

# ACCOMMODATING SUB-ORBITAL FLIGHTS INTO THE EASA REGULATORY SYSTEM\*

Jean-Bruno Marciacq<sup>(1)(2)</sup>; Yves Morier<sup>(1)(3)</sup>, Filippo Tomasello<sup>(1)(4)</sup>, Zsuzsanna Erdelyi<sup>(1)(5)</sup>, Michael Gerhard<sup>(1)(6)</sup>

<sup>(1)</sup>European Aviation Safety Agency (EASA.) Ottoplatz 1, D-50679 Cologne, Germany

<sup>(2)</sup> Email: [jean-bruno.marciacq@easa.europa.eu](mailto:jean-bruno.marciacq@easa.europa.eu); <sup>(3)</sup> Email: [yves.morier@easa.europa.eu](mailto:yves.morier@easa.europa.eu);

<sup>(4)</sup> Email: [filippo.tomasello@easa.europa.eu](mailto:filippo.tomasello@easa.europa.eu); <sup>(5)</sup> Email: [zsuzsanna.erdelyi@easa.europa.eu](mailto:zsuzsanna.erdelyi@easa.europa.eu);

<sup>(6)</sup> Email: [michael.gerhard@easa.europa.eu](mailto:michael.gerhard@easa.europa.eu);

## ABSTRACT

The Treaty of the European Union allows for the development of common policies for all sectors of transport, including aviation, and its safety.

For this reason, the European legislator established in 2002 the European Aviation Safety Agency (EASA), located in Cologne, Germany, and gave it responsibility for the regulation of aviation safety, including airworthiness, air operations and flight crew licensing. Annex 8 of the International Civil Aviation Organisation (ICAO) to the Chicago Convention defines an aircraft as “*any machine that can derive support in the atmosphere from the reactions of the air other than the reactions of the air against the earth’s surface*”. Thus, Sub-orbital Aeroplanes generating aerodynamic lift during the atmospheric part of the flight are considered to be aircraft. Their airworthiness, crews and operations are under the remit of EASA. EASA is therefore currently preparing to fulfil its role in relation to civil suborbital flights, aircraft and operations.

This paper describes the approach proposed by EASA to accommodate sub-orbital space flights into its regulatory system, from the perspectives of aircraft certification and operation.

## 1 INTRODUCTION

The recent, rapid and successful developments in the domain of commercial spaceflights have highlighted the need to develop corresponding regulations, in order to protect both paying passengers, and ensure that risks to people on the ground or in the air are appropriately mitigated.

As explained in further details hereafter, the present remit of EASA focuses on aircraft, the definition of which excludes rockets and capsules. The scope of this paper therefore meets the definition of space tourism as recently defined by ESA: “*suborbital flights [performed] by privately funded and/or privately operated vehicles*”<sup>1</sup>[1], but limited to winged aircraft, including rocket-powered aeroplanes, and excluding rockets

Thus, we have chosen to define the product which is the scope of our interest as “Sub-orbital Aeroplanes”. This term encompasses both the operational pattern (sub-orbital, therefore requiring less speed/energy to climb and be spent on the return) and the type of vehicle, namely an aeroplane (airborne with wings) able to climb up to the upper limits of the atmosphere, which may be also considered as the lower limit of outer space, as discussed hereafter for the potential legal implications this may have. Although presenting specific design characteristics, these vehicles would be very similar to existing aeroplanes in operations for most of their flying pattern [2]. Therefore the approach chosen by EASA is to complement existing rules to capture the specific features of such Sub-Orbital Aeroplanes, rather than developing new specifications from scratch.<sup>2</sup> This “small steps” approach, as defined and applied by the late Marcel Dassault in his projects, allows to accommodate new technologies and operational ranges, while minimising the effort, resources and associated programmatic risk.

### 1.1 International Technical and Regulatory Context

Since the Ansari X-Prize competition, dozens of suborbital space projects have flourished throughout the world, including Europe, along with the actual beginning of the development of the associated required ground infrastructures called “spaceports”, some of which are currently under construction [3].

In particular, EASA has started to be approached by potential applicants, which reinforced the need to get ready to support the first application(s). With this goal in mind, the EASA Internal Safety Committee of the 8<sup>th</sup> July 2008 agreed to proceed with the preliminary steps, that is to write and present a paper at the 3<sup>rd</sup> IAASS Conference in Rome, in order to perform preliminary investigations on how to accommodate such projects in the existing EASA regulatory framework.

<sup>1</sup> Galvez A. and Naja G., on *Space Tourism*, in ESA bulletin 135-August 2008

\* The views expressed in the paper are those of the authors and do not commit the Agency or represent the Agency’s view nor the view of the Community Institutions.

<sup>2</sup> This approach has been, for instance, followed by EASA also for Unmanned Aerial Systems (UAS).

## 2 INTERNATIONAL LEGAL CONTEXT

From a legal perspective, the Chicago Convention has to be taken into consideration as well as the aviation related Regulations and Directives of the European Union [4]. For comparison, the U.S. concept will be mentioned. Finally, as Sub-orbital Aeroplanes will also touch, if not enter outer space, internal space law issues must also be considered.

### 2.1 Chicago Convention

Among the Agencies of the United Nations or similar international intergovernmental bodies, the International Civil Aviation Organisation (ICAO) can be considered a “success story”. In fact it has allowed the development of international civil aviation for more than sixty years, to the point that this mode of transportation has become the favourite one for long range travel between different countries and over flying a number of other States or stretches of high seas.

ICAO was established by the Chicago Convention<sup>3</sup>, which was signed on 07 December 1944 by 52 Contracting States, which today number almost 200. Article 1 of the Chicago Convention recognises the complete and exclusive sovereignty of each Contracting State over the airspace above its territory (including territorial waters). As a consequence, international standards adopted and published by ICAO are addressed to said States and not directly to natural or legal persons. In other words ICAO standards do not have direct force of law in the Contracting States. Article 12 of the Chicago Convention clarifies that each Contracting State undertakes to adopt measures to implement and enforce rules of the air in its territory. The same article requires that these regulations in force in the States should conform, to the greatest possible extent, to the standards adopted by ICAO. Similarly, Article 38 of the Chicago Convention refers to regulations applicable in the Contracting States in order to actually implement the ICAO technical annexes to the Chicago Convention.

However, Article 44 of the same Convention assigns to ICAO objectives for the safe and orderly growth of aviation, in a larger geographical area (i.e. “throughout the world”) than the territory and territorial waters of Contracting States. In other words, also flights over-water between Contracting States come under the scope of ICAO. Even in this case however, ICAO in practice does not establish law directly applicable to natural or legal persons. Article 17 of the Convention establishes that aircraft have the nationality of the State in which they are registered. Furthermore the ICAO Council has divided the airspace over the entire world into Flight Information Regions (FIRs) spanning also over the high seas. Responsibility to establish rules of the air and to provide air navigation services has then been delegated

to the contracting State to whom each FIR has been assigned.

This is however balanced by Article 33, which guarantees the mutual recognition of certificates issued by Contracting States.

In conclusion, ICAO provisions are not directly applicable to aviation personnel or operators, unless transposed into national law by Contracting States. In practice however, most States have done so, in order to remain part of the international aviation system, which brings them significant economic and social benefits.

### 2.2 Aviation law in the European Union

#### 2.2.1 General

The principle of sovereignty implies that only States can adopt, publish and enforce measures with force of law. The Chicago Convention for instance is indeed based on it. The same principle has been totally applied until 1957 for international relations. However, in that year, six European States, signed the Treaty establishing the European Economic Community on 25 March on Capitol Hill in Rome. Such a Treaty, while maintaining independence and sovereignty for each of the six signatory States, established institutions (e.g. the Council and the European Commission) with delegated powers to adopt and publish legally binding measures, which are directly applicable to natural and legal persons acting in the territory of the Community. In other words some attributes of the sovereignty had been delegated to a supra-national entity without the need to create a larger State.

The Treaty of Rome contained Articles 74 to 84, giving the Community the possibility to establish a common policy and common rules for transport. Article 84 (2) required unanimity in the Council, in order to establish common provisions for air transport. This requirement has greatly delayed the development of binding common rules for aviation in Europe. Technical cooperation existed. This led however via the Joint Aviation Authorities to the harmonization of several technical rules, but on a best endeavors principle.

Nevertheless, in 1986 the Single European Act was signed by the 12 States belonging to the European Community at that time. The Single European Act introduced the principle of qualified majority voting in order to adopt common policies, in particular (Article 16.5 therein) for air transport. It entered into force on 1<sup>st</sup> July 1987 and was widely used by the European Commission lead by Jacques Delors (1985-94) in order to establish Community law in a number of fields. Since then the number and scope of basic EU legal instruments applicable to aviation safety constantly expanded, some major ones summarized in Table 1 hereafter:

<sup>3</sup> Convention on International Civil Aviation, 1944, as amended 2006 (ICAO Doc 7300/9).

Year	Act	Topic
1991	Directive 670	Mutual recognition of aeronautical licences
1991	Regulation 3922	Harmonization of technical aeronautical rules
1994	Directive 56	“Independent Investigators”
2002	Regulation 1592	Establishment of EASA
2003	Directive 42	Safety occurrence reporting
2004	Directive 36	Safety Assessment of Foreign Aircraft (SAFA)
2004	Regulations 549, 550, 551, 552	“Package” of 4 Regulations on the “Single European Sky” (SES)
2005	Regulation 2111	“Black list”
2006	Regulation 1899	EU-OPS for commercial air operators
2008	Regulation 216	First extension of EASA to Operations and Flight Crew Licensing
2008	COM final 388, 389, 390	Proposals for SES reform & for extending EASA to aerodromes and ATM (Air Traffic Management) / ANS (Air Navigation Systems)

**Table 1: EASA Main Milestones and associated Regulations [F. Tomasello – EASA]**

In conclusion, the Member States (today 27) of the Community, now the European Union, as established by the Maastricht Treaty<sup>4</sup>, have progressively discharged their obligation to transpose the ICAO standards into law applicable in their territory, not individually, but collectively. This is not contradicting any of the Articles of the Chicago Convention.

Conversely, EU law does not contain the “minimum” requirements, but “the” requirements. In fact minimum requirements are necessary to ensure safety, but additional requirement adopted nationally may distort the internal market. EU Member States are therefore not allowed to establish additional requirements in the fields where community competence has been established by the legislator.

### 2.2.2 EASA Role and Procedures

The European Aviation Safety Agency (EASA) has been established by Regulation (EC) No 1592/2002<sup>5</sup>, meanwhile repealed and replaced by Regulation (EC) No 216/2008<sup>6</sup> (hereinafter referred to as “Basic Regulation”). Initially its competence was limited to airworthiness and environmental compatibility of aeronautical products (i.e. aircraft, engines or propellers). The Basic Regulation does not explicitly

<sup>4</sup> Treaty on European Union, 1992 (OJ C 191 of 29 July 1992).

<sup>5</sup> Regulation (EC) No 1592/2002 of 15 July 2002 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency. (Official Journal 240 L 1 7.9.2002).

<sup>6</sup> Regulation (EC) No 216/2006 of 20 February 2008 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency, and repealing Council Directive 91/670/EEC, Regulation (EC) No 1592/2002 and Directive 2004/36/EC (Official Journal 79 L 1, 19.3.2008).

define the term aircraft. Therefore the ICAO definition contained in Annex 8 to the Chicago Convention applies: “an aircraft is any machine that can derive support in the atmosphere from the reactions of the air other than the reactions of the air against the earth’s surface”. For example, “hovercraft” are therefore not considered as aircraft and are out of EASA’s competence. On the other hand, civilian aeroplanes and helicopters, but also sailplanes and aerostats (i.e. either balloons or airships) are subject to EASA common rules for airworthiness, on the basis of Article 5 of the Basic Regulation.<sup>7</sup>

In this context the EU legislator has decided that:

- Legally binding implementing rules for airworthiness, in compliance with the Basic Regulation can only be adopted by the European Commission having received an Opinion from EASA for that purpose;
- Airworthiness codes, i.e. Certification Specifications (CS) and Applicable Means of Compliance (AMCs) applicable to specific products (e.g. large aeroplanes) can be adopted and published by EASA, but they are not legally binding;
- A “certification basis” has to be defined for each product subject to certification, based on the Airworthiness Codes, but adapting them for each specific case through “Special Conditions” (SCs);

Only EASA is competent to issue type certificates in the EU, Norway, Iceland, Lichtenstein and Switzerland. The type certificate attests that the design of a product complies with its individual certification basis.

Sub-orbital Aeroplanes deriving support from the atmosphere for the largest part of their flight, are considered as aircraft by EASA. Being considered as aircraft, the legal framework of EASA also applies to that specific product. EASA is therefore ready to be consulted by interested designers, and even to receive applications for airworthiness approvals.

If and when necessary, depending on developments and proposals by industry, EASA might even issue a “policy”, i.e. a document offering guidance in order to develop the certification basis for Sub-orbital Aeroplanes. Should the need arise, even specific CS could be issued for such products, once sufficient experience has been acquired. But, as explained above, the absence of a CS at the moment does not prevent the airworthiness approval of the design of a Sub-orbital Aeroplane.

<sup>7</sup> Some aircraft are not subject to Regulation (EC) No 216/2008, see Art. 4(4) and Annex II of this Regulation. These are e.g. some historic aircraft, some aircraft specifically designed for research experimental or scientific purposes, aircraft in service in military or police forces.

Any new policy will in any case be developed through the rulemaking procedure<sup>8</sup>, which means public consultation on the content of the rules, through the Notice of Proposed Amendment (NPA) process.

### 2.3 US concept

In 1984 the U.S. Space Launch Act established the basis for licensing and promoting Commercial Space Flights in the US, which led to the creation of the Office of Commercial Space Transportation under the Clinton Administration, which was then relocated to the FAA/AST[5][6][7][8]

The U.S. National Space Policy [9] authorized by George W. Bush in 2006 further aimed to “*encourage an innovative commercial space sector, including the use of prize competitions*” such as the successful \$10 Million Ansari X-Prize, won by Burt Rutan and Paul Allen of Scaled Composites with the SpaceShipOne/White Knight carrier Two Stage To Space (TSTS) system on October 4, 2004. [10][23]

Having faced this launch of the first commercial sub-orbital spaceflight (Space Ship One), the United States needed to describe the legal basis applicable to those activities. The solution found was carried by the fact that the same authority (FAA) was responsible to issue certificates / approvals regarding aviation safety as well as to license launches into outer space. This solution is based on the license to carry on launches into outer space. The Congress has adopted the Commercial Space Launch Amendment Act, signed by the USA President on 23 December 2004. The Commercial Space Launch Act now is the legal basis for the FAA to regulate commercial human spaceflight with the aim to protect the safety of uninvolved public on the ground in terms of launch and re-entry (including air- and spaceworthiness, protection of health and safety of flight crew and flight participants, training and medical check of flight crew and participants).

In December 2006, the FAA AST published its Final Rulemaking “Human Space Flight Requirements for Crew and Space Flight Participants”, the purpose of which is to establish minimum standards and specific requirements for licensing space launches. The significant difference between licensing and certification must be underlined at this point, since it bears substantial consequences in the approach chosen: in the first, the operator bears the full responsibility of its operations, whereas in the latter, the certifying authority takes a part of the responsibility. There are advantages and drawbacks to both methodologies, which may have to be adopted in order to best fit in the existing regulatory framework of each country.

<sup>8</sup>[http://www.easa.europa.eu/ws\\_prod/g/doc/About\\_EASA/Manag\\_Board/2007/MB%20Decision%2008-2007%20amending%20rulemaking%20procedure9ba9.pdf?page=3](http://www.easa.europa.eu/ws_prod/g/doc/About_EASA/Manag_Board/2007/MB%20Decision%2008-2007%20amending%20rulemaking%20procedure9ba9.pdf?page=3).

### 2.3.1 Applicability of International Space Law

In addition to the international and European air law context described above, international space law has to be considered. Sub-orbital Aeroplanes may also enter extra-atmospheric (i.e. outer) space. This can almost be taken for granted without knowing where air space ends and outer space starts, as a purpose of offering such flights is to bring people into outer space, i.e. to at least touch outer space. However, although a clear and commonly accepted legal delimitation does not exist,<sup>9</sup> it is at least possible to legally draw a line where outer space is attained: every flight which goes beyond 100/110 km above sea level must legally be considered as having entered outer space. This 110 km delimitation is used by many outer space lawyers and goes back to a Russian proposal in the United Nations Legal Subcommittee to the Committee on the Peaceful Uses of Outer Space on the Agenda Item of “Definition and delimitation of outer space”.<sup>10</sup> So far only one State has seen the necessity to delimit air space and outer space in a national legislation and has therefore also chosen the 100 km opinion.<sup>11</sup> Those who are not supporting the (arbitrarily set) 100 km (or 110 km) delimitation, take a physical approach: air space ends where the air cannot support the machine any more and outer space begins where an object can (at least) briefly maintain an orbit. This opinion was for first brought up by Theodore von Kármán, which is why that line between air space and outer space is sometimes named Kármán line. Calculations of that line differ, and this is why some people see it at 53 miles (ca. 84 km) and others at 60 miles (almost 100 km).

Almost all provisions on outer space activities in international law are applicable whenever the line between air and space law is crossed. Only few provisions require that an orbit is taken.<sup>12</sup> This is why also “sub-orbital” activities, including Sub-orbital Aeroplanes are potentially subject to most of the space law provisions.

If a Sub-orbital Aeroplane passes that line and enters outer space, it is subject to a set of outer space rules, which are very often quite different from the rules provided for in (international) air law. While air law originates from national rules set up under the sovereignty of States about their airspace and eventually harmonised on an international level through treaties and agreements<sup>13</sup>, space law originates in international law. No state can claim sovereignty over any part of the outer space. Legal provisions, therefore, can only be set up by the international agreements of community of

<sup>9</sup> See e.g. UN Doc A/AC.105/769 or Gbenga Oduntan, “*The never ending dispute: Legal theories on the spatial demarcation boundary plane between airspace and outer space*”, in Hertfordshire Law Journal 2003, pages 64 et seq.

<sup>10</sup> UN Doc A/AC.105/769, para.3.

<sup>11</sup> Section 8 of the Australian Space Activities Act (1998) defines that an object is launched into outer space when it is launched “in an area beyond the distance of 100 km above sea level (...)”.

<sup>12</sup> E.g. Art. 2 (1) of the Convention on Registration of Objects Launched into Outer Space, 1975 (1023 UNTS 15).

<sup>13</sup> In the case of the EU a number of sovereign States exercise together their respective sovereignties in the fields where common action has been agreed.

States (i.e. on the UN level). Only those issues explicitly mentioned in these agreements as being a national issue can be regulated by States.

The legal issues highlighted in the following section aim to identify different concepts in (international) air and space law which need to be solved, if one considers that both air and space law apply to activities of Sub-orbital Spaceflights.

### 3 AIRWORTHINESS AND CERTIFICATION

#### 3.1 General

The conventional way to certify a complex aeroplane is to issue a Type Certificate (TC). The type certificate is issued by EASA after a process by which the Agency notifies the type certification basis and finds after a technical investigation that the type design is compliant with the certification basis. The designer is responsible for showing compliance to this certification basis and must declare that compliance has been shown.

The type certification basis comprises the applicable airworthiness code complemented by special conditions if necessary to address:

- unusual features or
- unusual operations or
- features for which experience in service on similar design has shown that an unsafe condition may develop.

The type certification basis must ensure compliance with the Essential Requirements for airworthiness included in the Annex 1 of the Basic Regulation (EC) No 216/2008.

As their name already indicates, the essential requirements are the conditions to be fulfilled by a product, a person or an organisation to ensure as much as possible that the public is not unduly affected by their operations or activities. They address therefore the means by which risks associated with a specific activity can be eliminated or reduced to an acceptable level. To achieve this goal, hazards and associated risks must be identified and analysed to determine the requirements that are essential to mitigate the unacceptable risks. As far as mitigating measures are concerned, it is also important to insist that they must be proportionate to the safety objective. This means that they must not go beyond that which is necessary to achieve the expected safety benefit without creating undue restrictions that are not justified by that objective.

The airworthiness codes are the standard means to show compliance of products, parts and appliances with the essential requirements.

These airworthiness codes contain specifications relative to performance, handling qualities, structures, design and construction, power-plant installation, systems and equipment, operating limitations and limitations.

In addition, the designer must demonstrate its capability to design by obtaining a Design Organisation Approval also issued by the Agency.

Individual aircraft receive a certificate of airworthiness issued by the Member States when they comply with the type design and are in condition for safe operations.

To be pragmatic, this general approach could be used in the case of Sub-orbital Aeroplanes. EASA is legally competent for aeroplanes irrespective of the fact whether they enter outer space or not. There are of course no airworthiness codes for such machines yet but the idea would be to take an existing one, adapt it and complement it by the necessary special conditions to address the points that are listed in paragraph 3.

The issue will be to define which airworthiness code is used as a starting basis. Looking at the aeroplanes that are under design now, CS-23 [11] (below 5700kg maximum take-off mass) or CS-25 [12] (above 5700kg maximum take-off mass) are obvious candidates taking into account that below the rocket ignition / ballistic phase, these aeroplanes behave as classical aeroplanes.

However a type certificate may not be issued if compliance with essential requirement cannot be found (in particular during the rocket / ballistic phase). In such cases, the possibility of issuing a Restricted Type Certificate (RTC) exists. RTCs may be issued when the type certificate is inappropriate and the aircraft is designed for a special purpose, for which the Agency agrees on the fact that it justifies deviations from the essential requirements. The general approach is the same as for type certificate but it allows including in the certification basis a list of paragraphs of the applicable airworthiness codes that the Agency finds inappropriate for the special purpose for which the aircraft is to be used. Restricted type certificates would include any additional limitations for the use related to the special purpose. Thus, restricted type certificates seem the most realistic avenue for Sub-orbital Aeroplanes.

Type certificates and restricted type certificates assume that the aeroplane will be produced in large numbers.

In the case there would be only a very limited series of aeroplanes produced, the possibility of a Restricted Certificate of Airworthiness (RCofA) based on Specific Airworthiness Specifications (SAS) would also be possible. The restricted certificate of airworthiness would in this case be issued by the Member States but the approval of the design would stay with the Agency. However, in the case of Sub-orbital Aeroplanes, this approach is not favoured by the Agency for continuing airworthiness reasons.

Another type of airworthiness certificate may be considered in this context: the Permit to Fly (PtF). However, permanent PtFs can not be used in the context of commercial operations and complex aircraft, but would be issued pending the delivery of the type certificate or more likely the Restricted Type Certificate for the sole purpose to allow flight testing. Permits to Fly are issued by the Member States, and the associated flight conditions are approved by the Agency. Permits to Fly and associated flight conditions may also be issued by an appropriately approved design organisation.

Airworthiness does not stop at certification. The continuing airworthiness of the aeroplane must be ensured, as this is a fundamental point for safety. Modifications and repairs must be approved. Occurrences in service must be analysed and corrective action taken if necessary. The designer has a key role to play here. This is the reason why the Agency supports the Type Certificate or most likely the Restricted type Certificate approach meaning that the holder of such certificate must demonstrate its capability for design.

The issue of production must also be considered. Manufacturers of Sub-orbital Aeroplanes should obtain a Production Organisation Approval. The issue of an approval attests the ability to produce.

Organisation approvals are a key feature of the approach adopted by the legislator for airworthiness. Broadly speaking, they contain the following elements:

- Means necessary for the scope of work (e.g. facilities, personnel, procedures, etc)
- Management system
- Arrangements with other organisations as necessary
- Occurrence reporting and handling system.

Finally EASA plans to introduce into the Annex of Regulation (EC) No 1702/2003<sup>14</sup> (Part 21) a requirement on TC and RTC holders to obtain an Operational Suitability Certificate: this certificate will facilitate the entry into service of aircraft by defining among others a minimum syllabus for pilots and maintenance, certifying staff, type ratings and a master minimum equipment list.

### 3.2 Technical Issues

Besides existing certification requirements for standard aeroplanes, called CS-23 for small (<5.7t) and CS-25 for large (>5.7t) aeroplanes in the EASA regulatory system, additional requirements would have to be developed to address the specific characteristics and operations of Sub-orbital Aeroplanes. The aim would be to ensure an equivalent level of safety as currently pertains to existing aeroplanes, as far as possible considering the inherent risks linked to such endeavours at the outer limit of the atmosphere and the novelty of this domain.

The regulatory mechanisms used to cover such cases are called Equivalent Safety Findings (ESF) and Special Conditions (SCs). These additional requirements, which are made public, are covered by Certification Review Items or CRI in the EASA system; their aim is to discuss in detail and for each project the reason for applying additional or different requirements. For example, some CRIs corresponding to high altitude/high speed characteristics have already been developed for

small High Performance Aircraft (>25.000ft, M>0.6), such as the Very Light Jets (VLJs) in order to complement the CS-23 and reach an equivalent level of safety (ELOS) as required from the Large Aircraft as per the CS-25, whereas to impose directly all CS-25 requirements to smaller aircraft would have been inapplicable.

The CRIs are in fact proprietary exchange letters between the applicant and the authority, calling out a variety of public requirements or guidelines as necessary to cover the required cases: Special Conditions (SCs), Acceptable Means of Compliance (AMC), Interpretative/Guidance Material (IM/GM), etc. CRIs are confidential, since they contain industrially sensitive information about the resolution of a specific certification issue. However, all the above listed documents, once established, may be used by all projects, when applicable.

In order to facilitate the indicative reference to existing requirements, we have chosen to quote them in [brackets] hereafter, with the origin of the reference (e.g. [FAA 460.11]). In the case of a link to EASA existing requirements, i.e. CS-23 and CS-25, for simplification purposes, only the reference of the paragraph is indicated (e.g.: [EASA 831] links to both CS-23.831 and CS-25.831).

Moreover, the following items should not be taken as a comprehensive list of requirements as such, but rather as elements for discussion. Therefore, because of the very nature of Sub-orbital Aeroplane projects, i.e. diverse and innovative, the main technical issues (and others) would have to be re-discussed thoroughly for each project on a case by case basis.

Last but not least, should design requirements not be completely fulfilled by the suggested design, because of technical and/or verification impossibilities, the corresponding hazards would have to be mitigated by Operational Hazard Controls, such as labels, placards, procedures and/or training of the crew and passengers.

#### 3.2.1 Basic Requirements:

Since Sub-orbital Aeroplanes are very similar to conventional aircraft in their design and operations for the non-rocket propelled and ballistic part of their flight, all basic requirements shall be fully applicable for the aerial phase of the flight.

In particular, Regulations (EC) No. 216/2008 and 1702/2003, including the Annex to Regulation (EC) No 1702/2003 (Part 21) and the Certification Specifications based on this Annex (CS-23[11] and CS-25[12]) are deemed fully applicable for the ground/air phase of the flight, at the exclusion of the rocket-powered and ballistic sub-orbital phases of the flight.

Nevertheless, a trade-off study shall be carried out for each application, in order not to apply too stringent requirements to aeroplanes simply based on their weight. The purpose is to avoid increasing the weight of a project because of more stringent requirements,

<sup>14</sup> Commission Regulation (EC) No 1702/2003 of 24 September 2003 laying down implementing rules for the airworthiness and environmental certification of aircraft and related products, parts and appliances, as well as for the certification of design and production organisations (Official Journal 243 L 6, 27.9.2003).

having to increase subsequently the fuel capacity to reach the same altitude, thus making them eventually potentially less safe in the end than aeroplanes with less stringent requirements. This shall be discussed and demonstrated on a case-by-case basis.

**3.2.2 Complement to existing requirements** when not included in existing Airworthiness Codes (the corresponding guidelines from FAA 14 CFR Part 460 Human Space Flight-Application Checklist [13] are mentioned between brackets for information):

**3.2.2.1 Environmental Control and Life Support Systems (ECLSS)** [FAA 460.11]:

Because of the necessity of a close loop system in the stratosphere, and although the basic requirements shall apply, a **toxic gases detection system** shall be implemented in order for example to ensure that CO<sub>2</sub> levels do not reach a threshold value which would incapacitate the crew [FAA 460.11(a)], so that, for example, CO levels stay below 1/20.000 ppm [EASA 831 (a)] and CO<sub>2</sub> levels do not exceed 0.5% in volume reported to ISO Standardized Atmosphere (25°C, 1013.2 hPa at Sea Level) [EASA 831 (b)]. It would therefore be recommended to use non-offgasing materials in the construction and outfitting of the vehicle where possible, and if not otherwise possible, to use the NASA SMAC system to determine the potential maximum concentrations and effects of hazardous substances in the cabin, and to mitigate them by appropriate means (manufacturing processes, containment, etc.) [NASA 1700.7b][14][IAASS-S-1700][15]

**Ventilation** [EASA 831]: Another side effect of microgravity is the lack of air circulation, because of the close loop system and the absence of convection in microgravity. Therefore, sufficient ventilation must be provided to crew and passengers throughout the stratospheric part of the flight.

Also because the pressurisation system needs to be modified for a closed loop system, redundant means of avoiding an untimely depressurisation shall be provided, along with the means to prevent crew incapacitation in case of **depressurisation**. The corresponding indications shall be provided to the crew [EASA 841].

To prevent adverse effects of an untimely depressurisation, the utilisation of pressurized suits may be considered, but then these suits would have to undergo a comprehensive qualification process according to Military Standards, since this type of equipment has not been used for civilian purposes yet.

On top of the applicable requirements for **Oxygen Supply** [EASA 1441-1449], this system shall be fully redundant [FAA 460.11(b)] and keep the ppO<sub>2</sub> in the cabin below 24.5% in all phases of the flight to prevent potential ignition. If the Oxygen Supply System is chemical, existing requirements would apply [EASA 1450]. A requirement shall be defined for **Carbon Dioxide Removal** systems, especially to prevent overheating and subsequent fire.

The **Temperature** Control system would have to be able to maintain not only acceptable temperatures in the cabin atmosphere (e.g. in the range of 18C-25C), but

also to prevent touch temperatures above 49C and below -18C to be accessible to the crew and passengers during the whole mission [NASA 1700.7B][15].

**3.2.2.2 Smoke detection and fire suppression** [EASA 851-865][FAA 460.13]: On top of the existing requirements, fan blowers should be added and function for the weightless part of the flight, in order to be able to detect smoke throughout the whole flight envelope. Also fire suppression means must be compatible with a closed cabin, and depressurization can only be used as a last resort and without impairing the crew or harming passengers, as per the above mentioned requirement to prevent cabin depressurization [FAA 460.111].

**3.2.2.3 Human factors** [FAA 460.15]:

**3.2.2.3.1. Personnel and Cargo Accommodation:**

On top of existing requirement [EASA 771], in case of a free-floating phase for the passengers, the Pilot compartment and Cabin shall be padded, with no sharp edges (minimum radius >5mm) or pinching points accessible at any time [NASA 50005][16]. Also, all parts of the equipment must not create any shatterable material release or sharp edges when broken (e.g. diodes shall be made of plastic, no glass parts exposed)[NASA JSC 28354][17]

Furthermore, the **Pilot Compartment view** shall be sufficient for the pilot to safely perform any required manoeuvres throughout the flight envelope [EASA 773]. If not otherwise possible, this requirement could be alleviated by the use of optical indirect viewing systems and the assistance of robust avionics.

Besides the existing requirements for **Cockpit Controls** [EASA 777], those would have to be designed for zero-g free floating operations (protected against untimely contact). Also, the design of the controls for the Reaction Control System (RCS) should allow the aircraft to be manoeuvred throughout its flight envelope while preventing any inadvertent manoeuvre.

**Door(s)**: [EASA 783] the door(s) shall be designed to prevent untimely opening by crew and passengers during all phases of flight (No handling point). Conversely, they shall be quickly openable by one person in case of an emergency. An emergency pressure equalization system shall be put in place for this purpose.

**Seats, berths, litters, safety belts and shoulder harnesses** [EASA 785]: The seats shall be adjusted in order for the crew and passengers to best support all potential accelerations during all phases of flight, especially at pull-up with rocket engine on, or during the resource upon re-entry (proposed requirement: 6g constant during 30 seconds). Apart from the zero-g free-floating phase, the crew and passengers shall be restrained to their seats by the means of harnesses.

Specific **Personal Protective Equipment (PPE)** may be considered for certain phases or all flight (Pressurized suits, helmets, visors against sun glare, etc.), but this will have to be considered on a case by case basis.

Beyond being impact resistant (inside/outside) as per [EASA 775], **windshield and windows** would have to be non-shatterable and non-scratchable, in order not to cause loose debris to float inside the cabin.

On top of the existing required **Pax information signs** [EASA 791], specific “0g” (e.g.: Blue) signs might be considered, as well as Return to seat/Fasten seat belts (Amber+Gong) annunciations, similar to the ones used in Larger Aircraft for Parabolic Flights, in order for all passengers to be seated and strapped before the re-entry begins. Also, a countdown to return to gravity could be displayed in the cabin.

**3.2.2.4 Emergency Evacuation** [EASA 803], and **Emergency Exit** [EASA 805-813]: On top of existing requirements for emergency evacuation on the ground, which would have to be adapted on a case-by-case basis to the specific projects (e.g. rounded shape vs. square shape to better accommodate pressurization and weight constraints), the provision for an in-flight bail out shall be considered, along with the use of parachute rescuing systems. As per EASA 813, the Emergency Exit shall not be obstructed by obstacles, in other words the internal cabin layout must not prevent evacuation. However, if instrument panels or equipment are part of the emergency detachable part [23], this shall be reviewed on a case by case basis.

**3.2.2.5 Emergency Equipment** [EASA 1411-1415]: depending on mission profile, the corresponding emergency equipment shall be considered.

**3.2.2.6 Onboard Recorders** [EASA 1457-1459]: because of the novel design characteristics of such aeroplanes and their mission profile, Flight Data Recorders and Cockpit Voice Recorders shall be provided, in addition to Telemetry if available.

### **3.2.3 Specific systems and operations (Vehicle):**

**3.2.3.1. Exposure to high/cold temperatures:** For temperature, a sufficient air conditioning and/or heat sink system shall be provided, should any part of the vehicle become extremely warm or cold during a part of the flight such as it would jeopardize the safety of the vehicle or its occupants.

**3.2.3.2. Exposure to radiations** shall be counteracted by design, should the exposure time and levels be above commonly acceptable norms. If deemed critical, radiation measuring devices may be integrated inside the vehicle and/or provided to each member of the crew.

**3.2.3.3. High skin temperatures / kinetic heating:** all parts of the aircraft subject to kinetic heating during acceleration and/or re-entry shall be designed to accommodate the heat generated in order not to jeopardize the integrity of the structure and the proper functioning systems contained inside. Potential deformation of structures due to thermal expansion/retraction or degradation shall be accounted for, so that it would not jeopardize the handling qualities, proper functioning and/or structural integrity of the aircraft. Wherever critical and for test flights, temperature sensors and/or indicators may be used to monitor critical parameters.

#### **3.2.3.2. Rocket Boosters/Engines:**

Rocket engines shall be designed to minimize burst hazards and prevent inadvertent firing.

In particular for liquid or hybrid rocket engines, pressure relief valves and fuel dump systems must be provided, as well as a fuel cut-off in order to be able to

interrupt the burn at any time, should a contingency situation occur.

For solid rocket engines, a jettisoning system shall be implemented, in order to allow an aborted climb and safe return of the vehicle when already ignited. In such cases, the booster(s) should have their own guidance, signalization (transponder) and recovery/flight termination system, in order not to endanger the safety of the public on the ground or other aircraft.

All rocket engines shall be fully tested successfully several times (proposal: three times as a minimum) on the ground in their flight configuration and for the full duration of the burn before being used for actual flights. In case Vectored Thrust is used to control a critical phase of the flight, it shall be two-fault tolerant.

**3.2.3.3. Attitude / Reaction Control Systems:** The same principle applies to Reaction Control systems, which shall be at least redundant and should neither jeopardize the safety of ground personnel nor of the carrier aircraft (if the case of a Two Stage To Space configuration), thus being secured both against inadvertent firing and runaway.

#### **3.2.3.4 Propellant(s):**

Toxic/Explosive fuels shall be contained at all times to prevent exposure of ground personnel and crew, inadvertent spillage and non-explosive burst. Containment/crashworthiness

In order to cope with an aborted mission and premature return, as well as with unused fuel after a successful mission, the crashworthiness of tanks and solid rocket engines must be ensured such as to prevent any spillage and ignition.

In the case of liquid/gaseous propellants, a Fuel Jettisoning system must be implemented, provided environmental requirements are observed.

#### **3.2.3.5 Operations in Weightlessness (0g):**

All fluids shall be contained throughout the parabolic part of the flight, i.e. in weightlessness (Fuel, Oil, etc...) in order not to jeopardize the safety of the flight or the restart after the maximum expected 0g period.

**3.2.3.6 Turbofan Engines safing for restart:** in the particular case of a Single Stage To Space vehicle (SSTS), the restart of the turbofan engines shall be ensured after the rocket propelled and ballistic part of the flight. To this end, comprehensive shutdown and safing procedures shall be established in order to minimize hazards and ensure a safe restart in due time.

#### **3.2.3.7 Instruments/Avionics**

In addition and/or combination with conventional aeroplane instruments, specific space instruments shall be provided to the pilot(s) in order to maximize their situation and orientation awareness in all phases of flight, especially at high altitudes and unconventional flight attitudes. For example, a spheric-type earth-like Horizon, Radar Altimeter and efficient Guidance and Navigation System (e.g. redundant an efficient GPS) shall be made available. Because of the degradation of GPS reactivity at high speeds, alternate/independent means of guidance shall also be considered for redundancy.

Flight Directors/ Pilot Assisting Devices shall be customized to provide the pilot(s) with the best

understandable information in a synthetic form, in order for them to optimize the trajectory in all phases of flight and recover from abnormal situations.

Cabin Pressure and gas monitoring devices shall be provided to the crew, with the associated Cautions and Warning visual and/or aural annunciations.

#### **3.2.4 Intra-Vehicular Activities (IVA) Requirements:**

For the parabolic part of the flight in weightlessness, standard Intra-Vehicular Activities requirement would apply, as per [NASA NSTS 1700.7b][14].

#### **3.2.5 Specific Equipment (Payload) Requirements:**

In particular, [NASA Form 1230] could be taken into reference for Payloads and Equipment installed on board the vehicle, and which shall remain secured throughout the dynamic parts of the flight.

In short, this checklist addresses the Structural failure of sealed/vented containers, sharp edges (min. radius 5mm in IVA), pinch points, shatterable material release (no glass), flammability, offgasing, batteries, touch Temperatures (-18/+49 Celsius), rotating devices and mechanisms, electrical power (bounding [EASA 867], mating/demating), and contingency return/rapid safing. In case one of the requirements could not be met, a Unique Hazard Report would have to be developed according to existing standards [NASA 13380][18].

**3.2.6 Ground Support Equipment:** A Ground Safety Data Package would have to be established in order to address all potential hazards on the ground, especially with respect to fuelling operations, untimely ignition of engines and/or activation of Reaction Control Systems, as well as protection of (ground) crews, passengers and public during all ground operations: assembly, testing, parking/stowage, fuelling, ground checks, boarding, taxiing, take-off and (premature) return and landing [NASA KHB 1700.7][19]

**3.2.7 Environmental Requirements:** Potential showstoppers, such as the disruption of the ozone layer, the atmosphere contamination because of smoke residues or release of toxic propellants would need to be addressed in accordance with and in complement to existing environmental requirements [3].

**3.2.8 Crew/PAX Qualification and Training:** the crew is considered an integrated part of the safety of the system, therefore it must be trained and qualified accordingly [FAA 460.5] taking into account all potential off-nominals and contingencies, abort/emergency, and Human Behaviour and Performance aspects in all phases of flight, including microgravity [20] in order to minimize hazard to the public and passengers. Crew Training shall be performed using representative hardware and applying standards for Training Records and CQRM [FAA 460.7] [21].

Space flight participants shall also comply with training requirements [FAA 460.51] for emergency cases and be informed of the risks [FAA 460.45]. In order to define and implement such training, it would be useful to

consult existing entities which are already providing this type of training to astronauts, such as the European Astronaut Centre (EAC) located in Cologne, Germany.

**3.2.9 Verification Programme** [FAA 460.17]: an integrated verification programme would have to be conducted successfully before allowing passengers on board, including flight testing.

### **3.3 Legal implications when entering outer space (Spaceworthiness)**

While EASA is competent to certify the type of a Sub-orbital Aeroplane being an aircraft, the jurisdiction of the EU (and all States) ends where outer space begins. States have agreed on a different legal concept for activities carried on in outer space. As a part of that concept, the Community of States has established a national responsibility for States for national activities in outer space (Art. VI Outer Space Treaty<sup>15</sup>). States have to authorise and supervise such activities. This responsibility is not transferred to the EU as part of the aviation competences. EASA cannot deal with that (very short) outer space part of the sub-orbital flight, unless it agrees with the States to enforce this responsibility on their behalf.

This responsibility indirectly includes aspects of spaceworthiness as described above (in addition to the airworthiness). The spaceworthiness of a Sub-orbital Aeroplane is not directly mentioned within the International Treaty (or in Community law). However, States can be held internationally liable for damages caused by a space object.<sup>16</sup> Some States<sup>17</sup> therefore have included the approval of the spaceworthiness of a space object<sup>18</sup> within their national legislation about space activities,<sup>19</sup> requiring the operator to carry out the activity in a safe manner and without causing damage to persons or property. Such national legislation would apply in addition to what will be established by EASA as the certification basis for the air flight part.

Unlike the approval of airworthiness under the EASA legal framework, only individual objects (not the type of Product) are subject to this spaceworthiness approval.

As stated above, the approval of spaceworthiness is not subject to the competences of the European Union, including EASA. Should a wider scope be required in

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<sup>15</sup> Treaty on Principles governing the activities of States in the exploration and use of outer space, including the moon and other celestial bodies, 1967 (610 UNTS 205).

<sup>16</sup> See Art. VII Outer Space Treaty; see also the Liability Convention, Convention on International Liability for damage caused by space objects 1972 (961 UNTS 187).

<sup>17</sup> On the European level namely: Norway (Act on Launching Objects from Norwegian Territory etc. into Outer Space, 1969), Sweden (Act on Space Activities, 1982, Decree on Space Activities, 1982), UK (Outer Space Act, 1986), Belgium (Law on the activities of launching, flight operations or guidance of space objects, 2005), The Netherlands (Rules Concerning Space Activities and the Establishment of a Registry of Space Objects - Space Activities Act, 2006) and France (Bill Nr. 2008-518 relating to spatial operations, 2008).

<sup>18</sup> A Sub-orbital Aeroplane is considered a space object, see para. 7

<sup>19</sup> These States have established such national space legislation in order to implement their international obligation to authorise and supervise non-governmental space activities according to Art. VI (2) of the Outer Space Treaty.

the future, in order to bring such activities on the crossroads of air and space under one single jurisdiction, this has to be decided by the (European) legislator. However, appropriate agreements could already be established today between EASA and the responsible State for the activity in outer space (typically the State of operator), in order to avoid double processes which would be a burden for industry. EASA is ready to explore this possibility with the administrations involved.

## 4 FLIGHT CREW LICENSING

### 4.1 Crew training and qualification

It is obvious that the flight crew of a spacecraft has to fulfil certain requirements for initial training, proficiency, testing and medical fitness [22]. Sufficient scientific, operational and managerial experience for this exist, mainly in public space organisations, such as NASA or ESA. When looking however at commercial space tourism operations carried out by private operators, the issue is not only whether crews possess sufficient knowledge, it is also necessary to ensure that:

- Proper rules exist in order to clearly establish responsibilities and privileges for natural and legal persons;
- Such rules are accompanied by Acceptable Means of Compliance (AMCs) and published (e.g. training syllabi);
- Mechanisms exist to oversee and enforce the application of the rules (e.g. issuing, suspending or revoking pilot licences).

Article 7 of Regulation (EC) No 216/2008 has extended the mandate of EASA to propose legally binding implementing rules and to issue AMCs in relation to flight crew, their medical fitness, their training organisations, as well as to the person entitled to check medical fitness, to train the pilots or to test their skill. On this legal basis the Agency has issued a NPA<sup>20</sup>, which can be commented upon until 15<sup>th</sup> December 2008 by interested parties. The NPA contains the proposed rules with regard to pilots (commercial or private) of aeroplanes, airships, balloons, helicopters and sailplanes.

According to the rulemaking procedure, EASA will then issue a Comment Response Document (CRD) summarising the comments received to the NPA, followed by an Opinion addressed to the European Commission. The latter will present, based on said Opinion, legally binding rules across the EU (and Norway, Island, Liechtenstein and Switzerland)<sup>21</sup>.

It is expected that such common rules for the “traditional” pilots will be published and enter in force in 2010.

However, new demands are also emerging for pilots “on the ground”, taking responsibility for the flight of Unmanned Aerial Systems (UAS). Since both Sub-orbital Aeroplanes (SoA) and UAS are aircraft, and EASA has legal competence to establish rules for their pilots, it is not excluded that EASA might undertake in addition one or two specific rulemaking tasks, aiming at establishing legal certainty also for these categories of pilots across the EU (and Norway, Island, Liechtenstein and Switzerland).

According to EASA’s rulemaking procedure such a rulemaking task can only be initiated if it is included in the rulemaking programme. Such a programme is decided in cooperation with stakeholders. The first step is for one organisation to complete the appropriate Rulemaking Proposal Form<sup>22</sup> and send it to EASA.

Should the above possible task(s) be undertaken by EASA, of course the medical requirements applicable to the mentioned new pilot categories will need to be defined. One could say that UAS pilots and SoA pilots are at two opposite extremes. The former in fact operate on the ground in normal room conditions (i.e. for them the medical requirements could be similar to those of air traffic controllers). By contrast, SoA pilots operate in an environment, which is even more severe than the cockpit of a traditional aircraft, whose operations are limited to the dense atmosphere.

### 4.2 Passenger safety

Furthermore, in the case of space tourism, paying passengers will inhabit the SoA cabin. They would also be in a potentially severe environment under abnormal conditions; even during normal operations they will experience intense accelerations and absence of gravity. It seems obvious that they should be medically fit for such experiences. However, the issue here for EASA is not whether sufficient scientific knowledge exists on this matter, but which legally binding rules have to be established.

Currently, no rules have been established for the medical fitness of paying passengers on board commercial air transport aircraft. This approach (i.e. “do nothing”) could be continued even for sub-orbital flights. Some might however argue that the peculiarities of sub-orbital flights do require the establishment of rules to protect potential passengers from a medical standpoint, and also in order to avoid jeopardizing the safety of a flight because of passenger sickness or loss of consciousness. But even if such a principle is accepted, many alternatives do exist, such as obliging operators to simply publish medical guidelines before selling tickets, or obliging passengers to acquire a medical certificate, or to require operators to check the medical fitness of the passengers before confirming the flight.

<sup>20</sup>[http://www.easa.europa.eu/ws\\_prod/r/doc/NPA/NPA%202008-17a.pdf](http://www.easa.europa.eu/ws_prod/r/doc/NPA/NPA%202008-17a.pdf)

<sup>21</sup> So called “comitology” procedure.

<sup>22</sup>[http://www.easa.europa.eu/ws\\_prod/r/doc/rp/Rulemaking%20Proposal%20Form.doc](http://www.easa.europa.eu/ws_prod/r/doc/rp/Rulemaking%20Proposal%20Form.doc)

Should it come to proposals, EASA will consult stakeholders, according to the rulemaking procedure mentioned above. In particular several entities in Europe, which are already delivering medical certifications to astronauts, such as the MEDES/IMPS in Toulouse, France or the DLR-Flight Clinic in Cologne, Germany, or to parabolic flight participants, such as the CEV in France, may be consulted in order to benefit from their expertise.

### 4.3 Legal implications of entering outer space

The international space law treaties do not contain any rules on how to deal with flight crew certification or passenger training. However, another issue comes up for flight crew and passengers, being slightly different from what is ruled by Art. 25 of the Chicago Convention.<sup>23</sup>

The Rescue Agreement<sup>24</sup>[24] establishes additional rights to the crew (and maybe the passengers) of a Sub-orbital Aeroplane. Unlike the title, the text of the Agreement refers to “personnel of the spacecraft”. The term spacecraft is not defined in the Agreement. Based on the principles of the ICAO taxonomy, a vehicle may be considered as a spacecraft if it is designed to fly in the environment of outer space, especially if it is not (no longer) deriving support from the reactions of the air. This applies to Sub-orbital Aeroplanes. Hence, the personnel of such aeroplanes enjoy the rights and privileges of that Agreement, i.e. rescue support and assistance from any state in which the spacecraft has landed in case of accident, distress, emergency or unintended landing (Art. 2), as well as of the states which are in a position to do so in case the landing took place on international territory (Art. 3) and safe and prompt return to the representatives of the launching authority (Art. 4). From the wording, it is questionable whether passengers can be considered as “personnel of the spacecraft”, but it might be necessary considering the fundamental reasons which led to the Agreement.

## 5 AIR OPERATIONS

### 5.1 Technical considerations

On the 27<sup>th</sup> March 1977 two “Jumbo jets” filled with passengers collided at Los Rodeos airport on the Tenerife Island. To this day, it is still the worst aviation accident ever to have occurred in terms of the number of fatalities. At that time it was common among ICAO Contracting States, when trying to understand the causal factors of an accident, to consider the “machine”, the human and the environment<sup>25</sup>. However, a few years before (1972), Professor Elwyn Edwards of the University of Birmingham, having acknowledged that

<sup>23</sup> Each contracting State undertakes to provide such measures of assistance to aircraft in distress in its territory as it may find practicable, and to permit, subject to control by its own authorities, the owners of the aircraft or authorities of the State in which the aircraft is registered to provide such measures of assistance as may be necessitated by the circumstances.

<sup>24</sup> Agreement on the Rescue of Astronauts, the return of Astronauts and the return of Objects launched into outer space, 1968 (672 UNTS 119).

<sup>25</sup> ICAO Circular 18-AN/15 published in 1951.

modern machines had more and more software embedded in them, conceived the SHELL model to analyse safety events: Software + Hardware + Environment + “Live ware” (= human operator). Captain Frank Hawkins, involved in the investigation of the Tenerife accident, then proposed in 1979 to turn the SHELL model into SHELL, i.e. repeating the “L” twice, to mean that not only the individual (e.g. the pilot) had to be considered in respect of aviation safety, but also the “organisation” (i.e. the air operator). The SHELL model was accepted by ICAO in 1989<sup>26</sup>. Immediately after (1990) ICAO adopted Amendment 19 to its Annex 6, requiring States to establish rules in order to issue a specific “Air Operator Certificate” (AOC) to organisations offering commercial air transport to citizens. Consequently in the EU the legal obligation for the AOC was established in 1992<sup>27</sup>.

Besides the development of such aeroplanes, the main activity regarding Sub-orbital Aeroplanes would be considered commercial air transportation. Therefore, in the present regulatory framework, EU-OPS<sup>28</sup> would apply, with the need of exemptions in order to adapt to the very specifics of sub-orbital flight operations. The corresponding Air Operator Certificate would have to be issued by the Member States for operators operating from their territory.

Moreover, compliance with EU-OPS also includes compliance with the EASA maintenance requirements, which would require the operators of Sub-orbital Aeroplanes to obtain a Continuous Airworthiness Management Organization agreement (CAMO). Also, Sub-Orbital Aeroplanes would have to be maintained and refurbished between flights in Part-145 organisations, in full compliance with existing Maintenance Organisations requirements, provided the necessary adjustments to capture the very specific characteristics of Sub-orbital Aeroplanes (e.g.: handling of hazardous/toxic fluids/explosives, etc.)

Last but not least, for the sake of convenience and consistency between Aircraft and Spacecraft maintenance organisation and systems, it may also be worth developing a common Space Transportation Association (or STA) nomenclature, similar to the well known and worldwide used ATA-100 Chapters.

Finally, the mentioned Regulation (EC) No 216/2008 gives the European Commission the responsibility to establish detailed implementing rules applicable to air operators, see Art. 8. A specific Notice of Proposed Amendment (NPA), containing EASA’s opinion for

<sup>26</sup> ICAO Human Factors Digest N. 1 (Circular 216-AN/13).

<sup>27</sup> Article 9 of Council Regulation (EEC) No 2407/92 on licensing of air carriers (Official Journal 240 L 1, 24.8.1992)

<sup>28</sup> Annex III to Regulation (EEC) No 3922/91 on the harmonisation of technical requirements and administrative procedures in the field of civil aviation (Official Journal 373 L 4, 31.12.1991), as last amended by Regulation (EC) No 859/2008 (Official Journal 254 L 1, 20.9.2008).

such as implementing Regulation concerning operations of conventional aircraft is planned to be published before the end of 2008.

It is however obvious that specific rules for operators of UAS and of Sub-orbital Aeroplanes are also required, e.g. in terms of mission planning, filing a flight plan, briefing passengers on safety and so on. In the case of Sub-orbital Aeroplanes, it is likely that the safety briefing may be quite extensive and necessary to be delivered before boarding the cabin, i.e. through on-ground training.

Even in this case, a specific rulemaking task could be planned and initiated depending on the requests by stakeholders, following the rulemaking procedure.

## 5.2 Legal implications of entering outer space

As already explained in paragraph 2., EASA is presently not competent to deal with the very short period of the sub-orbital flight which would take place in outer space. For this very specific part of the flight, the operator would have to take additional operational requirements into consideration.

In principle, the jurisdiction (and control) over an object launched into outer space is held by one of the launching States<sup>29</sup> (see Art. VIII Outer Space Treaty and Art. II Registration Convention<sup>30</sup>[25]). As the Treaties clearly define which States can become launching States (and therefore State of Registry), it will not in all cases necessarily be the same State which has jurisdiction of the vehicle as an aircraft (see Art. 17 of the Chicago Convention) although it is also referred to as the State of Registry.

Nevertheless, this does not cause any problems for Sub-orbital Aeroplanes. Although such aeroplanes are considered space objects<sup>31</sup>, they are not subject to registration as space objects. This is because space objects only need to be registered if they are launched into an Earth orbit or beyond an orbit, as per Art. II Registration Convention. A Sub-orbital Aeroplane is launched into outer space, but not into an orbit or beyond an orbit. Sub-orbital Aeroplanes therefore do not need to be registered as space objects. The purpose of registration is to keep track of objects which remain in outer space on a certain orbital position. This is not the case for Sub-orbital Aeroplanes. No State therefore holds jurisdiction and control over a Sub-orbital Aeroplane as a space object according to Art. VIII Outer Space Treaty.

<sup>29</sup> The launching States are the State which launched the object, which procured the launching, from whose territory the object was launched as well as from whose facility the object was launched, see Art. VII Outer Space Treaty as well as Art. I (a) Registration Convention. The State of Registry is one of those States, as jointly determined by the Launching States.

<sup>30</sup> Convention on Registration of Objects launched into Outer Space, 1976 (1023 UNTS 15).

<sup>31</sup> See Paragraph 7.2.

Theoretically, this means that there is no (other<sup>32</sup>) jurisdiction over this specific object while in outer space. However, in practice, operational provisions are applied by the State responsible for the activity according to Art. VI Outer Space Treaty.<sup>33</sup> This is lawful, as Art. VI Outer Space Treaty applies to all activities in outer space and not to objects launched into an orbit (and therefore subject to registration as a space object).

These operational provisions set by the State responsible for the space activity are a few basic requirements for the space flight. These are made binding to private space activities through requirements in the national legislation, mostly within the general authorisation allowing the applicant to undertake space activities. While in outer space the Sub-orbital Aeroplane has to respect international law, promote international cooperation, avoid harmful contamination of the outer space as well as adverse changes to the Earth's environment etc.<sup>34</sup> National legislation might have to set up additional operational requirements.

## 6. TRAFFIC MANAGEMENT

### 6.1 Collision avoidance with other aviation traffic

Community competence on Air Traffic Management (ATM) was already established in 2004 on the basis of the "Single European Sky" (SES) package of four Regulations<sup>35</sup>. In turn, ATM comprises Air Traffic Services (ATS) and the latter also Air Traffic Control (ATC) in certain classes of airspace, as defined by ICAO. All the upper airspace over the EU belong to "Class C", which means that therein the flights operating under Instrument Flight Rules (IFR) are "separated" by an Air Traffic Controller from the ground. It is assumed herein that spacecraft will indeed operate under IFR and they will cross the upper layers of the atmosphere during climb and descent. In fact, most Upper Air Traffic Control Centres (UACCs), at least in theory, are declared to have vertical competence from a defined Flight Level (e.g. FL 195 = 19,500 feet) up to "unlimited", although today in practice they do not execute any task in order to control space flights. Nevertheless, when developing the implementing rules for ATM, the upper limit of its competence could be set around FL 3300-3600 (i.e. 330,000-360,000 ft, around 100-110 km), or even higher (e.g. FL 4000, around 120 km) to cover the highest sub-orbital flights and overlap with space controlled areas, although specific rules should be established for this ballistic part of the flight.

<sup>32</sup> Other jurisdiction than the jurisdiction over the Sub-orbital Aeroplane as an aircraft while in air space.

<sup>33</sup> See Paragraph 2 above

<sup>34</sup> For a full list see Art. I to XII Outer Space Treaty.

<sup>35</sup> Regulation (EC) No 549/2004 of the European Parliament and of the Council of 10 March 2004 laying down the framework for the creation of the single European sky ; Regulation (EC) No 550/2004 of the European Parliament and of the Council of 10 March 2004 on the provision of air navigation services in the single European sky; Regulation (EC) No 551/2004 of the European Parliament and of the Council of 10 March 2004 on the organisation and use of the airspace in the single European sky; Regulation (EC) No 552/2004 of the European Parliament and of the Council of 10 March 2004 on the interoperability of the European Air Traffic Management network

From an ATM point of view the operation of a Sub-orbital Aeroplane (SoA) can be split into different phases:

- Filing a flight plan at the conclusion of the mission planning: no major differences in this respect are foreseen in relation to conventional aviation;
- Receiving instructions for “flow management” (e.g. delays before departure, because of high traffic density foreseen at a certain time in defined volumes of airspace): this could be minimised by selecting an appropriate departure aerodrome and hours for the mission, avoiding areas and times of high traffic congestion (e.g. central Europe in the early morning);
- Operating at the departure aerodrome, which, depending on the characteristics of the SoA and on the traffic therein, may impose restrictions.
- Operating from an aerodrome with less other traffic, which may alleviate interaction issues;
- Climbing through the atmosphere (up to FL 450 = 45,000 ft = around 14 km from earth’s surface). If the performance of the SoA is similar to that of conventional aviation, this phase should not pose problems in relation to separating them from other traffic. If the performances are significantly different in terms of rate of climb or speed (either very low, e.g. in the case of aerostatic lift, or very high) special ATC procedures may apply. However the basic procedures to cater for special needs (e.g. air shows, large military exercises, climb of weather observation balloons, etc.) are already in place today and could easily be adapted to the needs of SoA. Of course the likelihood of “flow management” measures (i.e. delayed departure) will greatly depend on the time and geographical area chosen by the operator and include the fact that some Sub-orbital Aeroplanes will return to land in gliding, requiring traffic priority.

The same considerations apply to the descent (below FL 450) and landing phase, during which the SoA will operate sustained by atmospheric lift. The segment of the atmospheric flight above FL 450 during climb is even easier, since during that phase the SoA will be fully controllable by the crew, while those layers of the atmosphere are not populated by significant conventional aviation traffic.

Conversely, some aspects of the sub-orbital mission require further study in relation to ATM:

- The rocket propelled and ballistic portions of the flight, during which the ATC service may even not be required (e.g. having properly planned the mission in advance and having avoided the simultaneous presence of two SoA in the same space volume);
- The initial descent phase, which may involve flight at high Mach number;
- The procedures to exit from ATC procedures and then to resume them, which is a new topic not necessary to be analysed for conventional aviation.

For the latter the predictability of the ballistic trajectory could be very relevant, also because the future ATM system (currently being developed for Europe by the SESAR JU<sup>36</sup>) is expected to be largely based on predicted trajectories, more than on an intervention by the Air Traffic Controller in real time.

## 6.2 Radio frequencies

As soon as the Sub-orbital Aeroplane leaves air space and enters outer space, the allocation of frequencies (e.g. for communication with ground control) would need to be assigned on an international level. However, ICAO has already standardised the aeronautical mobile (communication) satellite services, which have now been operational for almost ten years and compliant with the ITU Radio Regulations. This service and its foreseen developments could possibly be used also for that portion of the flight too. The State of the operator has to oversee that appropriate communication has been established between the operator, ATC and the vehicle.

## 6.3 Legal implications for traffic management in outer space

No legal requirements exist yet for Space Traffic Management (STM). There have been some research projects on such requirements, stressing the need to establish such services.<sup>37</sup> This does not only include the traffic management between air flights and space flights but also the traffic management whilst being in outer space.

Rules intending to achieve safe access to outer space, safe operations of space activities, collision avoidance as well as the prevention of pollution can be found within national space acts and other national regulations (e.g. licensing regimes). But one has to take into account that these rules originally were not meant for dealing with traffic management. One may differentiate between rules applicable to all space operations and those applicable only to a certain phase of space operations (launch / in-orbit / re-entry).<sup>38</sup>[30]

Specific attention should be paid to the mitigation of the risk of collision of Sub-orbital Aeroplanes with space debris. Here again, some States have set up national rules as part of their space legislation, which is not affected by any competence of the European Union established for air traffic management. Those rules are part of the initial license for undertaking space activities.<sup>39</sup>

## 7 LIABILITY ISSUES IN CONTINGENCY CASES

The operator of a Sub-orbital Aeroplane faces several liability risks. Two of these risks need a deeper

<sup>36</sup>[http://www.sesarju.eu/public/subsite\\_homepage/homepage.html](http://www.sesarju.eu/public/subsite_homepage/homepage.html)

<sup>37</sup> See e.g. the IAA Cosmic Study on Space Traffic Management (ed. C. Contant-Jorgenson, P. Lala, K-U Schroggl), IAA 2006.

<sup>38</sup> For a deeper analysis see the IAA Cosmic Study on Space Traffic Management (ed. C. Contant-Jorgenson, P. Lala, K-U Schroggl), IAA 2006, pages 40 et seq.

<sup>39</sup> See e.g. Sec. 5 (2)(g) UK Outer Space Act; 14 CFR Sec 415.39, Sec 417.07, Sec 417.129 and Appendix A to Sec. 440. of the US Commercial Space Transportation Licensing Regulation

evaluation with regard to their specificities of air and space activity:

### 7.1.1 Passenger liability

Air carriers might be held liable by passengers (or his/her legal successors for damages caused to passengers, baggage and goods, and also for damage caused by delay. This liability is based on the “Warsaw System”. The Warsaw System is a set of rules based on the Warsaw Convention,<sup>40</sup>[27] which have been modified and amended several times throughout the last century because of the growth of air traffic.<sup>41</sup> The latest module to the Warsaw System was set in 1999, when the Montreal Convention<sup>42</sup> was signed. The applicability of the Warsaw System to sub-orbital spaceflights might already be questionable, as the carriage has to be an international one. That means, broadly speaking, that the point of departure and the point of destination or an agreed stopping place as agreed by the parties have to be in different States. If, nevertheless, assuming the applicability of the Warsaw System, the carrier can be held liable for injury or death he can also be held liable for damage to baggage (payloads) and goods.

This legal system as described for air carriage seems to contradict the legal system established for space carriage: international space law never looked at passenger rights, other than crew. Therefore no rules exist yet, in principle. However, there is one article upon which the States agreed when dealing with third-party liability rights. Although it was probably not intended, this article excludes the possibility for passengers to claim for liability. Third party liability is excluded for any damage caused to a national of the launching State as well as to foreign nationals during that time that they participate in the operation of that space object (Art. VII Liability Convention). However, it has to be noted that the Liability Convention deals with the Liability of States (i.e. launching States). This liability is established in addition to the liability of the operator of an aircraft (according to national tort law).

The Warsaw System – only applicable to international flights – is therefore not contradicting the liability concept established by international space law.

### 7.1.2 Third party liability

In case a Sub-orbital Aeroplane causes damage to a third party (anybody to whom no contractual relationship was established), the legal systems of international air and space law vary.

A protection of damages caused by air traffic to third parties on the ground was established in the Rome Conventions.<sup>43</sup>[28] Only few states have signed and

ratified these Conventions, hence they have a very narrow application. Nevertheless, the principles described below have been adopted in the legislations of many states; and are therefore becoming important. The Rome Conventions establish an absolute liability to the operator of the aircraft (Art. 2 Rome Convention 1952) if the damage was caused by an aircraft in flight. The operator may be exonerated if he/she proves that the damage was caused solely through the negligence or other wrongful act or omission of the person who suffered the damage. The liability of the operator is limited. The exact amount depends upon the weight of the aircraft (Art. 11). No limitations exist, if the person who suffered the damage proves that the damage was caused by a deliberate act (or omission) of the operator (Art. 12). Collisions of aircraft are hardly covered by the Rome Conventions. Only Art. 7 states that in such case both operators shall be liable (to a third party).

Third party liability in outer space law is dealt with differently. In principle, liability is established for damages caused by space objects. A space object is any object that is in outer space (or intended to be launched into outer space). As soon as a Sub-orbital Aeroplane is in outer space at one moment of its flight<sup>44</sup>, it is a space object to which the Liability Convention applies. Unlike established in the Rome Conventions, it is not the operator of a space object that is held liable according to international space law. The operator of a space object might be liable only according to national (tort) law. These national (tort) laws applicable to space objects are not harmonised by an international Convention. Rather than holding liable the operator, the international space law establishes an additional state liability. The liability is established to the launching states (the state who launches or procures the launching of a space object as well as the state from whose territory of facility a space object is launched), Art. VII Outer Space Treaty and the Liability Convention. This liability is also established as an absolute liability in case the damage occurred on the surface of the earth or to an aircraft in flight, but it is a fault liability if the damage is caused to (another) space object. Other than in the Rome Conventions, these liabilities are unlimited.

The relationship and appropriateness of both legal systems to apply to Sub-orbital Aeroplanes still have to be clarified.<sup>45</sup>[28] Thus, for example, it could be discussed whether the state liability as established by Art. VII Outer Space Treaty and the Liability Convention is acceptable and appropriate for such sort of commercial sub-orbital spaceflights. Similar discussions have already taken place in order to determine the applicable law in case an aircraft collides with a ship on the high seas.<sup>46</sup>[29] As the Treaties apply

<sup>40</sup> Convention for the Unification of Certain Rules Relating to International Carriage by Air, 1929

<sup>41</sup> A list of the Protocols and Conventions amending the Warsaw Convention can be found e.g. in I.H. Diederiks-Verschoor, *An Introduction to Air Law*, 8<sup>th</sup> Ed, 2006, pages 102 et seq.

<sup>42</sup> Convention for the Unification of Certain Rules for International Carriage by Air, 1999.

<sup>43</sup> Convention on Damage caused by Foreign Aircraft to Third Parties on the Surface, 1952 including the Protocol to Amend the Convention on Damage caused by Foreign Aircraft to Third Parties on the Surface (Montreal Protocol) 1978; International Convention for the

Unification of Certain Rules Relating to Damage Caused by Aircraft to Third Parties on the Surface, 1929.[28]

<sup>44</sup> Cf. above 2.3.1

<sup>45</sup> See e.g. Peter P.C. Haanappel, “Envisaging future aerospace applications – passenger and third party liability in aerospace transport”, in: S. Hobe, B. Schmidt-Tedd, K-U Schrogl (ed.), “Project 2001 Plus – Global challenges for air and space law at the edge of the 21<sup>st</sup> century”, Cologne 2006, pages 231 et seq.

<sup>46</sup> I.H. Diederiks-Verschoor, *An Introduction to Air Law*, 8<sup>th</sup> ed, 2006, page 241.

however, third parties can rely on both liability concepts.

## CONCLUSION

If we limit ourselves to the case of Sub-orbital Aeroplanes as defined in this paper, EASA has the regulatory framework and the procedures to consider certifying them as aircraft. The certification would most likely take the form of a restricted type certificate (RTC). The challenge will be in adapting existing airworthiness codes and the development of special conditions necessary to cover this category of aircraft to ensure the appropriate level of safety. The Agency would need to complement its existing expertise in aircraft structures, systems, flight, power-plant, etc by accessing the expertise specific to rocket / ballistic flight.

With the same assumption, operational rules (EU-OPS today, EASA Part-OPS in the future) and maintenance regulations (Regulation (EC) No 2042/2003<sup>47</sup>) provide a basis for operations and maintenance respectively but would need exemptions to cover the case of Sub-orbital Aeroplanes. The challenge will be in the identification, development and agreement of such exemptions.

While waiting to develop a policy, and in order to follow closely the novel design and techniques used by such aeroplanes, EASA may also offer a cooperative research framework to applicants, in order to jointly prepare the terrain at best for their applications.

Also, in order to pave the way for future long-lasting rulemaking activities, especially concerning operations and licensing, potential applicants are encouraged to route their request for proposed rulemaking as soon as possible via their representatives in EASA consultative forums, such as the Aero Space Defence (ASD) group at the Safety Standards Consultation Committee (SSCC).

Due to the distribution of responsibilities between the different actors in the Community system as well as for the distribution of responsibility for the air flight parts and the space flight part, a close cooperation between the Agency, the Commission and the Member States would be necessary.

Last but not least, cooperation with ESA, FAA and ICAO is deemed essential as their expertise and experience would help the Agency considerably in the first phase of our proposed approach, which is to adapt aviation requirements to the novelties introduced by Sub-orbital Aeroplanes. In the future, should the scope be extended to Spaceplanes, i.e. beyond the outer limits of the atmosphere, a more global cooperation with all parties would be necessary to explore the technical,

operational and legal aspects of this fascinating and challenging endeavour.

## Abbreviations and Acronyms

*Table 2. List of Acronyms.*

ACS	Attitude Control System
ANS	Air Navigation Services
AOC	Air Operator Certificate
AST	Office of Commercial Space Transportation (FAA), Washington DC
ATA	Air Transport Association: standardized aircraft systems classification (Civil Aviation)
ATM	Air Traffic Management (≠ STM)
CAMO	Continued Airworthiness Management Exposition
CEV	<i>Centre d'Essais en Vol</i> : French Flight Test Centre
CofA	Certificate of Airworthiness (≠ RCofA)
COTS	Commercial Orbital Transportation System (≠Commercial Off-The-Shelf: Commercial Equipment)
CRI	Certification Review Item
CS	Certification Specifications
DLR	<i>Deutsche Luft und Raumfahrt</i> : German Space Agency
EAC	European Astronaut Centre, Cologne, Germany
ELoS	Equivalent Level of Safety
ESA	European Space Agency
EASA	European Aviation Safety Agency, Cologne, Germany
ECLSS	Environmental Control and Life Support Systems
EU	European Union
EVA	Extra-Vehicular Activity (≠IVA)
FAA	Federal Aviation Administration
FIR	Flight Information Region
GM	Guidance Material
GSE	Ground Support Equipment
HPA	High Performance Aircraft (H>25.000ft, M>0.6)
IFR	Instrument Flight Rules
IM	Interpretative Material
ISC	Internal Safety Committee (EASA)
ISS	International Space Station
IVA	Intra-Vehicular Activity (≠EVA)
MCC	Mission Control Center
MEDES	Institute for Medicine and Physiology in Space (MEDES/IMPS, Toulouse, France)
NASA	National Aeronautics and Space Administration
NPA	Notice of Proposed Amendments
NSTS	National Space Transportation System (NASA Reg.)
OHC	Operational Hazard Control
PPE	Personal Protective Equipment
PTF	Permit To Fly
RCofA	Restricted Certificate of Airworthiness (≠CofA)
RCS	Reaction Control Systems
RTC	Restricted Type Certificate
SAS	Specific Airworthiness Specifications
SC	Special Condition
SES	Single European Sky

<sup>47</sup> Commission Regulation (EC) No 2042/2003 on the continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks (Official Journal, 315 L 1, 28.11.2003).

SEAR JU	SES ATM Research Joint Undertaking
SoA	Sub-orbital Aeroplane
SSTS	Single Stage To Space
STM	Space Traffic Management (≠ ATM)
STS	Space Transportation System=US Space Shuttle
TC	Type Certificate
TSTS	Two Stage To Space
UACC	Upper Air Traffic Control Centre
UAS	Unmanned Aerial System (=UAV+Ground Segment)
UAV	Unmanned Aerial Vehicle
VLJ	Very Light Jet

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