, para.6]

For the use of RPAS, the Italian regulations define two different operation scenarios:

Non-critical specialized operations : do not include overflights, even in the event of a failure, of congested areas, crowds of people, urban areas and infrastructure, restricted areas, railway lines and stations, highways and industrial plants. Flights are conducted in the airspace volume "V70" and 150 m horizontally away from congested areas and 50 m from persons which are not involved in the operation, in daylight conditions, in uncontrolled airspace outside of Aerodrome Traffic Zones (ATZ) and at a minimum distance of 8 km to the next airport as well as departure and approach paths.

Critical specialized operations : are VLOS operations that do not meet the limitations/conditions of non-critical specialized operations.

[29, art.8, para.5a/b]

All RPAS and ground stations have to be equipped with an identification plate and RPAS must be provided with a Flight Manual for RPAS with less than 25 kg MTOM [29, art.8, para.2 and 3]. For RPAS with MTOM more or equal to 25 kg, the RPAS and ground station are also registered by the ENAC in the "Remote Piloted Aircraft Register" [29, art.9, para.1].

4.5.4 UAS Airworthiness Requirements

RPAS with MTOM less than 25 kg

The requirements for the airworthiness of the RPAS are covered by the authorization (critical specialized operations) or declaration (non-critical specialized operations), described in chapter 4.5.5, except for RPAS which are built in series (requirements for RPAS with MTOM of more than or equal to 25 kg are applicable). [29, art.8, para.2]

RPAS with MTOM more than or equal to 25 kg

Airworthiness is confirmed either with the issuance of a permit to fly or a Restricted Certificate of Airworthiness (for RPAS with Restricted Type Certificates and therefore RPAS which are built in series) [29, art.10, para. 1]. A permit to fly is issued for experimental tests, scientific purposes or to demonstrate of compliance, as well as for specialized operations of RPAS with no Restricted Type Certificate. After completion of the experimental tests (which need a permit to fly and must be conducted by pilots with ENAC authorization in unpopulated areas and in segregated airspace) and demonstration of compliance to the RPAS regulations, the permit to fly for the specialized operations will be issued for a maximum of three years. [29, art. 10, para. 4,5,6,7]

For RPAS built in series, the Restricted Certificate of Airworthiness will be issued to the manufacturer with unlimited validity (as long as the requirements, limitations and conditions are fulfilled), if the RPAS design comply with the type certificate requirements and compliance is shown by experimental tests [29, art. 10, para.8,9,10].

A noise certificate is not necessary [29, art.11, para.1].

4.5.5 UAS Operational Requirements

RPAS with MTOM less than 25 kg

Non-critical specialized operations : Compliance to the RPAS regulations is declared by the operator [29, art.8 para.1]. The declaration should contain: a description of the system with information about the capabilities and performances for safe operation (in case of series built RPAS: a conformity certificate by the manufacturer); outcome of the experimental test phase; description of the operation; risk assessment for the safety of the operation; RPAS flight-, operations- and maintenance manual. [29, art.8, para.9]

Critical specialized operations : Compliance shall be recognized by ENAC [29, art.8 para.1]. A technical and operational organization has to be established with defined procedures (manual) for flight operations and maintenance of the system [29, art.8 para.7]. The same information provided for non-critical specialized operations as described before should be contained in the application for authorization of critical specialized operations. [29, art.8, para. 11]

If the RPAS will be built in series, a restricted type certificate can be issued by ENAC and all requirements for RPAS with a MTOM of more than or equal to 25 kg are applicable. [29, art.8, para.4]

Accident and incident reporting has to be conducted for non-critical as well as for critical specialized operations. [29, art.8, para. 13]

Applications for authorization for experimental tests as well as flights for scientific purposes are allowed and should be undertaken in unpopulated areas in segregated airspace at a “suitable” distance from persons and buildings. [29, art.8, para. 16]

RPAS with MTOM more than or equal to 25 kg

The Operator or RPAS with a MTOM more than or equal to 25 kg must have a authorization from ENAC. The complexity of the investigation to get an authorization is based on the risk of the operation. [29, art.12, para.1, 2]

The operator has to fulfill the following objectives:

- a technical and operational organization has to be established by the operator with the appropriate qualifications,
- a designated “Technical Manager” for the management of operations, airworthiness and training,
- the RPAS must have a valid certification/authorization,
- an “Operations Manual” has to be established with the relevant information about the management of the operations, airworthiness and training,
- a maintenance program has to be established according to the instructions of the manufacturer for the RPAS, and
- data relevant for flight time, significant events concerning the safety, maintenance and replacement of parts, has to be recorded.

[29, art.13, para.1a-1e], [29, art.14, para.1, 2]

Accidents and serious incidents have to be reported to ENAC by the operator, manufacturer, design organization, pilot or maintenance organization. [29, art.15, para.1]

All flights have to comply with the rules of the air and other regulations issued by ENAC for the relevant airspace. The RPAS operations should be conducted in VLOS and within the predefined airspace volumes “V70” and “V150”, described in chapter 4.5.3.[29, art.16]

The operations in those airspace volumes have to be conducted under the following conditions:

- not less than 150 m horizontally away from congested areas and at least 50 m from persons which are not involved in the operation,
- during daylight, and

- in uncontrolled airspace outside of Aerodrome Traffic Zones (ATZ) and at a minimum distance of 8 km to the next airport, including departure and approach paths.

[29, art.16, para.3a-3c]

If RPAS operations will be conducted in controlled airspace or outside of the conditions and limitations defined above, an authorization has to be obtained from ENAC. [29, art.16, para.4]

Furthermore a valid minimum third party insurance according art. 7 of Regulation (EC) No.785/2004 is required. [29, art.20]

4.5.6 UAS Pilot Requirements

RPAS with MTOM less than 25 kg
The requirements for the remote pilot of the RPAS is covered by the authorization (critical specialized operations) or declaration (non-critical specialized operations), described in chapter 4.5.5, except for RPAS which are built in series (requirements for RPAS with MTOM of more than or equal to 25 kg are applicable). [29, art.8, para.2]

RPAS with MTOM more than or equal to 25 kg
The pilot is responsible for flight safety during the whole operation and has to be at least 18 years old. The remote pilot needs a civil pilot license or an attestation by an Italian VDS according Presidential Decree No. 133/2010 and has to attend a training program for the relevant RPAS from the manufacturer or an accredited organization from ENAC. [29, art.17, para.1, 2, 3]

ENAC requires a valid second-class medical certificate, specifically "Medical Organization and medical certificates of fitness for the achievement of licenses and aeronautical certificates". [29, art.17, para.4]

The authorization for the pilot is valid for a maximum of five years and the pilot is only allowed to conduct flights if he/she has performed three take offs and three landings with an authorized RPAS within the last 90 days before the date of the operation. [29, art.17, para.7, 8]

4.6 Forthcoming Civil UAS Regulations in Non EU-Countries

A few countries, even without having specific UAS regulations enforced, allow civil operations of UAS on the basis of exemptions by the national civil aviation authority. In most of the cases, they rely on a case-by-case assessment conducted by an expert of the CAA, who grants exemptions based on the requirements of the manned aviation regulations or on the basis of model aircraft rules. Norway leads the way in facilitating flight permissions for BVLOS activities in the area of Svalbard (Spitzbergen), where the population density is extremely low.

The authorizations of civil UAS activities in Norway and Switzerland are described in further detail in the following sub-chapters.

4.6.1 Norway

The Civil Aviation Authority of Norway published an Aeronautical Information Circular (AIC-N 14/13, [14]) on June 20th, 2013, which contains explanatory and advisory information about UAS operations in Norway. It represents no official regulation, but describes how to get a permit to fly on an exemption basis.

The CAA Norway defines VLOS operations as following:

- 400 ft AGL maximum flight altitude and
- in visual line of sight, observable with the naked eye without the help of any technical aid.

Every private person or company intending to conduct commercial RPAS operations must receive permission for the use of UAS. The applicant needs to assure, with the help of a safety analysis, that no third party will be in danger due to the UAS operation, and must outline mitigating actions in case of a failure of the system. VLOS operations can be conducted in the mainland of Norway as well as arctic regions and over the sea within the limitations and restrictions issued with the permit to fly by the CAA Norway. Flights above crowds of people are only allowed upon authorization of the CAA and if every person on the ground agrees with that in written form. In some cases a NOTAM (Notice to Airmen) has to be promulgated 12 hours before a flight. UAS flight permissions will be valid up to a maximum of two years. Furthermore the operator of an UAS requires a third party insurance dependent on the MTOM according to the Norwegian Aviation Act §11-2 (luftfartsloven) equivalent to EC 785/2004. A license for the remote pilot from the

Norwegian National Security Authority is only necessary for conducting BVLOS flights according to [44].

An Operation Manual [15] must be enclosed in the application containing the following sections:

- Part A: General Description
- Part B: Operating Documentation
- Part C: Authorized Operations (incl. Risk Analysis and Standard Operating Procedures)
- Part D: Training and Qualification of the Personnel
- Part E: Technical/Maintenance Routines

BVLOS operation authorization is also possible, especially in the arctic area of Svalbard (Spitzbergen) and over the sea by submitting a risk assessment to the CAA prior to each flight (or series of flights). The remote pilot must hold a valid license from the Norwegian National Security Authority. A NOTAM will be issued for every BVLOS activity whether operated in uncontrolled or controlled airspace in consultation with the ATC.

It is expected that Norway will introduce their first official UAS regulation by the end of 2014. Norway was one of the pioneers of authorized UAS VLOS operations. [44]

4.6.2 Switzerland

Switzerland has no specific UAS regulations at the moment. No specific requirements are available for UAS which are used for commercial or scientific purposes below 30 kg in VLOS conditions. They can be operated without authorization of the CAA if:

- they have a MTOM below 30 kg,
- operated in unaided visual line of sight,
- operated below 150 m AGL,
- they are more than 100 m away from crowds of people,
- they are more than 5 km away from civil & military airports,
- automatically flown by autopilot, within visual line of sight, if the remote pilot can take over control of the UAS at any time,
- there is valid third party insurance of about 1 Mio. CHF for UAS with a MTOM of more than 500 grams and
- the use of cameras is allowed (subject to data protection regulations).

[16]

All other civil UAS operations, whether they be UAS with more than 30 kg MTOM, operated in BVLOS operations, operated with the help of technical aids (e.g. video cameras, observers, etc.), flown over populated areas and crowds of people or in restricted airspace, requires a case-by-case evaluation by the Federal Office of Civil Aviation (FOCA).

5 Analysis

The first part of this section analyzes the different UAS regulations of the previously selected national countries. Each sub-chapter examines the UAS requirements according to the four different main categories:

- Applicability & Detailed Classification of UAS
- Airworthiness Requirements
- Operational Requirements
- Pilot Requirements

Afterwards the various aspects of the regulations will be summarized and assessed.

5.1 Comparison of the National UAS Regulations in Europe

Over time UAS have decreased in both size and weight due to the expeditious development of processing power in computer chips, propulsion systems, digital radio systems, and so on.

In 1999 the company AeroVironment Inc. introduced a large solar powered UAV called "Helios" with a wingspan of 247 ft (approx. 75 m), weighing approx. 900 kg, capable to reach 96.863 ft (approx. 29500 m), which was only allowed to fly in segregated airspace [4]. In 2005, THALES developed the UAS "Watchkeeper", with a wingspan of 10,5 m, and weighing 450 kg, for the British Army to use in military airspace [58], [56, p.194]. Afterwards smaller UAVs with civil applications were developed. In the beginning conventional fixed wing and rotary wing UAVs were introduced. As an example, in 2011, the "Gatewing X100" UAV was introduced, a fixed wing aircraft weighing only 2,2 kg with a wingspan of 1 m [61]. The latest developments are the multicopter systems with four, six, eight or more propellers that generate lift and are used for changing the attitude of the vehicle fully controlled by autopilots.

Due to the low take-off mass of the systems, the national authorities are responsible for the certification of these systems. The Basic Regulation (EC) No.216/2008, which is applicable in all European member states, defines that aircraft with a MTOM below 150 kg fall under the jurisdiction of the relevant national authority [31, p.L79/32-33].

Thus, the different European countries developed their own legal framework for the certification of UAS. One of the first countries in Europe, which introduced UAS regulations, was the United Kingdom in the year 2002 [19]. France and Germany followed in 2012 with their UAS regulations and at the end of 2013 and beginning of 2014 Italy and Austria established their legal frameworks for the certification of UAS [9], [71], [49], [34]. A lot of other countries, which currently have no official UAS regulation enforced, authorize civil UAS operations on an exemption basis as Norway and Switzerland do.

The UK, France, Germany and Italy put their main focus on the competences and skills of the remote pilot, whereas Austria has more stringent requirements for technical authorization.

Pilot Requirements - UK vs. Austria
Here is an example of the UAS regulations from the UK compared with those from Austria: UK defines three different weight categories of the UAS for the pilot qualification (0-7 kg, 7-20 kg, 7-150 kg) as well as two different risk cases (see table 4.3 of chapter 4.1.6). The civil aviation authority accredited the qualified entities "EuroUSC" and "Resource Group", which offer pilot training in theoretical as well as practical knowledge. Therefore the CAA of UK defined different UAS licenses for Small UAS, Light UAS and UAS according to the classification of UAS in the UK (see table 4.1 of chapter 4.1.3).

In the UK several pilot licenses are available:

BNUC-S™ : Basic National UAS Certificate from EuroUSC for small UAS

BNUC™ : Basic National UAS Certificate from EuroUSC

CPL(U) : Commercial Pilot License (Unmanned)

ATPL(U) : Airline Transport Pilot License (Unmanned)

However, for the technical authorization, no airworthiness certificate is required for commercially used UAS with a MZFW below 20 kg in the UK.

In Austria, even if UAS with a MTOM up to 150 kg is to be operated in populated areas, only a theoretical examination in aviation law is necessary for a flight permission. For the technical permission on the other hand, UAS with a MTOM below 5 kg that is operated in densely populated areas must have various redundant main systems. Certification specifications for UAS with a MTOM up to 750 kg of the JARUS working group is applicable as a basis for the authorization.

A first good overview about the legal situation of UAS in Europe is shown in figure 5.1 from the public section of the UVS-International website, current as of March 2014.

REGULATION MONITOR

RPAS Regulation in Europe

Status: 17 March 2014

RPAS REGULATION IN EUROPE								
		MTOM	**In place**		**MTOM**	**In Preparation**		**Comments**
01	Austria[F]	< 150 kg	VLOS					
02	Belgium[F]				< 150 kg	VLOS		Finalised (2013), but not in force
03	Bulgaria							
04	Croatia							
05	Cyprus							
06	Czech Rep.[F]	< 150 kg	VLOS	BLOS				In place (May 2013)
07	Denmark[F]	< 150 kg	VLOS					In place (Jan. 2004)
08	Estonia							
09	Finland[F]				< 150 kg	VLOS		Expected mid 2014
10	France[F]	< 25 kg	VLOS	BLOS	< 150 kg	VLOS	BLOS	In place (Apr. '12) - To be update in 2014
11	Germany	< 25 kg	VLOS					In place (2013)
12	Greece[F]							
13	Hungary[F]				< 150 kg	VLOS		
14	Ireland[F]	< 20 kg	VLOS					In place May 2012)
15	Italy[F]	< 25 kg	VLOS					In place (Dec. 2013)
16	Latvia							
17	Lithuania[F]	< 25 kg	VLOS		< 150 kg	VLOS		Expected mid 2014
18	Luxembourg							
19	Malta[F]				< 150 kg	VLOS		In preparation
20	Nethlerlands[F]	< 25 kg	VLOS		< 150 kg	VLOS		In place (2012) - Update in preparation
21	Poland[F]	< 150 kg	VLOS	BLOS				In place 2013
22	Portugal							
23	Romania[F]							
24	Slovakia							
25	Slovenia[F]							
26	Spain[F]				< 25 kg	VLOS		In preparation
27	Sweden[F]	< 150 kg	VLOS					In place (Mar. 2013)
28	UK[F]	< 20 kg	VLOS					In place (2002) + Several updates since
	Sub-Total		**12**	**3**		**8**	**1**	
29	Iceland				< 150 kg	VLOS	BLOS	
30	Norway[F]							Expected mid 2014
31	Switzerland[F]	Model aircraft rules apply			VLOS over people/crowds			Directive expected 2014
	Sub-Total					**1**	**2**	
	Total		**12**	**3**		**9**	**2**	
	[F] RPAS aerial operations facilitated = Permit to Fly is granted by NAA, based on specific national rules, possibly on a case-to-case basis & for a limited duration *(incl. in countries where no national regulation exists)*.							

The information contained in this document has been complied from data obtained from one or several of the following: European Aviation Safety Agency (EASA), EUROCONTROL, Joint Authorities for Rulemaking on Unmanned Systems (JARUS), Ministries of Transport, National Aviation Authorities (NAA), NAA web sites, Qualified Entities, National Associations (*Austria, Belgium, France, Germany, Italy, The Netherlands, Norway, Spain, UK*), National Working Group (*Denmark*) - UVS International thanks these contributors for their cooperation.
This document does not imply that the views expressed in it represent the views of the aforementioned organisations.

UVS International - 86 rue Michel Ange, 2nd Building, 2nd Floor, 75016 Paris, France
Tel.: 33-1-46.51.88.65 - Fax: 33-1-46.51.02.55
www.uvs-international.org - www.uvs-info.com - www.testranges.org - 17 March 2014 - Page: 1/1

Figure 5.1: Overview of European UAS Regulations Developed by UVSI [10]

The various regulations for the UK, France, Germany, Italy, Austria, Norway and Switzerland concerning the acquisition of a flight permission for UAS were described in detail in chapter 4. The following sub-chapters discuss the differences as well as parallelisms of those regulations.

5.1.1 Applicability & Detailed Categorization of UAS Regulations

The differences in the applicability and classification of UAS between the various selected European countries are considerable.

- **Weight Limit**
  The categorization according to weight limits has been introduced in every country by now. There is a commonality in weight limit at 25 kg MTOM of UAS. Every country, except the UK which set the limit to 20 kg MZFW (but if fuel is to be added, the MTOM will be also around 25 kg), has defined a weight limit at 25 kg MTOM. Germany and Austria defined as well a lower UAS weight limit at 5 kg MTOM, whereas in Germany this limit is only valid for electrical UAS. In France there are two other limits at 2 kg MTOM and a special case for UAS in populated areas with a MTOM of 4 kg. The UK defined a second mass limit as well, at 7 kg MZFW which is only relevant for operational and pilot requirements but not for airworthiness requirements. Because Norway has no official UAS requirements, no weight limits for UAS are applicable except the 150 kg limit.

- **Population**
  In fact, almost all of those countries regulate VLOS operations of UAS in VLL (below 500 ft) up to 150 kg. Only Germany prohibited operations of UAS with a MTOM with more than 25 kg. France considered a RPAS category in their decree for UAS with more than 25 kg but there is no defined scenario where these UAS are allowed to be operated in a general way.
  A legal basis for the authorization of flights in unpopulated areas is developed in almost all countries, but only France and Austria defined permissible scenarios in populated areas (permits to fly on a special authorization level are possible in all countries under certain limitations). However every type of operation could be allowed by the competent national civil aviation authority on a case-by-case evaluation in any event. As an example, Norway authorizes every UAS operation on a case-by-case evaluation due to not having officially published UAS requirements other than the aeronautical information circular (AIC-N 14/13) from the CAA Norway.

- **BVLOS**
  The French UAS decree is one of the first which considers BVLOS operations, though specifically only in unpopulated areas and with light UAS. In other countries only VLOS operations are predefined by the regulations. Norway grants BVLOS operations on a very generous basis for operations in the area of Svalbard (Spitzbergen) and over the sea between Norway and Greenland, where the population density is extremely low.

- **Summary**
  The overview, depicted in figure 5.2, shows that for every selected country, the predefined scenarios and UAS weight classes are shown by colored bars, distinguished by VLOS and BVLOS operations. The different selected countries are shown on the vertical axis according to their first introduction of regulations for UAS (on the top is the country with the earliest regulation for UAS, the bottom showing the most recent). Additionally, the name and number of the relevant national regulation for UAS as well as their first introduction is denoted.
  The horizontal axis shows the weight limits increasing from the left to the right. Each country has two main rows which are illustrating the distinction between VLOS and BVLOS regulations. More precisely defined scenarios by country are listed to the right. White areas are undefined or are scenarios/weight classes which are not regulated by the competent authorities at the moment and only permissible on a case-by-case evaluation.
  The colors of the bars show the complexity of the defined requirements for each of the categories in an increasing order from green with low requirements via yellow and orange, up to red bars showing strict regulations.

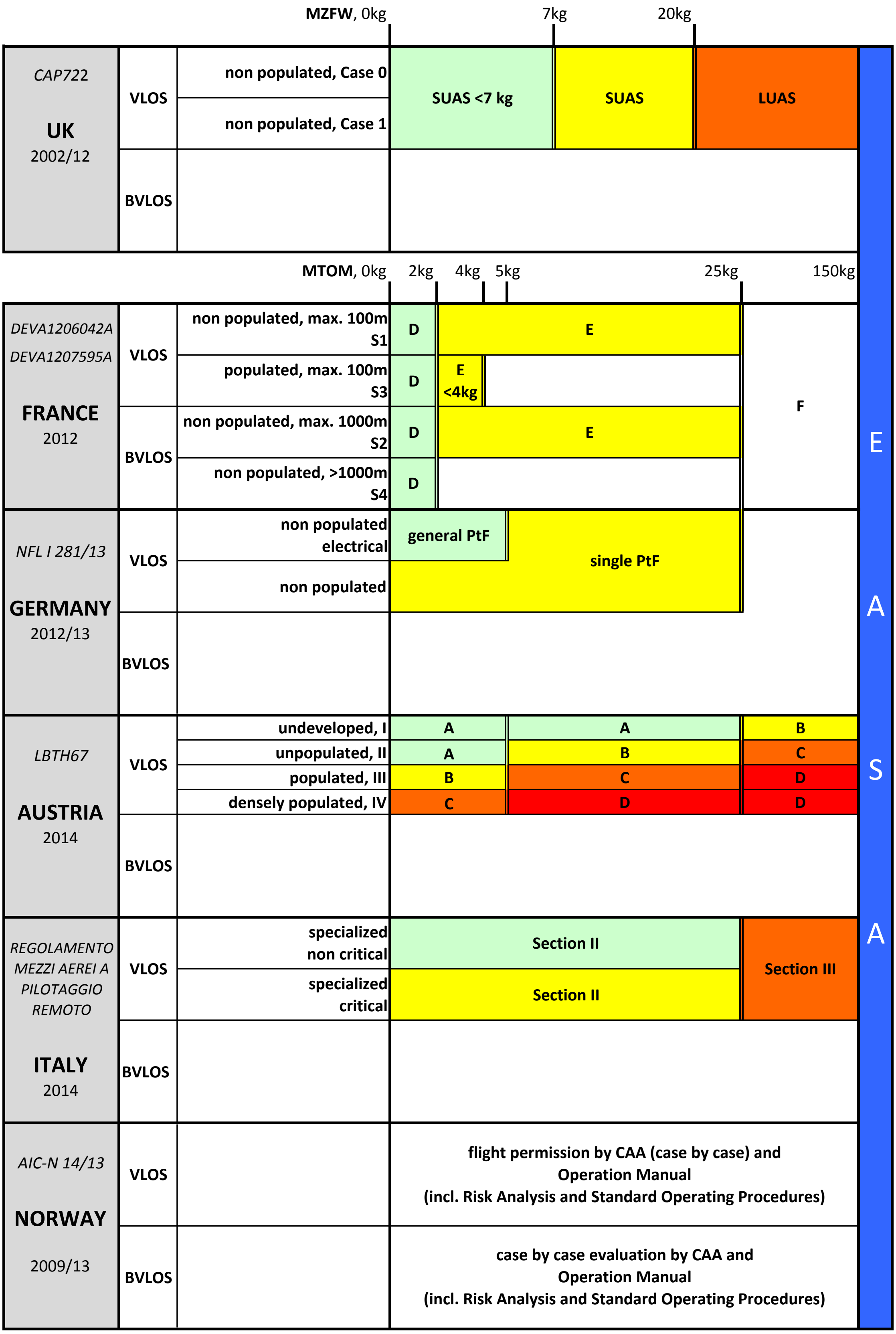

Figure 5.2: Comparison of the Applicability & Detailed Categorization of UAS between the Different Countries

5.1.2 UAS Airworthiness Requirements

The airworthiness requirements differ drastically between the various countries. Every country has increasing requirements for the airworthiness depending on the weight of the UAS and the density of the population of the operation area. For UAS with a small MTOM it is often sufficient that the applicant assesses the airworthiness and announces the results within a declaration.

- **No special airworthiness requirements (Green)**
  No special airworthiness requirements or certification specifications are valid for UAS with the following weights:

  - up to 20 kg MZFW in unpopulated areas in the UK,
  - up to 25 kg MTOM within the “S1” scenario in France,
  - up to 5 kg MTOM for electric UAS in Germany,
  - up to 25 kg for specialized non critical operations in Italy, and
  - up to 5 kg MTOM or even 25 kg MTOM (depending on the population density) in Austria.

  All those categories with no specific airworthiness requirements are colored in green in figure 5.3. Norway has no specific airworthiness requirements at all. The authorization of the whole system is based on the operation manual as well as a safety assessment by the CAA Norway on a case-by-case evaluation.

- **Specific Requirements (Yellow, Orange and Red)**
  A more detailed assessment is required in France for all other scenarios other than “S1” up to 25 kg MTOM. In addition to the airworthiness assessment of the operator, various safety and flight tests have to be conducted (FMEA, etc.). In Germany all UAS with a MTOM of more than 5 kg or all UAS which are not electrically driven up to 25 kg require an assessment of airworthiness by the competent authority. Explicit specifications of those requirements are not mentioned within the German regulation. In Italy all UAS up to 25 kg MTOM other than specialized non critical operations (e.g. flights in congested areas, in the vicinity of people, in urban areas and close to infrastructure, etc.) are required to be assessed by the competent authority, but again no clear specifications or guidelines are defined by the Italian regulation. Austrian UAS of category “B” up to 25 kg can be assessed by the operator according to attachment “B” (similar to a model aircraft specification) of the Austrian UAS regulation (LBTH67). All other UAS in Austria, thus category “B” exceeding 25 kg MTOM and category “C” and “D”, require an assessment according to the draft certification specifications (tailored case-by-case evaluation)

published by the JARUS working group (CS-LURS, CS-LUAS, etc.).
In all other EU-countries UAS with a maximum take-off mass of more than 25 kg (or 20 kg MZFW in the UK) require a certificate of airworthiness on the basis of a case-by-case evaluation by the competent authority, except for Austria where the requirements are well defined by the matrix categorization of LBTH67. A special case is defined in the UK, where for UAS with more than 20 kg MZFW, a certificate of airworthiness is usually required, except if the UAS is flown within the operational limitations of light UAS (below 20 kg MZFW). In this situation the competent authority is allowed to authorize a permit to fly on a case-by-case evaluation with no application of all requirements from the manned aviation.

- **Summary**
  The overview, depicted in figure 5.3, shows the different airworthiness requirements for each country marked by colored bars. Each country has two main rows which illustrate the distinction between VLOS and BVLOS regulations. More precisely defined scenarios by country are listed to the right. White areas are scenarios/weight classes that are undefined or which are not regulated by the competent authorities at the moment and only permissible on a case-by-case evaluation.
  The colors of the bars should show the complexity of the defined requirements for each of the categories in an increasing order from green with low requirements via yellow and orange, up to red bars showing strict regulations.

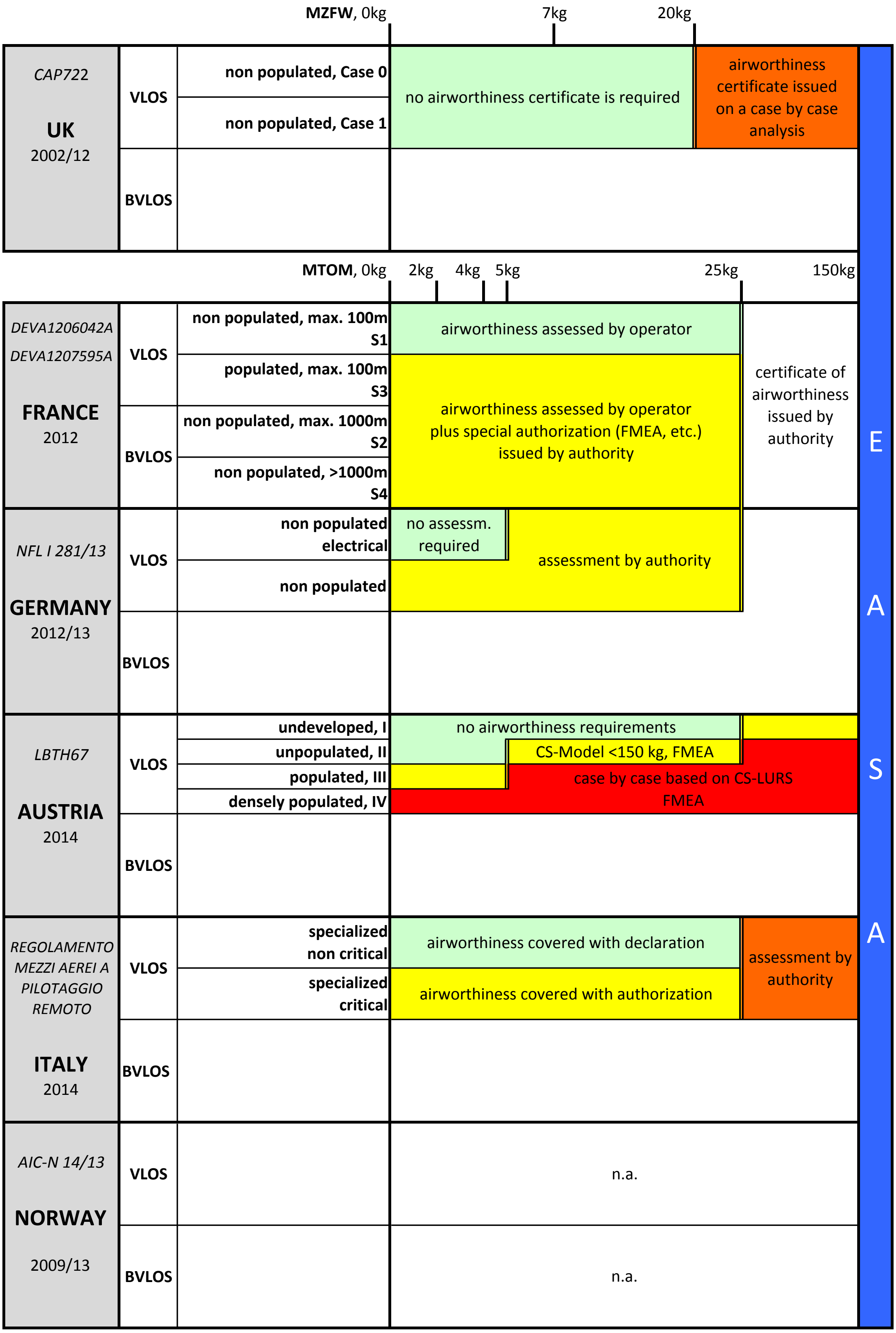

Figure 5.3: Comparison of the Airworthiness Requirements for UAS between the Different Countries

5.1.3 UAS Operational Requirements

Most of all authorized UAS flights in the European countries are based on VLOS operations at the moment.

- **VLOS**
  The requirements for the acquisition of permit to fly within visual line of sight for light UAS up to 25 kg and in unpopulated areas are well defined almost everywhere. The maximum flight altitude above ground is limited by the minimum flight altitudes of the manned aviation around 400 ft or 122 m (in the UK) to 500 ft or 150 m (France and Austria) depending on the national rules of the air and UAS scenarios. Germany limited the maximum flight altitude to 100 m AGL and Italy, for specialized non-critical operations, to 70 m AGL. In Norway the general maximum VLOS operating altitude is 400 ft or 122 m but can be extended on an exemption basis by the national CAA.
  The VLOS radius of operation around the remote pilot is defined differently in each country. The UK and Austria defined the radius of operation to a maximum of 500 m, whereas Italy for specialized non-critical operations to 200 m and France to only 100 m for “S1” and “S3” operations. Germany limits the radius to “in visual line of sight of the remote pilot” but not to a certain distance.

- **BVLOS**
  France, one of the first countries to authorize BVLOS operations, set the maximum altitude to 50 m for the scenario “S2” and 150 m for “S4”. The radius of operation in France for BVLOS is limited to 1000 m for UAS up to 25 kg and greater than 1000 m for UAS with a MTOM of up to 2 kg. In Norway the area of operation for BVLOS operations is individually defined for each flight and announced via NOTAM.

- **Summary**
  All other operational limitations outside of these predefined scenarios will be defined depending on the area of operation and weight class of the UAV by the competent authority of the individual country on a case-by-case evaluation.
  The whole overview is depicted in figure 5.4, where for every selected country the different operational requirements are shown by colored bars. Each country has two main rows which illustrate the distinction between VLOS and BVLOS regulations. More precisely defined scenarios by country are listed to the right. White areas are scenarios/weight classes that are undefined or which are not regulated by the competent authorities at the moment and only permissible on a case-by-case evaluation.

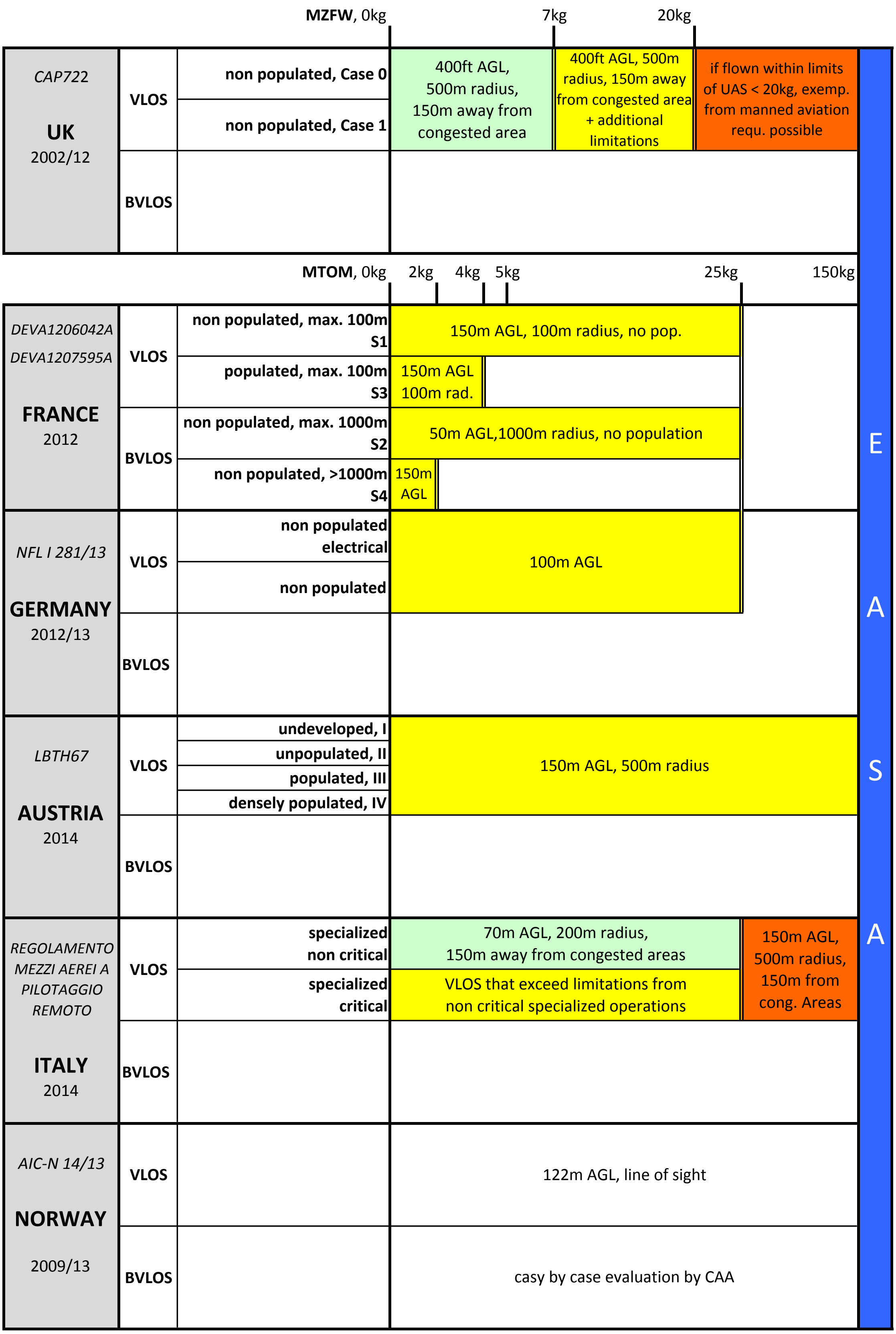

Figure 5.4: Comparison of the Operational Requirements for UAS between the Different Countries

5.1.4 UAS Pilot Requirements

The requirements for a remote pilot of a UAS ranges from no pilot license up to aviation licenses for manned aviation.

- **UK - most advanced**
  The investigation of the pilot's skills as well as the whole license system is most advanced in the UK compared to all other countries. Special UAS related licenses were developed such as the BNUC-S and other licenses from the manned aviation like the CPL and ATPL, which were modified and adapted to the special requirements of unmanned systems. These special licenses are called CPL(U) and ATPL(U), where "U" stands for unmanned systems.

- **No special remote pilot assessment**
  As it is the case for all other UAS requirements, especially for light UAS operated in areas with a low density of population, often no special pilot competences are necessary and the remote pilot or the operator is responsible for the safety of the operation. For example in Austria, the operator is responsible for the pilot skills of UAS up to 25 kg MTOM in undeveloped areas or UAS up to 5 kg in unpopulated areas (the definition of the different areas is stated in chapter 4.4.3). The same is applicable in the UK (up to 20 kg MZFW and for the risk case "0", see chapter 4.1.6) and Italy (up to 25 kg for specialized non-critical operations, see chapter 4.5.3), where also no special license is required and the competence of the remote pilot is covered within the declaration to the competent authority in Italy or a simple UAS license like the BNUC-S is required (UK). In Germany only UAS up to 5 kg which are electrically driven and operated in unpopulated areas are allowed to be controlled by a remote pilot with no special license or assessment by the authority. Pilots do not require a license for all VLOS operations in Norway.

- **Remote pilot assessment**
  In France, either the operator is responsible for the competence of the pilot of UAS up to 25 kg MTOM for the scenarios "S1", "S2" and "S3" or a training organization assesses the competence of the pilot. For BVLOS operations within scenario "S4" of UAS up to 2 kg MTOM, a private pilot license with a minimum of 100 flight hours is required. This is due to the fact that this scenario allows UAS flights beyond visual line of sight more than 1000 m away from the remote pilot in unpopulated regions. BVLOS operations in Norway require a pilot license from the Norwegian National Security Authority. In Germany, UAS with other than electrical types of propulsion or heavier than 5 kg up to 25 kg MTOM, the competences of the remote pilot will be assessed by the competent authority. An equivalent assessment of the remote

pilot skills is required in Italy for UAS with the same upper limit of 25 kg MTOM for specialized critical operations.

- **Austria**
  In contrast, Austria is more liberal in the requirements for remote pilots, where it is possible to operate UAS with a maximum take-off weight between 25 kg and 150 kg (or category "B" UAS, see chapter 4.4.3) in undeveloped areas with only a declaration of the pilot to comply with the requirements. Even for UAS of up to 5 kg MTOM operated in populated areas, the self declaration is sufficient. Only UAS of category "C" and "D" require a civil pilot license in Austria. If the pilot has no license, only a theoretical examination in aviation law for UAS is necessary but no practical assessment.

- **Summary**
  In contrast to Austria, the remote pilot requirements for UAS of more than 25 kg MTOM in other countries are more stringent. Italy demands a civil pilot license, France requires a flight demonstration and assessment of the civil aviation authority and the UK postulates in their regulation that the remote pilot needs a CPL(U) or the BNUC license from the qualified entity EuroUSC dependent on the safety situation. In fact, those requirements are much higher and in almost all cases a practical assessment is necessary, whereas in Austria no practical examination is required for the pilot other than the weight and density of population.

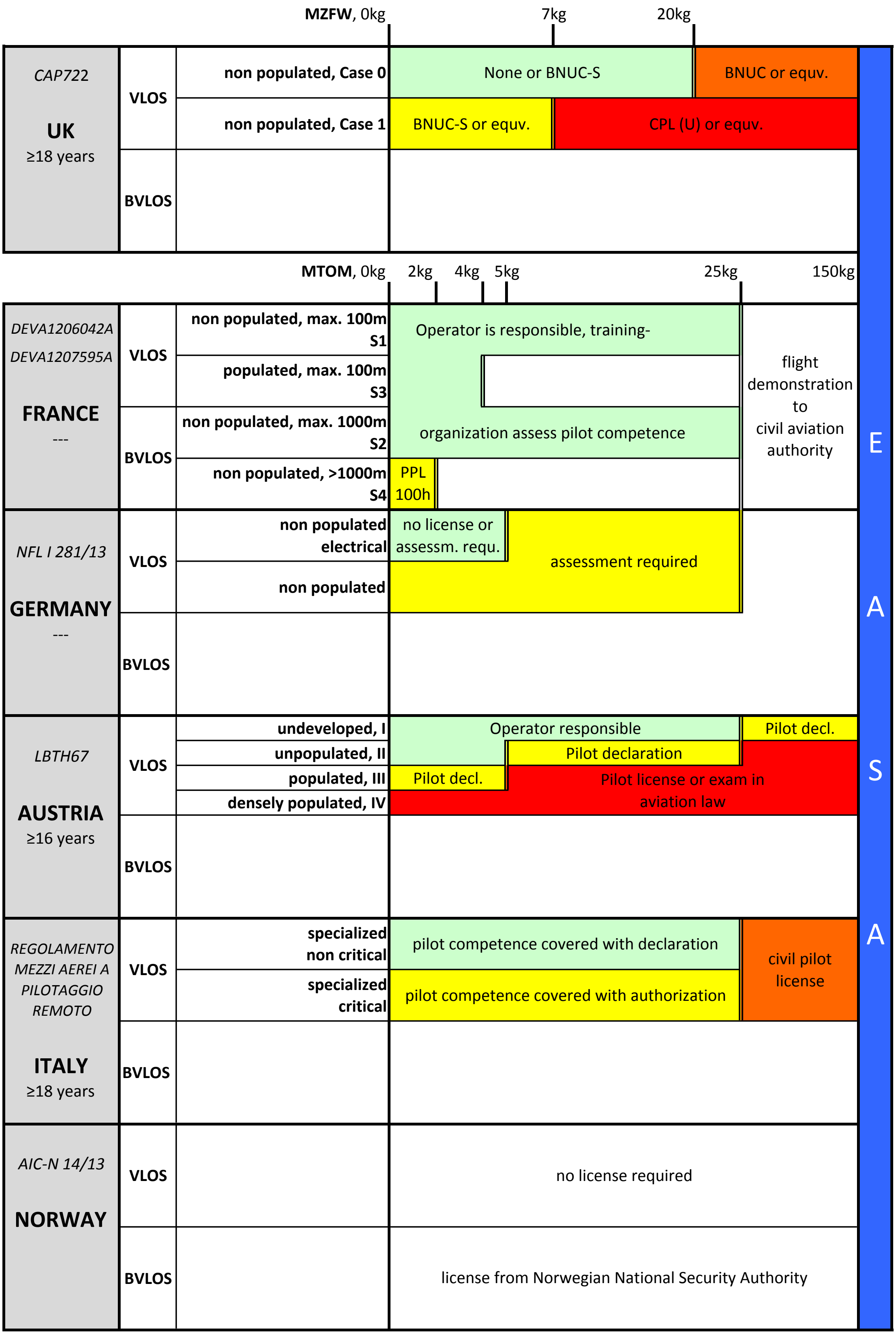

Figure 5.5: Comparison of the Pilot Requirements for UAS between the Different Countries

5.1.5 General Summary

Every country has introduced their own UAS regulations. Whenever new regulations are published, they take from previously drafted publications (e.g. the 25 kg weight limit) and studies from the international working groups and civil aviation authorities. Subsequently all similarities and differences between the various national UAS regulations are summarized.

- **VLOS - Similarities**

  25 kg weight limit : The 25 kg weight limit has been introduced in all national UAS regulations except in the UK (20 kg MZFW weight limit, but if fuel is to be added, the MTOM will be also around 25 kg).

  Third party liability assurance : The insurance requirements are rather similar between the various requirements. All regulations refer to EC 785/2004 as a minimum for third party liability assurance, which sets the minimum limit of liability to 750.000 SDR for aircraft with a MTOM below 500 kg.

  VLOS operations in unpopulated areas : Every national regulation has specific requirements for UAS operations in areas with low population density. In most cases these requirements are rather low and the authorization can be required with low efforts and investment costs. This is a result of all CAAs following a step-by-step approach for gaining practical experience through authorizations of civil RPAS operations with low risks for third parties.

  Safety assessment for heavy RPAS within populated areas : If operational scenarios for UAS inside populated areas are defined, a detailed safety assessment of the whole system for the particular flight or series of flights has to be conducted and evaluated by the competent authority.

  Maximum altitude for VLL operations 150 m : The maximum flight altitude for VLL operations never exceeds 150 m AGL.

  Maximum radius for VLL operations 500 m : The maximum radius for VLL operations around the remote pilot never exceeds 500 m.

  No pilot license for low risk operations : Most of the countries do not require a pilot license or specific pilot competences for VLL RPAS operations in areas of low population density, especially for light UAS (e.g. below 25 kg).

  No airworthiness requirements for light RPAS : In almost all countries, no airworthiness assessment according to specific requirements is necessary for light RPAS in areas with a low population density.

Case-by-case evaluation for all operations outside of UAS regulations : Every civil RPAS operation which is not covered by the UAS regulations can be authorized on a case-by-case evaluation by the competent authority. The operational limitations and restrictions as well as the technical requirements for the system will be specified for each particular case and scenario.

- **VLOS - Differences**

Certification specification for light RPAS : An actual specification for the technical certification is only available in Austria. For light RPAS operated in areas of moderate risk, an adopted certification specification from model aircraft is being introduced by the CAA of Austria. In case of failure of RPAS which are flown within an area of higher risk to third parties, the CS-LURS/CS-LUAS is required to identify the technical requirements of the RPAS. The UK and France introduced guidance material for the determination of certain minimum equipment for the operation in the defined scenarios but no certification specification. The qualified entity "EuroUSC" developed an assessment plan which is called the "Light UAS Scheme" which covers airworthiness-, operational- and pilot requirements.

Airworthiness requirements : The airworthiness requirements vary from absolutely no specifications except for a self assessment (for light RPAS in unpopulated areas) via case-by-case decisions (for most RPAS with more than 25 kg MTOM), to specific certification specifications with minimum equipment requirements (for RPAS within populated areas in Austria).

Validity period of authorization : General permit to fly certificates are valid between one and two years dependent on the country.

UAS operational scenarios : Most of the countries defined VLOS conditions (e.g. 150 m AGL and 500 m radius) where all RPAS independent of the weight are allowed to be operated. Only France defined specific scenarios (e.g. 50 - 100 m AGL, 100 m - 1000 m radius), where only certain RPAS of specific weight classes are allowed to be operated.

Pilot licenses : In almost all countries the competences of the remote pilot is more important than the technical state of the system. In Austria are the practical skills of the pilot rather insignificant.

Minimum pilot age : The minimum age of the remote pilot for UAS varies between 16 (e.g. Austria) and 18 years (e.g. UK).

Maximum flight altitudes : The maximum flight altitudes vary from 70 m (Italy) up to 150 m AGL (Austria and France).

- **BVLOS - Similarities**

  Only possible in unpopulated areas : In France and Norway, which are two of the first countries to allow BVLOS activities, the operation of RPAS in BVLOS conditions is limited to unpopulated areas.

  Case-by-case evaluation : Every BVLOS operation is connected with a case-by-case evaluation by the competent authority depending on the class of RPAS, type of operation, risk to third parties, etc.

  Pilot license necessary : In both countries, a pilot license for the remote pilot is required. In France a private pilot license with a minimum of 100 flight hours is necessary for BVLOS operations exceeding a radius of 1000 m around the remote pilot. Norway requires a pilot license from the Norwegian National Security Authority.

- **BVLOS - Differences**

  Maximum flight altitude : In France the maximum flight altitude for BVLOS operations is limited to 150 m for RPAS with a MTOM of 2 kg or even 50 m for RPAS with a MTOM of up to 25 kg. Norway has no limitation for the weight of a RPAS or the flight altitude. Even in controlled airspace the operation could be authorized together with a NOTAM.

  Maximum weight : In general, France authorizes RPAS for BVLOS operations up to 25 kg MTOM. Norway has no limitation for weight.

5.2 Assessment & Recommendations

The previously summarized similarities and differences of the various national UAS regulations will be assessed in this section on the basis of the main four categories of chapter 5.1.
The assessment as well as the recommendations for future UAS regulations and requirements express the personal opinions of the author of this thesis.

- **Applicability & Detailed Categorization of UAS Regulations**

  Assessment: The categorization of different UAS requirements is regulated according to the MTOM of the UAS at the moment. From various discussions, it can be concluded that it is not a good choice in every case to use the weight as the main deciding factor. Due to the miniaturization, future light RPAS would be able to operate at high altitudes in controlled airspace and will have a long endurance to reach areas of operations which are far beyond the visual line of sight and also beyond radio line of sight.

  Recommendation: Therefore, it would be better to use the potential risk for third parties, whether on the ground (population density) or in the air (uncontrolled or controlled airspace) and the class of airspace as the deciding factors, rather than the weight of the RPAS. The opportunities and capabilities of RPAS will further increase at the same time the weight of these systems will decrease, and therefore the weight classes have to be changed from time to time.

  Assessment: Either way, the risk for third parties remains the same if a RPAS with 80 kg or 2 kg crashes in an undeveloped area. On the other hand if a RPAS is operated above populated areas with people on the ground the risk for third parties is independent on the weight but the collateral damage is different. Because of the weight classes, nowadays many manufacturers develop an RPAS up to a certain weight limit (to stay in a lower requirements class) on the cost of safety.
  Many different weight classes have been introduced by the national UAS regulations (2 kg, 4 kg, 5 kg, 7 kg, 20 kg, 25 kg and 150 kg). The 25 kg weight limit is defined in almost all UAS regulations except in the UK.

  Recommendation: For the forthcoming short future the weight classes will maybe remain as the relevant factor. The 25 kg weight limit covers at the moment most of the UAS used for civil applications today and should be retained. According to feedback from the various national UAS associations, the 7 kg (MZFW) weight limit from the UK should be taken as the first weight limit rather than 2 kg, 4 kg or 5 kg MTOM. Most of the systems which weigh below 2 kg are more or less toys and have an insufficient reliability due to low safety margins. These low weight classes end up decreasing safety rather than increasing it.

Disregarding the discussion on the categorization due to weight and risk of RPAS, the decision on the competent authority, whether on the national or the European level is highly important. In my opinion, many different national UAS regulations are uneconomical and disadvantageous to everybody. For cross border operations, every country would have to accept the other national UAS certifications, which is difficult if the requirements are completely different. One solution could be a common harmonized legal framework for the certification of UAS. The responsibility for the authorization can remain at the national authority depending on the type of UAS operation. A lot of business cases from SMEs require only VLL limitations which is better if the national authority is responsible because they have more competency about the local situations than the EASA (e.g. urban areas, alpine regions, etc.). Operations above the VLL altitudes and especially in controlled airspace should be regulated on a European level (e.g. EASA). The common legal framework will open the European market, independent on the competent authority which grant the authorization.

- **UAS Airworthiness Requirements**

Assessment: Airworthiness requirements are very important for the certification of UAS. At the moment only guidance material (in France and UK) is available to get an understanding of which systems shall be part of a UAS for specific applications and operations within defined limitations. Austria is the first country which published specific certification specifications for UAS from 0 kg MTOM up to 150 kg, whereas for the certification specification for UAS between 25 and 150 kg it refers to the draft CS-LURS from the JARUS working group which is applicable for UAS up to 750 kg. Therefore, it must be further adopted.

Recommendation: A self declaration, which is currently applicable for light RPAS within unpopulated areas (e.g. Italy and Germany), is a practical way to obtain experience with UAS in areas with low risk for third parties. But for a complete integration and authorization of heavier RPAS within populated areas, specific requirements on the basis of certification specifications shall be developed to avoid nontransparent case-by-case decisions by the CAAs and to accelerate the process of the certification.

- **UAS Operational Requirements**

  Assessment: The operational requirements and limitations greatly differ between the relevant countries. France introduced a few scenarios with high restrictions (only 100 m radius, 50 m AGL or only 2 kg MTOM) compared to other national regulations. On the other hand, these scenarios facilitate a fast growing number of authorizations in France by the NCAA. In France, when initial regulations were introduced in 2012, the number of approved operators increased from 86 in 2012 to more than 650 in June 2014. [9, p.6] Only France and Austria defined operational scenarios within populated areas in their national UAS regulations, but of course with more restrictions and limitations than for areas with a low population density. The step-by-step approach for the authorizations of UAS is recognizable in every country. There are far more authorizations for VLOS operations in unpopulated areas than for populated areas or even for BVLOS operations. With those first authorizations in areas with a low population density, the NCAAs would acquire experience to facilitate the authorizations of these systems in areas of higher risk and with a higher MTOM.
  In particular, the maximum flight altitudes vary between the countries. Flight altitudes of 50 or 70 m are often too small for commercial operations.

  Recommendation: The categorization of VLL operations which are defined within the European RPAS roadmap (see chapter 3.1.3) should be adopted by every country in the foreseeable future. One possible solution might be to define a general upper limit for VLL operations (e.g. 150 m) but to allow an exemption for operations around and above obstacles which are higher than this limit (e.g. 30 m around and above of each obstacle) because within this close distance to an obstacle no activities of manned aviation would occur.

  Assessment: The limitation of flights within the visual line of sight (UK: 500m, France: 100m, Germany: “visual line of sight”, Italy: 200m or 500m, Austria: 500m) restrict the field of application and commercial operations too. For inspections of long oil pipelines, high voltage power lines or natural disaster monitoring in mountainous regions, the visual line of sight limitation “kills” every business case and therefore the existence of a large number of SMEs which are going to offer such service flights. Filippo Tomasello already stated that all developed safety rules should protect the citizens on the ground and in the air, but on the other hand “cost-efficient” regulations should be introduced [59], or in Filippo’s words: “Neither kill humans...nor small and medium-sized enterprises (SMEs)!”

- **UAS Pilot Requirements**

  Assessment: A special focus should be set on the competences of the remote pilot because in the end the pilot is responsible for the decisions of the actual flight path and that responsibility will not be transferred to any technology in the foreseeable future. The theoretical knowledge about the legal framework of the aviation system as well as the practical control skills of the remote pilot are of equivalent importance. The UAS should act and react like an aircraft of the manned aviation.

  Especially because most of the operators today are coming from business areas other than the aviation industry with no knowledge about different airspace classes and rules of the air, a special education for remote pilots of UAS is required. In no other areas is one allowed to operate a vehicle without a license. For model aircraft which are used for sport and recreational purposes, you often need no license because they are operated at locally limited flying fields. Commercially used RPAS for applications with a certain deadline pressure, the remote pilot requires the competence to decide about the flying conditions, so a specific UAS training is very important.

  A necessity for a private pilot license or other licenses from the manned aviation is not very suitable in my opinion. It is only acceptable for the first transition phase, where no experience with UAS is available. For the near future, adequate special licenses for the special characteristics of a UAS are absolutely necessary, as already introduced in the UK. Special UAS licenses were developed from the qualified entity EuroUSC.

  Recommendation: The remote pilot requires the same knowledge as a "real" pilot (air law, flight performance, flight planning, human performance, meteorology, navigation, operational procedures, principles of flight and radiotelephony). For light RPAS it could be sufficient to have a basic license for remote pilots independent on the different types of vehicles (fixed wing, rotary wing, multi copter, etc.), but for more complex UAS of higher weight, special trainings should be necessary. For these UAS, a special "typerating" could be offered by the manufacturer of the system.

6 Outlook & Conclusions

The first part of this section should give an overview of the upcoming changes to UAS regulations on a European level as well as a future outlook for the UAS regulations in Austria.

At the end a final conclusion will complete this master thesis.

6.1 Outlook - European UAS Regulations

- **Views of the European Commission**

  The European Commission realized the importance of UAS for the industry of Europe and confirmed it by the Staff Working Document SWD(2012) 259 as well as the Communication COM(2014) 207 (see chapter 3.1.2 and 3.1.4). The Commission addresses public concerns like safety-, security- and privacy issues and on the other hand fosters the development of a market for civil UAS applications. The EC itself can not develop regulations, but offer financial funding through the Horizon2020 program to enable a progress driven by the industry. Ongoing studies, mandated by the EC, deal with liability and insurance questions as well as privacy issues. The outcome of all these studies together with all the ongoing work within the working groups (e.g. JARUS), a common EU regulation will be the result. The EC can amend the Basic Regulation, to assign the responsibility also for UAS with a MTOM below 150 kg to EASA, as well as introduce implementing rules with the help of the opinion from EASA on basis of the JARUS working process. The industry can contribute by preparing acceptable means of compliance to comply with the regulations in an acceptable way.

- **Role & Views of EASA**

  EASA, as the responsible civil aviation authority in Europe, can assist in developing a common market for all European member states. First, the Basic Regulation has to be amended, so that EASA takes responsibility also for aircraft with a MTOM below 150 kg. Afterwards, EASA will have the opportunity to establish an initial set of common rules for enabling economic cross-country operations within the EU for RPAS [28, p.5], [32, Annex I, p.3].

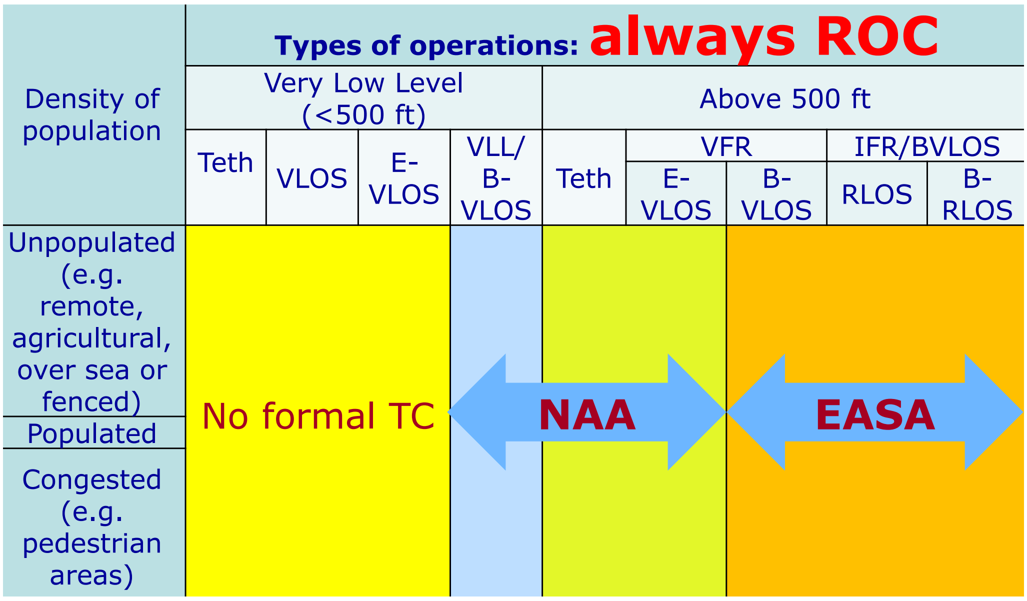

Figure 6.1: Possible European RPAS Applicability Matrix according to Filippo Tomasello [59]

- **Views of Filippo Tomasello (from EASA)**[3]

  Filippo Tomasello, the UAS Rulemaking Officer for EASA, presented the future steps, which will be done by EASA, at the RPAS CivOps conference in 2013 and the RPAS 2014 conference in Brussels. The key information was to establish common and proportionate EU regulations for the certification of RPAS. It is obvious that for VLL (below 150 m) VLOS operations in segregated airspace the RPAS rules cannot be the same as for BVLOS operations above 150 m AGL in controlled airspace. Furthermore, the mass of the UAS will be a second priority for determining the responsible authority (EASA vs. NAA). More important is the type of operation, whether in VLOS VLL or BVLOS in controlled airspace. So EASA will put its authorization focus on BVLOS operations (VFR and IFR) above the minimum flying altitudes (e.g. 150 m AGL), whereas the NAAs with their limited resources will have responsibility for the certification of RPAS in VLL operations (below 150 m) conducted in VLOS and BVLOS as well as for special operations like EVLOS or tethered RPAS above 150 m AGL (see figure 6.1). All certifications, whether granted by EASA or the NAAs will be on the basis of a common statutory source, to enable cross-country operations throughout the EU [59], [60]. According to the presentation of Filippo Tomasello at the CivOps Conference in December 2013, the first opinion to adopt the Basic Regulation therefore is in the second quarter of 2015 [59].

[3] Views and figures cited with the kind permission of Filippo Tomasello

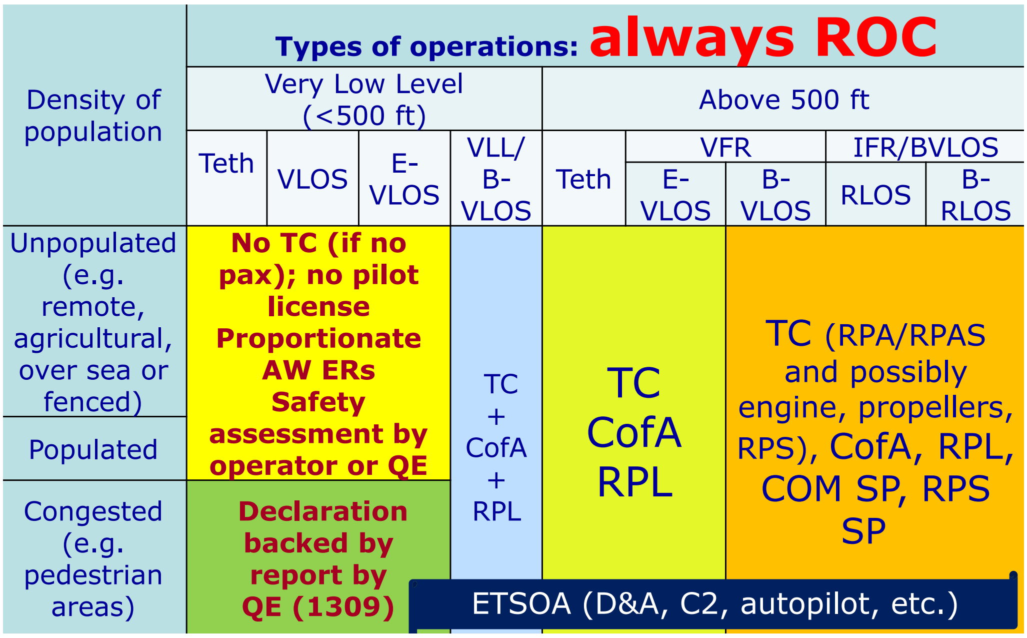

Figure 6.2: Possible European Certification Requirements according to Filippo Tomasello [59]

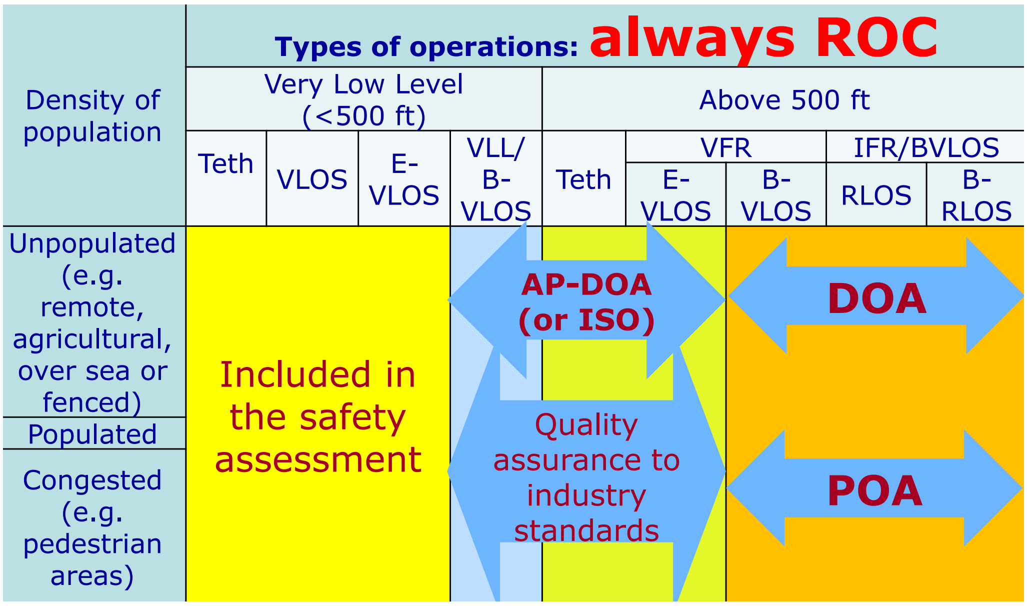

Figure 6.3: Possible European Design and Manufacturing Requirements according to Filippo Tomasello [59]

- **Outlook**

  Figures 6.1, 6.2 and 6.3 show a possible classification for European UAS regulations according to a proposal by Filippo Tomasello. Figure 6.1 shows the responsibilities of EASA and the NAAs depending on the type of operation but independent on the population density. Whether a full type certificate (TC) with a certificate of airworthiness (CofA) and a remote pilot license (RPL) is required (for all operations above 500 ft AGL and BVLOS operations below 500 ft) or only a declaration of operational safety with a safety assessment (for all VLL operations except BVLOS), is shown in figure 6.2. These are the operational requirements for conducting aerial work with RPAS. The operator itself requires in all cases a remote operator certificate (ROC) independent of the type of operation and population density. Figure 6.3 illustrates the requirements for a RPAS manufacturer and designer. A Design Organization Approval (DOA) as well as a Production Organization Approval (POA), as mandatory in the manned aviation industry, could be required only for RPAS operated above 500 ft AGL and far beyond the visual line of sight in controlled airspace. For operations with a lower risk, only a safety assessment is necessary (RPAS operated in VLL operations) or a standard quality assurance according to industry standards like the EN9100 certification could be required.
  As can be seen in figure 6.2, EASA fosters the idea of introducing a qualified entity which is assigned by the competent authority to undertake some tasks. Such tasks could be the assessment of the technical aspects of a UAS for low risk operations like VLOS and EVLOS operations on a national level as illustrated in figure 6.2.
  A successful introduction can be seen in the UK, where the qualified entity (QE) EuroUSC is assigned from the CAA of the UK to assess the pilot competences as well as the technical requirements of a UAS. This QE is already extending their tasks to other countries like the Netherlands, Belgium, Italy, etc.
  Herein before mentioned objectives would lead to a harmonized legal basis for the certification of UAS in Europe. It is questionable if the deadlines of the forecast, as described in the European RPAS roadmap (see chapter 3.1.3), can be kept, as for instance the first NPA, which aimed to implement the Amendment 43 to Annex II of ICAO into the Part-SERA, was rejected in 2012 and revised in 2014. So there might emerge further delays, which results in harmonized UAS regulations within Europa at a later date than stated in the European RPAS roadmap.

- **JARUS**
  The results from the various international working groups and institutions will influence the future UAS regulations to a great extent. As stated in the European RPAS roadmap, especially the JARUS working group is responsible for a great number of deliverables for operational requirements as for instance for design-, manufacturing-

or maintenance organizations of UAS as well as airworthiness requirements like certification specifications. Therefore, these deliverables will influence future UAS regulations in Europe to a great extent.

6.2 Outlook - Austrian UAS Regulations

Austria established their first UAS regulation in 2014, later than other European countries. On the other hand, the regulation profited from the experiences of the other national civil aviation authorities as well as outcomes from the JARUS working group.

Before the introduction of the Austrian UAS regulation, every commercial operation was done within the gray area of model aircraft regulations, which was not legally correct.

Now that a legal framework has been introduced, the operator community from all aerial service areas is frustrated because of severe restrictions even for authorized operations (noise limitations, operational restrictions such as a 20 minute flight time maximum per day, etc.), high certification costs (Austro Control charges the consumed time per hour of their employees, which can result in certification costs of more than €1.000,–) and high technical requirements (for instance redundant flight control systems or the application of certification specification (developed for UAS up to 750 kg) for light UAS below 25 kg).

At the moment the civil aviation authority of Austria authorizes UAS of category "A", "B" and even partially "C" for general operations, but category "D" only on the basis of one time permit to fly certificates. This is due to the fact that the authority prefers a step-by-step approach for the UAS certification. They would gain experience by granting light UAS for low risk operations (e.g. in unpopulated areas) at first. Afterwards, on an individual basis, first single permit to fly certificates will be granted for heavier UAS and in areas with more population. At the end, fully developed requirements will enable the operation of UAS up to 150 kg in all sectors of airspace, independent of the population density.

First changes due to the results of the experience gained during the last year of first UAS authorization could be:

- omission of noise measurement certificates for electrically driven UAS up to 5 kg MTOM
- development of a specific multi-rotor certification specification due to the high amount of multi-rotor systems (on the basis of the draft certification specification for multi-rotor systems up to 25 kg, developed by the Austrian Aeroclub, AAI and FH JOANNEUM [54])

- flat charges of about a few hundred euros for standard UAS authorizations

These changes will probably be introduced with the first revision of the LBTH67 in spring 2015. In particular with the multi-rotor certification specification, which was based on the CS-LURS in a bachelor thesis written by a student from FH-JOANNEUM at Austro Control, will be a further step forward in meeting the demands of the UAS community.

One of the biggest issues for UAS operators is the lengthy certification process from the application until the authorization. Especially for operations with a short lead time prior to the job and where the operator is dependent on single permit to fly due to the high population density, it is often the case that the flight authorization is issued after the job has taken place. The long processing time is due to the fact that the Austro Control has a limited resource of personnel available for granting flight permissions of UAS in contrast to the huge amount of applications. According to a statement from Austro Control, approximately 220 applications were received by the end of July 2014. Only around 45 general flight permissions were granted which will last for one year and a few single flight permissions.

On the basis of the idea from the EU to introduce a qualified entity, which is completely independent and is able to assess if the technical requirements are fulfilled by an UAS, the Austro Control and Aero-Club are considering a division of work. It could be possible, that the technical experts of the Aero-Club, who have a high competence in assessing the technical status of a model aircraft, are allowed to examine UAS of category “A” and “B” according to the technical requirements of the LBTH67. The final issuance of the flight permission, the technical assessment of complex UAS of category “C” and “D” as well as the definition of the appropriate operational limitations remain under the responsibility of Austro Control.

6.3 Final Conclusions

The development of a legal framework for certifying UAS is a highly important and topical issue due to the numerous possibilities for civil applications. Quite recently, Amazon and Google announced their research projects for a new era of parcel delivery. Google relies on a blended wing body concept which is able to take-off and land vertically, whereas Amazon is focused on a multicopter system. [8], [6] Furthermore BP, an important and large energy company, launched a project for the first authorized BVLOS operations for monitoring their pipelines in Alaska. [7] The versatile areas of applications exist and are described in chapter 1.2 in further detail.

The basis for all these commercial applications are a profound legal basis for the certification of UAS. Engineers are often too concentrated on the technical aspects of a system and completely forget about the ability to guarantee a certification, which is crucial for a successful business case.

- **ICAO & JARUS**
  On the international level, ICAO perceived the importance of UAS and published guidance material about the introduction of UAS into the international aviation system and also about future international air traffic with UAS. The most important working group for the development of specific UAS regulations is JARUS, which is a consortium of many different national civil aviation authorities, working on certification specifications and requirements for personnel licensing of remote pilots, communication links and certification of design-, manufacturing and maintenance organizations of UAS up to 750 kg MTOM. A overview about the international efforts of these institutions is given in chapter 2.

- **Europe**
  The European Commission and their subsequent agency, EASA, are the key players in introducing harmonized UAS regulations in the foreseeable future on the European level. The European RPAS roadmap, where the actions which need to be taken from all the European stakeholders are described, and further efforts for the development of a legal framework for UAS are illustrated in chapter 3.
  At the moment, countries are developing their own legal basis for the certification of UAS up to 150 kg MTOM (see chapter 4) more or less successfully (for assessments and recommendations on the national level, see chapter 5).

- **Further developments**
  A stepwise approach for the certification of UAS can be seen in the various countries carried out by the civil aviation authorities. Light RPAS operated within areas of low risk for third parties and under VLL limitations receive their authorization in a relatively simple way. But for a full integration of UAS into the common airspace (even controlled airspace and above populated areas) the key technology of detect & avoid systems for preventing collisions with other objects in the air, as well as industry standards to guarantee the same safety standards as in the manned aviation, need to be developed and defined by regulations. Another big issue is the absence of a dedicated frequency spectrum for the use of UAS. The next World Radiocommunication Conference (WRC) in 2015 will hopefully conclude on a solution for a harmonized use of radio frequencies, in particular for UAS.
  A big problem are illegal flights of UAS, whether unintended or intended. A lot of commercial UAS applications are conducted without a permit to fly, either because of stringent requirements and long lasting certification processes or because of ignorance. The CAAs in most of the European countries have not enough resources to manage the high amount of applications and on the other hand to execute penalties for illegal flights without authorizations. A liberal step-by-step introduction of unmanned systems into the common airspace together with the UAS industry is essential to handle unlawful UAS activities in the future.
  It is certainly not specific, the means of achieving full integration of UAS, but for the foreseeable future it can be concluded that the national authorities will further develop their UAS regulations guided by the international and European institutions (see chapter 6.1 and 6.2). If enough experience and knowledge about these systems has been obtained by the national as well as supranational authorities and the missing (certifiable) key technologies are developed, harmonized UAS regulations will make it possible to achieve commercial civil applications of unmanned aircraft systems across national boundaries.
  It will be fascinating to see, which current national UAS regulations will form the basis for future harmonized European UAS regulations and of course there are a lot more thesis that can – and will – be written about this topic in the future.

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