NASA Facts

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The X-38

The X-38 project is a series of five prototype research vehicles developing technology to build and operate a space station crew return vehicle (CRV). The wingless CRV, when operational, would be the first reusable human spacecraft to be built in more than two decades.

Three X-38s are serving as testbeds in the development program and NASA Dryden Flight Research Center, Edwards, Calif., is the site of the program's atmospheric flight-testing. A fourth vehicle will be space-rated and used to evaluate the CRV design when it is released from an orbiting space shuttle to return to Earth.

The design of the X-38 incorporates the wingless lifting body concept pioneered at Dryden. Six unique lifting body configurations were tested at Dryden between 1963 and 1975. Data from the aerodynamic studies contributed to the design and operational profile of the space shuttles and is reemerging to help develop the CRV.

When operational, the CRV will be an emergency vehicle to return up to seven International Space Station (ISS) crewmembers to Earth. It will be carried to the space station in the cargo bay of a space shuttle and attached to a docking port. If an emergency arose that forced the ISS crew to leave the space station, the CRV would be undocked and — after a deorbit engine burn — the vehicle would return to Earth much like a space shuttle. The vehicle's life support system will have a duration of about seven hours. A steerable parafoil parachute would be deployed at an altitude of about 40,000 feet to carry it through the final descent and the landing. The CRV is being designed to fly automatically from orbit to landing using onboard navigation and flight control systems. Backup systems will allow the crew to pick a landing site and steer the parafoil to a landing, if necessary.

The first test flight of an X-38 from an orbiting space shuttle is currently scheduled for April 2002. The first of the four planned CRVs is expected to be docked and operational at the International Space Station in the year 2006.

NASA's Johnson Space Center, Houston, Texas, manages the X-38 program and works with personnel from Dryden Flight Research Center, and Langley Research Center, Hampton, Va.

The Vehicles

The X-38 design closely resembles the X-24A lifting body flown at Dryden from April 1969 to 1971. Wingless lifting bodies generate aerodynamic lift — essential to flight in the atmosphere — from the shape of their bodies.

The 28 research missions flown by the X-24A helped demonstrate that hypersonic vehicles like the space shuttle returning from orbital flight could be landed on conventional runways without power. The X-24A was modified in 1970 and designated the X-24B in 1971, the last lifting body configuration was tested in the 12-year research program at Dryden.

The three prototype X-38s used in the atmospheric flight testing program are 24.5 feet long, 11.6 feet wide, and 8.4 feet high, approximately 80 percent of the planned size of the CRV. The prototypes are designated V131, V132, and V131R. The V131 prototype was modified for additional testing beginning in the summer of 2000 and now carries the designation V131R. A fourth prototype, V133, will incorporate the exact shape and size of the planned CRV.

The atmospheric test vehicles, built by Scaled Composites, Mojave, Calif., are shells made of composite materials such as fiberglass and graphite epoxy, and strengthened with steel and aluminum at stress points. Vehicle weights range from 15,000 pounds to about 25,000 pounds. They land on skids — reminiscent of the famed X-15 research aircraft — instead of wheels.

The fourth X-38 in the program will be V201, the space-rated vehicle that will be flown back to Earth from an orbiting space shuttle. NASA is constructing it at the Johnson Space Center. Its inner compartment, representing the crew area, will be a pressurized aluminum chamber. A composite fuselage structure will

enclose the chamber and the exterior surfaces will be covered with a Thermal Protection System (TPS) to withstand the heat generated by air friction as the vehicle returns to Earth through the atmosphere. The TPS will be similar to materials used on the space shuttles, but much more durable — carbon and metallic-silica tiles for the hottest regions, and flexible blanket-like material for areas receiving less heat during atmospheric reentry.

Much of the technology being used in the X-38 is off-the-shelf, but that doesn't mean it is old or out-dated.

The flight control computer and the flight software operating system are commercially developed and used in many aerospace applications. The space-flight X-38 prototypes will have newly designed actuators.

The current electro-mechanical actuators that move the vehicle's flight control surfaces for pitch, yaw, and roll control have been used on earlier NASA, Air Force, and Navy aeronautical research projects.

Inertial navigation and global positioning systems, similar to units used on aircraft throughout the world, will be linked to the vehicle's flight control system to automatically steer the vehicles along the correct reentry path during atmospheric tests and during the space flight test.

Using global positioning already programmed into the navigation system, the flight control computer becomes the autopilot that flies the vehicle to a predetermined landing site.

The U.S. Army originally developed the design of the parafoil that deploys in the atmosphere and carries the X-38 to Earth. The shroud lines of the steerable parachute are attached to risers linked to actuators controlled by the flight control system. The flight control system receives inputs from the inertial navigation and global positioning units to determine where the vehicle is and steers the parachute until it gets to its destination. During the descending flight, the direction and speed of any winds are calculated by the flight control system and steerage corrections are automatically made. The parafoil guidance system also predicts wind direction across the landing zone and automatically turns the vehicle up wind for a safe landing.

During atmospheric tests at Dryden, the X-38s are dropped from the wing pylon of NASA's B-52 launch aircraft at altitudes ranging from 25,000 feet to 45,000 feet. The higher altitudes give engineers more time to study vehicle aerodynamics and handling qualities during its controlled, unpiloted gliding descent before the steerable parachute is deployed.

GenCorp Aerojet, Sacramento, Calif., is developing the propulsion unit that will be used during the X-38 de-orbit tests. After the X-38 is released from the shuttle cargo bay, the small aft-mounted deorbit rocket will be fired to slow the vehicle's speed to let gravity begin pulling it back to Earth. The rocket unit will be jettisoned during the descent phase. The same deorbit propulsion unit will more than likely be used on CRVs operating with the International Space Station.

A Flush Air Data Sensing System (FADS) developed at Dryden is being used on the X-38 to collect vehicle air speed and attitude (pitch and yaw) data. This information is fed into the flight control computer to maintain the desired flight path. FADS uses tiny ports to collect the aerodynamic data instead of using conventional probes that extend into the air stream. FADS data is also monitored by test personnel on the ground during test flights.

A bank of storage batteries will provide electrical power on each of the X-38 test vehicles to operate the avionics, navigation, guidance, flight control, and parachute steering systems.

The X-38 that will be test flown from the space shuttle and the future CRV itself will use nitrogen gas attitude control systems for guidance and control during flight in space where conventional control surfaces are ineffective.

X-38 Test and Development Schedule

X-38 flight-testing began in March 1998 with Vehicle 131 and it will continue atmospheric testing with Vehicle 133 through 2004 or 2005**,** when space-rated Vehicle 201 is released from an orbiting space shuttle for a test trip back to Earth.

Vehicle 131 was taken aloft by the B-52 launch aircraft for several captive-carry flights beginning in July 1997 to study its aerodynamics while attached to the aircraft's wing pylon. Two brief free flights followed, in March 1998 and February 1999, to study launch characteristics and to assess the operation of the parachute, from deployment of the small drogue through reefing of the main parafoil and landing. Data from the two flights have helped improve drogue deployment and led to landing skid improvements.

Following the two flights, Vehicle 131 was returned to Scaled Composites to be modified into the actual shape of the future CRV. The vehicle, now designated V131R, has been delivered to the Johnson Space Center where navigation, guidance, flight control, and parachute deployment systems are being installed. The modified vehicle will have the aerodynamics and atmospheric flight capabilities of the full-size CRV in the summer of 2000 when a series of up to six atmospheric test flights is scheduled to begin.

Vehicle 132, which also has the bulbous X-24A shape, carries a full flight control system, including electro-mechanical control surface actuators similar to those to be used on the CRV. V132 was test flown in March and July of 1999 with its final flight on March 30, 2000. It was the highest, fastest and longest flight to date.

The primary objectives of the flights are testing and validating the parachute deployment and steering systems, along with the vehicle's automatic flight control system.

Atmospheric test vehicle 133 is representative of the size and shape of the planned CRV. It will be used to fully test the spacecraft's integrated avionics, guidance, and flight control systems, while studying the vehicle's aerodynamics, handling qualities, and the reliability of the parachute and its steering system.

Space-rated Vehicle 201 will be ready for its test flight from an orbiting space shuttle in the spring of 2002. The flight will be a final proof-of-concept test for the CRV development program.

Results from the uninhabited re-entry test will contribute significantly to the assessment of safety and reliability of the CRV before an operational vehicle is used to carry humans from the ISS back to Earth.

The Dryden Connection

The connection between Dryden and the X-38 prototypes begins with the lifting body program of the 1960s and 70s, from which the CRV concept emerged. It now encompasses engineers involved in flight test planning and technicians working on the design and integration of vehicle systems. Dryden personnel help operate and staff mission control centers during test flights, and provide expertise in the areas of flight research, aerodynamics, and flight-control systems.

The concept of using a parafoil to autonomously recover a spacecraft from orbit and make a precision landing was successfully tested at Dryden between October 1991 and December 1996 in a project called the Spacecraft Autoland. In 1995, this concept was extended to flying a one-sixth scale X-38 using a small parafoil.

Precursors to actual X-38 flights were made to evaluate vehicle control under the parafoil using a four-foot model of the vehicle. The instrumented test article was carried into the air and dropped 13 times from a Cessna U-206 at California City, Calif., near Dryden.

One of the most prominent components of X-38 support is the B-52 launch aircraft used to take the X-38 to drop altitude. The aircraft, older than any B-52 still flying, is the same launch aircraft used in the X-15 program and was the so-called "mother ship" for all lifting bodies in that nine-year research program. The aircraft has been reconfigured to support a variety of crewed and uncrewed research vehicles that needed to be carried aloft to begin their flights back to the dry lake or conventional runways of Edwards Air Force Base.

The electro-mechanical actuators that move the flight control surfaces on the X-38s are a product of aeronautical research at Dryden. They were developed as space and weight-savers for all-electric flight control systems on new aircraft.

Dryden's involvement with the X-38s also extends to the personnel who have helped develop the flight software that will be used on V201, and its vehicle's guidance, flight control, and flight termination systems.

Pre- and post-flight vehicle inspections are conducted by a team of Dryden maintenance and engineering specialists accustomed to working with unconventional crewed and uncrewed research vehicles.

Through the entire X-38 planning and development program, Dryden engineers and technicians have served as consultants in a variety of disciplines. These include vehicle handling and flying qualities, guidance and control systems, test planning, and analyzing the flight test data.

Project History and Participants

The X-38 project began at the Johnson Space Center in early 1995 using data from past lifting-body programs and the U.S. Army's Guided Precision Delivery System tests from Yuma Proving Grounds in Yuma, Ariz. Flight tests began in Yuma using pallets dropped from an aircraft to study and develop the steerable parafoil system.

In early 1996, a contract was awarded to Scaled Composites for the construction of two atmospheric test vehicles. The first vehicle, V131, was delivered to the Johnson Space Center in September 1996, where it was outfitted with avionics, computer systems, and other hardware in preparation for its initial flight tests at Dryden. The second vehicle was delivered to JSC in December 1996.

In October 1998, Scaled Composites received an additional contract to modify V131 into V131R.

GenCorp Aerojet, Sacramento, Calif., is designing and building a de-orbit propulsion unit that will be used on V201. The base contract, valued at $16.4 million, is for one propulsion stage for the V201 flight test, with an option for a second unit. There is a second option in the contract for five operational flight units if the project is approved and the operational CRVs are built. All options would have a potential value of $71.9 million.

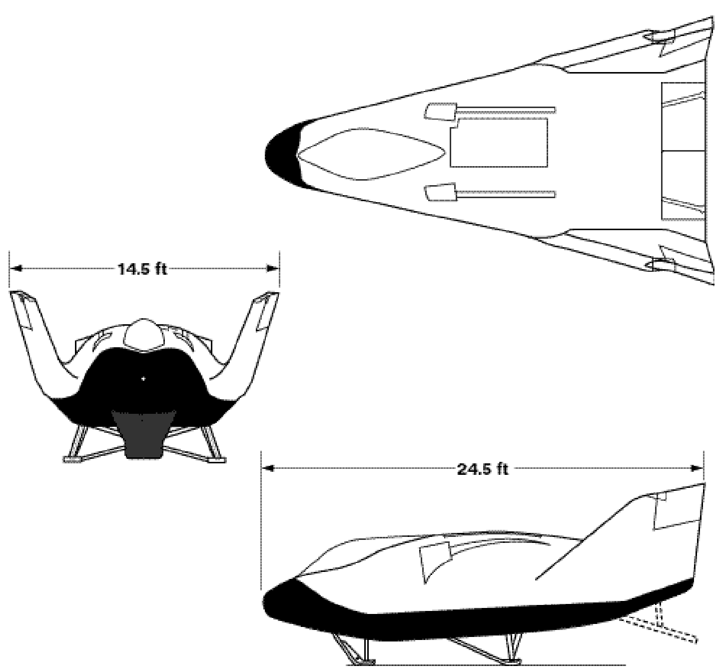
Total projected cost to develop and flight test the X-38s is approximately $700 million. Using available technology and off-the-shelf equipment has significantly reduced project costs, when compared to other space vehicle projects. Original estimates to build a capsule-type CRV were more than $2 billion in total development cost.

About 100 people, mostly civil servants, are currently working on the X-38 project at the Johnson, Dryden, and Langley centers. The X-38 project is the first in which a prototype space vehicle has been built-up in-house by NASA at the Johnson Space Center, rather than by a contractor. This approach has advantages. By building the vehicles in-house, NASA engineers have a better understanding of the problems contractors experience when they build vehicles for NASA.

The agency's X-38 team will have a detailed set of requirements for the contractor to use when the operational CRVs are built. This type of hands-on work dates back to the National Advisory Committee for Aeronautics (NACA), predecessor agency of NASA.

The Future

Once CRVs are operational at the International Space Station, modified follow-on versions of the vehicles could be used for brief science missions after being placed in orbit by Space Shuttles or expendable booster rockets such as the American Delta series and the French Ariane.



X-38 three view.