ON THE FRONTIER

Flight Research at Dryden, 1946–1981

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Serving Gemini and **Apollo:** 1962–1967

NASA's major priority in the **1960s** was, of course, space. The agency's activities were related to three major manned spacecraft projects, Mercury, Gemini, and Apollo. Beyond Apollo, the agency had at best vague plans for some sort of semipermanent orbital space station supplied by an Earth-to-station "shuttle." In truth, however, NASA had not formulated long-range plans beyond the lunar landing. Because of the intensity of the space program, particularly during the early **1960s,** NASA channeled the activities of all the field centers and stations toward some aspect of it. The Flight Research Center during this time concentrated its efforts on various means of returning men from space—means such as the Paresev and lifting body, which will be discussed later—and analyzing how to land on the moon. This work was directly related to Gemini and Apollo, and to the later Space Shuttle as well. However, Flight Research Center labored under one serious handicap during the **1960s,** a handicap that almost cost the center its existence. In an agency dominated by spaceflight, FRC appeared to be anachronistically obsessed with aeronautics.

WHITHER FRC?

In point of fact, FRC's research during the **1960s** was oriented primarily toward spaceflight, though with a heavy aeronautical flavor: hypersonic flight within the upper atmosphere and into and back from space; the low-speed handling qualities of spacecraft; lifting reentry schemes; and support of space research at other NASA centers, such as high-altitude drop tests of Mercury spacecraft's drogue parachute. Since FRC relied heavily upon research aircraft—vehicles having wings—the center seemed to be concentrating its activity on the airplane in the era of the spacecraft. But these aircraft were actually being used as tools for studying problems that were basically space technology. Research on the X–**15,** for example, clearly benefited spaceflight studies more than, say, supersonic aerodynamic research. This tended to be missed among individuals who were not familiar with the true scope of the center's research. FRC suffered simply because no spacecraft were being managed from the center, no boosters were being developed by its engineers, no rockets were being launched there.

As early as **195'7,** the percentage of FRC's research staff involved with space studies had begun to grow. This, too, was missed, possibly because most of these internal studies went no further than FRC's "front office," in part because many of them were speculative and not directly involved with mainstream NASA budget items. Even in the **1960s,** the actual percentage of FRC's personnel involved in space-related research appears from available internal evidence to have been higher than shown in published NASA statements. Table 3 shows the distribution of permanent personnel at FRC by fiscal year and budget activity, as set forth in NASA's budget estimates, at two year intervals from **1960** through **1968. A** closer examination of these data, however, raises serious questions as to their accuracy and possibly indicates a source of misinformation that might well have convinced many within NASA and outside the agency—including Congress—that FRC was far less in step with the times than it actually was.

The NASA budget estimate for **1960** states that approximately **90%** of FRC's staff was engaged in "aircraft technology." Yet by **1959** the personnel breakdown in HSFS internal planning documentation indicates that no more than **40%** were working on aircraft studies. Fully **35%** were studying boost-glide (i.e., orbital) aircraft, another **16%** were examining satellites (both manned and unmanned), **5%** were engaged in ICBM and anti-ICBM research, and **4%** were studying antiaircraft missiles.' These figures certainly could not have changed in favor of aeronautics in one year. Clearly budget request statistics from **1960** to **1968** are misleading because they lump together such major activities as the **X-15** and lifting body programs as "aircraft technology" when, in fact, these programs were space related. In **1962,** fully **84.5%** of FRC's staff was officially listed under "aircraft technology," but it is doubtful if more than **20%** was engaged on purely aeronautical (i.e., flight within the atmosphere) projects at that time, and no more than **40%** in **1968.** Since so many of the **X-15** and lifting body programs were related to manned spaceflight, it is inconceivable that FRC, in **1964,** had only **8.3%** of its staff investigating manned spaceflight activities. This figure should have been in the author's calculations, about **40%** as well, based on the flight research activities surrounding these projects, the number of employees engaged with them, and the amount of paperwork (an indication of administrative "prioritizing" of projects) generated by them.

These statistics from NASA's budget requests are misleading in another way: they ignore the trait of "ad hocracy" (in Alvin Toffler's

Table 3
Distribution of FRC Permanent Personnel by Program, 1960–1968
(Number Assigned and Percentage of Total)

Program	1960[a]	1962	1964	1966	1968
Manned Space Flight	0	6	50	34	0
	0.0%	1.2%	8.3%	5.6%	0.0%
Space Applications	0	0	0	0	0
	0.0	0.0	0.0	0.0	0.0
Unmanned Space Investigations	0	1	3	1	0
	0.0	0.2	0.5	0.2	0.0
Space Research & Technology	0	45	51	104	92
	0.0	8.6	8.4	17.2	16.2
Aircraft Technology	---	443	344	308	325
	90.0	84.5	56.8	51.1	57.4
Supporting Activities[b]	---	29	157	156	149
	10.0	5.5	26.0	25.9	26.3

[a]Actual positions unavailable for FY 1959–60; percentages from NASA Office of Programming, Budget Operations Div., *History of Budget Plans, Actual Obligations, and Actual Expenditures for FY 1959 through 1963* (NASA, 1965), sect. 8.
[b]Includes tracking and data acquisition, data analysis, and technology utilization staff.

SOURCE: Nimmen, Bruno, and Rosholt, *NASA Historical Data Book, 1958–1968*, vol. 1, *NASA Resources*, NASA SP–4012 (Washington, D.C.: NASA, 1976), Table 6–31, p. 277.

words) that has always characterized FRC's administrative style. Its small staff has never been divided by rigid administrative lines and networks separating programs, authorities, and administrative units; instead, specialized small work forces have been formed to accomplish certain projects or goals—such as the Paresev, lifting body, and lunar landing simulator.* Workers ostensibly "assigned' to aeronautics projects might suddenly be called upon to participate in a space-related project. They might still show up on organizational charts as "aeronautics" personnel, when, in fact, they often flitted back and forth from "aero" to "space" as the research need arose.

Doubtless the failure to portray adequately the wide-ranging air and space interests of FRC lay equally between FRC and NASA Headquarters. FRC's casual though highly effective administration showed little inclination to set up a sharply structured bureaucracy that would clearly divide the activities of the center between aeronautics and astronautics, or spaceflight. Because of the small size of the center and the need to shift people to meet constantly changing project structures, such a bureaucracy would have made little sense anyway. Unfortunately, the persons in NASA Headquarters charged with preparing and submitting budget requests to Congress type-cast the FRC as an "aeronautics" center. Communication between FRC and Headquarters was inadequate, although Paul Bikle recognized the danger of being perceived as an aeronautics-only facility and worked hard to move FRC into the mainstream of space-related programs. Paresev, lifting bodies, and the lunar lander were Bikle initiatives. FRC's staff may well have failed to graspjust how single-minded the non-NASA governmental community, especially Congress, was when it came to "emphasizing" aeronautics or astronautics in the early **1960s.**

All this would constitute little more than a curious footnote to FRC's managerial style and visibility during the **1960s** were it not for a critical event: an attempt by some congressional elements to close down the center at the conclusion of the X–**15** program.

As has been mentioned, the X–**15** so dominated FRC's activities in the early **1960s** that some saw FRC and X–**15** as **so** intertwined that the end of the latter would spell the demise of the former. This feeling had reached the halls of Congress, and in the summer of **1963,** during consideration of NASA's **1964** budget, the influential House Committee on Science and Astronautics (later the House Committee on Science and Technology) recommended closing the Flight Research Center since, in members' judgment, "no known future aircraft projects will specifically require the continued existence of the Flight Research Center beyond the date when the X–**15** project will be completed."[3] Dr. Raymond Bisplinghoff, OART director, worked hard over the next few weeks to save FRC, pointing out that NASA envisioned its participation in a range of programs in both aeronautics and space activities. Fortunately, the Senate Committee on Aeronuatical and Space Sciences restored funding for the FRC, on grounds that it would be vital to the upcoming American supersonic transport testing program. By the end of the summer, FRC was safe, having survived a serious attempt to legislate its **demise.**[4]

With hindsight, it is ironic that FRC was saved at a criticaljuncture of its existence by an anticipated need to support the American SST—which program itself fell to the congressional axe of **1971.** By that date the center was again well established with a variety of research projects, primarily in aeronautics, that necessitated its continued existence. Further, its major role in flight testing the upcoming Space Shuttle was already mapped out.

That FRC was so well established again by **1971** stemmed from a variety of factors but chiefly from the aggressive policies and initiatives of center director Paul Bikle. In **1963,** at his urging, De Beeler and senior FRC staffers prepared a comprehensive five-year plan for the future direction of the **center.**[5] This document served as a general guide for center activities through the end of the decade. The plan (Table **4)**

Table 4
FRC Five-Year Research Plan, 1963:

Continuing Activities

Aeronautics Technology

Studies of SST operational problems using modified service aircraft.

Space Technology

X–15 flight operations (X–15 follow-on program).
Paresev studies.[a]
Active support and research on Dyna-Soar.[b]

New Initiatives

Aeronautics Technology

Renewed military service testing, starting with F–111.

Development of a mulitpurpose airborne simulator using a modified Lockheed JetStar transport to simulate a wide range of aircraft, from hypersonic reentry vehicles to SSTs.

Investigation of the handling qualities of light airplanes to improve general aviation safety.

Space Technology

Flight testing of M2–F1 lifting body and development of supersonic lifting bodies to assess the low-speed handling qualities and approach and landing characteristics of lifting body spacecraft.

Development of a lunar lander simulator to serve as a training device for the Apollo program.

Studies of an advanced hypersonic research vehicle successor to the X–15.

[a]A kite-like landing system for spacecraft, to be discussed subsequently.
[b]Dyna-Soar was terminated at the end of 1963.

emphasized continuing four on-going air and space activities while developing six new initiatives. Some of these, such as lifting bodies, continued into the 1970s. By the mid-1960s, then, the Flight Research Center clearly knew where it was going in the future, even if others elsewhere were not so certain.

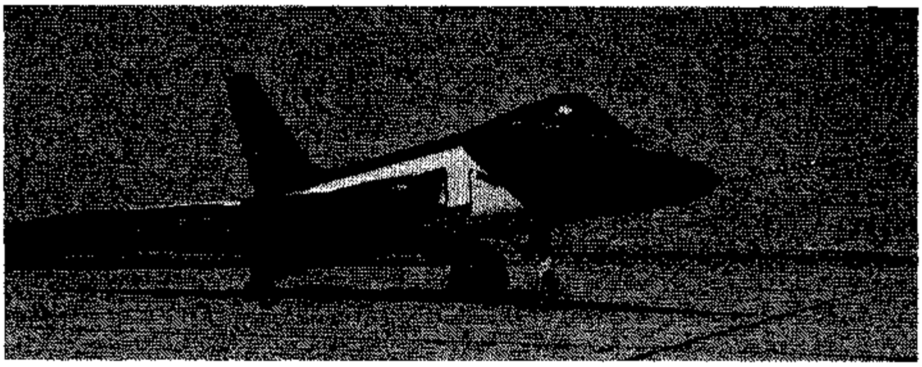
EARLY SPACE RESEARCH AT FRC

FRC's research in support of NASA's space program began in 1959 when, at the request of the Space Task Group, the center flew a series of

F–104 flights to drop test versions of the Project Mercury spacecraft's drogue parachute from altitudes above 15 000 meters. As a result of these tests, critical design problems were discovered and corrected before the spacecraft first flew.[6] The center's greatest early space effort, however, was on the planned Dyna-Soar program, the X–20A.

Dyna-Soar, the "Round Three" after the X–15, was a Sanger-like boost-glider designed to be lofted into orbit by a Titan III booster. Dyna-Soar had three major objectives: to demonstrate controlled lifting reentry from space and acquire data useful for the development of other lifting reentry spacecraft; to investigate a pilot's ability to perform useful tasks in space; and to explore piloted, maneuverable reentry including landing at conventional airfields.' Its general configuration was that of a hypersonic slender delta, a flat-bottom glider using radiative cooling. Under development for the Air Force by Boeing, Dyna-Soar was pushing technology in many areas, including high-speed aerodynamics, high-temperature structural materials, and reentry protection concepts. Eventually, questions over its utility, research potential, and safety forced cancellation of the craft in December 1963. Nevertheless, Dyna-Soar was a generally useful design exercise; much of the research encouraged by this program significantly influenced subsequent Shuttle studies. Like others of the X series before it, the X–20A thus acted as an important research focal point.'

The Dyna-Soar project office, in conjunction with NASA, had selected an FRC pilot, Milt Thompson, as the only NASA pilot to fly the craft. Further, FRC had complete responsibility for stipulating the X–20A's instrumentation requirements. Center engineers had already prepared papers on Dyna-Soar's expected operational problems and the possibility of air-launching it from B–52 and B–70 motherships.[9] In early 1961, the FRC had received two "castaways," prototypes of the Douglas F5D–1 Skylancer, an experimental Navy fighter that had not been placed in production. The F5D–1 had a wing planform very similar to that projected for Dyna-Soar; FRC pilot Neil A. Armstrong recognized that the Skylancer could be used to study Dyna-Soar abort procedures. How to save the pilot and spacecraft in the event of a launch-pad booster explosion was a problem of great concern to the Dyna-Soar team. The X–20A Dyna-Soar had a small escape rocket to kick it away from its booster, but no one really knew what kind of separation flight path and landing approach would best bring Dyna-Soar safely to earth. Armstrong developed a suitable maneuver using the F5D–1; it consisted of a vertical climb to 2100 meters, pulling on the control column until the "X-20A" was on its back, rolling the craft upright, and then setting up a low lift-to-drag-ratio approach, touching down on a part of Rogers Lake that was marked like the 3200-meter landing strip at Cape Canaveral. Following Dyna-Soar's cancellation,



Neil A. Armstrong prepares to fly a Dyna-Soar abort simulation in one of the Flight Research Center's Douglas F5D–1 Skylancer aircraft.

FRC continued to fly the F5Ds in support of lifting body and SST studies, before retiring the aircraft in **1970**.[10]

PARESEV: A SPACE-AGE KITE

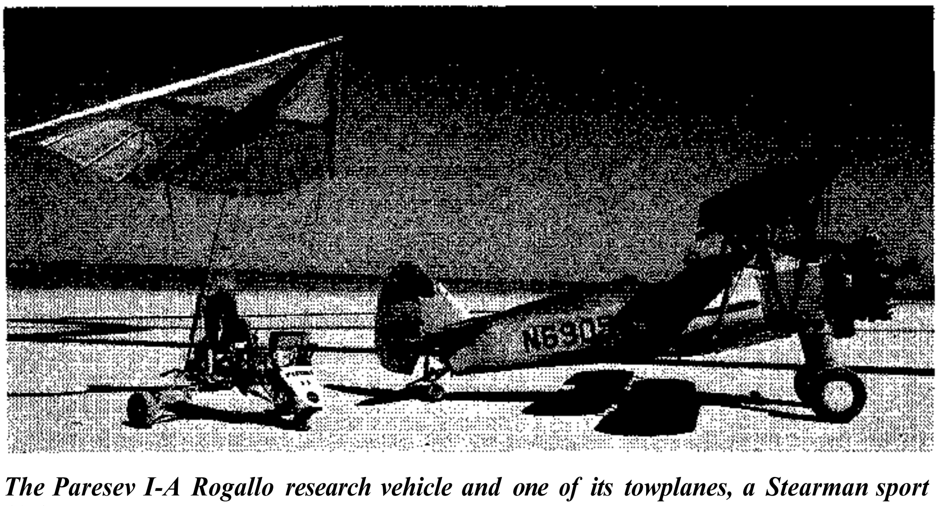
The center's major space research support activities concerned the Paresev and the Lunar Landing Research Vehicle (LLRV), developed and flown at the FRC in support of the Gemini and Apollo programs. Paresev was an indirect outgrowth of kite-parachute studies by NACA Langley engineer Francis M. Rogallo. The "Rogallo wing" was a diamond profile with a flexible covering attached to a V-shaped (point foremost) leading edge and a longitudinal keel. **As** with a parachute, the air filled out the sail-type surface, giving it its shape. In the early **1960s,** this shape seemed an excellent means of returning a spacecraft to Earth. **A** spacecraft could streak in through the atmosphere and then, at much lower altitudes and subsonic speeds, deploy a stowed Rogallo wing, enabling the astronauts on board to fly it down to an airplane-like landing, obviating the need for a water landing and recovery flotilla. **NASA** engineers had begun studying how the agency could apply the Rogallo wing to current spacecraft projects, especially one tentatively designated Mercury Mark II.[11]

In January **1962,** Mercury Mark **II** became the Gemini program, America's second major man-in-space venture, involving a two-man crew and encompassing extravehicular "spacewalks," rendezvous, and docking. In May **1961,** when Mercury Mark **II** was slowly evolving, Robert R. Gilruth, director of NASA's Space Task Group, requested studies of an inflatable Rogallo-type "Parawing" for spacecraft. Several companies responded; North American Aviation produced the most acceptable concept and development was contracted to that company. At a **28–29**

November 1961 meeting, NASA Headquarters launched a paraglider development program, with Langley doing wind tunnel studies and Flight Research Center supporting the North American test program. NASA grafted the parawing scheme onto the Mercury Mark II **program.**[12]

Paraglider development involved solving major design difficulties of stowing and deploying the wing, ensuring that the crew would have' adequate control over the parawing-equipped craft, and providing satisfactory stability, control, and handling qualities. The Flight Research Center's technical staff was never convinced that the scheme was workable. Eventually, because of poor test results and rising costs and time delays, the idea was dropped from Gemini in mid-1964. FRC engineers and pilots had believed that any vehicle so equipped might present a pilot with a greater flying challenge than contemporary advanced airplanes. They thought that NASA should acquire some sort of baseline experience before attempting development and flight of Parawing on a returning spacecraft. After returning to Edwards, they continued their discussions among themselves.

The best way to acquire such experience, of course, was by building and flying a Parawing. Two who actively favored such an approach were center research pilots Neil Armstrong and Milt Thompson. They approached Paul Bikle, who liked the idea, but recognized that both pilots had heavy Dyna-Soar commitments; FRC could not spare their services elsewhere, even to a project as interesting as the proposed Parawing. Instead, Bikle called in a group of center engineers under the direction of Charles Richards, a team composed of Richard Klein, Vic Horton,



The Paresev I-A Rogallo research vehicle and one of its towplanes, a Stearman sport biplane.

Gary Layton, and Joe Wilson. Bikle's instructions were characteristically short and to the point: build a single-seat Paraglider and "do it quick and cheap." All this took place just before Christmas 1961. The team, now totaling nine engineers and technicians, set to work on this "Paraglider Research Vehicle," conveniently abbreviated Paresev. Seven weeks later, after expending $4280 on construction and materials, the team rolled out the Paresev I. It resembled a grown-up tricycle, with a rudimentary seat, an angled tripod mast, and, perched on top of the mast, a 14-square-meter Rogallo-type parawing. The vehicle weighed 272 kilograms, had a height of over 3.4 meters, and a length of 4.5 meters. The pilot sat out in the open, strapped in the seat, with no enclosure of any kind. He controlled the descent rate by tilting the wing fore and aft, and turned by tilting the wing from side to side. NASA registered the Paresev, the first NASA research airplane to be constructed totally "in-house," with the Federal Aviation Administration on 12 February 1962. Flight testing started immediately.[13]

At first, with ingrained caution, engineers tested the Paresev by towing it behind a utility vehicle. Technicians drove a tow vehicle up to 95 kilometers per hour on the lakebed; the Paresev lifted into the air at about 65 kilometers per hour, followed by a dusty gaggle of "chase" cars and motorcycles. Milt Thompson, one of the two project pilots (the other being NASA's Bruce Peterson), would let the plane float along a few feet off the ground as he gained familiarity with the vehicle. The original configuration had several faults. The control system had built-in lag; pilots used to the sensitivity of modern jet aircraft found that the Paresev flew as if "controlled by a wet noodle."[14] Because cloth-covered airplanes often used Irish linen, the Paresev design team decided to use it for the wing surface. Dick Klein and Gary Layton visited a sailmaker in Newport Beach; he cast a quizzical eye at the material and suggested Dacron instead. The team stuck with linen, found it did indeed have a number of problems including flutter at the trailing edge, and changed to Dacron at a later date.[15] The Paresev was difficult to fly—Thompson considered it more demanding than the later lifting bodies. He made several hundred ground tows and 60 air tows, recollecting later that "it was a lot of fun."[16] But it had its moments of danger, too. During one ground tow, Bruce Peterson got out of phase with the lagging control system and developed a rocking motion that got worse and worse; just as the tow truck started to slow, the Paresev did a wing-over into the lakebed, virtually demolishing the Paresev and injuring Peterson, though not seriously.

The accident ended the days of the Paresev I; FRC technicians salvaged only the tripod from the wreck. They totally rebuilt the vehicle, this time with a much more sophisticated control system using a conventional stick and rudder system. They took the sailmaker's advice and used a Dacron wing. This became the Paresev I–A. Ground tows quickly indicated this paraglider handled better than its predecessor, and NASA moved to flight tests. To tow the I–A, FRC rented a Stearman biplane from a Tehachapi sailplane operator. Later a Cessna L–19 Bird Dog was acquired on loan from the U.S. Army Reserve. The Paresev project team also flew a smaller wing on the I–A. During Paresev I–A tests, tow planes dragged it to 3000 meters before release. For a test pilot used to the confined but comforting environment of a supersonic jet, it was an eery sensation to sit out in the open, like a pre-World War I aeronaut, strapped in the seat. In addition to Milt Thompson and Bruce Peterson, Neil Armstrong, Emil "Jack" Kleuver (an Army pilot detailed to FRC), astronaut Gus Grissom, and Langley research pilot Bob Champine—a Muroc old-timer—flew the little craft. It underwent one further modification, as the Paresev I–B, equipped with an inflatable Gemini-type wing as well. NASA ended flight tests on the Paresev in 1964, having completed over 100 flights."

The Paresev program is a good example of the Bikle low-cost do-it-quick approach. Originally scheduled as a two-month flight test project, the program became interesting enough to warrant running for two years. Eventually engineers evolved a useful vehicle having acceptable handling characteristics. Nevertheless, it was a big step from this simple technology demonstrator with a rigid and fixed wing framework to a stowable, inflatable parawing on an actual spacecraft that could be relied on to return a crew safely to Earth. At the same time that NASA's Paresev was concluding so agreeably, North American's complex Gemini Paraglider program had already forced a test pilot to abandon one of the vehicles in flight—hardly encouraging. The long process involved in making the relatively unsophisticated Paresev an acceptable craft indicated the magnitude of the task awaiting those developing such devices for spacecraft.

NASA's FLYING BEDSTEADS

NASA's major undertaking in the 1960s was the Apollo program, an ambitious and breakneck-pace effort to place astronauts on the moon by the end of the decade. It is difficult now to relive those hectic days, to imagine the level of activity at NASA centers around the country, the frantic pace of meetings, the sense of mission that pervaded the agency and its workers. Virtually every worker felt privileged to work for the agency, and even the wing-oriented NACA old-timers did their best to contribute to the national space effort.

One of the many critical questions in the Apollo program was the descent to the lunar surface. The descent vehicle would only be operating in a gravity 1/6 that of Earth's, but the airless moon dictated a strictly propulsion-borne descent, not an aerodynamic descent. Grumman was