A Regulatory Policy for the Prospective Commercial Space Transportation Certification and Operations in Italy

Edition 1 – July 2016

INDEX

Introduction

Several operators have indicated that their spaceplanes will be ready to commence commercial operations within the next five to ten years. Italy – also thanks to the ENAC-FAA Memorandum of Cooperation of 12 March 2014, recently renewed and extended to Agenzia Spaziale Italiana - ASI and with the valuable support of Italian Air Force - ITAF – has the potentiality to allow this kind of operation from its territory under an *ad hoc* regulatory framework that can be set out in accordance with the Italian Air Navigation Code.
The present policy document aims at defining a path to determine what would be required, from an regulatory and operational perspective, to enable spaceplanes to operate from Italy in the near future.

To this purpose it is clear to ENAC that two key points have to be realised:

(i) define a clear legal and regulatory framework, and
(ii) identify suitable locations (at least one spaceport) from which operations can be carried out.

Among the key elements for the future national regulatory framework, there should be, at least,

- the adoption of a Safety Management System for both spaceplane airworthiness and operations, based on a comprehensive global risk assessment, and
- the need to operate within segregated airspace.

According to recognized definitions (e.g. the ICAO definition) a spaceplane involved in commercial space-flight operations must be considered an aircraft; moreover it appears clear, that in an European environment future commercial space-flights design, production, maintenance, operations and licensing activities shall be carried out under the EU and EASA legal and regulatory framework, that in any case, for the time being, hasn't been set up, yet.

Meanwhile, in order for operators to be allowed to start space-flight operations from Italy in a (relative) short term, ENAC envisages the possibility that sub-orbital spaceplanes shall be considered as "aircraft specifically designed or modified for research, experimental or scientific purposes, and likely to be produced in very limited numbers" and therefore operated, under the Italian national rules, as provided in Annex II of the present EU Basic Regulation (EC) No. 216/2008.

In this respect, due to the fact that experimental aircrafts are not normally allowed to conduct commercial operations, specific exemptions could be issued for spaceplanes and, as an example, flight crew and participants should have to be duly informed, before flight, of the inherent risks of the operations and acknowledge receipt of this information in writing as informed consent. In doing so, these paying participants will also acknowledge and accept that they will not benefit from the normal safeguards expected for commercial transport (they are therefore not considered passengers in the traditional sense).

It is of paramount importance to be clear about the risks with the involved people. In fact spaceplanes cannot currently achieve the same safety standards as commercial aviation (if never they will be able to do it); therefore before allowing spaceplanes to operate from Italy, the Government should be aware of and accept that these kind of operations carry a higher degree of risk than most consolidated aviation operations, at least for the people on board.

On the other hand, the risk for the uninvolved general public (i.e. the thirds and the goods on ground) should be protected against the risks coming from this kind of operations at the same (accepted) level of the current commercial aviation or, at least, at the same level of the corresponding segment of manned aviation (a similar approach has been following by ENAC about the risk for thirds parties on ground coming from RPAS operations, based on the ICAO equivalence principle).

One of the most important factors in protecting the uninvolved general public is the choice of a launch site for spaceplanes – a spaceport, with adequate characteristics. These consist first of all by easy access to the sea and low population density in the region of the spaceport.

Is there a possibility of using military infrastructures at least at the beginning waiting for the definition of a national regulation for civil spaceports that could allow the conversion of the actual civil aerodromes into spaceports or built new ones.

Another solution could be an airport already designated for experimental RPAS activities complying with spaceport *ad-hoc* requirements, like the Taranto-Grottaglie airport which has been already set up as a “test bed” for this purpose.

Policy Development and Acknowledgements

This document intends to outline the fundamentals of a regulatory policy that would be further detailed by developing the specific legal, certification and operational standards applicable to the aspects described in the following paragraphs.

The initial work has been performed by a small group of ENAC professionals under the guidance of the Deputy Director General which has been given the mandate to coordinate the development of the necessary internal expertise on commercial space transportation and the relationship in this matter at international and national level.

Waiting for a more formal setting-up of a dedicated internal function, once the technical and regulatory expertise in space transport has been consolidated, duly acknowledgment for the present work is to be given to:

Mr. Carmine Cifaldi, former ENAC Director of Airworthiness Regulation, now retired;

Mr. Marco Sandrucci, avionic professional, ENAC Turin Operations Office;

Mr. Giovanni Di Antonio, type certification professional, ENAC Airworthiness Regulation Dept.

A special acknowledgment for the valuable contribution of ITAF Staff and to Gen. Roberto Vittori, Space Attaché at the Italian Embassy in Washington, D.C. – USA, that are actively pursuing all the initiatives for the realisation of a project aimed at bringing the commercial space transport activities in Italy.

The initial draft of the present policy has been presented to and discussed with aerospace public research centres, academic institutions and industry, whose comments have been taken in consideration in this first edition.

Moreover the draft policy, at the various stages of development, has been presented in international fora (FAA COMSTAC ISPWG, September 2014; 1st ICAO Space Symposium, March 2015, 19th FAA Commercial Space Transportation Conference, February 2016, 2nd ICAO Space Symposium March 2016, CESMA Hypersonic Flight Symposium, June 2016) receiving positive acknowledgements and comments by the participants.

Benedetto Marasà

ENAC Deputy Director General

20 July 2016

Chapter 1 - National background

Italy began its efforts and investments in the space sector in the 1960s and became one of the most significant players in the world in space science, satellite technologies and the development of mobile systems for exploring the Universe. It cannot be forgotten that at that time, before the establishment of the European Space Agency (ESA), Italy was one of the only three States in the world capable of insert a satellite into orbit autonomously (the other two were of course the USA and URSS).

Today Italy, being the third contributor country to the ESA, plays a key role at the European level and has taken part with a considerable share in many of the most interesting scientific missions of recent years. Some of the most important and fascinating projects have been the construction and activities of the International Space Station where Italian astronauts are by now at home, the participation at the GALILEO project, the European geo-positioning system and, more recently, the participation in the ROSETTA mission and the launch of the IXV (Intermediate eXperimental Vehicle) for studying the re-entry from orbit severe environment and the related technological challenges.
In all, of the major missions planned for future years-from Venus to the comets, up to the outer limits of our solar system,-there will be a piece of Italy.

Italy through to the work of Italian industry pursues a tradition in the field of research in space propulsion. Particularly in the field of rocket propulsion, Italy has gained significant knowledge and expertise both in military and civil sector: the design and production of the Ariane first-stage solid propellant busters and the leadership in the European programme VEGA, the small rocket fully designed in Italy, are two significant examples.

Since 1988, all the above has been coordinated and managed by ASI (Agenzia Spaziale Italiana), a government agency under the control of the MIUR (Ministero dell'Istruzione, dell'Università e della Ricerca).

Due to the fact that the prospect of commercial space travel is soon becoming reality and the envisaged scenario will involve winged vehicles having take-off and landing capabilities potentially from a consistent number of locations within a same country, engaging aviation space with sub-orbital paths and trajectories impacting the consolidated commercial and general aviation traffic and providing services for human and good transportation, ENAC, the Italian Civil Aviation Authority, has considered it necessary to start a progressive involvement in the space sector.

The above has led to the signing of a non-binding "Memorandum of Cooperation on Commercial Space Transportation Development" between ENAC and the FAA on March 12, 2014 and a number of valuable meetings and workshops among ENAC, FAA AST (Office of Commercial Space

Transportation) and ITAF (Italian Air Force), the latter under an additional agreement for cooperation with ENAC for the scope of developing procedures and standards to support flight test activities of commercial sub-orbital flights within Italian National Air Space.

Furthermore, in September 2014, commercial sub-orbital flights regulation and experimental activity have been addressed by ENAC Board of Directors as one of the four areas of research and development projects to be financed.

Since then, an increasing number of initiatives have been developed to increase the knowledge and expertise of ENAC staff in the space sector, among which was the active participation to workshops and training courses in space matters, to several international symposia and conferences, where "state of the art" presentations have been made and, more importantly, becoming member of the the ICAO Space Learning Group, joining the most advanced international organisations in space regulation and operations, with the aim of contributing to development of the basic rulemaking pillars of civil space transportation.

Finally, the renewed Memorandum of Cooperation FAA-ENAC-ASI signed in Rome last 30 June 2016, and the associated continuing cooperation with ITAF, provide further impulse to ENAC to become a qualified reference point for the perspective (initially experimental and subsequently operational) activity of suborbital space vehicles In Italy.

Chapter 2 - Space operations regulatory and legal framework

2.1 Current initiatives

Space operations, as are supposed to be developed in the near future, will mainly be based on winged vehicles able to take off from a suitable runway of a “spaceport” (e.g.: XCOR Aerospace and Reaction Engines SKYLON programs) or able to be carried up to specific altitude (40.000 – 50.000 ft) by a specially designed or modified carrier aircraft and then released to begin a subsequent self-powered rocket based ascent phase (e.g.: Virgin Galactic WhiteKnightTwo / SpaceShipTwo program). Whatever the initial ascent phase will be, these vehicles are supposed to climb up to over 300.000 ft and then begin a re-entry trajectory, generally not longer engine assisted, where aerodynamic forces for asset, direction and speed control are supposed to be conveniently used to return to land on a runway.
Since these vehicles behave as aircraft while in the atmosphere and as spacecraft while in the space, the commonly used class definition of “spaceplane” seems to be adequate.

In the near future, spaceplanes are most likely to be used for spaceflight experience, scientific experiments and satellite launches. Therefore, the most comprehensive scenario will involve flight crew, “participants” and paying goods.

2.2 Legal context

Whether current legislation addresses spaceplanes and sub-orbital operations is a current issue among aviation authorities and agencies.
There are five United Nations treaties and agreements applicable to space:

1. Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, 1967 (“Moon Agreement’);
2. Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (“Outer Space Treaty”);
3. Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space, 1968 (“Rescue Agreement”);
4. Convention on International Liability for Damage Caused by Space Objects (“Liability Convention”);
5. Convention on Registration of Objects Launched into Outer Space (“Registration Convention”).

With the exception of the Moon Agreement, the applicability of the remaining treaties to spaceplanes depends on the definition for “Outer Space” and the boundary for where it begins. A useful convention would be to consider outer space the region above and outside the Karman line (100km or 1,57% of Earth’s radius) but the issue whether it is possible or useful to establish a legal boundary between airspace and outer space has been debated in the doctrine since the beginning of space missions.

The implication of a strict outer space delimitation on sovereign rights and national security against progress of space technology reflected on the fact that no agreement still exists on a fixed airspace-outer space boundary, while a large consensus has been reached on the five treaties above.

Although spaceplanes are not mentioned in the above treaties, it seems appropriate that, for the portion of mission where a spaceplane behaves as a spacecraft (namely when it cannot derive support from interaction with the surrounding air) the space law is applicable.

This implies, briefly, that each State is responsible that space activities carried out by State citizens or organisations are consistent with the international obligations of the State and do not jeopardise public health or the safety of persons or property. Moreover, the State must provide and update a register of space objects launched and accept liability for third party damage.

Besides, according to the ICAO definition of “aircraft”, spaceplanes can undoubtedly be considered aircraft for the portion of mission where they derive support in the atmosphere from the reactions of the air; therefore the existing set of civil aviation safety regulation (aviation law) would also apply to them and, generally speaking, to spaceplanes commercials operations because involving paying participants or goods on board.

In the EU, safety aviation rules are prepared by EASA and issued by the EU Institutions (Parliament – Council - Commission) in the form of regulations covering aeronautical product certification, continuing airworthiness, personnel licensing, aircraft operations, aerodrome and airspace/air navigation. Within this framework, since spaceplanes used for spaceflight experience would be providing air transport, they would be expected to comply with the standards for air commercial transport which are generally more demanding than those for general aviation or light aircraft.

However, due to present technology limits and stage of development of programs, spaceplanes cannot yet achieve the same safety standards as commercial aviation (e.g.: catastrophic failure rate better than 10^{-7} for flight hour). By requesting the same standards it would imply that no operations could take place.

A further option derives from the possibility for spaceplane operations to be exempted from EASA regulation. As a matter of the fact, although EU has legal competence, it has not exercised that competence so far because no regulation specifically applicable to spaceplanes has been issued, yet. In this framework, and similarly to aircraft, personnel and operations excluded from applicability of EASA Basic Regulations (ref. Reg. (EC) No 216/2008, Annex II (b) “*aircraft specifically designed or modified for research, experimental or scientific purposes, and likely to be produced in very limited numbers*”), Member States may consider to be entitled to regulate spaceplane operations nationally.

In other words, in the transition period until EU would issue specific regulations for spaceplanes and their operations, Member States might classify spaceplanes as experimental aircraft and therefore apply national standards.

2.3 Italian regulation for spaceplanes as experimental aircraft: a look forward

To build up a national legal and regulatory framework allowing suborbital flights in Italy, a three phases approach is envisaged:

- Phase I – Experimental flights (near term)
- Phase II – Flights with participants on board (mid term)
- Phase III – Routine transport (long term).

It should be mentioned that the Italian Air Navigation Code does not provide any altitude limitation for air navigation of the objects defined as aircraft, nor include a definition of spacecraft (or spaceplanes) as flying objects different from aircraft. A formal legal approach to the future scenario of commercial space transportation, in particular for sub-orbital vehicles performing horizontal take-off and landing, will be a need in the future, but the present content of the Air Navigation Code is not considered as a legal obstacle for the development of Phase I i.e. experimental sub-orbital activity of spaceplanes as outlined in para. 2.1 and 2.2 above.

For this purpose a lift-supported spaceplane could be considered an aircraft i.a.w. ICAO definition – *"Any machine that can derive support in the atmosphere from the reaction of the air"*.

In the framework of current Italian national aviation regulation, experimental aircraft are not allowed to conduct commercial transport operations; however exemptions might be granted that, subject to specific conditions and limitations, permit occasional sub-orbital spaceplanes flight experience for paying participants and cargo.

The proposal of exemptions and the definitions of conditions and limitations should be based on and should take into account the following considerations:

1. Spaceplanes operations should not imply a risk to uninvolved persons and properties higher than the one caused by current aviation traffic.
2. Presently, spaceflight is an inherently high-risk activity, where both technology and operational experience are under development. Each person directly involved in spaceplanes operations on board (e.g.: flight crew, cabin crew, participants) or at ground (e.g.: during launching, take-off or landing phases) and any customer under contract for cargo transportation should have been aware of such a risk (potentially affecting health and properties on board) by the operator and should be in condition of understand it. A written acknowledgement of such a risk should be signed for each operation (informed

consent).

3. Informed consent does not absolve the operator from liability claims brought by involved parties, their families or legal represent ant in the event of death or serious injury following a spaceplane accident or serious incident. Nor informed consent does absolve the operator from adopting policies aiming at constantly improving the overall safety of the operations.

4. Modern aeroplanes in commercial operations achieve a catastrophic failure rate better than 10^{-7} per FH, general aviation standards are better than 10^{-4} per FH: a figure of 10^{-4} per FH should be established as the acceptable target for short term spaceplanes sub-orbital operations.

5. In the short term, due to the fact that spaceplanes operations most likely to start in the coming years will be by USA operators and developed in accordance with US standards, any national regulation proposed should take into consideration and possibly be compatible with those standards. The option to adopt entirely or part of the USA (FAA AST) regulation for all commercial spaceplane activities should be taken into consideration, as well.

6. In the longer term, the aim of National regulation for commercial spaceplane operations will be to arrive at a risk-based regulatory framework and to encourage an acceptable level of safety without constitute an unnecessary burden for the development of this new industry. Adequate flexibility to allow for future regulatory development in the EU should be the target, also.

2.4 Overview of USA standards

On the basis of the non-binding FAA-ENAC “Memorandum of Cooperation on Commercial Space Transportation Development” (now extende to ASI), an assertive step forward has been made for sharing the comprehensive FAA AST background and knowledge and for mutual understanding of the conditions under which spaceplane operations can be authorized out of the US territories.
In the frame of the MoC, a number of valuable meetings and workshops among ENAC, FAA AST and ITAF (ITalian Air Force) have taken place. The following is a brief overview of the FAA AST operative framework.

In the US, space regulation is the responsibility of the FAA AST, under the Commercial Space Launch Act 1984 (CSLA). The FAA AST issues licences and permits for commercial launches of orbital rockets and sub-orbital rockets – including spaceplanes.

For a commercial space launch, two licences are required: one for the vehicle (or the operator) and one for the launch site (spaceport). Vehicle licences are granted based on acceptance of an application supported by information about payload, environmental impact and safety (giving comprehensive details of the launch schedule, trajectory and the systems being used).

FAA AST performs a sort of mandatory technical investigation (familiarisation phase) on the content of the application and on the operator. The FAA AST has a six months time to review each formal licence application.

A similar but longer procedure applies to obtain a licence for the launch site: the mandatory environmental impact assessment can take up to two years. Obtaining a new licensed launch site appears to be a critical timeline issue for an operator willing to expand his area of operations.
Once licensed for a specific type of flight with a specific type of spaceplane, the operator may easier extend his licence with slightly different payloads or trajectories or with similar type of spaceplane from the same site.

One essential requirement for every flight involving paying participants is the 'informed consent' signed by each participant.

Additionally, a holder of a launch licence or permit must inform any crew and spaceflight participants that the US Federal Government has not certified the launch vehicle as safe and a reusable launch vehicle operator must inform a spaceflight participant in writing about the risks of launch and re-entry, and the safety record of the vehicle type (Section 50905 of the 2004 Amendment to the CSLA).

As part of the ENAC staff knowledge development on space transport regulation**,** a US FAR Parts 400–460 preliminary analysis has been carried out in order to identify issues (i.e. requirements to be adapted/investigated further) and set of action items for:

- the evaluation of FAA Regulation for adoption in Italy with possible adaptations;
- validation of a FAA Permit issued to a US Operator for experimental operations in Italy

Issues were classified against priority/criticality with a code colour:
RED: deserving priority on management and resolution;
AMBER: requiring adequate management after red issues work out;
GREEN: not applicable at this stage.

Some significant identified RED issues are:

- recognition/validation of a License/Permit for a US operator would require a Bilateral Agreement and the definition of jurisdiction over operations;
- kind of launch site authorization in case of Experimental Permit;
- spaceplane configuration management and relevant impact on the Risk Assessment – authority to inspect;
- mishap reporting and investigation roles of US and Italian Authorities;
- financial responsibility (PART 440) to be analyzed for applicability and adaptation.

Chapter 3 - Spaceplane safety and airworthiness aspects

3.1 Foreword

A spaceplane should only be operated if it is in an "airworthy" state, i.e. if it has been designed, manufactured and maintained to be fit for its intended purpose.

In order to be able to establish whether or not a specific spaceplane is in airworthy state a well defined set of certification codes and technical requirements should have been set for design, manufacturing, maintenance and for the related organisations and people involved.

To date no such a comprehensive standards have been established – even if tentative efforts begin to this direction – nor the existing set of regulations developed for commercial aviation or space operations are completely applicable to spaceplanes; a certification approach to spaceplane operation is not feasible at the moment and in the near future.

Therefore, waiting the spaceplane industry matures and the regulatory bodies (as the European Aviation Safety Agency - EASA) commence to fill the gap developing specific certification codes and technical requirements, a direct comprehensive, global approach to safety is deemed necessary in order to adequately take into account and cover the airworthiness aspects related to spaceplane operations.

This alternative approach should include a systematic global risk assessment that considers all the hazards related to the design, manufacturing, maintenance and operation activities, aiming at minimizing the risk for third parties on ground and, possibly, people onboard.

3.2 Airworthiness of initial spaceplane operations

In order for a spaceplane operator to be allowed to start commercial space-flight operations from Italy in the short term, ENAC envisages the possibility that sub-orbital spaceplanes be considered as "experimental aircraft" under Italian national rules, according to the Annex II of the EU Basic Regulation (EC) No. 216/2008[1] .

This framework would allow an approach to airworthiness aimed at securing the safety of the general public, while also providing an acceptable level of safety for spaceplane occupants.
In this context, the airworthiness of a spaceplane should be strictly related to the kind of operations to be carried out and the approval process should focus on the verification that the

[1] According to the Annex II of the EU Basic Regulation (EC) No. 216/2008 these aircraft must be "specifically designed or modified for research, experimental or scientific purposes, and likely to be produced in very limited numbers"

spaceplane is able to safely operate within a specific set of conditions and limitations to be established as a function of its design and specific operational activities to be carried out.

Nevertheless, it must be taken into account that in the short term sub-orbital operations are likely to use spaceplanes that have been designed and manufactured in the US which, due to ITAR[2] constraints, should operate under a wet lease type arrangement and require an FAA AST launch licence.

Two main points should, then, be considered by ENAC to assure the airworthiness of a US spaceplane that would operate in Italy:

- the recognition of the FAA AST verification process, and
- the development of a global risk assessment to be performed by the operator as an integral part of its Safety Management System - SMS.

3.3 Recognition of the FAA AST licensing process

ENAC should recognize the safety evidences verified by FAA AST. This implies:

a. to fully understand the FAA AST regulatory system and verification process;
b. to set up in Italy a legal and regulatory system that could integrate as much as possible the FAA AST system in order to minimize the differences between the two regulatory systems;
c. subsequently, to clearly and unambiguously define the differences between the Italian and US regulation and establish, as necessary, the additional ("delta") requirements that a US operator has to comply with in order to be allowed to operate from Italy.

The MoC between FAA, ENAC and ASI on the matter creates the pre-conditions to develop the above.

3.4 SMS and Total Hazard and Risk Assessment approach

In order to ensure the airworthiness spaceplane operations in the short term, taking into account that spaceplanes are likely to be produced in small numbers, and waiting for the definition of a mature "certification-like" process, an alternative airworthiness assurance process to that employed for commercial transport aircraft should be implemented.

This approach should be based on a formal and systematic safety assurance approach that includes a global risk assessment and should be performed by the operator that, in turn, should be involved in some extent in the spaceplane design and production process. In particular the operator should develop the knowledge and have access to the data that are necessary to

[2] The ITAR is the US International Traffic in Arms Regulations. Being considered and classified as "weapon" spaceplanes are subjected to the ITAR provisions.

identify the hazard and assess the risks related to its operations. The operator should, therefore, be capable of managing such risks within a formalised Safety Management Systems (SMS).

What is here called the “global risk assessment” is meant to be a “Total Hazard and Risk Assessment” i.e., as said, a formalized, well structured, rational and comprehensive assessment that takes into account all the hazards related to the intended operations and verifies that they are adequately controlled in order to lower the risks for third parties on ground and, possibly, for people onboard, at acceptable levels[3].

In the light of the above:

- The operator should implement the management of spaceplane design, production, maintenance and operational risks as an integral part of an approved Safety Management System. This should include the continuing airworthiness issues.
- ENAC should develop and define an acceptable methodology for developing the global risk assessment, to be implemented by the operator. This should be done in the light of the maximum interoperability, taking into account what is required by FAA AST. As a matter of fact the FAA AST licensing system includes assessments of safety standards used by the designer, the manufacturer and the maintenance operator, and operating procedures; therefore the methodology to be developed should give due recognition to FAA AST verification of these assessments, allowing the operator – at the same time – to show compliance with the possible “delta requirements” that ENAC could mandate to fill the gap between the US and Italian regulation. An option could be the approval of the operator organization and its SMS, leaving then to him the privilege of performing its global risk basement (according to the specific Italian regulation) without any further verification from ENAC, even if this approach would imply a much heavier involvement in approving the operator organization and subsequently in oversighting it.

This approach will need to be based on a clear understanding of the FAA AST process and, specifically, the extent to which spaceplane flight crew, participants and the uninvolved general public are protected from an accident or serious incident occurring, as well as the mitigation of the effects of a vehicle failure or break-up.

For a clear understanding of the industrial or governmental standard used for designing, manufacturing and maintaining the spaceplanes (e.g. those developed by the NASA) is deemed highly desirable to have an indication of the minimum level of safety granted to the people on board.

[3] The FAA addresses the subject in the AC 431.35-2A “Reusable Launch and Reentry Vehicle System Safety Process”. As an example of Total Hazard and Risk Assessment approach it is also possible to refer to the paper of ASCOS Safety Certification “Risk models and accident scenarios in the total aviation system” (EU 7th Framework Programme) and to the Swiss FOCA document “Guidance for an Authorization for Low Level Operation of RPAS” based on the ASCOS model.

To practically implement the above approach to the airworthiness of initial spaceplanes operations, ENAC should have access – to some extent – to the operator SMS data along with to the splaceplane design, manufacturing and maintenance data, at least as far as it is needed for verifying the “delta” requirements and reviewing the operator global risk assessment. This should be the object of a specific agreement in the context of the ITAR discussion.

Finally, the approach to the airworthiness based on the implementation of a global risk assessment can be applied as well to manned and unmanned spaceplanes[4].

[4] It is worthwhile to mention that the approach based on a global risk assessment has been already adopting by the JARUS (Joint Authorities for Rulemaking on Unmanned System), of whom Italy is a member, for the approval of the Low Level Operation RPAS (LLO-RPAS) with a maximum take off mass not greater than 30 kg, for which a certification-like approach based on the compliance with airworthiness codes, is deemed impractical.

Chapter 4 - Airspace management and requirements

Air Traffic Management, and Airspace Management (ASM) generally, have the purpose to ensure the safety and integrity of the flight operations and all airspace users.
Across Europe (and within Italy) airspace is managed on the basis of the Flexible Use of Airspace (FUA) concept, with the purpose of make the most efficient use of it. The driven principle is that airspace should not be designated as either military or civil airspace, but should be considered as a joint, shared resource.
When for contingency reasons some types of operation will need to take place within segregated airspace, the FUA concept should ensure that any necessary segregation of airspace is based on real usage within a specific time period and airspace volume through the daily allocation of flexible airspace structures.

4.1 Spaceplanes operations issues

It is obvious that any spaceflight mission will necessarily impact airspace below 50.000 ft and potentially create hazard to other airspace users.

Although the number of spaceflight operations in the coming years (and even later) will be very low, due to the fact that:

- the nature of spaceflight operations and relevant maturity impose conservative standards for separation with other standard airspace traffics, and
- minimising the risk to the uninvolved general public, people and properties on ground may imply less or no flexibility in designing low altitude routes, paths and trajectories (e.g.: in take-off or launching and re-entry phases),

the volume of airspace impacted by each of these operations may be significant compared with other "standard" airspace traffics and the conditions to be set for this operations may impact others traffics significantly.

As an example, Italy, in line with other European countries, has in place the ENAC Regulation RAIT - "Regole dell'Aria" (Rules of the Air – Italy) which, in accordance with Regulation (EC) No 923/2012 and the applicable parts of ICAO Annex 2, sets certain standards that flight crew are expected to follow – such as precedence among types of aircrafts and ability to change trajectory to avoid collisions. Obviously these features will be unattainable for almost the entire of spaceplanes under development once take-off or launch commences, since they will be committed to a planned trajectory. Recovery of non-powered spaceplanes from high altitude will also require careful integration with existing airspace activity, also.

Spaceplane operations will be difficult to integrate through normal Air Traffic Management scenario: keeping spaceplane launches separate from normal aviation as far as possible and creating areas of segregated airspace seems to be the most adequate means to safely permit commercial spaceflight operations in the near term.

In any case, the involvement of the national air navigation service providers (mainly ENAV S.p.A.) shall be necessary.

4.2 The option of airspace segregation

Italy is not new with civil experimental activities requesting, basically for safety reasons, segregation from other general air traffic. Segregation of airspace is the present common approach to the management of Remotely Piloted Aircraft System (RPAS) activities in Italy.

As an example, the SMAT ("Sistema di Monitoraggio Avanzato del Territorio") experience held in September 2011 from Cuneo Levaldigi airport (north of Italy) was a Phase 1 of a programs of mission flights aimed to demonstrate an integrated surveillance capability using three different RPAS (AleniaAermacchi "SKY-Y", SELEX "Falco" and NIMBUS "C-FLY2") flying at the same time on three different and segregated portions of italian airspace, two of the three RPASs departed from the same Cuneo Levaldigi airport.

However, facing with spaceplanes operations, some additional constrains and difficulties arise.
A general principle followed when processing applications for segregation of an area is the evaluation of the relevant impact on other public interests in using that area or services and, in order to minimise service disruption, airspace users should be excluded from a segregated area for the shortest time possible. What is unclear at this stage is how much time would be needed for spaceplane launch and recovery and how flexible this needs to be.

For spaceplanes operations, an additional element of flexibility would be required to take into account weather conditions related constrains (which will be more demanding than those for commercial aviation) and dimension of the segregated area (which will depend on the type of spaceplane, flight profile and failure modes scenario analysis).

Location of the spaceport is also a factor which is directly dependent on the possibility to segregate the airspace around it and vice versa. According to this vision, to enable initial spaceplane operations, basically there should be at least a spaceport connected to a segregated airspace structure. Both spaceport and segregated airspace together need to be adequate to safely support the operations of a given spaceplanes.

For the reasons above, and considering that in the near term the impact of airspace segregation on other airspace users is likely to be small as the numbers of expected spaceplane flights will be relatively low, a case-by-case approach seems to be the most suitable.

The option of airspace segregation is in line with policies taken in the USA where, however, extensive military segregated airspace areas are used for the launch and recovery of spaceplane test flights. In the US, all such kind of operations to date have utilised segregated airspace; all licensed US spaceports have significant, existing, restricted military airspace within which much of the activity can occur. This limits their interaction with other air traffic.

In Western Europe, large under-used airspace areas suitable for a segregation are difficult to find, or probably impossible.

The option of using military operation designated areas and/or military aerodromes which can be used as spaceports (eventually with adequate infrastructural and procedures modifications) could be a mean that is worth considering to permit near term experimental spaceflight activity, at least.

In Italy, ENAC and ITAF have an agreement for cooperation ENAC for the purpose of developing procedures and standards to support flight test activities of commercial sub-orbital flights within Italian National Air Space.

Nevertheless, the possibility of using non-military site should be explored. Whether is difficult to use airport engaged in commercial aviation, for obvious reasons, at least experimental activities could be hold in airport already designated for experimental RPAS activities adapted to become spaceport complying with spaceport necessary requirements.

This would imply to define and implement at that location specific *ad-hoc* regulation for spaceports. The requirements for an adequate launching and re-entry site are discussed in the next Chapter.

Chapter 5 Spaceports management and requirements

5.1 Foreword

The identification of a suitable spaceport is a necessary condition to allow spaceplane operations from Italy. The needs for a suitable spaceport location are related to operations, safety, meteorological conditions and economic factors, therefore a trade-off is necessary.

5.2 Spaceport requirements

The following factors should be considered for selecting a suitable spaceport location.

1. Operating criteria

   A spaceport will need to be a large site and have a runway that is between 2750 and 5000 meters long, depending on the kind of spaceplane. Shorter runway length may be acceptable depending on the spaceplane characteristics and performances.

2. Safety factors

   Due to the priority of protecting the uninvolved general public, the ideal location will be away from densely populated areas and located in any case in a region characterized by a low population density that is, in fact, a crucial parameter in estimating the expected average casualties due to space launch and re-entry missions, as requested by the FAA AST. As a matter of fact, a "casualty analysis" has to be carried out for obtaining an FAA AST licence, demonstrating that the safety target of $3*10^{-5}$ casualties per mission is met[5].
   To date, this has resulted in the FAA AST licensing operations only in areas of very low population density such as desert or coastal locations.
   A spaceport will also need the protection of segregated airspace.

3. Meteorological considerations

   From a technical and operational point of view a spaceport should not have strong crosswinds and should be clear of clouds. This last point would also deal with commercial issues, giving the possibility to experience the view of the Earth from space; this clearly represent a key attraction for paying occupants and a strong motivation to operate such flights, at least at the beginning. In the light of the above the following general meteorological requirements should be considered in selecting a spaceport (taking into

[5] See the FAA AC 431.35-1 "Expected Casualty Calculations for Commercial Space Launch and Reentry Missions".

account that different needs there might be for each commercial space operation, that use specific spaceplane, and between commercial flights and scientific-research flights):

a. low crosswind at ground;
b. prevailing wind oriented toward the runway;
c. low upper-air wind;
d. low level of clod-cover (i.e. as many hours of sunshine as possible);
e. low rainfall.

4. Environmental requirements

This aspect mainly deals with noise, air quality and use of hazardous materials legislation.

Accepting that spaceplanes will be considered as aircraft, aviation environmental regulations will also apply to spaceplane operations in principle.

Given the initial low volume of flights expected, spaceplanes should be able to operate from existing aerodromes within the environmental standards expected. Nevertheless, derogations could be envisaged having the spaceplane been defined as “experimental aircraft”, even if their impact on environmental issues cannot be completely ignored, posing real concerns for the general public and the environment in the neighbouring areas to the spaceport, like emissions and noise related to the use of rocket engines or the operation of large carrier aircraft.

It is therefore envisaged that, for each kind of operation, a specific and comprehensive environmental impact assessment should be developed by the operator against the current national and international aviation environmental regulation for aircraft, aerodromes and airspace, covering issues such as noise, air quality (including carbon emissions) and the storage of hazardous materials.

The environmental impact assessment should be reviewed and accepted by ENAC with the aim at issuing an authorization for operations from a specific spaceport. Any deviations with respect the current applicable environmental regulation should be duly highlighted and specific limitation, restrictions and conditions should be established accordingly, as necessary to grant the minimum level of environmental safety and protection.

In addition, close coordination with the Italian Ministry of Environment should be established in order to avoid contentious issues with other involved Institutions and public local authorities.

5. Logistic issues

A spaceport will need good transport links, possibly also from the sea. It should have as well the adequate infrastructures for preparing, storing and filling the rocket solid or liquid (cryogenic) propellant components.

5.3 Feasible sites in Italy

ENAC strongly believes Italy has the potential and the capability for hosting one or more spaceports that could meet the necessary requirements, even if no site has been identified yet.

In order to allow spaceplanes operations in Italy, in the short term, this work may be initially done in cooperation with ITAF and the Italian MoD in order to identify a candidate aerodrome that may fulfil as much as possible the above said criteria.

A suitable alternative would be to use an airport seldom used for commercial traffic, where experimental activities are already authorised (e.g. for flight testing of prototype aircraft or RPAS) complying with the characteristics and requirements for a spaceport as discussed above.

This could be the already mentioned Taranto-Grottaglie airport, which is also a certified civil aerodrome in accordance with the ENAc Regulation complying with the ICAO Annex 14 – Vol 1 standards.

It may be considered as alternative options, waiting for a civil spaceport that could fully comply with any future spaceport safety regulation.

An initial candidate location could be in a coastal area in the South of Italy. In the future, with a better understanding of sub-orbital spaceplane safety performance and the possibility of the development of suitable certification codes, it may be possible to relax the coastal location requirement (that is directly linked to the low-population density requirement), even if a coastal location shall, in any case, help to meet the some environmental requirements.

Chapter 6 Space crew requirements and licensing

6.1 Background

Historically, space crew started being selected from military services and have continued this way for the majority of missions; therefore, the majority of spacecraft crew to date have been highly trained and physically fit, even before selection for a space mission.

As operations have evolved, longer missions with larger crews have become possible and specialised roles with different skills for crew members have developed. Depending on the spaceflight programmes, the responsibility to ensure that crew members were appropriately trained and competent has been managed by the respective national space agencies.

As the spaceflight scenario will progressively move from experimental to commercial operations, it can no longer be assumed that either space agencies or military administrations take responsibility for commercial flight crew training and competence and, as for general and commercial aviation, either national aviation Authorities or EASA are expected to set their own regulation.

Since, as in aviation, the safety of the operations depends also on the skills and knowledge of the spaceflight crew and, specifically for spaceflight operations, on the ability to cope with the unique stresses of spaceflight, spaceflight crew licensing model would need to address both technical competence and physical ability.

6.2 Short-term licensing solution

So far, all the operators candidates for experimental or commercial spaceflight operations in the near term are from USA, therefore, whatever the legal scenario in Europe and Italy will be, both spaceplane and its crew will have to meet FAA AST requirements.

In particular, US FAR Part 460, places a responsibility on operators to ensure that all members of the flight crew:

- have appropriate experience;
- are appropriately trained for their craft; and
- have demonstrated an ability to withstand the stresses of spaceflight in sufficient condition to safely carry out their duties so that the vehicle will not harm the public.

The option to validate FAA AST process is probably the most convenient and suitable for the near term. In accordance with Annex III to Regulation (UE) No. 1178/2011 (the Aircrew Regulation), this should be accomplished by a validation process, which requires the pilot to

- hold a valid ICAO-compliant licence;

- hold at least a Class 1 Medical Certificate issued in accordance with Annex IV to to Regulation (UE) No. 1178/2011 - Part-MED;
- have successfully completed a skill test on the appropriate aircraft or in a synthetic training device designed to replicate the operation of the aircraft, with an examiner designated by the competent authority.

In case operations will be conducted on spaceplanes classified as experimental aircraft under Annex II of the EASA Basic Regulation, ENAC as the competent authority could add further requirements.

6.3 Long-term licensing solution

In Europe, no organisation has yet been given a mandate to develop a regulatory framework for spaceflight crew licensing and competence. However, both ESA and EASA have indicated a broad position on spaceflight crew competence which differs from that of the FAA AST, although these positions date back some years ago.

In particular, ESA approach is based on a formal training process which last four years and is composed by five sequential phases:
- selection;
- basic training;
- advanced training;
- mission-specific training;
- onboard training.

The above approach is focussed on astronauts and long-term space orbits, which are different missions from those envisaged for sub-orbital spaceplanes.

EASA approach has been published in the year 2008 in the paper “Accommodating sub-orbital flights into the EASA regulatory system” [6] and basically it acknowledges the scientific, operational and managerial experience of the space agencies (NASA and ESA) for space operations but highlights additional considerations for commercial space tourism operations carried out by private operators regarding the need of:
- proper rules in order to clearly establish responsibilities and privileges for natural and legal persons;
- such rules are accompanied by Acceptable Means of Compliance (AMC) and published;
- mechanisms to oversee and enforce the application of the rules (example being the issuing, suspending and revoking of pilot licences).

[6] J-B Marciacq, Y Morier, F Tomasello, Zs Erdelyi, M Gerhard (2008) ‘Accommodating suborbital flights into the EASA regulatory system’, EASA conference paper

ENAC position for the longer term is for a common European policy which extends the current Aircrew regulation (Part-FCL, Part-MED, etc) to Space crew; national space agencies standards, experiences and considerations expressed by EASA in the 2008 paper must be conveniently taken into consideration.

6.4 Medical requirements and assessment for space crew

Like in aviation, the fitness and performance of commercial space crew clearly has to be assured not only for their and any participant's protection, but also to protect, as far as possible, the uninvolved general public.
Since space environment and spaceplane operations imply additional issues and constraints than those in aviation, aviation standards for flight crew could be conveniently considered as a baseline from which a specific standards needs to be developed and established.

So far, although specific standards have been established for the International Space Station astronauts [7] and some draft policies begin to address the issue for shorter space experiences [8] [9] [10], there are currently no common standards that apply to sub-orbital operations.

In the short term, the majority of spaceplane pilots will probably be already qualified either as astronauts or as military pilots, therefore any applicable medical requirements set for sub-orbital space operations seems to be fulfilled.

In the long term; both identification of an adequate medical standard for space crew and commitment the relevant assessment to a medical national network are mandatory steps in order to set a system similar to the one for commercial aviation. While the latter can be conveniently provided by the current established aviation national network of aeromedical centres with some additional information and training, the former needs adequate European or even worldwide harmonisation.

As an example, according to US Code of Federal Regulations Title 14, parts 401, 415, 431, 435, 440 and 460, since 2006 FAA AST requires all spaceplane flight crew to hold, as a minimum, a Second Class Airman Medical Certificate but more recently an escalation to First Class seems to be more adequate[11].

In Europe, taking into account Regulation (EC) No. 216/2008 (EASA Basic Regulation) and Aircrew

[7] E Messerschmid, J-P Haignere, K Damian and V Damann (2000) 'EAC training and medical support for International Space Station astronauts',
[8] FAA AST (2013) 'Draft Established Practices for Human Space Flight Occupant Safety'
[9] J-B Marciacq and A Ruge (2013) 'Sub-orbital and orbital pilots licensing and passengers medical screening/training',
International Astronautical Association (IAA) 19th Humans In Space Conference, Cologne, July
[10] Aerospace Medical Association Commercial Spaceflight Working Group (2011) 'Position paper: sub-orbital commercial spaceflight crewmember medical issues'
[11] R Jennings, J Vanderploeg, M Antunano, J Davis et al (2012) 'Flight crew medical standards and spaceflight participant medical acceptance guidelines for commercial space flight'

Regulation No. 1178/2011, a EU Class 1 medical certificate could be the aviation baseline on which additional medical requirements might be deemed necessary to be added. However, it should be developed on an international basis, with the ambition of worldwide acceptance.

Chapter 7 Participants requirements

7.1 Medical requirements and assessment for participants

At the current state of the art and technology, spaceplane flights will expose both participants and flight crew to hazards at levels not usually encountered in commercial air transport, such as reduced ambient pressure, a reduced oxygen level, high G, microgravity, high noise levels, increased radiation exposure, vibration and thermal extremes.

Not only the above conditions may have consequences on the affected participants, even the safety of entire space or sub-orbital mission might be in danger due for example to an anomalous/unwanted behaviour or illness of a participant if no adequately managed.

To date, there is no Italian or European regulation identifying medical requirements for passengers in aviation commercial operations, however the majority of operators have an advisory service for the screening of participants with medical conditions who could potentially suffer from a commercial aviation flight.

A similar and more demanding approach should be adopted for commercial space operations.
An option could be requesting each participant to hold a valid medical certificate for space flights; due the limited number of participants, this would add negligible workload to the national medical system specifically addressed for the purpose. Furthermore, an additional assessment could be deemed necessary shortly before each flight.

This two-stage approach means that significant health risks can be identified early on, and those with the most serious conditions can be excluded well in advance of the flight.
It also means that, should a participant’s health have changed in any important way in the intervening period, the operator is able to identify this and, where appropriate, prevent the participant from flying.

Therefore the competent authority should require spaceplane operators to have a management system in place that specifies overall strategy for the management and mitigation of the medical risks to participants and a medical advisory capability for individual risk management.

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