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Chapter 9

Ups and Downs of Space Tourism Development in Sixty Years from Moon Register to SpaceShipTwo Crash*

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Abstract

To the human beings' imagination, dream, and expectation, the sequence of "space tourism" is Moon tourism, Earth orbital tourism, and then suborbital tourism. But the sequence in actual development is just reversed: Earth suborbital tourism is first, then orbital tourism, and finally Moon tourism. In 1954, three years before the successful launch of the first human's artificial satellite, the world's oldest travel company, Thomas Cook in Great Britain, initiated the "Moon Register." Enthusiasts could sign an option for a commercial trip to the Moon and the company guaranteed to provide tickets at the earliest possible date. After 60 years, on 31 October 2014, the first SpaceShipTwo (SS2) of Virgin Galactic developed for commercial suborbital space tourism (SST) and scientific research crashed in the Mojave Desert in California during a test flight. Although the first privately paid space tourist traveled to the International Space Station in 2001, it was only for millionaires but not the general public. In 2004, the Space-

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ShipOne won the Ansari X prize to shed the first light on SST. However, the commercial SST operations originally planned to be realized in 2008 is long overdue. The SS2 is one of the reusable suborbital launch vehicles developed for the SST and other purposes. Some others are the Lynx, Spaceplane, and Dream Chaser. The tragedy of the SS2 crash caused the sacrifice of one senior test pilot. But it also woke up tourists that the long overdue SST might be just a few years away. The purposes of this chapter are to review and discuss the ups and downs of space tourism development in 60 years from 1954 to 2014, and to look forward from 2015.

Acronyms

EASA: European Aviation Safety Agency

ESA: European Space Agency

ESTEC: European Space Research and Technology Centre

EU: European Union

FAA: Federal Aviation Administration

FAA/AST: Federal Aviation Administration's Office of Commercial Space
Transportation

FESTIP: Future European Space Transportation Investigations Programme

GCTC: Yuri Gagarin Research and Test Cosmonaut Training Centre

HEO: high Earth orbit

HIS: humans in space

HOTOL: Horizontal Take-Off and Landing

HTHL: horizontal takeoff and horizontal landing

IAA: International Academy of Astronautics

ISCOPS: International Space Conference of Pacific-basin Societies

ISS: International Space Station

JRS : Japanese Rocket Society

LEO: low Earth orbit

NAL: National Aerospace Laboratory (Japan)

NASA: National Aeronautics and Space Administration

NTSB: National Transportation Safety Board (US)

OST: orbital space tourism

P2P: point-to-point

PHAS: private human access to space

RLV: reusable launch vehicle

RM2: RocketMotorTwo

SNC: Sierra Nevada Corporation

SpaceX: Space Exploration Technologies
SRLV: suborbital reusable launch vehicle
SS1: SpaceShipOne
SS2: SpaceShipTwo
SST: suborbital space tourism
SSTO: single-stage-to-orbit
TSC: The Spaceship Company
UN: United Nations
UNWTO: United Nations World Tourism Organization
VTOL: vertical-takeoff-and-landing
VTVL: vertical takeoff and vertical landing
WK1: White Knight One
WK2: White Knight Two

I. Introduction

From the ancient to the current age, it seems that the sequential order of human beings' dreams on space tourism were from Moon tourism to OST and then to SST. But nowadays, the actual development sequence is from SST to OST to Moon tourism. The UNWTO defined tourism as "The activities of persons traveling to and staying in places outside their usual environment for not more than one consecutive year for leisure, business and other purposes." [1] Therefore, the "tourism" is a kind of "activity" in which people must travel to some other "place" outside their usual environment for "purposes." In ancient times, people could see the Moon when looking at the sky and imagine that it was very "close" to them than the many stars. Therefore, they dreamed that someday they might make a "tourism" trip to the Moon. This is probably why there were so many old legends about Moon tourism. [2,3]

Basically, from the 1950s to 1960s, the intended place or destination of people's space tourism was the Moon, especially after the Moon landing of Apollo 11 in 1969. Then in the 1970s, people gradually realized that both the technology and cost for Moon tourism were extremely too high to be reached in the near future. Therefore, from the 1980s to 1990s, people's focus changed to OST. There were many attempts and concept developments during those two decades. But again, there was no real achievement. Although in the 2000s, Russia successfully sent seven tourists to the ISS by using its Soyuz systems, it was a kind of OST for millionaires but not for the general public. Only after the SS1/WK1 won the Ansari X Prize in 2004, did people's focus switch to SST. There are many RLVs being developed since then. [4,5,6]

In 2004, Laing and Crouch proposed five categories within the space tourism market and to reorder the sequence: (1) virtual—virtual reality helmets allowing people to gain a bird’s eye view into space; (2) terrestrial—incorporating space camp, theme park, space museum, and other activities together to provide a space experience without leaving the Earth’s surface; (3) near-space—very high altitude supersonic cruises allowing people to experience short periods of weightlessness and high altitude sightseeing, etc.; (4) suborbital—bringing people to sufficiently high altitudes to watch the Earth’s curvature and blackness of space without leaving Earth’s orbit; and (5) LEO/HEO—actual Earth orbital experiences lasting from hours to days or even weeks. [7] To extend from the above categories, one sixth category could be added: (6) Earth-Moon orbit/interplanetary orbit—taking people to the Moon, Mars, etc.

It has been 60 years since the initiation of the Moon Register in 1954 to the crash of the first SS2 on 31 October 2014. There were many ups and downs in space tourism developments during the time period. This chapter studied the ups and downs and looked into the future from 2015 in the following sections: Section II presents the human beings’ dreams and imaginations on Moon tourism; Section III describes human beings’ high expectations on OST; Section IV states the change from OST to SST; Section V summarizes the ups and downs from Moon Register to SS2 crash and looks beyond; and Section VI gives the conclusions.

II. Dreams and Imaginations on Moon Tourism

Chinese Ancient Legend about Space

It was said that “The sky has no boundary and the sea has no bottom.” Now it is rather easy to understand where the bottoms of sea are, but it is still very difficult to know where the boundary of sky is. The Moon was called “Mother Moon” or “Lady Moon” in Chinese legend. It can be equivalent to the Goddess of the Moon, the Chang E, or the Artemis.

In the far, far ancient time, it was said there were 10 Suns. Usually the 10 Suns orbited the Earth regularly one by one, but in one day they came together. The Earth became too hot and it was very difficult for people and everything to survive. A marksman archer named Hou Yi used his arch and arrow to shoot down nine Suns so that people were relieved. In order to thank him, people acclaimed Hou Yi to be the king. But then he became a tyrant and people were bogged down in difficult days again. Even more, he wanted to be immortal and asked a goddess to give him the elixir. To save the people, his wife Chang E stole

and took the elixir. She then became so light and flew to the Moon and lives there forever with unlimited longevity. Children were taught to worship the Moon whenever they see it in the sky, so that the Mother Moon would protect and bless them. [2]

Basically, the Chinese Lunar Exploration Program, Chang E, was named after the Goddess of the Moon in the Chinese ancient legend.

Moon Register

In 1954, three years before the launch of the first artificial satellite and seven years before the first astronaut traveled to space and orbited the Earth, the world's oldest travel company, Thomas Cook, initiated the "Moon Register" in Great Britain and could be considered as the pioneer of space tourism. The company guarantees to provide tickets for commercial trips to the Moon at the earliest possible date. Over 1,000 enthusiastic people have "registered" and been enlisted. [8,9]

In 1992, about 2,000 people signed up within a couple of months when the Moon Register campaign was launched in Germany. It means that people are still interested in the program even 38 years after the initiation of the Moon Register. [8]

First Moon Flights Club

In 1968, the same year Apollo 8 brought the first group of human beings to orbit the Moon, Pan Am Airlines announced its commercial flight plans to the Moon. The First Moon Flights Club was thus formed. The company printed 100,000 member cards and attracted more than 93,000 members. Although Pan Am Airlines still did not have any real flight plans, or even any concept about the flight on when and how, many of the members were convinced with high expectations. Some of them totally believed that they would be able to get on that flight someday. Actually, the plans were not completely crazy since Neil Armstrong and Buzz Aldrin landed on the Moon in the Apollo 11 mission in 1969. But the waiting list was closed in 1971 to reduce the incurred administrative cost. Then Pan Am Airlines went bankrupt in 1991 and the members' dreams could not be realized any more through the club. A typical letter sent from the First Moon Flights Club to its member is shown in Figure 9-1. [10]

PAN AMERICAN WORLD AIRWAYS

Dear Moon First Flighter -

Thank you for your confidence that Pan Am will pioneer commercial Space travel, as it so often has here on Earth.

We have every intention of living up to this confidence.

The enclosed card confirms this intent, and formally recognizes your intrepid spirit. It also reflects by serial number, your position of record on our Waitlist For Moon First Flights. (All requests are handled in order of date received.)

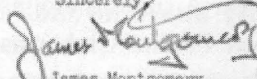
Starting date of service is not yet known. Equipment and route will, probably, be subject to government approvals. Fares are not fully resolved, and may be out of this world.

We ask you to be patient while these essentials are worked out. They are necessary requirements before we may accept deposits or make confirmed reservations.

Meanwhile, we plan to keep you informed of all important developments.

Again, thank you for coming to Pan Am first. That's exactly what we intend to be. On Earth. To the Moon. Any place else.

Sincerely,


James Montgomery
Vice President - Sales

JM/DR
Att

P. O. BOX 2212 BOSTON, MASSACHUSETTS 02107

Figure 9-1: A typical notification letter from the First Moon Flights Club to its members. [10].

Therefore, from the 1950s to 1960s, human beings went from dreams and imaginations to a real landing on the Moon. The US Apollo program won the space race against the USSR. On the other hand, one of the extensive concept designs for space tourism purposes consisted of a reusable aerospace transportation vehicle, orbital tourist hotel, a schedule of two flights daily, etc. It was pre-

sented in 1967 and published in 1968. [11] However, the Apollo program demonstrated to the public that realization of Moon tourism was still far away from them. In the government sector, the United States used a major national program to win the game. And in the private sector, there was no existing technology. There was even no initiative for the development of such high challenging as well as an extremely high cost system. [12]

III. Orbital Space Tourism—Human Beings’ High Expectations

Change from Moon Tourism to OST

After realizing that Moon tourism was still a dream and an imagination until the late 1960s and early 1970s, human beings’ intention changed to OST (or simply space tourism) gradually. But during the 1970s, basically there was not much progress in all aspects of space tourism: concept discussion, technical development, academic research, etc. Then people’s interest came back when the US Space Shuttle era began in 1981. The first flight of the Space Shuttle took place on 12 April 1981, exactly 20 years after the first-ever human spaceflight.

Rogers elaborated [12] the four fundamental reasons why it is important that space tourism should become a large and dynamic space activity: (1) as an end in itself; (2) as a means to achieving other space ends; (3) as a facilitator of other space activities; and (4) as a clear expression of our society’s character. He said that he heard and used the expression “space tourism” for the first time in the mid-1960s, about 1965. However, it took 40 years from when the first governmental astronaut flew to Earth orbit on 12 April 1961 to when the first privately paid millionaire tourist traveled to the ISS on 28 April 2001. [4,5,6,12]

As shown in Table 9–1, there are many potential experiences and activities in LEO. [4,13] During the 40 years from 1961 to 2001, there were many intended developments in Europe, Japan, Russia, the United States, and the private sector. But no realization was successfully achieved, besides Russia.

Table 9–2 shows the estimated number of passengers per year versus the price at different phases in 1985. Phase 1 is the pioneer phase at a very high price with the market expected for very wealthy and high interest in space individuals. In the second phase, the service could become a regular basis and the service could be more comfortable with more extensive facilities than in the first phase. The price would still remain at a high level so that high-income groups would be the primary customers. Then, in the mature phase, the costs could have fallen drastically to a popularized level due to the factors of economic prosperity, advancement in technology, market competition, etc. The market capacity could

become large enough to bring the service to a significant proportion of the general tourists. On the other hand, turnover would be much higher than phases 1 and 2. [13]

Experience and activity	Examples
High g acceleration	Ascending flight phase
High g deceleration	Reentry flight phase
Micro g	Free falling and orbiting phases
Orbiting the Earth	About 15 daytime and night-time changes in 24 hours
Earth observation	Earth curvature, terminator, phenomena of terrestrial, atmospheric and oceanic sciences
Astronomical observation	Moon, planets, Sun, stars, nebulae
Low gravity sport	Gymnastics, flying, ball games
Etc.	Etc.

Table 9-1: Potential experiences and activities in LEO.

Phase	Price (1985 Dollars)	Passengers/Year
Pioneer	1,000,000	50
	500,000	100
Exclusive	100,000	500-1,000
	50,000	5,000
	25,000	30,000-40,000
Mature	10,000	100,000-1,000,000

Table 9-2: Estimate of passenger numbers per year vs. price in 1985.

Development in Europe

It was reported that an opinion poll carried out in the United Kingdom, [13] the initiative country of the Moon Register, in the early 1980s showed that more than 50 percent of those under 45, and 65 percent of those under 25, would like a holiday in space. Subsequent market studies conducted at the German Aerospace Centre reported initial research indications that 4.3 percent of the German population was willing to spend roughly an annual salary (around several 10,000 USD in mid-1990s) for a holiday trip into space. [5,14] Survey results in southern England held in mid-2011 showed that 55 percent (38 percent male and 17 percent female) were very possible and possible in participating in space tourism, 36 percent (10.5 percent male and 25.5 percent female) were not so possible and

impossible, and 9 percent (4.7 percent male and 4.3 percent female) were neutral. [15]

In the early 1980s, the concept of a SSTO space plane HOTOL was designed in the United Kingdom by Rolls-Royce and British Aerospace. Both the German Sänger and the French STS-2000 programs were the follow-on of HOTOL. The ESA tried to merge all this research within the FESTIP. A two-stage HTHL with about a 40-tourist capacity and a launch mass of under 40,000 kg had been considered too. Figure 9-2 shows the concept configuration of Sänger launch vehicle. As to the spaceport, in view of the potential growth of launch rates and the convenience of logistic support, the southern tip of Spain had been chosen as shown in Figure 9-3. [8,16]

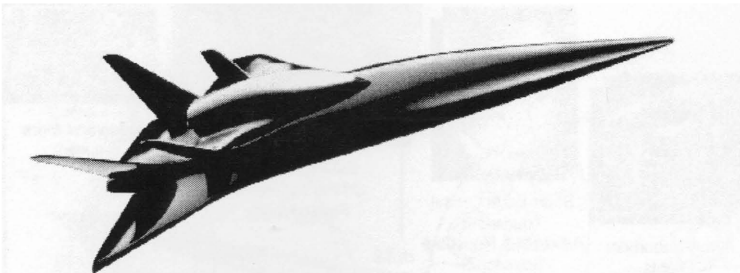


Figure 9-2: Sänger launch vehicle for space tourism. [8].

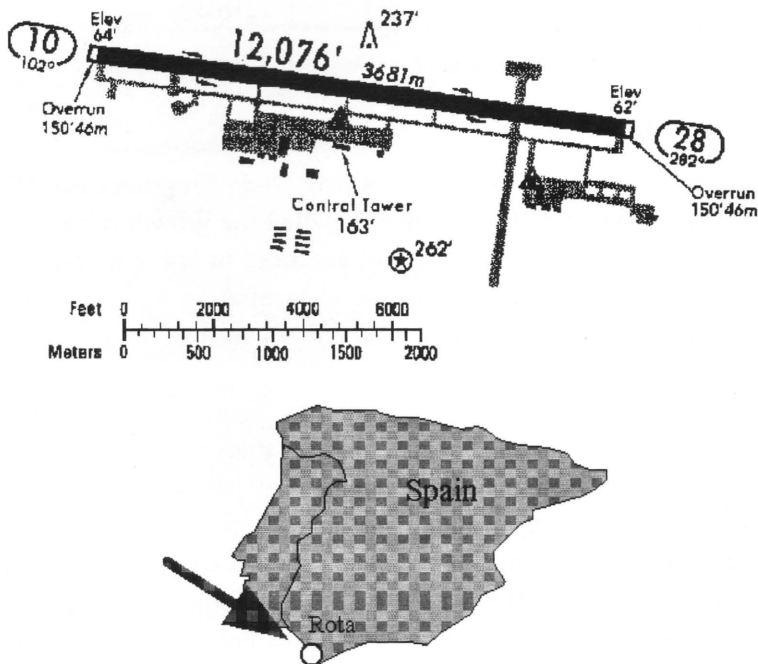


Figure 9-3: Proposed spaceport location in Europe. [8].

Figure 9–4 shows the European space tourism roadmap with four sub-scenarios. Most likely, the space tourism business could be initiated by short SST, followed by short OST in an advanced reusable spacecraft that allowed several orbits around Earth. Extended stays in space hotels would become a reality in the far future. Preliminary analyses showed that excluding transportation, accommodation in the Space Hotel Berlin would cost about 100,000 USD per night. [5,14]

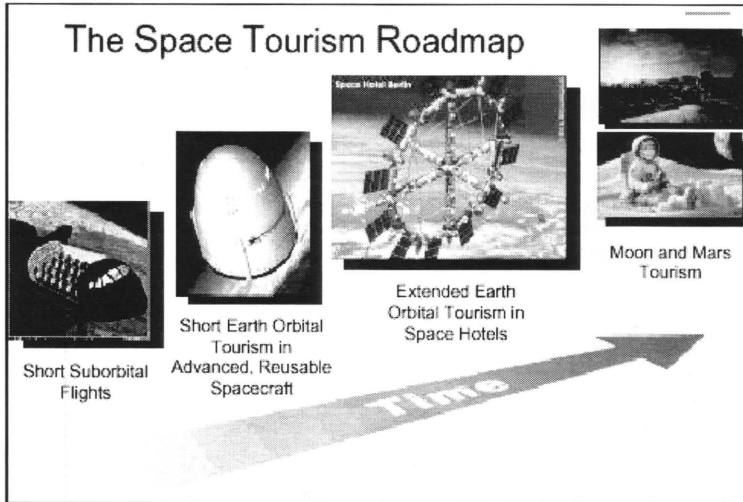


Figure 9–4: European space tourism roadmap with its four sub-scenarios. [14].

Development in Japan

The JRS had carried out its Space Tourism Study Program since 1993 with many papers and reports published. It had impelled the growth of related activities and caused an increased recognition of Japanese in space tourism development. Also, the study work extended to the concentration on regulatory issues, the development of VTOL demonstrator vehicle, as well as the commercial and media activities. [17,18]

On 4 April 1993, the JRS held the first Space Tourism Conference as a part of the organization’s Annual General Meeting. Its study program consists of the research areas in space medicine, enterprise, transportation, and passenger service. [3,19] In 1993, the survey of 3,030 Japanese people revealed that more than 70 percent under 60 years old and more than 80 percent under 40 years old would like to visit space. Besides, 70 percent would be willing to pay up to a three-month salary for the trip. The study was done under the auspices of the Japanese NAL and was considered convincible. [3,20,21]

In 1995, NAL sponsored a similar study and found that interest in traveling to space is also high for North Americans. The survey of 1,020 North Americans revealed that 75 percent under 40 years old were interested, 60 percent were interested between 40 and 60 years old, and 25 percent were interested between 60 and 80 years old. [3,20,21]

In 1997 and 1998, the JRS established three committees to study the above-mentioned space tourism issues: Transportation Research Committee, Space Tourism Business Research Committee, and Commercial Space Transportation Legislation Research Committee. As shown in Figure 9-5, concept design of the transportation system Kankoh-maru for space tourism had been announced. The designed capacity is 50 passengers. [22,23]

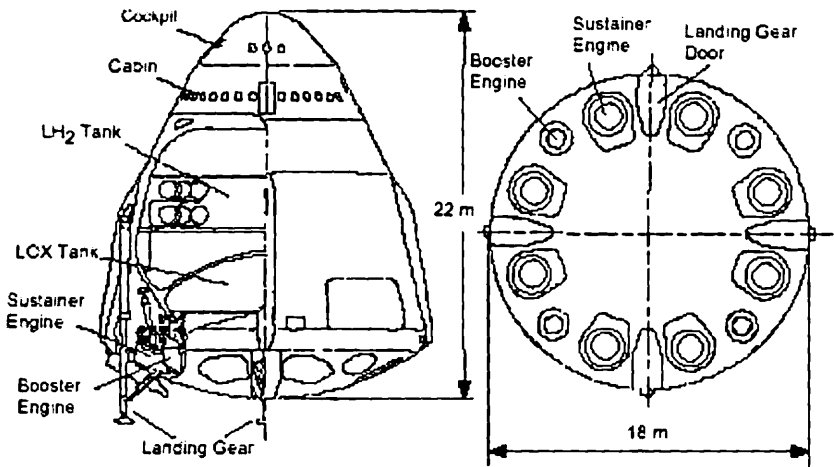


Figure 9-5: Kankoh-maru spacecraft [9].

Based on the assumption of \$25,000 (1998 US dollars) per ticket and 100,000 passengers per year, the initial profit rate could achieve 10 percent. The rate could reach 20 percent if the growth in passengers was 100 percent annually. These data were in line with the Transportation Research Committee’s assumption of manufacturing eight Kankoh-maru vehicles per year. In the Commercial Space Transportation Legislation Research Committee, most of the members were from the aviation industry. They tried to build bridges between the rocket community and the civil aviation community. [22]

Development in the United States

Every year, there are tens of millions of people visiting the National Air and Space Museum in Washington, DC, and similar museums in many other

countries. Various other space camps and conventions also represent the large and continuing space tourism market taking place on the Earth's surface. Earlier, in the 1980s, an independent market study made in the United States on true travel to space found that over 40 million people would like to take a trip on a space shuttle, and some 55 million would like to take a cruise ship-like space trip. In total, they would be willing to pay some 900 billion US dollars to do so, or about 40 billion US dollars per year. [5,24]

In 1984, a US Congress report noted that "Only when a large number of our citizens, representative of a broad cross-section of our society, begin to experience the 'space adventure' directly, will the space domain and space activities gradually begin to move into the mainstream of our 'non-national security' interests and concern." [24]

The Society Expeditions, an American company specializing in exotic vacations, studied the feasibility of providing space tourism to the general public. In August 1985, the company presented a plan to NASA, and then announced on 29 October 1985 that it was taking reservations for space tours scheduled in 1992. Space Travel was another US company proposed to offer passenger tickets for riding on the Space Shuttle. However, NASA rejected all proposals.

In any case, it did not mean that NASA did nothing in the area of public access to space in the 1980s. NASA's philosophy was to share space with all citizens, instead of opening it to the tourists. As such, NASA did choose one teacher in the Teacher in Space Program, and also tried to seek a journalist and an artist. But all these efforts failed or ended due to the *Challenger* explosion accident in 1986. [3,21]

Finally, on 16 September 2014, NASA announced a critical component of Launch America, the country's highly anticipated next chapter in human spaceflight. Boeing and SpaceX share the US \$6.8 billion "space taxi" contract. [25]

Development in Russia

No matter what had been done in the development of space tourism so far, the Russian state space agency, Roscosmos, is the only institute that realized the activities. It sent seven tourists (one of them made the trip two times) to ISS by using its Soyuz rocket and spacecraft systems from 2001 to 2009. [4,5,6] One of the major purposes of Roscosmos in doing the space tourism activities was to raise budget to support the space program of Russia. Therefore, each trip was priced tens of millions in US dollars. After the entire retirement of the US Space Shuttle fleet on 21 July 2011, the US government purchased seats on the Soyuz systems in order to send its astronauts to and bring them back from the ISS. The results were that both Soyuz systems and the ISS had no spare seats for tourists.

The Russian's OST activities were halted since then. However, this is the true commercial OST activity, even up to 2015. Per news reports, Russia plans to resume OST activities in 2018. [26,27]

For the training of a general public to become an OST tourist, the candidate must be trained one half year in the Russian Federal State Organization GCTC. Main areas of activities of the State Organization include: [28]

- Organization of cosmonaut/astronaut selection and training, medical examination, post-flight medical maintenance and rehabilitation;
- Development, arrangement, and modernization of ground-based technical facilities used cosmonaut/astronaut training;
- Conduction of scientific research and development related to the problems of manned cosmonautics;
- Providing cosmonauts with special flying training using aviation equipment of the Cosmonaut Training Centre;
- Rendering services for the commercial projects which conform to the Centre activity profile.

There are many training facilities:

- Simulators:
 - ✓ ISS RS Mockup facility
 - ✓ TV Soyuz complex simulator
 - ✓ ISS crew training facility with the elements of virtual reality
 - ✓ Astro-navigational dynamic facility
 - ✓ Low pressure chamber SBK-80
 - ✓ Surdochamber (isolation chamber)
- Weightless environment training facility (hydrolab)
- Centrifuge
- Flying laboratories
- Etc.

Development in Private Sector

The Phoenix concept of VTOL SSTO was conceived in 1972 as a means to provide inexpensive access to space. The basic concept was carried into the 1980s and was improved so that the vehicle could be built with existing technology and be suitable for use by non-astronaut passengers. [29] At about the same time of dealing with NASA, the Society Expeditions announced in September 1985 the signing of a contract with Pacific American Launch Systems, a private company planning the development of a low-cost, reusable launch vehicle, the Phoenix. It was an agreement for Pacific American to provide launch services to Society Expeditions over five years from 1992. The proposed service was a 12-hour flight in polar orbit using a reusable launch vehicle, which can carry 20 pas-

sengers with tickets priced at \$50,000 per person. Based on the operations of one flight weekly, it represented a demand of about 1,000 passengers per year. As of June 1986, some 250 people had placed deposits of \$5,000 each with Society Expeditions to book seats for 1992, which meant that the demand did exist at the level estimated by Society Expeditions. [13,29,30]

IV. Change from OST to SST

However, despite such high levels of interest reported in many national and international studies, OST would not feasibly be affordable in the short-term due to exorbitant space transportation costs in the order of several 10 million US dollars. But perhaps in the first decade of the 21st century, SST could present precursor activities that allow short flights in space by ascending vertically or horizontally into suborbit, and then descending and landing at the departure airport. Ticket prices in this case would be affordable within a range of 10,000 to 100,000 US dollars. [5,14]

Item	SST	OST
Required physical threshold	Low (for most passengers to pass)	High (for well-trained astronauts)
Training time	Several days	One half year
Flight time	1.5 to 2.5 hr	1 to 2 wk
Price	250,000 USD or lower	Several 10 million USD
High g flight	Yes	Yes
Zero g flight	Yes (several minutes only)	Yes (several days)
Earth orbit flight	No	Yes
Earth curvature observation	Yes	Yes
Earth scene observation	Yes (lower altitude only)	Yes
Atmospheric layer and night sky observation	Yes (not very significant)	Yes
Good weather condition	Very important	Not much effect

Table 9-3: Comparison of required thresholds and experience items between SST and OST [4,5]

Table 9-3 presents the comparison of required thresholds and experience items between SST and OST. It is seen that SST could have very much the similar experiences as OST but with relatively lower physical thresholds required.

Although there is still no commercial tourism in the SST market, many kinds of traffic tools for SST are under development including: Spaceplane, Lynx Suborbital Vehicle, SS2/WK2 combination, VTVL Vehicle, Dream Chaser. [5,14]

Basically, there are five major private developers of SST, one in Europe and four in the United States.

Development of SST in Europe

Airbus Defense and Space has been working on Spaceplane for nearly a decade but has said very little about the project. In 2007, the firm revealed that it would be a HTHL Spaceplane and carry four passengers to reach 100 km altitude. At that time the firm intended to sell it to tourism companies. Price per seat per trip was expected to be at least 200,000 US dollars, per estimates. Two full market analysis campaigns were conducted in 2007 and 2010, respectively. A second one was conducted after the international financial crisis in 2010 and had the opportunity to optimize the quality of models by focusing in the Asian region. On 1–4 May 2014, a quarter-scale prototype of Spaceplane passed the first drop test in Singapore. [31,32,33]

In Switzerland, the S3 Company plans to develop the suborbital shuttle for small satellite launch, as well as for P2P intercontinental passenger flight in the future. [34]

As to the regulation and legalization in SST, the issues are still under discussion since both the ESA and representatives from the EASA of EU seemed to be uncertain whether suborbital space activities would be considered aviation or spaceflight. However, in the recent developments the view has changed. The EU is reexamining the legal status of private human suborbital flight and researching whether it might be regulated as aviation or spaceflight. For the longer term and international considerations, it has been suggested that the best solution for regulation may be to create a “*sui generis*” legal regime specifically for the particular nature of suborbital spaceflights. [5,35,36]

Development of SST in the United States

In 1981, Robert Truax designed the reusable VolksRocket X-3 (Arriba One or Skycycle X-3). He could be considered as the first real pioneer to try to build a privately funded manned suborbital rocket for space tourism. [5,30] In 1982, Scaled Composites was established in Mojave Spaceport, Mojave, California, United States. It was known for its unconventional designs and for the use of non-metal composite materials. [4] The four major SST developers and their designs in the United States are briefly introduced as follows.

1. Lynx Suborbital Vehicle of XCOR: The Lynx of XCOR is a two-seat, piloted space transport vehicle, which will take humans (one pilot and one passenger) and payloads on a suborbital flight and then return safely to land at the takeoff runway. It is a HTHL vehicle using its own fully reusable rocket propulsion system. Major features include high tempo operations of up to four flights per day, rapid call-up with fast turnaround between flights, low cost O&M, and a focus on safety and reliability. Lynx will operate as an FAA/AST-licensed SRLV. XCOR has already passed the AST licensing process with an earlier vehicle concept, and is actively involved in the development of the statutory and regulatory framework within which Lynx will operate. The Lynx Mark I and II are designed to fly to 61 km and 100 km altitudes, respectively. And the Mark III is a much more advanced model for carrying extra weight. [37]

2. SS2/WK2 of Virgin Galactic: The SS2/WK2 combination is a spaceship/mother-ship concept design and the whole system is currently under development and flight testing. The spaceship SS2 is actually an air-launched glider with a rocket motor and a couple of extra systems for spaceflight. It will carry six passengers and two pilots to 100 km altitude. Each passenger gets the same seating position with two large windows, one side window, and one overhead so that everyone can get a chance to see the great view. After the third powered flight test of SS2 performed on 10 January 2014, a change to the fuel to be used in its rocket engine was announced by Virgin Galactic in May 2014. Even worse, one of Virgin Galactic's SS2 crashed in the Mojave Desert of California, while performing a test flight on 31 October 2014. Currently, the TSC is building the second SS2 to accommodate potential lessons from the ongoing NTSB investigation. According to Virgin Galactic's official announcement on 4 May 2015, the second SS2 will enter into testing later in 2015. Obviously, the interruptions caused significant delay in its flight test as well as commercial flight operations. [38]

3. VTVL Vehicle of Blue Origin: Blue Origin is currently developing technologies to enable human access to space at dramatically lower cost and increased reliability. It is focused on developing RLVs utilizing rocket-powered VTVL technology. Its New Shepard system will take astronauts to space on sub-orbital journeys. [5] The space vehicle system was flight tested in unmanned condition on 29 April 2015 for the first time. It reached a test altitude of 93.574 km and a speed of Mach 3 as planned. [39]

4. Dream Chaser of SNC: Developed under the SNC Space Exploration Systems product line, the Dream Chaser is a winged spacecraft that provides a flexible, credible, and affordable solution for ISS crew transportation. It is also a viable path to the future of commercial human space flight operations. It can car-

ry up to seven crewmembers. SNC currently has one suborbital test vehicle with some unmanned flight tests already performed, and its first orbital vehicle is now under construction. [40]

Besides the development of RLVs for SST, the US government issued Rules for Space Tourism in December 2005. Currently, no other country has such rules. [5]

V. Ups and Downs from Moon Register to SS2 Crash and Beyond

Based on this study, the ups and downs of space tourism development in 60 years from the Moon Register (1954) to the SS2 crash (2014) are presented in Table 9-4.

Time	Events	Up/Down
1954	Moon Register [8,9]	Up
1957	Launch of Sputnik 1 [41]	Up
1961	First astronaut orbiting the Earth [42]	Up
1965	"Space tourism" was used for the first time circa 1965 [12]	Up
1968	First Moon Flights Club was formed by Pan Am [10]	Up
1969	First astronaut to walk on the Moon [42]	Up
1981	Robert Truax designed VolksRocket X-3 [30]	Up
1981	The first flight of space shuttle	Up
1984	US Congress report noted citizens space adventure [43]	Up
1986	Explosion of space shuttle <i>Challenger</i> during launch [44]	Down
1991	Pan Am Airlines bankruptcy ended the First Moon Flights Club [10]	Down
1996	X Prize Foundation announced the X Prize [45]	Up
1997	First international symposium on space tourism held in Bremen, Germany [46]	Up
1997	Flight manual of Japanese Kankoh-maru published [23]	Up
1998	NASA administrator spoke about space tourism [47]	Up
1998	Space Adventures, Ltd., founded in Virginia, United States	Up
1999	Russian commercial spaceflight company MirCorp was created [48]	Up
1999	FAA/AST brought long-term commercial development of space tourism [49]	Up
2001	First commercial space tourist traveled to ISS [4]	Up
2003	Disintegration of space shuttle <i>Columbia</i> during reentry [50]	Down
2003	MirCorp was closed [48]	Down

2004	SSI/WK1 won Ansari X Prize [45]	Up
2006	FAA issued the rules and regulations to govern private human spaceflight [51]	Up
2007	Test explosion of oxidizer flow system for SS2 [38]	Down
2008	IAA held the first PHAS Symposium [52]	Up
2010	SpaceX successfully orbited and recovered its first Dragon space capsule [53]	Up
2011	IAA held the second PHAS Symposium [54]	Up
2012	FAA issued a permit to Scaled Composites allowing SS2 test flights powered by RM2 [38]	Up
2012	NASA selected SNC, SpaceX, and Boeing for next generation commercial human spaceflight capabilities [55]	Up
2013	Dream Chaser completed first free flight test [40]	Up
2014	A quarter-scale prototype of SpacePlane passed the first drop test [56]	Up
2014	Virgin Galactic announced change to the fuel used in RMS [38]	Down
2014	NASA announced that Launch America, Boeing, and SpaceX share the "space taxi" contract [25]	Up
2014	Crash of the first SS2 during flight test on 31 October [38]	Down
2015	The second SS2 will enter into testing [38]	Up

Table 9–4: Ups and downs of space tourism development from 1954 to 2014.

The items listed in Table 9–4 are, nevertheless, far from exhaustive. In particular, there are no events listed in the 1970s. But the list is somewhat representative. It is seen that there are many more ups than downs, roughly 28 to 7. Using Table 9–4 as an example to trace the course of space tourism development, it needs lots of effort to reach a certain level of achievement. But one incident or mistake or accident might turn all the previous labor and effort to nothing. On the other hand, one single major event might light up limitless hope in the general public.

Before the famous aviator Charles Lindberg accomplished the unprecedented New York to Paris solo nonstop flight by piloting the *Spirit of St. Louis* 33.5 hr. to win the Orteig Prize in 1927, people were still wondering about the airplane and had no any idea about aviation. Many famous aviators sacrificed in pursuing the Orteig Prize before Lindberg. Elinor Smith Sullivan, winner of the 1930 Best Woman Aviator of the Year Award, said that:

“Before Lindbergh’s flight, people seemed to think we (aviators) were from outer space or something. But after Charles Lindbergh’s flight, we could do

no wrong. It's hard to describe the impact Lindbergh had on people. Even the first walk on the moon doesn't come close. The twenties was such an innocent time, and people were still so religious—I think they felt like this man was sent by God to do this. And it changed aviation forever because all of a sudden the Wall Streeters were banging on doors looking for airplanes to invest in. We'd been standing on our heads trying to get them to notice us but after Lindbergh, suddenly everyone wanted to fly, and there weren't enough planes to carry them." [4,57]

For SST, the current situation is, in atmosphere, like the aviation era before Lindbergh's trans-Atlantic flight. In the SS2 crash, one senior test pilot sacrificed. But the crash reminded the aviation, space, and tourism communities as well as the general public that the development of space tourism is kept going. By looking forward from 2015 and beyond, it could be believed that the development in SST is approaching maturity. Also, the OST and Moon tourism probably could be expected in the coming, but not too far away, future.

VI. Conclusions

Starting from the Moon Register initiative of Thomas Cook Travel Agency in 1954, this chapter elaborated and treated the ups and downs of space tourism development in 60 years to 2014, the crash of the first SS2. Also addressed was looking forward from 2015. During the 60 years, or ever since the ancient age, the dream of human beings' space tourism downgraded from Moon tourism to OST and then to SST. Nevertheless, people still have very high expectations to realize their dreams from SST to OST and then to Moon tourism and beyond, eventually in the future. There were many ups and downs. But one down could cancel out many ups. Thanks to the construction of the second SS2 and the continuing developments of Spaceplane, Lynx, and Dream Chaser, the SST could come true in the coming years. Also, thanks to the space taxi and other similar cooperation programs between governmental and private sectors, the OST and beyond might not be just a dream of general public people anymore within the not too far away future.

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