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Universal Space Systems

Space Adventurer Assessment/Report

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Due to the dynamics of the Space Tourism Industry, the information contained here is as accurate as possible at the time it was researched, collected and written. The first publication of the Universal Space Systems Space Adventurer Assessment/Report will be up to date with the latest information at the time of release.

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Space Tourism Spaceships

Background

Space Tourism is projected to eventually become a multi-billion dollar industry when safe, reliable, consumer acceptable and inexpensive (relatively speaking) vehicles are built to support a commercial space endeavor. (1) Up until now, only the Russian, American and Chinese governments have successfully launched people into space on-board expensive government built spaceships, as indicated in the table below:

	Vehicle	Capability	Operational Timeframe	Crew Capacity
Russian	Vostok	Orbital	1961 - 1963	1
	Voskhod	Orbital	1964 - 1965	3
	Soyuz	Orbital	1967 to present	3
	Clipper (or Kliper)	Orbital	Under Development	4-6
American	Mercury	Sub-orbital & Orbital	1961 - 1963	1
	Gemini	Orbital	1965 - 1966	2
	Apollo	Orbital	1967 - 1972	3
	Space Shuttle	Orbital	1981 to present	7
	Crew Exploration Vehicle	Orbital	Under Development	4-6
Chinese	Shenzhou	Orbital	2003 to present	3

All of the above vehicles, with the exception of the Russian Clipper and the two American vehicles, the Space Shuttle and the Crew Exploration Vehicle, are single use only vehicles capable of no more than one trip into space. In that sense they are considered to be very expensive, expendable spaceships.

The Vostok, Voskhod, Soyuz, Mercury, Gemini, Apollo and Shenzhou (a Chinese derivative of the Russian Soyuz) are all space capsules placed on top of a launch stack consisting of either single or multi-stage rockets. This arrangement of space hardware is called the launch configuration. The capsule holds the crew and provides the command and control capabilities to "fly" the spaceship, a communications network to the ground support team, as well as the environmental systems for the health and safety of the occupants traveling into the harshness of space. The launch stack provides the necessary propulsion or thrust to lift the entire launch configuration off the launch pad with enough energy to pull free from the gravitational tug of earth and head into space. At a pre-determined point in time during the launch phase of the mission, the capsule is separated from the launch stack and travels upwards with the crew to its destination in space while the launch stack falls harmlessly back to earth.

Mercury capsule on top of the Redstone rocket

The landing configuration for the Vostok, Voskhod, Soyuz, Mercury, Gemini, Apollo and Shenzhou is via a system of multiple parachutes attached to the space capsules and arranged to provide maximum deceleration and cushion the fall. The Mercury, Gemini and Apollo capsules were designed to land in the ocean with a relatively soft touchdown while the other two capsules land on the ground.


Mercury capsule in ocean after parachute landing – NASA picture

The Space Shuttle is not a capsule but a multi-purpose space vehicle with a crew compartment, mid-deck (storage, galley, sleeping locations, hygiene facility), lower deck and payload bay for cargo (science experiments, satellites, etc.). This vehicle is launched attached to the side of a unique launch stack. The launch configuration consists of an External Tank that feeds the Shuttle's three Main Engines and two Solid Rocket Boosters.

Space Shuttle launch at Kennedy Space Center – NASA picture

As in the smaller vehicles previously described above, the Space Shuttle has enhanced command and control capability, a communications network and advanced environmental systems. In addition, the Shuttle is outfitted with a Remote Manipulator System (robotic arm) that is controlled from the Shuttle's mid-deck, which allows the crew to manipulate cargo in the payload bay without ever leaving the Shuttle. If the need arises, however, the crew can exit/enter the Shuttle with appropriate Extra Vehicular Activity hardware (i.e. spacesuits) via an air-lock hatch attached from the lower deck to the payload bay.

The Space Shuttle is essentially a space cargo airplane with no engine capability for a controlled landing (i.e. a rather large and bulky glider) but it does have the ability to land on extended airport-type runways. This landing configuration allows for a one-time approach and soft touchdown at a pre-determined landing location.

Space Shuttle landing at Kennedy Space Center – NASA picture

The actual launch configuration of the Russian Clipper and American Crew Exploration Vehicle (CEV) is not known at this time because the concepts are still in the development phase. Preliminary data suggests that the Clipper will be a modified version of the existing Soyuz arrangement while the Crew Exploration Vehicle will use some existing Space Shuttle components (External Tank, Solid Rocket Boosters and Main Engines). Probably the biggest difference in the Crew Exploration Vehicle arrangement will be a fallback to a capsule based design and the location of that vehicle from the side of the launch stack to the top of the launch stack thereby eliminating all the problems NASA has recently faced with insulation foam debris shedding from the External Tank and damaging the Space Shuttle.

Preliminary design of Russian Clipper crew vehicle – Air show picture

Preliminary concept for NASA CEV – Shown launching from Florida

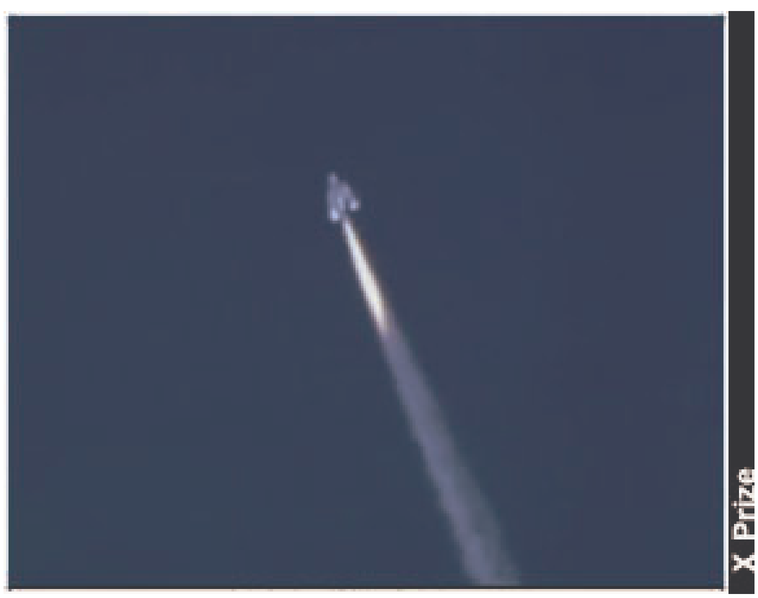
The landing configuration for both the Clipper and the Crew Exploration Vehicle is also is not known at this time. It is assumed that the Russians will continue to use their existing technology of landing the vehicle on the ground via a system of multiple parachutes attached to the vehicle. The Americans on the other hand, will probably revert back to the soft ocean landing via parachutes used in the early days of the NASA space program, if the final vehicle design turns out to be capsule shaped and without wings.

A New Beginning For Human Spaceflight

In 2004 the first private, non-government entity, Scaled Composites LLC, successfully built and launched private citizens on-board the first sub-orbital spaceship since the American Mercury Project in the early 1960s. The unique vehicle that accomplished that feat came from the mind of famed aviator designer, Burt Rutan. Burt's company, Scaled Composites LLC, backed by the huge financial holdings of former Microsoft executive, Paul Allen, developed the vehicle with the intention of winning the $10,000,000 (USD) Ansari X-Prize. To win the Ansari X-Prize competition, a spaceship with the capability of flying 3 people, had to make two successful sub-orbital trips to the edge of space (2) within a two-week period. Burt Rutan's spaceship and carrier airplane, SpaceShipOne and the White Knight respectively, won that competition hands-down.

The White Knight carrying SpaceShipOne

The spaceship built by Scaled Composites LLC was the first in what will be a long line of safe, reliable and inexpensive vehicles intended to transport tourists on a sub-orbital trip into space. Other than the venerable Russian Soyuz spaceship that was used for the first tourists in space, there currently are no other orbital spaceships, government or non-government built, available for commercial paying passengers. Numerous start-up aerospace companies, however, are working behind the scenes to get ahead of the competition once sub-orbital Space Tourism takes root. For now, the prime focus of Space Tourism is on sub-orbital spaceflight, which is where our focus will be.



SpaceShipOne in flight – on the way to winning the Ansari X-Prize

As a side note it is worth mentioning here that Burt Rutan is already involved with another company, Transformational Space or tSpace as it is called, to build an orbital spaceship! tSpace may not be the front-runner in that “race” though because a start-up aerospace company called Space Exploration Technologies Corp. or SpaceX is well along in the launch schedule for their Falcon 1 vehicle and development continues in the more powerful Falcon 5 and Falcon 9 rockets. Elon Musk the President and CEO of SpaceX and the sole financial backer of his company (he made his fortune with the Internet company PayPal), leaves little doubt that his future plans include Space Tourism.

Falcon 1 – SpaceX picture

There were other sub-orbital space vehicles under design and development to compete for the Ansari X-Prize, however, none were anywhere close to being in a flight ready state when Scaled Composites LLC won the prize. Since that time, CEO Sir Richard Branson of Virgin Airlines, has licensed the technology and formed an alliance with Burt Rutan’s company for the right to commercially fly a second generation of SpaceShipOne and the White Knight for Space Tourism. Sir Richard’s new Space Tourism company is known as Virgin Galactic. Recently, a second partnership between Burt and Sir Richard has resulted in a company called The Spaceship Company. As the name implies, this company will simply manufacture spaceships (probably the same design that Virgin Galatic will fly) for other Space Tourism companies.

Spaceship Designs

Even though Scaled Composites LLC’s spaceship won the Ansari X-Prize many of the other companies that were working towards the same goal have continued to press on with their designs/concepts in the hopes of producing a similar sub-orbital spaceship and become an active player in the Space Tourism industry. Some of these companies will be actively participating in the follow-up Ansari X-Prize competition known as the X-Cup. Although this competition will not be structured in the same manner that the X-Prize was, the companies that want to be a part of the Space Tourism industry will use this opportunity to demonstrate/prove their space hardware concepts. Other companies will simply continue to work to get their vehicles launched without becoming involved in the yearly X-Cup competition.

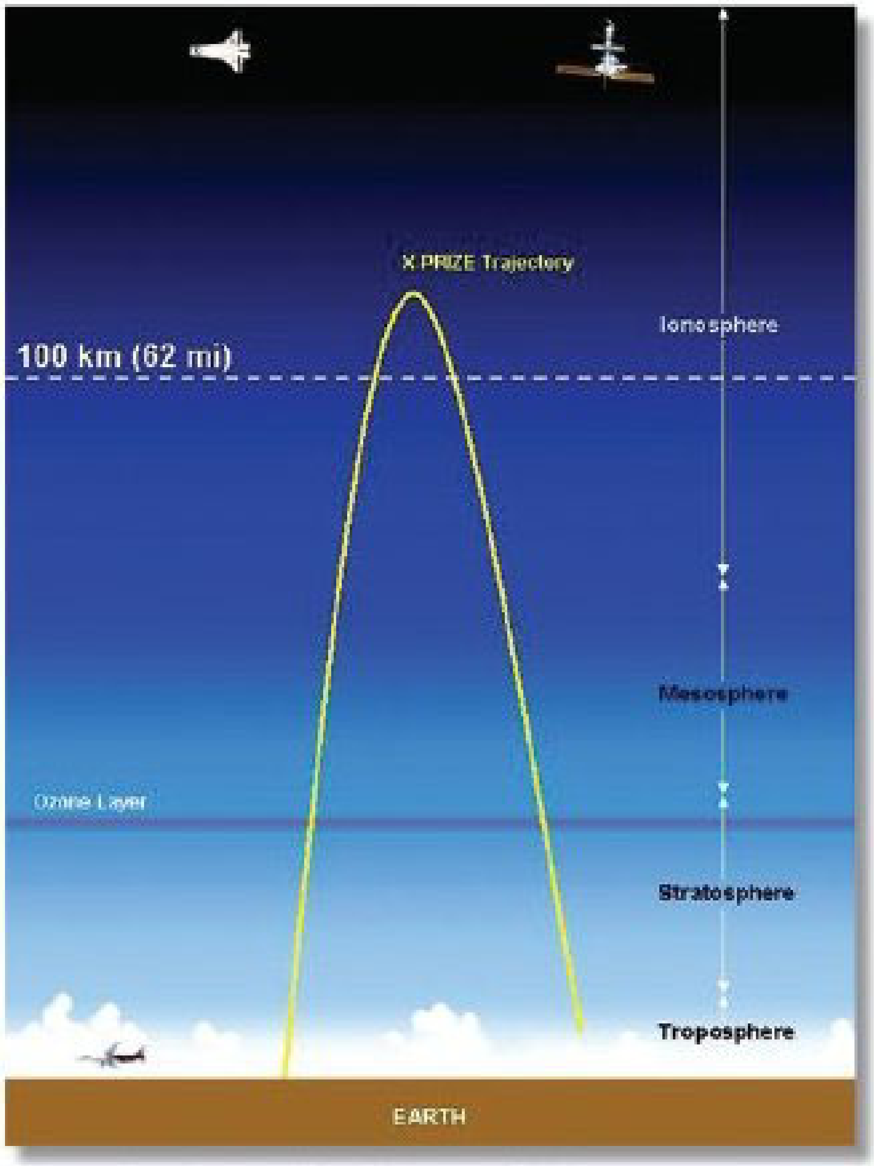
The best way to describe spaceships to be used for future sub-orbital Space Tourism flights is to label them as Reusable Launch Vehicles (RLV) as opposed to the expendable Mercury spaceship. Below is an overview of every significant launch and landing method for RLVs that are currently on the drawing board, under development or proven to work.

There exists a considerable amount of disagreement as to what should be the correct configuration for an inexpensive, yet safe, spaceship for Space Tourism to succeed. Needless to say there are many different and unique sub-orbital spaceships in the works and the SpaceShipOne/White Knight design configuration is only one type of a launch/landing platform. Generally speaking the launch and landing characteristics of a spaceship, sub-orbital or orbital, can be classified into a category. Because a spaceship is truly NOT an airplane like a Boeing 737 with known launch and landing characteristics, it is important to understand the different categories of launch and landing as outlined below.

– The Launch Aspect

Launch methods for a spaceship can be categorized as Vertical Takeoff, Horizontal Takeoff or Air Launch. Each of these methods will be discussed here, however, based on factors of safety, customer acceptance and affordability, the preferred method of a sub-orbital RLV launch is Vertical Takeoff using hybrid rocket engine propulsion. **(3)** At this point in time there has never been either a sub-orbital or orbital space flight using a rocket powered Horizontal Takeoff space vehicle or a combined rocket and jet powered Horizontal Takeoff space vehicle. But that is not to say that it can't happen. There have been successful air launches – the best and most recent example of this is the SpaceShipOne/White Knight combination of vehicles. That design is only one of six possible Air Launch configurations!

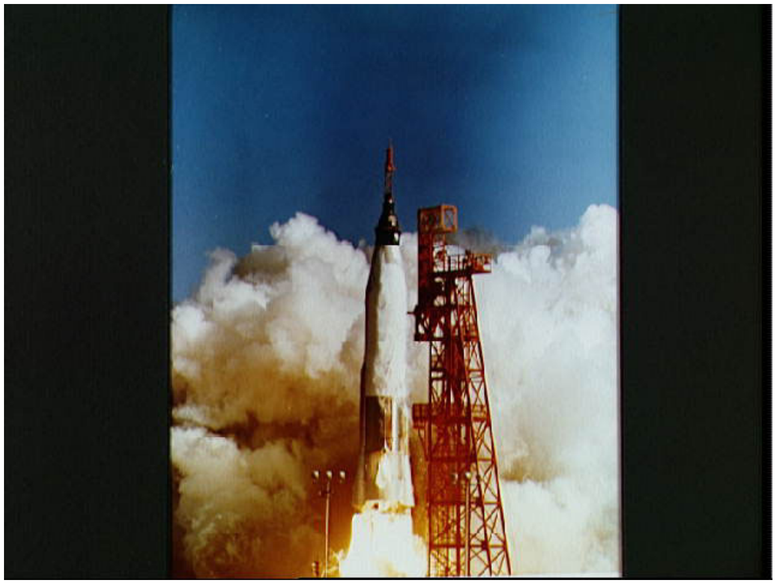
The typical launch trajectory (path that the spaceship will fly into space) for a sub-orbital spaceflight is shown below. Note that a substantial portion of the flight is above the atmosphere where the only propulsion system that can work is a rocket engine due to the vacuum of space (i.e. a lack of oxygen). No matter what launch method is used to send a vehicle into space, the rocket motor velocity must account for several "losses" that affect performance – Gravity (the pull of Earth's gravity on the vehicle), Drag (caused by friction between the vehicle and Earth's atmosphere) and Steering (the ability to control or steer the vehicle along the planned trajectory). All of these losses must be taken into account by the Aerospace/Aeronautical Engineers no matter what the sub-orbital or orbital spaceship design turns out to be. For all sub-orbital cases, one can expect the speed of the spaceship in the range of Mach 3-4. **(4)**



X-Prize sub-orbital trajectory – Sub-orbital Institute graphic

Vertical Takeoff

Both the American and Russian government space programs use the Vertical Takeoff launch method to place people into space. These launch configurations are either single or multistage, expendable launch stacks where only a portion of the entire launch configuration, the spaceship (capsule), is safely returned to Earth. This is the launch method that most people are familiar with having seen pictures or videos of Mercury, Gemini, Apollo or Vostok, Voskhod or Soyuz spaceships taking off from their launch pads. A sub-orbital Vertical Takeoff RLV would be closer in comparison to the Mercury (capsule) – Redstone rocket (launch stack) launch configuration than any of the other previously listed vehicles. Generally speaking. this launch method requires a larger amount of propellant to get the vehicle into the air.


Mercury/Redstone - Vertical Takeoff – NASA picture

A three (3) person sub-orbital Vertical Takeoff RLV could actually be smaller than the one (1) astronaut Mercury–Redstone which was capable of reaching orbit (almost twice the distance to the edge of space) at a speed of Mach 7. **(5)** This launch configuration can easily carry the necessary fuel in the launch stack required to reach the edge of space (or in the case of a orbital spaceship, to escape Earth's gravity and reach orbit). Vertical Takeoff RLVs also have enough propellant margin in the stack that allow them to use relatively low technology pressure fed rocket engines. The launch stacks then are "basically pressurized balloons under an axial compression load and are subject to very little bending and no twisting moments during takeoff." **(6)**

A vertical takeoff trajectory allows for a relatively simple but prepared launch site. The preparation time required to set up and launch the sub-orbital RLV after it has been transported to the launch pad could be as low as one to two hours assuming everything flows nominally.

Space transportation studies done over the past 20 years have come to the same conclusion - Vertical Takeoff is the preferred method of launch for a number of engineering reasons. We will not overwhelm you with those details, however, should this peak your interest the studies include the European Space Agency's (ESA) Future European Space Transportation Investigations Program (FESTIP), Russia's Oryol program, Japan's project HOPE and the American's Access to Space Studies, Space Transportation Architecture Studies & the US Space Launch Initiative (SLI). **(7)**

Horizontal Takeoff

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References

(1) NASA NRA 8-27 Harris Poll, 2000

(2) Edge of space = altitude of 328,000 feet; 62.5 miles, 100 kilometers (Internationally recognized boundary by The Federation Aéronautique Internationale)

(3) Marti Sarigul-Klijn, Ph D. and Nesrin Sarigul-Klijn, Ph D., "Flight Mechanics of Manned Sub-Orbital Reusable Launch Vehicles with Recommendations for Launch and Recovery, AIAA 2003-0909

(4) Mach 3 = 761 mph (the speed of sound) x 3 = 2,283 mph / Mach 4 = 761 mph x 4 = 3,044 mph (Supersonic speed)
Subsonic = M<1; Transonic = M=1; Supersonic = M>1; Hypersonic = M>5

(5) Mach 7 = 761 mph x 7 = 5,327 mph (Hypersonic speed)

(6) Marti Sarigul-Klijn, Ph D. and Nesrin Sarigul-Klijn, Ph D., "Flight Mechanics of Manned Sub-Orbital Reusable Launch Vehicles with Recommendations for Launch and Recovery, AIAA 2003-0909

(7) C. H. Eldred, el al, "Future Space Transportation Systems and Launch Vehicles", Progress in Astronautics and Aeronautics, Vol. 172, 1997

Pictures

All pictures are referenced as indicated next to the picture.

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