Ref. Request for Services under Framework Service Contract No. ENTR/2009/050— Lot 1 (Contract No. 30-CE-036363/00-01)

EVALUATION OF THE EUROPEAN MARKET POTENTIAL FOR COMMERCIAL SPACEFLIGHT

Prepared for: THE EUROPEAN COMMISSION ENTERPRISE AND INDUSTRY DIRECTORATE-GENERAL

18th February, 2013*

FINAL REPORT

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* resubmitted on 28 MAR 2013

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1 EXECUTIVE SUMMARY

Within the present study an evaluation of the European Market potential for commercial suborbital spaceflights was conducted, with a focus on deriving a clear picture of the global commercial spaceflight market, its dynamics and trends and any hurdle slowing down or preventing its full development. Also part of the study was a dedicated analysis of the European scenario, to outline existing gaps with U.S. in terms of industrial capabilities and regulatory frameworks, with the final objective to identify possible options for EU actions to boost EU industry competitiveness and foster market development in Europe.

The study was scoped towards suborbital spaceflight (a flight up to an altitude around 100 Km, altitude of the *Karman Line*, the generally accepted theoretical line separating airspace from outerspace) *from point A to point A*, i.e. suborbital point to point transportation was only considered as a possible strategic implication. A significant step in the study for data collection and validation was represented by a stakeholder consultation process: relevant players in the value chain (vehicle developers, service operators, spaceports, regulatory authorities or regulatory experts and general experts) were engaged in interviews, either in teleconference or in Face to Face (F2F) meetings.

1.1 INDUSTRY AND MARKET ASSESSMENT

NOTA BENE:

This market assessment study has considered a wide range of stakeholders with an emphasis on:

- ***those having a high readiness level in term of vehicles' operation,***
- ***those having a significant capital support.***

The industry was characterized by looking at the different sub-segments composing its value chain: Vehicle developers; Service providers/vehicle operators; Spaceports; and the role played by insurance companies. The external factors shaping the competitive environment and providing the boundary conditions for industry proliferation and development were also analysed: Regulatory frameworks; Private and public capital; Institutions/government.

The analysis of the vehicle development scene in the U.S. shows 4 companies with man-rated SRVs under development, 2 of which (*Virgin Galactic* and *XCor*) are expected to start operations between 2013 and 2014. The vehicle development business is characterized by high inherent risk (technological complexity coupled with high investments), and possibly as a consequence of that, most companies involved in the business are relatively small start-ups rather than large aerospace conglomerates (established aerospace incumbents possibly find the venture at this stage too risky for their brand equity).

Commercial spaceports are being considered and developed in many locations in evident expectation of sustained flight rates and global operations. These new infrastructures add up to the already existing spaceports used for SRV vehicles and sub-systems testing. Spaceports in the U.S. have benefited from institutional support at state level (i.e. funding for site development/building or tax advantage), in view of the expected positive externalities that can be realized for the local economies in case routine spaceflights operations are established at the sites (tourism boost, creation of technology aggregation poles, positive outreach effect and promotion of technology careers).

As of today, the offerings of 3 out of 4 of the prospective imminent vehicle developer's market entrants are channelled through service operators: a classic *manufacturer-operator* model akin to that of the aviation industry is consolidating in the industry as the beginning of commercial operation approaches. Two business models are currently in place: wet-leasing and vehicle/manufacturer ownership. The first model is the only seen possible in the medium term for operations outside of the U.S., due to export licence issues linked to SRV vehicles being subjected to ITAR regulation.

Insurance companies will eventually operate along the entire value chain and provide liability insurance to operators, manufacturers, and specific packages to passengers: In the U.S., vehicles manufacturers and operators are required to take out liability insurance for any damage to third parties (i.e. parties not involved with the flight). There, the U.S. federal government provides potential indemnification for third party liability in excess of the insured amount. In any case, insurances premiums are possibly going to be very high at the beginning, until companies demonstrate a safe flight track record.

Favorable external conditions and a strong heritage of technical resources may be considered at the base of the birth of the industry in the U.S. The main factors that led to the current suborbital industry include: the build-up of a critical mass of key technologies and human resources: since the dawn of the space age in the late 50s and 60s; large private capital availability, from wealthy investors coming from the new economy with an enthusiasm for space; the onset of a commercial Space Race, spurred by the Ansari X-prize, which fostered continued investments and technical development; quick institutional acknowledgement of the commercial relevance of the new industry, with FAA-AST promptly regulating commercial suborbital spaceflight right after the X-Prize, allowing the newly born vehicle developments to plan an easy access to market; federal grants and in-kind support, provided by agencies like NASA, USAF and DARPA, and state-level support.

FAA-AST regulation of commercial suborbital spaceflight introduced a licensing regime, based upon limited liability for the SRV manufacturer and the operator, and an informed consent to the risk involved for the prospective passengers to the flight.

Suborbital vehicle development in Europe is still in its preliminary stages. Among the European companies with SRV plans, *EADS-Astrium* and *Dassault Aviation* stand out for their size and heritage. The concepts proposed by those two companies retain an aviation-like approach to safety (the two companies see certification by an aviation authority as a *conditio sine qua non* to reach the market), understandable in view of the need of those companies to protect their brand equity (in their core aviation and space businesses) and in view of the development approach that those companies take in their industrial practices (an approach that goes hand in hand with certification). The publicly declared involvement/interest of *Astrium* and *Dassault* is in stark contrast with the American development scene, where no large aerospace corporation have publicly declared to be interested in commercial suborbital spaceflight. In terms of technological capabilities, while the U.S. retains a significant technological lead, it is reasonable to believe Europe capable of bridging the current gap with the U.S., the key for that being an appropriate resource commitment in developing SRV systems.

Operations in Europe are planned, by either U.S. operator or prospective EU operators, in the mid-term through the use of U.S. developed vehicles; however, such plans may be hindered by U.S. Export control regulations.

Europe lack so far institutional support on commercial spaceflight at European Union level. The issue is twofold: 1) EU has never stated any strategic interest on commercial spaceflight; 2) there is a lack of regulatory clarity at EU-level, which may hinder both SRV development plans and the possibility to have operations in the European airspace, a deficiency that ought to be fixed in order for the market potential to fully develop.

The above hurdles notwithstanding, the number of companies with development plans, and the number of prospective operators, together with the plans of several local governments to develop spaceports' infrastructure, show the level of interest that commercial spaceflight is gathering in Europe, and, consequently, the need for institutional actions capable of supporting the new market.

The financial relevance of the new market, and the opportunity for new players' entry was assessed in the study by looking at demand assessment studies and comparing the expected demand with the currently foreseen supply capabilities. The simple comparison of the operational capabilities of the vehicles expected to begin commercial flights in the near future and the advance sales backlog is enough to state that two or more years of operations would be required to fulfil the existing backlog. Going beyond advance ticket sales, predicting the balance of supply and demand is less straightforward: the two demand assessment studies analysed produced widely different estimations, resulting from varying assumptions in terms of addressable demand and safety of flight.

The study highlighted the regulatory aspect as a key enabler for market development. The current FAA-AST regulatory approach was analysed and compared with a possible aviation-like certification approach, taking EASA processes as a reference.

FAA-AST approach, which effectively treats suborbital flight as spaceflight, involves an informed consent for passengers, limits the liability of the SRV manufacturer and the operator only to third parties not involved in the flight, allows new entrants to get to operations quickly, and allows for continual technical improvements without the need to cease operations. The main cons of such an approach include a possible fragmentation in safety standards among different vehicle concepts, and in a low perceived safety of flight by prospective participants.

On the other hand, an aviation-like certification framework puts the liability to manufacturer/operator and to the certification authority, creates standard safety requirements, increases perceived safety of flight and therefore the appeal to customers, facilitates business expansion (since certification is product-related). The main cons of a certification framework at this stage of the market are the likely higher cost and approval time requirements, which may represent a barrier to entry for smaller players, as well as the time requirement to set-up such a framework, which may postpone market entry for prospective players in Europe.

The strategic importance of commercial suborbital spaceflight and its impact on European competitiveness was also assessed: apart from human experiential spaceflight the sector is susceptible of a multitude of other possible applications, with implication for technology development, scientific research, technology transfer into other sectors in the aerospace field and in other technology fields.

1.2 GAP ANALYSIS AND INSTITUTIONAL ACTIONS

The gap analysis between Europe and U.S., validated through several rounds of stakeholder consultation, highlighted that, while technology gaps do not represent a showstopper for the European industry, the lack of regulatory clarity and, for vehicle development, the lack of institutional support and institutional and private funding currently prevent the market from blossoming in Europe along the entire value chain.

The main institutional action deemed necessary is the establishment of a clear regulatory framework for SRV operations in Europe. As for the type of regulatory regime to pursue, two different options, with different pros and cons, were analysed: an aviation-like certification approach, in other words a regulatory frameworks that adopts structure, methodologies and processes from the current aviation certification framework established and managed by EASA; an *ad-hoc* regime, intermediate between the FAA-AST licensing system currently in place in the U.S. and an aviation-like certification framework.

Pursuing a full certification process right from the start would benefit large European companies with an interest/plan in SRV vehicle development as it would allow them to build a sustainable global market for their products. On the other hand, such an approach would lead to dismiss any prospect for SRV operations in Europe before the next decade thus damaging the medium term prospects of European spaceports.

An ad-hoc regime, intermediate between aviation and space, would possibly ensure the possibility to have SRV operations in Europe in the medium term, allowing Europe to stay relevant in the SRV industry, but could probably lead to large European companies to delay/downplay their development plans to a later stage.

The two approaches described above are not mutually exclusive: provided with appropriate resources, a regulatory authority could ideally pursue them both in parallel.

In addition to providing regulatory clarity, an EU institutional action could be conceived to provide an official recognition, on EU's part, of the relevance of commercial suborbital spaceflight for future European aerospace industry's competitiveness, with a clear manifestation of strategic interest at policy level, or with the insertion of SRV-related technology themes in future FP programmes.

2 INTRODUCTION

2.1 OBJECTIVE OF THE STUDY

The objective of the study was to conduct an evaluation of the European Market potential for commercial suborbital spaceflights. More specifically, the study aimed at:

- Deriving a clear picture of the global commercial spaceflight market, its dynamics and trends and any hurdle slowing down or preventing its full development
- Zooming in on the European scenario, outlining existing gaps with U.S. in terms of industrial capabilities and regulatory frameworks
- Identifying possible options for EU actions to boost EU industry competitiveness and evaluate their potential in the market context

The general scope above was further framed down into the following major focus areas:

1. *Global market structure:* a strong focus was put in understanding the dynamics that led to commercial spaceflight market development in the US. The main market drivers were examined
2. *Prospective global and European market size:* existing market forecast data were used and critically compared in order to derive an estimation of the expected market size at global and European level and to frame the main demand drivers
3. *Technical capabilities gap assessment:* a summary of the key technologies required for commercial spaceflight vehicles' development and operations was produced, and a gap analysis was conducted between the U.S. and Europe in order to highlight any criticality in access to technology as well as operational readiness
4. *Demand and supply:* both global demand and supply were characterized
5. *Financials for Commercial Suborbital Spaceflight ventures:* in order to support the supply-side market characterization and the market drivers analysis, financial estimations of capital and operational expenditures for a commercial spaceflight venture were carried out, and an associated financial analysis was conducted
6. *Institutional and regulatory enablers:* a specific focus was put into the role that institutional and regulatory drivers play in the market dynamics, and a regulatory gap assessment was conducted between the U.S. and Europe
7. *Areas of Intervention for EU and related impact:* assessment of possible EU institutional actions to promote market development in Europe, and evaluation of the expected impact

2.2 STUDY SUBJECT DEFINITION AND SHORT BACKGROUND

Suborbital spaceflight refers to a flight up to a very high altitude which does not involve sending the vehicle into orbit: the typical altitude threshold of suborbital spaceflight is defined at around 100 Km (altitude of the *Karman Line*, the generally accepted theoretical line separating airspace from outerspace[1]).

Unmanned suborbital spaceflight has been common since the dawn of the space age, through the use of sounding rockets for various science and technology related purposes. In the last decades, however, suborbital spaceflight enjoyed a new popularity due to the rise of commercial spaceflight interest: such interest was fuelled by the development of new vehicle concepts suitable also for human transportation by privately-funded companies, intended to address a sizeable demand for spaceflight experiences from the wealthy public.

As mentioned, commercial suborbital spaceflight encompasses several potential applications (and, consequently, several possible market segments, as depicted in Figure 1) that can essentially be divided into:

- *Cargo:* microgravity research and technology testing have been typical applications for suborbital flights; additional cargo applications like small satellite deployment into LEO from suborbital heights, and remote sensing are also expected to take place as secondary applications from the development of new suborbital reusable vehicles
- *Human suborbital flight:* the main emerging market, the one that propelled the commercial renaissance of suborbital spaceflight, is represented by human flight as a touristic experience

While all the market segments reported above will be taken into account in the study, the main focus is on the newly emerging *human suborbital spaceflight* segment, as the one with the higher revenue potential in the short term, and with the higher strategic interest and long-term impact.

It is important to point out that Commercial Human Suborbital Spaceflight is intended, within this study, as *flight from point A to point A*, i.e. a leisure activity rather than actual transportation: a "spaceflight experience", comprising a view of the earth from the edge of space and a few minutes of microgravity. In the remainder of this study, we will refer to the above as ***Experiential Spaceflight***.

The evolution to Point to Point transportation (P2P) is not explored within the study (from a demand/regulatory perspective): it is only addressed as a long term implication of Experiential Spaceflight from a technology and strategic perspective.

Commercial Orbital Flights and Zero-G experiences are, on the other hand, out of the scope of this study.

[1] *A Brief History of Space* – Physics.org (available online at http://www.physics.org/article-questions.asp?id=61 – Last retrieved on February 2013)

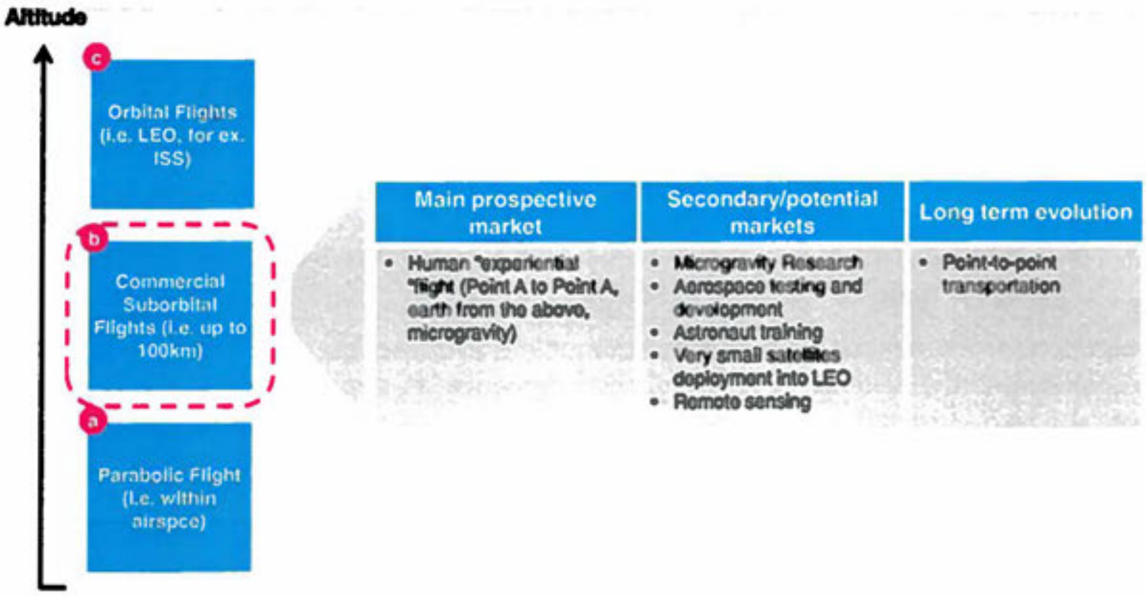

Figure 1 Commercial Suborbital Spaceflight rough definition and prospective markets

2.3 STUDY APPROACH

The study was conducted using the Hypothesis driven iterative approach, through the following steps:

1. *Starting scenario:* within this step, a preliminary market assessment and gap analysis was conducted via desk research and stakeholder consultation. An initial current base scenario was derived
2. *Identification of issues:* on the basis of the preliminary market assessment, a set of issues/hurdles to market development in Europe were identified in the following sub-categories:
    a. *Technology:* technology and system readiness levels, market access to key technologies
    b. *Geographical demand and operations:* possible geographical spread of operations, local and global demand
    c. *Financing:* capital and operational expenses requirements, access to capital
    d. *Regulation:* regulatory frameworks currently in place
3. *Generation of hypotheses:* for each of the identified issues, hypotheses on possible causes or on statements of belief were formulated, and the data required for an analysis and validation were determined
4. *Analysis and validation:* the required data was procured, and the hypotheses tested
5. *Iteration:* the tested hypotheses were then either validated/refined, or rejected, in an iterative process until a conclusive view on the issue was reached
6. *Recommendations:* as a result of the conclusive views developed, a proposal of possible actions to address the issues was produced, and their impact quantified

2.3.1 Stakeholder consultation

A crucial step in the data collection process and in hypotheses' validation and refinements was represented by a stakeholder consultation process: relevant players in the commercial suborbital spaceflights value chain were engaged in interviews, either in teleconference or in Face to Face (F2F) meetings. Stakeholders belonging to the following categories were addressed:

- Vehicle developers
- Service operators
- Spaceports
- Regulatory authorities or regulatory experts

The following table shows the interviews conducted.

	Name	Type	Region
1	EADS Astrium	Vehicle Developer	Europe
2	XCOR Aerospace	Vehicle Developer	US
3	Sierra Nevada Corp.	Vehicle Developer	US
4	Dassault	Vehicle Developer	Europe
5	The Spaceship Company	Vehicle Manufacturer	US
6	Kistler Space Systems/Rocketplane	Vehicle Developer	US
7	S3	Vehicle Producer/Operator*	Europe
8	Virgin Galactic	Vehicle Dev/Operator	US
9	Space Expedition Corporation	Operator	Europe
10	Kiruna Space Centre Sweden	Spaceport	Europe
11	Mojave Air and Space Port	Spaceport	US
12	FAA AST	Regulation	US
13	EASA	Regulation	Europe
14	Faculty of Law, University of Leiden	Regulation	Europe
15	Swedish National Space Board	Regulation	Europe
16	UK Ministry	Regulation	Europe
17	IPSOS	Market research company	Europe

*No additional details available to the public by February 18th 2013

Table 1 – Conducted Interviews

Additional stakeholders were originally identified and reached out to (table 2), but the attempts to engage them in interviews were not successful.

Name	Type	Region
Armadillo Aerospace	Vehicle Developer	US
Blue Origin	Vehicle Developer	US
Space Adventures	Operator	US
Spaceport America	Spaceport	US

Table 2 - Stakeholders who have not responded to the request for contact

In the appendix, the general guidelines followed during the interviews are reported for each stakeholder category.

3 HIGH-LEVEL INDUSTRY AND MARKET CHARACTERIZATION

While suborbital spaceflight has been routine since several decades, in the form of cargo applications with sounding rockets, commercial propositions of suborbital human spaceflight represent a relatively new market offering: this new market has stemmed from the development, by privately funded companies, of man-rated suborbital reusable vehicles designed to offer prospective passengers the experience of spaceflight.

These companies created a new spaceflight industry, targeting mainly human experiential flight (but expressing interest in other secondary market segments as well), with the aim to bring down the cost of space access and to increase potential flight rates, in order to ultimately create sustained routine space transportation.

As of today, successful prototyping of required assets (that is, suborbital reusable vehicles - SRV) have not yet led to routine manned operations: the industry may start operating in late 2013, with the expected first commercial flights of two industry players, *Virgin Galactic* and *XCor* (through the service operator *Space Expedition Corporation*). The industry has recorded, since 2004, sizeable advance sales, estimated at a total of 725 reservations for *Virgin Galactic* and *XCor*[2]: even assuming a non-negligible cancellation rate, this would result in cumulative prospective revenues of around 100M$ for the next 3 years[3]. To those numbers, around 200 additional reservations may be added for *Armadillo Aerospace Hyperion Vehicle*[4].

The next subsections describe the industry structure, outline the main external factors that helped shaping the industry and develop the market, and characterize the market in terms of expected demand and current and expected supply.

3.1 INDUSTRY STRUCTURE AND EXTERNAL ENVIRONMENT

The industry was characterized by looking at the different sub-segments composing its value chain (Figure 2) including:

- Vehicle developers
- Service providers/vehicle operators
- Spaceports

The external actors shaping the environment and providing the boundary conditions for industry development and expansion were also analysed. Those include:

- Regulatory authorities
- Private and public investors
- Institutions/government

In addition the role of insurance companies, whose services potentially span the entire value chain, was considered.

2 *Source:* Stakeholder consultation; The Tauri Group [1]

3 *Source:* Booz & Co. analysis on the basis of: advance sales data released by the Virgin Galactic and XCor; average ticket price; expected pace of operations

4 *Source:* The Tauri Group [1]

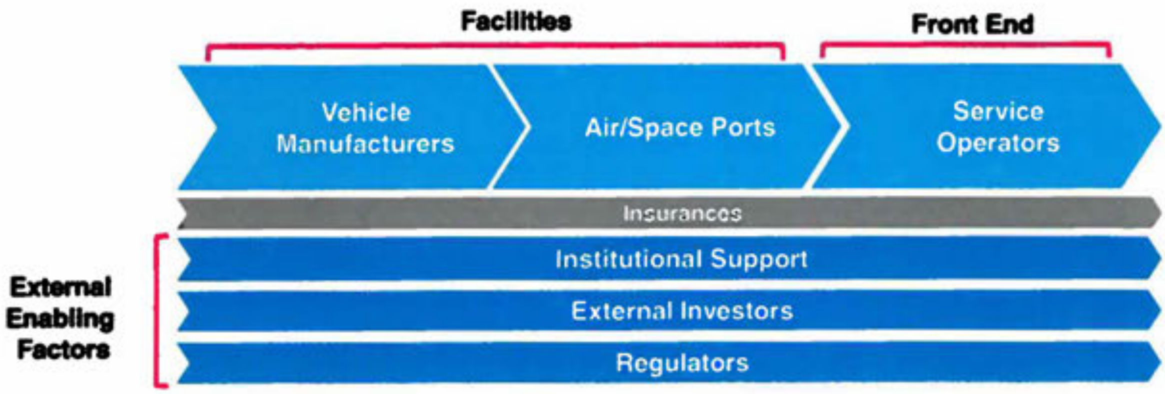

Figure 2 – Industry value chain and external enabling environment

3.1.1 Vehicle manufacturers

The SRV Developers' segment is fragmented. A number of start-ups populate the scene, with no large aerospace company directly involved in the development of a commercial suborbital vehicle.
Six companies have SRV in the development phase:

1. *Scaled Composites/Virgin Galactic:* SC/VG *SpaceshipTwo*, that will be launched using the carrier aircraft *WhiteknightTwo*, is the evolution of the X-Prize-winning *SpaceshipOne*

2. *XCor Aerospace:* XCor is developing the *Lynx*, a small Horizontal Take-off, Horizontal Landing (HTHL) SRV capable of transporting one passenger in addition to the pilot

3. *Blue Origin: Blue Origin* is developing a Vertical Take-off Vertical Landing (VTVL) man-rated SRV, the *Blue Shepard*, whose status of development is not publicly known

4. *Armadillo Aerospace: Armadillo* is developing a Vertical Take-off Vertical Landing (VTVL) man-rated SRV, the *Hyperion*. To reach that goal, the company has developed and tested in various guises several unmanned rocket powered vehicles (among which the STIG-A1, the MOD, the QUAD)

5. *UP Aerospace:* the company developed the SpaceLoft XL Sounding rocket family dedicated to cargo transportation for corporate, military and educational payloads

6. *Masten Space Systems: MSS* is developing a line of VTVL vehicles for unmanned suborbital research flight

The first 4 companies mentioned above have man-rated SRVs under development. At least 2 of those (*Virgin Galactic* and *XCor*) are expected to start operations between 2013 and 2014.
The vehicle developers' scenario may be characterized as follows:

High Inherent Risk: The development of new type of space transportation vehicle, capable of performing routine suborbital flights with limited maintenance while assuring a high level of safety for its pilot and occupants is a risky endeavour, that requires large upfront investments, skilled workforce, innovative technological and system design solution and that may lead to failures and/or delays. In case of failure in particular, the consequences for the whole sector could be dramatic with a huge public opinion backlash that could set back the industry for many years. As will be detailed at the end of this section, almost all current developers have recorded vast delays in their development schedules and have postponed the beginning of commercial operations several times

- *Geographical distribution:* All the companies mentioned above are U.S. based. As explained in greater detail in section 3.1.5, in the U.S. favorable conditions have arisen for the creation of the new spaceflight industry, and this has led to a head start over the rest of world

- *Average company size and heritage:* the companies listed above are relatively small start-ups (with the exception of *Scaled Composites*[5]) rather than large aerospace conglomerates. Part of the motivation for the low exposition from large aerospace market players may be found in the high inherent business risk of the newborn industry, which, as mentioned above, is founded upon innovative assets (SRVs) with high prospective operational risks in their first years of operations; it is indeed reasonable to assume that established incumbents (especially in the aviation field) would find the venture at this stage too risky for their brand equity integrity[6]

- *Financial backbone of the new industry:* 3 out of the 6 companies developing SRVs (and 3 out of 4 of the ones developing man-rated SRVs) were or still are largely backed by new-economy billionaires:

    - Paul Allen (*Microsoft*): Paul Allen financed ***Scaled Composites***, for the development of *SpaceShipOne* (up to the X-Prize winning flights)
    - John Carmack (*ID Software*): John Carmack, co-founder of the software house that became popular for the videogame series *Doom*, is the founder and lead engineer of ***Armadillo Aerospace***
    - Jeff Bezos (*Amazon*): Jeff Bezos is the founder of ***Blue Origin***

    The huge investable capital of those individuals provided the required financial nucleation point for the new ventures

- *Indirect large aerospace conglomerate involvement:* as mentioned above, no large player from the Aviation sector has currently a direct, significant stake in the newborn SRV industry. However, indirect involvement of large Military and Space sector players does exist: *Scaled Composites* is, since 2007, a fully-owned subsidiary of *Northrop Grumman*; *Sierra Nevada Corp.* supplies the engine to *Scaled Composites' SpaceshipTwo* vehicle.

It's important to mention here that the expected beginning of operations dates reported here are assumed on the basis of the public statements made by each company, and reiterated during the stakeholder consultation process. Those dates have been revised several times in the past 6 years: development schedules of man-rated SRVs have proven to be extremely challenging, with expected maiden flights' dates slipping several times.

[5] *Founded in 1982, Scaled Composites has a heritage in the development of experimental aircraft.*

[6] *Source of the data backing this assumption:* Stakeholder consultation.

Figure 3 – Man-rated SRVs expected to fly in the coming years

The test activities conducted so far by the four developers of man-rated SRVs provide, in a way, an indication of the proximity to operations:

1. *Scaled Composites/Virgin Galactic* conducted for *SpaceShipTwo* several captive flight tests, and several gliding tests, the last of which, at the end of 2012, was conducted with the engine mounted on-board of the SRV

2. *XCor Aerospace* conducted several tests on the engine and other subsystems. As of today, no flight test for the actual Lynx vehicle has been conducted

3. *Blue Origin* only divulged to the press the results of one failed short-hop VTVL test of a prototype vehicle[7]. Not much is known about current testing activities at the company

4. *Armadillo Aerospace* conducted Vertical Take-off, Parachute Landing tests on its unmanned vehicle STIG-A1, as well as VTVL tests on the Super MOD and QUAD vehicles

It is important to stress out, then, that **no manned suborbital test flight was conducted since the 2004 X-Prize winning performance of *Scaled Composites* with the *SpaceShipOne*[8].** Taking that into account, it's reasonable to assume the concrete possibility of further delays before commercial operations start.

3.1.2 Spaceports

Commercial spaceports are being considered and developed in many locations in evident expectation of sustained flight rates and global operations. These new infrastructures add up to the already existing spaceports used for SRV vehicles and sub-systems testing.

[7] Jeff Bezos – *Taking the long view* – The Economist (available at: http://www.economist.com/node/21548487 - Last retrieved on February 2013)

[8] *Source:* Stakeholder consultation.

Figure 4 shows the spaceports currently used for SRV vehicle testing, or currently in the planning stage, that will possibly be involved in Commercial human spaceflights in the near future:

- **Mojave Air and Space Port (U.S., California):** possibly the most prominent base for SRVs development and testing, with a long heritage on experimental aircraft testing, Mojave Air and Space Port hosts *Scaled Composites*, *XCor* and *Masten Space Systems* development and test facilities. Additionally, *The Spaceship Company*, the manufacturing company fully owned by *Virgin Galactic* that will serialize the production of *SpaceshipTwo*, is also based on the Spaceport premises.
  The Spaceport will possibly be a base for *XCor Lynx* commercial operations, as a back-up or supplement to Spaceport Curacao. The Spaceport is also a candidate for hosting Virgin Galactic operations, instead of, or in addition to, Spaceport America

- **Spaceport America (U.S., New Mexico):** The construction of this site was promoted by New Mexico state government, with public investment in excess of 200M$. Spaceport America is the site chosen by Virgin Galactic for its operations. At the end of 2012, negotiations were on-going between VG and New Mexico over state-level liability regimes with VG threatening to move operations elsewhere in case full liability protection was not given not only to the operator itself, but also to vehicle manufacturer and its suppliers. At the end of January 2013, an agreement was reached[9]

- **Spaceport Sweden (EU, Sweden):** Already used for sounding rockets suborbital launches, Spaceport Sweden, located in the northern location of Kiruna, has signed a preliminary agreement with Virgin Galactic to serve as its European pole of operations (although VG's operations over there are subjected to Sweden providing the required regulatory framework – possibly independently to the rest of Europe - and to VG obtaining an export licence clearance for *SpaceshipTwo*)

- **Spaceport Scotland (EU, UK):** A former RAF base in Lossiemouth, another possible location for Virgin Galactic's operations in Europe

- **Spaceport Curacao (Curacao):** The chosen site of operations for XCor through the European (NL) operator Space Expedition Corporation

- **Oklahoma Spaceport (U.S., Oklahoma):** This site was funded by Oklahoma state and was supposed to be the main operational site of *Rocketplane XP*, before the company filed for bankruptcy a few years ago

- **Spaceport Malaysia (Asia, Malaysia):** currently planned, supposed to serve as main operations' site for the European venture *TALIS Enterprise*

- **Singapore Spaceport:** Astrium plans to operate its space-plane from Singapore Changi Airport. Additionally, Singapore government has stated interest in opening up dedicated spaceport facilities next to Changi airport.

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[9] *NM Senate OKs liability limits for space companies*, 31 Jan 2013, CNCB (available at: http://www.cnbc.com/id/100423575/NM_Senate_OKs_liability_limits_for_space_companies - last retrieved: February 2013)

The list above is not meant to be exhaustive; it does include, however, the main sites associated with planned SRV operational activities in the medium term. Other locations being considered for spaceports include Spain (Barcelona), France (TBD), Germany (TBD), Alaska and Virginia (FAA has already issued licenses for spaceports in these two locations), Alabama, Colorado, Hawaii, Indiana, Washington, Wisconsin and Wyoming.
As already stated, among the sites mentioned above *Mojave Air and Space Port* has a special status as the site that hosted the first private manned suborbital flights in 2004 within the X-Prize context, and is, as of today, the largest site for development and testing for suborbital spaceflight, with a number of companies located within its premises and, overall, a total of 500 people working on space applications and testing.

The following general considerations can be made concerning existing and prospective spaceports:

- *Institutional support:* Most of the U.S. Spaceports have benefited from a certain degree of institutional support (at state level): the support was either financial (i.e. funding for site development/building) or fiscal (tax advantage). The rationale for local government supporting such initiatives lays in the **expected positive externalities** that can be realized for the local economies in case routine spaceflights operations are established at the sites. Such externalities are: tourism boost, creation of technology aggregation poles, positive outreach effect and promotion of technology careers. It is expected that similar institutional support will happen for other locations outside the U.S. as well

- *Location as a possible competitive differentiator:* given the current characteristics of the Experiential Spaceflight offering (around 200K ticket price, and need for a 1-week training before flight) the actual flight location does not have a significant logistics or cost impact on the overall experience. However, the location may still represent a value-added, and, therefore a differentiating factor, from the point of view of the customer experience: a big part of the flight value proposition is represented by the fact that passengers look forward to glancing the earth from the edge of space; therefore, being able to see a familiar country or continent partial outline (like Europe for European customers) may be seen as an important factor by prospective passengers

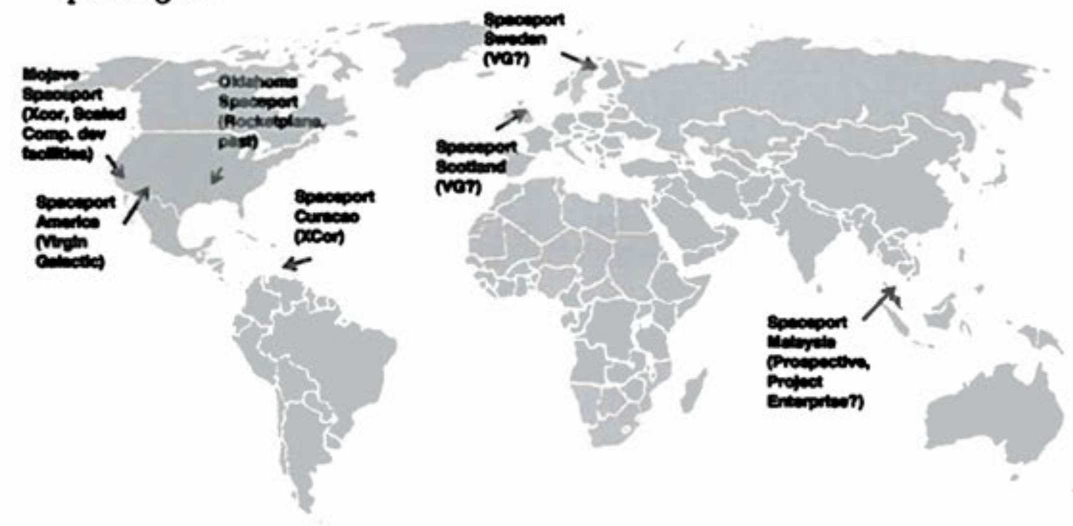

Figure 4 – Geographical distribution of the main spaceports associated to SRV vehicle testing and/or prospectively involved in commercial human spaceflights operations in the near future

3.1.3 Service Operators

While at the very onset of the industry there was not a clear distinction between vehicle producers and service operators (with developers intending, initially, to serve also as operators), with commercial operations becoming closer in time there has been a consolidation of a classic *manufacturer-operator* model akin to that of the aviation industry.

As of today, the offerings of 3 out of 4 of the prospective imminent vehicle developer's market entrants are channelled through service operators:

- The vehicle developed by *Scaled Composites* will be exclusively operated by *Virgin Galactic*

- *XCor* vehicle will be operated by the *Space Expedition Corporation* (which represent only the first of a series of expected operators leasing *XCor's Lynx* vehicle[10])

- *Armadillo Aerospace* vehicle will be operated by *Space Adventures*

Two different business models are currently in place for the operators above:

- *Vehicle Wet Leasing*: Wet leasing is a leasing arrangement inspired by the aviation sector; the vehicle producer provides the SRV and complete crew for operation and maintenance to the operator, which pays a yearly lease covering a given number of yearly flights. The operator provides fuel and covers spaceport fees, and any other taxes. **Wet leasing is the only leasing arrangement realistically allowed in the short term**, due to the strict export licence restrictions in place for SRV vehicles under ITAR regulations (wet lease effectively limits accessibility to sensitive technologies or systems in the vehicle for the lessee, since operations and maintenance are conducted by a crew provided by the manufacturer)
  Space Expedition Corporation (SXC) (NL, EU), will lease the *XCor Lynx Mk.I* and, later on, the *Lynx Mk.II* and operate them from Spaceport Curacao. *XCor*, who had started taking reservations for the Lynx before signing a deal with SXC, transferred all the reservations to SXC.
  Space Adventures (U.S.), after trying its own vehicle development (abandoned due to excessive required budget forecast) will wet lease, when available, *Armadillo Aerospace's Hyperion* vehicle

- *Vehicle Ownership (full manufacturing company ownership)*: *Scaled Composites* developed *SpaceshipTwo* within a joint venture company formed in 2005 with *Virgin Galactic*, *The Spaceship Company (TSC)*. While the first *WhiteknightTwo* carrier aircraft and the first *SpaceshipTwo* were built by *Scaled Composites*, *The Spaceship Company* has the mandate to produce the new units of both the carrier and the sub-orbiter. *Virgin Galactic* acquired 100% ownership of TSC in 2012, by acquiring the 30% stake still owned by *Scaled Composites*. As a result, VG will be the owner of the SRV used in its operations. In a way, the model *Virgin Galactic* put in place with *The Spaceship Company* (producing company fully owned by the operator) can be considered the specular of a typical business model in the aviation industry where the operator is usually a fully or partly owned subsidiary of the vehicle producer

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10 As of the report publication date, *XCor* was in talk with 6 prospective operators from the U.S., Europe and Asia, some of which had already secured enough capital (source: stakeholder consultation)

The business models described above could potentially be complemented in the future with additional models inspired by business aviation: an example would be the full or partial ownership of the operator by the vehicle manufacturers, a business arrangement that is being considered by some prospective new vehicle developers[11].

3.1.4 Insurance companies

The insurance industry has for many decades been involved in space, mostly in satellite launching activities, with insurance of spacecraft and liability insurance (including third-party liability and product liability). The insurance sector (including European players), is getting prepared to offer specific products to the new commercial suborbital spaceflight industry; both manufacturers/operators and individual spaceflight participants represent potentially lucrative target segments:

- ***Insurance for manufacturers/operators:*** The FAA-AST (Federal Aviation Authority Office of Commercial Space Transportation) 2004 amendment to the 1984 Commercial Space Launch Act, which addressed the regulation of commercial suborbital spaceflight (see section 3.5 for a detailed description of the regulatory regime put in place by the FAA-AST in the U.S. for SRV), also posed as a requirements for human spaceflight vehicles manufacturers and operators to take out liability insurance for any damage to third parties (i.e. parties not involved with the flight). Such insurance must include within its coverage also contractors and subcontractors of the spaceflight manufacturer and operator. The U.S. federal government provides potential indemnification for third party liability in excess of the insured amount (i.e. liability which surpasses the amount of insurance or demonstration of financial responsibility but does not exceed US$ 2.5 billion)

- ***Insurance for spaceflight participants:*** spaceflight participants are not, by U.S. Law (in Europe no regulation for SRV exists as of yet) required to be covered by an insurance policy, and therefore, commercial operators initially may leave spaceflight participants the choice about the opportunity of a personal insurance. In the short term, however, it is expected that most spaceflight participants, being High Net Worth Individuals, would choose to have a personal insurance, while in the medium term it's reasonable to assume that operators could consider pricing models including insurance to their spaceflight participants as an option.

Therefore, we may assume insurance companies as transversal players that will eventually operate along the entire value chain.

Insurances premiums are possibly going to be very high at the beginning, until companies demonstrate a safe flight track record[12]. Safety concern may even annihilate the interest of the insurance sector for human commercial suborbital spaceflight altogether, should flight failures - whether by one or several operators - occur in the early stages of the new industry: in order to make sustainable the insurance for SRV flight, risk reduction, regulation and clear liability sharing are seen as pivotal.
In the medium term, it's likely that insurance premiums will vary depending on the specific regulatory regime in place (see table 5 in section 3.5.2: with stricter safety requirements imposed by regulation, the risk premium from insurances is supposed to decrease).

[11] Data for this statement coming from the stakeholder consultation

[12] *Space Tourism Insurance to Be Expensive* – Space.com (available at http://www.space.com/4937-space-tourism-insurance-expensive.html - Last retrieved on February 2013)

3.1.5 Competitive Dynamics

At this early stage in the new industry's lifecycle, with no actual commercial operations yet, the competitive dynamics within the segments of its value chain can only be characterized in its main expected features.

A few points, as a matter of fact, can be raised on the expected product offering and pricing and how that can possible affect competitive strategy: most of those points are directly dependent upon the vehicle concept being used.

The main differentiating factors and, therefore, the main related competitive advantages, are possibly going to be[13]:

- *Ticket price*
- *Real and perceived safety of flight*
- *Comfort*
- *Completeness of the experience* (altitude, duration, quality of the microgravity experienced, conviviality and sharing factor in the experience)

Most of the competitive factors listed above relay on the actual type of vehicle used to deliver the market offering, which is, in turn, differentiated by:

- *Vehicle concept*: the concept type is going to affect actual and perceived safety, as well as comfort
- *Vehicle size and operational capabilities*: the size of the vehicle, or, more specifically, the number of passengers it can host, and its operational capabilities are going to impact the ticket price, the comfort, and the completeness of the experience

3 different vehicle concepts are expected on the market in the medium term:

1. *Air Launched [Horizontal Take-off via Carrier Aircraft], Horizontal Landing* (ALHL): this is the concept developed by *Virgin Galactic*
2. *Horizontal Take-off, Horizontal Landing* (HTHL): an example is the *XCor Lynx* vehicle, as well as the failed *Rocketplane XP* concept and the EADS Astrium proposed Space-plane. Those two are further differentiated by their propulsion configuration, which affects factors like environmental impact and their space-port operational needs:

    - *XCor's Lynx* is equipped with a single liquid rocket engine, used for the whole duration of the flight
    - EADS-Astrium concept (and the failed Rocketplane XP concept) involves a jet engine for take-off and a rocket engine ignited at high altitude to reach suborbital height

3. *Vertical Take-off, Vertical Landing* (VTVL): an example is represented by *Armadillo Aerospace's Hyperion* vehicle, or *Blue Origin's Shepard*

Each of the concepts above is expected, in turn, to be differentiated by each vehicle developer through the adoption of varying (and proprietary) design and technical solutions (including

[13] The factors listed here were found to be the main demand drivers in the IPSOS/Astrium market research study (see section 3.4)

different vehicle sizes and related capacity in terms of paying passengers) to achieve the desired level of safety and the desired operational capabilities. As of today, it's not clear what the implications of the different concepts being developed are on factors like **safety** (robustness of the concept) and **comfort** (level of G factors, number of axis of motions of the vehicle and its effects on the passengers' comfort).

In terms of vehicle size and operational capabilities, as of now vehicles capable of hosting from 1 to 6 paying participants are being developed, while little is certain about the actual vehicles turnaround time, expected to be measured in flights/week for at least the first 2 years of operations. Concepts expected in the medium term have differentiating attributes like:

- Expected end-user ticket price for profitable operations ranging from \$95,000 to \$200,000
- Capacity ranging from 1 to 5/6 paying passengers
- Expected vehicle turnaround of 1 flight/week to 5 flights/week
- Experience proposed varying from buckled vs. free floating microgravity phase, and passenger group experience vs. co-pilot experience

It's difficult to predict how the competitive scene will evolve at this stage. Possible scenarios may include the emergence of a single dominant design solution offering the best balance of user satisfaction versus operational efficiency, or the consolidation of different product offering catering to a premium segment (with maximized user satisfaction) and a Low cost SRV experience (maximizing efficiency).

Jet carrier-aircraft, rocket-powered suborbital vehicle (for ex. Scaled Composites/Virgin Galactic)

Horizontal-takeoff, horizontal-landing (HTHL) (for ex. XCor Lynx vehicle)

Vertical take-off, vertical landing (for ex. Armadillo Aerospace, Blue Origin)

Figure 5 – The three main vehicle concepts under development

3.1.6 External Factors

Favorable external conditions and a strong heritage of technical resources may be considered at the base of the birth of the industry in the U.S. The main factors that led to the current suborbital industry can be summarized, in chronological order of occurrence, as follows (Figure 6):

1. *Build-up of a critical mass of key technologies and human resources:* since the dawn of the space age in the late 50s and 60s, the US aerospace industry has been at the forefront of any relevant technological advancement in space. Along the years, a sizeable pool of resources was amassed both in the government and the private sector. Key technologies for access to space are accessible on the market from multiple sources in the US, and so is a significant human capital in the field

2. *Private capital:* In the late 90s, many wealthy investors with an enthusiasm for space endeavors poured capital into the nascent commercial space industry. Many of those came from the new economy, and had huge disposable personal capital to invest in these new ventures

3. *Commercial Space Race:* In the late 90s, the Ansari X-prize spurred interest and fostered fast-paced development. After the Ansari X-Prize victory by Scaled Composites in 2004, *the X-Prize Foundation*, together with the state of New Mexico, has continued to spur interest in rocketry with the X Prize Cup, an Air & Space Expo that hosts different events and demonstrations: a particularly notable example is the Lunar Lander Challenge held in 2009

4. *Quick institutional acknowledgement of the commercial relevance of the new industry:* right after the X-Prize, FAA-AST produced the Commercial Space Launch Amendments Act in 2004, regulating commercial suborbital spaceflight with a licensing approach, requiring informed consent of paying participants and allowing the newly born vehicle developments to plan an easy access to market

5. *Federal grants and support:* Several contracts were awarded by both NASA and U.S. Air Force to incumbents like *Virgin Galactic*, *Xcor*, and *Blue Origin* (for example, NASA committed US$22 million of funding to *Blue Origin* under the *CCDev phase 2* programme in April 2011). Moreover, use of NASA and Air Force facilities for testing (for ex. wind tunnel tests for free) was allowed for free, in exchange for the test data. Finally, the support and interaction has so far been two-sided, since other than providing funding and grants, federal agencies also provide for commercial opportunities: both *Virgin Galactic* and *XCor* have submitted their vehicle as reusable launch vehicle for carrying research payloads in response to NASA's suborbital reusable launch vehicle (sRLV) solicitation, which is a part of NASA's Flight Opportunities Program

6. *State level support:* Several state governments issued grants and promoted tax benefits for new commercial space ventures (for ex. Texas state attracted a new R&D facility from *XCor*, Oklahoma state funded development of the now bankrupt *Rocketplane XP*

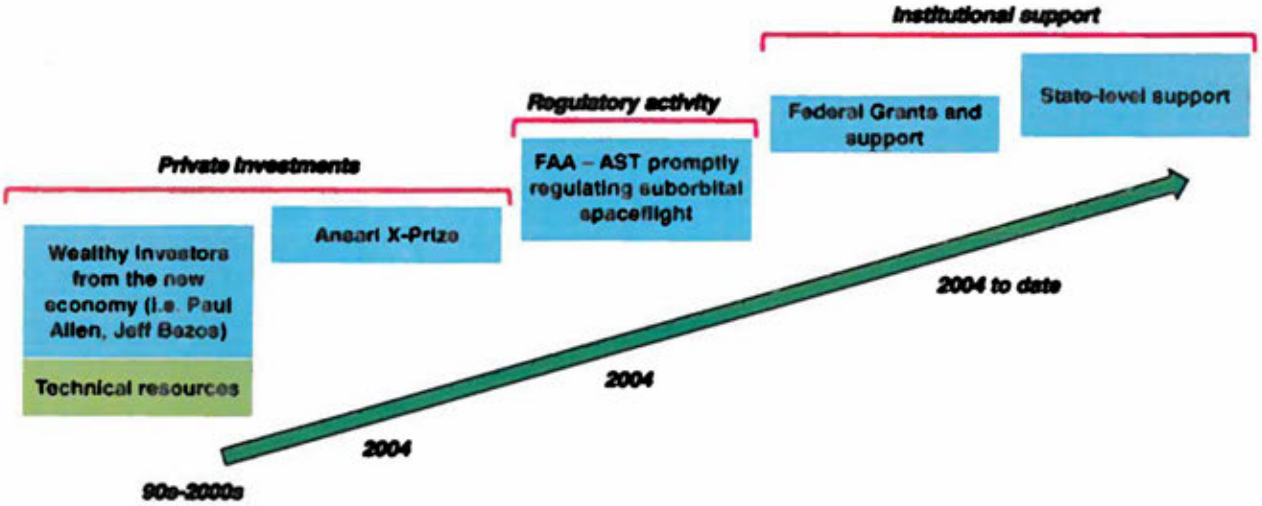

Figure 6 – Factors behind the fast-paced development of the commercial suborbital spaceflight industry

3.2 EUROPEAN SCENARIO

The European commercial spaceflight industry is, at present, less developed when compared to the U.S. As in the previous sections, a distinction can be made for the 3 main segment of the value chain.

3.2.1 Vehicle developers

According to publicly available information, there is no European company with a SRV in an advanced development stage. Several companies, though, have development plans at varying stages of progress. Those include:

- *EADS – Astrium (FR-DE-UK-ES):* Since 2006, Astrium has in its development plans a HTHL business jet-sized space-plane able to carry four passengers up to an altitude of 100 Km. The space-plane is supposed to take off and land conventionally from a standard airport runway using jet engines, and to reach suborbital altitude using a rocket engine. The company is currently in the process of gathering capital to move into actual development. In 2012, Astrium signed a deal with a Singapore-based company (*Hope Technik*)[14] for the development of scaled demonstrator (a flying test-bed to test aerodynamics and GNC that will be dropped from a helicopter and perform a gliding test). This reinforces Astrium ties with Singapore on this project, as it adds up to the desire of the European manufacturer to operate a fleet of space-planes from Singapore's Changi Airport
- *Copenhagen Suborbitals (DEN):* a not-for-profit organization that is developing a Vertical Take-off, Parachute Landing concept (VTPL), comprising a suborbital capsule called *Tycho Brahe*, and a suborbital rocket launcher dubbed Heat 1-X. Copenhagen Suborbital is based entirely on private donators and sponsors and enrolls the work of part time specialists, with the intent to share as much as possible technical information on their development with any interested parties, within the limits of EU export control regulations[15]
- *S3 (CH): Swiss Space Systems Holding SA (S3)* is a company founded in 2012 and headquartered in Switzerland that has the objective to develop, manufacture, certify and operate suborbital spaceships to launch small satellites up to 250kg in orbit and to perform passengers flights (no additional details available to the public by February 18th 2013)
- *TALIS Enterprise (DE): TALIS Enterprise* is a German company that is advertising its work in a consortium of 5 prominent and leading European technology companies and institutions to develop two rocket-powered aircraft. The first aircraft *Black Sky* is expected to be a manned rocket plane for experimental edge of space flights and is supposed be the prototype of the final suborbital space-plane *Enterprise*, able to carry a greater cargo and more passengers to an altitude of 130 Km. *TALIS Enterprise's* partners include, among others, the *Swiss Propulsion Laboratory* (SPL), the University of Zurich, and the German branch of the space consultancy VEGA

[14] *Wind beneath HOPE's wings* (available at: http://www.eng.nus.edu.sg/ero/news/index.php?id=1122, last retrieved on February 2013)

[15] Source: *Copenhagen Suborbitals mission statement* (available at: http://www.copenhagensuborbitals.com/mission.php - last retrieved on February 2013)

- *Dassault Aviation (FR):* has conceptual studies for a suborbital manned vehicle called Vehra (Vehicule Hypersonique Réutilisable Aéroporté) Suborbital Habité (VSH) based on the canceled NASA X-38 and ESA Hermes studies from the '90s. The project is still alive, and the company is approached by potential operators of such a vehicle, but the actual state of development (if any development is ongoing) is not publicly known
- *Booster Space Industries (BE):* is developing an ALHL sub-orbital space-plane for manned and cargo flights

Of all the European companies involved, **only Copenhagen Suborbitals released test flight information** about a test launch of its Heat 1-X rocket conducted in 2012 from their launch site (a platform out in the Baltic Sea)[16]

3.2.2 Air/Space Ports

One commercial spaceport is already active in Europe and several others are being considered. Those include:

- *Spaceport Sweden Kiruna:* already active as commercial spaceport and used for sounding rockets but currently lacking touristic infrastructure, the spaceport Sweden has an advance non-binding agreement with *Virgin Galactic* for operations of the *SpaceShipTwo*
- *Spaceport Scotland* (prospective): Spaceport Scotland is, as of now, an initiative to stimulate interest in the possible use of a Scottish location for the UK's first commercial operational spaceport, intended to serve for satellite launches as well as commercial human spaceflight. The RAF Lossiemouth airbase in Scotland was identified as candidate location thanks to its being conveniently placed for polar orbit satellite launch
- *Northern Ireland/South West of England* (prospective): Northern Ireland or South West of England represent two alternative locations suggested by the UK Institute of Directors (IoD) as potential sites for a UK Spaceport (a facilities deemed strategic for the space sector in the UK[17], and bound to bring economic development and technology site aggregation)
- *Barcelona* (prospective): The Aerospace Cluster of Catalonia (BAIE) is promoting the region (and, in particular, the surroundings of Barcelona) as a location for a commercial spaceport[18]. As of a few years ago, the BAIE had achieved a generalization of the Catalan General Airports Plan to allow the use of airfields and airports also for space activities, and was actively pursuing lobbying and outreach activities to spread awareness on Commercial Spaceflight in the region

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16 *Danish Rocketeers Launch Private Space Capsule Escape System Test* – Space.com (available at http://www.space.com/17094-private-space-capsule-test-copenhagen-suborbitals.html - Last retrieved on February 2013)

17 Dan Lewis, *Space: Britain's New Infrastructure Frontier*, May 2012 (downloadable from: http://www.iod.com/mainwebsite/resources/document/space-britains-new-infrastructure-frontier-may12.pdf - Last retrieved on February 2012)

18 Gloria Garcia-Cuadrado, *Spaceport Challenges & Milestones* - International Symposium on Private and Commercial Spaceflight, 20-21 October, 2010 New Mexico (available at: http://www.ispcs.com/files/ww/files/presentations/cuadrado.pdf - Last retrieved on February 2013)

- *France (location TBD) and Germany (location TBD)*: initiatives for European spaceports in France and Germany were signaled by EASA[19]. Not much information is available on the development of those endeavors

The interest demonstrated by regional government on spaceport initiatives shows that the strategic importance of those facilities for the local development is well understood. The potential for technology aggregation, high education in science and technology, and, more simply, touristic development motivates what appears to be a race towards being first in the line with a European facility for Commercial Spaceflight.

3.2.3 Operators

Of the 3 major operators, two, *Virgin Galactic* and Space Expedition Corporation, are European:

- *Virgin Galactic* (US-UK): VG's offices are based in the U.S. (in Washington, Mojave, Spaceport America and Pasadena). However, the company is part of Virgin Group Ltd., a British multinational company
- *Space Expedition Corporation* (SXC) (NL): The Company was established in 2008 and is based in Amsterdam, The Netherlands and on the Island of Curacao in the Caribbean. In July 2012, *XCOR* named SXC as the new General Sales Agent (GSA) for the Lynx vehicle[20] (SXC was previously announced as the first wet lease customer for a Lynx production vehicle with planned flights from Curacao). As GSA, SXC has the responsibility for ticket sales and for astronaut training and relations for XCOR Lynx flights. Like already mentioned for some U.S. company, SXC is backed by entrepreneurs of new economy extraction
- *Cosmica Spacelines* (FR): a small operator currently in the process of securing capital to lease, when available, the Lynx XCor vehicle. *Cosmica* plans to offer customers repeat flights through membership to *Cosmica Elite*, a spaceflight club

Several other prospective European operators are reportedly in the process of securing capital and of approaching U.S. vehicle manufacturers (and/or prospective European vehicle developers)[21], a fact that shows entrepreneurial interest arising in Europe within the sector.

3.2.4 External factors in Europe

The European scenario, while not exhibiting the same level of advancement of the U.S. one on SRV development, shows a rising interest from investors, companies, and local government. The external conditions in Europe, however, differ from the U.S. in a few critical areas:

- **Institutional support**: while the U.S. has institutionally supported the industry at various levels from its inception, EU has not officially asserted the strategic nature of

[19] *Source: Stakeholder consultation*

[20] Press release: *XCOR Aerospace Announces Space Expedition Corporation (SXC) As General Sales Agent For Space Tourism Flights* – July 12th, 2012 (available online at http://www.xcor.com/press-releases/2012/12-06-07_XCOR_announces_SXC_as_general_sales_agent.html - Last retrieved on February 2013)

[21] Source: Stakeholder consultation

suborbital spaceflight for its competitiveness; on the other hand, some EU-level declarations went in the opposite direction of declaring commercial suborbital spaceflight as a luxury activity for rich people, something EU would not support with taxpayer's money. Even at national level, the support given to prospective vehicle developers has been limited. This lack of acknowledged support may possibly undermine private investors' confidence and make the gap between plan and execution more difficult to bridge

- **Regulatory environment:** As of today, no clear regulatory position exists at EU level. This impact the commercial spaceflight market on two levels: it affects vehicle development plans (as the design of a new vehicle is tied to the regulatory framework in which it has, ultimately, to operate) and the related supporting private investments outlook; it impacts on possible operations of American-developed vehicles in Europe, as the uncertainty in the near future evolution of the regulatory scene on the matters increases the financial risk of any adaptation required to comply to the currently standing national space laws (where available). A more detailed account of the regulatory scene in the U.S. and Europe, and its implications for the market is reported in section 3.5

3.2.5 U.S. Export policies issues: implications for Europe

The most immediate way to have Commercial Spaceflight Operations in Europe would come from the possibility for US-developed vehicles to be operated from European spaceports, either by U.S. operators or by European operators via a wet-lease arrangement. For this to happen, U.S. vehicle manufacturers would require export clearance, and, since all US-developed vehicles fall within the International Traffic in Arms Regulation (ITAR), concrete difficulties may arise.

Together with the U.S. Arms Export Control Act, ITAR has in fact a direct policy impact on the upstream commercial spaceflight value chain, affecting the possibility for U.S. SRV manufacturers to sell or wet-lease their vehicles to foreign countries. Both those regulations aim to control the export of defence-related products and services as listed on the United States Munitions List (USML) in order to safeguard U.S. national security and further U.S. foreign policy objectives. While it may be argued that a 100% commercial suborbital vehicle should not be prone to ITAR, it's a fact that the technologies entailed by these systems have a strong dual-use character, may readily be used in a military system as well; moreover:

- The transfer of knowledge and technology between the US government and commercial players happening in this early stage of the commercial spaceflight industry is expected to continue, since, for example, the future developments of the unmanned orbital space-plane *Boeing X-37 OTV* into a manned 6-crew converge strongly with the plans of *Virgin Galactic* to scale their systems up into orbital space-planes with the next generation(s)

- Companies with ties to the military sectors like *Northrop Grumman* (100% owner of *Scaled Composites*) and *Sierra Nevada Corporation* (prime contractor for the engine of *SpaceShipTwo*) have currently a stake in the commercial spaceflight market

Given these connections with the military sector, it is expected that space-plane technologies will remain under the grip of ITAR at least in the short term.

On the long run, this might open up a technology export opportunity for European companies similar to the Sat-Com sector. There, the US made ITAR applicable to satellites, and satellite components, triggering the European satellite industry to develop "ITAR-free" communication satellites to gain an independency from US-regulated products, thereby ensuring/improving its access to specific markets. As a result of the increased European and global competition in the Sat-Com business (and pushed by Satellite industry organizations such as the Aerospace Industries Association and the Satellite Industry Association), recently the U.S. congress relaxed Satellite ITAR regulations to allow U.S. satellite and satellite component manufacturers to compete globally[22]. The implications that can be drawn from the Satellite market case seem to suggest that the congress would not feel appropriate to lift ITAR regulations on SRV until the following occurs:

a) A significant global market develops
b) EU SRV developers/manufacturers threaten to cut U.S. industry out of the global market

It's possible to conclude that a relaxation of ITAR rules for SRVs is not expected in the short term. U.S. SRV manufacturers appear to be, however, confident to get export licences for operations outside of the U.S., at least under wet-lease arrangements: wet-lease is supposed to limit technology exposure to non-U.S. personnel and technicians, thus possibly making an export licence easier to obtain[23].

3.2.6 European scenario – Summary

The current European scene retains some peculiarities and hurdles with respect to the U.S. one:

- Suborbital vehicle development in Europe is still in its preliminary stages. Among the European companies with SRV plans, *EADS-Astrium* and *Dassault Aviation* stand out for their size and heritage. The concepts proposed by those two companies retain an aviation-like approach to safety (the two companies see certification by an aviation authority as a *conditio sine qua non* to reach the market), understandable in view of the need of those companies to protect their brand equity and their core aviation (and space) business. The publicly declared involvement/interest of *Astrium* and *Dassault* is in stark contrast with the American development scene, where no large aerospace corporation have publicly declared to be interested in commercial suborbital spaceflight
- Operations in Europe by U.S. developed vehicles may be hindered by U.S. Export control regulations
- Europe lacks so far institutional support on commercial spaceflight. At European Union level, the issue is twofold: 1) EU has never stated any strategic interest on commercial spaceflight; 2) there is a lack of regulatory clarity at EU-level, which may hinder both SRV development plans and the possibility to have operations in the European airspace, a deficiency that ought to be fixed in order for the market potential to fully develop

The above hurdles notwithstanding, the companies with development plans, and the number of prospective operators, together with the plans of several local governments to

[22] *U.S. Congress Relaxes Satellite ITAR Regulations*, December 26, 2012, Satellite Today (available at http://www.satellitetoday.com/ifc/U-S-Congress-Relaxes-Satellite-ITAR-Regulations_40316.html - Last retrieved on February 2013)

[23] Source: Stakeholder consultation

develop spaceports' infrastructure, show the level of interest that commercial spaceflight is gathering in Europe[24], and, consequently, the need for institutional actions capable of supporting the new market.

3.3 TECHNOLOGY GAP ASSESSMENT

Commercial suborbital spaceflight requires critical technological development mainly along three axes, as depicted in table 3.

	Guidance, Navigation and Control (GNC)	Propulsion Systems	Structures
Description	GNC deals with the design of systems to control the movement of vehicles (cars/ships/spacecraft)	Propulsion systems provide for the thrust of a spacecraft	Structures provide for mechanical stability aerodynamic features
Associated Items	**Guidance:** Trajectory **Navigation:** Location/Velocity **Control:** Manipulation of acting forces	Liquid rocket engines Hybrid rocket engines Rocket propellants Control units, tanks, etc.	Aerodynamic loads Fuselage Wings Control surfaces
Challenges	Human reaction time is too slow for high speed vehicles (rocket-powered vehicles)	I_{sp} vs. thrust Storability Reusability Reliability Control	Metals vs. composites ⇒ specific properties/functional properties/fatigue behaviour/reparability
Relevant Commercial and Non-commercial applicable on-going Projects	**ULA, P&WR, NASTAR, etc.:** Emergency Detection System (EDS) for ATLAS V & Delta IV; Initial Testing completed in '10	**Aerojet:** LOX/RP-1 engine LOX/CH$_4$ engine LH$_2$ Turbo pump	**XCOR - Lynx:** All-composite airframe; successful wind tunnel tests in 2010 at MSFC
	NASA, USAF, DARPA: Autonomous Flight Safety System (AFSS), centred on cost reduction of range safety; latest test on a Terrier-Orion sounding rocket	**Sierra Nevada Corp.:** Liquid/solid hybrid rocket motor for its Dream Chaser orbital space plane plus SS2's RocketMotorTwo	**Scaled Composites:** All-composite airframe; successful captive carry tests in 2010 and 2011
	NASA, SpaceX: ISS & Dragon Ultra-High Com Unit (CUCU)		

Table 3 – Overview of main critical technologies

[24] This is also testified by additional European entrepreneurial initiatives in orbital spaceflight like *Excalibur Almaz* based on the Isle of Man

Guidance, navigation and control (GNC), propulsion systems, and structures are essential to enable Suborbital Reusable Vehicles (SRV) to be operated both in a safe and commercially successful manner:

- **GNC:** Although an SRV does not experience velocities comparable to an orbital rocket (a SRV will fly at maximum 1-2 Km/s, compared with 8 Km/s for a rocket), the human reaction time is too slow at these speeds for full control. Therefore the pilot is supported or even replaced by a dedicated GNC computer. Additionally, the control mechanisms for the stratosphere cannot rely on aviation legacy control surfaces, requiring, on the other hand, a different technological solution. Given the need to operate SRVs in flight envelopes that blend aviation regime and space regime, it's easy to realize how critical GNC is in suborbital spaceflight
- **Propulsion:** propulsion systems come in numerous fashions; as solid, liquid, hybrid concepts and recently as air-breathing scramjet variants. The various concepts have one thing in common; their strategic importance, due to their possible use on Intercontinental Ballistic Missile (ICBM) and/or orbital rockets; the more efficient the engine, the higher mass the payload, be it a warhead, a satellite or a passenger. Given its military importance, most developments in the USA are connected to military programmes or involve government-related entities. On the specific SRV application, given the need for reusability and ignition control, only liquid and (partially) hybrid rocket engines are applicable. This leaves out solid rocket motors, while air-breathing engines are too far along the line to be applicable within the current generation of SRV
- **Materials and structures:** High performance materials allows for considerable mass savings, thus increasing the system's payload capabilities. A proper structural design complements and enhances the use of the proper material, and provides the vehicle with mechanical stability while allowing the fulfilment of the required aerodynamic performances. As SRVs do not reach orbital velocities, their return into the Earth's atmosphere does not inflict high temperatures on their airframe, hence SRV concepts do not rely on a heat shield. Still, there are temperature variances to be taken into account; from -80°C within the stratosphere up to 100°C or more during re-entry, largely dependent on the flight profile. The low temperature range allows the utilisation of polymer-based, carbon-reinforced composite materials, with all their benefits in terms of high specific properties. Given the increased utilisation of composite materials in the aviation sector, there is a great technology transfer potential to be utilised once the SRV market has established itself

The U.S. aerospace industry masters relevant technologies in all 3 macro-areas listed above, and, with the *SpaceShipOne* flight in 2004 and the expected flights of *SpaceShipTwo* and of *XCor's Lynx*, they will soon reach a very high system readiness level, and an operational proficiency. As for Europe, the following considerations can be made on the TRLs in those key areas:

- **GNC:** while it is not easy to assess the TRL of relevant GNC technologies and systems in Europe, it is reasonable to assume access to technology at a proper state of advancement (mission analysis and flight profile, guidance, software at a high TRL, flight control and surfaces TRL may be lower on account of the specificity of the SRV application requirements)

- **Propulsion:** Europe plans on investing in LOX/LHC liquid propulsion at institutional level[25] and mentions of industrial investments in the same area can also be made (although the TRL at industrial level it's not in the public domain). However, for this technological area, a lower level of access to technology and a markedly lower overall TRL can be possibly assumed for Europe with respect to the U.S. (where this technology is, for example, mastered by *XCor*)
- **Materials:** Europe masters advanced materials processing and advanced structural design, thanks to a strong technical and industrial footprint in the aviation and military service. No significant technological gap is expected in this area

Concerning the U.S. vantage point with respect to Europe, it's worth pointing out that:

- The U.S. lead is mostly an effect of the head-start of the American industry, which, as already largely mentioned, benefitted from significant venture capital injections and governmental support starting from the kick-start of the Ansari X-Prize in 1996. The prize called for the competitors, "to build and launch a spacecraft capable of carrying three people to 100 kilometres above the Earth's surface, twice within two weeks". The prize was claimed in 2004[26] and up to then US$100 million had been invested along the way in new technologies in its pursuit

- As of today it is mostly just *Scaled Composites/Virgin Galactic* and *XCor* that provide the U.S. lead: *Scaled Composites* masters airframe and control surfaces/mechanisms construction whereas *XCor* masters propulsion (reusable and re-ignitable liquid propulsion). Other U.S. competitors mentioned in the previous sections (*Armadillo Aerospace, Blue Origin*) are pursuing new developments and innovative approaches as much technical as operational

In conclusion, while the U.S. retains a significant technological lead, it is reasonable to believe Europe capable of bridging the current gap with the U.S., the key for that being an appropriate resource commitment in developing SRV systems.

[25] *LYRA: VEGA evolution* – Italian Space Agency (available at: http://www.asi.it/en/activity/transportation/lyra - Last retrieved February 2013)

[26] Relying on several rich donors, among which was Microsoft so-founder Paul Allen, the final winner was the Tier One project with the experimental space plane *SpaceShipOne*.

3.4 MARKET ASSESSMENT

A market assessment was conducted by using publicly available data sources. In the next sub-sections, a demand analysis (conducted on the basis of 3 published market reports), and supply analysis are presented.

3.4.1 Demand analysis

Three publicly available market studies were retrieved and critically analysed, together with advance reservation sales data provided by operators, in order to derive a consolidated picture of the expected demand for commercial suborbital spaceflight and of the main expected demand drivers.

The three studies analysed are:

- *IPSOS/Astrium*: a study conducted by the market research company IPSOS under contract from EADS-Astrium. The study was conducted in 2007, and updated in 2010 to account for the changed world economy outlook after the Global Financial Crisis. The study was never made fully publicly available. A limited set of the study results were published in 2011[27]

- *The Tauri Group/FAA-AST:* the study was released in September 2012, and is publicly available on the FAA website

- *A study on Space Tourism in India, conducted by the University of Petroleum and Energy Studies, Dehradun, India*[28]: the study published in 2010 includes a demand assessment on the Indian market

Table 4 shows the main features of the three studies.

The IPSOS study was conducted through qualitative and quantitative primary research, performed via face-to-face interviews and online surveys to a sample of High Net Worth Individuals (HNWI) selected from Europe, the U.S. and Asia. A net worth range was considered, and a different probability (willingness) to take on the trip was assumed for different income sub-ranges.
The offer pitched to the survey respondent proposed an experience characterized by "safety and comfort comparable to first-class airline flight".
6 scenarios differentiated by the ticket price trend in time were assumed. Figure 10 shows the yearly predicted demand in 2 of the analysed scenarios: scenario 1 assumes stable ticket price, while scenario 2 assumes ticket price decreasing in time (details on the ticket price scenarios were not published).
The study predicts a significant demand in both scenarios, with a marked dependence on ticket price evolution. The results show, even in case of stable ticket price in line with current estimates, a sizeable demand building up in the 15 years after the assumed start of commercial operations.

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27 *[1]* T. Le Goff, A. Moreau, *Astrium suborbital spaceplane project - Demand analysis of the suborbital space tourism, 3rd International ARA Days, Arcachon, France, May 2011*

28 *[2] Space Tourism in India* – available at http://cas.upes.ac.in/pdf/Research.pdf (last retrieved: January 2013)

Study	Year	Methodology	Addressable demand calculation assumptions	Geographical markets surveyed	Scenarios analysed
IPSOS/ Astrium	2007-2010 (the study, conducted in 2007, was updated in 2010 to account for the changed economy status after the GFC	- Qualitative and quantitative primary research - Online survey and F2F interviews	A net worth range was considered, and a different probability (willingness) to take on the trip was assumed for different income sub-ranges	- US - Europe - Asia	6 scenarios differentiated by the ticket price trend in time
Tauri Group/ FAA-AST	2012	- Qualitative and quantitative primary - Research Online survey	A 5M$ threshold in investable assets was chosen to identify the high net worth individuals' population	- US (data extrapolated for other regions)	- 1 constant ticket price over the next 10 years (120K$, average of current prices) - 3 growth scenarios based on prospective economic conditions
Space Tourism in India	2010	Quantitative primary research (only 15 responses obtained, remaining sample base response extrapolated) Survey	The number of HNWI with disposable net worth >1M$ was assumed as the potential user base	India	1 scenario characterized by decreasing ticket price

Table 4 – Main features of the two demand analysis studies examined

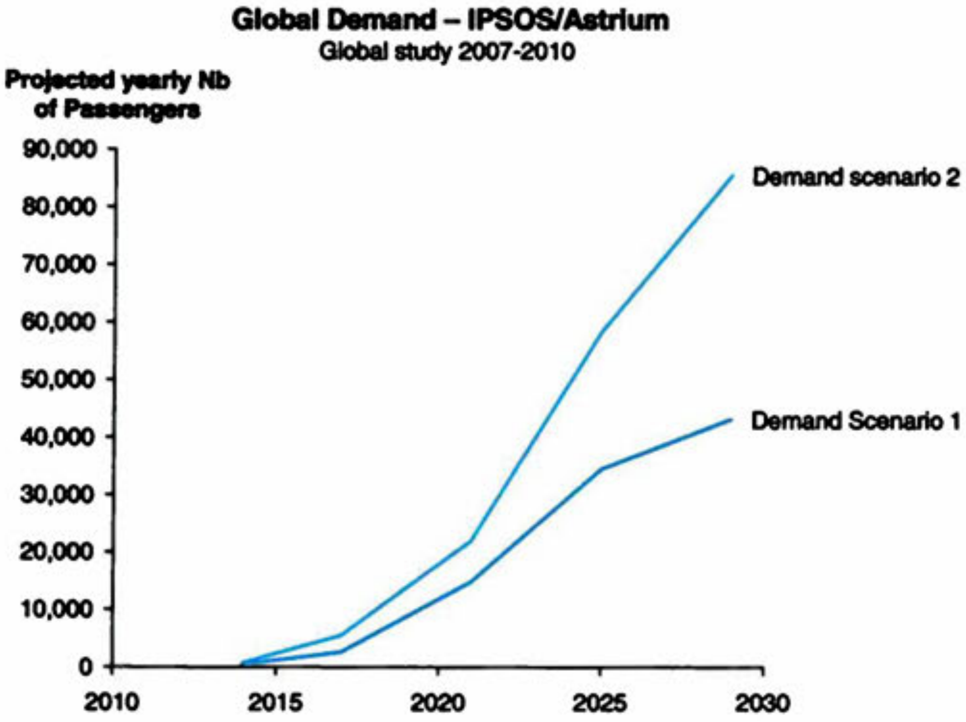

Figure 7 – Yearly predicted demand in 2 of the 6 scenarios analysed in the IPSOS study

The Tauri Group study was conducted through online surveys, on a sample of HNWI from the U.S. The HNWI sample was selected among individuals with a high net worth in excess of 10MUSD. Results were then extrapolated for the rest of the world. Within this survey, an informed consent flight regime was presented to the respondents.

The study assumed stable ticket price equal to an average of the current advance prices (around 120,000 USD), and 3 demand scenarios, differentiated by the possible political and economic environment:

- *Demand scenario 1:* environment of dramatic reduction in spending compared to today, due, for example, to worsened global economy
- *Demand scenario 2:* predictable political and economic environment
- *Demand scenario 3:* Growth, reflecting new dynamics emerging from marketing, branding, and research successes

The results show demand numbers that are significantly lower than those produced by the IPSOS study (of as much as 2 orders of magnitude in the pessimistic case). The difference is possibly explainable considering the different sampling choice between the two studies, as well as, possibly, with a different type of offer (in terms of safety and comfort) pitched to the respondents.

The Tauri study estimated also the market for other possible sub-segments (for ex. Scientific research): the study concluded that manned flight is going to be, by a wide margin, the major revenue driver for commercial suborbital spaceflight in the next 10 years.

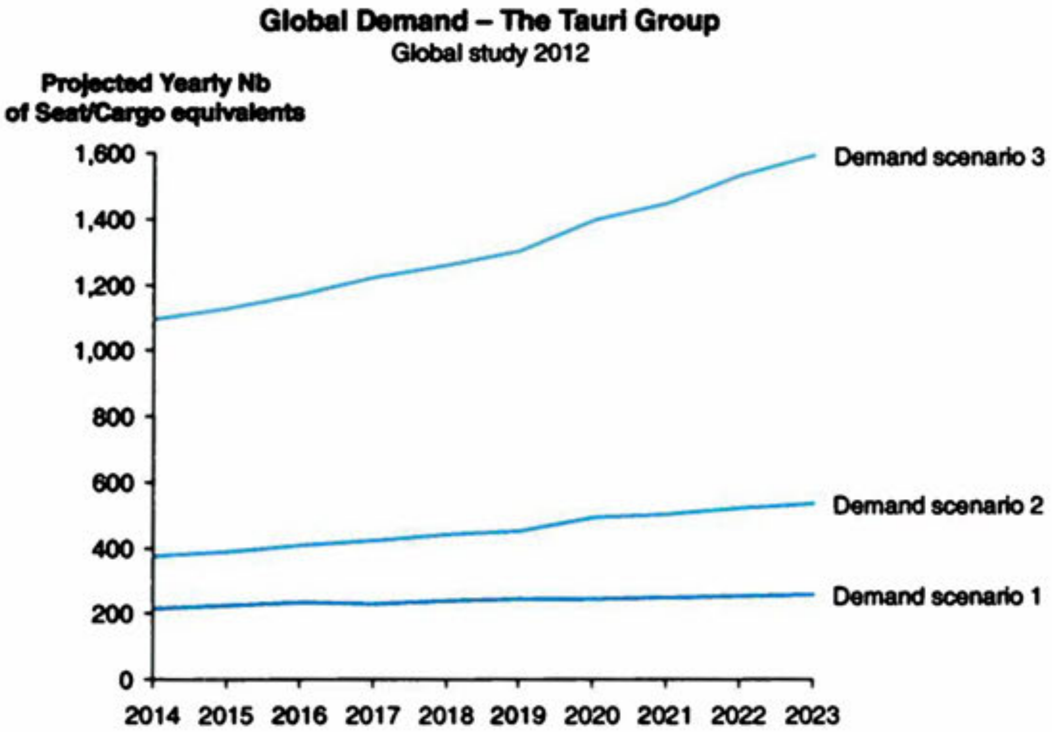

Figure 8 - Yearly predicted demand in the 3 scenarios analysed in the Tauri Group study

As showed above, the two studies produced starkly different results, with differences in numbers exceeding, in some scenarios, 2 orders of magnitude. The differences are explainable by considering the following differences in base assumptions:

- *Different assumptions at the base of the HNWI sample choice:*
    - ***IPSOS Study assumption 1:*** the IPSOS study considered a set of net-worth ranges, assigning a different probability to the willingness to take part to suborbital spaceflight to different net-worth brackets (the higher the net-worth, the higher the probability)
    - ***Tauri Group Study assumption 1:*** The Tauri group study only considered HNWI with a net worth in investable assets higher than 5MUSD as potential customers. The Tauri group also assessed the space enthusiasts' population (individuals with lower net worth with high enthusiasm for space activities that could be willing to take part to the experience) but found it to be only a few % of the estimated total population

  The two different assumptions above lead to a wide difference in addressable segment size between the two studies, and may be one of the major reasons behind the vast differences in estimated demand

- *Level of safety in the suborbital flight experience pitched to the respondents:*
    - ***IPSOS study assumption 2:*** the study pitched the respondents with two offers: in one, the spaceflight would have the comfort and, above all, safety level akin to those of a first-class airliner and the involvement of a company with a highly recognisable brand and proven track record like EADS was shown; in the other, safety aspects were downplayed no mention of EADS-Astrium as the spaceplane builder was present. The study reportedly found huge differences in the response. Numbers reported here refer to the first offer case (i.e. safe, comfortable and backed by a large company)
    - ***Tauri group study assumption 2:*** the Tauri Group study assumed just "appropriately safe" SRV operations

  The offer of a comfortable and *completely safe* experience for IPSOS may have had an effect on the response rate, due to the low assumed risk of the flight, and is possibly another major reason for the great difference in demand estimation between the IPSOS and the Tauri Group Study

The main identified demand drivers as emerged from the two studies are:

- *General Public Awareness:* The IPSOS study pointed out a low public awareness about commercial suborbital spaceflight, with respondents showing confusion with zero-G flight and orbital flight. Outreach and marketing campaign would boost the HNWI interest
- *Ticket price:* Ticket price appears to play a significant role in demand evolution. Price elasticity, tested in both studies, was found to be extremely high

- *Perceived safety of flight:* Perceived safety of flight not tested in the TAURI study. Results of the IPSOS study find it to be a major demand driver, with many HNWI expressing a strong interest conditioned to a proper assured safety track

- *Other qualitative factors:* **Sense of adventure** one of the primary motivation for prospective users; **Elite experience and pioneering** other significant motivations

The market assessment included in the report Space Tourism in India was based on a very small number of HNWI responses (only 15, instead of the planned 150). As such, its results are based on an extrapolation of the responses of the remaining sample base, and are possibly less significant than those included in the previous 2 studies. The demand estimated in the report is more in line with the IPSOS study than with the Tauri Group study. The study also confirmed the main demand drivers of suborbital spaceflights already outlined above.

The analysis of the three demand assessment studies highlighted the following:

- *There is a considerable difference in demand estimations performed within different studies*: the estimated demand is widely dependent upon the basic assumptions on the potential user base size, and on the extrapolations' assumptions

- *Demand appears to be global, and uniformly distributed at global level:* the IPSOS and the Tauri Group studies assign a roughly equal share of the demand to the U.S., EU and Asian territories

3.4.2 Supply analysis

The short/medium term commercial suborbital spaceflight supply can be estimated from the expected operational capabilities for the four U.S. commercial suborbital spaceflight vehicle developers with plans to enter the market in the next 3-4 years (Figure 9).

Company	Fleet	Operational capability	Advance sales
Virgin Galactic 	Currently 1 WhiteKnight2 and 1 SpaceShip2 (a second WK2 and SS2 are planned), ultimately 3 WK2 and 5 SS2s in operation	Each SS2 can carry 6 paying participants 1/5 SS2, weekly launched could carry 300/1500 PAX p.a.	As of 2012 around 500 tickets in advance sales
XCor 	1 system in development, no information on future production plans	Each Lynx can carry 1 paying participants 1 Lynx, weekly launched could carry 50 PAX p.a Plans are, however, to have at least 200 flights per year (equal to 200 passengers p.a.)	As of 2012, 175 tickets in advance sales
Armadillo Aerospace 	Still at early testing stage, data outlining their commercial strategy has not been published yet	1-3 passengers	1 confirmed passenger as of 2010
Blue Origin 	Development status not publicly-known, data outlining their commercial strategy has not been published yet	3 passengers	/

Figure 9 – Expected short term supply capabilities in Suborbital Spaceflight

Virgin Galactic's SpaceShipTwo can carry 6 paying participants, and has an expected flight turnaround of 1 week. As of now, 1 *SpaceShipTwo* and 1 *WhiteKnightTwo* (the carrier aircraft) are planned to enter operations, while a second *SpaceShipTwo* and *WhiteKnightTwo* are expected in the following year. In addition, Virgin has already announced plans to manufacture 3 more SS2 and 1 more WK2 – ultimately there shall be five *SpaceShipTwo* and three *WhiteKnightTwo* in operation. Taking into account the weekly flight turnaround, this surmounts to 300 to 600 paying participants in the first years (with 1 and 2 SS2 in operations respectively) and up to 1500 paying participants per year when routine operations are achieved with 5 SS2. For the sake of this analysis, the current plans based on just the vehicles under planned production (2 SS2) are assumed: this leads to an expected supply capability of 300 to 600 paying passengers per year.

XCor's Lynx space-plane can carry one paying participant; XCor has not announced how many space-planes will be put into operation in the years to come. The Lynx is expected to have a flight turnaround of less than 1 week. XCor expects the vehicle to be able to fly 500 times per year, and to be profitable for a prospective operator at 200 flights per year. Assuming a conservative stance, the operational capability of the Lynx may be considered to be 50 (in case of weekly turnaround in the first period of operations) to 500 paying passengers per year.

As far as the other two manned SRV manufacturers are concerned (*Armadillo* and *Blue Origin*) any data outlining their respective commercial strategy has not been made publicly available.

The data summarized above allow a synthesis of the total expected supply capabilities in the short term ranging from **350** to about **1000** paying participants per year.

3.4.3 Conclusions – Demand and Supply comparison

Expected demand and supply were compared, taking into account:

- Demand forecast (assessed in separate studies)
- Vehicles expected to begin operating in the near future, and their operational capabilities (number of passengers, expected frequency of flights)
- Advance sales recorded by the first operators

The simple comparison of the operational capabilities of the vehicles expected to begin commercial flights in the near future and the advance sales backlog is enough to state that 2 or more years of operations would be required to fulfil the existing backlog. It's important to stress out, though, that not all the reservation made may end up being actual flights: some of those reservations may have been made just for the exclusivity factor of being on the list for a pioneering experience and the people who paid just to be in the pioneering elite (as a form of luxury status symbol) may back-up when the time comes to take part to actual experience (for fear or lack of conviction on the safety of flight), even if that entails losing the advance payment or the entire payment. This is a typical occurrence with ultra-high-end luxury goods and experience[29].

Going beyond advance ticket sales, predicting where the balance of supply and demand is going to lie is less straightforward:

1) If we assume an interest for a wide range of high net-worth individuals, and if we assume a flight experience that is as safe as commercial aviation, the estimated demand is well in excess of this expected supply (about two orders of magnitude more). In a way, this hypothesis, by assuming a vaster potential user base and a high safety of flight may be considered linked to the hypothesis of a certified SRV (i.e. fulfilling the requirement of an aviation-like certification approach)
2) If we assume the conservative hypothesis that almost only HNWI with a net-worth in excess of 5MUSD in investable assets would be willing to take part to this type of experience, and we assume an experience that is "only safe enough", the estimated demand numbers are in the same ballpark of the expected supply capabilities

[29] *Source:* Stakeholder consultation.

3.5 REGULATORY FRAMEWORKS

Suborbital Commercial Spaceflight involves flying through the atmosphere up to the generally accepted threshold of space (100 Km altitude). Since most of the flight envelope sits within the borders of airspace, and being most of current SRV concepts winged vehicles that fall within the general definition of Aircraft[30], the regulation of Commercial Suborbital Spaceflight is not a clear cut matter: SRVs' operations touch, as a matter of fact, both the Aviation and Space fields, with all the potential regulatory implications deriving from the related different legal grounds.

As already mentioned in the previous sections, in the U.S. the regulatory scene for Commercial Spaceflight through man-rated Suborbital Reusable Vehicles was set in 2004 by adopting the clear stance of considering SRVs as space vehicle, and having the FAA-AST (Federal Aviation Authority – Office of Commercial Space Transportation) issue a temporary licensing regime (see next sub-section for more details).

The regulatory scene in Europe is, on the other hand, still unclear, due to a variety of factors:

- *Uncertainty on the jurisdiction for SRVs flight at European level:* there is still a strong debate over the opportunity to have Commercial Suborbital Spaceflight fall within Aviation or within Space, a choice that bears many legal and procedural consequences
- *The lack of a European Space Safety Authority:* as of today, space launches are regulated at member state level. Only aviation safety is regulated at European level by the European Aviation Safety Agency (EASA)

Figure 10 shows the regulatory authorities for Space and Aviation in the US and Europe, and their respective current regulatory scope.

[30] Definition of an aircraft is "any machine that can derive support [i.e. lift] in the atmosphere from the reactions of the air other than the reactions of the air against the earth's surface" : this includes aeroplanes (fixed-wing aircraft), rotorcraft (rotating wing aircraft), balloons (which use their differential density as compared to the one of the air) and excludes de facto hovercraft and ekranoplans, as well as rockets (symmetrical bodies not using the interaction of the air for their lift, but solely the thrust of their rocket engine(s)) (source: ICAO Annex 6 and 8).

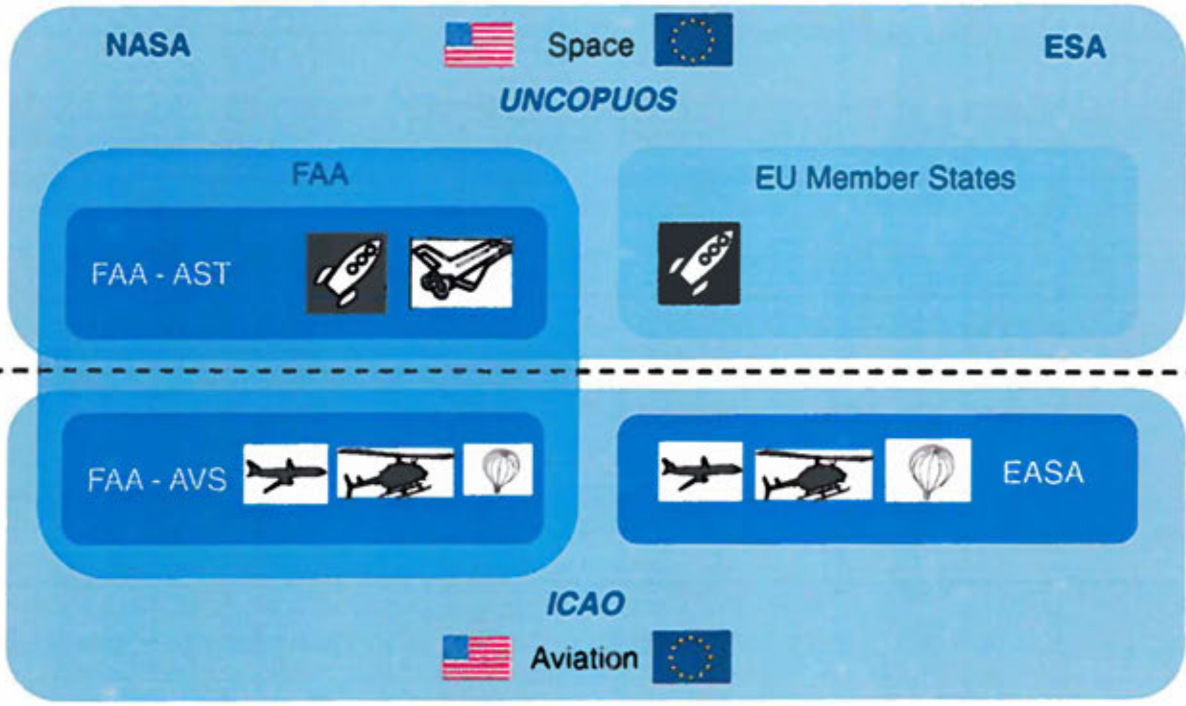

Figure 10 – Space and Aviation regulatory authorities in the US and in Europe

3.5.1 Regulatory approaches

In this sub-section, the two main regulatory approaches that can be followed for Commercial Suborbital Spaceflight are described. Those are:

- The licensing approach, which was adopted by FAA-AST to regulate SRVs in the US, akin to space launches' licensing
- An aviation-like certification approach, which would potentially follow procedures and regulatory layers akin to those currently used for commercial aviation

It's important to stress here that the two approaches above represent two extremes, and that *a gradient of intermediate regulatory stances could be conceived for SRVs.*

It is also important to note that the difference in meaning between certification and licensing is not, in principle, clear cut; in the remainder of this section, we would refer to the two following terms to describe two approaches that have different scope and applicability:

- **Certification** is a systematic process that applies separately to products, operators, and crew/pilots. A certified product can be operated by any certified operator, which, in turn, can hire any certified pilot.
- **A license** is, on the other hand, a permission granted to a specific entity/individual to operate a given product in specific, well defined conditions (location, pilot, etc.): it applies to the ensemble of product/operator/location, and in the US does not imply a systematic check of compliance, but rather an analysis of the argumentation provided by the license requester.

3.5.1.1 FAA – AST licensing process

The US-Congress issued the Commercial Space Law Amendment Act (CSLAA) in 2004, which gave to the FAA-Office of Commercial Space Transportation (FAA-AST) the mandate to both supervise and promote all commercial spaceflight activities, without fully regulating them initially until 2008. Due to delays in the industry to develop and actually launch commercial space vehicles, this mandate was extended two times, last time in 2012 until 2015.

Based on this mandate, FAA-AST published a set of high-level requirements (Commercial Space Transportation Statute and Regulation – 14 CFR 400 series), aiming at delivering launch (and return when applicable) licenses to all commercial rocket-powered "launches", ranging from unmanned rockets to Reusable Launch Vehicles (RLV) and covering as well their operations and operators. The high level requirements are related to lower safety objectives compared to conventional aviation (where the safety objectives here refer to the safety of third parties uninvolved with the flight – i.e. people or things on ground)[31].

FAA-AST requirements apply amongst other to manned "suborbital rockets" which have to have a "launch and return" license before they intend to ignite any rocket engine. Before that point, the FAA supervises the safety and licenses the flight of the unpowered glider (and carrier aircraft in the case of two-stage concepts) by the means of Experimental certificates delivered by its aviation branch FAA-AVS. As an example, the *SpaceShipsOne* and *Two* and their carrier aircraft *WhiteKnightOne* and *Two* all got an Experimental Certificate from FAA-AVS (along with the corresponding usual "N-" registration applied to all aircraft manufactured and operated in the US), and the ensemble received a launch and return license from FAA-AST in order to perform rocket-propelled flights[32].

It should be noted that the FAA-AST licensing system does not cover orbital operations, only the ascent to and return from orbit. In order to also cover it, the FAA signed in 2012 an Agreement with NASA to supervise the orbital part, including compliance with international legal and technical requirements (for example, to allow the Dragon capsule to dock to the ISS). Thus, in the US, commercial spaceflights are currently fully legally covered, by the US-government for the legal framework and partial liability (to third parties), by FAA-AVS for the aviation part, by FAA-AST for the rocket-propelled part and by NASA for the orbital part.

The FAA-AST licensing process for Suborbital Reusable Vehicles (SRV) requires the submission, from the applicant, of a documentation proving the fulfilment of the above-mentioned requirements, which includes:

- All design details of safety features, and analysis carried out to demonstrate the safety achieved with the pursued design

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[31] The safety objective is set at a 3E-05 (30 chances in 1 million) probability to have fatalities on the ground per SRV flight vs. 1E-06 (1 chance per million flight) to have a fatality in the air or on the ground per flight.

[32] FAA-AST Licenses are required before igniting a rocket engine, regardless of the altitude to be reached by the end vehicle.

- Any applicable test data available, including legacy data in the absence of data referred to the actual hardware. Legacy data may include data related to similar vehicles or engines or subcomponents that have flown in the past

From the above documentation, FAA-AST starts preparing with the applicant a preliminary launch license package, and, when this package is almost ready, the applicant applies for the license, which shall be delivered within 3 months. In the meantime, the applicant gets a test Flight Permit, with which he is allowed to conduct test flights with no paying participants.

The additional flight data coming from the test flights is then submitted by the applicant, and used by the FAA-AST to produce the final license package.

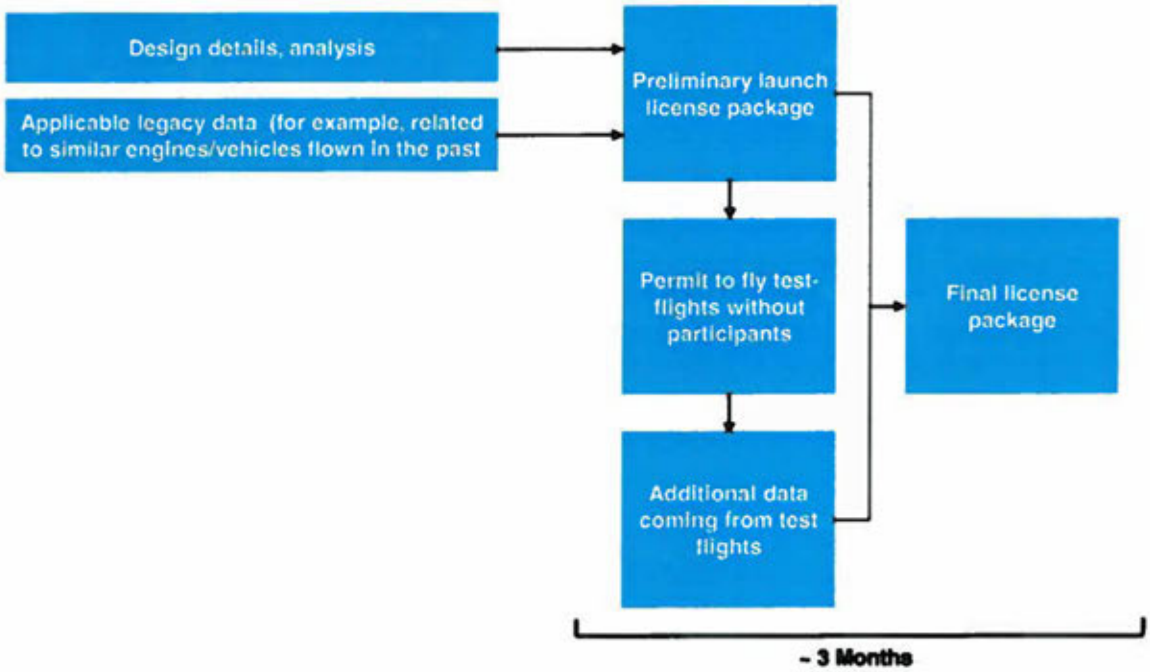

Figure 11 – Schematic of FAA-AST licencing process for a prospective applicant

The license is, as already mentioned above, related to the ensemble vehicle/operator/location: in case of a location change, for example, a new license is required.

The license does not cover any liability to the passengers, which are, on account of that, simply called "participants" (by law, liability to paying customers has to be in place for them to be called "passengers"): more specifically, they are referred to as Space Flight Participants (SFP). Space Flight Participants have to sign an informed consent, stating that they have been sufficiently informed by the operator of the potential risks, and that they waive any claim in case of accident[33]. Likewise, the license doesn't cover any liability to the flight and ground crew or operator either. The only liability mandated by the license is towards third parties not involved with the flights (non-involved public and property on the ground or in the air).

It's important to note here that, in a similar way to what happens with space launches where the launch country takes over liabilities on third parties (in accordance to the application of

[33] It's important to note that in several U.S. states, like in California, informed consent is not legally binding for any industry outside the commercial space transportation (source: Stakeholder consultation)

1967 Outer Space treaty and the 1972 Liability Convention assigning liability to the launching State for damage caused to third parties), in the U.S. the Federal Government takes over the liability to third parties not involved in the flight, and puts a limit to the liability of operators to third parties damages. This represents an important factor for commercial SRV operators in the U.S. at this stage of the industry. The federal level indemnification in case of accident is complemented by indemnification regimes at state level; at this regard, it's important to point out that not all the U.S. states have the same liability frameworks for SRV flights. The following states:

- Colorado
- Texas
- Florida
- Virginia
- New Mexico (as of January 2013)

put, through indemnification, a limit to the liability of *both* operators and suppliers to third parties damages (the operator and/or supplier would cover the damage up to the limit, and the state would cover damages in excess of the liability limit – although at present it is not clear how that would happen; the damaged parties would possibly have to sue the state to get indemnification).

The arrangement concerning Federal and State level liability regimes poses an important question on who is going to take over the liability financial back-up in case US players would want to operate from outside the US: it's unlikely for the US government to retain its backup role, and it's not immediate to have EU states' governments to act as backup either.

As already mentioned, the licensing approach described above is supposed to converge into a fully-fledged certification approach in due time. Originally, the switch was supposed to happen in 2012, but it has since been postponed to 2015[34]. Most probably, it will be postponed again until 2020, as commercial players have expressed the need to have at least 8 years of continual commercial operations in order to have the required flight data to support certification rule-making[35].

3.5.1.2 *Aviation-like certification process (Reference: EASA process)*

In an aviation-like certification regime, liability exists for damages to third parties, crew, and paying customers (passengers), and it goes to vehicle operator/manufacturer first, and, in a second instance, to the certification authority.

Certification can be seen as an important step to market for vehicle producers. Certification is divided in separate blocks covering independently *product*, *operations*, *flight/commercial/ground crew* (the corresponding certificates are in the latter case called Licenses). A product (vehicle) is usually certified independently of the entity operating it: once certified, can be sold or leased to any operator. The operator is certified and licensed separately. Certification is required for safety and can therefore be seen as a required step to create market products that can be sold or leased.

[34] *Source:* FAA-AST

[35] *Source:* Stakeholder consultation

Figure 12 – Certification: areas of application

To describe an aviation-like certification process, we will refer here to the typical EASA process for the creation of a new set of certification rules. The EU regulatory process (the creation of a new set of certification rules) EU law first and foremost is set forth in Regulation (EC) NO 216/2008 referred to as the Basic Regulation (Tier 1), is then developed into Implementing Rules (Tier 2), and then further down into Certification Specifications (Tier 3) and finally into Acceptable Means of Compliance and Guidance Material (Tier 4):

1. Basic Regulation (BR) 216/2008: sets the scope, lists exclusions, sets Substantive and Essential Requirements (ER) and establishes EASA and its functioning (organisation, budget, etc…);

2. Implementing Rules (IR) set common binding requirements: for example Regulation (EC) 748/2012 for the initial airworthiness and environmental certification – to initially certify the aircraft as well as to deliver Design and Production Organisation Approvals (DOA/POA), and Regulation (EU) 2042/2003 for continuing airworthiness and the approval of organisations and personnel involved in the maintenance related tasks – to cover the post-certification life of the aircraft;

3. Certification Specifications specify the technical requirements as non-binding, "soft" law on the basis of which e.g. a product can be certified in accordance with the substantial and essential requirements: for example, CS-23 (for smaller and commuter aeroplanes), CS-25 (for Large Aeroplanes) or CS-E (for Engines) or EASA-OPS (for operations); where such certification specifications cannot be met, industry can work with EASA to demonstrate an Equivalent Level of Safety (ELoS), which is systematically documented in Special Conditions (SC), which in turn become public (to ensure an equal level playing field);

4. Acceptable Means of Compliance and Guidance Material (AMC/GM): they provide guidance on a particular subject and, as equally non-binding material, may provide complementary information. They specify how compliance can be demonstrated.

For changes to the BR and IR, the process starts with EASA producing "opinions" to the European Commission. Those opinions are developed on the basis of the Agency's Rulemaking Procedure, which implied the involvement of interested stakeholders and open public consultation before submission. On the basis of such opinions, the Commission starts the legislative process, which then leads the European Parliament and Council (in the case of BR amendments) or the Commission (for IRs respectively) for the adoption of these Regulations. The process that leads to the drafting and approval of IRs may therefore include strong negotiations among member states and interested stakeholders. In order for the Implementing Rules to be approved, a majority of votes in favour is required (no full consensus needed). If, hypothetically, a member state is not in favour of an IR which is approved anyway, the rule is binding even for the member state that did not approve it.

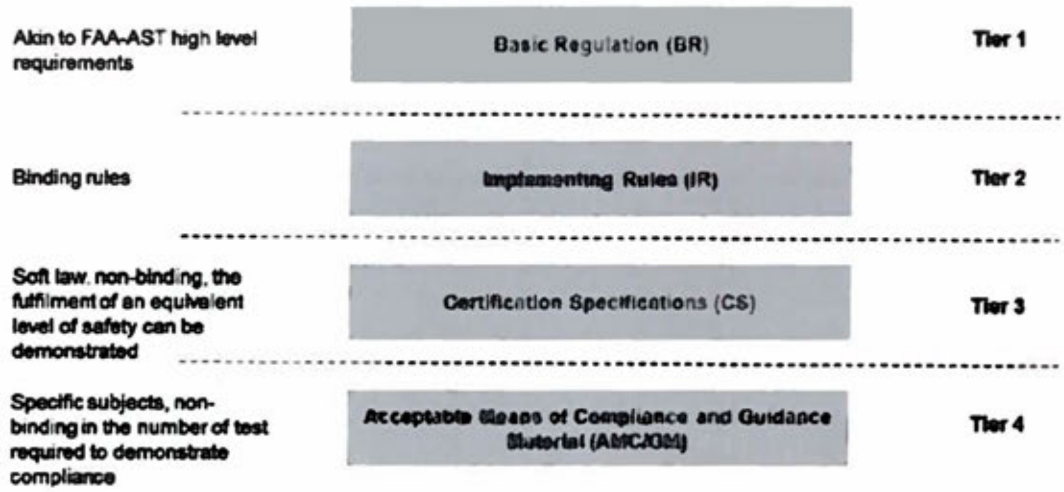

Figure 13 – Certification Rules' Tiers

Possible process for developing legislation and certification specifications for new vehicles (like SRVs) would start from existing aviation rules, developing a delta to account for the differences arising from the new vehicle concepts, and adapt them to the specific requirements for the new vehicle concept.

The aviation rules would only serve as a starting point. As an example, the number of pilots mandatory for Commercial Air Transport (CAT) in Europe is 2; in SRVs, having a requirement for two pilots would most probably heavily damage profitability, as it would cost too much, eliminating a seat for a paying customer; EASA could for example work out the possibility of an amendment to the rule concerning this specific requirement in order to ensure viability of the SRV concepts.

The timeframe for a certification of a new SRV vehicle is estimated by EASA at around 3 to 5 years depending of the novelty and complexity of the vehicle (for reference, General Aviation has a certification timeframe of maximum 3 years and Large Aircraft, which are more complex, are to be approved within 5 years).

Financial impact of certification is constituted by:

- *Certification charges:* Applicants to certification for a new vehicle in EU have to pay a lump sum covering fees and charges for certification on a yearly basis for the duration of the certification process. It is unlikely that this relatively low sum will represent a financial barrier to any prospective SRV vehicle developer

- *Impact on vehicle design and development; testing cost to prove compliance to certification requirements*: a vehicle that has to comply with certification standards is expected to cost more to produce and to operate (on account of the additional required redundancies). Also, proving the compliance to certification standards requires a certain degree of extensive testing, including, possibly, flight testing. The financial impact from this perspective is difficult to estimate at this stage (without an actual certification standard in place) but is expected to be, at the very least, non-negligible

3.5.2 Comparison between the FAA-AST licensing approach and an aviation-like certification approach

Table 5 reports a comparison of the two regulatory approaches described in the previous section, outlining their main pros and cons from a market perspective, and also highlighting the main impacts along the value chain (on vehicle developers, operators and spaceports).

Regulatory Approach	Pros	Cons	Impact on Vehicle Developers	Impact on Operators	Impact on Spaceports
US Licensing approach (FAA-AST): - Treats suborbital flight as spaceflight - Informed consent for passengers - Liability to third parties	- Lean approach - Allows new entrants to get to operations quickly - Allows for continual technical improvements without the need to cease operations	- Possible fragmentation in safety levels - The licence to fly is related to the ensemble of vehicle, operator, location - Low perceived safety of flight	- Lower time and cost to market - Continual technology and system development - Lower perceived safety of flight by end customers may slow down the market after initial early adoption spike	- Higher Risk - Possibly higher insurance premiums	Requires dedicated spaceports
Aviation-like Certification: liability to manufacturer/operator and to certification authority	- Creates standard safety requirements Increases perceived safety of flight, and appeal to customers - Certification is product related	- Higher cost and time requirements may represent a barrier to entry for smaller players	- Higher time to market - Higher development CapEx - Increased perceived safety level is a competitive advantage	- Lower Risk - Lower insurance premiums - Higher OpEx	Certified vehicles may be able to fly from any conventional airport, making dedicated spaceports less strategic

Table 5 – Comparison of the FAA-AST regulatory approach with an Aviation-like certification approach

3.5.3 Regulatory activities on-going in Europe

Scattered regulatory efforts on SRV are ongoing in Europe:

- **Netherlands**: Regulation is to be launched in Curacao for Space Expedition Corporation operations of *XCor Lynx* vehicle
- **Sweden**: there is work towards a licensing-like national regulation to allow VG to fly from Spaceport Sweden (and treat *SpaceShipTwo* as a sounding rocket)
- **UK**: the UK Space Agency and the Airworthiness authority have instituted a working group running since the end of 2011 to address regulatory matters for commercial space at large (dealing with both suborbital and orbital), driven by Reaction Engine Limited (SKYLON project)

- **EU-funded Fast 20XX project (managed by ESA): regulatory assessment aimed at point-to-point transportation, only partially relevant to Suborbital spaceflight in the short term**
- **EASA: various investigatory activities on-going (papers published, permanent contact with all interested EU prospective developers, some US developers, and FAA-AST), defined a category for suborbital spaceflight: Suborbital Aircraft (SoAs)**

3.5.4 Potential Scenarios for SRV regulation in Europe

Five possible scenarios can be assumed for SRV regulation in Europe:

- ***Scenario 1 - SRV are considered space vehicles:*** as such, regulation is left to the individual member states (national space laws). EASA, as the Aviation Authority, would check that SRVs' operations do not step into aviation territory, that is, that they do not jeopardize aviation safety.

- ***Scenario 2 - SRVs are considered aircraft; but mandate for regulation is left to member states*** *(SRV explicitly excluded from EASA scope by a change to the Basic Regulation):* member states develop delta rules starting from existing aviation rules, SRV can only fly within one MS until mutual recognition between states is achieved through agreements (1 Type Certificate per state). EASA could potentially step in at a later stage for harmonization; which may be by then rendered difficult (same situation as EU aviation before the JAA – Joint Aviation Authority);

- ***Scenario 3: SRVs are considered aircraft; mandate for regulation is given to EASA, within its current organization and rules:*** EASA would start from existing aviation rules to develop a new legal framework for SRVs with an amendment for the BR and create a set of essential requirements similar to the FAA-AST ones. After this step, two possible sub-scenarios can be assumed:

    a. *Harmonised implementation:* EASA develops binding Implementing Rules and non-binding Technical requirements, so that compliant SRVs can fly into/from every member state (including A to B); Agreement for third country operators would be required, only Type Certificates (no License) would be accepted from US manufacturers and operators based on bilateral EU-US agreement

    b. *Non-harmonised implementation:* EASA lets the member states develop their own implementing rules for the essential requirements. In this case, SRVs compliant to a given country's set of implementing rules would only be allowed to fly in that country, and not anywhere else in Europe. At a later stage, eventually, harmonization from EASA would occur and Sub-scenario 3-b would converge into 3-a

- ***Scenario 4 - SRVs are considered cross-over between aeronautics and space, mandate for regulation is given to EASA, a new branch of EASA is created to deal with Space (EASA – AST, akin to what the US have done with FAA and FAA-AST):*** the new entity within EASA would either pursue:

    c. *A harmonised implementation*

    d. *A non-harmonised implementation*

In a similar way described for scenario 3. The new entity could possibly be afterwards even tasked for space regulation at EU level, in cooperation with the Members States (which have each their Space Law and sovereignty) and maybe ESA for the orbital part (akin what FAA-AST did with NASA).

- ***Scenario 5 - SRVs are considered cross-over between aeronautics and space, mandate for regulation is given to another EU-institution, or a new institution is created ad-hoc***

Figure 14 summarizes the scenarios described above.

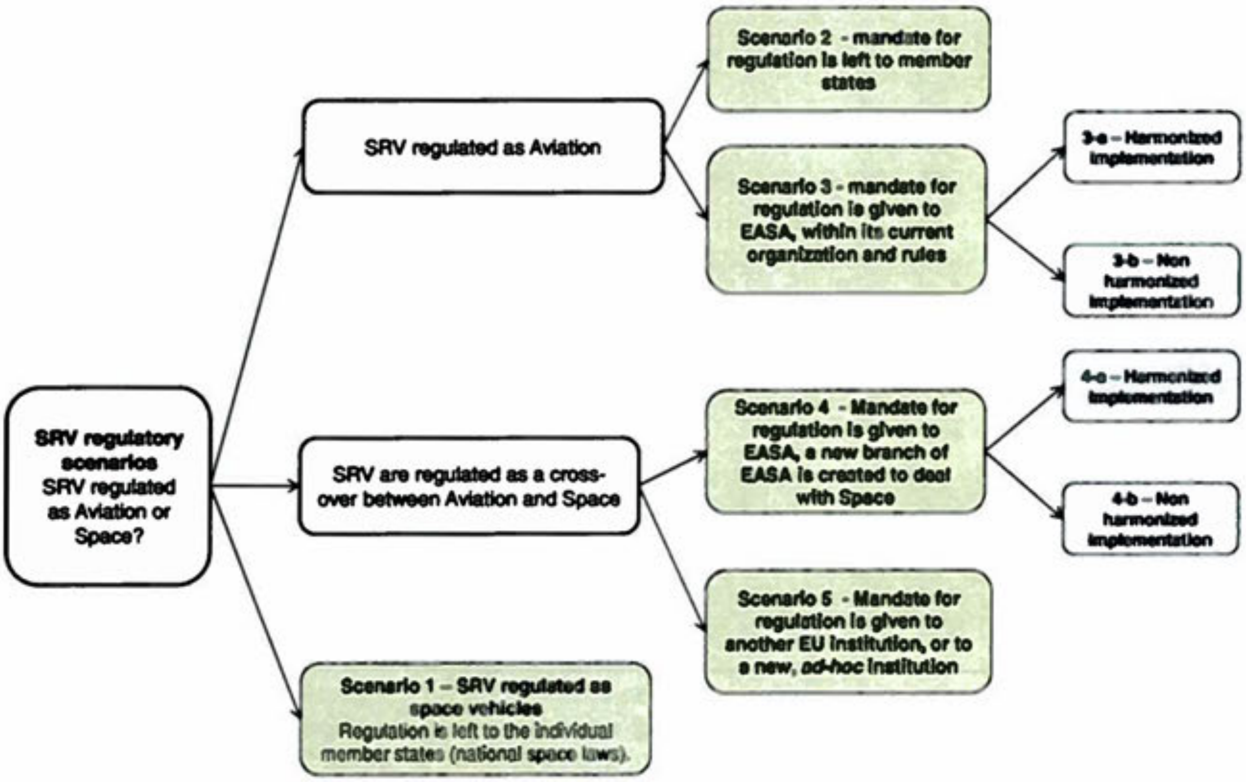

Figure 14 – Potential scenarios for SRV regulation in Europe

3.6 STRATEGIC IMPACT OF COMMERCIAL SUBORBITAL SPACEFLIGHT

As already mentioned, Human experiential flight represents only one of the potential market segments for Commercial Suborbital Spaceflight (albeit the one with the highest revenue potential by far and the one that is mostly driving innovation in design); other potential revenue sources can be identified, in the short and medium term:

- *Testing (Aerospace technology testing and in-flight demonstration):* SRV have a potential to serve as flying test-beds for technology demonstration for unconventional and innovative technologies applicable to both aviation (for example, to UAS) and space applications. Such testing could also serve to achieve technology qualification and/or certification
- *Cargo applications (Very small satellites deployment into LEO):* SRV can be used to deploy, from suborbital altitude, small satellites into LEO in a cost effective way

In the medium term, when routine operations are established, additional foreseeable applications include:

- *Remote sensing:* SRV suborbital flights could be used with earth observation payload, for imaging applications for commercial, civil governmental or military applications
- *Basic and applied research:* SRV can potentially be used in a range of basic and applied research applications that include, among others, suborbital astronomy (astronomical observations from above the lower atmosphere), space medicine (the study of the effects of microgravity and accelerations on the human body) and, microgravity research. SRV are competitive in all those areas with almost all current means of experimentation (parabolic flights, atmospheric balloons, drop towers and so on)

To provide a proxy for the possible impact of SRV in cargo applications that are currently mandated to sounding rockets, it's worth reporting that in 2011 NASA spent $45.9 million in sounding rocket launches, conducting **13 launches**. Assuming half of the programme cost was actually destined to building payloads, the remaining half would buy **236 *Lynx* flights**, that is, about **4.5 flights per week**[36]. The potential for cost saving assured by SRV with respect to sounding rockets is thus very large. Considering the added benefits of performing microgravity research with SRV instead of compared to using the cheapest alternative i.e. parabolic flights (longer exposition times to microgravity and radiations - 3-5 minutes compared to about 20 consecutive seconds), it's easy to realize that SRV cargo applications enable a whole new market (positioned between parabolic and sounding rockets/orbital) for both governmental and industrial research.

In the long term, suborbital spaceflight may pave the way for point-to-point high speed transportation, and also (directly and indirectly) contribute to lower the cost of access to orbit:

- *P2P transportation:* point A to point A suborbital flight is expected to evolve, in the long run, into suborbital high-speed P2P transportation, with potential applications

[36] *Sounding rockets and low-cost access to space* (available at http://www.citizensinspace.org/2012/11/sounding-rockets-and-low-cost-access-to-space/ - Last retrieved on February 2013)

in fast intercontinental package delivery, high-speed passengers' transportation (e.g. EADS-Astrium Zero-Emission High Speed Transport (ZHEST) and REL Lapcat projects) and high-speed troops transportation and deployment (military)

- Orbital Reusable vehicles: Some EU companies such as Reaction Engines Limited (REL) are already developing orbital aircraft concepts, taking off and landing horizontally from conventional runways (e.g. the Skylon project), to bring and recover payloads and/or humans to/from orbit. Some systems and operations could be profitably first test-proofed on SRVs at lower costs and risks (e.g. Rocket Engines and Reaction Control Systems), before being scaled-up for orbital vehicles.

In addition to the impact of SRV technologies and systems *per se*, the strategic impact of commercial suborbital spaceflight is also realized through the spaceport infrastructures, which have already proven, in the U.S., to bring a local economy boost and to serve as technology aggregation poles. In the long run, positive externalities from the presence of spaceport include an outreach effect and a boost to the appeal of technology for young students and professional, with a sizeable impact on the overall local competitiveness.

Figure 15 summarizes the complementary markets and the strategic implications of commercial suborbital spaceflight in the short-, medium- and long-term.

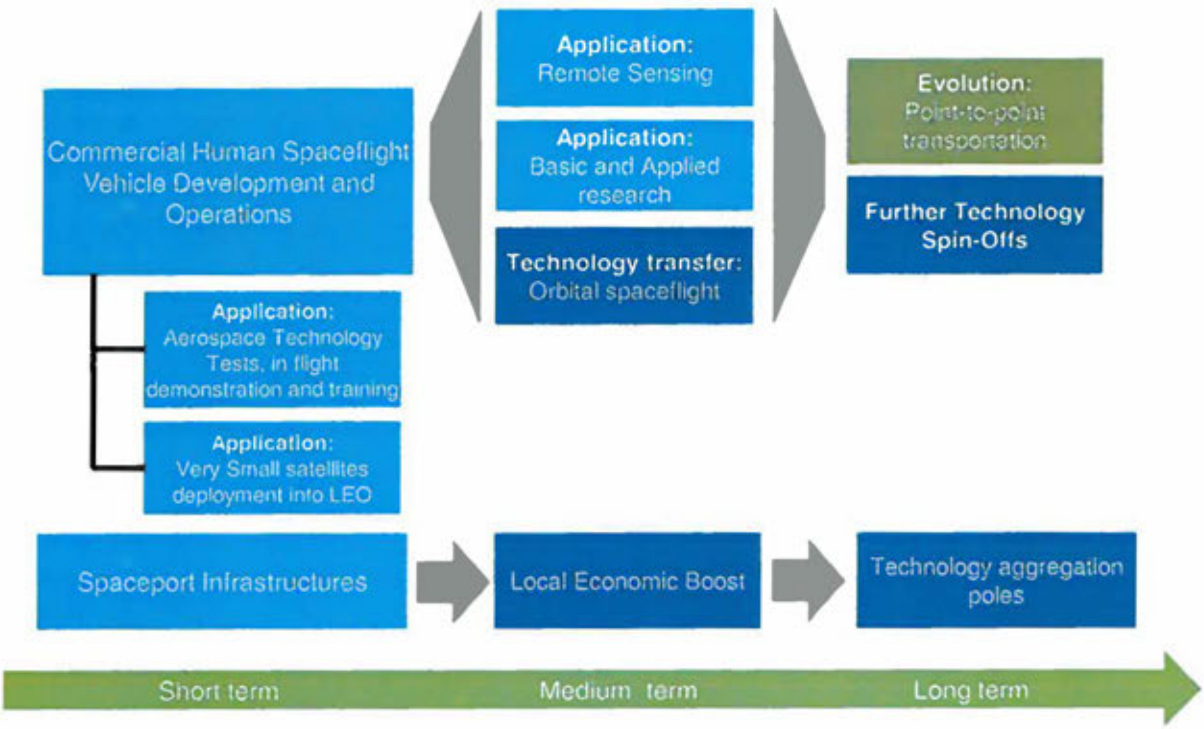

Figure 15 – Complementary market segments and strategic implications of Commercial Suborbital Spaceflight

3.6.1 Suborbital Spaceflight Environmental Emissions

One of the major potential institutional and public concerns on Commercial Suborbital Spaceflight is represented by its expected impact on environment. The push for green transportation is global, with Europe at the forefront of environmental impact reduction for air travel, as testified by the ambitious targets in terms of emissions' and noise reduction set in the ACARE Strategic Research and Innovation Agenda for 2050. Environmental concerns may affect the long-term strategic perspectives and implications of SRV technologies and systems.

Environmental impact is basically conducible to two areas, noise and emissions. Different expected impact can be predicted for different types of vehicle concepts. A brief qualitative analysis is reported below:

- *Noise:* SRV noise impact is related to the take-off phase, and to the sonic boom. For the take-off, different impacts are expected for different concepts:

    - ***Astrium Space-plane concept:*** Astrium spaceplane concept include a conventional jet engine for take-off, therefore the expected impact is in line with conventional aviation
    - ***Virgin Galactic SpaceShipTwo:*** The *SpaceShipTwo* leaves the ground through the carrier aircraft *WhiteKnightTwo*, powered by jet engines. Therefore, noise impact in line with conventional aviation is expected also in this case
    - ***XCor Lynx and Blue Origin***: Both those concepts, although different (HTHL vs. VTVL), foresee a take-off through the use of rocket engines. It is therefore expected in those cases a noise impact much greater than that of conventional aviation, although the use of LOX/LHC engines (at least in *XCor*'s case) should lead to noise levels much lower than those of a solid rocket motor

    As for the sonic boom, independently from the specific concept considered, since the vehicles are expected to break the sound barrier in an almost vertical ascending phase, it is expected to have a narrow footprint on ground, i.e., it is not expected to affect significantly the surroundings of the spaceport

- *Emissions:* again, even here different impacts can be expected for different engine concepts:

    - ***LOX/LHC engine:*** the LOX/methane engine is assumed to be relatively green. Emissions are estimated to be on par, per passenger and per kilometre, with those of a commercial airliner
    - ***Hybrid engine:*** the hybrid engine has a higher impact in terms of emissions with respect to a liquid LOX/LHC engine. A 2010 research published on the Geophysical Research Letters funded, among others, by NASA, assessed that soot emitted by hybrid engine-powered SRVs in the upper atmosphere would lead to significant disruption to the world's climate: the stratospheric layer of rocket soot would remain relatively localised in latitude and altitude, with a resulting strong impact on global warming

Given the expected impact of hybrid engines on the environment (and coupling this with the other operational disadvantages coming from the use of those engines), it is reasonable to assume that eventually SRV propulsion will be entirely based on LOX/LHC. Research is on-going, as a matter of fact, on new rocket propellant blends with the objective to reduce their environmental impact.

4 ECONOMICS

The economics of sub-orbital space flight will be a major driver to future market dynamics, from early adoption, to long term demand and overall market development. In this section the economics of different players in the value chain are estimated and compared, and the financing needs of the industry are analysed.

An estimation/assessment of the following costs was conducted within the desk research and the stakeholder consultation phases of the study:

- Non Recurrent Costs (NRC) for vehicle development
- Recurrent cost (cost of vehicle production)
- Operational costs:
- Vehicle wet-lease costs:

The above costs were estimated for different categories of vehicles (different concepts of U.S. SRVs, and for a certified space-plane). Given the variety of vehicle concepts examined (characterized by different operational capabilities and by different non-recurring and operational costs), and the confidentiality/sensitiveness of some of the information collected, the data above were used to estimate relevant economics for a generic SRV concept capable of hosting 3 paying passengers per flight under an intermediate regulatory regime (cross over between aviation & space regimes); increasing flight rates capabilities (flights per week) were also assumed to reflect improvement in operational efficiency.

Table 6 show the operational scenario assumed in the model.

Operations scenarios	Years into operations											
	1	2	3	4	5	6	7	8	9	10	11	12
Low operations scenario												
# of vehicles	1	1	2	3	3	3	4	4	5	5	5	5
# of flights/week/vehicle	1	2	2	2	2	3	5	5	5	5	8	10
High operations scenario												
# of vehicles	1	2	3	3	5	5	5	5	5	5	5	6
# of flights/week/vehicle	2	3	3	3	3	4	6	6	6	8	10	12
Ticket price scenario low ops	200,000 $	200,000 $	200,000 $	200,000 $	200,000 $	180,000 $	180,000 $	180,000 $	180,000 $	180,000 $	150,000 $	150,000 $
Ticket price scenario high ops	150,000 $	150,000 $	150,000 $	150,000 $	150,000 $	120,000 $	120,000 $	120,000 $	120,000 $	120,000 $	100,000 $	100,000 $

Table 6 – Operational scenarios for financial estimations

The profit margin and an IRR over 12 years were then estimated for:

- An operator wet-leasing the SRV(s)
- A manufacturer wet-leasing vehicles to operators

4.1 OPERATOR

For the estimation of a typical operator profit margin, assumptions were made on the operational scenario (number of vehicles; number of flights/week/vehicle) evolution along a period of 10 years and a related evolution of the ticket price (assuming as a starting point the current industry standard of 200,000USD). Values were estimated for the initial Start-up investment (including wet lease for 1 year and additional start-up capital) and for the OpEx (yearly vehicle wet lease - that includes vehicle operating cost and maintenance cost – fuel cost, spaceport fees and SG&A).

- Wet lease cost: 30M euro/vehicle/year
- Spaceport fees: 0.7M euro/year
- SG&A: 3% of revenues

Revenues were estimated for participants' flight, sponsorships and piggyback cargo.
Figure 16 shows the evolution of the profit margin under the two possible operational scenarios: higher flight rate at a lower ticket price and lower flight rate at a higher ticket prices. In both cases, the operator is profitable after 2 years of activity, with a profit margin around 10%, and reaches a significant profit margin in excess of 40% after 5-6 years. The estimated IRR over a period of 10 years is, for both scenarios, around 30%.

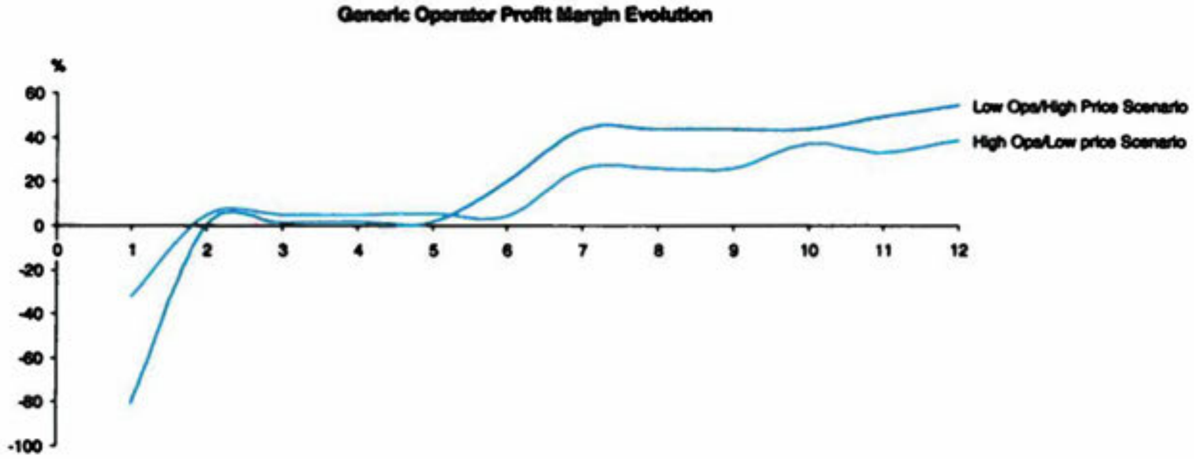

Figure 16 – Profit margin for a generic SRV operator under two operational scenarios

4.2 MANUFACTURER

With high NRC for vehicle development, the industry requires a high EBITDA margin from lease operations. The estimations made assume a NRC of around 400M euro, a cost of production of around 40M euro and a wet lease revenue of around 30M euro per vehicle per year. Figure 17 shows the EBITDA margin for a SRV manufacturer that wet leases its vehicles to a series of operators, assuming 2 vehicles in 2014, reaching 10 vehicles under wet lease by 2022.

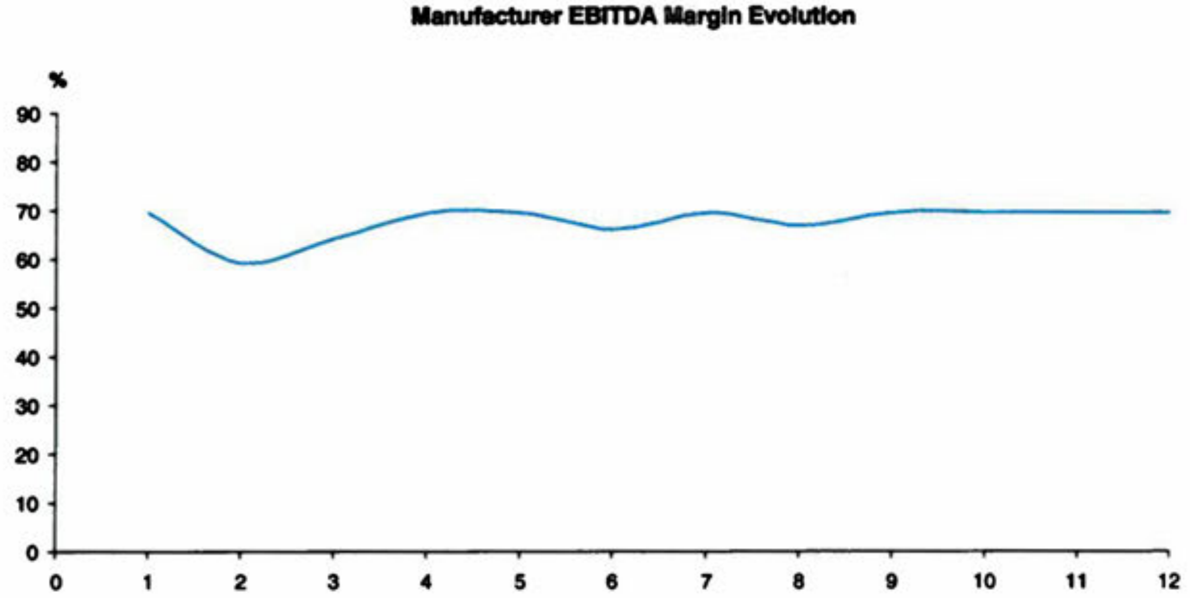

Figure 17 – Profit margin (EBITDA) for a SRV manufacturer

The operating profit margin for a manufacturer that engages into leasing can be significant, reaching around 70% under the assumptions given above. This should offset the high NRC for vehicle development, and the cost of assets (production of vehicles), leading to an estimated IRR of about 20%.

5 STAKEHOLDERS CONSULTATION KEY TAKE-AWAYS

The key messages out of the stakeholder consultation can be summarized as follows:

- Most stakeholders agree on the fact that lack of clarity at regulation and institutional level in EU is hurting the development of a European market
- U.S. Vehicle developers and operators see the current FAA-AST regulatory approach at this stage as the only reasonable approach to allow market development, and they would welcome a similar regime in Europe
- US Operators would be willing to operate from Europe
- In Europe, manufacturers view a licensing approach as risky as any accident may undermine the credibility of the sector and hold back the industry
- Prospective European vehicle developers would want to have a certification approach in place in Europe: they see this as a necessary step before moving to actual vehicle development and they are confident to have enough technical know-how to develop certifiable vehicles

6 GAP ANALYSIS RESULTS

6.1 GAP ANALYSIS

A consolidated view on current drivers and hurdles at EU level was obtained. Table 9, 10 and 11 summarize the main findings from the technology, regulatory and financial points of view respectively.

6.1.1 Technology

As concluded in the technology assessment section, access to key technology is, in Europe, more limited than in the U.S. There are gaps in the technology readiness level of some of the key technologies required for suborbital spaceflight (in particular on propulsion).

Mostly, though, Europe lags behind in terms of system readiness level, that is, in the implementation and technology demonstration at system level: while several efforts were made in the past at ESA and National Space Agencies' level in the demonstration of relevant technologies using flying test-beds, and while a number of companies have development plans for commercial SRVs, no reusable suborbital vehicle has been ever demonstrated in Europe.

However, given the industrial capabilities available in Europe, and the sufficient access to critical technologies, it may be concluded that technology gaps do not represent a showstopper for the European industry. The advancement of some key technologies (and also the demonstration in relevant flight conditions) might benefit from institutional funding, as this may help ease the financial strain and the cost to market for prospective developer, while at the same time also proving beneficial for other possible space applications (like orbital spaceflight).

Technology			
Gap/Issue	**Assessment**	**Conclusion**	**Main supporting data**
Technical capability gap between Europe and U.S. in terms of: - Vehicle system design - Access to critical technologies - TRL of critical technologies -Infrastructures	- System readiness levels in Europe is low - Access to some key technology is more limited than in the US (i.e. propulsion concepts) due to a lack of critical supply mass - TRL of some key techs is lower than in the US	- While gap exist in Europe, technology is not a showstopper - Critical technologies (engine, GNC, structures) while not in the same fashion, quantity, and variety, are available in EU - Sufficient cumulative capabilities exist at EU level to tackle the development of a competitive space-plane	- Analysis of the critical techs and their availability in Europe - EU industrial capabilities - Talks with Industrial stakeholders

Table 7 – Technology hurdles to market development in EU

6.1.2 Regulations and institutional support

The European regulatory scene concerning SRV flights is, at present, fragmented. No coordination at European level exists, and only scattered efforts are on-going:

- Some countries (Sweden) are looking to regulate SRVs as spaceflight, setting up a regulatory regime similar to the one in use in the U.S.
- In some other countries, national aviation authorities are looking into the matter, to derive a certification framework akin to the one in use in the aviation sector
- In Europe, industrial players with SRV development plans are in touch with EASA to set up a certification process for their upcoming vehicles

As assessed through the stakeholder consultation process, the current situation creates significant hurdles for the development of a SRV market in Europe, impacting stakeholders within the value chain in different ways:

- **European vehicle developers:** as opposed to American vehicle developers (who deem the licensing approach as the best for the market at this stage) many of the prospective developers see an appropriate certification framework as a *condicio sine qua non* for entering a vehicle development phase. A possible reason for that is given by the different caliber of the European players with respect to the U.S. ones: whereas in the U.S. vehicle developers are small start-ups (or, in the case of Scaled Composites, companies specialized in vehicle prototyping and testing), the majority of the prospective European players are (or are associated with) large corporations operating also in the aviation business. As such, those company have:

  - A significant brand equity to protect: a vehicle that is not certified as safe is deemed too risky as any failure may jeopardize their core business (aviation)

  - A well-established *modus operandi* in their development phases, deriving from aviation and requiring the support of a certification authorities from the initial phases of the design

  Those large European players are, like other EU-SMEs (S3 and Booster Industries), reaching out to EASA to start a process that would, eventually, lead to a certification for their vehicle. EASA has a mandate to assist any company that approaches them to certify their products, organisation and/or operations. For those players, getting a fully recognized certification framework at European level is an important requirement to go on with their plans, as they do not deem possible to obtain the required certification otherwise. **It is the opinion of all the industrial parties involved that any clarity at European level would, in the medium and long term, be extremely beneficial**

- **American vehicle developers:** U.S. SRV manufacturers are, for the time being, focused on the American market. As such, they are not aware or concerned about regulatory regimes in Europe. However, since operations from Europe are planned by operators using U.S. developed SRVs, in the medium term the regulatory scenario in Europe is going to affect U.S. manufacturers as well. The common stance from U.S. manufacturers is that, again, **a unified framework in Europe would be beneficial**, as it would allow the vehicle to be wet-leased to multiple operators in the old continent, thus maximizing their revenue potential. Contrary to what European players intend to pursue, though, U.S. manufacturer would see a regulatory framework based upon the FAA-AST one (a licensing system, rather than a fully-fledged certification approach) as the way to go, at least in the short-medium term. They believe that an aviation-like certification framework would be too cumbersome, and even end-up as a hurdle for the newly developing industry

- **European Operators**: in the absence of a clear regulatory regime that allows SRV operations in Europe, **EU operators are currently considering operating from outside Europe** (SXC from Curacao, TALIS Enterprise from Malaysia)

- **U.S. Operators:** it's not an immediate priority for U.S. operators to start operations outside of the U.S. (the main effort for them as of now is to have operations started in the U.S., and to have them happen routinely). In the medium term, though, there is an interest for them to open up to other spaceport locations outside of the U.S., and this is subjected to the existence of proper regulatory frameworks. **While they would see beneficial a European wide coordination, U.S. players would consider operating from selected EU countries (in case national frameworks end up being in place)**, and, as U.S. manufacturers, they would rather have a licensing system in place rather than a certification framework

- **European Spaceports**: The short term interest for European spaceports is to get U.S. produced vehicles operations; from a regulatory standpoint, a framework akin to the U.S. one is preferred, as the one that would more easily allow operations in the short-medium term. Likewise, a pan-European regulation is not of the utmost importance to spaceports, with a national regulation deemed sufficient, at least in the short/medium term. It is important to stress here, though, that any operations of U.S. vehicles outside the U.S., even in form of wet-lease, is subjected to ITAR export license clearance: there is, therefore, uncertainty on the actual possibility to have U.S. vehicles operating outside of the U.S. in the short term.

In conclusion, the analysis demonstrated, overall, an opportunity, if not a need, for Europe to develop a clear framework for SRV regulation in Europe, benefiting in the process all the stakeholders involved, at different degrees.

Regulation and institutional support			
Gap/Issue	**Assessment**	**Conclusion**	**Main supporting data**
Lack of a unified regulatory approach in Europe Lack of institutional support	EU is not presently coordinated at regulatory level Various regulatory initiatives are on-going at individual country level EU does not institutionally support suborbital flight (not included in long term strategic objectives for EU)	Lack of regulatory coordination creates market hurdles at technology development, financial, and operational level Lack of institutional support creates hurdles at financial level US players are fine with FAA-AST approach and want it in place for 8 years after operations start EU players seek certification out of the gate	Analysis of regulatory frameworks and related implications Interviews of regulatory entities, commercial players ACARE Strategic Research and Innovation Agenda

Table 8 – Regulatory and institutional hurdles

6.1.3 Financials

The main financial issue in Europe is related to vehicle development. Investment requirements for operators do not appear to be a showstopper, with an EU operator already established, and several others in the process of raising capital[37].

Non-recurring costs for vehicle development are highly dependent on the vehicle's concept, size, and operational capabilities, and may vary from 10s of millions of euros to 1-2 billions of euros[38] depending on the vehicle concept and on the possible pursuit of certification out of the gate. They represent the primary hurdle to vehicle development. The lack of institutional support and, in lesser way, of regulatory clarity, from EU on Suborbital Commercial Spaceflight has an effect on investors' confidence, making capital-raising more difficult for vehicle developers, since Europe is not seen as a friendly environment for this type of business.

The conclusion of the analysis is that support at EU level on Commercial Suborbital Spaceflight may help with capital-raising for vehicle development; such support may happen in the form of:

- Official statement of the strategic importance of suborbital spaceflight for Europe
- Funding of R&D projects/programmes on technologies that may have applications/impact on SRVs (this would help ease the strain on the NRC requirements)

Financials			
Gap/Issue	Assessment	Conclusion	Main supporting data
- High NRC for development and testing / compliance or certification - Lack of private investors - Lack of institutional funding or non-funding in-kind support	For vehicle development: - Lack of financing is what is preventing a major player from starting development - EU lacks any form of funding support for development activity at EU level (some country-level funding on going) For operators - There seems to be investor interest in bringing operations to Europe	For vehicle development: - Institutional support (at EU political and strategic level) may create confidence from private investors for vehicle development - Use of facilities in-kind may also help ease the strain of initial NRC, enforce the feeling of support and enhance investors' confidence	Interviews of commercial players

Table 9 – Financial hurdles

[37] *Source*: Stakeholder consultation

[38] *Source*: Stakeholder consultation

6.1.4 European Demand

The demand studies analysed and the rough geographical breakdown of the advance sales (reservations) show the global character of the demand for SRV flights, with both advance sales and sales forecast equally distributed across U.S., Europe, and Asia.

European demand can be potentially fully addressed by global players in the absence of EU-developed and operated vehicles, or in the absence of operations in Europe with U.S. vehicles: given the nature of the SRV flight experience (point A to point A, need for about a week of training before flight, price in excess of 100Keuro), the location of the offer is not important from a strictly logistic point of view: moving to the U.S. from Europe to take part to the flight, even in business class, has a minimal cost and time impact on the overall experience.

While not having a direct impact on logistics, location has, however, a commercial relevance, due to the following:

- Customers may be interested in seeing, from space, a specific place they know or they are attached to: therefore, there may be an interest in flying from Europe rather than from the US for the European customer base

- Since the SRV flight experience entails a period of training of up to a week[39], the spaceport location's surrounding area also becomes relevant: being close to other touristic attractions (rather than flying from a remote or desert location) may represent a plus

This leads to the conclusion that European spaceport locations may play a significant role in addressing European and global SRV flight demand.

In terms of carriers, European demand can be addressed by U.S. vehicles operating in Europe only if:

- An adequate regulatory framework for SRVs is set in place in the given European location

- The U.S. vehicle producer manages to get ITAR export licence issues sorted

This leads to conclude that there is room for European player to address European and global demand, and, again, that there is a dire need of regulatory clarity concerning SRVs flight in Europe.

[39] *Source:* Stakeholder consultation

7 POTENTIAL INSTITUTIONAL ACTIONS

Table 11 shows the proposed institutional actions to address the hurdles identified above. Those actions, presented in order of priority, were tailored to the actual expected possible degree of intervention of the EU in the matter.

Action #	Field	Type of action	Possible strategy
1	Regulations	Clarity on regulations at EU level	Evaluate all scenarios
1-a	Regulations	Identify all possible regulatory routes in Europe and the regulator role	Evaluate possible scenarios and roles for regulators at EU level
2	Institutional support	Express EU interest at political and strategic level towards Suborbital Spaceflight	Get Suborbital spaceflight in the strategic research agenda as on objective for 2050
2-a	Institutional support/funding	Insert SRV-related themes in FP programs ESA funding of SRV-related technology development	Identification of funding themes related to subsystems that have spin-offs in other fields Involvement of ESA to stimulate technology developments and operational testing with dual application in suborbital and orbital

Table 10 - Proposed actions for EC intervention

Each of the two couples of actions is detailed and assessed in the next sub-sections. The assessment is conducted qualitatively in accordance to:

- Expected impact on EU vehicle developers
- Expected impact on EU operators
- Expected impact on US vehicle manufacturers
- Expected impact on US operators
- Expected impact on EU spaceports
- Expected impact on external investors' confidence in the EU SRV market

The impact of the actions is assessed by determining, for example, the qualitative effect on the number of SRV in operation in the EU market (either from EU or US manufacturers/operators), the number of operators and the number of spaceports in EU, as well as the expected impact on the European economy (where possible, quantitative estimates are attempted).

Given the high uncertainty on market forecast numbers, the lack of an initializing value for European demand, the confidentiality concerning the plans of most EU prospective vehicle operators on the offer being planned, the impact on expected revenues as a quantitative metric in the assessment, where used, is accompanied by strong assumptions.

In the impact assessment, reference to short, medium and long term is made, in accordance to the following definition:

- Short-term: 3-5 years (from beginning of SRV operations in the U.S.)
- Medium-term: 5-10 years (from beginning of SRV operations in the U.S.)
- Long-term more than 10 years (from beginning of SRV operations in the U.S.)

7.1 ACTION 1 AND 1-A – REGULATORY FRAMEWORKS FOR SRV IN EUROPE

The first potential action for intervention concerns the establishment of a coordinated EU regulatory framework for SRV. The two options available are:

1. *No regulation at EU-level:* regulation is left to the individual member states, which will choose the type of regulatory regime to apply to allow commercial operations of SRVs in their respective country borders. Individual states can, for example: consider SRVs as space vehicles and apply national space laws; classify them as aircraft, and issue dedicated regulatory regimes; or start issuing certification procedures which will be valid at national level. This options would lead to the ***scenario 1*** or to the ***scenario 2*** described in **section 3.5**

2. *Regulation at EU level:* EU takes actions to promote an EU-wide coordination of regulatory efforts for SRV's commercial operations

A subsequent decision point deals with the possible implementation route for a pan-European regulatory effort, entailing both the entity that should supersede the process and held regulatory duties on SRVs, and the specific regime to adopt. Concerning the regulatory regime:

2.1. *SRVs are regulated as aircraft (certification framework similar to the one in place in the aviation sector):* this option involves using processes and practices akin to those employed, for example, by EASA or FAA-AVS in the certification of new aircraft, with comparable expected times to certification for a new SRV

2.2 *SRVs are regulated as a specific innovative vehicle with an ad-hoc regime:* this option involves a tailored regulation framework for SRV, that, for example, maybe intermediate between the current FAA-AST one and an aviation-like certification regime, with a planned evolution into full-certification in due time.

It's important to note that a regulatory framework faithfully mimicking the FAA-AST one is not considered applicable to Europe, due to expected difficulties in dealing with liability issues at European and at national level.

Concerning the regulator role:

a) Regulatory role given to the existing EU regulatory body for aviation, EASA (either within its current organization, or within a new ad-hoc branch)

b) Regulatory role given to a new European regulatory institution (created for the scope)

Figure 18 shows the decision tree for action 1 and 1-a, with the different available options.

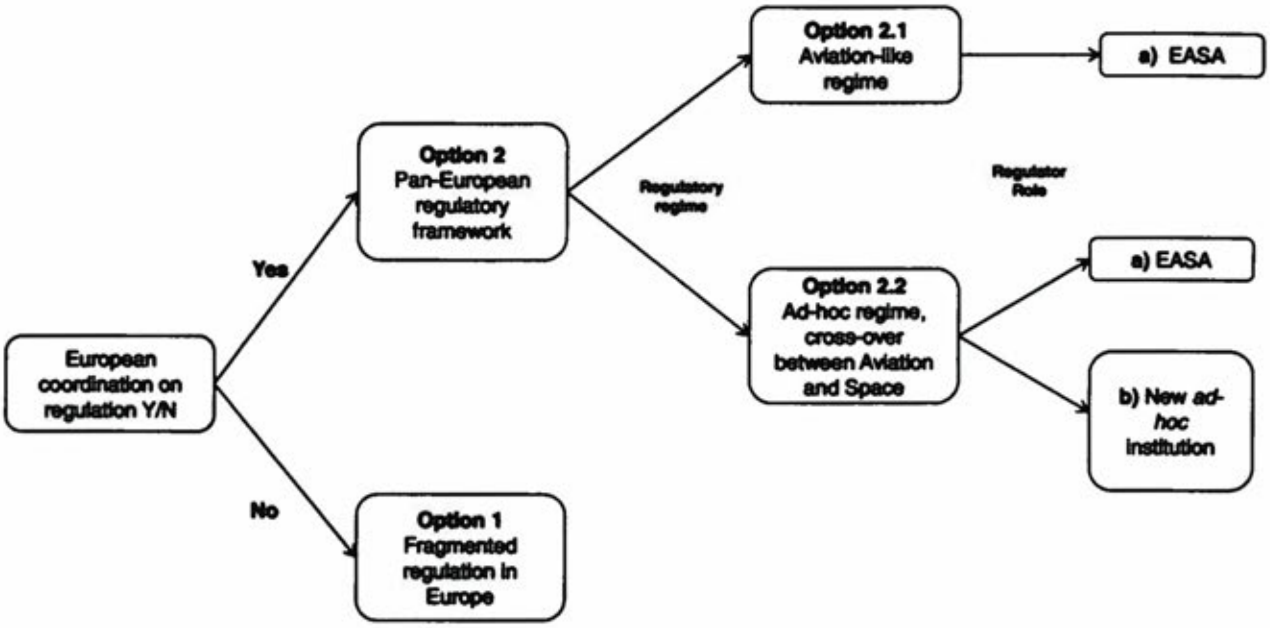

Figure 18 – Action 1 and 1-a decision tree

Table 12 maps the regulatory options for intervention to the possible regulatory scenarios defined in section 3.5.

Option #	Description	Sub-option (regulatory regime)	Sub-option (regulator role)	Regulatory scenario (as defined in section 3.5)
1	No action, fragmented regulatory scenario	/	/	Scenario 1 and/or 2 (individual countries regulating SRVs as either space or aviation)
2	Pan European regulatory framework	2.1 – Aviation-like	a) EASA	Scenario 3
2	Pan European regulatory framework	2.2 – Cross-over between aviation and space	a) EASA	Scenario 4
2	Pan European regulatory framework	2.2 – Cross-over between aviation and space	b) New European regulatory institution	Scenario 5

Table 11 – Mapping of regulatory options and the related resulting scenarios (as defined in section 3.5)

The next subsections show the assessment of each of the options described in the Table.

7.1.1 EU coordination at regulatory level

On the basis of the concluding arguments of the gap analysis, it's easy to realize that a EU coordination at regulatory level would be mostly beneficial for all the players along the value chain, and also help send a strong message to external investor, thus helping the build-up of the market.

EU stance on SRV regulation	Impact on EU vehicle developers	Impact on EU Operators	Impact on US vehicle manufacturers	Impact on US operators	Impact on EU spaceports	Impact on market investments in EU	Overall impact
Option 1 - No action (no regulatory framework at EU-level)	-	-	=	=	=	-	-
Option 2 - Pan-European regulatory framework	+	+	+	+	=	+	+

No impact or negligible impact (either negative or positive) =   Negative impact -   Positive impact +

Figure 19 – Evaluation of the decision point on the opportunity to have EU coordination on SRV regulatory frameworks

Choosing to pursue a clear regulatory framework in Europe would benefit almost all the stakeholders along the value chain, by creating a safer business environment, fostering investments, and opening new local markets within Europe.

The expected impact of a regulatory coordination in the long-term is estimated as follows:

- *Number of vehicles operating in Europe:* The action is supposed to affect positively the number of SRVs operating in EU in the next decade. Depending on the specific regime chosen, having a clear regulatory view in Europe would help, in fact, to open operations for a number of prospective EU operators wanting to use US vehicle in Europe. US manufacturers (again, depending on the specific regime implemented) would see Europe as a safer market to get into, and put more efforts into clearing export licence issues sooner. Additionally, having a clear regulatory stance at EU level sends a strong signal on the acceptance of SRV flights, and helps prospective European vehicle manufacturers and operators in their capital-raising efforts

- *Number of operators:* For which concerns operators, as already mentioned in the first bullet above, a clear regulatory environment is expected to raise investors' confidence in the EU market, facilitating the birth of new companies (operators); likewise, existing or prospective operators would find it easier and to spread their operations across Europe

- *Number of spaceports in EU:* even though a regulatory framework at European level is not a requirement for spaceport (since a favourable national law is possibly enough to enable operation at national level), a clear regulatory environment, by fostering investments in SRV manufacturing and in operations, would lead subsequently more countries and private investors to bolster investments in infrastructures for SRV flight. This would have a positive impact on the number of spaceports located in Europe

7.1.2 Type of regulatory regime

Figure 20 shows the evaluation of decision point, related to the type of regulatory regime possible for Europe for the new-born SRV industry. The analysis here depicts the expected qualitative impact on the various players on the value chain in accordance to the conclusions drawn in the study and within the gap analysis.

Regulatory approach	Impact on EU vehicle developers	Impact on EU Operators	Impact on US vehicle manufacturers	Impact on US operators	Impact on EU spaceports
Aviation-like	+	=	-	=	-
Ad-hoc regime (cross-over between aviation and space)	-	=	+	=	+

No impact or negligible impact (either negative or positive) = Negative impact - Positive impact +

Figure 20 – Evaluation of the two options for SRV regulation in Europe

The next subsections provide a detailed explanation for the evaluation results depicted in Figure 20 above.

7.1.2.1 *Aviation-like certification approach*

For an Aviation-like regulatory approach, the rationales for the expected impacts are

- **Impact on EU vehicle developers:** a distinction here can be made between large companies like *Astrium* and *Dassault* and prospective small developers (like *Copenhagen Suborbitals*). The impact on the formers is expected to be positive in the medium-long term, since those companies, with a core business in other aerospace sectors, seek aviation-like safety standards as a protection towards their brand equity, as a market enabler to sell their vehicles around the world, and also as a barrier to entry and competitive advantage over U.S. developed vehicles. For prospective small companies, that, as of now are extremely limited in number in Europe, such a regime would represent an obstacle, a barrier to entry which could even just leave them out of the European market

- The impact on **EU operators** would probably be not immediately positive. EU operators' short-medium term plans involve the use of U.S. developed vehicles, which would have a hard time complying with stricter regulations in Europe. On the other hand, in the long term, such a regime could make it easier for operators to establish a sustainable business and expand their operations across Europe

- The impact on **US vehicle manufacturers and operators** would be possibly not beneficial: most U.S. vehicle manufacturer and operators see the U.S. as primary base for operations in the short-term (their main focus is to get operations started in the U.S., with global expansion only supposed to happen after routine operations have been established). However, the timing for routine operations in place in the U.S. and a certification regime established in Europe may be comparable: as of now, it's difficult to estimate how long it would take to the industry to be fully established in the U.S. (it is expected to be in the range of 2-3 years, based on our field interviews), but on the other hand an aviation-like certification approach would certainly take 3-5 years to be implemented in Europe. At such a later stage, a certification regime would make it difficult for them to operate in Europe as it would require significant investments in the adaptation of their current vehicles and in the pursuit of the required certification

- The impact on **EU dedicated spaceports** would possibly be negative. Talks are on-going as of today between U.S. operators and some European spaceports: any plan for operations would require an effort on the U.S. operators' side to clear export licence issues for Europe, and, considering also the current focus on U.S. until routine operations are established, this could take 3-5 years to happen. If a certification framework is being considered, and expected to be launched in the same timeframe, U.S. operators may consider the effort not worthy at this time (as they would have then to comply with new and stricter regulations in Europe). Moreover, in the long-term an aviation-like regime makes it possible, ideally, for an SRV to fly from a conventional airport, thus limiting the strategic importance of dedicated spaceport infrastructures altogether

If such a regime takes place, it is expected that limited or no SRV operations at all take place in Europe in the short, and possibly medium, term (until certified SRV vehicles are developed).

Such delay in starting operations in Europe may lead to a of loss of relevance in the short term, and in the long term may create competitive advantage to European manufacturers. With that regime in place, European manufacturers would capitalise on the attractiveness

of a safer alternative to US licenced spaceships, at least until the US put their certification regime in place. It would give the certification entity (e.g. EASA) a lead or put it at par with the FAA.

If such a regime takes place, and the following assumptions are realized under such regime:

- **SRV development plans:** Current European SRV development plans take-off and reach **production without significant delays/issues by the next 10 years**
- **Demand:** ***Demand estimations based on a high safety of flight offer are confirmed in the range of 30,000 per year by mid next decade worldwide*** which translate into a fleet of about 20 vehicles flying twice a day
- **European market share:** European players achieve a 30% global market share in operations and around 40% of the global vehicle market, thanks to a competitive advantage over U.S. vehicles
- **Ticket price:** A 200K euro ticket price
- **GDP Impact:** The GDP impact is calculated using an industry economic factor of 3, as an average of those estimated for aviation[40] and space, that are taken as proxies

...the following economic impact can be speculated in the long term (i.e. after more than 10 years from the beginning of SRV global commercial operations):

- 2-3 major European SRV manufacturers in Europe, capturing roughly **30 to 50%** of a global demand
- Estimated revenues for operations in the range of **2B Euro per year**
- A GDP impact on the European economy estimated in the range of **6B euro per year**
- **Approximate impact on job creation:** In the long term, such a market would possibly sustain 50 thousand jobs in the space sector, of which 10 thousand highly qualified jobs, accounting for an expansion of the space workforce of around 20%[41]

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[40] "*The multiplier effects of air transport can be calculated as a ratio of the sum of catalytic, indirect plus induced demand effects to the direct demand effects, in terms of output and employment. It is estimated that each dollar of output produced in the air transport industry worldwide creates a demand of $3.25 output in other industries.*" ICAO page X, and 2-1 (available online at: http://legacy.icao.int/ATWorkshop/C292_Vol1.pdf - Last retrieved on February 2013); NASA estimated the impact of its activity at its centres and for its manufacturing contractors: "*Conservative economic analysis performed by Southwest Business Research estimates economic impact up to 2.5 times the size of expenditures*" Main JSC economic impact (available on line at http://www.nasa.gov/centers/johnson/pdf/459378main_jsc_economic_impact_09final.pdf – Last retrieved on February 2013);

[41] The space sector in Europe is estimated to account for around 40 thousand jobs in the space industry, plus around 250 thousand jobs in associated areas. Source: ESA – *Europe in Space* (available online at http://www.esa.int/About_Us/Welcome_to_ESA/Europe_in_Space - Last retrieved on February 2013)

7.1.2.2 *Intermediate Ad-Hoc regime*

For what concerns an ad-hoc regime (cross-over between aviation and space), the impact analysis results depicted in Figure 20, page 64, are justified as follows:

- **EU vehicle developers**: large European companies would see their development plan, already based on certified design, hindered by the lack of a full aviation-like certification regime, and would possibly not pursue their current development plans; it's difficult to predict if they would scale-down their plans, or wait, postponing to a long-term phase their intended plans. This would also affect their prospect in Asia where safety of flight is particularly valued. Smaller start-up would probably welcome a less demanding approach

- **EU operators** would have it easier to bring operations of U.S.-developed vehicles to Europe, although the amount of effort/adaptation required would depend on the specificity of the regime adopted. In general, they would have a lower time and cost to market, while still reaping the benefit of a unified European approach, allowing them to plan operations from multiple countries

- **US vehicle developers and operators** wouldn't be much impacted, because they are focused in the short/medium to reaching routine operations in the US first, but would probably be more encouraged to qualify their vehicles for European operations under an initially lighter regime than certification

- **EU spaceports** would initially benefit, with an ad-hoc regime, from a more friendly environment allowing for a quicker start of SRV operations

Such an intermediate regime could potentially lead to European SRV operations faster (i.e. in the medium term). Depending on the specificity of the adopted ad-hoc regime, U.S. vehicles could be operated in Europe within 5 year' from the beginning of U.S. operations.

If such a regime is implemented, and the following assumptions are realized:

- **SRV development plans:** ***Current European SRV development plans for certified vehicles are either postponed or scrapped in favour or new plans based on different design approaches***; start-up companies develop new projects. In total, a few of those manage to reach production status in 5-10 years
- **Demand:** Demand estimations assumed here is an average between the expected demand in case of a certification regime and the conservative demand estimation based upon a licensing regime, i.e. about 10,000 passengers per year
- **European market share:** European vehicle manufacturers are assumed to compete with at least 5 other players from the U.S.
- **Ticket price:** A 200K euro ticket price
- **GDP Impact:** The GDP impact is calculated using an industry economic factor of 3, average between the ones for aviation and space, that are taken as proxies

...the following economic impact can be projected in the long term:

- **1-2** small/medium European SRV manufacturers in Europe, capturing roughly **10%** of a global demand[42]
- Estimated revenues for operations in the range of **300M Euro**

[42] *10% is estimated on the basis of 6 vehicle manufacturers globally and a late entry for European manufacturers*

- A GDP impact on the European economy estimated in the range of 1B euro
- **Approximate impact on job creation:** In the long term, such a market would possibly sustain 5 thousand jobs in the space sector, of which one thousand highly qualified jobs, accounting for an expansion of the space workforce of around 2.5%

7.1.2.3 Summary

It is important to point out that the two approaches described above are not mutually exclusive, since two parallel processes could be considered with:

- An ad-hoc regime to be put in place in a shorter timeframe
- A full certification process, to be adopted in a medium-term timeframe

Those two regimes could be drafted out at the same time. Such a solution would allow retaining the benefits of both approaches:

- Avoid the risk of loss of relevance in the initial phase of the market due to late entry
- Support the EU large industry in their development and business process with a proper certification process

The above would obviously have a toll on the resources required for the regulatory effort, which would have to be much higher in order to accommodate the management of both processes at the same time.
Figure 21 summarizes the assumed timeline for possible SRV operations in U.S. and Europe.

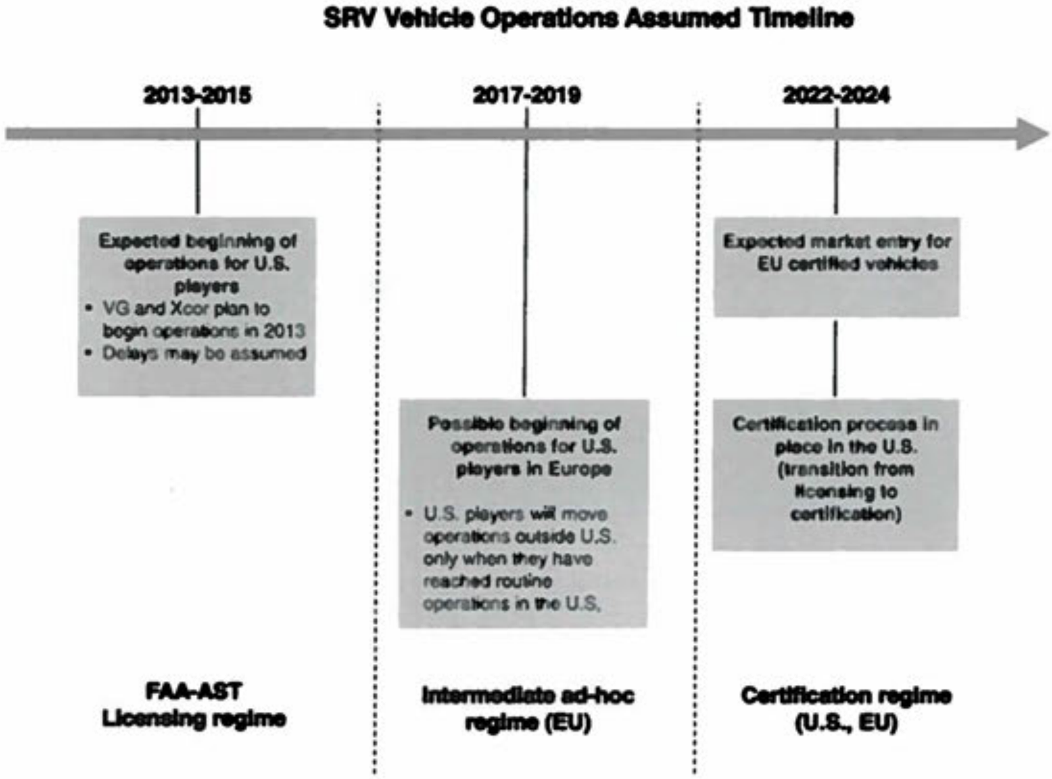

Figure 21 – SRV operations assumed timeline: for EU operations of U.S. vehicles, an intermediate ad-hoc regime would be required

7.1.3 Regulator's role

The final decision points concerning the regulatory action is related to the role of the regulatory institution; in case an Aviation-like regulatory regime is chosen, the choice of the regulatory institution is immediate: the European Aviation Safety Agency would be best suited to put in place a regulatory framework based upon aviation rules. In case an intermediate approach is chosen, of the two possible routes involving either EASA or a new entity created for the scope, EASA would still be preferable for the following reasons:

- Time and cost concerns: creating a new institution would be too time and cost consuming, requiring a decisional process at EU level that could last years
- Opportunity: EASA has already been studying the issue of SRV regulations, and already has working relationships with FAA-AST which would speed-up the regulatory process and its harmonisation

7.2 ACTION 2 AND 2-A

The study showed a need for:

- Recognition, on EU's part, of the relevance of commercial suborbital spaceflight for future European aerospace industry's competitiveness
- Clear manifestation of strategic interest at policy level
- Possibly, some institutional funding to ease on the development cost strain for new European assets

The options proposed here to achieve the above objectives are:

- **Insertion of suborbital point-to-point transportation in the Strategic Research and Innovation Agenda** (prepared by ACARE and depicting EU strategic interest in aviation up to 2050): suborbital point-to-point transportation is assumed to be not environmentally friendly, and, as such, not fit to figure within the ACARE Strategic Research and Innovation Agenda (which has in its objective a drastic decrease of emission on ground and in air for 2050). However, as mentioned in section 3.6.1, suborbital spaceflight by LOX/HC liquid propulsion is supposed to have the same emissions per passengers per kilometre as a transcontinental flight[43]. Moreover active R&D on liquid rocket propulsion is on-going on new fuel mixtures to reduce emissions
- **Insertion of SRV-related themes (with possible applications in other fields) in FP programme:** while it would be difficult to have in FP programme themes that directly relate to SRV, it is conceivable to have themes concerning technology development of interest for SRV but that have other mainstream applications in aviation and or space (i.e. in the propulsion, avionics, or airframe structure fields). In this way, vehicle developers would have a minor kick-start in their development costs
- **Invitation from EC to ESA to insert SRV-related themes (common themes to suborbital and orbital, for example) in ESA funded programmes:** along the same lines, EC can invite ESA to add SRV-related themes to its technology programmes that also have an application, for example, to orbital space transportation

Figure 22 shows an evaluation of the benefits of those actions to the main stakeholders, as well as a qualitative assessment of the ease of implementation.

[43] *Source:* Stakeholder consultation

Regulatory approach	Impact on EU vehicle developers	Impact on EU Operators	Impact on US vehicle manufacturers	Impact on US operators	Impact on EU spaceports
Insertion of suborbital point-to-point transportation in the Strategic Research and Innovation Agenda	+	=	=	=	+
Insertion of SRV-related themes (with possible applications in other fields) in FP programme	+	=	=	=	=
Invitation from EC to ESA to insert SRV-related themes in ESA funded programmes	+	=	=	=	=

No impact or negligible impact (either negative or positive) =   Negative impact   Positive impact +

Figure 22 - Evaluation of options for other institutional actions for SRVs in Europe

Even though the insertion of SP2P in the SRIA only directly benefits vehicle developers (by creating confidence in investors on the fact that Europe is supporting suborbital flights in an official guise) and spaceports (again, by showing that Europe is a friendly environment for SRV operations), it should be pursued for its relative ease and low cost/effort of implementation on EC's part.

The insertion of SRV-related themes in FP and ESA programmes is more delicate, and may require a more in-depth feasibility assessment.

Action 2 is going to have a smaller impact on the market, affecting the metrics in a more indirect way. The main beneficiaries of the action would be European vehicle manufacturers that would possibly have benefits in capital-raising.

7.3 EU ACTIONS ROADMAP

The three categories of stakeholders - SRV manufacturers, SRV operators and spaceport operators - have in the short term diverging interests, while in the longer term they all need a stable regulatory environment conducive to investment, safety and profitability.
The main actions from the EC side should focus on the regulatory environment first, in order to provide visibility to industry players including non-European players. An ad-hoc regime at EU level provides clarity and ensures European coordination from start. As for the exact regulatory route to follows, the two possible avenues provide different pros and cons for the various stakeholders, as identified in section 7.1.
Figure 23 below shows the expected roadmap for action 1 and 1-a) outlining the expected timing for the two different regulatory options analysed.

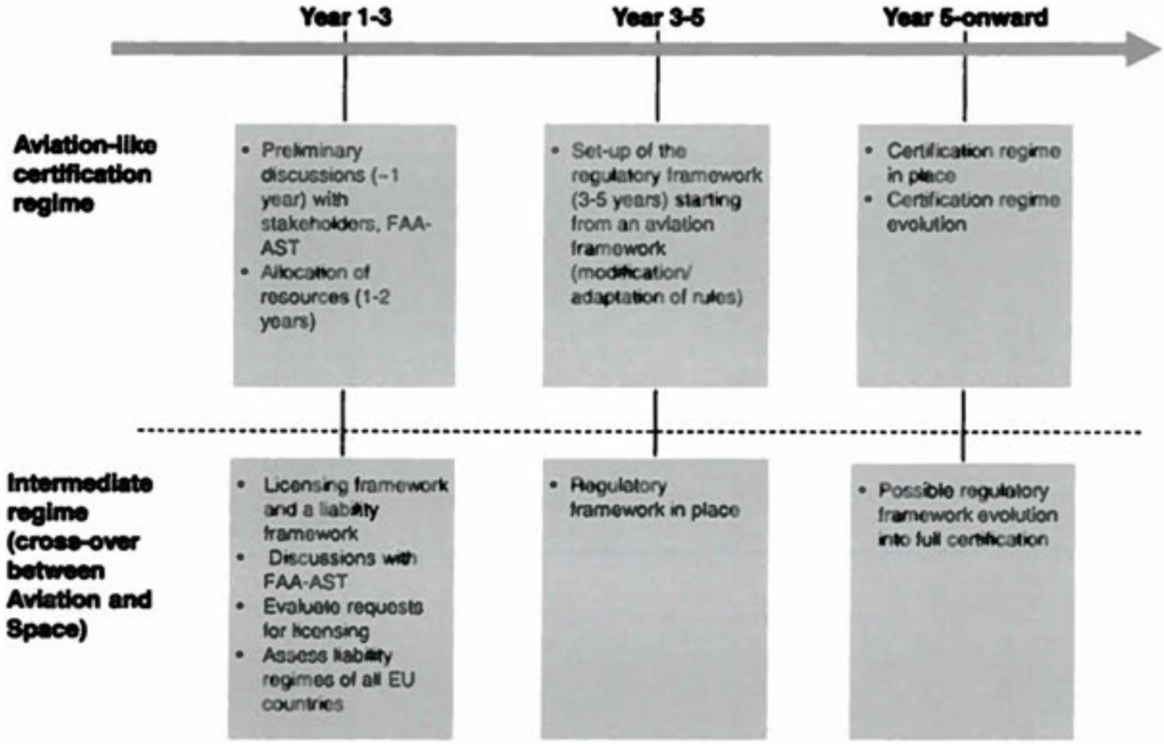

Figure 23 – Expected roadmap for action 1 and 1-a), for the two different regulatory regimes analysed

Figure 24 shows a similar roadmap for action 2 and 2-a).

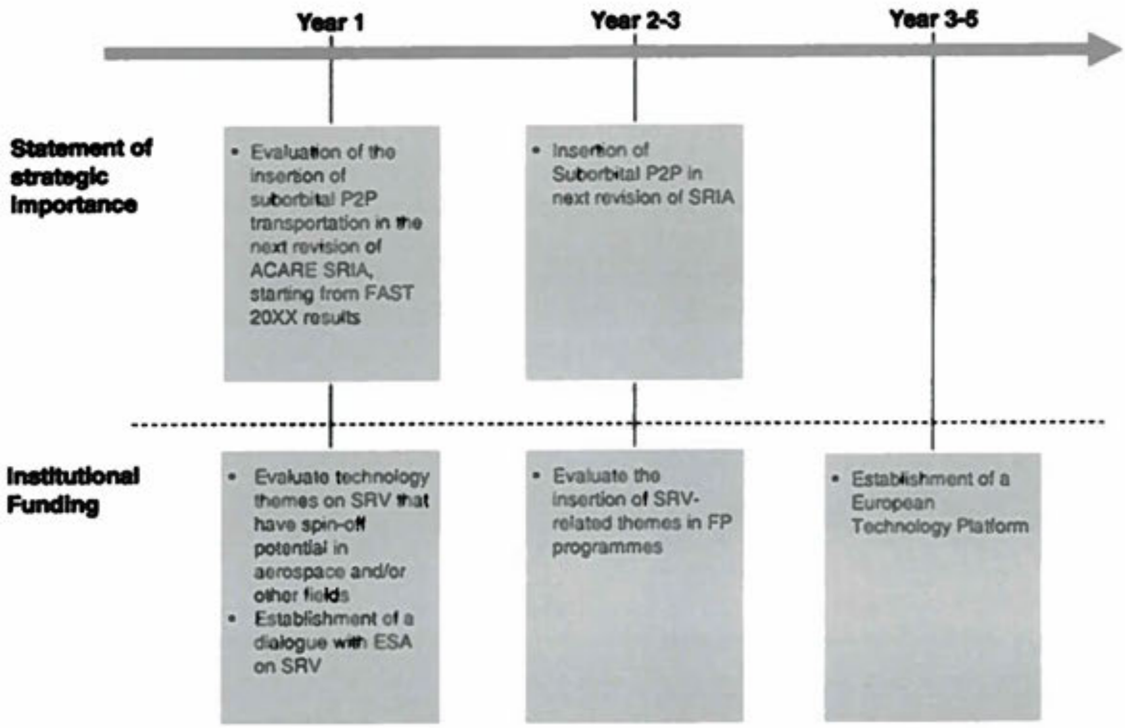

Figure 24 – Expected roadmap for action 1 and 1-a), for the two different regulatory regimes analysed

8 CONCLUSIONS

The analysis of the commercial suborbital spaceflight sector showed a highly strategic market in the making in the U.S., and, as of today, a rising level of interest in Europe; the importance of this market for European competitiveness and the need to pursue institutional actions in order to foster its development in the EU also clearly emerged from the study.

The dynamics that led to the birth of the new industry in the U.S. owe a lot to favourable external factors, which included a wealth of venture capital from private investors and a significant institutional support, realized through grants and access to facilities and expertise and, above all, through the prompt establishment of a light regulatory regime to allow easy market entry for prospective vehicle manufacturers and operators.

Demand analysis studies highlight a high dependence of the demand estimations over base assumptions like prospective user base and perceived and actual safety of flight. The demand build-up estimations vary over a wide range, but suggest a base for a sustainable business. Most importantly, the demand is global, with current prospective ticket-buyers coming uniformly from U.S., Europe and Asia. Current expected supply is limited to operations in the U.S.: prospective operations are indeed planned around the globe, but those may be hindered by U.S. export licence issues.

The European scenario is much less developed than the U.S. one. There is strong interest in bringing U.S.-developed SRV operations in Europe, with capital being raised by prospective operators, one commercial Spaceport already active (for sounding rockets launches) and several other spaceport locations being considered. Various companies have stated interest in SRV vehicle development in Europe: those include start-ups, and, contrary to the U.S., large aerospace corporations, that presently have concrete development plans (albeit not yet in an executive development phase).

However, the external factors that contributed so strongly to the market birth in the U.S. appear to be lacking in Europe, with no institutional support being provided, and a lack of coordination and regulatory clarity at European level. This last point appears to be critical for the development of the market in Europe. Almost all stakeholders along the value chain, including U.S. players, see a clear regulatory framework in place as a mandatory step to for market development, as the only measure that can:

- Create a safe business environment
- Raise investors' confidence
- Provide business sustainability in the long run

The assessment of the strategic importance of commercial suborbital spaceflight highlighted its multi-fold implications in industrial competitiveness, scientific research, technology transfer, local regions' development, culminating into the long-term evolution of the concept into Point-to-Point Suborbital transportation.

Taking into account the relevance of Commercial Suborbital spaceflight for European medium and long term competitiveness, and the current hurdles to its development, it appears clear at this stage the need for EU to pursue an institutional action in order to provide Europe with the support needed to sustain the new market.

The main institutional action deemed as necessary at this stage for Europe is represented by a push for the establishment of a clear regulatory framework for SRV operations in Europe. As for the type of regulatory regime to pursue, two different options, with different pros and cons, can be conceived:

- An aviation-like certification approach, meaning with that a regulatory frameworks that adopts structure, methodologies and processes from the current aviation certification framework established and managed by EASA
- An *ad-hoc* regime, intermediate between the FAA-AST licensing system currently in place in the U.S. and an aviation-like certification framework

Pursuing a full certification process right from the start would benefits large European companies with an interest/plan in SRV vehicle development: those companies see a certification regime as a necessary step to be accomplished in Europe in order to make their development plan sustainable, and their prospective business in the new market sound. On the other hand, such an approach would lead to dismiss any prospect for SRV operations in Europe before the next decade (since U.S. players may not find it worthy to invest resources into moving operations in Europe under the prospect of an impending regulatory framework that would require them to update/evolve their vehicle concepts and that could simply jeopardize their capability to operate), thus damaging the medium term prospects of European spaceports.

On the other hand, an ad-hoc regime, intermediate between aviation and space, would probably ensure the possibility to have SRV operations in Europe in the medium term, provided that ITAR related export licences concerns are dispelled in due time. This would allow Europe to stay relevant in the SRV market already in medium term, but could probably lead to large European companies to delay/downplay their development plans to a later stage. The ad-hoc regime could still converge into a full certification at a later stage.

The two approaches described above are not mutually exclusive: provided with appropriate resources, a regulatory authority could ideally pursue them both in parallel.

In addition to the need for regulatory clarity, the study showed also a need for an official recognition, on EU's part, of the relevance of commercial suborbital spaceflight for future European aerospace industry's competitiveness, with a clear manifestation of strategic interest at policy level. Such a need is implicitly addressed if a regulatory framework is established in Europe; however, the strategic need for commercial spaceflight could be further stressed with additional policy or funding actions, like including suborbital P2P transportation into the strategic objectives for aviation in Europe for 2050, or including SRV-related themes (with impact/implications in other technology areas, within and out of the aerospace sector) in future FP programmes.

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10 APPENDIX

10.1 ACRONYM AND ABBREVIATIONS LIST

ACARE	Advisory Council for Aerospace Research in Europe
EASA	European Aviation Safety Agency
FAA	Federal Aviation Administration
FAA-AST	Federal Aviation Administration Office of Commercial Space Transportation
FP	European R&D Framework Programme
GNC	Guidance, Navigation and Control
ALHL	Air Launched, Horizontal Landing
HTHL	Horizontal Take-off, Horizontal Landing
ITAR	International Traffic in Arms Regulation
LOX/HC	Liquid Oxygen/Hydrocarbon rocket propulsion
P2P	Point-To-Point
SC	Scaled Composites
SOA	Suborbital and Orbital Aircraft
SP2P	Suborbital Point-To-Point Transportation
SRIA	Strategic Research and Innovation Agenda
SRV	Suborbital Reusable Vehicle
TSC	The Spaceship Company
UAS	Unmanned Aircraft Systems
VG	Virgin Galactic
VTPL	Vertical Take-off, Parachute Landing
VTVL	Vertical Take-off, Vertical Landing

10.2 STAKEHOLDER CONSULTATION: INTERVIEW GUIDELINES

Interviews of current players

1 – Market

- How would you characterize your current customer base, from a geographical standpoint? Can you provide any information on demand geographical distribution?
- What pace of operation do you foresee?

2 – Regulatory Environment

- How would you characterize the process that led FAA-AST to produce the commercial space act and to propose the currently employed licensing system? Was it a top-down or a bottom-up process?
- What impact had the Act in the decision for your company to get into the business?

3 – Technology and safety issues

- What do you think are the most critical/enabling technologies for cost efficient suborbital flight?
- How critical is reusability/flight frequency to the sustainability of commercial suborbital spaceflight business?
- What are the most critical safety concerns, and how are they addressed design-wise in your vehicle?
- Once your vehicle development was approaching final stages, what type of qualification procedure did you follow to qualify for operations according to current regulations?
- Do you depend on critical technologies that are only available in US, which ones?
- Do you think informed consent is sustainable or when the market grows FAA will go towards something more certification-like?

4 – Opportunities in Europe

- Would you consider/Are you considering moving part of your operations in Europe? If yes, where? If no, what is preventing you from doing so?
- Do you see the lack of a EU-level regulatory framework for suborbital spaceflight as a hurdle for the development of a European industry in the sector, and for operations in Europe?

Interview of European prospective players

1 – Market

- Your strategy to enter the commercial suborbital spaceflight market
- Insights on the current size of the market and the expected short-term evolution
- Geographical demand
- Main hurdles to market development, globally and in Europe

2 – Regulation

- Your awareness (and/or involvement) on any regulatory activity currently going on in Europe, at both National and Communitarian level
- Your view on the licensing/informed consent regime in place in the U.S.
- Your view on an aviation legacy-based certification approach
- Your view on the current lack of a EU-level guidance in suborbital spaceflight regulations

3 – Technology and safety issues

- Your view on what are the most critical/enabling technologies for cost efficient suborbital flight
- Your view on what re the most critical safety concerns, and how were they addressed design-wise in the your concept

4 – Financials and external investments

- Your concept development costs as compared to the U.S. competition
- Your expected operational costs
- Any hurdle preventing third parties from investing in your venture, or in other ventures taking place in Europe

5 – Opportunities outside Europe

- Would you consider development and production in Europe and operations outside of Europe?

6 – EU Actions

- What action could the EC undertake in order to promote the development of the commercial suborbital spaceflight industry in Europe?

Interview of Regulators and Spaceports

1 – Current status

- Are you aware of any regulatory activity currently going on in Europe concerning suborbital spaceflight?
- If yes, how would you characterize such an activity (executive, consultative)?
- Where you approached by any industrial player on the subject?
- Can you briefly describe your activity in the field?

2 – Aviation vs. Space

- What would you say are the advantages of one approach over the other?
- What is the current stance by European players (regulatory institutions, industrial player) towards the regulatory approach to be followed (aviation vs. space)?
- Which approach would you recommend at this stage in Europe?

3 – National vs. Pan-European

- What would be, in your opinion, the impact of having individual European countries promoting their own markets through national space law?
- What long term issues do you foresee as a result of a regulatory fragmented environment?

4 – Recommendation to the EC

- What kind of institutional action would you envision from the EC?