Normal Procedures

SECTION II

TABLE OF CONTENTS

	PAGE NO.
Introduction	2-1
Preparation for Flight	2-1
Preflight Check	2-1
Captive Taxi and Flight	2-6
Prelaunch	2-7
Ballistic Control and Reaction Augmentation System Operation	2-12
Launch	2-12
Flight Characteristics	2-12
Engine Operation	2-12
Engine Burnout	2-12
Shutdown Procedure	2-14
Aborted Launch	2-14
Descent	2-14
Before Landing	2-14
Landing	2-14
After Landing	2-14
Before Leaving Airplane	2-15

INTRODUCTION.

The research mission of the X-15 requires flexibility of operation; for this reason, the procedures presented in Section II are subject to change. The procedures presented are for a typical mission, and do not reflect any special research requirements.

PREPARATION FOR FLIGHT.

PILOT-COCKPIT COMPATIBILITY.

For efficient flying of the airplane and to ensure optimum escape conditions if ejection is necessary, the pilot-cockpit compatibility adjustments must be accomplished as outlined in the X-15 Maintenance Manual, Report No. NA-58-770.

FLIGHT RESTRICTIONS.

Refer to Section V for detailed airplane and engine limitations.

WEIGHT AND BALANCE.

Refer to Section V for weight and balance limitations. For loading information, refer to Weight and Balance Technical Manual, T.O. 1-1B-40.

ENTERING COCKPIT.

When the airplane is in place on the pylon of the carrier airplane, the cockpit can be entered from either side. A hydraulically operated, adjustable stand is raised to the cockpit ledge to permit normal entry to the cockpit. (See figure 2-1.)

WARNING

If the pilot prebreathes 100 percent oxygen, the visor must not be opened at any time during ground or flight operation.

PREFLIGHT CHECK.

BEFORE EXTERIOR INSPECTION.

Check Form 781 for engineering status and to make sure that the airplane has been serviced for the scheduled mission. (See figure 1-16 for servicing points.)

EXTERIOR INSPECTION.

Because of the mission of this airplane and the personal equipment used by the pilot, it is not feasible for the pilot to perform an exterior inspection.

CANOPY AND EJECTION SEAT CHECK.

Before entering cockpit, check canopy and ejection seat as follows:

1. Canopy ejection mechanism - Check.

   Open canopy fully to visually check canopy remover mechanism and that initiator ground safety pins are

ENTERING COCKPIT

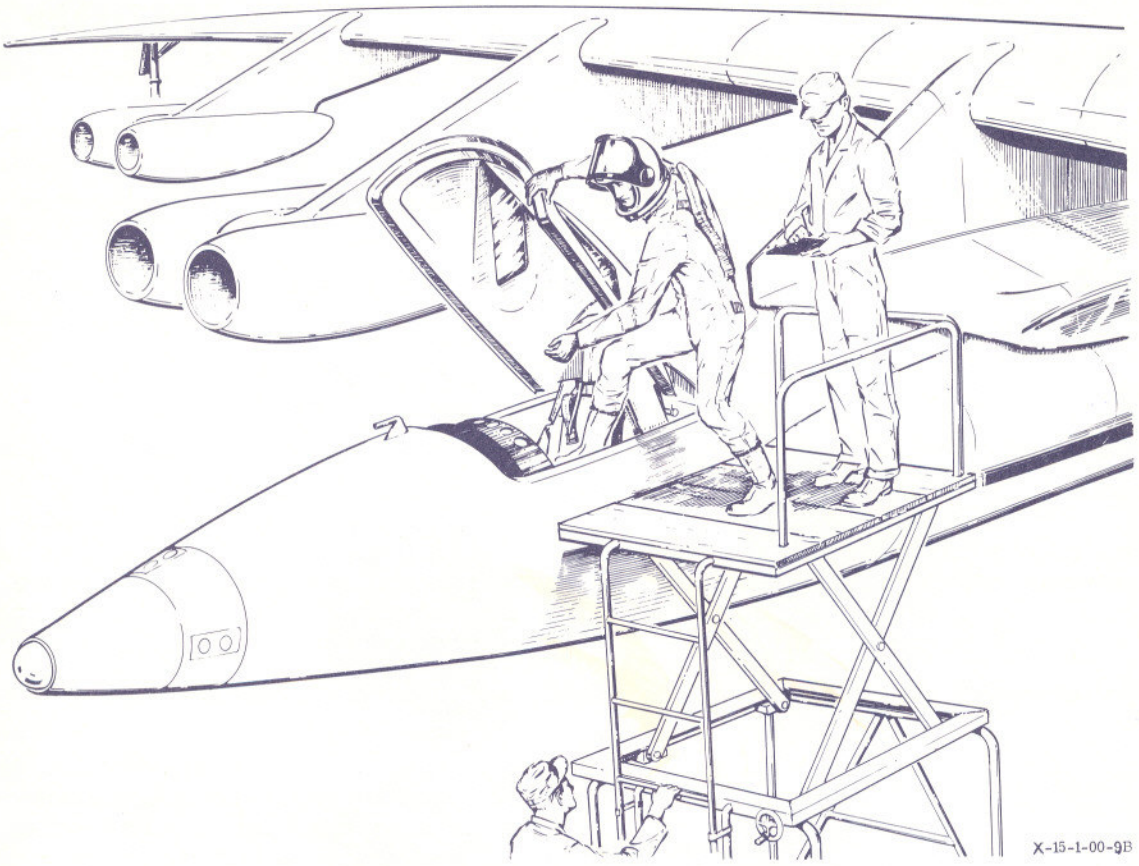


Figure 2-1

installed. Also check tubing and fitting from canopy initiators to canopy remover.

2. Foot restraints - Check visually.

   Check that foot restraints are in the open position.

3. Ejection seat safety pins - Check visually.

   Check that ejection seat safety pins are installed in seat initiators. Also check tubing and fittings from initiators to seal ejection catapult.

4. Canopy external handle and external emergency jettison handle - Check.

   Make sure canopy external manual and emergency jettison handles are stowed properly and that door is closed.

5. Ejection handles - Down and latched.

INTERIOR CHECK.

Before the interior check of the cockpit is made, certain instrument readings must be checked. (See figure 2-2.)

Personal Equipment.

Before the interior check of the cockpit is made, the following personal equipment should be connected and adjusted with the aid of ground personnel:

1. Pressure suit integrated harness - Attach harness to parachute risers and shoulder harness straps.

2. Integrated restraint harness - Fasten to seat.

3. Emergency oxygen system actuating cable - Connected.

   Check that the emergency oxygen system actuating cable is connected to the right-hand seat ejection handle.

4. Personal equipment quick-disconnect - Insert and lock.

COCKPIT INSTRUMENT READINGS AFTER SERVICING

NOTE
All readings are based on requirements for a full-duration mission.

INSTRUMENT		LOW	NORMAL	HIGH	REMARKS
PROPELLANT SOURCE PRESSURE GAGE		3500	3500 to 3600	3600	High limit is below minimum relief valve setting.
H_2O_2 SOURCE AND PURGE PRESSURE GAGE (BOTH POINTERS)		3500	3500 to 3600	3600	
APU SOURCE PRESSURE GAGE (BOTH POINTERS)		3600	3700 to 3900	3900	High limit is below minimum relief valve setting.
CABIN HELIUM SOURCE PRESSURE GAGE		3500	3500 to 3600	3600	
HYDRAULIC TEMPERATURE GAGE		−55°C	−30° to 50°C	95°C	During hydraulic servicing, hydraulic cart should be hooked up and fluid circulated to maintain temperature within limits shown. Hydraulic pressure should be maintained within limits shown.
HYDRAULIC PRESSURE GAGE (BOTH POINTERS)		3200	3400 to 3600	4500	
AC VOLTMETERS		190	190 to 210	210	Limits shown are required for proper operation of airplane components and are controlled by ground cart output.
PILOT'S OXYGEN PRESSURE GAGE		2950	2950 to 3300	3300	
H_2O_2 TANK AND ENGINE CONTROL LINE PRESSURE GAGE	"C" POINTER	575	575 to 600	620	High limit indicates excessive regulator leakage.
	"T" POINTER		0		Tank vented.

X-15-1-51-10

Figure 2-2

When the pressure suit quick-disconnect is inserted and locked, oxygen, communication, and ventilated suit leads are mated and connected.

5. X-15 LN_2 supply switch - Check OPEN.

   Confirm with launch operator that the switch is OPEN.

6. Rudder pedals.

7. Pilot's oxygen system selector - B-52.

8. Physiological package wiring - Connect.

After connecting and adjusting personal equipment, make a left-to-right check of the cockpit by sections as shown in the paragraphs that follow.

NOTE

Electrical power will be supplied from the carrier airplane at this time.

Left Console.

1. Pressure suit ventilation knob - As desired.
2. Vent suit heater switch - HIGH or LOW, as desired.
3. Radio controls - OFF.
4. Face mask heater switch - OFF.
5. Intercom switch - ON.
6. Antenna selector switch - As desired.
7. Trim control switch - Normal.
8. Ready-to-launch switch - OFF.
9. Wing flap switch - UP.
10. Jettison trim switch - OFF (Center).
11. Speed brake handles - CLOSED (forward).

12. Ballistic control stick - Check attachment and freedom of movement.
13. RAS function switches - STANDBY.
14. RAS accelerometer switch - OFF.
15. Vent, pressurization, and jettison control lever - VENT.

    The vent valve on the NH_3 tank will be manually closed before flight, to prevent losing NH_3 during captive flight. When the vent, pressurization, or jettison control lever is placed in the PRESSURIZE or JETTISON position and then back to VENT, the NH_3 vent valve will then be open.

16. Throttle - OFF.
17. Jettison stop switches - STOP.

    Check that all three switches (LOX, H_2O_2, and NH_3) are in the STOP position.

18. Auxiliary launch switch - OFF (guard down).
19. Landing gear handle - IN.

Instrument Panel (Engine Instruments).

1. Propellant emergency pressurization switch - OFF.
2. Ignition-ready light - Check OFF.
3. No-drop caution light - Check OFF.
4. Idle-end caution light - Check OFF.
5. Valve malfunction caution light - Check OFF.
6. Stage 2 ignition malfunction caution light - Check OFF.
7. Turbopump overspeed caution light - Check OFF.
8. Engine vibration malfunction caution light - Check.
9. Fire-warning light - Check OFF.
10. Helium release selector switch - OFF.
11. Engine master switch - OFF.
12. Engine reset button - Check.
13. Engine precool switch - OFF.
14. Engine prime switch - OFF.
15. Turbopump idle button - Check.
16. Igniter idle switch - OFF.
17. Propellant tank pressure gage - Check.
18. Propellant pump inlet pressure gage - Check.
19. Fuel line low caution light - Check.
20. Propellant manifold pressure gage - Check.
21. H_2O_2 compartment-hot caution light - Check OFF.
22. Chamber and stage 2 igniter pressure gage - Check.
23. Liquid oxygen bearing temperature gage - Check.

Instrument Panel (Flight Instruments).

1. Pilot's oxygen-low caution light - Check.
2. Accelerometer - Set and check.
3. Azimuth indicator - Set.
4. Altimeter - Set.
5. Attitude indicator - Set.
6. Fuel quantity gage knob - Check.
7. Pitch angle set knob - As required.

Instrument Panel (Electrical, Hydraulic, and Cockpit).

1. Emergency battery switch - OFF (guard down).
2. No. 1 generator-out light - Check OFF.
3. No. 2 generator-out light - Check OFF.
4. No. 1 and No. 2 generator switches - OFF.
5. APU No. 1 switch - OFF.
6. APU No. 1 warning and caution lights - Check OFF.
7. No. 1 ballistic control switch - OFF.
8. No. 2 ballistic control switch - OFF.
9. APU No. 2 warning and caution lights - Check OFF.
10. APU No. 2 switch - OFF.
11. APU H_2O_2 pressure gage - Check 0 psi.
12. Clock - Check and set.
13. Mixing chamber temperature gage - Check.
14. APU bearing temperature gage - Check.
15. Cabin pressure altimeter - Check.

Center Pedestal.

1. Pitch function switch - STDBY.
2. Roll function switch - STDBY.

3. SAS test switch - Check OFF.
4. "Yar" function switch - STDBY.
5. Yaw function switch - STDBY.
6. SAS caution lights (four) - Check ON.
7. SAS gain selector knobs - Set.

   Set the gain selectors at the following: Pitch, 8; roll, 6; yaw, 8.
8. Ball nose test button - Check.
9. Research instrumentation - Set as required for mission.
10. Engine oscillograph record switch - As required.
11. Ram-air lever - CLOSED.
12. Radar beacon switch - As required.
13. Stable platform instrument switch - ON.
14. Engine vibration recorder switch - OFF.
15. Cockpit ram-air knob - OFF (in).
16. DC voltmeter selector switch - BUS.
17. DC voltmeter - Check.

Right Console.

1. Canopy emergency release handle - IN.
2. Stable platform power switch - EXT.
3. Nose ballistic rocket heater switch - OFF.
4. Ventral arming switch - DE-ARM.
5. Cockpit lighting switch - OFF.
6. Indicator, caution, and warning light switch - NORMAL.
7. Fire-warning light test button - Push to test.

   Fire-warning light ON indicates continuity of detection circuit.
8. Windshield heater switches (two) - OFF.
9. Circuit-breaker panel - Check circuit breakers as required.
10. Restraint emergency release handle - IN.
11. Pressure cooling lever - OFF.
12. No. 1 blower switch - OFF.
13. No. 2 blower switch - OFF.
14. Cabin source helium shutoff valve switch - OFF.
15. APU cooling switch - SINGLE.
16. Alternate cabin pressurization switch - IN.
17. Console control stick - Check attachment and freedom of movement.
18. Center control stick - Check attachment and freedom of movement.
19. Alternate trim switch - Centered.

    Check alternate trim switch on the center control stick for freedom of operation.
20. Windshield purge handle - OFF (down).
21. Windshield anti-fogging handle - OFF (down).

Interior Inspection Operational Check.

1. Augmented cooling system - ON.

   Refer to "Operation of Ram-air and Augmented Cooling System (Captive Flight)" in Section IV.
2. Oxygen system - Check.

   Check that breathing oxygen is being supplied from the carrier airplane.
3. Face mask heater - Check.

   Move face mask heater switch to HI and check operation, then move switch to OFF.
4. Intercom - Check.

   Check communication between carrier airplane and X-15 Airplane.
5. DC voltmeter switch - BUS.
6. Calibrate instrumentation.
7. Launch light - Test.

   Push to test launch light; have verification from carrier pilot and launch panel operator.
8. Indicator, caution, and warning lights - Check.

   Place the indicator, caution, and warning light test switch at TEST. All indicator, caution, and warning lights (except the fire-warning light) will come on; this is only a test of the bulbs.
9. Ground safety pins - Removed.

   Have crew chief remove the six ground safety pins and display pins.
10. Close canopy.

COCKPIT INSTRUMENT READINGS BEFORE TAKE-OFF

NOTE
All readings are based on requirements for a full-duration mission.

INSTRUMENT		LOW	NORMAL	HIGH	REMARKS
PROPELLANT SOURCE PRESSURE GAGE		3300	3500 to 3600	3900	Low limit is minimum pressure required for full-duration mission. High limit is maximum pressure relief valve setting.
H_2O_2 SOURCE AND PURGE PRESSURE GAGE (BOTH POINTERS)		3000	3500 to 3600	3900	
APU SOURCE PRESSURE GAGE (BOTH POINTERS)		3300	3600 to 3900	4200	
CABIN HELIUM SOURCE PRESSURE GAGE		3300	3500 to 3600	3900	Relief valve set for 3900 maximum.
HYDRAULIC TEMPERATURE GAGES		−125°C	−75°C to 0°C	95°C	Temperature below low limit can cause excessive pressure drop and restriction of flow.
AC VOLTMETERS		190	190 to 210	210	Limits shown are required for proper operation of airplane components.
H_2O_2 TANK AND ENGINE CONTROL LINE PRESSURE GAGE	"C" POINTER	575	575 to 600	620	High limit indicates excessive regulator leakage.
	"T" POINTER		0		Tank vented.
PROPELLANT TANK PRESSURE GAGE	"A" POINTER	0	0 to 30	68	Vent valve manually closed.
	"L" POINTER		0 to 5		Tank vented.

X-15-1-51-11

Figure 2-3

CAPTIVE TAXI AND FLIGHT.

TAXI.

1. SAS function switches - Check.

   Move SAS function switches to ENGAGE and check; functions should trip during taxiing because of carrier airplane motions and no hydraulic pressure. Return function switches to STDBY after each function trips.

2. Radar beacon switch - ON.

BEFORE TAKE-OFF.

Before take-off of the carrier airplane, recheck the following:

1. Ram-air lever - CLOSED.
2. N_2 or helium release switch - AUTO.
3. Jettison stop switches - STOP.
4. Instrument Reading - Check.

   See figure 2-3 for proper instrument readings.

TAKE-OFF

During take-off, monitor all instruments, and relay to the carrier pilot or launch operator any information that could affect the planned mission.

1. Ventral arming switch - ARM.
2. Windshield heater switches - ON.
3. Engine master switch - ON.
4. Engine reset button - Push (one second).
5. Engine precool switch - PRECOOL.

   Precool the engine for 10 minutes on, then 20 minutes off, as instructed by ground control.

CLIMB.

After take-off, during the climb and cruise part of the flight, the liquid oxygen tanks of the X-15 Airplane will be topped off from the carrier airplane.

1. Instrument power switch - ON.
2. Telemetering power switch - ON.
3. Course indicator - Check operation.
4. Face mask heater switch - As required.
5. Communications - Check.

   Confirm radio communication with chase plane and ground station, and also that communication is available between X-15 Airplane, chase plane and carrier airplane, and chase plane and carrier airplane with ground station.

6. Liquid oxygen top-off cycle - Check.

   Confirm that liquid oxygen top-off from the carrier airplane liquid oxygen climb tank is satisfactory.

7. Hook heater - Confirm ON.

   Confirm with launch operator that hook heater is ON.

8. Nose ballistic rocket heater switch - ON.
9. Blower switches - OFF (15,000 feet).

   Move blower switches to OFF at 15,000 feet altitude.

10. Ram-air lever - OPEN.

CRUISE-CLIMB TO LAUNCH ALTITUDE.

During cruise-climb to launch altitude, the pilot of the carrier airplane will start the time-to-go sequence. Confirm with the launch operator that the liquid oxygen top-off is satisfactory and that the liquid oxygen cruise tank has been started to complete the top-off.

At start of climb from 35,000 feet cruise altitude to 45,000 feet launch altitude, accomplish the following:

1. Ram-air lever - CLOSED.
2. Blower switches - BLOWER ONLY.

NOTE

If cabin pressure of 35,000 feet is not maintained during climb to 45,000 feet move blower switches to BLOWER & LN_2.

Engine Check.

Check and report the instrument readings. If instruments are not within limits, check with ground control for alternate mission if below limit.

NOTE

Values exceeding limits noted may indicate regulator failure.

PRELAUNCH.

BEFORE COUNTDOWN.

Before countdown, check location and time to go; then complete final cockpit check as follows:

1. Engine precool switch - OFF.

   After precooling is completed, return precool switch to OFF.

NOTE

If a delay in launch is required, the engine can be maintained in a precooled condition for an extended period of time by moving the engine precool switch to PRECOOL for approximately 7-1/2 minutes every 20 minutes.

2. Ram-air lever - CLOSED.

WARNING

The oxygen supply to the pressure suit helmet must be on and the helmet visor must be down before the cockpit is pressurized with nitrogen.

3. Cabin source helium shutoff valve switch - CLOSED.
4. Pressure cooling lever - ON.
5. APU cooling switch - NORMAL.
6. Blower switches - BLOWER & LN_2.
7. Oxygen system - Switch from carrier supply to X-15 Airplane supply.

   Rotate oxygen selector valve on seat leg guard to X-15 Airplane. Check for oxygen flow.

8. X-15 LN_2 supply switch - Check CLOSED.

   Confirm with the launch operator that the switch is CLOSED.

9. Inertial height indicator - Set.

10. Ventral arming switch - ARM.

11. Intercom switch - OFF.

12. Communications - Check.

    Check communications with ground station, carrier pilot, and chase pilot.

13. Intercom switch - ON.

14. APU No. 1 - Start.

    As APU No. 1 comes up to speed, hydraulic pressure will increase to as much as 4500 psi for a short time. However, pressure should stabilize at 3200 to 3400 psi within 30 seconds after APU No. 1 starts.

15. APU No. 2 - Start.

    As APU No. 2 comes up to speed, hydraulic pressure will increase to as much as 4500 psi for a short time. However, pressure should stabilize at 3200 to 3400 psi within 30 seconds after APU No. 2 starts.

16. No. 1 generator switch - ON.

    Move No. 1 generator switch momentarily to RESET, then to ON. Check No. 1 generator voltage.

17. No. 2 generator switch - ON.

    Move No. 2 generator switch momentarily to RESET, then to ON. Check No. 2 generator voltage.

18. No. 1 and No. 2 generator-out lights - OUT.

19. DC voltmeter selector switch - STRAIN-GAGE.

20. DC voltmeter switch - BUS.

    Check voltage on dc voltmeter.

SAS IN-FLIGHT CHECK.

Before launch, perform the following functional check of the SAS system.

1. "Yar" function switch - STDBY.

2. Gain selector knobs - Set.

   Set the gain selectors at the following: yaw, 8; pitch, 6; roll, 8.

3. Yaw, pitch, and roll function switches - ENGAGE.

   Check that the yaw, pitch, and roll caution lights are out.

4. SAS test switch - WORK, then OFF.

   Move SAS test switch to WORK and check that the SAS yaw, pitch, and roll caution lights blink continuously; then release switch to OFF.

5. Yaw, pitch, and roll function switches - OFF, then ENGAGE.

   When the switches are moved to OFF, check that the caution lights burn steadily; then move the switches to ENGAGE, and check that caution lights go out.

6. SAS test switch - MON, then OFF.

   Move SAS test switch to MON, and check that the SAS pitch yaw, pitch, and roll caution lights blink continuously; then release switch to OFF.

7. Yaw, pitch, and roll function switches - OFF, then ENGAGE.

   When switches are moved to OFF, check that the caution lights burn steadily; then move the switches to ENGAGE, and check that the caution lights go out.

NOTE

If a SAS malfunction is suspected during flight, the pilot can perform the preceding check at his discretion. The SAS check may be performed on any one function or a combination of pitch, roll, and yaw functions.

COUNTDOWN.

1. Liquid oxygen transfer switch OFF (performed by launch operator) - Check.

2. Fuel quantity gage knob - Set at preselected start point or 100 percent.

3. Instrumentation switches - ON.

4. Ball nose test button - Depress; then release.

   Depressing the ball nose test button electrically simulates a predetermined airplane attitude, and the ball nose should drive to a position that cancels out the signal and causes the angle-of-attack indicator to show about a 5-degree nose-down indication. The sideslip indicator will also read about a 15-degree sideslip to the left. When the button is released, the ball nose should drive to the extreme position and appear as a 40-degree nose-up indication on the attitude indicator and a 30-degree sideslip to the right on the sideslip indicator. These readings should be maintained for 2 to 3 seconds; then the ball nose should resume normal operation, driving rapidly without overshoot to indicate the actual angle of attack and sideslip of the airplane.

NOTE

Since the actual airplane attitude may approximate that of the error signal when the button is pressed, positive indications of proper ball nose operation are full-scale readings obtained on the indicators when the button is released and the subsequent return to normal angle-of-attack and sideslip indications.

5. Instrument readings - Check. See figure 2-4 for proper instrument reading before pressurization.

6. Vent, pressurization, and jettison lever - JETTISON.

   The tests will be conducted concurrently on all three systems (liquid oxygen, ammonia, and hydrogen peroxide).

7. Jettison stop switches - JETT.

   Launch operator will visually check for vapor emitting at the jettison port, and notify X-15 Airplane pilot.

8. Vent, pressurization, and jettison lever - PRESSURIZE.

   When the vent pressurization, and jettison lever is moved to PRESSURIZE, ammonia and liquid oxygen will be supplied to the turbopumps. Hydrogen peroxide will be supplied to the pump emergency cutoff valve.

9. Liquid oxygen top-off flapper valve - Check.

   Obtain confirmation from the launch operator that vaporous oxygen is no longer emitting from the liquid oxygen overboard vent of the X-15 Airplane pylon.

WARNING

If liquid oxygen continues to emit from the pylon vent, indicating that the flapper valve is stuck open, the launch must be aborted.

10. SAS function switches - ON.

11. Flight controls - Check.

    Move all flight controls through allowable travel; receive verbal acknowledgment from the launch operator that all controls are operating properly. Refer to "Launch Limitations" in Section V for allowable travel.

12. Trim system - Check.

    Move horizontal stabilizer through allowable trim travel; receive verbal acknowledgment from the launch operator that trim is operating the stabilizer properly. Refer to "Launch Limitations" in Section V for allowable trim settings.

13. Launch trim - Set.

    Reset launch trim; receive acknowledgment from launch operator.

14. Chamber and stage 2 igniter pressure gage - Check, (both pointers, 0 psi).

15. Data recorder - ON.

16. Engine precool switch - PRECOOL.

    The engine will continue to prime (at high flow rates) until the actual start stops the prime.

17. Engine prime switch - PRIME.

    Move engine prime switch to PRIME for one second, and check ignition ready light ON. Approximately 30 seconds is required to prime, with the prime valve at high-flow orifice position.

NOTE

- If the engine precool switch is off, the engine prime valve is actuated to the low-flow orifice position.
- The prime can be stopped at any time by placing the engine prime switch at STOP PRIME momentarily, then releasing it. This closes the liquid oxygen and NH_3 tank main propellant valves and the H_2O_2 safety valve. The engine is then automatically purged for 17 seconds.

18. Turbopump idle button - Depress for one second.

19. Telemeter and radar switches - Recheck.

20. Communications - Check.

    Check communication with ground station, carrier pilot, and chase pilot.

21. Instruments - Check.

    After pressurization and before launch, check instruments for proper readings. See figure 2-5.

22. Ready-to-launch switch - ON.

    Verbally check with carrier pilot and launch operator that the ready-to-launch light is on.

23. Igniter idle switch - IGNITER.

    Operation of igniter idle is limited to 30 seconds. When the igniter idle switch is placed to IGNITER, the ignition-ready light goes out for 2 seconds while the engine is purged with helium and the igniter spark plugs are energized. When this phase is completed, the ignition-ready light comes on again. When 7 seconds remain of the normal igniter idle phase, the no-drop caution light will come on. With the no-drop caution light on, the pilot must terminate the igniter idle phase (by moving the engine prime switch to STOP PRIME) or continue on to the launch phase.

COCKPIT INSTRUMENT READING BEFORE PROPELLANT SYSTEM PRESSURIZATION

All readings are based on requirements for a full-duration mission.

(APU'S OPERATING)

INSTRUMENT		LOW	NORMAL	HIGH	REMARKS
PROPELLANT SOURCE PRESSURE GAGE		3000	3500 to 3600	3900	Low limit is minimum pressure required for full-duration mission. High limit is maximum relief valve setting.
H_2O_2 SOURCE AND PURGE PRESSURE GAGE (BOTH POINTERS)		2500	3500 to 3600	3900	
APU SOURCE PRESSURE GAGE (BOTH POINTERS)		3000	3500 to 3900	4200	
APU H_2O_2 TANK PRESSURE GAGE (BOTH POINTERS)		500	550 to 610	630	Pressure above high limit indicates faulty regulator.
CABIN HELIUM SOURCE PRESSURE GAGE		3000	3500 to 3600	3900	Low limit is minimum pressure required for 30 minutes operation of air conditioning and pressurization system. High limit is maximum relief valve setting.
HYDRAULIC TEMPERATURE GAGES		−100°C	−75°C to 0°C	95°C	Low limit is minimum temperature for APU starting.
HYDRAULIC PRESSURE GAGE (BOTH POINTERS)		2600 (AT MAX FLOW DEMAND)	3200 to 3400 (STATIC)	4500	4500 is pump relief valve setting and is acceptable for 30 seconds after APU start.
			2900 to 3400 (WITH FLOW DEMAND)	3500	3500 is maximum after 30 seconds after APU start.
APU BEARING TEMPERATURE GAGE (BOTH POINTERS)		25°C	80°C to 130°C	150°C	
MIXING CHAMBER TEMPERATURE GAGE (BOTH POINTERS)		−60°C	−45°C to −35°C	−25°C	Continuous low temperature operation indicates possible injector malfunction, using excessive liquid nitrogen. Temperature increase above −25°C indicates possible injector malfunction or liquid nitrogen depletion. Liquid nitrogen depletion will best be indicated by rapid decrease of cabin helium source pressure.
AC VOLTMETERS		190	195 to 205	210	Limits shown are required or proper operation of airplane components.
LIQUID OXYGEN BEARING TEMPERATURE GAGE		−40°C	−10°C to 30°C	30°C	
H_2O_2 TANK AND ENGINE CONTROL LINE PRESSURE GAGE	"C" POINTER	575	575 to 600	620	High limit indicates excessive regulator leakage.
	"T" POINTER		0		Tank vented.
PROPELLANT TANK PRESSURE GAGE	"A" POINTER	0	10 to 30	68	High limit indicates regulator leakage. Vent valve manually closed.
	"L" POINTER		0 to 5		Tank vented.

X-15-1-51-9

Figure 2-4.

COCKPIT INSTRUMENT READINGS AFTER PROPELLANT SYSTEM PRESSURIZATION

NOTE
All readings are based on requirements for a full-duration mission.

(APU'S OPERATING)

INSTRUMENT		LOW	NORMAL	HIGH	REMARKS
PROPELLANT SOURCE PRESSURE GAGE		2500	3300 to 3400		Low limit is minimum pressure required for full-duration operation.
H_2O_2 SOURCE AND PURGE PRESSURE GAGE (BOTH POINTERS)		2000	2700 to 3200		
PROPELANT TANK PRESSURE GAGE (BOTH POINTERS)		45	45 to 58	68	High limit is high setting of primary relief valve.
PROPELLANT PUMP INLET PRESSURE GAGE	"L" POINTER	45	45 to 58	68	
	"A" POINTER	45	45 to 58	68	Pressure readings applicable only after engine prime sequence is initiated.
APU SOURCE PRESSURE GAGE (BOTH POINTERS)		3000	3500 to 3700		Low limit is minimum pressure required for full-duration mission.
APU H_2O_2 TANK PRESSURE GAGE (BOTH POINTERS)		500	550 to 610	630	Pressure above high limit indicates faulty regulator.
CABIN HELIUM SOURCE PRESSURE GAGE		3000	3300 to 3400		Low limit is minimum pressure required for 30 minutes operation of air conditioning and pressurization system.
HYDRAULIC TEMPERATURE GAGES		−75°C	−75°C to 150°C	230°C	Temperature above high limit will cause seal deterioration.
HYDRAULIC PRESSURE GAGE (BOTH POINTERS)		2600	2900 to 3400	3500	High limit is system relief valve setting.
MIXING CHAMBER TEMPERATURE GAGE (BOTH POINTERS)		−60°C	−45°C to −35°C	−25°C	Continuous low-temperature operation indicates possible injector malfunction, using excessive liquid nitrogen. Temperature above −25°C indicates possible injector malfunction or liquid nitrogen depletion. Liquid nitrogen depletion will best be indicated by rapid decrease of helium source pressure.
AC VOLTMETERS		190	195 to 205	210	Limits shown are required for proper operation of airplane components.
APU BEARING TEMPERATURE GAGE (BOTH POINTERS)		25°C	80°C to 130°C	150°C	
H_2O_2 TANK AND ENGINE CONTROL LINE PRESSURE GAGE (BOTH POINTERS)		550	575 to 600	620	High limit indicates above-normal regulator pressure. Pressures below 575 will result in pressures below the engine specification inlet requirements for full-thrust missions.
LIQUID OXYGEN BEARING TEMPERATURE GAGE		−40°C	−10°C to 30°C	30°C	If bearing temperature is below low limit, launch must be aborted.

X-15-1-51-12

Figure 2-5.

CAUTION

The igniter idle phase must be terminated immediately if the idle-end caution light comes on, as damage to the engine chamber will occur because of insufficient cooling.

24. Chamber and stage 2 igniter pressure gage - Check (short hand, 150 psi in approximately 5 seconds).

25. Ready-to-launch - Countdown by carrier pilot.

BALLISTIC CONTROL AND REACTION AUGMENTATION SYSTEM OPERATION.

Since most missions will involve flight at altitudes where ballistic control system operation will be required to maintain airplane attitude, the ballistic control system should be turned on before launch, in order to be available for use when required. The reaction augmentation system should be turned on as soon as possible after engine burnout. To turn on the ballistic control and reaction augmentation systems, proceed as follows:

1. No. 1 and No. 2 ballistic control switches - ON.
2. Accelerometer switch - AUTO.
3. Reaction augmentation function switches - ENGAGE.
4. RAS-out light - Check out.

LAUNCH.

During launch, the following X-15 Airplane control surface deflections are recommended:

Stabilizer	
Symmetrical deflection	0° to -2° (stabilizer leading edge down)
Differential deflection	0°
Vertical stabilizer	0°
Speed brakes	0° (in)
Flaps	0° (up)

After release from the carrier airplane, proceed as follows:

1. Throttle - Inboard to 50%.

   Throttle must be moved to 50% by the time the idle-end caution light comes on.

2. Chamber and stage 2 igniter pressure gage - Check.
3. Propellant manifold pressure gage - Check.
4. Propellant tank pressure gage - Check.
5. H_2O_2 tank and engine control line pressure gage - Check.

FLIGHT CHARACTERISTICS.

Refer to Section VI for information regarding flight characteristics.

ENGINE OPERATION.

NORMAL INDICATIONS DURING START.

When the thrust chamber is fired, the following indications will be evident in about the sequence given. These indications occur in rapid sequence (about 5 seconds).

1. Turbine whine.
2. Turbine exhaust steam will be seen at the exhaust overboard discharge line.
3. Fuel and liquid oxygen manifold pressure will rise to rated values and will be stabilized by the pump governor.
4. Igniters will be operating.
5. Pressure of the chamber will rise to a point where chamber pressure will be shown on the indicator gage.

   The liquid oxygen and fuel will automatically stop bleeding overboard.

6. Chamber pressure will reach rated value.
7. Thrust chamber will emit a great deal of noise.

ENGINE THRUST CONTROL.

Engine thrust is controlled by movement of the throttle between 50% and 100% thrust. Engine response to throttle movement is very rapid, 50% to 100% in approximately 1.5 seconds.

NORMAL OPERATING CONDITIONS.

See figure 2-6 for proper instrument readings for all systems during powered flight.

ENGINE BURNOUT.

Propellant exhaustion will result in the following:

1. Fuel or oxygen manifold pressure drops, with consequent shutdown by low manifold pressure safety circuit.
2. Fuel manifold pressure drops below oxygen pressure.
3. Engine runs rough or jet flame is unsteady.
4. Pump cavitates with consequent overspeed cutoff.

COCKPIT INSTRUMENT READINGS IN FLIGHT

NOTE
All readings are based on requirements for a full-duration mission.

(ENGINE OPERATING)

INSTRUMENT		LOW	NORMAL	HIGH	REMARKS
H_2O_2 SOURCE AND PURGE PRESSURE GAGE (BOTH POINTERS)		800	3000 (GRADUALLY DECREASING)		Pressure below low limit may result in erratic engine operation.
PROPELLANT TANK PRESSURE GAGE (BOTH POINTERS)		40	45 to 53	68	Upper limit is high setting of pressure relief valve.
PROPELLANT PUMP INLET PRESSURE GAGE	"L" POINTER	35	40 to 70		
	"A" POINTER	35	40 to 55		
APU H_2O_2 TANK PRESSURE GAGE (BOTH POINTERS)		500	550 to 610	630	
CABIN HELIUM SOURCE PRESSURE GAGE			1000 to 3400		Liquid nitrogen nearing depletion when pressure reaches approximately 1000.
HYDRAULIC TEMPERATURE GAGES		−55°C	0°C to 150°C	230°C	Temperature above high limit can cause seal deterioration.
HYDRAULIC PRESSURE GAGE (BOTH POINTERS)		2600	2900 to 3400	3500	Low limit is minimum pressure required for surface deflection at maximum load. High limit is system relief valve setting.
APU BEARING TEMPERATURE GAGE (BOTH POINTERS)		25°C	80°C to 130°C	200°C	Temperature above high limit may cause damage to APU.
MIXING CHAMBER TEMPERATURE GAGE (BOTH POINTERS)		−60°C	−45°C to −35°C	−25°C	Continuous low-temperature operation indicates possible injector malfunction, using excessive liquid nitrogen. Temperature above −25°C indicates possible injector malfunction or liquid nitrogen depletion. Liquid nitrogen depletion will best be indicated by rapid decrease of cabin helium source pressure.
AC VOLTMETERS		190	195 to 205	210	Limits shown are required for proper operation of airplane components.
H_2O_2 TANK AND ENGINE CONTROL LINE PRESSURE GAGE	"C" POINTER	550	575 to 600	620	Pressure below 450 may result in malfunction shutdown. Pressure exceeding high limit indicates regulator malfunction.
	"T" POINTER	550	565 to 600	620	Pressure below 565 is below minimum engine specification H_2O_2 inlet requirements for full-thrust missions.
PROPELLANT MANIFOLD PRESSURE GAGE	"L" POINTER	380	440 to 1050	1200	Pressure above high limit indicates injector blockage. Operation below low limit will result in malfunction shutdown.
	"A" POINTER	435	495 to 1150	1300	
CHAMBER AND STAGE 2 IGNITER PRESSURE GAGE	LONG POINTER	310	345 to 600	630	Operation outside limits shown may result in engine damage.
	SHORT POINTER	315	350 to 630	660	During operation, second-stage igniter pressure should be above main chamber pressure.

X-15-1-51-13

Figure 2-6.

SHUTDOWN PROCEDURE.

To shut down engine, proceed as follows:

1. Throttle - OFF.

   Retard throttle to 50%; then move outboard to OFF.

   NOTE

   The ignition-ready light will go out for approximately 5 seconds. During this time, the engine is purged with helium. After purging, the ignition-ready light comes on. The engine is now on stand-by prime condition. Restart can be made by moving throttle to 50%.

2. Igniter idle switch - OFF.
3. Engine prime switch - STOP PRIME momentarily, then release.
4. Engine master switch - OFF.
5. Vent, pressurization, and jettison lever - VENT.

ABORTED LAUNCH.

If for any reason the decision is made to abort the launch after the countdown has started, proceed as follows:

1. Prime switches or switch - OFF or STOP PRIME.
2. Engine master switch - OFF.
3. No. 1 and No. 2 generator switches - OFF.

   Check that both No. 1 and No. 2 generator-off lights come on.

4. APU switches - OFF.
5. Oxygen selector - B-52.

   Reselect B-52 oxygen supply, and check.

6. Ventral arming switch - DE-ARM.
7. Carrier pilot - Notify.

   Notify carrier pilot and launch operator when launch abort procedure is completed.

CAPTIVE JETTISON.

To jettison fuel from the X-15 Airplane after an aborted launch, proceed as follows:

1. Source pressure - Check.
2. Jettison stop switches - Recheck JETT.
3. Vent, pressurization, and jettison lever - JETTISON.

   Check jettison by pressure bleed on the source pressure gages. Stop jettisoning when propellant source pressure reaches 600 psi.

4. Jettisoning - Check.

   Have chase pilot verify that fuel is jettizoning.

5. Vent, pressurization, and jettison lever - VENT.

   After propellant has been jettisoned, move control to VENT.

DESCENT.

Normally, the descent will be prebriefed, however, it will be constantly monitored and controlled from the ground.

CAUTION

Because of the high rate of descent and the reduced stability at low Mach numbers, the speed brakes are not to be used at full deflection below Mach 1.5.

BEFORE LANDING.

During descent, just before entering the landing pattern, check all controls and instruments for landing.

NOTE

Before landing, preferably on the downwind leg of the landing pattern, but in no case above 17,000 feet above sea level, move vent, pressurization, and jettison lever to PRESSURIZE, to prevent sand and dust from entering the airplane propellant system during landing. The altitude limitation is necessary to preclude structural deformation of the airplane propellant tanks due to a pressure differential which would tend to collapse the tanks.

LANDING.

See figure 2-7 for the recommended landing pattern and procedures. See figure 2-8 for the recommended low speed, low altitude landing pattern.

CAUTION

- To provide ground clearance, the lower ventral must be jettisoned before landing. The ventral should be jettisoned a minimum of 1500 feet above the terrain.
- Directional control is reduced when the lower ventral is jettisoned; however, adequate directional control is available for landing.

AFTER LANDING.

After landing, as soon as the airplane stops, proceed as follows:

1. Canopy - Open.

2. Face plate - Remove.
3. Ram-air door - Close.
4. Wing flap switch - UP.
5. SAS function switches - STDBY.
6. Ventral arming switch - DE-ARM.
7. External power - ON.
8. APU switches - OFF.

   Bleed off hydraulic system pressure. This will help prevent accumulator failure due to slow bleed-down of hydraulic system pressure, especially at elevated temperatures.

9. Speed brake levers - Full aft position.

WARNING

Before operating the speed brakes, be sure the fuselage rear section around the speed brakes is clear, because the brakes operate rapidly and forcefully and could injure any personnel near the brakes.

10. Center control stick - Full forward.
11. Rudder pedals - Actuate.

    Deplete hydraulic pressure by actuating rudder pedals.

BEFORE LEAVING AIRPLANE.

Before leaving the airplane, complete the required airplane forms and then verify the following cockpit control positions:

LEFT CONSOLE.

1. Radio controls - OFF.
2. Intercom control - B-52.
3. Vent suit heater switch - OFF.
4. Wing flap switch - UP.
5. Antenna selector switch - LOWER.
6. Trim control switch - NORMAL.
7. Ready-to-launch switch - OFF.
8. Jettison trim switch - OFF.
9. Speed brake handles - Full forward.
10. Vent, pressurization, and jettison lever - VENT.
11. Throttle - OFF.
12. Jettison stop switches - STOP.
13. Auxiliary launch switch - OFF.
14. Landing gear handle - IN.

INSTRUMENT PANEL.

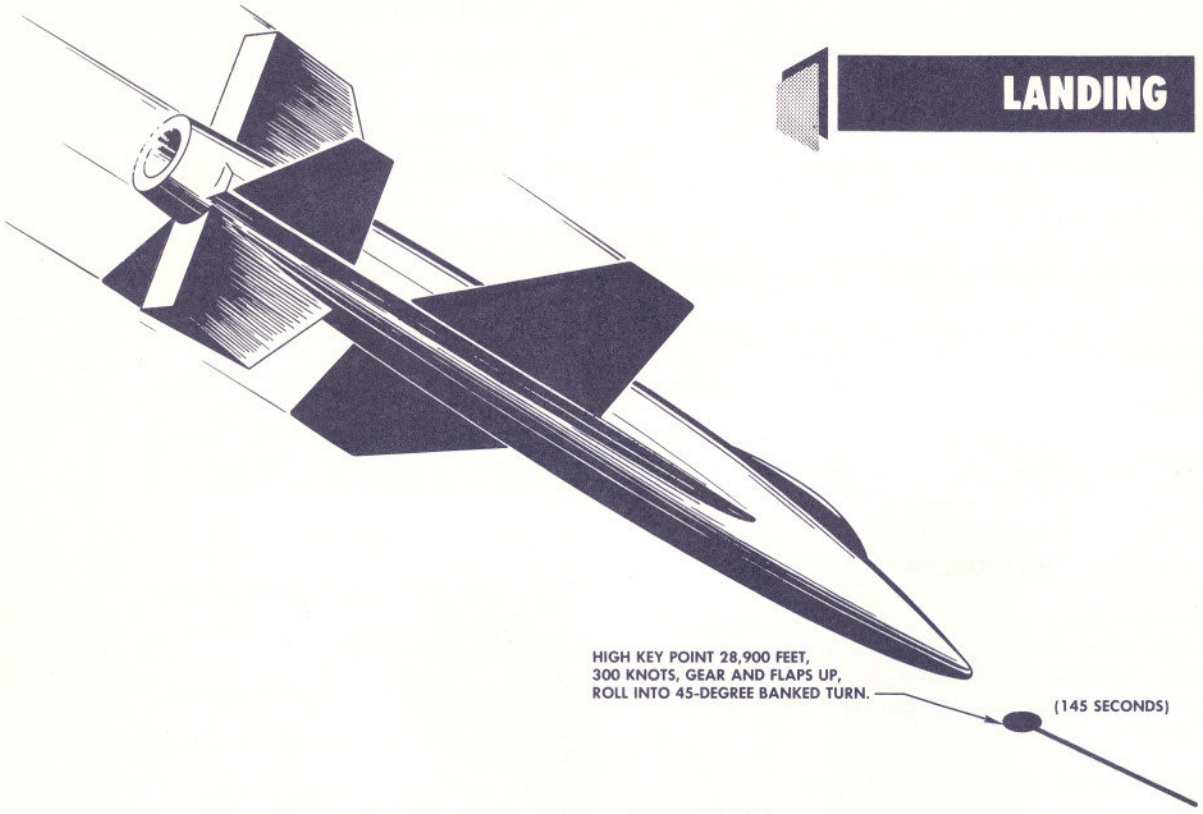
1. Engine master switch - OFF.
2. Emergency battery switch - OFF.
3. Generator switches - OFF.
4. APU switches - OFF.
5. Ballistic control switches - OFF.

CENTER PEDESTAL.

1. SAS function switches - STDBY.
2. Research instrumentation - OFF.
3. Ram-air lever - CLOSED.
4. Cockpit ram-air knob - CLOSED (in).
5. Radar beacon switch - OFF.
6. Stable platform instrument switch - ON.

RIGHT CONSOLE.

1. Canopy emergency release handle - IN.
2. Stable platform switch - OFF.
3. Nose ballistic rocket heater switch - OFF.
4. Cockpit lighting switch - OFF.
5. Indicator, caution, and warning light switch - NORMAL.
6. Windshield heater switches (two) - OFF.
7. Pressure cooling lever - OFF.
8. Blower switches - OFF.
9. All circuit breakers - OFF.


LANDING
HIGH KEY POINT 28,900 FEET,
300 KNOTS, GEAR AND FLAPS UP,
ROLL INTO 45-DEGREE BANKED TURN.
(145 SECONDS)

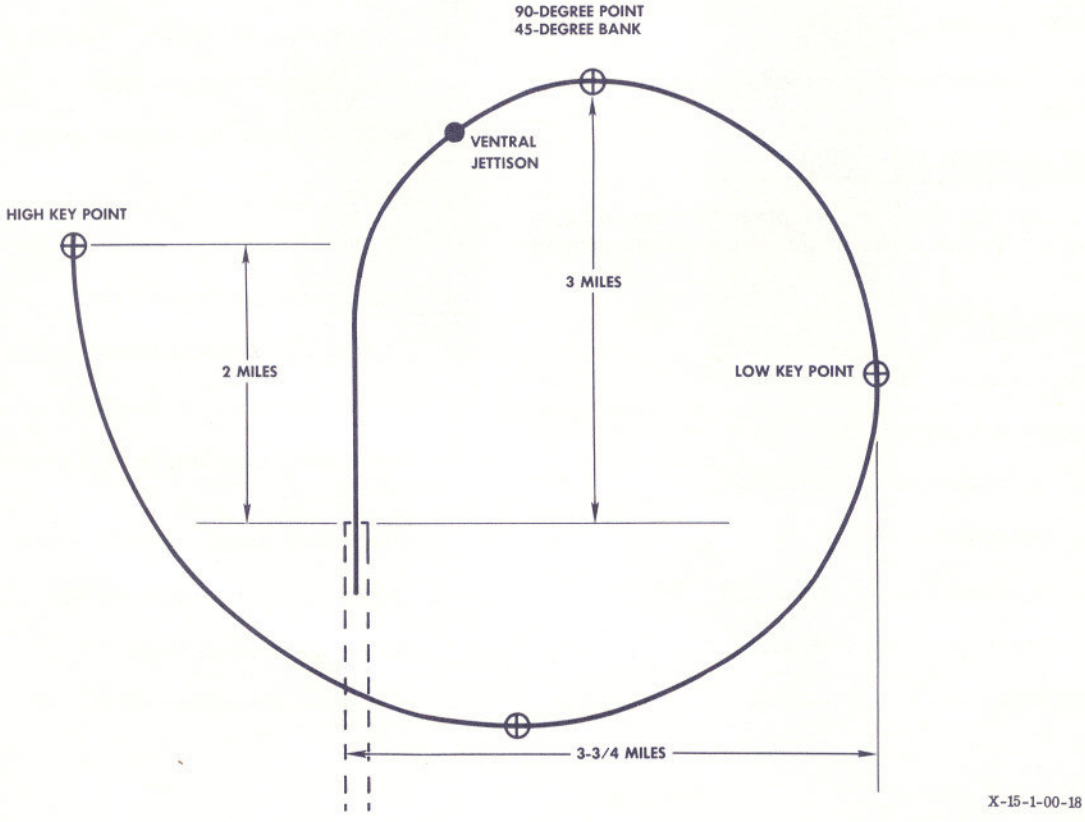
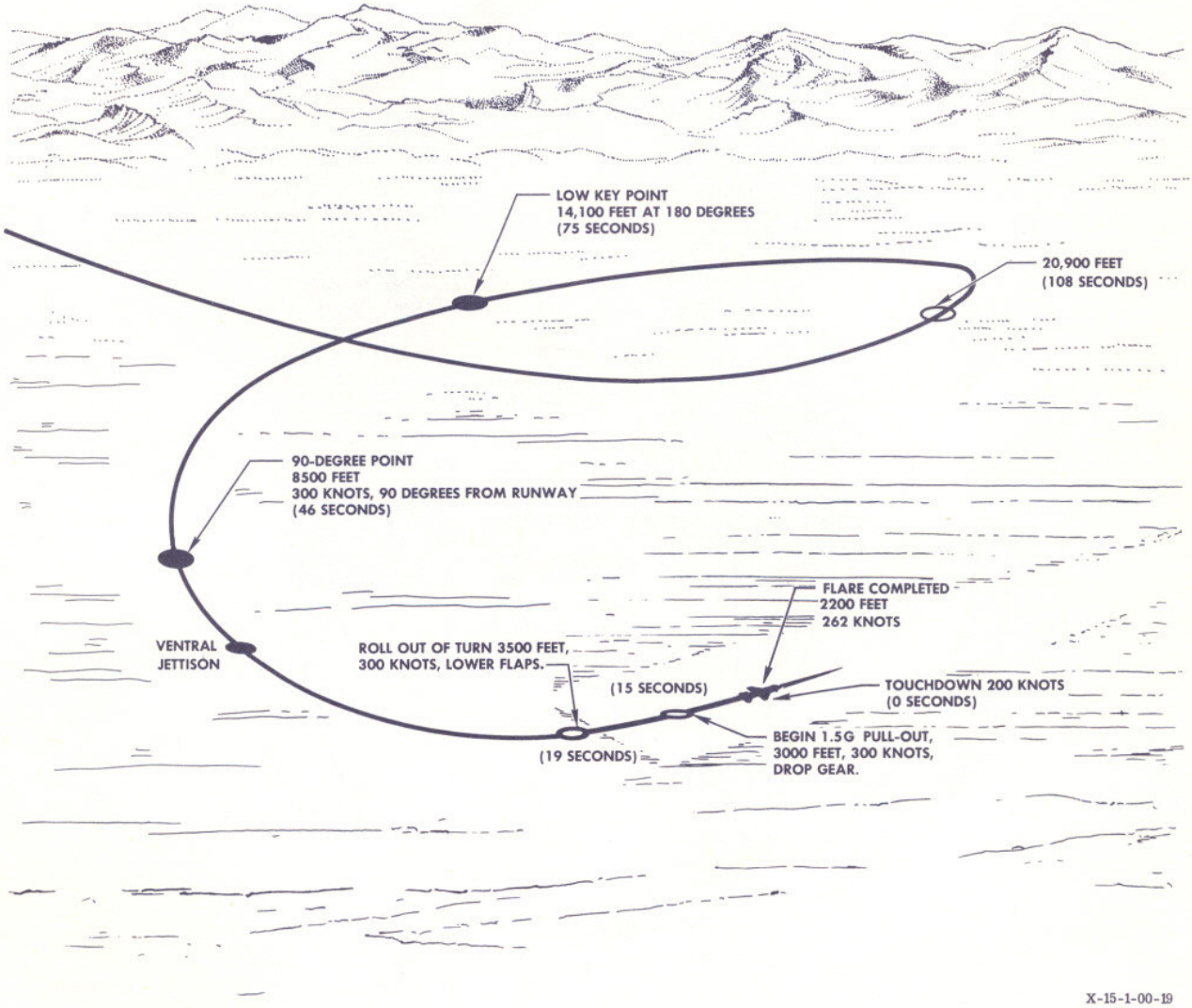

90-DEGREE POINT
45-DEGREE BANK
VENTRAL
JETTISON
HIGH KEY POINT
2 MILES
3 MILES
LOW KEY POINT
3-3/4 MILES
X-15-1-00-18

Figure 2-7

PATTERN (TYPICAL)

NOTE

- **Before landing, preferably on the downwind leg of the landing pattern, but in no case above 17,000 feet above sea level, move vent, pressurization, and jettison control lever to *PRESSURIZE*, to prevent sand and dust from entering the airplane propellant system during landing. The altitude limitation is necessary to preclude structural deformation of the airplane propellant tanks due to a pressure differential which would tend to collapse the tanks.**
- **To ensure safe recovery of the ventral, the ventral should be jettisoned 1500 feet above the terrain.**
- **If the high key point for landing cannot be reached, reduce airspeed to 240 knots IAS until subsequent key point can be reached. Then dive to increase airspeed to 300 knots IAS.**



X-15-1-00-19

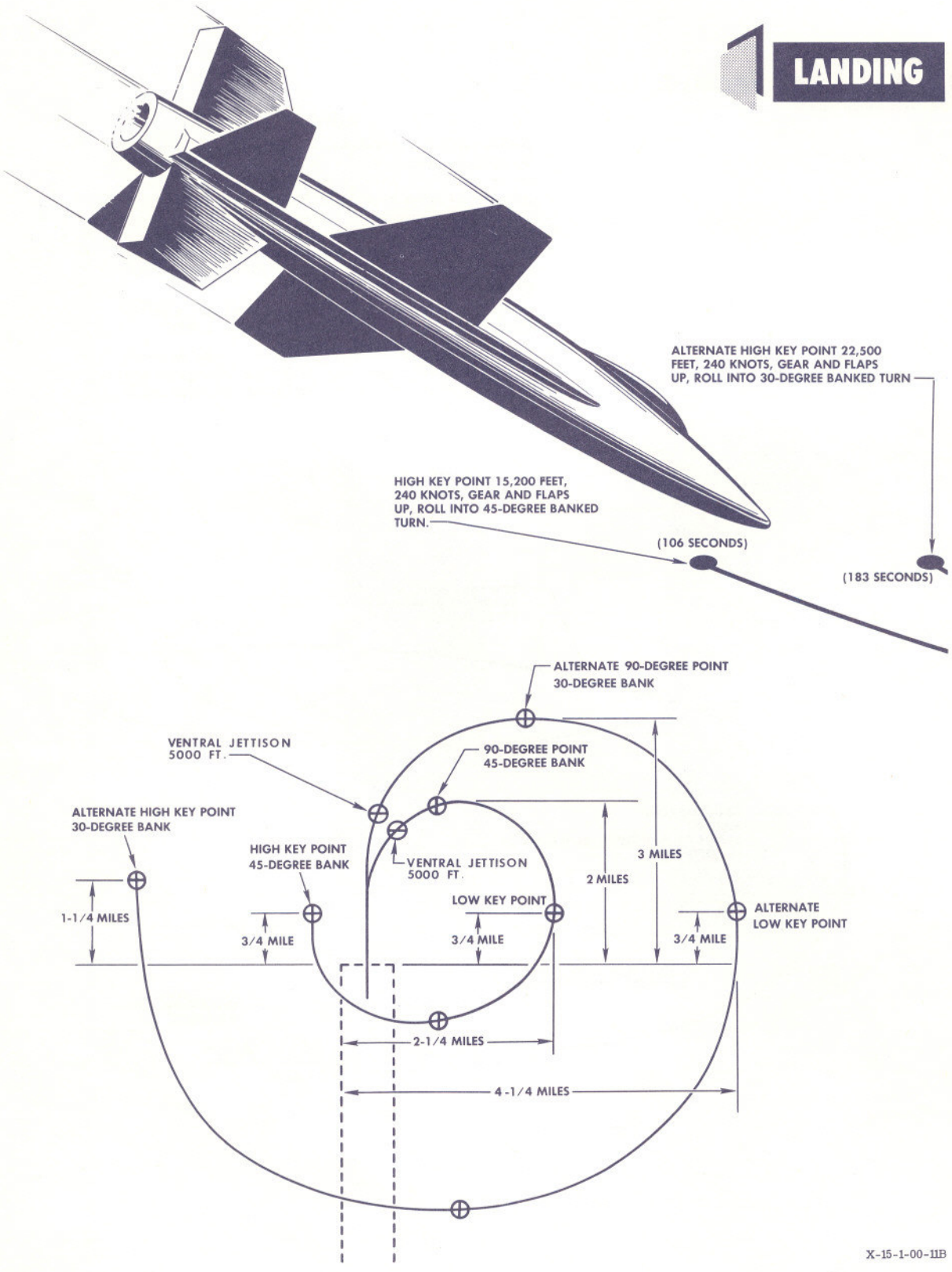
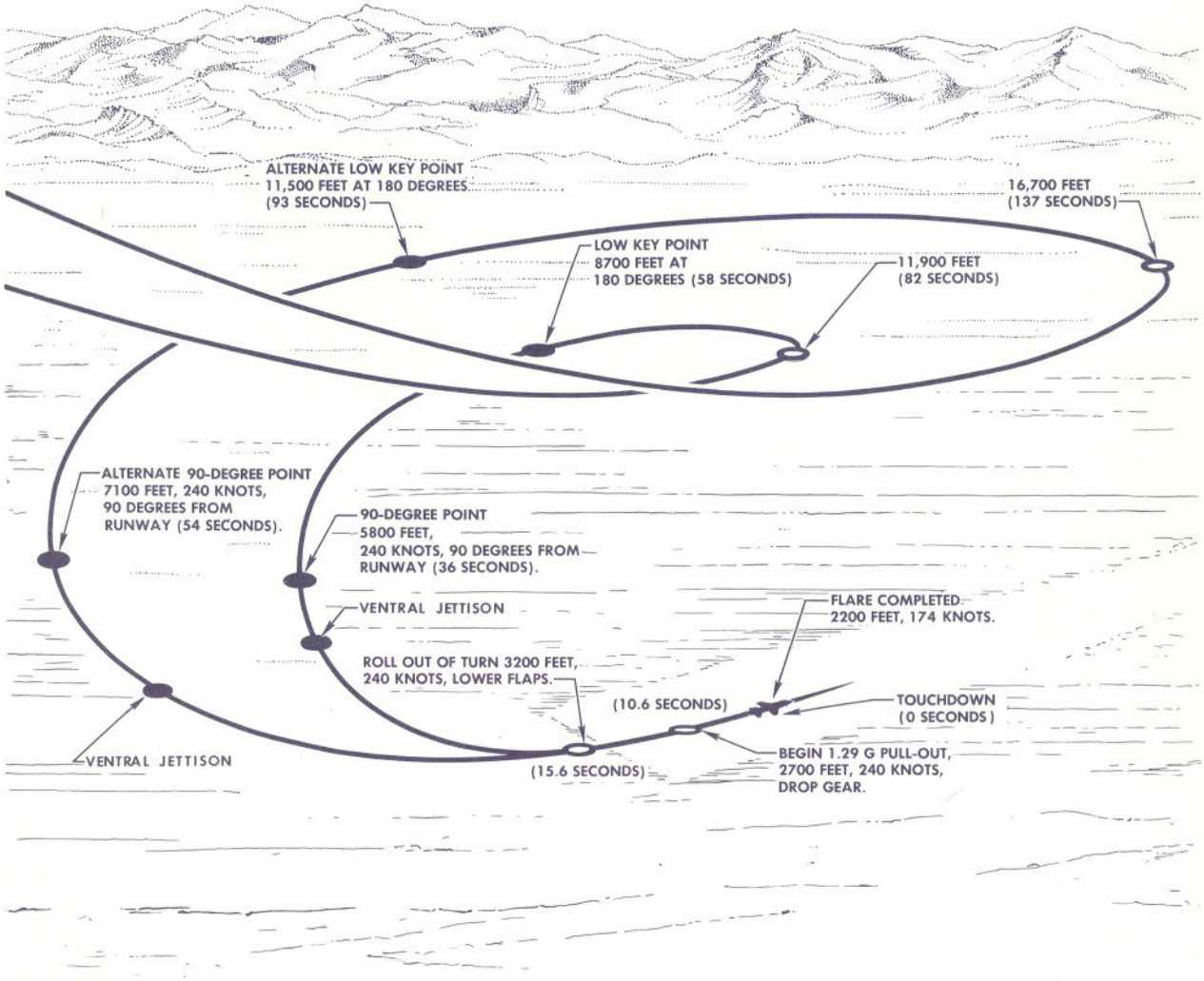

LANDING
ALTERNATE HIGH KEY POINT 22,500 FEET, 240 KNOTS, GEAR AND FLAPS UP, ROLL INTO 30-DEGREE BANKED TURN
HIGH KEY POINT 15,200 FEET, 240 KNOTS, GEAR AND FLAPS UP, ROLL INTO 45-DEGREE BANKED TURN.
(106 SECONDS)
(183 SECONDS)
ALTERNATE 90-DEGREE POINT 30-DEGREE BANK
VENTRAL JETTISON 5000 FT.
90-DEGREE POINT 45-DEGREE BANK
ALTERNATE HIGH KEY POINT 30-DEGREE BANK
HIGH KEY POINT 45-DEGREE BANK
VENTRAL JETTISON 5000 FT.
3 MILES
2 MILES
LOW KEY POINT
ALTERNATE LOW KEY POINT
1-1/4 MILES
3/4 MILE
3/4 MILE
3/4 MILE
2-1/4 MILES
4-1/4 MILES
X-15-1-00-11B

Figure 2-8

PATTERN (LOW SPEED—LOW ALTITUDE)

NOTE

- **Before landing, preferably on the downwind leg of the landing pattern, but in no case above 17,000 feet above sea level, move vent, pressurization, and jettison control lever to *PRESSURIZE*, to prevent sand and dust from entering the airplane propellant system during landing. The altitude limitation is necessary to preclude structural deformation of the airplane propellant tanks due to a pressure differential which would tend to collapse the tanks.**
- **To ensure safe recovery of the ventral, the ventral should be jettisoned 1500 feet above the terrain.**



X-15-1-00-10C