Virginia Aviation History Project

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The NACA Wallops Experience 1945-1950

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Introduction

First Little Joe vehicle (LJ-1) with prototype Mercury Capsule, ready for launch at Wallops, August 21, 1959.

After World War II, when the National Advisory Committee for Aeronautics (NACA), began the development of new technologies for researching the emerging problems of transonic and supersonic flight, the agency took advantage of a relatively young cohort of WWII ex-GI's, their farsighted old-line NACA managers, and new technology developed during WWII. Other organizations in the country similarly benefited from this infusion of youth, talent, and ability but the NACA was among the fortunate in possessing real challenges of strategic significance and individuals who were uniquely qualified to respond to them through innovative application of these technologies to one of the important national problems. Many of these returning GI's had successfully operated aircraft, ships, and submarines and their weapons systems during the war, and they brought a wealth of competence and eagerness to come to grips with the real problems of flight and to search out the next increment of data using the new technologies of telemetry, radar, and reliable solid fuel rockets.

The Approach

At the NACA's Langley Memorial Aeronautical Laboratory at Hampton, Virginia, the emergence of many of these individuals as real problem-solvers enabled their bosses to persuade the NACA to extend the "bomb drop" technique pioneered at Langley for high speed testing by investing modest resources into their proposals for the development and long-term operation of a Flight Test Station at Wallops Island, Virginia, using the rocket-boosted-freely-flying-model technique. This approach was capable of reaching the required speeds and, coupled with the telemetry and radar observations, provided significant data for some of the nation's critical technology programs for aircraft and missile operations at transonic and supersonic speeds when other techniques were unsuccessful or marginal.

Technician Durwood Dereng measures elevation of double Deacon booster prior to launch of RM-10 research model at Wallops, February 6, 1951

The Team

The Team that cooperated at many levels to work this revolution in aerodynamic development was not a single fixed group – individuals came and went during this period at all levels of the NACA organization. The Team was not confined to those in Langley's Pilotless Aircraft Research Division (PARD) or at Wallops, but included individuals in Langley's Instrument Research Division (IRD), the Dynamic Model Engineering Section of the Engineering Division (DMES), and the shops which actually built the hardware. During the later years (1950 to the establishment of NASA in 1959), the Korean War and the heightening of the Cold War in general put pressure on NACA to accelerate aircraft and missile research and the Team trained many of the younger engineers included in the influx of approximately 700 new hires.

The NACA management (the Committee) exerted only a high level of control over these efforts, defining overall goals and generally approving the detailed proposals developed by Langley. Significantly, the Committee conducted periodic reviews of this work both at Langley and at the Wallops facility itself, where they witnessed several "shots" defining significant milestones in these programs. The Committee at this time consisted not only of the NACA Washington Office (Headquarters) managers, but also high level managers from other branches of government – the Army, the Navy, the Bureau of Standards, the Weather Bureau and, significantly, executives from major aircraft related industries such as the airlines, aircraft and missile manufacturers, the oil industry, and academia. Thus the goals, methods, and results of the research were readily known to not only the Committee, other government offices, direct users in the development and operations of the next generation of products, but also those who would train the next generation of researchers in those disciplines. The experience of this cohort of NACA researchers and managers provided a significant NASA contribution to the nation's aeronautics and space program of the 1960's, including aircraft, missiles, and both the unmanned and manned space programs.

The Technology

The basic telemetry system used in the "bomb drop" technique was developed in-house by the NACA Langley Instrument Research Division. Its application to the rocket boosted model technique required "hardening" the electronics to both the shock of the rocket ignition and the high acceleration levels during the burning of the rocket. One approach to this was "potting" some of the components in a plastic compound. These same forces had to be withstood by the rest of the rocket including the fin assemblies. Early on, one launch resulted in the "successful" launch of the telemetry and the burning rocket minus the fins. These types of problems were soon solved by the Dynamic Model Engineering Section. Some models were extremely simple, consisting of the booster rocket and an uninstrumented model for getting the drag of related fuselage shapes at transonic speeds. Speed and deceleration were determined from the ground with a Doppler radar; the model trajectory was measured with a tracking radar and the atmospheric properties were determined with a standard Weather Bureau radio sonde. These measurements sufficed to permit the determination of the drag from the rate of change of velocity, the Mach number and dynamic pressure. Many times these models were launched with the Wallops Helium gun instead of a rocket. Better drag measurements were made when an on-board accelerometer was used along with the ground based radars. These techniques provided badly needed data on drag of bodies and wing-bodies at transonic speeds at a time when the data could not be obtained any other way.

Other simple models consisted of a wing assembly with deflected ailerons which being placed at the tail of the rocket also served as stabilizing fins. As the rocket flew and spun up due to the deflected ailerons, the roll rate was monitored on the ground by changes in received signal strength due to a carefully shaped antenna pattern from a simple radio carried on board the model. This was called the spin-sonde technique. The combination of the rolling effectiveness and damping-in-roll of the aileron-wing combination could be studied as the model flew through the transonic speed range. Speed and trajectory were again measured by the ground based radars. The elastic properties of the wing were changed from model to model; thus, the combined effects of aero elasticity and Mach number on the rolling effectiveness of many wing-aileron combinations were determined.

A model of the Air Force's Convair F-102 sits poised for launch from Langley's Wallops Island facility. The coke bottle shape of the model on the bottom follows the area rule. Photograph published in Winds of Change, 75th Anniversary NASA publication, by James Schultz (page 60).

Launchers evolved too. At first, a rail launcher was constructed but was never used because it was inefficient; the high accelerations available from the available solid fuel rockets permitted the use of "zero length" launchers. Simple "A Frame" or crutch launchers were developed and then "zero-length" launches of various designs were used extensively.

Higher speeds were reached by installing bigger rockets in-series behind the test article. Two, three, four, and even five stage combinations were successfully developed, with the DMES team evolving many useful design techniques to handle the problems of aero elasticity, heating, high inertia, and aerodynamic loads. These multistage boosters were usually assembled with the launcher horizontal, and DMES decreed that each such assembly be designed to handle the loads caused by a 200 pound man holding on to the nose section of the last stage, since the work was performed on elevated platforms and the technician would naturally grab and hang onto the nose if he slipped while performing the checkouts. In addition to the basic in-line staging technique used at Wallops and elsewhere, the double underslung booster technique was developed and successfully used to test models with large wing areas which would have created unacceptable aeroelastic problems in an in-series configuration. This is the same technique employed by the NASA Shuttle 15 years later. Yet another configuration – the tow booster, where the model was pulled by the booster at the end of a steel cable – was tried and worked. A deflector protected the model from the direct effects of the rocket exhaust.

The Wallops radar operators developed a skill unequalled anywhere in the country for tracking the correct stage of separating multistage boosters. The war surplus Doppler and position radars they used were modified by the Langley and Wallops Team to fit the new research application.

Wallops automatic programmer being monitored by F.H. Forbes, July 29, 1950. Doppler radar recorders are behind Forbes. Photograph published in A New Dimension; Wallops Island Flight Test Range: The First Fifteen Years by Joseph Adams Shoartal. A NASA publication (page 100).

Complete aircraft configurations were also tested with one or more boosters. Small "pulse rockets" directed at right angles to the longitudinal axis were used to obtain changes in the angle of attack or sideslip, permitting determination of basic static and dynamic longitudinal or lateral stability from examination of the accelerometer traces. When Robert Gilruth and IRD developed the angle of attack vane and angle of sideslip vanes, lift-curve slopes could also be determined, giving even more complete data on static and dynamic longitudinal and lateral stability. The development of hydraulically or pneumatically pulsed controls permitted measurements of control effectiveness. Later, the Aero-Pulse technique for causing a pitch control surface to automatically pulse on response to the aerodynamic forces on it was developed and successfully tested. These more complete models included from 2 to 14 channels of telemetry for measurement of flow angles, accelerations, pressures, control positions, and other quantities. IRD developed this system so that the dynamic response could be nearly identical for all measured items, a feature which the modern telemetry system does not easily provide.

PARD's Propulsion Branch developed a ramjet propulsion system to provide more efficient launch vehicles than the solid fueled war surplus boosters. Working with industry, exotic slurries of hydrocarbons and metal powders were successfully tested on the ground in the Wallops Pre-flight Jet Facility and in actual flight tests. Later that same branch was responsible for the initial design of the 4-stage SCOUT solid fuel launch vehicle during the late 1950's.

Take off of a five-stage missile research rocket from Wallops Island in 1957. The first two stages propelled the model to about 100,000 feet; the last three stages were fired on a descending path to simulate the reentry conditions of ballistic missiles. Photograph and caption published in Winds of Change, 75th Anniversary NASA publication (page 72), by James Schultz.

By the early 1950's, most of the basic technologies for gathering data at transonic and supersonic speeds were developed. By this time, the transonic tunnel had been developed and put into operation at Langley, and the extreme urgency for obtaining basic performance data with flight testing had passed, although the free-flight testing continued until the formation of NASA in 1959, providing tare- and wall-interference-free cross checks of the transonic tunnel data and valuable dynamic stability in both longitudinal and lateral modes. Also, the speed range was extended to hypersonic speeds and those data went directly into the ICBM reentry vehicle design, and later the Mercury capsule design.

Closure

It is apparent that the innovative explosion of the Wallops experience did not occur in a vacuum, but was a result of the combination of a national problem and a team that was basically "turned loose" to solve the problem. As the capabilities of Wallops developed, other NASA Centers, agencies, and countries utilized them too. There were other rocket programs in the U.S. and in other countries, both to develop weapons and to obtain aerodynamic data. Thus cooperation and competition existed on both a national and international level, with some duplication, but inevitably a cross fertilization that benefited all. Most of those involved in the Wallops experience in the early years probably did not fully recognize nor appreciate the unique and healthy environment in which they worked, with technical and personal integrity from the top down, and with freedom and truly challenging competition for ideas and solutions.

16-inch Free Flight Ram Jet Drop Model mounted under the wing of F-82 Fighter airplane ready to be taken up to altitude and released at Wallops Island where its path, speed, and engine performance would be recorded during drop.

Author's Note

I have not attempted to describe all of the techniques developed to perform the transonic testing discussed here but only to highlight some of the ones that appeared significant to me when I came to PARD in late 1949. Neither have I tried to describe in detail these significant ones. For that, the reader is directed to Joseph A. Shortal's excellent one volume summary "A new Dimension; Wallops Island Flight Test Range – the First Fifteen Years." NASA RP 1028, December 1978, and his 3 part detailed account "History of Wallops Station – Origins and Activities Through 1949", CN 123031 at the Langley Library. I have used these sources to prop up my flagging memory and to provide some of the illustrations and references. I have discussed this topic with some of those who were there – "Spud" Youngblood of IRD, Max Faget of the Propulsion Branch, Barry Graves of IRD – and some others, but the overall thesis is my own.

References:

"A New Dimension: Wallops Island Flight Test Range – the first Fifteen Years", Joseph A. Shortal, NASA RP 1028, December 1978

"History of Wallops Station – Origins and Activities Through 1949", Joseph A. Shortal, CN 123031

SP-4311, Way Station to Space, Harold D. Wallace, Jr., available at http://history.nasa.gov/SP-4311

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