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EADS Astrium

« Now, of course, the great thing about the solar system as a frontier is that there are no Indians, so you can have all the glory of the American expansion's myth without any of the guilt. »

Sarah Zettel

For Hughes Laporte-Weywada, taking the high road was an expression to interpret both on the figurative and literal sense. Eight miles above the ground, on command of his Cessna 162, Hughes was thinking about the future of Astrium's suborbital project once again. Tomorrow was the meeting with the CTO Robert Lainé and the chairman François Auqué and he had not yet determined how to present the issue.

Hughes had dedicated his career to launch vehicles and rocket propulsion. Starting in 1981 during Ariane 5 development, he had held various positions in launch vehicle system design before leading Arian activities as Head of Astrium Launcher Business line. Appointed Astrium Deputy Chief Technical Officer five years ago, he was also at the head of Astrium's suborbital space plane activities... and all the issues and interrogations bounded to it.

The combination of Virgin's financial resources, its marketing prowess, and its association with the technical expertise and experience of Scaled Composites, had put the company at the forefront of this emerging field. Astrium therefore needed the right strategy to compete, knowing that it would enter the market much later and did not have the same structural agility.

The future of the industry was still blurry and each competitors had his own view on the issue. Overall uncertainty was an important component of space tourism, at every level. For instance, all competitors seemed to claim they'd have the lowest costs and the technological uncertainty as well as the absence of publicly displayed details advancement of each venture made it hard to know who was right.

Looking beyond the credit crunch to space jet's prospects Hugues liked to say he "(...) worked on the Ariane [rocket] during some really difficult days. I do not underestimate the difficulty of [developing space jet]."

Shall they proceed with their current strategy? Or was their ambition too high? Should they just wait for few years and develop a point-to-point? Shall they partner with a firm to sell their tickets? Should they count on pre-sales, just like Virgin Galactic, one of their main competitors? Did they burn steps? Did they want to go too fast? Was it still an attractive market if they could not enter it before 5 or 6 years?

Instead, he compared the project with the history of Airbus, which entered the airliner market many years after Boeing but over time was able to close the gap. *“If we believe this is a long-term market, there is no problem”*.¹

As he pulled up the handle of the aircraft to go above a large set of clouds, Hughes tried to look at all the facts with a fresh eye.

A Bourgeoning Industry

The Emergence of Space Tourism

On April 28, 2001, Dennis Tito, a California-based multi-millionaire, was sent in orbit, becoming the first space tourist of human history. Launched aboard a Russian Soyuz capsule, Tito proved that travelling beyond the frontier of the atmosphere was not just the privilege of a selected few, but that anyone with drive, motivation—and at the time, a saving account of \$20 million—could become an astronaut. The success of Tito’s experience showed the way to few other wealthy adventurers, announcing the dawn of a new era in the history of aerospace: that of private space exploration.¹

In this respect, space tourism undeniably represented its first step. In its most basic form, space tourism is defined as a tourism activity in which participants pay for flights into space. More broadly, the definition also includes related activities, such as astronaut trainings and zero gravity flights—in a leisure context. Agencies specialized in space tourism began to appear in the late 1990’s, essentially developing two types of services: orbital and suborbital flights. Orbital flights were 1 to 2 weeks trips to low Earth orbit. Particularly costly and complex to organize, such flights had essentially been reserved to a fistful of multibillionaires such as Dennis Tito, and had solely been successfully implemented by one provider—a venture between the Russian Space Agency and Space Adventures, an American space tourism company. Private suborbital flights providers were planning to offer a more accessible experience: a short excursion at an altitude of 100km, conventionally considered the frontier of space.² During a journey of an hour to two hours and a half, passengers were to

¹ A detailed timeline on the history of space tourism is provided in **Appendix C**.

² Unlike countries, space has no official frontiers. The Kármán line, which lies at an altitude of 100 kilometres (62 mi) above sea level, is commonly considered the boundary between Earth’s atmosphere and outer space. The Kármán line’s norm is accepted by the *Fédération*

experience few minutes of zero gravity, while observing the curvature of the Earth from the edge of space. Although the basic suborbital technology was known for years in the aerospace industry, no suborbital space tourism programme had yet been operating as of 2010.

Surveys had already been conducted on the wide interest of public for space tourism.³ Yet, prior to Futron's study, published in 2002, none had thoroughly analyzed potential demand for the industry.⁴ Basing its estimates on a price ticket of \$100,000, Futron estimated that demand increase exponentially to reach 15,000 passengers per year by 2021, generating a \$700 millions of revenue throughout the industry [See **Appendix D**]. More optimistic analysts considered that by then, it would have had reached the 20,000 customers. In fact, the perceived risk of the activity still hindered a large number of potential passengers of which participation in a program would very much dependent upon the success of first launches and the level of safety provided.

Authorities' Intervention

In contrast to the early days of aviation, complex legal frameworks governed activities in both the atmosphere and space after the middle of the 20th century. Originally, such framework did not permit commercial passenger flights to space.

In the United States, the Commercial Space Launch Act of 1984 compelled the Secretary of Transportation to "*encourage, facilitate, and promote commercial space launches by the private sector*".⁵ In the mid-1990s, the private sector recorded a fast growth, responding to global demand for commercial satellite launch services. Nonetheless, a downturn in the telecommunications services sector led to a decline of the demand.ⁱⁱ

The commercial launches industry underwent a revolution with the emergence of suborbital reusable vehicles, also opening the doors to space tourism. As a

Aéronautique Internationale (FAI), an international standard setting and record-keeping body for aeronautics and astronautics.

³ In the late 90's, the Japanese's National Aerospace Laboratory surveyed citizens in Asia, America and Europe to estimate the wide interest of various nations for space tourism. The poll revealed that 60% to 80% of the population was willing to spend the equivalent of a month salary to get into space. Although in most cases, a month of salary would have not been enough to afford such journey, the survey highlighted the fascination of mankind for space.

⁴ Founded in 1986, Futron Corporation is a technology-consulting firm based in Bethesda, Maryland, with primary competencies in engineering analysis, risk management, and space industry analysis. The Space Tourism Market Study, of which parts of the results are reproduced in appendix, also included an estimated demand of orbital space tourism. It was based on interviews conducted on 450 US citizens with revenues of more than \$250,000 per year or a net worth of at least \$1 million.

⁵ At that time, the U.S. government was the sole entity launching civil and commercial payloads into orbit from the United States. However, the Space Shuttle Challenger accident in January 1986 pushed the U.S. government to progressively transfer responsibilities for commercial launches to the private sector.

“hybrid” activity, sub-orbital space tourism invoked elements of both air law and space law, and called for the development of a new legal framework. Urged by early investors, the US authorities amended the Commercial Space Launch Amendments Act in December 2004 to allow paying passengers to fly aboard suborbital vehicles at their own risk. Under the terms of the legislation, the FAA—*Federal Aviation Administration*—regulated the reusable suborbital rocket industry for eight years, beginning in 2012. The FAA implemented a licensing process focusing on public safety and safety of property, while leaving space tourism companies with room for experimentation in the technical design of their vehicles.⁶ Among the set of rules, space vehicles were expected to take off from specialized spaceports—either converted military airports or custom-built locations—in order to minimize impacts on commercial aviation.⁷ Also, future passengers had to be informed of the risks involved with the activity and be able to provide written consent that they understood the danger. Space tourists also had to be given pre-flight training to handle emergency situations such as a loss of cabin pressure or fire.ⁱⁱⁱ

Regulations were not the only contribution of US authorities to the infant industry. In February 2010, President Barack Obama unveiled the 2011 budget request for NASA. The request was to provide a new direction for the aerospace organisation; it included a \$6 billion boost over five years to support commercial spaceflight development but scrapped NASA's Constellation programme to return astronauts to the moon. Following this line which looked for many as a budget cut, NASA announced the same week its intention to use privately built spaceships to launch astronauts to space instead of government vehicles, and unveiled awards for a total of \$50 million to support commercial spaceflight efforts. The awards joined the two billion-dollar of contract already in place between NASA and private space industry to supply unmanned cargo shipments to the ISS.^{iv}

In Europe, laws governing private sector space endeavours such as satellite launches existed for a long time, but no regulation for commercial human spaceflight had yet been developed. The European space tourism industry was therefore subject to national frameworks which, in most cases, were inappropriate for such activity. The issue of finding a suitable spaceport from

⁶ The FAA issued four types of licenses: a launch license—for expendable launch vehicles—a reusable launch vehicle mission license, a re-entry license, and a launch or re-entry site operator license. The first three types of licenses were granted to operators of a launch vehicle, and the fourth to operators of a spaceport. Licenses for vehicle operations were granted for one launch or re-entry, a series of launches or re-entries, or a period of time.

⁷ Spaceports were being developed to accommodate anticipated commercial space tourism flights. As of August 2006, the United States had five federal launch sites, six spaceports with an FAA launch site operator's license, and an additional eight spaceports have been proposed. New spaceports were also to be built outside the United States. Space Adventures, in partnership with other investors, planned to develop a \$115 million spaceport near Changi Airport in Singapore and a \$265 million spaceport in Ras Al-Khaimah near Dubai in the United Arab Emirates.

which to operate launches was representative of these legal difficulties. Two sites were sensed as strong candidates: Kiruna's Sweden Spaceport and a Royal Air Force station located in Lossiemouth, Scotland.⁹ Yet the two sites were facing differing futures; while the former location benefited from tangible advancements in Swedish regulatory framework, the latter was to deal with an unclear legal structure and a mild support from national authorities.^v

A Giant in the Space Tourism Industry

The European Aeronautic Defence and Space Company

The European Aeronautic Defence and Space company (EADS) was a European aerospace and defence company with revenue up to €43 billion a year and a workforce of more than 116,000 people. Founded in 2000, the group was the result of a merger among three major European aerospace companies: DaimlerChrysler Aerospace (Germany), Aerospatiale-Matra (France) and Construcciones Aeronáuticas (Spain). The merger was partially motivated by the need to compete effectively with their main American counterparts, McDonnell Douglas and Boeing, who had joined their forces three years earlier.

Astrium set apart, EADS had three core divisions: Airbus, Eurocopter and Defence & Security. Airbus, a world leading aircraft manufacturer, was the main revenue generator for the company. In 2009, the division had contributed 66% of EADS' total revenues while other departments took up about 10% each. EADS' long-term strategy was articulated in its strategic roadmap: *Vision 2020* [See **Appendix A**; **Appendix B** displays the financial statements of the firm, as of 2009].

EADS Astrium

Built in 2006 around the unification of three former EADS divisions, Astrium was Europe's largest space company. In 2009, the firm had generated €4.8 billion in revenue—11.2% of EADS' total revenue. Structurally, Astrium encompassed three major business units: Satellites, Space Transportation and Services. The satellites division was a world leader in the design and manufacture of satellite systems; the space transportation division was Europe's prime contractor for civil and military space transportation, having worked on project such as Ariane launchers and French's ballistic missiles for nuclear deterrent force; finally, the services division was especially known for its Telecom Services department, the world's only one-stop-shop business for packaged satellite-based communications services and solutions, operating in any telecom frequency band, for both commercial and military customers.

⁹ The high population density of most European countries restrained the number of locations from which to operate launches in optimal safety conditions.

The Genesis of Astrium's Space Tourism Programme

The idea for a suborbital space tourism programme emanated from a group of fresh German, British, French and Spanish engineers, back in 2005. At the time, handfuls of commercial spaceship projects were already under development, with design varying significantly from one to the other; for instance, while Armadillo Aerospace's rocket was to takeoff and land vertically, Scaled Composite's *SpaceShipOne* was intended to be launched midair from a carrier plane. Astrium's team had surveyed all the existing concepts and had found most of them lacking engineering or business-model seriousness. *"There are those who think you can design a rocket plane in a garage,"* said Robert Lainé, Astrium's CTO. *"Suffice it to say, that's not our niche."*

Astrium's engineering team found interest in the *Rocketplane XP*. The vehicle developed by Rocketplane Kistler resembled a traditional airplane powered by two turbojets and a rocket engine: Astrium TBN. A first proposal based on a similar design soon reached the desks of Astrium's executives. More than an opportunity for tourism activity, reusable suborbital vehicles potentially represented the future of the airplane industry. The firm's managers saw in space tourism programmes the opportunity to draft the foundations for Hypersonic point-to-point transportation, with which a London-Tokyo flight would become the matter of a couple of hours: *"Our vision is that this credible market will turn from space tourism to high speed transportation, exactly like the aircrafts of "moderate" performance of the 1900's were used for maiden flights of people willing to experience the sensation of flight, and then evolved into high performance and safe aircrafts used by people just wanting to be transported from A to B in a safe, comfortable vehicle."* In this respect, the design of the *Rocketplane XP* revealed particularly relevant, for such space plane could take off and land like any standard aircraft. After careful reviews, the proposal found approval from the board of directors.

A larger team was quickly built around the project, drawing together experts from different EADS subsidiaries and several industry partners. In few months, the team presented a spaceship concept which could offer a 90 minutes journey to the frontier of space, including 90 seconds of vertical propulsion up to Mach 3, three minutes of near zero gravity. Whether the company would run as an operator or solely as a vehicle producer was still unclear; several options were under discussions. The draft for an inclusive space tourism programme had been outlined, featuring a 7-day training prior to the journey, during which participants would be accommodated in a luxury theme park specifically built for Astrium's customers. First commercial flights would be scheduled for 2012, operating with an initial park of five vehicles. With passengers each paying about 200,000€ (\$267,000), the company expected to attract as many as 30% of the market—about 5,000 customers per year by 2020. An alternative option was to contract with external operators. Questions of how to charge operators and

whether to sign for an exclusive contract agreement with only one operating partner were still pending.

Like most of its competitors, Astrium had also built its spaceplane with an eye on complementary markets. The weightlessness phase could be of great use for astronauts' training and scientific research.¹¹ The vehicle could also be used for homeland security missions or even be reconfigured to send small satellites into orbit, representing a real opportunity for further expanding the world's satellite network. Contrary to other traditional satellite launchers, the TBN was reusable, making it less environmentally damaging, while also ensuring increased operating flexibility and low cost.^{vi}

Astrium's Spaceship

The crossed experience compiled by EADS' different subsidiaries made Astrium's engineers pretty confident on their ability to design a craft that met the stringent safety and operating-cost constraints of a space-tourism business. The rocket engine of the spacecraft would use the technology of the Vulcain, Ariane 5's main engine. Yet, the model had been redesigned so as to burn methane instead of hydrogen and be reusable thirty times.¹² Overall, the plane's estimated life approximated ten years at a flight rate of once per week. Although engineers took the *Rocketplane XP* for model, their final spaceship entailed significantly different features. *Rocketplane* had been developed on a start-up budget, and so its engineers had repurposed an existing aircraft fuselage to use as the spacecraft's body. EADS Astrium, in contrast, built a custom airframe of aluminium and carbon fibre in order to save weight. In addition to allowing the ship to carry one more passenger, the lighter design was intended to avoid problems of air-traffic control. The craft would have the capacity to climb up to about 11 km (39,000 feet) under jet power, high enough above ordinary air traffic to avoid a collision.^{vii} Such design was meant to allow flights operations from civil airports, just like standard airplanes.

A particular attention had been given to the cabin design so as to maximize free movement during microgravity. The Australian designer Marc Newson, who

¹¹ In order to study fluid mechanics, biology, human physiology, combustion or fundamental physics, researchers often needed to recreate conditions of weightlessness. Various solutions had been explored. For instance, CNES was conducting scientific experiments during weightlessness onboard the Airbus A300-0G using parabolic flights. After an initial normal flight phase, the pilot brought up the nose until the aircraft climbed at a 45° angle, then reduced the power to the engines. The aircraft was going into a parabolic trajectory during which passengers were in free-fall, in real conditions of weightlessness. The weightlessness phase however lasted only 20 seconds and had to be repeated many times to obtain several minutes of experimentation. Astrium's TBN, which followed a parabola with a peak at 100 km, would provide scientists with weightlessness phases lasting three to five minutes.

¹² Hydrogen would require a much larger tank volume, inappropriate for the size of a space tourism vehicle. Methane also revealed a much more environmentally friendly combustible.

earned his reputation in the field of aviation and had been listed among the 100 most influential people in the world by Time Magazine, had been invited to conceptualize Astrium's spacecraft cabin. The cabin essentially consisted in a cylinder of a diameter of 2.3m (7ft 6in) with no floor dissecting it, allowing maximum room for the astronauts to float during the zero gravity phase. The vehicle could carry four passengers and a pilot, providing 3m³ (106ft³) of space to each customer. Fifteen windows—30% larger than civilian jet airliner windows—surrounded the cabin, to guarantee the best angle of the Earth once the vehicle was to reach space. After two years working in great secrecy, a full-scale mock-up of the cabin was presented at the Paris airshow—salon du Bourget—in 2007, announcing the next phase of the project: financing.

Financing the Programme

The programme required €1 billion (US\$1.4 billion) to complete the vehicle's design and build the first models. Related certification costs accounted for part of the estimated envelop. Indeed, Astrium's objective to make its jet vehicle fly from airports rather than spaceport imposed that the spaceplane comply with a long list of requirements specific to commercial aircraft. Such certification could take up to 7 years to acquire and required technology improvement as well as many flight-tests. The estimated budget was the largest of all suborbital space tourism projects. For comparison, Armadillo's vertical takeoff-and-landing spaceship had been estimated to cost of \$5.5 million to its investors. Armadillo's budget sounded unrealistic to Lainé and Laporte-Weywada: *"We develop a safe and certified vehicle targeting the long term market, not [a vehicle] for initial "adventurers" who will accept to sign any waiver to step in a vehicle. We also know the real cost of technologies, and announced it from the very beginning."*

Despite the €9.8 billion EADS had accumulated in reserve—as of 2009—the parent company had never been in a position to self-finance the development of the spaceplane. Reserves were set aside for key R&D programmes—such as the new generation of Airbus aircrafts—of which Astrium TBN did not seem to be part of. Astrium therefore looked for money from launch customers or investors wanting to finance the development and get money back from sales of planes afterwards. Private capital was considered the main source of funding but could be completed by refundable loans and regional development funding. Astrium managers had toured the world looking for both, but had come up empty-handed. In a context of financial crisis, both public and private investors were difficult to convince.¹⁵

¹⁵ Astrium TBN was not the only space tourism program facing financial investors' extreme cautiousness. Virgin Galactic's CEO had mentioned in a conference that his company was not considering raising funds through traditional financial markets given the economic situation, for it seemed a waste of time.

Two years after the project's first release at the Paris airshow, the company was forced to announce a slow down on the TBN, declaring it would "*not be in a position to start the programme quickly.*" Over these two years, the engineering team had been focusing on developing some of the key technologies needed for the vehicle, including its liquid oxygen/methane rocket engine as well as wind tunnel tests and re-entry simulations. The phase, called "pre-project", had now come to an end and Lainé and Weywada-Laporte felt there was "*no use to consider spending bits and pieces of money*" on additional technology work when the start date of the overall project was so uncertain. The slow down was only meant to be a short-term option, driven by the credit crunch. Laporte-Weywada noted: "*The [financial] crisis has not changed the perception of the [space tourism] market. It is long-term. It is a 20-30 year heavy trend market. This is why we will not give up.*"

The Suborbital Race

A high level of competition initially characterized the space tourism industry. Number of start-up companies had launched their own reusable spaceship project, particularly in the United States where the activity was stimulated with awards such as the X Prizes and NASA's competitions and contracts. While certain competitors ambitioned to achieve both the spaceship development and its commercialization, others planed to focus only on the former task and partner with a complementary firm at a later stage. In any case, the level of financing, expertise, support and advancement varied largely from one venture to the other, and some had already thrown in the towel. Yet, few bigger payers, such as Virgin Galactic stood out from the crowd.

Virgin Galactic

Richard Branson, the charismatic founder of Virgin Group, had long expressed his interest for space tourism. The Virgin Galactic name was already registered and trademark protected in the mid 90's. However, the creation of a joint venture with Scaled Composites in 2004 was referred to as the event that publicly announced his intention to enter the market. Founded by Burt Rutan in 1982, Scaled Composites LLC was an aerospace and specialty composites development company based in Mojave, California. The firm had worked on more than 30 experimental aircrafts and developed a broad experience in air vehicle design, tooling and manufacturing. In 2004, Rutan's company had been awarded the \$10 million X-Prize for the development of its first suborbital spacecraft prototype: *SpaceShipOne*—SS1. Designed to accommodate two passengers and a pilot, the vehicle was an experimental hybrid rocket motor spacecraft propelled and then "dropped" at high altitude by a twin-turbojet mother aircraft, the WhiteKnight—WK1. Financed through a joint venture with the multi-billionaire Paul Allen, SS1 had broken a number of records at its launch, being the first privately

funded spacecraft to accommodate passengers, exceed Mach 2 and Mach 3, and go beyond the symbolic barrier of 100km altitude.

Virgin Galactic's original plan back in 2004 was effectively to develop a commercial version of *SS1* that would have entered service as early as 2008. However, the company reconsidered its plan after talking with first potential customers: "*If we're going to pay \$200,000 to fly to space, we are not getting into a cramped little environment with no more space than a MiG. [...] We want to experience weightlessness, we want to move around the cabin*". The problem with the *SpaceShipOne* design was that its cabin was too small to allow the two passengers it accommodated to move around much in weightlessness. Potential passengers' feedback forced the company to move to a much larger spacecraft—something that Branson had wanted to do all along but not as soon. After its massive success, *SS1* was therefore sent to the Smithsonian Institution's National Air and Space Museum for retirement and its technology emulated for several flying model rockets, leading the way to the development of *SpaceShipTwo*. Virgin and Scale Composites therefore created a joint venture The Spaceship Company (TSC), which intended to build on the success of *SS1* to design a first generation of tourism spacecrafts. The partnership provided Rutan's team with the funds necessary to develop a new vehicle based on its prototype technology. Meanwhile, it allowed Branson to exploit it for commercial purposes via Virgin Galactic, TSC's primary and privileged customer. Virgin Galactic had contracted to purchase five *SpaceShipTwos* and two *WhiteKnightTwos*, building an initial fleet for its space tourism programme.

In 2005, Virgin Galactic announced a partnership with the State of New Mexico to build a state funded \$198m spaceport on a 27 square mile area of land in the southern part of New Mexico.¹⁶ The facility, which was the first private spaceport in the world, was inaugurated in 2009 in presence of local authorities and was unequivocally baptised *Spaceport America*. Virgin Galactic had already signed a contract to lease the place for 20 years, for a total price of \$200 million. The firm established its headquarters on the site, and decided it would operate its first space flights from there.^{ix}

SS1's little brother took several years to develop. An explosion during the engine's preliminary testings killed three employees and injured three others, calling for more cautious testings, slowing down the development phase.¹⁷ Finally unveiled to public in December 2009, *SpaceShipTwo* included major design

¹⁶ Benefits for the New Mexico state were significant. An independent study forecasted up to 5,000 new jobs and a \$1 billion boost to the region's economy as Virgin Galactic and other aerospace companies move from tourism into commercial spaceflight like low-cost satellite launches.

¹⁷ Following the incident, California safety inspectors have cited Scaled Composites for failing to provide adequate training for workers and fined the firm more than \$25,000. The firm then worked with state inspectors and officials to enhance worker safety and promised *SpaceShipTwo*'s rocket engine would not be considered finalized until the source of the explosion was pinned down.

improvements to the original prototype. Employing the same principle as Rutan's *SpaceshipOne*, *SpaceShipTwo* was carried up to around 15.24 km (50,000ft) before its single hybrid rocket motor propels it up to 110km above sea level at a speed of 4,180km/h (2,600mph). The whole trip was meant to last 2 hours and a half—an hour longer than Astrium's trip;¹⁸ The cabin had been redesigned to accommodate six passengers in addition to two co-pilots while changes in the engine had extended the weightlessness experience from 3.5 to 6 minutes. Thousands of press articles worldwide were written about the rollout event.

Following the unveiling, a Scale Composites' team initiated an 18- to 24-month flight test programme covering 50-100 flights. "*Now our challenge going forward will be to complete our experimental programme [and] obtain our FAA license [...]*" said George Whitesides, Virgin Galactic CEO—formally Chair of the reusable launch vehicle working group at the FAA. Rutan was confident on the last phase of development of the *SS2* and *WK2* and was already considering new ideas for *SS3* and *WK3*. He had also made a number of observations on competition, including some on Astrium's project: "*Like other spaceship concepts that take off from a runway or those that are rocket-powered vertically launched, the EADS vehicle will weigh more than twice as much per passenger as SS2 and require more than twice the rocket impulse. This relates to significant increases in operational and non-recurring development costs*".

At the beginning of his endeavour, Branson said he expected to need roughly \$100 million to make space travel a reality;^x it was unclear whether the investment made through TSC were taken into account and how this announced figure included the Spaceport America's lease; however, Virgin Galactic's representatives had made no further comments on the cost of the programme since then. The company had begun a phase of prospection for pre-sales tickets as a way to finance part of the investment. In addition to the space trip, the ticket included a compulsory 3-day training of which the content and minimum medical requirements were still debated with advisors. Starting price for the program was set at \$200,000 per person, plus a minimum \$20,000 refundable deposit.

A Facebook page as well as a Twitter account had been created, providing news to customers, media, and people expressing interest for the firm's endeavour. Accredited Space Agent had also been selected through a competitive process to handle spaceflight sales. Each of the 150 ASA agent—or agency—was appointed a particular region, covering more than 30 countries. As of October 2010, Virgin Galactic had signed in about 380 assured passengers for future flights, collected \$50 million in pre-sales tickets, and registered an estimated 150,000 people

¹⁸ A priori, the total duration of the flight was not to carry much weight on customers' decision. The time spent above the atmosphere as well as the one spent in zero gravity mode however, remained more important factors.

expressing a genuine interest for *SpaceShipTwo*'s adventure.¹⁹ In addition to a sub-orbital passenger business, Branson had planned to use the two vehicles to enter complementary markets. Services for science missions, astronauts' trainings and small satellite launches were considered.²⁰ Among these options, low cost small satellite launches were seen as a particularly attractive market by Branson, although it would require additional investments from Virgin Galactic to develop an expendable booster to propel up to 200 kilograms satellites into low Earth orbit. Virgin was studying the possibilities of such market with Surrey Satellite Technology Limited (SSTL), a company widely considered to be the leader in the smallsat industry.²¹

Space Adventures

Founded in 1998 by Eric C. Anderson, Space Adventures was a space tourism agency with headquarters in Texas and an antenna in Moscow. The company was well known for being the first—and only one—to have sent privately funded citizens to space.

Since its creation, Space Adventures had organized several privately funded missions to the International Space Station (ISS). The firm was well known for having sent the American businessman Dennis Tito for a reported \$20 million, making him the first private citizen to reach space. Tito loaded aboard the Russian spacecraft Soyuz—the only viable vehicle for private orbital tourism—and spent 7 days, 22 hours, 4 minutes in space, orbiting Earth 128 times. The event had been largely covered by media from all around the world, building the reputation of Space Adventures. Following this success, six other private citizens boarded on the Soyuz, each with the help of the agency, which was already discussing new opportunities such as a spacewalk and a 2-week expedition to circumnavigate the moon. Consolidating its supremacy on orbital space tourism, Anderson announced a new venture with Boeing in September 2010.²²

Space Adventures had also diversified its activities. In 2008, Anderson acquired Zero Gravity Corporation, the first and only FAA-approved provider of weightless

¹⁹ Despite the economic crisis, customers had continued to sign-up and only a few had asked for their deposits back. Among the latters, one person had lost all his money in the Bernard Madoff scandal.

²⁰ Virgin had already made a small step in this market, carrying atmospheric sensors for NASA. The data recorded by the sensors had then been used to calibrate NASA's Orbiting Carbon Observatory spacecraft slated for launch. Although the agreement did not involve any financial arrangement, the mission had contributed to burnish the company's scientific credential.

²¹ Ironically, SSTL had been acquired by EADS Astrium few years back.

²² The US Aircraft manufacturer built its own orbital vehicle, requesting Space Adventures to market it. Although Boeing's commercial space initiative mainly targeted professional astronauts, the additional seat capacity would be marketed to wealthy individuals, private companies, and government agencies.

flights to the general public. For \$4,950 per person, clients could experience weightlessness aboard a modified Boeing 727 accommodating 35 persons per flight.

As of 2010, Space Adventures was offering a broad range of programmes, from cosmonaut trainings to orbital missions, but did not have a suborbital space tourism programme yet. This was just about to change, as Anderson announced an exclusive marketing agreement with Armadillo Aerospace to develop a suborbital tourism programme. Fully self-funded, Armadillo was a developer of reusable rocket powered vehicles that had grown with a relatively small budget. As of 2006, its suborbital programme had cost slightly over \$2 million. All employees, including its founder, had other full-time jobs and contributed their efforts twice weekly on a voluntary basis. Yet, the start-up had already worked for NASA as well as the United States Air Force, and flown vehicles at every X-Prize Cup event. Basing their methodology on a building and testing approach, Armadillo's engineers were accounted for over 200 flight tests spread over a dozen different vehicles. Aside of suborbital spaceship development, the firm had stated long-term ambitions for orbital flights; in this respect, the firm had won \$350,000 by succeeding in *Level 1 Lunar Lander Challenge* in 2008 and \$500,000 in *Level 2* the following year.

In essence, Armadillo's main spaceship concept was a vertical take-off and landing vehicle which could carry two passengers inside a large clear bubble. Although the idea left most of the industry sceptical, Armadillo's engineers had already successfully demonstrated a vertical take-off and landing flight of one of their prototype, the third unmanned rocket in history to do so. Its CEO estimated that another \$3.5 million were needed to achieve a manned suborbital flight using a similar technology. The two firms had finally signed an agreement whereby Space Adventures would pay Armadillo unspecified amounts upon achieving certain milestones in the vehicle development effort. To complete the necessary funding, Armadillo's CEO expected to invest more of his own money into the venture, while looking at funding from NASA's Commercial Reusable Suborbital Research (CRuSR) program for flying scientific payloads.^{xi}

Tickets for Space Adventures' suborbital programme started at \$102,000. As of 2010, the firm had pre-sold 200 tickets. No precise information was given regarding the schedule of the first commercial flights, even though Space Adventures' CEO admitted his company would not be the first to launch its programme.

Xcor Aerospace... and a few dozens of others

"Well known future players aside, it is hard to know, among the tremendous number of other small projects, which are seriously competing and which are not." Hughe Laporte-Weywada confessed at the time.

Among these smaller players was Xcor Aerospace, a privately held corporation founded in 1999. Xcor had evolved from its original four founders to a team of 20 employees housed in a 10,375 square foot hangar on the Mojave Air & Space Port, in California. The firm funded its R&D projects from angel investors, targeted commercial development programmes, government research contracts and consulting services. While most of its staff had at least 20 years of experience in the aerospace industry, the company's board also included a business angel with expertise in general engineering, and a ten-year private-equity experienced member.

Lynx, Xcor's suborbital RLV, was a horizontal takeoff and landing vehicle similar to Astrium's vehicle and the *Rocketplane XP*. It used a concept of operations developed by the company's earlier rocket-powered vehicles. Its technology was designed to allow fast turnarounds between flights—2 hours—low operations and maintenance costs (O&M), and up to four flights per day, accommodating one passenger and a pilot per trip.^{xiii24} Such statistics appeared extremely optimistic, not to say unrealistic, to Astrium's managers. Lynx was to be operational by mid-2012 and would also be running for an FAA AST-license, a process that Xcor's engineers had already successfully passed with one of their previous vehicle concept, and of which they had deep knowledge, for they had been actively involved in the development of the regulatory framework.

In Xcor's space journey, the spaceflight participant would seat aside the pilot and take-off for a half-an-hour trip at 65km above sea level – arguably, lower than the edge of space. Passengers would experience weightlessness but would remain seated during the whole flight. Prior to the suborbital journey, potential participants would go through a five-day screening process which would include medical tests, seminars, altitude chamber training, and a g-force experience. Xcor had set price tickets to \$95,000 and had already obtained 20 ticket-purchase agreements, as of 2010. The team was also considering launch services to academic, scientific, engineering, and observation-related markets.

Many other corporations were running for suborbital race: the secretive Blue Origin, created by the founder of Amazon.com, and which was awarded \$3.7 million in funding by NASA for its spacecraft development; UP Aerospace, which rocketed cremated remains of a Star Trek actor into suborbital space; or Masten Space System, a company which was largely ignoring space tourism in favour of science and other markets... the list was long, without accounting for those who already threw in the towel, such as Rocketplane Kistler, the firm that had inspired Astrium's vehicle. Rocketplane's employees had vacated headquarters despite having originally won an up to \$207 million contract from NASA to service the International Space Station. After multiple requests for extra

²⁴ To be able to fly the Lynx several times a day, Xcor team had focused most of its work on the development of rocket engines that could be repeatedly and safely switched on and off, based on the utilization of piston pumps, much simpler than the turbo pumps used on standard space shuttles.

deadline, the firm saw its contract cancelled. Contract had been transferred to SpaceX—a company founded by PayPal and Tesla Motors founder—to develop its Falcon 9 launch vehicle and spacecraft. With investment markets dried up by the financial crisis, time had run out for Rocketplane Kistler who filed Chapter 7 bankruptcy in June 2010.²⁵ According to the bankruptcy filings, the defunct aerospace start-up company had \$108,250 in assets—primarily tooling and some components of the K-1 vehicle—and over \$7.36 million in liabilities. “*We did what we said we could do. Unfortunately, we did not complete the programme as originally conceived,*” one of the firm's manager said.^{xiii} At this stage, it was difficult to determine how many other competitors would not be able to meet their promises.

²⁵ Unlike Chapter 11 bankruptcy, where the company can reorganize, Chapter 7 involves the liquidation of assets. Whatever was left of Rocketplane had been sold off to cover its debts.

APPENDICES

Appendix A—Extract From Vision 2020

CHALLENGES

We face three major imbalances:

- **The EADS portfolio depends too much upon Airbus** which accounts for more than 64% of EADS revenues, and therefore has a high vulnerability to commercial aircraft cycles and to the huge financial burden of aircraft programmes.
- **EADS is mainly focused on platforms**, whose growth will probably be limited after 2010, even though the services linked to these platforms will experience considerable development in the coming years.
- **EADS sourcing is not global enough**: 77% sourcing and 97% employees are in Europe although 57% of our revenues come from outside Europe. Access to markets and technologies, cost reduction and protection against dollar volatility mean that we need to reinforce our industrial footprint and partnership-building outside Europe.

2020 STRATEGIC GOALS / TARGETS FOR EADS

Following the initiative of CEO Louis Gallois, EADS has formulated a strategic roadmap called Vision 2020. This blueprint for EADS' future was presented to the Board of Directors in January 2008. Since then, it has been turned into a Group-wide action plan, applied by every Division.

We aim to achieve:

The worldwide leader in air and space platforms and systems

Become the worldwide leader in air and space platforms and systems (mainly platform-related systems architecture and integration) with a complete portfolio of products, both commercial and governmental (commercial aircraft, military transport, mission aircraft, helicopters, fighters, UAVs, missiles, launchers, satellites, systems and secure networks).

Profitability

Achieve best-in-class operational and financial efficiency to reach 10% EBIT in the first half of the decade 2010-2020.

Focus on core and optimise financial means

Focus on core. This means a new business model approach and the reallocation of human/financial resources which are currently locked in non-core legacy activities. Divestments in non-core areas have to be implemented.

Balanced revenues

Achieve around €80bn turnover by 2020 and reach a 50/50 balance in Airbus / other Divisions' revenues.

Mission-critical service provider to our customers

Achieve a 25% services share—against 10%—of business by 2020 (hence €20bn), focusing on high-value services initially related to platforms, requiring and developing both customer intimacy and product intimacy.

Globalisation

Become a true global industrial company with 40% of EADS sourcing and 20% of EADS employees outside of Europe. Achieve \$10bn revenues in North America in non-Airbus businesses and gain a prime position with US Government.

Moving towards an eco-efficient enterprise

Move towards an eco-efficient company. Environmental issues are to become a transversal driver towards sustainable development. Airbus' ambitious targets are already defined. To be done for non-Airbus Divisions.

EADS PRIORITIES 2010

Improve the **ENGAGEMENT** of EADS employees by responding to their expectations on personal development, people management and common values; reinforce diversity, in particular gender diversity at every level.

Give the top priority to **CASH MANAGEMENT** to protect the Group's financial manoeuvrability.

Achieve the **SAVINGS** targeted by improvement and efficiency programmes at Division level as well as those set by Future EADS and foster integration.

Deliver and secure **KEY PROGRAMMES**—A400M, A380, A350, NH90 Naval,

Saudi border surveillance, US defence programmes.

Appendix B—Financial Statements EADS 2007 to 2009

EADS N.V. Consolidated Income Statements (IFRS) for the years ended 31 December 2009, 2008 and 2007

(in €m)	2009	2008	2007
Revenues	42,822	43,265	39,123
Cost of sales	(38,383)	(35,907)	(34,802)
Gross margin	4,439	7,358	4,321
Selling expenses	(924)	(933)	(864)
Administrative expenses	(1,272)	(1,253)	(1,314)
Research and development expenses	(2,825)	(2,669)	(2,608)
Other income	170	189	233
Other expenses	(102)	(131)	(97)
Share of profit from associates accounted for under the equity method	115	188	210
Other income from investments	19	23	86
Profit (loss) before finance costs and income taxes	(380)	2,772	(33)
Interest income	356	617	502
Interest expense	(503)	(581)	(701)
Other financial result	(445)	(508)	(538)
Total finance costs	(592)	(472)	(737)
Income taxes	220	(703)	333
Profit (loss) for the period	(752)	1,597	(437)
Attributable to			
Equity owners of the parent (Net income (loss))	(763)	1,572	(446)
Non-controlling interests	11	25	9
Earnings per share			
Basic	(0.94)	1.95	(0.56)
Diluted	(0.94)	1.95	(0.55)