RESEARCH AIRPLANES

presented by

NACA High-Speed Flight Research Station

Most of you no doubt are familiar in general with the research airplane projects from the talks given at the 1949 and 1951 Langley Inspections as well as from the numerous magazine and newspaper articles mentioning the over-all program. In addition, there have been articles and talks on particular phases, primarily on flight operations at Edwards, by various participants in the program. The research airplane program was initiated during the last war to extend flight data to transonic and low supersonic speeds at a time when wind-tunnel data were not obtainable in the transonic range. The program has since been extended to investigate the problems of swept-wing airplanes and other configurations at higher supersonic speeds. Some of the problems of stability, loads, and so forth, can best be studied in flight. Also flight experience reveals whether any important problems are being inadequately considered in our wind-tunnel and analytical research programs.

The airplanes utilized so far in the program are represented by these models. The Bell X-1 and Douglas D-558-I Skystreak were the first research airplanes, and were obtained to investigate the transonic characteristics of the conventional straight-winged airplane. Because the X-1 is rocket-powered, it possesses considerably better speed and altitude performance than does the Skystreak. The longer flight duration of the Skystreak enables a more complete investigation of the problems in its speed range than are possible with the X-1.

In order to conduct flight research on swept-wing high-speed airplanes, the Douglas D-558-II Skyrockets were obtained. These airplanes have a subsonic-type airfoil and were powered by jet engines with rocket boost for flight at supersonic speeds.

The behavior of a tailless airplane in the transonic speed range was of considerable interest because it was felt that some of the difficulties of conventional airplanes in the transonic speed range might be caused by the horizontal tail operating in the wake of the wing. The Northrop X-4 was obtained, therefore, to conduct stability and control research on an airplane with no horizontal tail.

The Bell X-5 was obtained in order that the effects of sweep angles between 20° and 60° could be determined. The sweep is variable in flight so that take-off's and landings can be made with the safer 20° sweep angle.

The last model is of the Consolidated Vultee XF-92A which was built as a flying mock-up of a proposed fighter. Because of the current great interest in triangular wings, it was recently repowered by a more powerful engine and was assigned to the NACA.

The performance range of our investigations is indicated on this chart; this point is representative of a modern swept-wing fighter, while this point indicates the speed and altitude reached by the first research airplane, the X-1, in 1947. The speed and altitude range covered to date by the research airplanes is shown by this point which was reached in 1951, and the performance expected of the X-1 airplane, as it is currently being modified, is shown by this point marked 1953. The speed and altitude range covered by the research airplanes is much greater than that of current service types, and thus our flight research program of today is exploring and evaluating problems in a speed and altitude range which will be encountered by service airplanes of the future.

The general problems of high-speed, high-altitude flight are: performance, stability and control, aerodynamic loads, aerodynamic heating, landing problems, and aeromedical problems concerned with the pilot's safety and health. Effective flight research to study these problems has required the development of new methods and equipment. Because of the small space available in the airplanes and because of the necessity for obtaining accurate data on each flight, the program has stimulated the development of small internal recording instruments and reliable telemetering. New test techniques were required by the short duration of high-speed flight, and by the large weight loss during flight resulting from the use of rocket engines.

I have attempted to give a brief description of the high-speed flight research program and the airplanes employed. Mr. __________ will now describe some aspects of the research on the Skyrocket airplane. These will serve as examples of the types of information being obtained and will illustrate the coordination between the flight program and the other research being conducted by the NACA.

The research-airplane program is producing flight data essential to the design of our future aircraft. In addition, these data and the superior flight experience obtained have served to stimulate the design of useful supersonic military airplanes. Because of classification the detailed results of the program cannot be discussed here, but it was felt that some of the related aspects would be of interest.

The high-speed flight research has been supported from its conception, through the design of the research airplanes to the planning of tomorrow's flight, by various research programs conducted at all three of our laboratories. In return, the flight data have served to point out new problems requiring laboratory investigation, and to indicate areas where existing solutions are adequate for the time being. Thus, the flight and laboratory research have complemented and aided each other. The Skyrocket project will be used to illustrate this interrelation of our flight and laboratory research.

A few examples of the research conducted during design of the airplane will be given first. When the Skyrocket project was initiated the concept of sweep had just been formulated. The basic designs were tested in one of our large high-speed tunnels. Studies of flap and control configurations pointed out weaknesses in knowledge and directed other wind-tunnel studies into the most profitable channels. Analytical studies predicted that lateral stability at low speeds would be critical even though the wings are drooped downward to reduce the adverse effects of sweep. The first flights verified this, and the vertical fin was increased in size. The spin-recovery techniques determined in the laboratory have been verified in flight as a result of inadvertent spins.

During the flight tests, problems were discovered which required the assistance of other NACA facilities. Because of lack of time only two examples of these problems will be given. At high supersonic speeds a condition of lateral instability was encountered, the explanation for which is shown on this chart. The directional, or weathercock, stability of the airplane without tail is unstable and almost constant through the Mach number range. The vertical tail contribution to directional stability (from here to here) is sufficient to make the complete airplane stable at subsonic speeds. At supersonic speeds, however, the efficiency of the vertical tail decreases with Mach number, eventually producing directional instability at higher speeds. When the airplane was designed, its supersonic characteristics were not considered most important because it was not expected to fly at high supersonic speeds. Prior to supersonic flight, analytical studies of the stability of the airplane indicated that it would be adequate except at low lift. After some supersonic flights, tests in a large supersonic wind tunnel showed that the directional stability loss was greater than had been anticipated. Means of improving the stability of the airplane through the speed range have been investigated by analytical and wind-tunnel studies, and are presently being put into use.

Another critical problem encountered in the flight tests is that of longitudinal pitch-up, or overshoot, in accelerated flight shown on this chart. When, for example, a 4g turn is attempted with a straight-wing airplane, no difficulty is encountered. With a swept-wing airplane, however, the airplane pitches abruptly to a greater acceleration than desired. This results from the unstable variation of pitching moment with lift, typical of swept-wing airplanes. At the time of the design of the Skyrocket, the amount of instability that could be tolerated was unknown; in flight the instability of the airplane was found to be excessive. Since that time, considerable work has been done in the various wind tunnels of the NACA to eliminate this longitudinal instability, and one of the Skyrockets is being used as a test bed for evaluating the most promising solutions resulting from these studies.

The flight research program has required the development of several specialized flight techniques because of the unique characteristics of these airplanes. One outstanding development is that of air launching to increase performance and safety. This technique was first suggested by the Bell Aircraft Corporation for launching the X-1 airplane. The launching procedure for the X-1 was so successful that it was adopted for the Skyrocket. Air launching permitted removal of the jet engine, and hence an increase of rocket propellant available which resulted in greatly increased performance. Another of the specialized techniques required is that of air-speed calibration at altitudes beyond the use of ordinary pressure reference such as fixed observation points or calibrated airplanes. A procedure of using modified radar and internal recording equipment to provide the pressure reference at high altitude has been devised. This equipment was developed by the Langley Instrument Research Division and is in daily use by NACA High-Speed Flight Research Station.

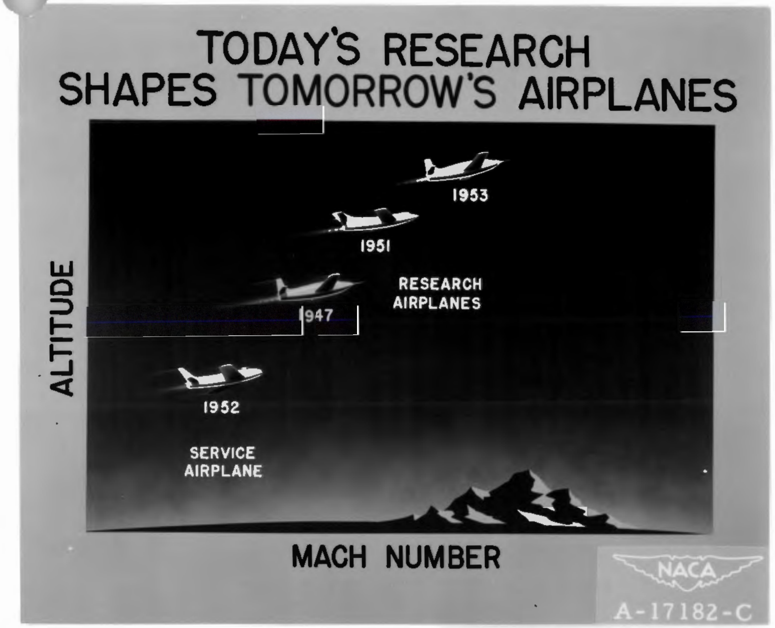
Let us now look at the airplane. Note the 35° swept wing and its slats and stall vanes for the improvement of control and lift at low speeds. The launching hooks used for attaching the airplane to the mother ship are visible projecting above the fuselage. This particular Skyrocket has both a jet and a rocket engine. The air intakes for the jet engine are located here behind the nose gear, and the jet exhaust is located beneath the fuselage near the tail. The rocket engine is located here at the tail; and a similar engine is on exhibit beside the airplane.

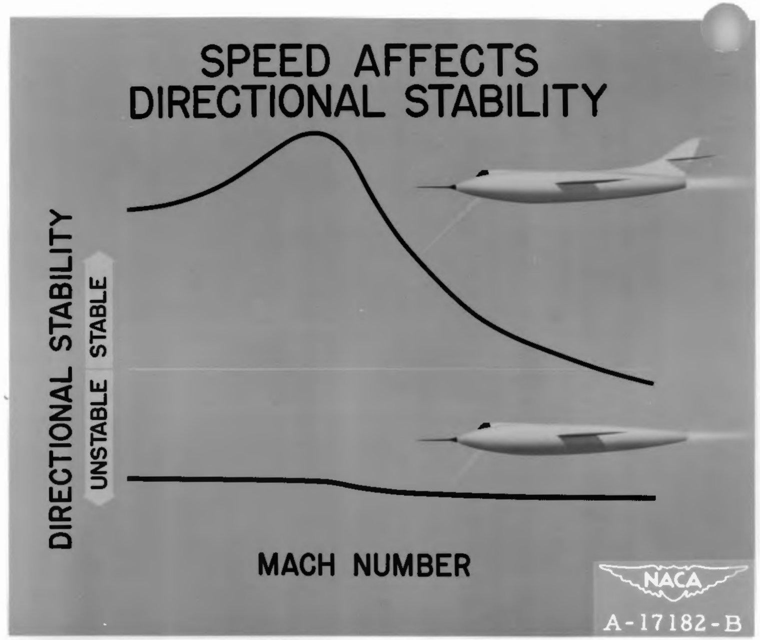
Flight research, particularly at high speed, is dependent upon accurate instrumentation. The NACA has devoted years to the development of flight instruments for recording strains, pressures, temperatures and control movements. The instruments which make up the payload of the Skyrocket are installed in this compartment directly behind the cockpit. This Skyrocket is instrumented by two 60-channel pressure recorders for recording the pressures over the left wing. A 36-channel oscillograph is installed for recording strains on the wing, and on the horizontal and vertical tails. All control surface angles and forces are recorded on a 12-element galvanometer. Other instruments are installed to record angular velocities and accelerations as well as the angle of sideslip, the angle of attack, and three components of acceleration.

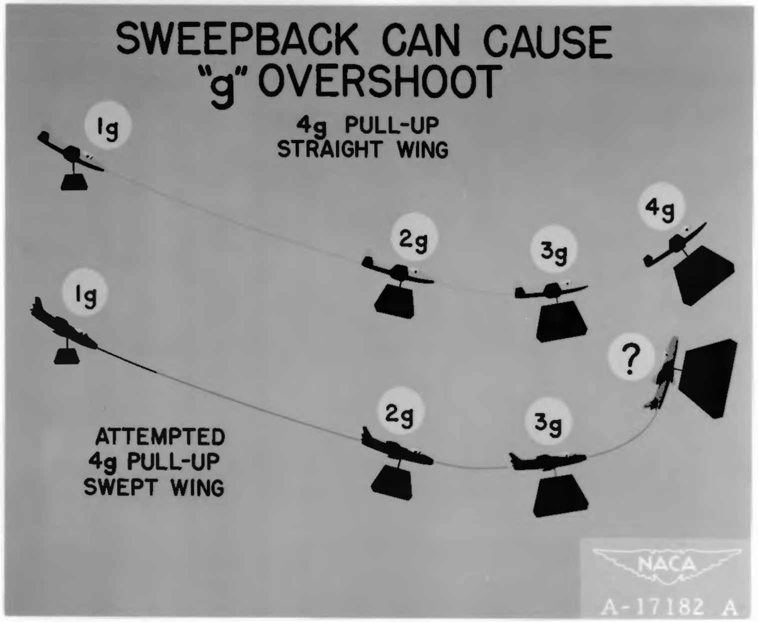
Pilot protection, consisting of a pressure cockpit for high altitudes and a jettisonable cockpit for escape at high speeds, is incorporated.

You are invited to inspect the airplane and the instruments in the brief time that remains at this stop.


Display for presentation of "Research Airplanes"




NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS
AMES AERONAUTICAL LABORATORY, MOFFETT FIELD, CALIF.