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OUTLINE OF THE X-15 PROJECT

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History

The X-15 is the latest of a line of manned research aircraft which began with the X-1. It got its start in the spring of 1952 when the NACA directed its laboratories to study the problems likely to be encountered in flight beyond the performance ranges then obtainable and to recommend methods to explore these problems. After considering laboratory techniques, missiles, and manned aircraft, it was decided that a manned vehicle capable of penetrating well beyond the usable atmosphere and of achieving a significant increase in ultimate speed should be built.

Early in 1954 an NACA team was assigned to determine the characteristics necessary for an aircraft capable of exploratory flight studies and the feasibility of building such an aircraft. It was determined that to be of research value commensurate with the cost, the vehicle must be capable of attaining extremely high altitudes and speeds, permitting explorations of aerodynamic heating, stability, and control, and the physiological and psychological problems of hypersonic and space flight as they affect the pilot.

In mid-1954 NACA representatives met with research and development groups of the Air Force and the Navy Bureau of Aeronautics to present the manned airplane as an extension of the cooperative research airplane program. Since both the Navy and

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the Air Force had similar independent research studies in progress, the NACA proposal was quickly accepted as a joint effort.

In December 1954, invitations were issued to contractors with experience in the design of high-speed, high-altitude aircraft to participate in the design competition for the X-15 airplane. Proposals resulting from the invitation were received and evaluated during the summer and fall of 1955. A contract was awarded North American Aviation for construction of three aircraft in December 1955.

Extensive wind-tunnel and structural component testing has been in progress since mid-1956. By September 1957 enough data had been collected so that construction of the first X-15 could be started. This aircraft was rolled-out October 15, 1958. Since that time it has been at Edwards Air Force Base undergoing preflight preparations.

Cost

The X-15 program, upon completion of the third vehicle, is expected to cost some $120 million in direct contract costs, plus sizable additional indirect costs consisting primarily of laboratory and wind-tunnel testing. Although the NASA has not contributed funds to defray the direct contract costs, it has supported from its operating budget an extensive amount of wind-tunnel testing and evaluation which has been indispensable in keeping the program on schedule. In addition, NASA has contributed many supporting flight-test programs.

Research Objectives

The X-15 rocket research airplane will carry more than 1,300 pounds of instrumentation, including about 600 temperature pickups and 140 pressure pickups in addition to the standard complement of internal recording stability and control and handling-qualities instrumentation. Strain-gages for measuring structural and aerodynamic loads are also included. Measurements will be made of the pilot's body temperature and pulse rate. An electrocardiogram will also be made. Selected quantities will be telemetered during flight.

The cost, effort, and instrumentation are expended to obtain knowledge of aerodynamic heating, heat transfer, heating of structural components, and of actual flight conditions beyond the earth's atmosphere.

Operation and use of reaction controls will be studied with this aircraft.

The X-15 will furnish stability and control information during actual exits and reentries to the denser atmosphere of the earth.

Finally, since the ultimate in space flight is its achievement by man, the X-15 is expected to furnish data on man's reaction to longer periods of weightlessness and his ability to control the aircraft during acceleration and deceleration.

Protection and Escape of Pilot

As a result of considerable human-factors research, it has been concluded that man is not a limitation to flight such as is expected in the X-15. In order to utilize the talents of the man, several protective steps have been taken.

The aircraft is intended to be as reliable as it is possible to achieve. Systems are redundant, where necessary, to accomplish this. The aircraft, itself, is designed to be the "escape capsule" over much of the performance envelope. In the denser atmosphere a stabilized ejection seat will be used for escape from the main vehicle. High-speed track tests of the escape system are in progress to demonstrate the system's function and the stability of the seat under low-and high-speed conditions. The full-pressure protective suit has also been tested during the track runs. The suit will provide breathing oxygen, altitude protection, temperature, and windblast protection.

The Airplane

The airplane is 50 feet long, has a wing span of 22 feet and height of 13 feet. The wing area is 200 square feet. The wing sweep at the quarter-chord line is 25°; weight at launch is 31,275 pounds. The XLR-99 rocket engine, designed by the Reaction Motors Division of Thiokol Corp., is capable of more than 50,000 pounds of thrust. Two XLR-11-5 rocket engines will be used on the initial powered flight.

The X-15 has several unique features. The skin is of Inconel-X to withstand high temperatures. The primary structure is of titanium and stainless steel to retain strength under elevated temperatures. Aluminum is used internally where high heat and loads are not a problem. Brazed sleeve tubing joints are used in the plumbing. About 65 percent of the X-15 is welded structure. The main landing gear is two steel skids located at the rear under the horizontal tail. The lower half of the bottom vertical tail is jettisonable for landing clearance. Lateral aerodynamic control is achieved by differential use of the horizontal stabilizer. The upper and lower vertical tails are characterized by wide, blunt trailing edges and by their extension to larger angles for speed-brake action. Reaction-control rockets are located on the nose and wing tips. Utilizing liquid nitrogen, the cooling system, weighing 150 pounds, has a cooling capacity of 27,000 BTU. Propellants to be used are liquid oxygen and ammonia. In the cockpit are three control sticks, a side-located aerodynamic control, a center aerodynamic control stick, and a side-located reaction-control stick.

Industry Participation

What began as a joint study between NACA, Air Force, and the Navy to develop specifications for an extremely high-altitude - high-speed aircraft has become a nationwide project. More than 300 firms were associated with North American in building the X-15.

Already, as a result of the intensive efforts to solve materials and construction problems, as well as systems temperature and pressure problems, the industry as a whole has benefitted from the X-15 program. Machining and welding techniques have been perfected for Inconel-X. High-temperature seals and fluids for hydraulic systems have been developed. These are but a few of the advancements achieved as a result of the X-15 effort.

Flight-Test Range

Surveys of areas suitable to utilize the full potential of the X-15 resulted in recommendations which culminated in the establishment of the X-15 High-Range between Wendover, Utah, and Edwards Air Force Base, California. There are at least three intermediate lakes, more or less on course, which appear adequate as emergency landing sites--Cuddeback, near Inyokern, Mud near Tonopah, Nev. and Jakes, near Ely, Nev.

Three range stations of 200-mile radar-range capability are being completed on High-Range. These are located at the NASA High-Speed Flight Station, Edwards, Calif., Beatty, Nev., and Ely Nev. They include telemeter-receiving equipment and communication equipment, as well as radar. The entire range is linked by land lines. The master station can communicate with the X-15 anywhere on the range. There are altitude- and position-plotting boards at each station. A master plotting board at the main control station at the High-Speed Flight Station will be plotted by information from Ely and Beatty, as well as Edwards.

Langley, Ames, and in the Air Force and Navy. By means of this coverage, a wide range of skills and specialist training have been brought to bear on the program from the pilot's standpoint.

The Human Centrifuge at the Aviation Medical Acceleration Laboratory of the Naval Air Development Center, Johnsville, Pa., was utilized as a tool for evaluating the influence of accelerations on results previously obtained on static simulators. This was initiated by programming the gondola for the flight profile of the X-15, then having the pilot fly a task which consisted of error signals on a roll presentation.

Later, a closed-loop circuit was utilized wherein the pilot was subjected to accelerations brought about by his control inputs as well as those involved with performance of the mission. It was determined that the instrument presentation "left something to be desired," to put it mildly. After checking out changes on static simulators, a second intensive closed-loop centrifuge program was completed, utilizing improvements in presentation controls and pilot restraint.

Flight work has not been neglected in connection with the X-15. Aircraft were flown with various types of side-arm control sticks. Reaction-control rockets were tested on the X-1B. The approach and landing problem of the X-15 was studied using a static simulator and an F-104 aircraft, and a recommended procedure was derived therefrom. It was anticipated that an

Role of the Pilots

While all this effort was going on, what of the pilots? Were they going about their daily affairs, to be brought in at the last minute when the bird was ready to fly? Far from that. They were participating from the inception of the program. Efforts were expended on the evaluation of the manufacturer's proposals for cockpit, escape system, control system, cockpit controls, instrument presentation and cockpit visibility. The operational concept was closely scrutinized by the pilots. Evaluations of proposed missions were made, utilizing static simulator setups to obtain more appreciation of problems peculiar to stability and control of an aircraft of this type.

After award of the contract, pilot participation in the program was intensified, ranging from work directly on the design of the aircraft to pressure-suit fittings.

At North American, and within the NACA, static simulators increased in complexity until problems of five and six degrees of freedom were being evaluated. Instrument display, control force, reaction-control handle operation, all were given intensive study. Best flight techniques for normal and emergency conditions were analyzed. Quantities for homing and guidance were checked and specified. To say that every possible mission has been flown on a simulator by all pilots assigned to the program would be erroneous, as it would be to omit pointing out that pilots not assigned to fly the X-15 have been active in the program at

F-104 equipped with reaction controls improved over those of the X-1B would have been flying in January, but technical delays preclude flight until later.

Pilots took an active part in selecting the location of High-Range. Before actual selection of its location, an exploration party in a "gooney bird" (DC-3) measured the length of several dry lakes. Then, those along the route between Edwards and Wendover, Utah were checked for suitability of surface. This proved rather hazardous, since the aircraft sank almost to the axles on one dry lake! At present, work is underway for standard marking of dry lake beds. This is not to be limited to those associated with High-Range, but will include all lakes adequate for emergency landing. Briefly, the markings are two black tar strips 300 feet apart, incorporating mile indicators. It is hoped they will be at least three miles long. If shorter, a dashed line will extend to the edge of the usable area from the end of the runway markings.

The pilot's pressure suit has undergone tests including demonstration of function at extreme altitude in an altitude chamber, under high-temperature conditions, under low temperatures, and under high accelerations on a human centrifuge. Each pilot who has a suit must undergo these tests. In addition, a TF-102 is being utilized at Edwards Air Force Base to provide actual flight experience for these pilots, both to service-test the pressure suit and also to accustom the man to working while wearing the suit.

Flight Testing

The flight testing of the X-15 will consist essentially of two portions. The first will be by the contractor, demonstrating that the aircraft is airworthy, that all the systems operate as intended, and the powerplant is dependable. There will be captive flights, where the X-15 is not released from the B-52 mother ship, to check systems under flight conditions; dry flights, launches without propellants; and, then, powered flights.

The second portion is the utilization of the aircraft to perform the research mission. At Edwards a Flight Test Steering Committee has been established, composed of representatives of the High-Speed Flight Station, Air Force Flight Test Center, and Navy. On this committee are the pilots assigned to the X-15 program by the NASA, Air Force, and Navy. The research flying of the X-15 will be handled as a joint effort under supervision of the steering committee, and the pilots will be assigned to flights on the basis of experience and skills to promote the most expeditious advancement of the program.

Of course, the test flights of the X-15 will be of a progressive nature, gradually building toward the ultimate performance of which the aircraft is capable. The X-15 will be launched at a location that will assure its ability to land at Edwards if the mission is successful, and also near an emergency landing area in case a malfunction occurs at, or shortly, after launch. Therefore, it is apparent that the dry lakes serve a dual purpose, both as launch sites and as intermediate emergency landing areas. The former will probably be their most likely use.

Conclusion

In conclusion, the X-15 is a cooperative research effort approaching nationwide participation in its scope. Its expeditious, successful prosecution should go a long way toward fulfilling the pertinent research objectives. I am confident our conviction that a pilot is capable of continuing to do a good job will be justified.