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FOREIGN TECHNOLOGY DIVISION

SPACE SHUTTLE

by

Ling Fu-Keng

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SPACE SHUTTLE

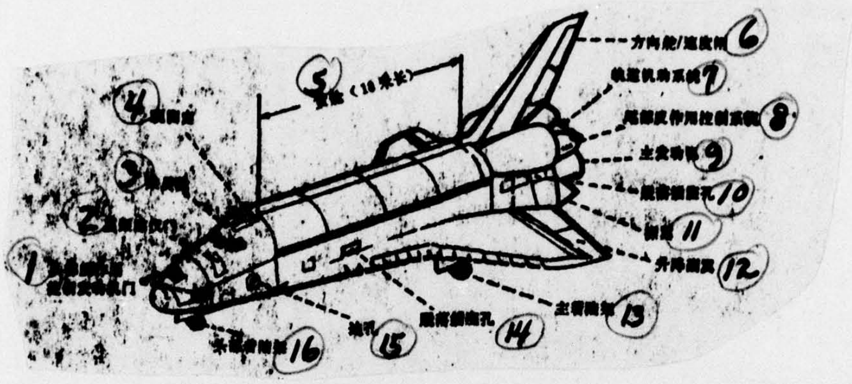
Ling Fu-Keng

Abstract: Space shuttle is one kind of aircraft which is capable of vertical launching like rockets and can leave the atmosphere and travel in space. Although it is a spaceship in that respect, it can also land in airports like regular aircraft. In essence, it combines space and aeronautic travel and has attracted wide attention. In view of the increasingly vigorous struggle for hegemony by the Soviet Union and the United States, the American's first successful space shuttle landing experiment will further intensify the space competition of the two super powers.

August 12, 1978, the space shuttle of the United States "Enterprise" successfully carried out its first manned landing experiment and generated wide interest. Everyone becomes interested in knowing what kind of aircraft is the space shuttle, what are its special features and how is its future? This article is written primarily to answer these questions.

What is a Space Shuttle?

Along with the continuous development of science and technology, more and more satellites and spaceships (hereon referred to as effective load) need to be sent into space. Therefore, the need for carrier rockets for such effective loads is also increasing. However, up to now, only one-shot carrier rockets are available; the carrier rockets are wasted after one launch and new rockets need to be designed and built for the next launch. Such passive situation has greatly impeded the development of space. Because of this, the development of a repeatedly usable aircraft-type carrier rocket has become an urgent need in the large scale reduction of space flight costs. Space shuttle was thus proposed as a repeatedly usable space travel vehicle.



Key: 1 - Reaction control engine door (nose); 2 - Star tracking device door; 3 - Cockpit; 4 - Observation window; 5 - Cargo space (18 m long); 6 - Rudder/speed valve; 7 - Orbit control system; 8 - Reaction control system (tail); 9 - Main engines; 10 - Disengagement recepticle opening; 11 - Flap; 12 - Aileron; 13 - Main landing gear; 14 - Disengagement recepticle opening; 15 - Side opening; 16 - Nose landing gear

Fig. 1 The exterior and main parts of the space shuttle

The space shuttle shown in Fig. 1 has a length of 37.2 meters, a wing span of 23.79 meters and its weight is 68 tons, comparable to a modern cargo plane. The flight environment a space shuttle must go through is much more demanding than that of an ordinary aircraft. On one hand, a space shuttle needs to have the aerodynamic profile suitable for hypersonic, supersonic, and subsonic flights in the atmosphere and horizontal landing; on the other hand, it must also have heat resistance systems capable of enduring the high temperature corrosion upon re-entry to the atmosphere. Finally, the space shuttle ended up with a tailless double triangle wing design and various heat resistant coatings which cover its exterior.

The space shuttle can be divided into three sections: front, middle, and tail. The front section houses the reaction control system and the passenger cabin of a capacity from four to seven persons. It can have 10 persons in emergency situations. The passenger cabin has three levels: upper level is the pilot cabin, center level is the personnel living quarters, and the lower level is for equipment.

Under ordinary circumstances, the astronauts and scientists carry out their duties in the personnel cabin where the atmospheric pressure and environment is similar to the conditions on earth and only ordinary clothing is necessary.

The mid section of the space shuttle is a large cargo space 18.6 meters long, 5.2 meters wide and 3.9 meters high. The total volume is over 300 cubic meters and the effective load capacity is 29 tons. In this cargo space, one can carry satellite, space station, large space telescope and other space equipment. Automatic mechanical arms and television are installed in the mid section to carry out the jobs of releasing the effective load it carries to its orbit or to capture other effective loads orbiting in space.

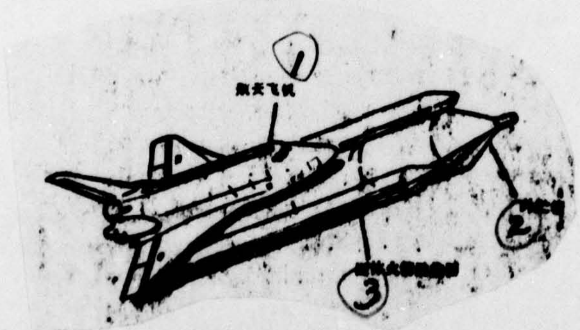
The tail section of the shuttle is more complex. It consists of the main engine system and the reaction control system which provices power for the shuttle's flight, in addition, aerodynamic control components are also in this section. The latter includes the elevating aileron, the flap, the vertical rudder and the speed brake. In the earth atmosphere, the space shuttle maintains good mobility and stability through the control of such aerodynamic devices.

Auxiliary components -- External Storage Tank and Solid Fuel Rocket Booster

To carry the transportation duties in space, the space shuttle is equipped with one external storage tank and two solid fuel rocket boosters.

Together with these auxiliary components, the space shuttle (itself may be called orbit spacecraft of commuting spaceship) should be called a space transport system of a space shuttle ensemble.

Fig. 2 shows the relative position of the space shuttle and the auxiliary components. As can be seen, the shuttle is fastened on the back of the external storage tank and the two solid fuel rockets are carried along the sides of the tank. The entire space transport system has a length of 56.14 meters and the total weight at take-off can be as high as 2000 tons.



Key: 1 - Space shuttle; 2 - External storage tank; 3 - Auxiliary solid fuel rockets

Fig. 2

Although the three main engines are at the tail section of the shuttle, the shuttle itself has no space for storing propellant fuel. The objective of the present design is to minimize the volume of the shuttle. The function of the external storage tank, therefore, is to store large amounts of fuel. An external tank of 30 tons tare weight can carry over 700 tons of propellant fuel. The tank is essentially a huge cylinder with a pointed head. Its diameter is 8.38 meters and its length 46.84 meters, with a total weight at take off close to 800 tons. Since the three main engines can only produce 600 tons of thrust, two solid fuel booster rockets are needed for sufficient thrust. The two solid fuel rockets are identical in structure. Each has a length of 45.46 meters, a diameter of 3.7 meters, tare weight of 80 tons, and can carry 500 tons of solid fuel propellant. The heart of the thruster is its solid fuel rocket engine capable of delivering 1200 tons of thrust. The space shuttle can take off in the vertical direction. Upon taking off, the solid fuel rocket engines and the main engines of the shuttle are fired simultaneously to push the shuttle upward. After approximately 115 seconds, at an altitude of 40 kilometers, the auxiliary rockets separate from the shuttle system and parachute to the ocean where they are recovered. The auxiliary rockets can be repeatedly used for twenty times or more. After separated from auxiliary rockets, the shuttle and its external storage tank will continue their acceleration and ascend relying on the main rockets engines. They reach the vicinity of the 800 kilometer orbit in about 480 seconds from take off. At this time, the shuttle will get rid of its external tank and enter the orbit using its own power and control system. The storage tank is not recovered and it is the only expendable item in the space transport system. Thus, after the orbit flight operation, only the shuttle returns to earth. Ordinarily, the shuttle will fly in orbit for seven days, but the time period can be shortened or prolonged up to 30 days.

Superior Features of the Space Shuttle

Compared to conventional spacecraft, the space shuttle is a new type of spacecraft. It can take off vertically like carrier rockets and carry out orbit flights like satellites and spaceships, and finally, it can coast and land at an airport like common airplanes. Its advantages are listed below:

1. Reduced space flight costs. Since space shuttles can be used more than one hundred times, just from the repeated usage, the launching costs are reduced by 90 percent. More importantly, by using space shuttles, the effective load's design can be simplified and worn out effective loads can be repaired in orbit. This amounts to even a greater saving than the repeated usage.

2. Increased safe and reliability of space flights. The overload acceleration value of the entire flight of shuttles does not exceed 3 g and the landing speed upon their return to the airport is below 300 kilometers per hour. In previous space flights, the product was sent to space for the first time and also for the last time. Without the screening and testing of a real space environment, the reliability is relatively low. For space shuttles, the repeated commuting between space and earth proves the reliability. Besides, the practice in the past on the re-entry of manned spacecraft was a spash down on the ocean on in fields, a major threat to the life security of astronauts. Whereas space shuttles, after their re-entry into the atmosphere, can use their wings and airfoil controls in coasting to and landing at the airport. The shuttle has in essence made the space flights close to being as secure and reliable as the ordinary aircraft flights, and changed the endeavor of space flight from an expedition to the practical application stage.

Because of the low reliability of the traditional mode of space flight, all the equipment had to go through elaborate simulation experiments before the launch. This amounts to several months of preparatory work at the launching site. Space shuttles, on the other hand, can take off again within two weeks. The advantages of simplified launching procedure and timely flight are of great value of military and civilian applications ~~alkie~~ alike. With space shuttles, one can carry out high speed transportation between any two points of the earth surface, rescue of astronauts, interception of nuclear missiles, detection of enemy surveillance satellites, and the destruction of enemy satellite communication systems.

3. Effective incorporation of modern science and technology into space flight. Much ground equipment cannot be sent to space with carrier rockets, often due to their odd shape or big volume. For instance, large telescopes work much more effectively in space where there is no atmospheric interferance. Unfortunately, present carrier rockets are unable to send large telescopes to space. Much modern scientific equipment must be modified before sent to space. The modification often reduces the quality and is time consuming. The large cargo space in the space shuttle enables the transportation of highly sophisticated scientific apparatus to space without modification. Further, space shuttles can also carry technical staff with common training to space and let them experience space experiments in person and advance their scientific research.

4. Diversification of space activities. In principle, the space shuttle can replace all the presently used carrier rockets and carry out space missions. It can release or recover many satellites at one time, and from these satellites, space probes can be launched to even farther

planets in the universe. Space shuttles can be used in the periodic transfer of personnel working in space and regular scheduled flights can be established for the supply of scientific research work in space. Using shuttles as a commuting vehicle between space and earth, the establishment of large space structures such as solar electric generation stations, hospitals, factories and so forth. When all these become reality, the vacuum, weightless and solar energy in space will be used in the treatment of disease which are incurable on earth, in the production of materials difficult to manufacture on earth, and in the performance of experiments which cannot be carried out in the earth surface environment.

The Prediction of a "Space Force"

Incidently, it has been proposed that the space shuttles may become a space orbit combat squadron and form the basis of a new armed forces -- the "space force." Although this prediction may sound premature at the present time, we should recall that when the airplane was emerging in 1903, the prediction of a new armed force, the air force, was not taken seriously by most people at the time.

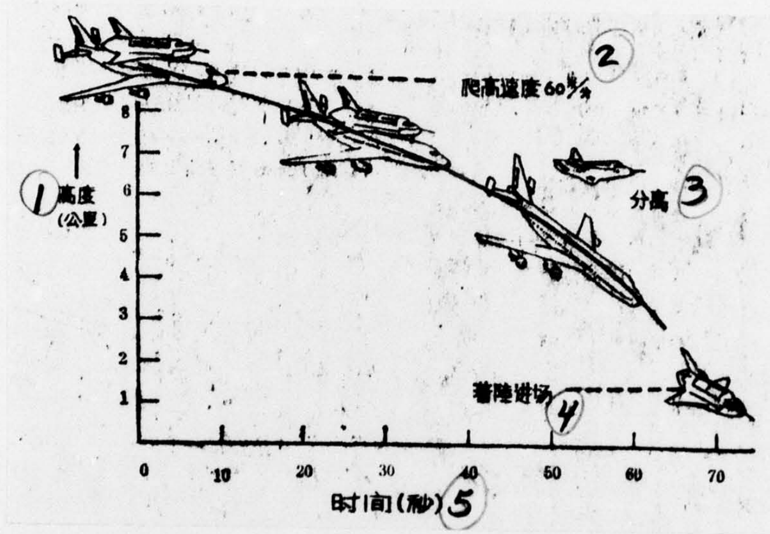
The experimentation with space shuttle so far is still confined to the approach and landing. Although the advantages mentioned above are very attractive, they look good on paper nevertheless. The real value would have to be judged after the challenge of practical application.

Approach and Landing Experiment

In order to test the aerodynamic characteristics, flight control functions and the airport landing operation of a space shuttle without extend fuel tank and auxiliary booster rockets, a space shuttle was carried by a large jet plane (such as a Boeing 747) in a piggy back fashion to a specified altitude in the atmosphere for flight tests. This test is called the approach and landing test of the space shuttle, or low altitude horizontal flight test. The jet plane which carries the shuttle is referred to as the carrier plane.

There are two stages to the approach and landing test. During the first stage, there is no pilot in the shuttle and the shuttle is fastened on the back of the carrier plane during the entire take off and flight, as well as the landing operation. In the process, large amounts of instrumentations are used to monitor and analyze the functioning conditions of the various systems on the space shuttle. In the second test stage, the space shuttle is controlled by its own pilots and the shuttle separates from the mother plane at a certain altitude and carried out its own approach and landing. The latter test is therefore known as the manual landing test. This test ensures the subsonic flight ability, aerodynamic characteristics, functioning of the entire system and its ability to coast and land.

A manned landing test was carried out successfully on August 12 of this year. To prepare the separation of the shuttle, the carrier plane takes a negative six degree angle and accelerates at an altitude of 13 kilometers so that the shuttle can obtain a smooth gliding condition. This maneuvre is the preparation for the separation which does not take place until the altitude of 6700 meters, see Fig. 3. After the separation, the carrier plane will turn right and the shuttle turns left to maintain a necessary horizontal distance. Then the shuttle pulls up to increase the vertical distance from the plane to 60 meters in 5 seconds. After that, the shuttle pilot will begin a series of dynamic flight operations to gain data on the aerodynamic conditions and the function of the flight control system. The shuttle will then dive to increase its speed and make two turns, at approximately 2000 meters height and 14 kilometers from the landing point, to aim at the runway. The landing gear is lowered at 100 meters and a final leveling is done at 30 meters altitude so that the vertical speed is 1 meter/sec. until touch down. From separation from the carrier to touch down, the total time is about 5 minutes and 20 seconds.



Key: 1 - Altitude (kilometer); 2 - Climbing speed 60 meter/minute; 3 - Disengage; 4 - Approach and land; 5 - Time (seconds_

Fig. 3

The manned landing test of the shuttle is carried out to simulate the actual flight of the shuttle and the entire process is done without active power, that is, the landing relies on the adjustment and control of the aerodynamic planes and flaps. Certain systems, such as the heat protection system, are of course, strict simulation parts since the re-entry test will not be done until the 1979 test of manned orbital flight.

In the history of transportation, the realm has expanded from land to sea, and then to air. Now the air transport has expanded to include space transportation, see Fig. 4. The currently developed space shuttle is not yet ideal for space transportation since its auxiliary components are too large in size and its flight procedure relatively complicated. Single stage space shuttles are now being developed, i.e., a single spacecraft with the auxiliary solid fuel booster rocket and external fuel storage tank. Until then, perhaps, the travel transportation in space will prosper like today's land, sea and air transportations.

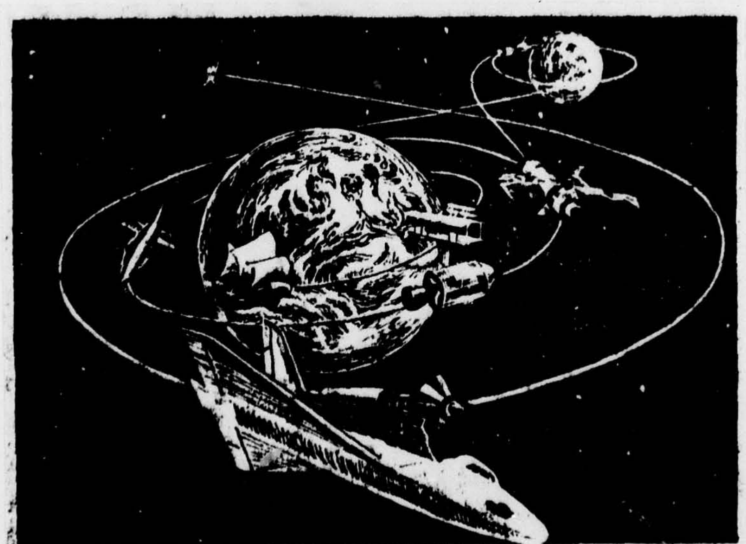


Fig. 4. Evolution of Transportation

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