Dear Richard,

The supersonic propeller program was a joint effort of the Air Force, Navy and NACA to explore the design and practicability of propellers for economic propulsion of aircraft to cruise at Mach numbers of up to 0.95. The NACA considered both the B-45 and the B-47 as candidate test beds, but the Air Force volunteered the XF-88 number 46-525, which was excess to their needs, and this was modified to become the XF-88B, as you know. The Air Force contributed the required modifications to the aircraft, a conventional 4-blade propeller (Curtiss) and the research propellers (built by Curtiss to the requirements of the NACA research program), the propeller gear box and a spare, which could accommodate three propeller rotational speeds through internal gear changes, whirl tests of the research propellers at WPAFB and acceptance tests and reports of the modifications accomplished. The Air Force Project Manager at WPAFB was Charles Beinnaman.

The Navy contributed the engines to the program. These included two Allison XT-38A-5 turboprop engines (one spare) to drive the propellers, and four Westinghouse J-34-WE-34 jet engines (two of these were in the XF-88A airframe). The afterburners were of McDonnell design.

The NACA was responsible for the research instrumentation, the program and its conduct, the data and reporting of research results.

Acceptance tests were conducted by the Air Force after aircraft modifications at McDonnell in June and early July of 1953. NACA personnel were in attendance to take part and for familiarization with the final product including flight and operating characteristics of the aircraft. The notes of my three flights for this purpose are enclosed as well as the Air Force flight acceptance report.
The XT-38 drive shaft and gear box had torque and thrust sensors, respectively. The thrust meter did not function well and was not used. The torque meter strain gages were on the shaft between engine and gear box. The actual torque absorbed by the propeller was, however, determined from the wake survey rake as was the thrust. Although provisions for the research instrumentation were made during the conversion work on the aircraft, the actual installation (including the momentum survey rakes) was completed after delivery to NACA Langley.

The XF-88B was ferried, after acceptance, by Capt. Fitzpatrick to Langley with a stopover at WPAFB where it was flown by other Air Force personnel. It arrived at Langley on July 13, 1953. The XF-88A, number 46-526, was later delivered to NACA Langley, also, where it served for spare engine and parts support.

The following is a tabulation of the use of the two aircraft at NACA.

**XF-88B, 46-525**

- Arrived July 13, 1953; total flight time 146:26 hrs.
- Turned over to Langley Base Salvage September 16, 1958 (used for practice fire fighting) 174:24 hrs.
- Total NACA flight time 28 hrs.
- First propeller research flight November 20, 1953
- Last propeller research flight January 17, 1958
- Total time in research flight status 4 yrs., 1 mo., 28 days
- Number of research flights 43
- Flights for familiarization of other pilots 3
- Total flights at NACA, Langley 46

**Project Pilots**
- Reeder, J. P.
- Alford, W. L. (deceased)

**Research Flights**
- 30
- 13
Other Pilots
- Whitten, J. B.
- Champine, R. A.

Average flight time per flight
Averaged 10.46 flights per year, or 5.43 hrs. per year

Familiarization Flights
1
2

Note: In research like this a great deal of work goes on between flights to reduce and examine data so as to decide what should be done on the next flight, and what changes and corrections must be made to instrumentation, propellers and propeller governing, gear boxes, etc., as well as to perform required maintenance on the one-of-a-kind equipment from airplane to propellers. The research characteristically proceeds slowly, but not because of a lack of effort.

XF-88A, 46-526

 Arrival date not determined, but later than XF-88B; total flight time 317:55 hrs.

 Turned over to Langley Base Salvage

Note: The XF-88A, which had an all-moving horizontal tail, in contrast to the fixed stabilizer and elevator of the XF-88B, was not flown by NACA because of lack of resources for operating both aircraft. It was used for spare engines and airframe spares, primarily. However, the aircraft was used briefly for evaluating a takeoff performance meter concept, but no lift offs were made. Taking account of weight, temperature and runway length the takeoff meter indicated whether, upon brake release, the longitudinal acceleration was adequate for safe takeoff under the prevailing conditions.

When acquired, the XT-38's were limited to 25 hrs. before scheduled overhaul, but before such time was acquired it had been extended to 50 hrs. However, at between 6-7 hrs. of operation foreign object damage was suffered which required compressor blade replacements. Pictures of the engine showing the damage are enclosed. Of course, the spare engine was installed while repairs were made to the first engine.
It's not surprising that foreign object damage did occur because of the numerous and lengthy ground runs for noise measurements and the vulnerable position of the XT-38 engine air intake.

The XT-38 propeller gear box ratios for 1700 and 3600 rpm were used in the research, but not that for 6000 rpm. A disintegration of the propeller brake (for-feathered operation) required rebuilding of one gear box.

Only three propeller designs were flown and reported on, the phases Va, Vb and VIIb, as indicated on the charts and by the reports enclosed. The program was discontinued when it was felt that maximum payoff had been achieved. An important factor was the rapid swing to jet power (with it speed and productivity potential) for military and commercial use. Actually, the program was a little late, for the times, in implementation.

The XF-88B aircraft performance for this test bed role was strictly marginal. Thrust-to-weight ratio for takeoff was 0.3 or less. Takeoff run, with afterburning, to 155 mph was generally 5000 feet or more (8000-foot runway at Langley at that time). Fuel limitations with the performance prevailing made the whole operation time critical. Flight time could not exceed about 40 minutes, and usually only one high speed run at altitude could be achieved. As soon as familiarity was achieved the XT-38 was started at 5000 feet (blade stall flutter was a limitation for takeoff) and the test propeller configuration was used for climb. Engine nozzles in non-afterburner operation were manually adjusted by rheostats in the cockpit for maximum temperature to obtain military thrust, which was the power used in climb. Sometimes at full throttle the nozzles would not close in response to rheostat adjustment until the throttles were retarded. Then they could be advanced again.

The afterburners did not perform satisfactorily. The thrust augmentation with afterburning was estimated to be about 1.41 in design. However, ground static tests at Langley measured only 1.12 to 1.19 in actuality.
Furthermore, the tailpipe nozzles, automatically controlled by temperature in afterburning operation, would frequently hunt, causing large fluctuations in thrust which damped poorly or not at all. The problem lay in the friction in the Arends' controls (flexible wire enclosed in flexible, anchored guide tubes) used to move the nozzles and did not seem to be amenable, for any length of time, to maintenance steps or lubrication. Afterburner light off could not reliably be achieved above 20,000 feet, and so the practice was to light them when reaching 20,000 feet, if used. However, blowout of one or both afterburners frequently occurred above 20,000 to 25,000 feet. This was hard to detect at times, and a rapid loss of fuel would occur before recognition. Re-lights were not generally possible without descending. We eventually did away with the afterburners and replaced them with straight tailpipes.

The aircraft was usually towed to the head of the runway where assurance of prompt takeoff clearance was obtained before engines were started. Engines were run up with brakes on and turbine outlet temperature limits set with the cockpit rheostats. Generally, both afterburners were lit, one at a time, and checked for temperature and steady operation before brake release. However, one day I was startled by the aircraft sliding down the runway. I thought the brakes weren't holding. Actually, the afterburners were putting out their best. After takeoff the afterburners were shutdown as soon as 230 mph in the clean configuration was obtained. The XT-38 was started at 5,000 feet at 250 mph and used in climb. During all operation with the propellers the cockpit noise was similar to that with a reciprocating engine, such as the Merlin or the Allison. Climb was made with the aircraft position with respect to the airbase always in mind so that, when the fuel state dictated, the data run could be started with the aircraft heading toward home.

For a speed over about Mach 0.85, the climb was continued to as high an altitude as the fuel state would permit, generally 30-35,000 feet. The highest altitude obtained during the NACA program was 39,000 feet over Wallops Flight Center during an airspeed static source calibration using ground radar.
At the highest altitude achieved for a test run the aircraft was accelerated in level flight, data system running, as long as practical. It was then dived to obtain the speed desired by 30,000 feet, if possible, but not so steeply that the rate of speed change might lead to large off-speed conditions of the propeller or oscillations in rpm. The governor time constant was adjustable to obtain good performance, but its setting was only an estimate for each propeller configuration. The governor never did cause a problem but such dives to obtain the higher speeds were not made often enough with a given propeller configuration to become thoroughly familiar with governing limitations.

On one flight, following the installation of a more elaborate XT-38 fire detection and warning system, which sensed temperature rate as well as temperature, the fire warning light came on during a dive.

The throttle of the XT-38 was pulled back, but to no avail. Finally, the propeller was feathered in the dive at a Mach number of 0.95 at 30,000 feet, and is documented in one of the enclosed reports. No major adverse effects were noted (or remembered) in this case. Also, the fire warning proved to be false and adjustment of the warning system sensitivity took care of the problem.

The elevator control of the aircraft was adequate to achieve the limit load factor or maximum useable lift coefficient throughout the subsonic operational envelope. At a Mach greater than 1.0, however, full back stick could develop only 0.75 "g" increment, or a load factor of 1.75 "g" for recovery, an indication of the increased degree of longitudinal stability and loss of elevator effectiveness caused by Mach numbers effects. This was of no consequence operationally in this case, however.

The general aircraft handling characteristics were adequate, and the drag rise and trim changes (tuck) in achieving supersonic speeds were mild and posed no difficulties. Buffet at 1 "g" in transonic flight was non-existent, to the best of my memory.
The highest Mach reached was 1.2 by Fitzpatrick in the acceptance tests at St. Louis. Many public complaints were received from the resulting sonic boom, however, which caused McDonnell authorities to prohibit further supersonic tests. Therefore, this kind of operation was minimized at Langley.

As mentioned in the pilot comments enclosed the control forces were manageable with boost off in up-and-away flight. However, one day after I had just made a high speed, high-propeller-power pass over some high ranking visiting observers at Langley the hydraulic control system failed. Although lateral control could be handled below 200 mph with one hand without major problems away from the ground, I found it a different story on the approach. I carried more speed (about 180 mph) to avoid the lateral trim changes during landing mentioned in my notes, and also to avoid a "settling" situation if forced to use two hands on the stick, leaving none for throttle operation. Actually, two hands were required on the stick continually to keep the aircraft lined up with the runway (it was a real sweat). I was beginning to be deeply concerned about flaring while keeping the aircraft aligned when, just about at flare height, the boost came back in, allowing me to land decently. The nose-down attitude during the approach apparently allowed remaining fluid into the system.

I have enclosed all the reports I can get my hands on, copies of library cards, photos with names of personnel and other explanatory information on the backsides where appropriate, and charts of the propellers that were originally planned with check marks to indicate those actually flown. In addition, I have added TN 3422 which reports noise tests of the conventional 4-blade propeller delivered with the aircraft. If you desire photos in the reports that have numbers indicated you may contact the Langley Public Affairs Office, Jack (Harper E.) Van Ness, for copies. You can call him at (804) 827-2932. Also, NASA Langley has an excellent technical library which cross-references technical information to an airplane that may have been involved, such as the XF-88B. Jane Hess is head of the Technical Library Branch, at (804) 827-2634, if you need library help.
I have contacted Jerry (Jerome B.) Hammack, Johnson Space Center, who was the project engineer on the XF-88B and he would be very glad to talk to you about the propellers and tests. He provided the aerodynamic design for the research propellers, considering structural aspects. He's particularly interested in your efforts because the work done with the XF-88B is pertinent to the current trend back to propellers for high speed flight. His office phone number is (713) 483-0123, extension 3126 or at home, (713) 334-2986.

Also enclosed is the report on the ground tests with the X-100 here at Langley. I have already sent you my pilot notes of the flights at Caldwell, N. J. From the only portion of the tests at Langley that I took part in I remember the obliteration of visibility in light dry snow in the forward "rooster tail" within ± 10 degrees of the aircraft centerline when pointing into the relative wind. A large area of fair visibility existed from about 10 to 45 degrees to the left or right of dead ahead. This suggested that operations at low speed under such conditions might be conducted with a yaw angle of about 20 degrees to the relative wind.

Sincerely,

[Signature]

John P. Reeder

P. S. I should add that the blade tip Mach numbers at design operating conditions for the three propellers flown were:

- Phase Va, $M_t = 1.7$ (supersonic into the spinner)
- Phase Vb, $M_t = 1.3$
- Phase VIIb, $M_t = 1.1$