File 8 MGA

(Gp-4) TEST REPORT

XB-70A

FLIGHT 1-7

(No. 1 Air Vehicle, No. 7 Flight)

4 March 1965

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PREPARED BY:

Joseph F. Cotton
Colonel Joseph F. Cotton
Test Director

Ira L. Plummer
Major Ira L. Plummer
Chief Project Engineer

XB-70 JOINT TEST FORCE (FTTB)

REVIEWED AND APPROVED:

GUY M. TOWNSEND
Colonel, USAF
Deputy for Systems Test

AIR FORCE FLIGHT TEST CENTER
EDWARDS AF BASE, CALIFORNIA

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I. SUMMARY:

1. The seventh flight (Flight 1-7) of XB-70, No. 001, crewed by Mr. Al White, North American Aviation, Inc (NAA), Pilot and Lt Colonel Fitzhugh Fulton, Air Force Flight Test Center (AFFTC), Copilot, was completed on 4 Mar 65. Takeoff from Edwards AFB runway 04, at a gross weight of approximately 485,000 pounds, occurred at 1018 hours PST. The landing on Edwards AFB runway 04 was at 1155, for a total flight time of one hour and thirty-seven minutes. Total supersonic time was one hour and two minutes. Highest speed and altitude attained were Mach 1.85 and 50,000 feet.

2. Although No. 3 engine did not rotate on the first attempt and a faulty hydraulic pump status indication forced shutdown and restart of No. 1 engine, the "manual" engine starts were completed in ten minutes. Slow speed brake chatter, as noted on previous flights, was experienced during taxi to the takeoff position. Due to an inoperative No. 3 fuel tank boost pump, and to increase the safety margin should another tank 3 boost pump fail during the takeoff roll, a planned power reduction was made just prior to takeoff rotation. This was satisfactorily accomplished without detectable change in acceleration rate.

3. The first attempt at landing gear retraction was unsuccessful and re-cycling was necessary to completely retract the gear. Flap retraction was normal, as was wing tip fold to 25 and 65 degrees. The flight proceeded to altitude where stability maneuvers were performed at Mach 1.4/41,000 feet, Mach 1.6/45,000 feet, and Mach 1.8/50,000 feet. Engine air induction system tests were accomplished at Mach 1.8/50,000 feet. After satisfactory completion of ram purge tests at Mach 1.68/50,000 feet, airstart tests of engines No. 1 and No. 3 were performed at Mach 1.4/41,000 feet. Airstart tests were also performed with engine No. 1 at Mach 0.8/25,000 feet. During this entire period, air-craft sensitivity to pilot aileron inputs was noted. This sensitivity increased when the wing tips were returned to the full up position.

4. Heavy air turbulence was encountered in the descent to the traffic pattern and during the approach to landing. Aircraft response to the turbulence was pronounced. A smooth touchdown was made without incident, but again, as in previous flights, the third drag chute failed to deploy.

II. TEST LOG:

0845	In cockpit - pressure suit checkout completed.
0910	"Before Starting Engines" checklist in progress with throat and bypass door checks complete.
0913	Preparing to start engines using manual start technique. EGT's during start ranged from 490° to 590°. No rotation was obtained on the first attempt to start No. 3 engine, however, it was normal on the second attempt. The No. 1 engine U_1 and P_1 pump status lights were slow to change to green and the engine was shut down. On the second start, telemetering showed the pressure to be normal even though U_1 status light stayed amber. The U_2 pump status light for engine No. 6 was slow to change to green after start but was O.K.
0923	Engine starts complete.
0935	Flight control check.
0942	Entrance door closed.
0954	Taxi out started.
1002	On runway -- in place.
1015	Total fuel 220.5, data on C/N 098.
1017:45	**Brake release.**
1017:52	Maximum afterburner - engines look good.
1018:07	120 Knots.
1018:22	180 Knots - throttles retarded to 100° setting.
1018:37	Lift off at 220 knots - Hydraulics check O.K.- Gear selected "up" - False master caution flashed on - Landing gear folded and rotated but stopped retracting approximately half way up - Throttles retarded to 88°.
1020	C/N 360 data off - utility systems check O.K. C/N 374 data on - gear selected down - 240 KIAS - gear locked down in approximately 20 seconds with gear lights showing the same conditions as reported by chase coming out of afterburner to mil power - data off C/N 425 - gear selected up and retracted normally (55 second cycle) - setting afterburner at 70° throttle angles - data on C/N 528 - off C/N 548 - flaps selected up (20 second retraction). Maximum afterburner set - pitot heat off - Refer off.
1025	Cabin altitude 6,000 feet - oxygen O.K. - Cooling doors closed.
1026	0.84 Mach and 20,000 feet - slight turbulence - entering cloud layer-abeam Barstow, California.
1029	Data on C/N 842 - approximately 29,000 feet - wing tips selected one-half (20 seconds to go down).
1030	Data off C/N 892 - cabin 6,000 feet and no change in windshield bellows TACAN shows Las Vegas at 78 NM - altitude 33,000 feet.

Test Log, Flight 1-7 (Cont'd)

1031	Level off at 35,000 feet and accelerating - 1.01 Mach.
1033	Starting left turn 55 NM from Las Vegas - chase indicates 1.15 Mach - acceleration is very slow.
1034	390 KIAS starting to climb slowly - cabin record switch off.
1035	Climb and acceleration are slow. Data Control advises to accelerate at 39,000 feet.
1037	163 NM to Milford TACAN - 37,000 feet.
1040	FACS on - C/N 1495 on and 1515 off.
1043	No change in windshield bellows - Mach 1.3 Water, ammonia and LN_2 all O.K.
1044	Data on C/N 1778 - wing tips going to 65° at 1.38, 39,000 feet. Data off C/N 1800.
1045	Data on C/N 1809 - opening bypass to 200.
1046	Bypass to 400 - Engines normal - Data off C/N 1883.
1048	148 NM to Bonneville - 1.4 Mach Data on C/N 2014 - augmentation turned off - data accidentally turned off.
1049	Data on C/N 2052 - augmentation being turned off - faulty master caution light.
1050	Augmentation turned on individually - data off C/N 2148.
1051	Data on C/N 2205 - stability maneuvers at 1.4 Mach.
1052	Starting left turn to 195 heading - 85 NM south of Bonneville, Utah.
1053	Data off C/N 2327.
1055	False master caution light.
1056	Data on C/N 2530 - stability maneuvers at 1.4 Mach.
1058	Data off C/N 2679.
1059	FACS on accelerating to 1.6 Mach.
1101	43,500 feet at 1.47 Mach.
1103	Mach 1.6 - data on C/N 2889 - stability maneuvers.
1104	Augmentation turned off beginning at C/N 2975 - encountered turbulence - false master caution light. Sideslip beginning C/N 3012.
1105	Data off C/N 3062.
1106	Lost all Mach and altitude tapes momentarily - copilot's altitude tape stuck at 50,000 feet. Maximum IAS of 520 attained.
1108	49,000 feet at 1.75 Mach - turbulence - then 50,000 feet at 1.79 Mach.
1109	Data on C/N 3208 - throat to 1.9 Mach then to 1.8 Mach setting - speed 1.83 Mach at 50,000 feet - bypass set 700 square inches.
1110	Bypass back to 400 at C/N 3299 - stability maneuvers with sideslip at C/N 3349 - slight rudder buzz with full rudder displacement.
1111	Data off C/N 3397.

Test Log, Flight 1-7 (Cont'd)

1114	Data on C/N 3518 - FACS off all at once - stability maneuvers at 1.8 Mach - maximum Mach of 1.85 at 49,000 feet.
1115	Data off C/N 3617 - mil power set to decelerate.
1117	Data on C/N 3707 - setting throats full open - data off C/N 3745 - 1.67 Mach, 450 KIAS at 50,000 feet.
1118	Data on for ram purge test - pressure dump switch on - cabin altitude increasing - slight pressure suit inflation - pilot placed purge switch on as cabin altitude neared 40,000 feet.
1119	Cabin altitude back to 33,000 feet as scoop extended - lost data momentarily but turned back on - pressure dump switch back to normal and cabin altitude dropped to 31,000 feet - speed 1.67 Mach at 49,600 feet.
1120	Repressurizing cabin - total fuel 65,500.
1121	Cabin altitude coming down - now at 9,000 feet - military power set on all engines to decelerate.
1122	Data off C/N 4108.
1123	Speed 1.51 Mach at 44,500 feet, oxygen 14 liters, water 4100, ammonia 460, EE temperature 37°, LN_2= 7/8, P_1 = 182, U_2 = 200.
1124	Speed 1.4 Mach, data on C/N 4146, bypass moved to 700 square inches at C/N 4162, bypass back to 400.
1125	Speed 1.36 Mach, tips selected to one-half.
1126	Data off C/N 4261, SSN set 40, data on C/N 4285 for engine shutdown and restart. No. 1 engine military then idle, rpm 76.5 - EGT 230° - nozzle 71%.
1127	No. 1 throttle off - 75% rpm - maximum afterburner other engines - speed 1.38 at 41,000 feet - EGT 160°.
1128	Air start on - throttle on at C/N 4369 - may have light off - EGT 170° - throttle advance shows engine running - air start switch off - power increased to military - data off C/N 4427.
1129	Data on C/N 4473, No. 3 throttle military then idle - rpm 76% - EGT 220°, throttle off - speed 1.43 Mach.
1130	Windmill rpm 67% - EGT 90° - total fuel 48,500.
1131	Left bypass to 700 square inches at C/N 4560 - then to 400 at C/N 4595 - rpm 67% - EGT 90° at C/N 4619.
1132	Airstart switch on - throttle idle - light off O.K. - data off C/N 4670 - engine normal.
1133	Engine 1, 2, 5, 6 at idle - engines No. 3 and 4 at 89% rpm - descending in slight dive at approximately 400 KIAS.
1134	Speed 1.1 Mach - 400 KIAS at 34,000 feet - data on C/N 4801, bypass door closed near 1.0 Mach at 30,500 feet.
1135	Bypass doors indicate 40 left and zero right when wheels moved to full close - wing tips selected "up".
1136	Total fuel 44,000 - No. 1 tank 4400.

Test Log, Flight 1-7 (Cont'd)

1137	Augmentation turned off - with tips up aileron sensitivity increased.
1139	Cabin record switch on - oxygen 12.5 liters - water 4000 - ammonia 430 - LN_2 3/4 - slowing to 0.8 Mach.
1140	Data on C/N 5091 - No. 1 engine rapid chop from military to idle - idle rpm - EGT 62% and 160°.
1141	Throttle shut off at C/N 5137 - rpm and EGT stayed at 62% and 160° - when throttle moved to idle rpm dropped rapidly to 34% and throttle moved back to shutoff.
1142	Windmill rpm stabilized at 31% - EGT 90° - data off C/N 5220 - tank No. 1 transferring - data back on C/N 5231 - airstart switch on - throttle to idle and rpm dropped rapidly to 28% - light occurred in 20 seconds with peak EGT of 320° - data off C/N 5276.
1144	Idle power on 1, 2, 5 and 6 engines - Nos. 3 and 4 set at 89% for descent.
1145	Altitude 17,000 feet.
1146	Altitude 15,000 feet.
1147	Flaps going down - speed 240 KIAS.
1148	Gear down (extended in 35 seconds).
1149	Altitude 10,500 feet - cabin altitude 5,500 feet - helmet visors up - nitrogen vents turned off - ammonia 430.
1150	Speed 240 KIAS - turbulence buffeting airplane - altitude 5,300 feet - tower reported wind as 60°/14 knots.
1152	Total fuel 32,500 - No. 3 tank 22,600.
1153	Tower reports F-101 drag chute just dropped on left side of runway 2,000 feet from approach end - landing gear camera turned on.
1154	Touchdown beyond drag chute on runway - braking parachute deployed at 140 - 150 knots - only two chutes blossomed.
1155	Parachutes jettisoned 60 knots - brake chatter at slow speed - stop on runway - digital data completely expended.
1158	Engine runs to military power on runway - sump low level light on.
1200	Taxiing in from runway.
1206	Parked in run station.
1208	Engine shut down.

III. DATA:

1. Fuel Data:

Time	0850	0953	1005	1026	1035	1036	1042	1043	1048	1054
Event	Run Station	Run Station	On Runway	20,000 ft Climbing	Supersonic Climbing	1.13 M Climbing	41,000 ft	1.3 M	1.4 M 41,000 ft	1.4 M 41,000 ft
Transfer Condition	None	#8 X-fer Complete	Auto #6 X-fer	Auto #6 X-fer	Auto #6 X-fer	Auto #6 X-fer	Auto #6 X-fer Complete	Auto #4 X-fer	Auto #2 X-fer	Auto #4 X-fer
Tank *										
1	17.2	17.2	17.3			17.4				
2	29.7	29.7	29.9			29.2				
3	33.7	33.7	33.7	32.7		33.4				
4	37.8	38.0	38.0			38.1		27.0		12.1
6L	38.6	38.6	37.4	17.3	8.4	4.8	2.6	OFF		
6R	38.7	38.7	37.4	18.3	8.7	4.7	1.3	OFF		
7L	10.5	10.6	10.7			10.3				
7R	10.6	10.7	10.7			10.6				
8L	8.1	2.4	3.1			2.9				
8R	8.8	2.4	2.8			3.2				
Total	235.5	224.5	223.0	180.0	165.0	158.0	142.5	139.5	128.0	111.0

* Fuel quantity times 1,000

Time	1057	1101	1107	1112	1116	1122	1129	1132	1133	1140
Event	1.4 M 41,000 ft	1.47 M 43,500 ft	1.8 M 50,000 ft	1.8 M 50,000 ft	1.7 M 50,000 ft	1.51 M 44,500 ft	1.4 M 41,000 ft	1.4 M 41,000 ft	1.4 M 41,000 ft	.8 M 25,000 ft
Transfer Condition	Auto #4 X-fer	Auto #4 X-fer #2 X-fer	Auto #2 X-fer	Auto #7 X-fer	Auto #7 X-fer	Manual #8 Just Turned On	Manual #8 On	Auto #1 X-fer	Auto #1 X-fer	Auto #1 X-fer
Tank *										
1								5.2	4.1	
2	17.8	16.6	5.9		OFF					
3						29.8				
4	7.2	.3	OFF							
6L										
6R										
7L				6.2	3.3	OFF				
7R				6.3	3.3	OFF				
8L							OFF			
8R							OFF			
Total	106.0	98.0	85.0	74.5	69.5	63.5	51.0	45.0	43.5	39.0

* Fuel quantity times 1,000

Time	1143	1145	1150	1152	1208					
Event	.8 M 25,000 ft	260 KIAS 17,000 ft	240 KIAS 10,000 ft	230 KIAS 4,000 ft	Run Station					
Transfer Condition	None	None	None	None	None					
Tank *										
1	OFF	0			0					
2		.3			.4					
3	27.0	27.0	24.6	22.6	16.8					
4		.6			.7					
6L		1.1			2.2					
6R		.4			.9					
7L		2.8			2.5					
7R		2.1			1.9					
8L		-.4			-.1					
8R		-.1			.3					
Total	38.0	36.5	34.5	32.5	28.0					

* Fuel quantity times 1,000

2. Hydraulic Quantity Log:

	P_1		P_2		U_1		U_2	
Time	F.L.	H.P.	F.L.	H.P.	F.L.	H.P.	F.L.	H.P.
0925*	168		168		167		169	
0940	176	190	168	195	167	180	169	178
1012	155		140		156		158	
1025	200		200		198		200	
1041	197		181		199		192	
1055	200		192		190		200	
1100	200						200	
1113	195		187		182		200	
1130			182		170			
1138	200		200		178		200	
1146	180		145		153		195	
1152	170		162		90		200	
1159	150		156		85		200	

F.L. - Fluid Level % (full - 200%)

H.P. - Head Pressure, pounds per square inch

*Hydraulics Serviced

IV. ENGINEERING COMMENTS:

1. Main Landing Gear Failure To Retract:

a. Shortly after lift-off, landing gear handle "up" was selected. The nose gear retracted; the main gear bogies folded, rotated; and both of the main gear struts started to retract but stopped about one-third of the way up. After an inspection by the chase aircraft the gear was re-cycled and then it retracted normally. Extension for landing was also normal. The most likely cause of the malfunction appears to have been that one of several switches in the landing gear system broke contact causing the strut control valve to go to the de-energized position thus cutting hydraulic pressure to the strut actuator. In addition to the gear handle switch and main gear safety switches, the left and right door pin switches and the bogie rotate lock switches are in series; thus any one switch, the associated wiring, or switch connections could have caused the problem.

b. During the aircraft down time after this flight, a series of landing gear cycles which included 10 normal extensions were made, and this problem did not repeat. Prior to these cycles an electrical modification was made to change the gear sequence. This change causes the main gear strut actuator to be pressurized down instead of being depressurized between the time the gear handle is selected up and the actuator is pressurized in the up direction.

2. Main Gear Actuator Bolt Failure:

The right hand main landing gear (MLG) strut actuator upper pin failed. This pin attaches the actuator to the structural "T" fitting in the roof of the wheel well. The failure is apparently a fatigue failure, and the head end of the pin separated. The pins on both left and right MLG strut actuators were replaced and a new design is in work. This hollow, internally threaded pin will be replaced with a solid pin. The internal threading originally provided for pin removal by special tools that are not now being used. Installation date for the newly designed pin is unknown.

3. Nose Gear Torque Tube:

The nose gear torque tube rubbed against the upper center part of the axle. This rubbing was caused by the nose gear axle deflection that resulted from the nose gear vertical load on this flight. The torque tube, which goes through the center of the axle, interconnects the two wheels for co-rotation. The tube has only about 3/32 of an inch clearance under no load conditions; and apparently, axle deflections with heavy nose gear loads were not taken into account in design. The torque tube is being redesigned to have a smaller external diameter through the center to eliminate the rubbing.

4. Propulsion:

No major in-flight problems occurred during the flight; however, minor problems were encountered with engines 1, 4 and 5. Engine shutdown and air starts were attempted with engines 1 and 3 at approximately 1.4 Mach and 41,000 feet and with engine No. 1 at 0.80 Mach and 25,000 feet. No problems were encountered when engine No. 3 was shut down. Engine No. 1 (S/N 170-574) did not shut down at 1.4 Mach because of a throttle or main fuel control (MFC) malfunction. The same problem occurred at 0.8 Mach; however, on a second attempt the engine was shut down. The engine has been removed from the air vehicle in order to replace the MFC. After a test cell run to check the new MFC, the engine will be reinstalled in the air vehicle. During the latter part of the flight the primary (A8) and secondary (A9) nozzles stuck closed on engine No. 5 (S/N 170-552). The nozzle condition was noted prior to engine runup after landing. The engine was removed from the air vehicle for nozzle area control (NAC) replacement. The engine will be reinstalled in the air vehicle prior to Flight 1-8. Post-flight investigation of the engine data revealed that engine No. 4 (S/N 170-558) had an engine speed roll-back problem prior to lighting the afterburner at takeoff. The same problem was noted when the afterburners were lighted prior to accelerating to climb speed at approximately 9,000 feet. This speed roll-back problem occurred before the roll-back normally associated with afterburner lights. The speed roll-back magnitude is between 400 and 500 rpm. A post-flight engine ground run with the engine still in the air vehicle showed the same roll-back indication. The engine was removed from the air vehicle and installed in the General Electric (G.E.) test cell. No indication of this abnormal roll-back occurred during test cell runs. The engine will be reinstalled in the air vehicle prior to Flight 1-8 for further investigation of the roll-back problem.

5. Brake Chatter:

Brake chatter during taxi occurred at higher speeds than has been experienced since brake "burn-in" on preflight taxi tests. Pilots reported brake grabbing or chatter at taxi speeds between 20 and 30 knots in addition to the previously experienced very low speed chatter. Considerable chatter was also noted on the right strut when turning into the runup pad. The brake computer was bench checked and found to be working properly.

6. Ram Air Scoop Operation:

At about Mach 1.5 and 50,000 mean sea level (MSL) the cabin pressure dump switch was turned on to vent cabin air outside thus reducing cabin pressure and initiating the ram air scoop extension. A cabin pressure decay ensued to 40,000 feet, and at that point, the pilot activated the cabin air purge switch. The cabin pressure then stabilized near the 34,000 foot level. As the instrumentation was not turned on during this period, ram scoop operation prior to

initiation of the purge switch can only be surmised; but the pilot's debriefing comment, of a momentary interruption in the air re-circulating system, substantiates the conclusion that ram air was working prior to purge switch initiation. One and two-thirds minutes after initial throw, the dump switch was closed and the cabin pressure stabilized at the 31,500 foot level. About two and one-half minutes after initial dump switch throw, the scoop was closed as the cabin repressurization phase was initiated. The cabin pressure increased from a 31,500 foot altitude to an 8,000 foot altitude in one and one-half minutes and then increased from the 8,000 foot altitude to 5,500 feet in another two minutes. Prior to the test the cabin was also at a 5,500 foot level. During the test the cabin experienced a 10.7 psi differential pressure when the actual altitude of the air vehicle reached 50,000 feet. In an attempt to bring the cabin altitude control to the design level of 8,000 feet, the cabin pressure regulator is being changed.

7. Instrumentation:

Of the 742 data parameters 49 did not perform satisfactorily. Twenty-five of these 49 parameters were not functional before flight. Twelve parameters did not check normal during the preflight calibration and 24 channels have been reported as having some discrepancy after the flight though a portion of these data in these parameters can be retrieved by manual calibration and analysis procedures.

8. Cockpit Instruments:

During the flight a failure occurred in the Mach number and altitude readout on the copilot's vertical scale indicator. Post-flight analysis revealed that a circuit breaker cutout was caused by a short in the amplifier to the indicator.

9. NASA Tests and Instrumentation Operation:

a. Velocity, Acceleration, and Altitude (VGH) Recorder:

A good VGH record was obtained of the entire flight.

b. Landing Gear Cameras and Instrumentation:

The cameras were turned on prior to touchdown and functioned correctly. Oronite hydraulic fluid had splattered on the main gear camera lenses reducing the quality of the pictures, but the data on the film was usable. Lense shades have been added since the flight to help shield the lenses from Oronite on future flights.

c. Landing Rate of Sink Sensors (arms):

All three rate of sink arms worked fine. As on Flight No. 5, the nose gear arm showed considerable wear. No data was

obtained from the wheel rpm pickups due to a signal conditioning malfunction.

d. Internal Noise Measurements:

Data was recorded in the takeoff, the climb to 35,000 feet, and the deceleration from Mach 1.1 to 0.8. The quality of all data was good.

e. Sonic Boom:

A sonic boom measurement was made at the NASA radar site at Beatty, Nevada as the XB-70 passed 3.5 miles to the east at Mach 1.8 and 50,000 feet.

f. Runway Noise:

Acoustical measurements were taken alongside the runway for the takeoff and the landing. There will be no runway noise measurements for the next two or three XB-70 flights.

V. OBSERVATIONS AND COMMENTS BY THE COPILOT:

1. Introduction:

The flight was scheduled for 1000 hours takeoff on 4 Mar 65. The flight plan was essentially a repeat of the flight plan to have been used on Flight No. 1-6. Tests scheduled were stability and control at supersonic speeds up to 1.8 Mach, operation of the ram purge system at 1.68 Mach, engine shutdowns and restarts at 1.4 and 0.8 Mach, operation of the throat and bypass systems, calibration of the airspeed system and a supersonic pass over a ground station at Beatty, Nevada for measuring the sonic boom overpressure and signature. The flight duration was one hour and thirty-seven minutes and all flight objectives were completed except one airstart at 0.8 Mach and the airspeed calibration.

2. Preflight and Flight Preparation:

I arrived at the airplane at 0630 and it appeared that the airplane would be ready as scheduled. I conducted an external inspection and an inspection of the electronic equipment (EE) bay without finding any discrepancies. Mr. White and I then reviewed, with maintenance and engineering personnel, the status of the airplane, and all carry over discrepancies. The most significant were an inoperative booster pump in the sump tank (No. 3) and a small hydraulic leak in the 10 port valve. The leak in the 10 port valve was of no concern since it only leaked when using the emergency extension system and the leak rate was considered to be acceptable. Since the No. 3 fuel tank feeds the engines at all times, an inoperative booster pump in this tank is very important. Mr. Spivak, North American Aviation, Inc., Assistant General Manager and Chief Engineer, briefed us that a small power reduction should be accomplished at 180 KIAS during the takeoff roll. Fuel flow rates would be very high at that time and by retarding from the full throttle position to 100 degrees throttle angle, the necessary safety margin would be provided in case another booster pump failed during the takeoff. At 0800, Mr. White and I entered the physiological van and began donning the full pressure suits. Approximately 30 minutes later we left the van with Mr. White going a few minutes ahead since only one pilot can be checked out at a time in the cockpit. At 0845, we were both strapped in the seats with all pressure suit checks completed.

3. In the Cockpit Prior to Taxi:

The "Before Starting Engines" checklist was completed and the gross weight was approximately 500,000 pounds with the total fuel quantity gauge indicating 235,500 pounds. Engine starts began at 0913 and were completed ten minutes later even though several problems occurred. The No. 3 engine did not rotate on the first attempt but

started normally on the second try. The No. 1 engine P_1 and U_1 hydraulic pump status lights did not change to green following the engine start, therefore, the engine was cut off. Telemetering confirmed that the pumps had operated normally and a second engine start was completed. The U_1 pump status light still did not show green but the P_1 status light was normal. Since telemetering showed all pumps to be satisfactory, it was decided to fly with the U_1 pump status indicator inoperative. The No. 6 engine U_2 pump status light was slow to change to green after engine start but was satisfactory for the remainder of the flight. All engines were started using the "manual" technique and the exhaust gas temperatures (EGT's) ranged from 490° to 550° with No. 1 engine the highest. All hydraulic systems were serviced to approximately 168%; however, difficulty was experienced in disconnecting the ground carts with the hydraulic systems reading the correct amount. The level would change when pressure on the ground cart was dumped. While attempting to lower the fluid level in U_1 system, almost all of the fluid from U_2 was depleted through cross flow. While still at the run pad control checks were completed and each engine was run at military power. Fuel in the No. 8 tank was used from slightly over 16,000 pounds down to approximately 5,000 pounds prior to taxi in order that the nose wheel reactive load would be less during taxi and takeoff.

4. Taxi:

Taxi out was started at 0954 and the instrumentation was turned on for the first left turn, the first right turn, and when taxiing over a rough ramp area. Brake chatter still occurred when the pedals were applied. The airplane was taxied onto the runway and a visual inspection performed by the crew chief. All hydraulic indications were normal except that the P_2 head pressure was slightly high at 210 psi.

5. Takeoff and Climb:

The total fuel, one minute prior to brake release, was 220,500 pounds. The parking brake was not set and the brakes were held manually by the pilot after stopping on the runway. The engines were set two at a time into maximum afterburner. Brake release was at 1018. It was still rough but the severity was considerably less than experienced on the last flight. After beginning to roll, all throttles were increased to maximum afterburner. Acceleration was rapid even with a gross weight of approximately 485,000 pounds. Near rotation speed of 180 knots indicated airspeed (KIAS), the throttles were retarded to the 100° throttle angle position as planned. There was no detectable change in acceleration rate. Lift-off came at 220 KIAS and after a quick hydraulic system check, the gear handle was selected "up". The nose gear went up and the main gear rotated and folded but stopped retracting approximately 1/3 of the way up. Data Control advised to re-extend the landing gear and it went down normally. After a short

wait and while at military power, in level flight at 240 KIAS, the gear handle was selected up again. This time the gear came up normally in about 55 seconds. After retracting the flaps, maximum afterburner was set and a 400 KIAS climb initiated. The master caution light illuminated several times but appeared to be a false warning. As requested by NAA engineering, numerous checks of cabin altitude and visual checks of the windshield bellows were made during the flight. No change in the bellows could ever be detected. The ground cooling doors all closed during the climb and the No. 6 fuel tank transferred normally with automatic sequencing set. A thin cloud layer was encountered around 20,000 feet and a little turbulence occurred at that time. The No. 3 tank was holding 32,700 pounds at the high level position. The wing tips were started down to 25 degrees between 29,000 and 30,000 feet while still in the climb. The TACAN locked on Las Vegas at around 100 nautical miles (NM). While still climbing, the acceleration checklist was completed and the airplane was leveled at 35,000 feet.

6. Accelerate and Climb:

The acceleration was started at 35,000 feet. After accelerating level from .95 Mach to 1.10 Mach a 390 KIAS climb was initiated to reach 41,000 feet. Acceleration and climb were very slow and it became obvious that an excessive amount of fuel would be required to reach 41,000 feet and accelerate to 1.4 Mach. Data Control advised to climb only to 39,000 feet and then accelerate to 1.4 Mach. Due to the slow acceleration rate, the photo chase airplane (F-104) was running very short of fuel, therefore, in order that photos could be obtained, the wing tips were selected to 65 degrees at 1.38 Mach. Approximately 80 NM south of the Milford TACAN, the wing tips were fully down and the photo chase airplane broke off for landing at Las Vegas. A small pitch transit occurred when all flight augmentation control system (FACS) were engaged simultaneously. Airplane acceleration rate improved considerably above approximately 1.3 Mach.

7. Stability at 1.4 Mach at 41,000 Feet:

The airplane was leveled at 41,000 feet and 1.4 Mach to obtain bypass door and stability data. Bypass doors on both sides were opened to 210 square inches and then to 400 with no apparent pitch change. Pitch, roll, yaw 1 and yaw 2 augmentation were turned off individually. When the last augmentation channel was turned off, a small aileron input apparently excited a lateral directional oscillation. Maximum yaw was slightly over 3 degrees. The oscillation appeared to be more directional than lateral and was not divergent. Yaw 1 and 2 were turned back on. A longitudinal pulse followed by a full rudder sideslip was then accomplished. Maximum sideslip was approximately $1\frac{1}{2}$ degrees. A release from sideslip with half rudder damped rapidly. The geographical location was 85 NM south of Bonneville, Utah and a left turn was needed for Space Positioning. The scheduled wind-up turn to 1.4 "g"

was completed in the left turn. Upon completion of the turn, yaw 1 and yaw 2 were turned off and another full rudder sideslip and a release from half rudder were accomplished. The sideslip angles were again approximately $1\frac{1}{2}$ degrees with full rudder and one degree at release from half rudder. It appeared that the pilot had more difficulty stabilizing in the full rudder sideslip because of the airplane's high sensitivity to aileron inputs, therefore, there was a small directional oscillation around the $1\frac{1}{2}$ degree yaw angles while full rudder was being held. Over-controlling with the ailerons is very easy to do and a concentrated effort appears necessary to prevent lateral directional oscillation.

8. Acceleration to, and Stability at, 1.6 Mach at 45,000 Feet:

The FACS were all engaged for the acceleration to 1.6 Mach. Total fuel was approximately 100,000 pounds. A course was selected toward the sonic boom measuring station at Beatty, Nevada. The acceleration rate, using maximum afterburner, appeared to be moderately fast with approximately three minutes being required to accelerate and climb from 1.4 at 41,000 feet to 1.6 Mach at 45,000 feet. A longitudinal pulse with the pitch augmentation "off" was followed by a full rudder sideslip to $1\frac{1}{2}$ degrees and then a release from half rudder, both with yaw augmentation on. Damping appeared excellent. A 1.45 "g" wind-up turn was completed to the right. With roll, yaw 1 and yaw 2 augmentation off, the full rudder sideslip and release from half rudder were repeated. Sideslip with full rudder was approximately 1.6 degrees. The period of the oscillation following the half rudder release appeared to be fairly long and the airplane damped in approximately one cycle. A TACAN lock on Beatty could not be obtained, but the set appeared to be functioning satisfactorily.

9. Acceleration to, and Stability at, 1.8 Mach at 50,000 Feet:

Slightly over two minutes were required to reach 1.8 Mach at 50,000 feet with all engines set at maximum afterburner. The pilot and copilot Mach and altitude tapes failed momentarily at 50,000 feet and began to drive. Within 20 seconds they were back to normal with the exception of the copilot's altimeter which stuck at 50,000 feet for the remainder of the flight. After speed and altitude were stabilized, the throat width was manually changed by moving the control wheels from the full open setting of 1.67 Mach to 1.9 Mach. After a short stabilization period, the throat wheels were moved to 1.8 Mach. The bypass doors were moved from 400 square inches to 700 and then back to 400. No trim changes were reported by the pilot as a result of throat or bypass door actuation and no changes in engine instruments could be detected. The sonic boom measuring station at Beatty was passed at 50,000 feet with the indicated Mach showing 1.82 to 1.83. The TB-58 crossed the station shortly afterward and should produce data for comparison purposes. With pitch augmentation off, a longitudinal pulse to 1.25 "g" was accomplished. The airplane damped in

approximately one cycle. A full rudder sideslip produced approximately 1.6 degrees of sideslip and the pilot reported a very slight rudder buzz with the fully deflected rudder. Apparently the yaw damper actuation was feeding back slightly to the rudder pedals. A release from half rudder damped satisfactorily. All FACS were turned off simultaneously without causing any unusual airplane disturbance. With the FACS off, full rudder produced 1.8 degrees of sideslip and the pilot reported that more lateral control was required than at the lower speeds. The release from half rudder again exhibited satisfactory lateral directional damping. A wind-up turn at 1.45 "g" completed the planned stability maneuvers. The highest speed during the flight was near the end of the stability series when the indicated speed reached 1.85 Mach at 49,000 feet.

10. Deceleration to 1.68 Mach:

Power was reduced to military for the deceleration with 69,500 pounds of fuel remaining. Transfer from No. 7 tank was in progress and the automatic sequencing was still operating satisfactorily. At approximately 1.7 Mach, the throat wheels were moved to the 1.67 Mach position to fully open the inlet. No change in engine instruments could be detected during the throat movement.

11. Ram Purge Tests at 1.68 Mach at 50,000 Feet:

With speed and altitude stabilized, the pressure dump switch was actuated to open a 25 square inch opening into the cabin so that automatic actuation of the ram air scoop could be checked. The cabin altitude immediately began to go up and reached 35,000 feet in 20 seconds. Both pilots' pressure suits inflated slightly. The maximum cabin altitude was 40,000 feet but decreased rapidly as the ram air scoop extended. The pilot manually selected the "purge" position for the ram air scoop as cabin altitude neared 40,000 feet. However, it appeared that the ram air scoop was completely extended an instant earlier and his action only acted as a safeguard. The cabin altitude stabilized at 33,000 feet until the pressure dump switch (25 square inch hole) was closed and then the cabin stabilized at 31,000 feet. The "repressurize" switch was actuated to retract the ram air scoop and return the cabin pressurization to normal. The scoop operated satisfactorily and the cabin altitude dropped to approximately 6,500 feet.

12. Deceleration to, and Airstarts at, 1.4 Mach at 41,000 Feet:

Military power was set for the deceleration. The No. 8 fuel tank was turned on manually to empty the tank and it transferred normally. No attempt was made to obtain automatic fuel sequencing from tank No. 8. At 1.4 Mach, both bypass doors were opened to 700 square inches and stabilized and then reset at 400. No engine or

trim changes were noted. The pilot made afterburner light offs on two engines while the bypass doors were in transit without causing any problems. The wing tips were raised to 25° and the speed and altitude were stabilized for engine air start tests. Because of close proximity to Edwards, these tests had to be performed in a slight turn. The No. 1 engine rpm was unlocked and the throttle retarded to military then idle. Rpm showed 76.5% - EGT 230° - nozzle 71%. When the throttle was placed in "cut off", the rpm only dropped to 75% and EGT to 160°. Maximum afterburner was set on the other five engines to hold speed and altitude. It was not detected at the time but it appears that this engine did not cut off because of a throttle malfunction. There was very little change in rpm and EGT when the throttle was cut off and when the throttle was placed in idle for restarting. After the supposed restart the throttle was advanced and engine response was normal. Power was reset on No. 1 engine and the No. 3 engine rpm unlocked and the throttle retarded to military then to idle. Rpm and EGT were 76% and 220° at idle. The throttle was then placed in the cut off position and rpm and EGT dropped to 67% and 90°. With the No. 3 engine cut off, the left bypass doors were opened from 400 square inches to 700 and after 10 seconds closed back to 400. Again no engine or trim changes could be detected. The light off on No. 3 engine appeared normal and occurred approximately 20 seconds after the throttle was placed in idle. The starting EGT was low.

13. Deceleration From 1.4 Mach and Descent to 25,000 Feet:

Engines 1, 2, 5 and 6 were retarded to idle and engines 3 and 4 were set at 89% rpm and a descent of approximately 400 KIAS established. The descent angle appeared quite steep and the rate of descent was high. Near 1.05 Mach, the bypass door control wheels were moved full aft to close the doors. The right bypass doors indicated full closed; however, the left bypass doors still indicated a 40 square inch opening. During the steep descent, P_1 hydraulic system indicated 138% but recovered to a normal indication after level off. The fuel quantity indicating system is also apparently affected by fuselage attitude. Total fuel indicated 43,500 pounds and tank No. 1 indicated 4,100 pounds just prior to the descent. Three minutes later in the descent, total fuel indication was 44,000 pounds and No. 1 tank indicated 4,400 pounds. The wing tips were returned to the up position and all augmentation turned off at .95 Mach. The pilot commented on the noticeable increase in aileron sensitivity after the wing tips came up. Instrumentation data remaining near the end of the descent was 15% digital and 25% analog.

14. Airstarts at 0.8 Mach:

The airplane was stabilized at 0.8 Mach and 25,000 feet for airstarts on No. 1 and No. 3 engines. The No. 1 engine was set at

military power and a snap deceleration to idle accomplished. Idle rpm and EGT stabilized at 62% and slightly under 200°. When the throttle was retarded to cut off, the rpm did not change. The EGT had gradually dropped to 160° but no change was noted at the time the throttle was moved to cut off. The airstart switch was turned on and when the throttle was moved to idle the rpm suddenly dropped to 34%. The throttle was immediately placed in cut off as it appeared that the throttle had been hung up and again had not shut the engine down. Windmill rpm and EGT stabilized at 31% and 90° with the throttle in cut off. When the throttle was placed in idle for restart, the rpm suddenly dropped from 31% to 28%. The light off occurred in approximately 30 seconds, followed by a peak EGT of 320°. For a short time, contact was lost with Data Control and it was decided to eliminate the last 25,000 feet airstart since fuel was beginning to get low. The No. 3 fuel tank was down to 27,000 pounds and was not being replenished since all other tanks were essentially empty.

15. Descent:

Engines 1, 2, 5 and 6 were retarded to idle and No. 3 and No. 4 engines were set at 89% rpm. Speed was maintained around 400 KIAS. After passing 15,000 feet, speed was decreased and the flaps were lowered and followed shortly by the landing gear. The hydraulic quantities were checked just prior to gear extension and indicated P_1 180% - P_2 145% - U_1 153% and U_2 195%. Approximately three minutes after the landing gear locked down, a hydraulic quantity check showed U_1 down to 90% but all others normal. The planned airspeed pace with a T-37 at 15,000 feet was eliminated from the flight plan because of fuel consideration; however, turbulence would have prevented it being accomplished. Both pilots raised their helmet visors and turned off the nitrogen vent in preparation for landing.

16. Approach and Landing:

After entering the pattern on a wide base leg, the airplane was turned over to me and I flew the base leg and the final approach until 3 miles from the runway. While holding 240 KIAS, turbulence was encountered and seemed to have a big effect on the airplane. It is surprising how much turbulence is felt in the airplane. The pilot began flying the airplane again approximately 3 miles out on final for runway 04 and turned on FACS for a short time because of the turbulence. However, he reported that no difference in flying qualities could be detected in that short time period. FACS was off during the remainder of the final approach and landing. Estimated flare speed obtained from Data Control was 189 KIAS and the Tower reported the wind to be a right crosswind at approximately 30 degrees from runway heading at 14 knots velocity. The crosswind and turbulence caused pilot effort to be high during the flare and touchdown. The touchdown occurred at approximately 180 KIAS and was so smooth that it was

difficult to tell the instant of ground contact. The braking parachute was deployed between 150 and 140 KIAS and jettisoned near 60 KIAS. The airplane deceleration was very noticeable although only two parachutes blossomed. Brake chatter was very apparent near the end of the landing roll as speed slowed below 25-30 knots.

17. After Landing:

While still on the runway, all engines except No. 5 were run up to military power. The No. 5 engine nozzle indicator showed full close, therefore, that engine was cut off. Digital data remaining indicated zero after landing. The sump low level warning light illuminated with 19,000 to 20,000 pounds of fuel remaining. I taxied the airplane approximately one mile while returning to the run station. Steering response was good but brake chatter was very disconcerting. All engines were shut down after taxiing into the run station. Indicated fuel remaining was 28,000 pounds total with 16,800 pounds in No. 3 tank.

18. Maintenance Discrepancies:

a. The master caution light gave many false warnings.

19. b. The landing gear failed to fully retract on the first attempt and required 55 seconds to lock up on the second attempt.

c. The No. 1 throttle appeared to hang up on two occasions when attempting to shut down the engine.

d. One of the tank No. 3 booster pumps was inoperative prior to flight.

e. A small leak existed in the ten port hydraulic valve prior to flight.

f. The pilot and copilot Mach and altitude tapes failed momentarily while at 1.8 Mach and 50,000 feet and then the copilot altitude tape stuck at 50,000 feet for the remainder of flight.

g. The No. 5 engine nozzle went fully closed after landing.

h. The No. 1 engine utility hydraulic pump status light was inoperative throughout the flight.

i. The left bypass indicated 40 square inches after setting manual wheel to full close.

19. Copilot's Summary:

1. Airplane stability appeared to be good out to the maximum speed attained with augmentation "ON" or "OFF".

2. Lateral directional oscillations are easily excited by aileron inputs.

3. Airplane acceleration was very slow between 1.0 and 1.3 Mach with approximately 10 minutes being required to go from 1.0 at 35,000 feet to 1.3 at 39,000 feet.

4. Extension of the ram air scoop was satisfactorily checked at 1.68 Mach and 50,000 feet. All other environmental control systems were satisfactory.

5. Bypass door and throat operation was excellent and caused no detectable engine or trim changes. The response to manual bypass wheel movement is very rapid. The check list and flight plan holder on the copilot's legs cause some interference with the throat and bypass wheels between his legs. On one occasion, the right bypass wheel was inadvertently moved causing the bypass door to open slightly more than desired.

6. Airstarts at 1.4 and 0.8 Mach were satisfactory although a probable throttle malfunction initially caused some question on engine characteristics.

7. All fuel tanks (Nos. 1, 2, 4, 6 and 7) except No. 8 transferred automatically into the No. 3 tank. The No. 8 tank was turned on manually, therefore, no opportunity occurred to check automatic sequencing on that tank.

8. The U_1 hydraulic quantity dropped from 153% to 90% when the landing gear was extended for landing. All other hydraulic indications were satisfactory throughout the flight.

9. Several hydraulic pump status lights were slow to indicate correctly after engine start.

10. Considerable difficulty was experienced in completing hydraulic fluid service prior to disconnecting ground hydraulic carts.

11. Brake chatter still occurred when the brakes were applied during taxi or landing roll-out below 25 knots.

12. Brake release for takeoff was still rough but of considerably less magnitude than on Flight No. 6.

13. Airplane response to turbulence is high.

14. Engagement of FACS on final approach made no apparent change in handling qualities.

15. Airplane touchdown was excellent even under conditions of turbulence and crosswind.

16. Fuselage attitude appears to have an effect on both fuel and hydraulic quantity indications.

17. Digital data was depleted and analog data was near depletion at the end of the flight.

18. Only two of the three landing parachutes blossomed.

19. A sonic boom measurement was obtained at approximately 1.8 Mach and 50,000 feet.

20. The electrical system gave satisfactory operation.

21. Wing tip operation was satisfactory.

22. TACAN and UHF operation appeared satisfactory.

23. The consumption rate on water, ammonia and liquid nitrogen appeared to be satisfactory.

VI. CONCLUSIONS:

1. Mission objectives were successfully achieved. The ram air scoop operational test at 1.68 Mach and the engine airstarts at 1.4 and 0.8 Mach were successful functional tests.

2. The aircraft systems which gave overall satisfactory operation are:

Flight controls	Fuel
Flaps	Engines
Hydraulics	Ram air scoop
Environmental	Wing tip fold
Electrical	Nose wheel steering
Oxygen	Instrumentation
AICS	Fire Detection
Communications	IFF
TACAN	

3. Several hydraulic pump status indicators were slow to indicate correctly during engine start. Considerable difficulty was experienced in completing hydraulic fluid service prior to disconnecting ground hydraulic carts.

4. Brake chatter was excessive during aircraft taxi both in the 20 to 30 knot range and when stopping the aircraft. Brake release for takeoff was still rough but of considerably less magnitude than on Flight No. 6.

5. Engine speed roll-back occurred prior to lighting the afterburner on No. 4 engine. No. 1 engine failed to shut down when the throttle was retarded to the cutoff position during airstart tests at 0.8 and 1.4 Mach.

6. The landing gear failed to retract on the first attempt.

7. The environmental control system did not maintain the cabin pressure altitude to 8,000 feet as designed.

8. A circuit breaker cutout caused failure of the altitude readout on the copilot's vertical scale indicator.

9. Airplane stability appeared to be good with FACS on or off. Lateral directional oscillations are easily excited by aileron inputs.

10. Automatic fuel transfer from tanks 1, 2, 4, 6 and 7 was successful. As planned, tank No. 8 was manually controlled.

11. Bypass door and throat panel operations were excellent and caused no detectable engine or trim changes.

12. The U_1 hydraulic indicated quantity dropped from 153% to 90% when the landing gear was extended for landing.

13. Airplane response to turbulence is high. Engagement of FACS on final approach made no apparent change in handling qualities. Landing touchdown was excellent even under conditions of turbulence and crosswind.

14. Only two of the three landing drag chutes blossomed.

15. The main landing gear actuator upper pin failed from metal fatigue.

16. Axle deflections with heavy nose gear loads caused nose gear torque tube rubbing.

VII. RECOMMENDATIONS:

1. Investigate the cause of the failure of the landing gear to retract. Conduct further gear retractions to increase gear retraction confidence and to verify the gear sequence change.

2. Investigate the engine speed roll-back condition on No. 4 engine.

3. Eliminate the heavy brake chatter which occurs when the brakes are applied at low speed and revise brake system or procedure to allow smooth release when beginning the takeoff roll.

4. Correct the cabin pressure regulating system to maintain the design pressure altitude.

5. Reduce the lateral control sensitivity.

6. Make necessary changes to the drag chute system to insure all three chutes will inflate at deployment.

7. Review for possibility of improving hydraulic servicing procedures.

8. Eliminate or minimize crossflow between utility hydraulic systems under normal operating conditions.

9. Improve the hydraulic pump status lights to give more rapid and reliable indications of changes in pump status.