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Management from the Nova School of Business and Economics.

The New Space:
Lessons from XCOR Aerospace Failure

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Abstract

The purpose of the case study is to analyze what went wrong in a failed space tourism company. The presented case showcases XCOR Aerospace as a benchmark where their experiences, methodologies, members and their background, financial results, and investors are discussed and evaluated. Furthermore, a reflection about XCOR's decisions and their achievements is performed, to better understand and explain the crucial factors that the company was missing, and which future companies can improve on. Therefore, questioning if there was anything that could have reversed XCOR's fate, or the company was destined to fail.

Keywords: Case-Study, Space Exploration, New Space, Space Tourism, XCOR Aerospace, Lynx Spacecraft, Jeff Greason, Management

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From ancient times, humans have been looking up to the sky and dreaming about exploring the stars. This journey started on October 4th, 1957, with the launch of Sputnik, the first artificial satellite to orbit Earth, launched by the Union of Soviet Socialist Republics (USSR) being the official catalyst to a Space Race between the USA and USSR that would last almost 20 years. A few years later, on April 12th, 1961, Yuri Gagarin was the first human to cross outer space and orbit the Earth in a flight that lasted 108 minutes. Almost one decade later, on July 20th, 1969, the first humans, Neil Armstrong, and Buzz Aldrin, landed on the moon. The competition between USA and USSR came to an end in July 1975 with the Apollo–Soyuz mission, when both countries collaborated, and a U.S. module was docked to a Soviet Union Soyuz capsule. The Space Race generated a ton of interest in space exploration through the public and inspired a generation to come. Even so that there was a time during the 1960s that Pan American World Airways, the largest international air carrier of the US in the 20th century, opened a reservation list for a first passenger flight to the moon. Although, this would never happen because the company went out of business in 1991.

Almost two decades ago, in 2001, Dennis Tito was the first official civilian space tourist paying roughly 20 million to spend a few days in the International Space Station (ISS) contracted by the Russian commercial spaceflight company MirCorp. Three years after, on June 21st, 2004, SpaceShipOne, developed by Mojave Aerospace Ventures, made the first privately funded human spaceflight. This resulted in the winning of US\$10 million of the Ansari X Prize on October 4th of the same year, which consisted in constructing and launching a spacecraft that would carry three passengers to an altitude above 100 km (62mi) twice in two weeks.

Both these events have created awareness of the space tourism market and subsequently, since the early 2000s, we are seeing a growing number of private companies

competing for a slice in this industry. Some of the most successful are Virgin Galactic, Space Adventures, Sierra Nevada Corporation, SpaceX, and Blue Origin.

Unfortunately, not all the attempts were good experiences, and some companies ended up being bankrupt for several reasons before or during the testing phases, such as XCOR Aerospace which will be discussed further.

Space Tourism

The Space Tourism concept is composed of several ideas and plans like the creation of permanent Space Hotels that will orbit around the Earth, suborbital and orbital flights, or even possible journeys to the Moon, Mars, or beyond.

To further understand the topic of space tourism, it is important to know that the main reason is for recreational purposes and that there is a difference between orbital and suborbital tourism. The first one is characterized by launching a vehicle that completes at least one orbit around the Earth. The latter, which is the focus of the discussion of this case, is a type of Space Tourism that consists of a flight aboard a spacecraft that travels past the “Karman Line”¹ for a few minutes, providing the passengers with a view of Earth’s curvature and giving the sensation of weightlessness. However, the spacecraft is not capable of reaching the speed and power needed to achieve orbit, thus it slowly falls towards Earth. Moreover, it is at this point that the atmosphere becomes too thin for conventional aircraft to fly without an effective propulsion system.

Past and future growth

In recent years, there has been a surge in the public interest for suborbital flights and space tourism as more people seek out unusual experiences like space travel. Moreover, new

¹ Suborbital human spaceflight boundary defined at an altitude of 80 km (50mi) by United States and 100 km (62mi) by Fédération Aéronautique Internationale, which is the world governing body for air sports.

firms are continuously entering this market, further enabling the development of new technologies that improve space transportation, making it more affordable and accessible to the public. One example is the use of reusable launch vehicles, which contribute to a decrease in costs, with a trip to space costing around US\$450.000 as of November 2021 aboard the Virgin Galactic spacecraft. On the other hand, there are several challenges for this market that keeps on delaying launch dates and dispelling investors, due to the dangers of the environment and expensive research and development costs.

Through a market study conducted by BIS Research in June 2021, it was estimated that the suborbital transportation and space tourism market will reach US\$2.6 billion by 2031 at an annual compound growth rate (CAGR) of 17.15% during the forecast period between 2021-2031.

XCOR Aerospace

In order to gain a better understanding of the space tourism trend and what causes some companies to eventually fail in this market, XCOR Aerospace's actions, accomplishments, and mistakes will be examined.

XCOR Aerospace was an American private spaceflight and rocket engine development company founded in 1999 by Jeff Greason, Aleta Jackson, Dan DeLong, and Doug Jones, fellow members from the Rotary Rocket Company. One of the plans for the business, which was based at the Mojave Air and Space Port in Mojave, California, was to create a spaceship named Lynx, that would be capable of performing suborbital flights on a regular basis.

“XCOR's business plan was always: develop a suborbital vehicle which would serve three markets (people, payloads (mostly science experiments), and upper stage missions (carrying a small upper stage for microsatellite launch), then use the profits from that to build a larger two-stage orbital system.” (Greason 2021)

Before building the Lynx spacecraft, XCOR focused its resources on developing the rocket engine that would power it. Throughout the years the company had designed more than fifteen rocket engines, performed beyond 5000 rocket tests without incidents, and flew two-rocket-powered aircrafts, such as the EZ-Rocket (twenty-six times) and X-Racer (forty times).

“The XCOR approach is to build safer and more reliable rocket engines first, then progress to the higher performance needed for orbital launch vehicles.”(XCOR Aerospace 2015b)

It was not until the beginning of 2008 that XCOR started testing its prototypes for the Lynx spacecraft and made plans to operate the vehicle in 2010. This led the company to sell its first tickets for a trip to space for US\$100.000 despite the construction of the spacecraft just beginning three years later. Later in July 2012, the company relocated its developing and manufacturing operations from Mojave, Los Angeles to Midland, Texas due to an incentive of the city of US\$10 million in cash. The biggest XCOR exposure to the public and ticket sales came when, during the 2013 Super Bowl, Axe announced that it would fly twenty-three customers into space aboard Lynx spacecraft.

In early 2015, Jeff Greason stepped out as CEO of the company, strictly overseeing the engineering, and Jay Gibson, an experienced aerospace veteran, replaced him. Later the same year, Greason and two co-founders left the company. After that, in 2016, about one-third of the company was laid off and in June 2017, all the remaining employees were laid off. The company filed for bankruptcy in November 2017.

Lynx Spacecraft: A dream

As previously stated, before the development of the Lynx spacecraft and the attempt to compete in the space tourism market, the company had tremendous success building rockets and rocket engines.

The objective of the Lynx spacecraft was to be able to perform a suborbital flight carrying one passenger and one pilot, making it possible to see Earth's curvature and experience weightlessness for a few minutes. Furthermore, the vehicle was planned to take off and land horizontally, like a conventional aircraft, and be able to have a fast turnaround between flights with a focus on safety and reliability. There have been three planned prototype models for the Lynx spacecraft with the first model firstly announced in 2008. Lynx Mk I is the prototype model for the reusable spacecraft, constructed by XCOR, that would be used to train pilots and crew and flight test the vehicle sub-systems including aerodynamics, life-support, propulsion, structure, re-entry heating, and tanks. The spacecraft features an all-composite light and strong airframe with the cockpit fabricated in carbon fiber, enabling the vehicle to reach a peak altitude of 62km (38.5mi) with the passengers experiencing weightlessness for about 4 minutes for a total flight duration of around 30 minutes. Moreover, Lynx Mk II is the production model of the reusable spacecraft that would carry passengers on a suborbital flight but with some improvements regarding performance, such as being able to achieve altitudes higher than 100km (62mi) and carrying an internal payload with a flight duration between 45 to 60 minutes. The third model, Lynx Mk III was planned to be an improved version of Lynx Mk II, equipped with a dorsal pod that would have the capacity to carry payload and launch microsatellites to low earth orbit.

Furthermore, in addition to launching microsatellites, Lynx could also be used for test pilot and astronaut training, in-cockpit experiments, upper atmospheric sampling, and personal spaceflight. However, due to the lack of space inside the cabin, passengers would not be able to unstrap. The Chief test pilot was Richard A. Searfoss, and the spacecraft could be operated up to four times daily. Additionally, the expected production cost of Lynx Mk I was US\$10 million and US\$12 million for the Lynx Mk II.

Unfortunately, the company was never able to complete the initial prototype of the spacecraft and the Lynx flight kept being delayed year after year until January 2016 when the company stated that it had no date for the test flights, further halting the development of the spacecraft in May of the same year. Sadly, there weren't any actual Lynx flights made by the company.

Funding and Investors

XCOR Aerospace had received a total of five series of funding rounds from 2007 to 2015. The first and second funding rounds were on Jun 2007 and August 2008, respectively, raising an undisclosed amount in both transactions. Moreover, XCOR Aerospace also raised US\$5 million in an equity round of funding in Feb 2012, from Boston Harbor Angels, Desert Sky Holdings LLC (investment vehicle company), Ester Dyson (executive founder of Wellville and active start-ups investor), Pete Ricketts (co-owner of the Chicago cubs), and Silicon Valley entrepreneurs. On May 27th, 2014, XCOR Aerospace secured US\$14.2 million in a Series B funding led by Space Expedition Corporation and several investors such as Esther Dyson, Pete Ricketts, and other early-stage backers.

Space Expedition Corporation was a company founded in 2008 and based in Amsterdam, the Netherlands that had been hired by XCOR Aerospace to sell tickets for a trip to space aboard Lynx spacecraft. Later on, in Jun 2014, XCOR Aerospace acquired all operating subsidiaries of Space Expedition to strengthen its position as a space flight company.

In 2015, a Chinese venture capital firm "Haiyin Capital" announced that it had invested in several high-tech U.S. firms, one of which was XCOR Aerospace, securing a deal value of an undisclosed amount. This was the last funding that the company had received.

Since XCOR's Aerospace creation in 1999, it was estimated that the total funding received by the company was more than US\$40 million, mostly being from venture funds.

“...Spaceflight is hard. There are many, many technical problems to solve. Just because you're not going to orbit, doesn't mean that you're not advancing the state of the art. I'm a former XCOR investor. I supported them not for their suborbital program, but for their orbital vision (reusability). The Lynx was a stepping-stone, a way of both funding their larger ambition and testing small parts of the larger system...Yes, I lost all the money. But it was worth a shot.” (Forum User 2018)

XCOR Governance: Jeff Greason

“We started with four founders and were probably six by the end of the first year; by the time we flew the EZ-Rocket we were about 12, by the time we flew the X-Racer we were about 35, by 2015 we were about 100.” (Greason 2021)

The lead figure in managing the aerospace engineering team of XCOR Aerospace was Jeff Greason, founder, and CEO of the company for sixteen years, where he mainly worked in the development of the suborbital space vehicle Lynx and its major subsystems like rocket propulsion.

Additionally, he had been part of several projects such as the Rotary Rocket Company where, between 1997 and 1999, he managed the engineering propulsion team and led the technical development of the company's rocket engines. Previously, Greason had worked at Intel from 1988 to 1997 where he was a member of the steering committee and helped manage the lead vehicle design team in developing a new semiconductor chip-making technique. Moreover, it was with these management experiences that he led XCOR's rocket engine projects and focused on a design-build-test cycle to boost product development. Greason studied Electrical Engineering at California Institute of Technology and was named the inventor of the year in 2002 by Time Magazine due to his team's work on the EZ-Rocket.

In early 2015 he abandoned the role of CEO and was placed as the Chief Technologist and later that year he abandoned the company. After leaving XCOR, he formed Agile Aero with Aleta Jackson and Dan DeLong. Thereafter in 2019, the company was acquired by Electric Sky where he is a co-founder and works as a Chief Technologist. Starting in 2020 Greason has been teaching advanced space propulsion as an instructor at the Kepler Space Institute.

Ticket Sales

The ticket pre-sale started in 2008 and approximately 282 people pre-purchased tickets for a ride on Lynx spacecraft. The company sold three different astronaut programs aboard the Lynx Spacecraft, the first one was the “Pioneer Program” that would reach an altitude above 60 km (37mi) aboard Lynx Mk I, costing US\$100.000 with 50% paid upon signing the contract and the rest three months prior to the flight. The second and bestselling program which sold out was the “Founder Astronaut Program”, where the first 100 people would have the opportunity to fly aboard the Lynx Mk II, reaching an altitude above 100 km (62mi) for a direct payment of US\$100.000 within seven days of signing the contract. After this, the “Future Astronaut Program” would happen with just a slight difference in the cost, being US\$100.000 with 50% of the payment being made within seven days of signing the contract and the remaining three months before the flight. All programs included a 3-night stay in a luxury hotel.

Supposably part of the money from the ticket sale was held in an escrow account in the case of bankruptcy to be refunded to the customers, however until this date most ticketholders have not been refunded. “[XCOR] shall have no obligation to hold any payments in escrow and may use such funds in the course of its business or operations,” (Harris 2017)

Through some sources, it was confirmed by Gibson that most of the money from the tickets was spent on the development of the Lynx spacecraft. “*Our astronaut community has*

been very understanding. But at the end of the day, the liability to the company would be very limited. So, if we were not to perform, then we just all walk away.” (Harris 2017)

“...Don't sell something you can't deliver, most especially to bypass accredited investor laws (by selling tickets versus securities). Don't misappropriate your customers' escrow accounts (the article specifically mentions these funds were to be held in escrow). This applies whether it's a \$100k ticket to space or a \$200 piece of electronic kit on Kickstarter.”

(Forum User 2018)

Moreover, we should consider that several space companies didn't even get as far as selling tickets to space before they went bankrupt or closed doors. This demonstrates the difficulties of working in the space field and an example was Armadillo Aerospace.

XCOR Aerospace Failure

“We were always very short of money -- rather incredibly so (by the time we flew the X-Racer, total spending in the company's history was in the single-digit millions of dollars), and we just ran out...” (Greason 2021)

The company's structure was capital intensive, and the funding began to dry out. To further mitigate this, as previously mentioned, in 2016 the company halted the development of the Lynx spacecraft and focused on building rocket engines, resulting in laying off about one-third of the employees. In 2017, XCOR lost its engine-building contract and was forced to lay off the rest of its employees. Later the same year, filed the document for bankruptcy which identified that the company had assets estimated between US\$1 to US\$10 million and liabilities between US\$10 to US\$50 million with more than 100 creditors.

One of the main problems of the company was that it had underestimated the complexity and lacked the funding needed to produce the Lynx spacecraft. Maybe the design of Lynx was wrong and following a conventional aircraft shape was a mistake, although most

of the components were custom designed. Moreover, the SpaceShipOne designer, Burt Rutan, believes that horizontal takeoff and landing can be dangerous because the spacecraft needs much more fuel than if it were carried aloft by a mothership like Virgin Space Ship Unity by Virgin Galactic which could carry up to six passengers and two pilots.

The slow growth of the space tourism market aligned with the suborbital spaceflights being, as of today, strictly for individuals that can afford a six-figure plus price tag per flight, we must consider that investors are apprehensive when it comes to investing in this industry.

In the space industry, there will be several trial-and-error efforts and in every experiment, success is desired, but failure is expected. Greason once said that companies should have the freedom to take risks and make mistakes in testing without one failure marking the end of the company.

Space Tourism Market: A Double-Edged Sword

“These days, space is no longer the exclusive domain of governments and institutions like NASA and ESA. Space offers boundless technology and business opportunities. To open the market for commercial space, frequency must increase, costs should drop and capabilities should dramatically improve. Key to commerciality of space is reusability. Engines, vehicles must have high usage rates, low serviceability requirements (quick turn times) and long life.”

(XCOR Aerospace 2015g)

The space tourism market is a double-edged sword due to its market difficulties and its potential rewards. The slow development of the market is an important aspect that keeps most companies from going forward. In this market, it's difficult to stand and progress without a large owner or firm continuously funding the capital-intensive operations. Moreover, as previously referred, the space market is heavily supported by trial-and-error efforts and when a company finds itself in a position where it lacks the funds needed to even try, it's the

beginning of the end. These factors, slowly prevent the most innovative and intelligent entrepreneurs from achieving their final goals.

“Suborbital human spaceflight is an intriguing but probably limited market -- hundreds of people a year at US\$100,000 price point, possibly thousands if the price point drops to under US\$50,000. That's a revenue stream of under US\$100 million a year. So addressing that requires a company and a strategy with investment in the US\$100 million range. Spending US\$1 billion to enter that market doesn't provide a reasonable return on investment.”

(Greason 2021)

When analyzing the most successful space companies such as Blue Origin, Virgin Galactic, or SpaceX, there is a critical factor that they have in common which is an extremely high net worth entrepreneur that possesses the means to self-fund the startup company. In contrast, XCOR Aerospace did not have a high-net-worth entrepreneur backing and financing its operations. Instead, the company had to rely on direct investments and funding from venture capital firms and entrepreneurs.

Throughout XCOR's history, there had been numerous difficulties and barriers that kept the company from going forward. Was there anything that could have reversed their fate, or the company was destined to fail?

5. What would you have done differently for XCOR Aerospace's success?

As previously mentioned, funding was an essential part of XCOR Aerospace's success. Thus, it had been important that the team had searched for faithful backers, investors, or investment firms with a long-term vision of the project, that continuously supported their activities no matter the immediate operational results. Keeping in mind that two decades ago, investments in the space industry were rather more difficult to access than as of today. Notwithstanding that, in the early years of the company, the team should have pitched their ideas and future products across different types of investors further using several marketing tactics to increase the company's exposure that over the long run would benefit them and increase XCOR's chances of loyal investors.

Additionally, instead of starting the development and construction of the Lynx spacecraft, XCOR could have kept its focus on the development of the rocket engines. Further working on contracts with large players and companies that would require this service. This would have increased both their revenues and exposure to a different market, consequently resulting in the gain of more capital to fund one of their goals which was to build a suborbital spacecraft named Lynx.

Also, XCOR Aerospace could have shifted the starting focus of the Lynx Spacecraft to just launching satellites instead of centering their attention on the space tourism market. This would help the company to target a broader type of market.

Moreover, XCOR shouldn't have promised any flight dates since there were substantial doubts that the company could meet their promises. This later forced the company to keep postponing flights, damaging XCOR's image and reducing interest from investors and the general public. As a result, the company should have only sold the tickets when they were sure that it would be possible to make the trips.

As already stated, contrary to “SpaceShipTwo”, the spacecraft constructed by Virgin Galactic, which had room for up to six passengers and two pilots, Lynx spacecraft only had room for one passenger and one pilot, affecting the efficiency of the vehicle. In consequence, one solution would be to re-design the Lynx Spacecraft to increase passenger capacity. Furthermore, to achieve this, XCOR could use the same method as Virgin Galactic where the spacecraft is carried aloft to a high altitude by a mothership further decreasing the amount of fuel needed and consequently its carried weight. Potentially, this would assist the spacecraft and create more room for other passengers.

6. What to do about the people that paid the tickets upfront? Should companies sell a service prior to testing their product?

The objective of this question is to instigate controversy in the answers of the students, further promoting discussion and the flow of ideas.

When we look at the “XCOR Trip delay and cancellation arrangement for Lynx Flight Participant & Conditions” exhibit there is only an “XCOR wants to DELAY flight” clause and not the possible scenario of a permanently canceled flight. As described in the case, supposedly part of the money from the ticket sale was held in an escrow account in case of bankruptcy to be refunded to the customers, however, most ticketholders have not been refunded. To aggravate the situation, Gibson confirmed that most of the ticket money was spent on the development of the Lynx spacecraft. This poses a serious problem for the customers since XCOR eventually went bankrupt and there is no hope of recovering any money.

Furthermore, when searching for the answer to this question, there are two sides:

1. The first one, where the customers should already be aware that, before the service purchase, the probability of the flight not occurring would be high and in the case that the company went bankrupt it wouldn't be possible to refund

their money, even the part held in an escrow. So, in the worst-case scenario, the customer would take the hit and just “move on”.

2. Contrary to this, the student could agree that it is not correct for a company to finance itself by selling tickets instead of securities. This action is seen as bad practice by XCOR Aerospace and shouldn't have been allowed before the construction of the Lynx spacecraft. Moreover, the company should have at least made a statement that not even the funds on the escrow were available in an event of bankruptcy.

Ultimately, one of the possible scenarios was to keep selling tickets prior to the development of Lynx. Nevertheless, let the customer comprehend that they incur uncommonly serious risks that, in the end, would result in them not ever receiving neither the money nor the flight experience.

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Appendix – Case Study

Exhibit 1: The Space Tourism Roadmap (ESA 2003)

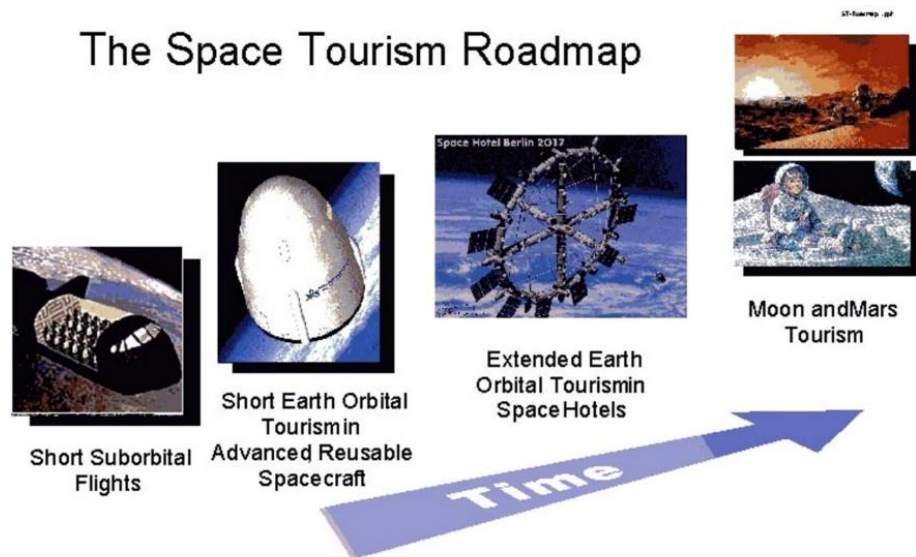


Exhibit 2: Lynx Main Engine Test (XCOR Aerospace and Masee n.d.)



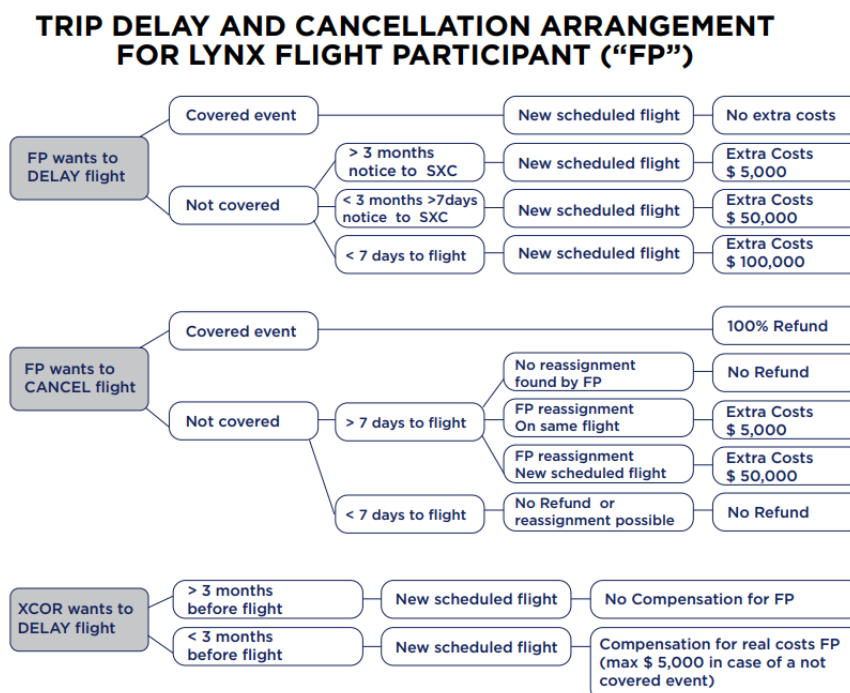
Exhibit 3: Lynx Spacecraft Launch View (XCOR Aerospace and Massee n.d.)



Exhibit 4: Lynx Mk. II Flight Profile (XCOR Aerospace n.d.)



Exhibit 5: XCOR Trip delay and cancellation arrangement for Lynx flight participants
(XCOR Space Expeditions 2015)



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The TDCA enters in force upon signature and payment of the Agreement by the FP and stays in force until the moment of the start of the LYNX Flight.

With regard to covered events: in order to be covered by the TDCA for medical reasons, the FP must successfully complete the first step of the Medical Examination of XCOR Spaceline and have obtained so-called “Step 1 Medical Clearance”, based on a medical questionnaire and a brief medical examination. Until the FP has obtained Step 1 Medical Clearance the cover is limited to “accident only”.

The TDCA is based on the conditions of the insurance agreement between XCOR Spaceline and insurance partner AON. In case of a covered event XCOR Spaceline is only obliged to refund any amounts to the FP insofar and to the extent that XCOR Spaceline receives payment under the insurance policy with AON. XCOR Spaceline shall not be required to incur any out-of-pocket fees or expenses in connection with the performance of its obligations under the TDCA.

In the event any claim will be made on the TDCA on medical grounds, a statement of an independent medical examiner, approved by our Medical partner DLR is required.

XCOR Spaceline expressly reserves the right to amend the terms of the TDCA.

* Covered events are (inter alia):

- personal serious illness or serious accident of the FP resulting in permanent and/or temporary disability to fly;
- strike at airport(s);
- volcanic ash cloud;
- natural disaster;
- accidents to the spacecraft and/or pilot.

** Non-covered events are (inter alia):

- weather conditions that prevent the LYNX flight;
- license issues;
- terrorism;
- “free will” not to fly (fear of flying, claustrophobia etc.);
- inherent vice and/or defect of the spacecraft;
- any loss or damage originating during the LYNX flight.

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Appendix – Teaching Note

Exhibit 1: XCOR Aerospace Lynx Mk I, Mk II, and Mk III Spacecraft Specifications

Spaceship	Lynx Spacecraft - 3 models: Mk I & Mk II & Mk II
Objective	Perform suborbital flights: carrying passengers, internal payload or launch microsatellites to low earth orbit
Passenger Capacity	2 People (1 Pilot + 1 Passenger)
Peak-Altitude	Mk I: 62 km (38.5mi) Mk II & Mk III: 100 km (62mi)
Weightlessness Duration	4 minutes
Total Flight Duration	Mk I: 30 minutes Mk II & Mk III: 45 to 60 minutes
Daily Trips	Up to 4 flights
Estimated Cost	Mk I: US\$10 million Mk II: US\$12 million Mk III: N.A.
Ticket Price	US\$100.000

Source: Information retrieved from the case by the author.

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