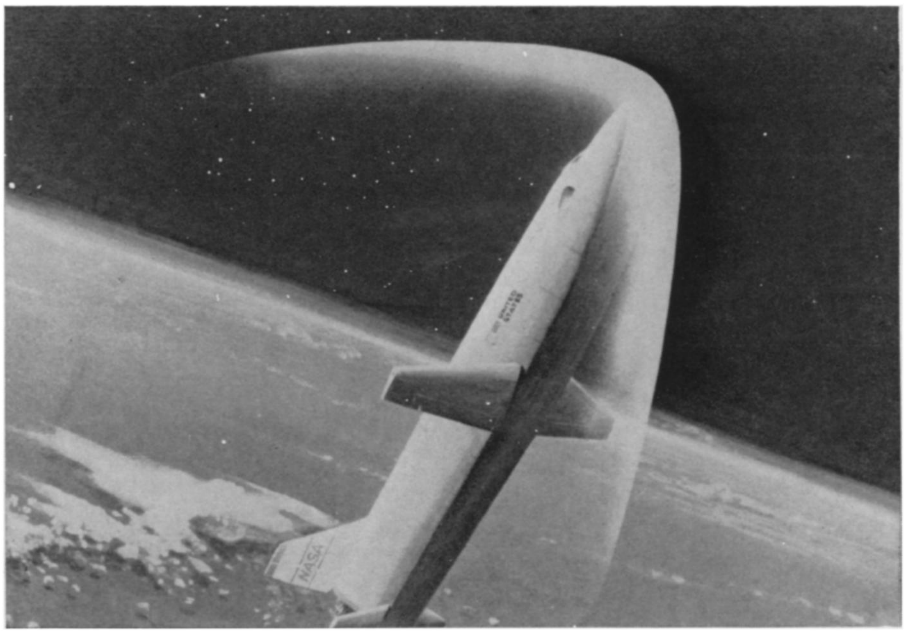
Next step in space: The shuttle

If technical problems are solved, reusable space vehicles are in the offing

by Everly Driscoll



Photos: NASA

A straight-wing orbiter reentering the atmosphere in a nose-up attitude.

Ever since the early days of rocket development during and immediately after World War II, space engineers have envisioned recoverable, reusable space transport rockets. The first rockets were developed to serve as weapons, however, and for military purposes the reuse capability was not needed. As the space effort evolved into a civilian program in the 1950's, the concept was revived; but when the race to the moon began there was no time to develop reusable flight hardware. The Apollo program used expendable hardware, designed for only one flight.

In today's more relaxed, less opulent, space atmosphere, the reusable concept may have its day. National Aeronautics and Space Administration is laying the foundations for space systems of the 21st century, and a major shift from the throwaway philosophy of the 1960's to a flexible, economical program that can respond quickly to changing political moods is considered essential (SN: 7/24, p. 53). For this, NASA needs hardware that is versatile and reusable.

The space shuttle proposes to answer both needs. In doing so, however, it has become a technological challenge. The shuttle has to combine the best of both aeronautical and space expertise to launch like a rocket, orbit like a spaceship, reenter and then maneuver and land like an airplane.

The full vehicle design consists of two reusable stages—booster and orbiter—both launched vertically. The booster would return immediately and land horizontally. The orbiter, riding astride the booster, would separate and go into orbit to deliver and pick up 50,000-pound payloads, ranging from crews and supplies to satellites and space station modules. The orbiter could also serve as a temporary space station, taking scientists on sortie flights for orbital research.

The improvement in time and expense over the Apollo concept is impressive. Apollo flights require extensive checkout and preparation, at least two months between launches, and thousands of ground support personnel; the shuttle ideally would have fast turnaround capability between landings and departures, could launch on several days' notice, and would require little ground support. The shuttle could be used 75 or more times a year. It would have four crewmen, two for the orbiter and two for the booster, and the orbiter could carry up to 12 nonastronaut passengers in a shirt-sleeve environment.

To carry out these goals a host of technological advances is needed. Whether they can be achieved in time for the proposed 1978 flight date is uncertain. Informal evaluations range from "unbuildable, undeliverable" to "difficult, but possible."

Despite some doubts by critics, NASA is continuing its early studies of the shuttle. In a first step, engineers at the Manned Spacecraft Center in Houston have built a mini-shuttle, one-tenth the size of the full vehicle (SN: 6/13, p. 580), to study the aerodynamics of reentry—a complicated problem, since the orbiter must enter in a nose-up attitude, then swing to a level cruise attitude for landing. In addition, this summer NASA began the second phase of studies—design and definition—which, like the feasibility studies of the 1960's, do not require massive funding from Congress. The two prime study contractors are North American Rockwell Corp. and McDonnell Douglas Corp.

One demanding problem being studied, says Dale Myers, Associate Administrator for Manned Space Flight, is the design and development of the air frame structure. It and its thermal protection system must be lightweight and extensively reusable. Equally important is the development of reusable, high pressure, liquid oxygen/liquid hydrogen engines. A third challenge is to integrate the mass of spaghetti-like electronics and control hardware that is normal in experimental systems such as Apollo into a streamlined system of black boxes that can be easily checked out and replaced as necessary.

Two general structural designs have emerged for the orbiter: a straight wing and a delta-shaped wing. The straight-winged vehicle can reenter the earth's atmosphere at a high angle. This shortens the duration of the highest heat load. The design would suit NASA needs, but the shuttle development depends on a wide range of users, one of which is the military, and the Air Force needs more of a lateral flight capability than the straight-wing design allows. After reentry the straight-winged craft could deviate to the left or right only 200 miles. The delta-winged craft could range to the left or right up to 1,500 miles. It could reenter the atmosphere at a lower angle and would be able to maneuver for a longer distance. But because frictional heating lasts for a much longer period, the heat shield requirement is more stringent for this design.

Each configuration has wings, and a winged rocket introduces aerodynamic forces avoided by the capsuled Apollo, such as air flow, buffeting stresses and hot spots. These forces place intense demands on the structure and control of the vehicle during launch, separation and reentry.

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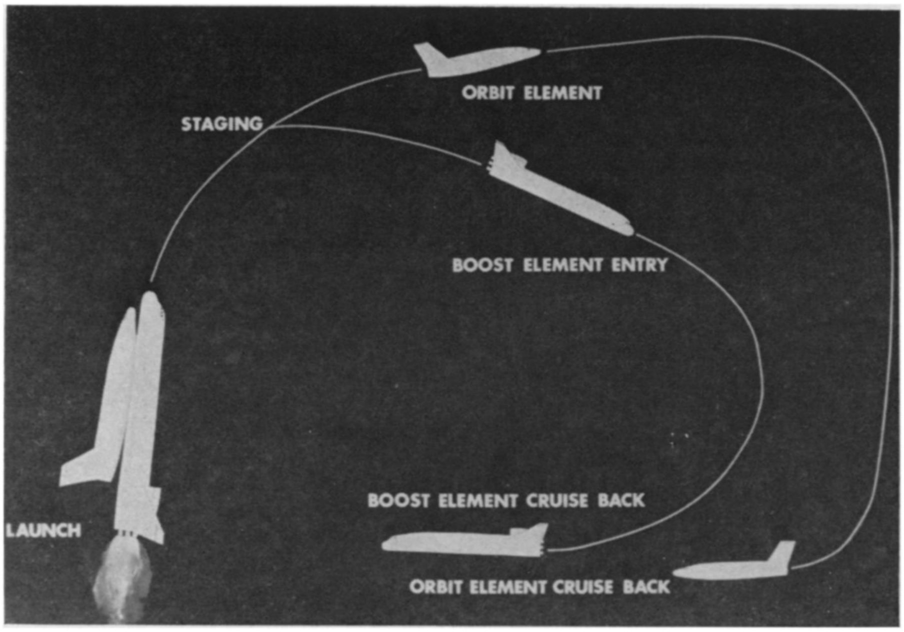
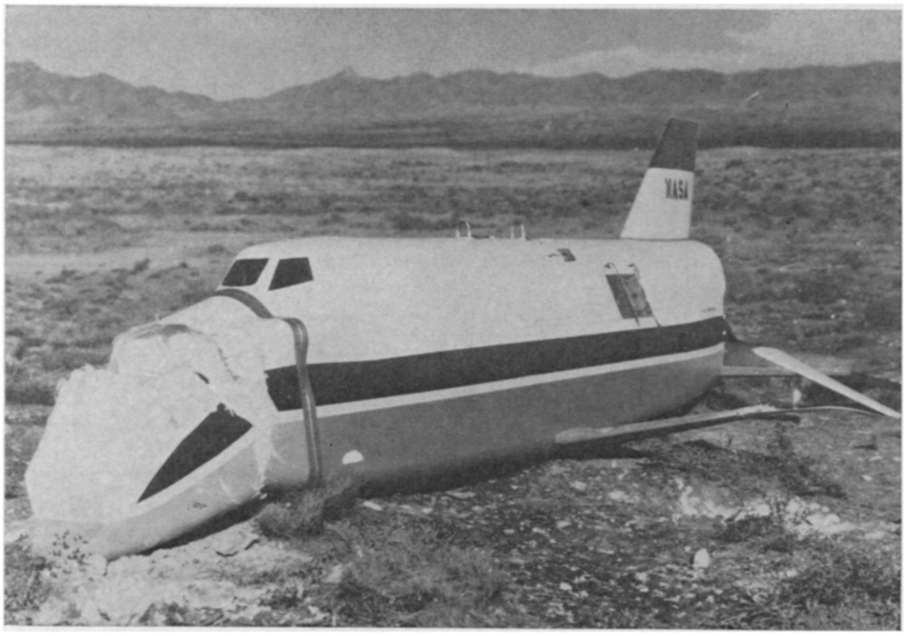


Booster and orbiter combine characteristics of both airplanes and rockets.

Armstrong: It's most significant.



A crushable nose cushions the landing of the mini-shuttle after flight test.

protect against temperatures ranging from 1,800 to 3,000 degrees F. and must be reusable. These high temperatures will require new materials. One likely candidate might be a dispersion-strengthened nickel-chromium alloy (SN: 1/24, p. 107) of extremely thin sheets (between 0.010 and 0.020 inch).

Reusable engines capable of 400,000 pounds of thrust using a high-pressure bell-nozzle concept are needed for the main propulsion system. The auxiliary propulsion system could include reaction-control thrusters, which use gaseous hydrogen and oxygen. Air-breathing engines for orbiter or booster reentry control are also being considered. But this need will depend on the ultimate requirements for cross-range maneuvering.

Streamlining the avionics for the shuttle will require sophisticated developments between now and 1978. The checkout and control systems must be fully automated. Advances in microcircuitry and cockpit instrumentation are particularly important, says Myers: the first to eliminate miles of cable, the second to reduce the number of mechanical switches in the cockpit.

The rate at which these new technological developments are achieved will depend partly on the progress of the state of the art. But to a large extent, the shuttle's development will depend on the priorities NASA chooses for the next decade (SN: 7/1, p. 93).

One key to the time-scale for the shuttle will be the availability of the $6 billion needed for the development and initial flight hardware—in comparison with the $16 billion for Apollo. Another will be the extent of international cooperation and funding. A third will be the political course of the new NASA Administrator (SN: 7/1, p. 93) and Presidential support.

No matter how the shuttle fares in the political arena, however, it clearly represents the second chapter in space exploration. It, or some similar system, "could be the most significant next development in space exploration, perhaps even comparable to the airplane and rocket," says astronaut Neil A. Armstrong, the first man on the moon, and now NASA's Deputy Associate Administrator for Aeronautics. "The shuttle," says Myers, "is the very keystone of this country's future role in space."

Moreover, the commitment to the shuttle is a commitment to a sizable space program. The shuttle's economy depends on its reuse and its reuse depends on the market. It has to fly at least 30 times a year for about six years to pay for itself. To fly this often it has to have some place to go, such as a space station, or have a definite mission. The shuttle development, therefore, is inextricably related to the overall space program and to the national commitment to it.

Should the go-ahead for a 1978 flight not be forthcoming, several alternatives are open. NASA could develop either the booster or orbiter first, instead of both simultaneously. It could develop a mini-shuttle, which could solve some aerodynamic problems, but would not be able to deliver all the promises of the full-fledged shuttle. Or NASA could continue to use existing logistic systems until a strong enough national or international impetus develops. □