North American Aviation, Inc.

X-15Δ Flight Manual

ProjectX-15
for
Orbiter Space Flight Simulator

International Airport Los Angeles 45, California
LOS ANGELES DIVISION

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Project***X-15*** Release History

*Project**X-15*** (historical X-15)
Version 1.0 — September, 2005

X-15 Delta
Version 1.0 — December, 2005

SYSTEM REQUIERMENTS,
RECOMMENDATIONS & SPECIAL CREDITS

See Appendix for system requirements,
recommended add-ons and credits.

CREDITS

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Aircraft mesh and animations & alternate history

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Flight performance and manual.

PRIMARY SOURCES

Hypersonic: The Story of the North American X-15, 2003
Valkyrie: North America's Mach 3 Superbomber, 2004
both by Denis Jenkins & Tony Landis, Specialty Press

www.wikipedia.org

SPECIAL THANKS

The authors are indebted to the generous support provided by members of the Orbiter community. Your spirited participation in Forum discussions played a vital role in developing this add-on.

Introduction

An Alternate History

The authors of *Hypersonic* suggest (pg. 215) that the loss of the number 2 X-15 in the fatal crash of Mike Adams' last flight in November of 1967 brought an end to consideration of the X-15 Delta. But they admit, in a footnote to that proposition, that the project ended because of the likely success of Apollo and having "too many things against it." ProjectX-15's ***X-15Δ*** is premised on an "alternative history" – a set of "what-might-have-beens" about the factors that brought the Delta program to an end. We've tried to imagine how the X-15Δ program, proposed by the X-15's builder, North American Aviation, in the early 1960s and on which work progressed until as late as the last quarter of 1967, might have gone on to reality.

Consider a very slightly different course of events. Say that the Air Force accepted the cancellation of the X-20 gracefully, but with the quid pro quo of increased support for taking the X-15 on to the next stages of development as a true spaceplane. Say Mike Adams didn't crash the number 2 bird. Say that visionaries at NASA realized in the mid-1960s that there would be a long hiatus after Apollo, that they saw this well before commitment was made to the Shuttle program, and that they embraced the X-15Δ as a way to continue manned spaceflight research and development in a meaningful way with no interruption after Apollo.

There is another line of "what-ifs" in our ***X-15Δ*** add-ons. This concerns the B-70 Valkyrie. The B-70 was destined to never go into full production by factors on a larger scale than those that ended the X-15Δ program. In particular, the development of smaller and smaller nuclear weapons, advanced electronics and computing, and the swift success of the Atlas, Titan and Polaris ballistic missile programs inevitably put the B-70 into the position of an experimental program of just a small number of aircraft. ProjectX-15 does not imagine that this could have changed. Instead, we propose just a few departures from the timeline of history as it actually occurred.

In reality, only two B-70s were built. But work on a third was already well along when the building program was shut down entirely. If just a little more support for the B-70 as a valuable high altitude Mach 3 development platform had been found, the third Valkyrie might have been built. We also imagine that another terrible air accident did not happen, the loss of the number 2 B-70 on June 8, 1966 in which, ironically, one of the X-15s pilots (Joe Walker) died when his F-104 chase plane collided with the B-70. With three flying XB-70s and without the strain of a fatal accident in the program, the possibility of utilizing one of the Valkyries as a launch platform for the X-15Δ would have been more attractive. In reality, North American proposed the idea, although the concept was never studied with the depth that had been devoted to the X-15Δ itself. We project that a Mach 3 launcher flying at 70,000 feet was available to the X-15Δ program.

Finally, we propose that a natural outcome of these two lines of "what-ifs" was the realization of another proposal that lurked around the edges of the X-15 program throughout its life: mounting an X-15 on top of a ballistic missile launcher for true orbital operations. Many different boosters were apparently considered for this idea, including those used in the Navaho cruise missile program and elements of the Saturn family of rockets. But the Titan 2 core had been man-rated in the Gemini program and the Air Force had devoted considerable study to use of the Titan 3c as a booster for the X-20. So we believe that it does not require much of a leap of imagination to picture the X-15Δ perched atop a Titan 3c for its career as a true orbital spaceplane.

Of course, there would be significant hurdles to make the X-15Δ a viable orbital vehicle, the most important of which would be dealing with the greater heat of reentry. But in reality, NASA and the Air Force were addressing this problem on many fronts throughout the 1960s and early 1970s, culminating in the successful (until *Colombia's* last flight, at least) use of special alloys and ceramic tiles on the STS system as it was designed and built in the 1970s. So we offer the X-15Δ as the vehicle with which the United States addressed the problem of Mach 20-plus flight.

With these modest assumptions, we envision the following timeline for the development and operation of the X-15Δ program. Events marked by "[S]" are illustrated by Orbiter scenarios.

ALTERNATE HISTORY TIMELINE

January 1968:	Final proposal for construction of the X-15Δ
March 1968:	Approval to covert Number 1 X-15 to Delta configuration
February 1969:	Rollout of X-15Δ Number 1
April 1969:	B-52 testing of the X-15Δ-1 begins [S]
May 1969:	B-52 testing of the X-15Δ-1 with drop tanks begins [S]
June 1969:	Approval to convert B-70 Number 2 into launch platform for the X-15Δ-1
July 1969:	North American Aviation proposes converting the two remaining X-15s into an advanced Delta configuration capable of orbital operations, and to use the B-70 launch platform for testing and training.
August 1969:	X-15Δ-1 achieves B-52 launched speed and altitude performance goals [S]
May 1970:	Rollout of Valkyrie launcher [S]
August 1970:	Mated flight of Valkyrie launcher and X-15Δ-1 [S]
November 1970:	First B-70 launch of X-15Δ-1 [S]
December 1970:	Approval of advanced X-15Δ conversions and the orbital program, after Senate testimony by Neil Armstrong and Chuck Yeager
January 1972:	Rollout of X-15Δ-2
April 1972:	First B-70 launch of X-15Δ-2 [S]
September 1972:	First orbital X-15Δ-2 flight [S]
October 1972:	Rollout of X-15Δ-3
January 1973:	First B-70 launch of X-15Δ-3 [S]
April 1973:	First Orbital X-15Δ-3 flight [S]
August 1973:	Orbital rendezvous of X-15Δ-2 and X-15Δ-3 [S]
December 1973:	X-15Δ-3rendezvous and dock with Skylab 4 [S]

X-15Δ

Spaceplanes — Section I

PROGRAM DESCRIPTION

The X-15 Delta program is a systematic rebuilding of the three existing X-15 aircraft intended to extend the original research mission of obtaining flight data at extremely high altitudes and hypersonic speeds (in excess of mach 5).

The X-15 Delta mission specifically includes:
- Testing the effects of prolonged hypersonic flight on the airframe and aircraft systems, on the pilot, and on the environment of the upper atmosphere.
- Testing the use of high performance launch vehicles including the B-70 Valkyrie, and Titan IIIc rocket.
- Testing the operation and utility of reuseable spacecraft in low earth orbit with the capability of landing on conventional runways.

X-15Δ-1 DESCRIPTION

The X-15-1 was the first of the three original X-15 aircraft to be rebuilt into Delta configuration. The Delta 1 is a single seat aircraft that retains the original X-15 thin airfoil and wing span, but the planeform is altered to a delta wing configuration. The delta wing is of particular benefit in reentry from low earth orbit. Retaining the original wing span allows the X-15Δ-1 to be launched in the established method from the B-52 carrier ship. The B-52 launches are intended to test the new configuration and flight systems and for pilot familiarization with the altered flight performance of the delta wing. The X-15Δ-1 can also be launched from the B-70 Valkyrie, at speeds up to mach three and an altitude of 70,000 feet. With this launch system the X-15Δ-1 can fly at hypersonic speed for a distance of 2,030 miles (2,650km), confirming the Delta flight system approach.

The X-15Δ-1 is powered by a modified XLR-99 rocket engine with 83,000 lbf thrust, continuously throttleable from 10% to 100%. The engine is fueled with anhydrous ammonia and liquid oxygen. Hydrogen peroxide ballistic control thrusters, identical to those used by the original X-15, provide attitude control for pitch, yaw and roll. The original X-15 landing skids are retained. All landings take place on Roger Dry Lake bed at Edwards Air Force Base.

In all, the Delta 1 is an intermediate between the original X-15 aircraft and the X-15Δ orbital spaceplanes.

X-15Δ-2 DESCRIPTION

The third X-15 aircraft was rebuilt into an advanced Delta configuration and redesignated X-15Δ-2. The single-seat Delta 2 is not launched from a B-52, which imposes limitations on wing span. The X-15Δ-2 has a thicker air foil and larger wing span accommodating a larger internal fuel supply. Launched from the B-70 Valkyrie, the X-15Δ-2 can fly at hypersonic speeds for distances of 2,200 miles (3,600 km) to test reentry flight profiles from low earth orbit. The X-15Δ-2 can also be launched by a Titan IIIc rocket for short duration missions (up to 24 hours) in low earth orbit.

The X-15Δ-2 is powered by a single hypergolic rocket engine. Designed by Space Technologies Laboratory, this engine is similar to their Apollo Lunar Module descent engine: fueled with Aerozine50 and dinitrogen tetroxide, re-startable and fully throttleable from 5% to 100% thrust. The maximum thrust is increased from 10,000 lbf for the Lunar Module to 80,000 lbf (356kN) for the X-15Δ-2. Additional hydrogen peroxide thrusters provide translational control along all three major axis, in addition to rotational control.

X-15Δ-3 DESCRIPTION

Components of the X-15A-2 aircraft were used in construction of the two-seat X-15Δ-3. The Delta 3 has an airfoil identical to the Delta 2 and can be launched from either the B-70 Valkyrie or the Titan IIIc rocket. The Delta 3 can fly longer duration earth orbital missions of up to three days. The internal fuel volume and engine thrust of the Delta 3 is identical to the Delta 2, although the two-seat Delta 3 dry-weight is somewhat greater.

Instrumentation in both the X-15Δ-2 and X-15Δ-2 is augmented with a modified version of the Apollo Guidance Computer (AGM) The DSKY AGM interface is located on the main instrument panel of the Delta 2 and Delta 3. The Delta 3 also has a DSKY interface on the secondary instrument panel in the rear crew compartment.

X-15Δ CUSTOM KEY COMMANDS

Key commands in this manual are depicted within brackets. [J] means press the "J" key. [CTRL] + [/]numpad means press and hold the control key, then press the / key on the number pad.

[J] Launch X-15 from carrier ship

[K] Extend/retract speed brakes

[G] Extend/retract landing gear

[L Shift] + [0]numpad
Jettison ventral fin *

[LShift] + [1]numpad
Open/Close main canopy

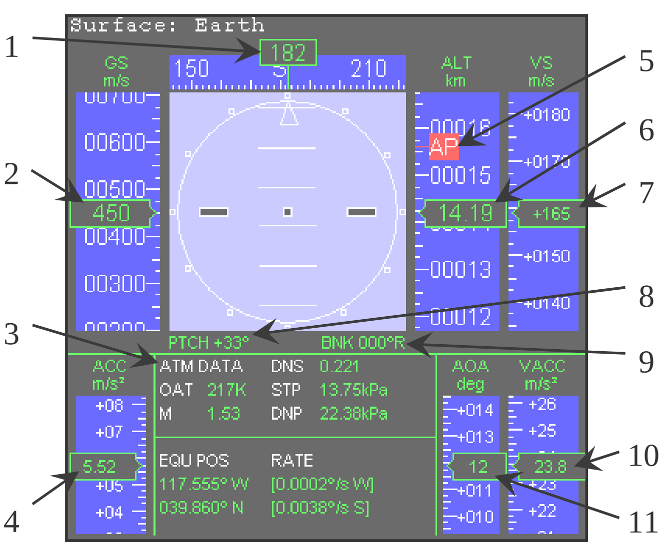
[LShift] + [2]numpad
Open/Close skylight hatch

[LShift] + [2]numpad
Open/Close rear canopy**

[LShift] + [3]numpad
Jettison external fuel tanks *

[LShift] + [3]numpad
Extend/Stow Mooring Grapple **

* X-15Δ-1 only
** X-15Δ-3 only



Surface MFD

Surface MFD

1 Heading (use marker on ribbon compass of Surface HUD to set precise heading to base.)
2 All speed indications in this manual refer to Ground Speed (GS)
3 Atmospheric Data:
OAT - Outside Air Temperature (Degrees Kelvin)
M - Mach Number
DNS - Atmospheric Density
STP - Static Presgure
DNP - Dynamic Pressure
4 Acceleration - See G Force Table on page 1-3
5 Apogee indicator
6 Current altitude
7 Vertical Speed
8 Pitch - Also read from Surface HUD, angular difference between horizon and direction indicator.
9 Bank indicator
10 Vertical acceleration
11 Angle of Attack - Angular difference between pitch and direction of travel (on Surface HUD this would be angular difference between the Direction indicator and the Prograde indicator)

X-15Δ GLIDE SLOPE AND LANDING

The typical landing approach is a 360° turn from a High Key Point as illustrated in the original X-15 flight manual. Increased wing area gives the X-15Δ series longer glide slopes and lower approach speeds than the original X-15 aircraft. For the Deltas, High Key Point is at 5km altitude and the recommended approach speed is 115 to 120m/sec. Flare-out begins at 100m/sec and touchdown at 90m/sec. Maximum vertical speed at touchdown is 3m/sec.

SPEED BRAKE TABLES

Altitude = 35km										
Distance to Base (km)	50	75	100	150	200	300	400	500	600	700
Set Speed (m/sec)				500	750	850	1100	1270	1450	1600

Altitude = 30km										
Distance to Base (km)	50	75	100	150	200	300	400	500	600	700
Set Speed (m/sec)		200	400	560	730	950	1160	1380		

Altitude = 25km										
Distance to Base (km)	50	75	100	150	200	300	400	500	600	700
Set Speed (m/sec)	180	310	440	600	780	1000	1220			

Altitude = 20km										
Distance to Base (km)	50	75	100	150	200	300	400	500	600	700
Set Speed (m/sec)	210	350	500	680	1000					

Altitude = 15km										
Distance to Base (km)	50	75	100	150	200	300	400	500	600	700
Set Speed (m/sec)	240	380	550							

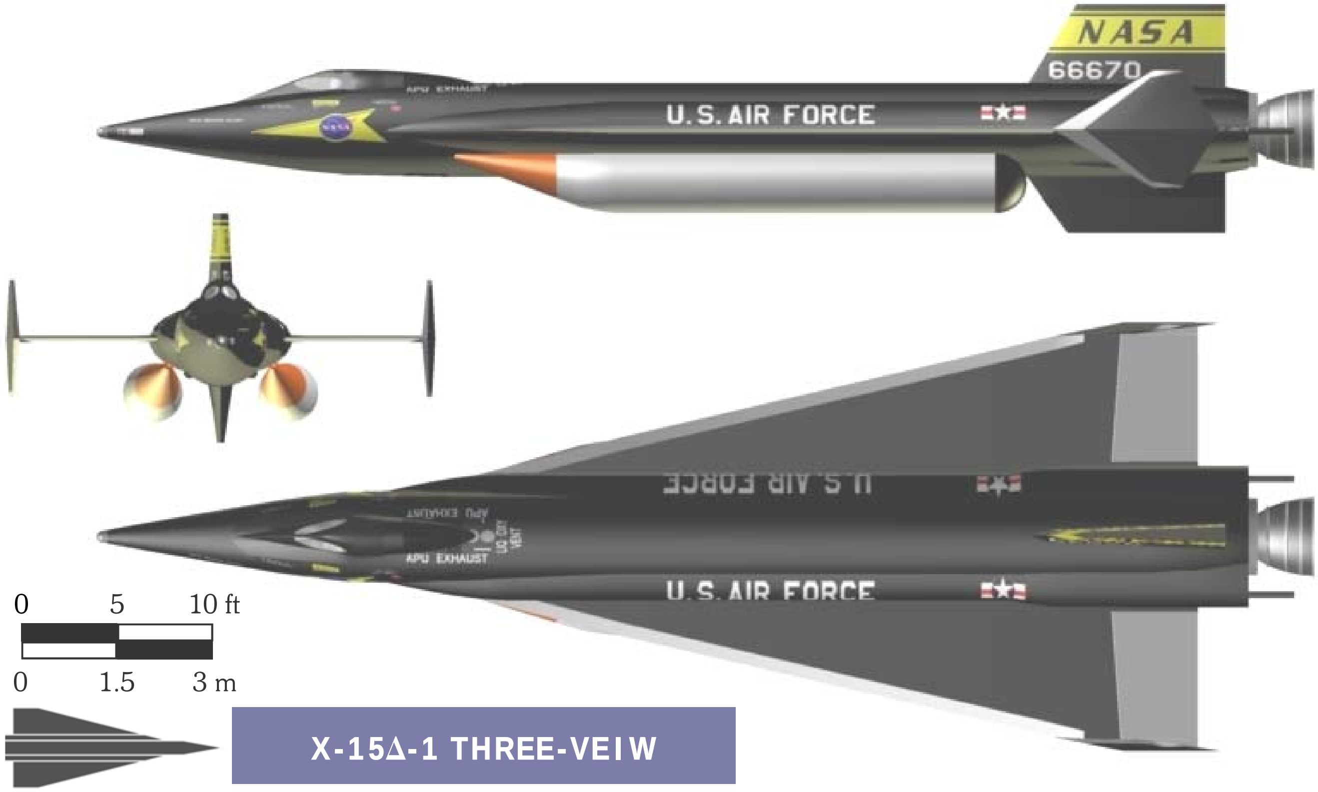
Instructions:
These tables provide maximum glide distance from an initial altitude and speed down to an altitude of 5 km — the landing pattern High Key Point.

- Note your **Altitude** and select the correct table
- Note your **Distance to Base**
- Set your **Speed** by extending and retracting speed brakes [K]

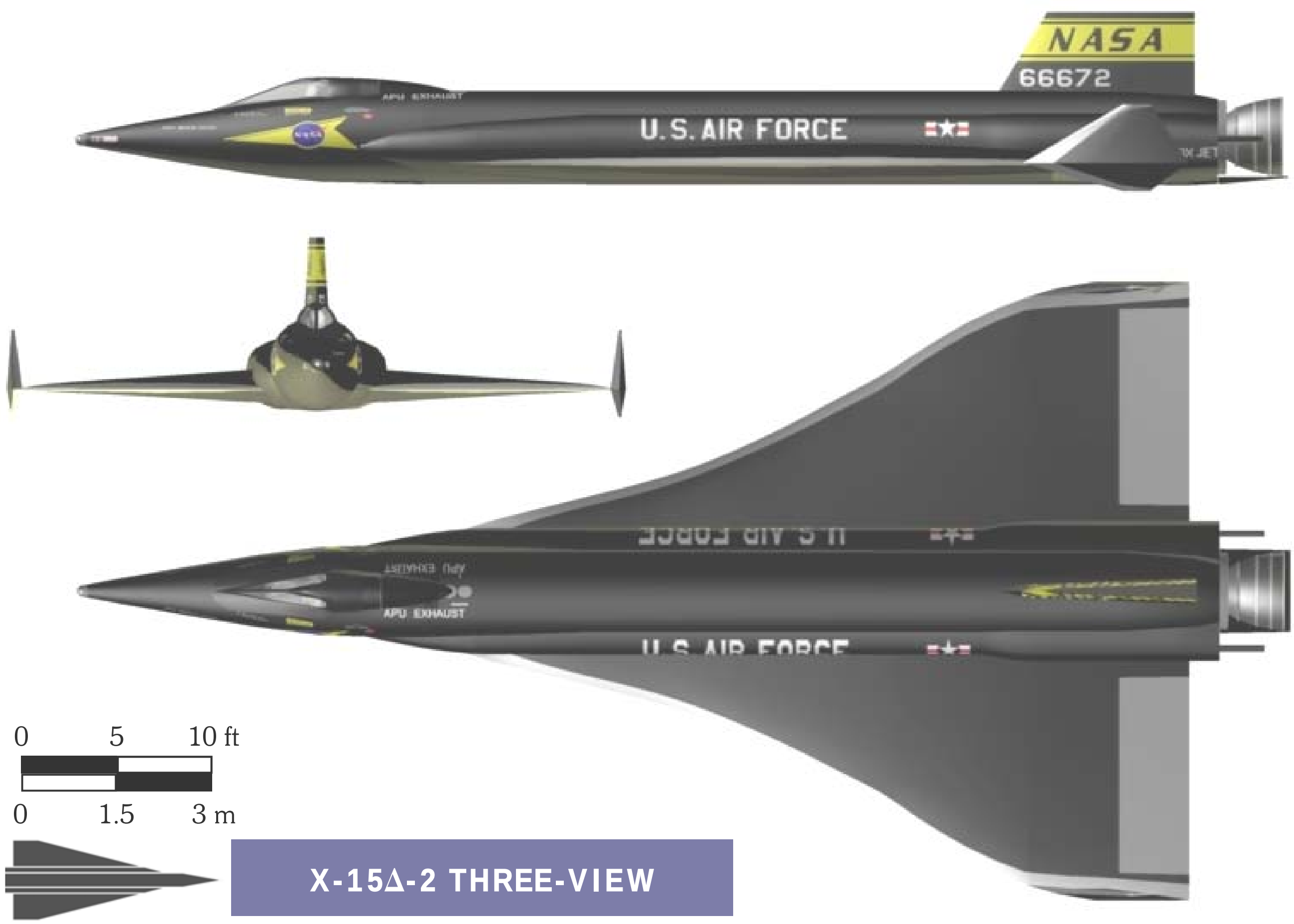
G FORCE TABLE

Acceleration/Deceleration meters/second^2	9.75	19.50	29.26	39.01	48.77	58.52	68.28	78.03	87.78	97.54
G Force	1g	2g	3g	4g	5g	6g	7g	8g	9g	10g

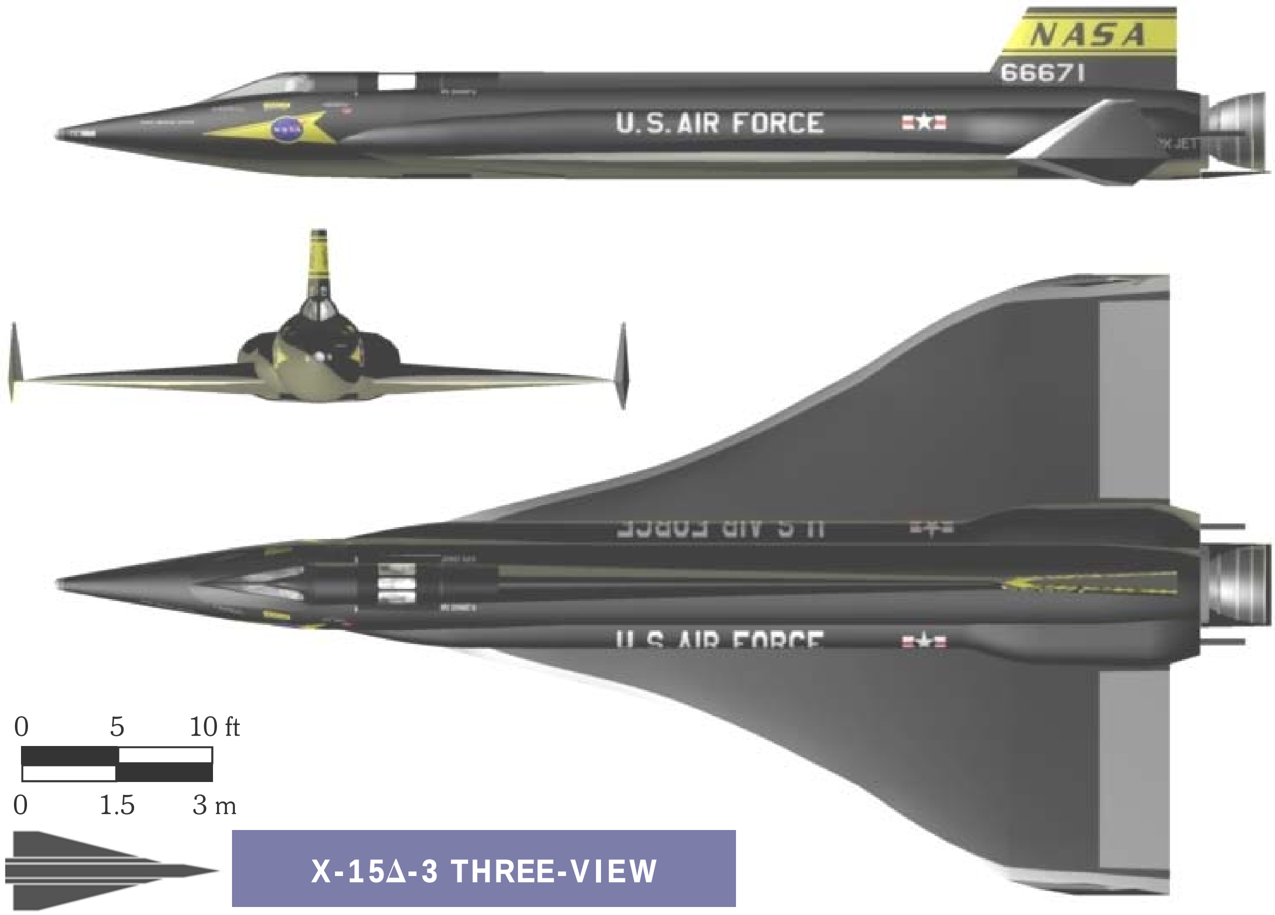
Notes: 6g is the maximum allowable force to be applied to the X-15Δ airframe.
2g is the preferred maximum force to be applied during orbital reentry.



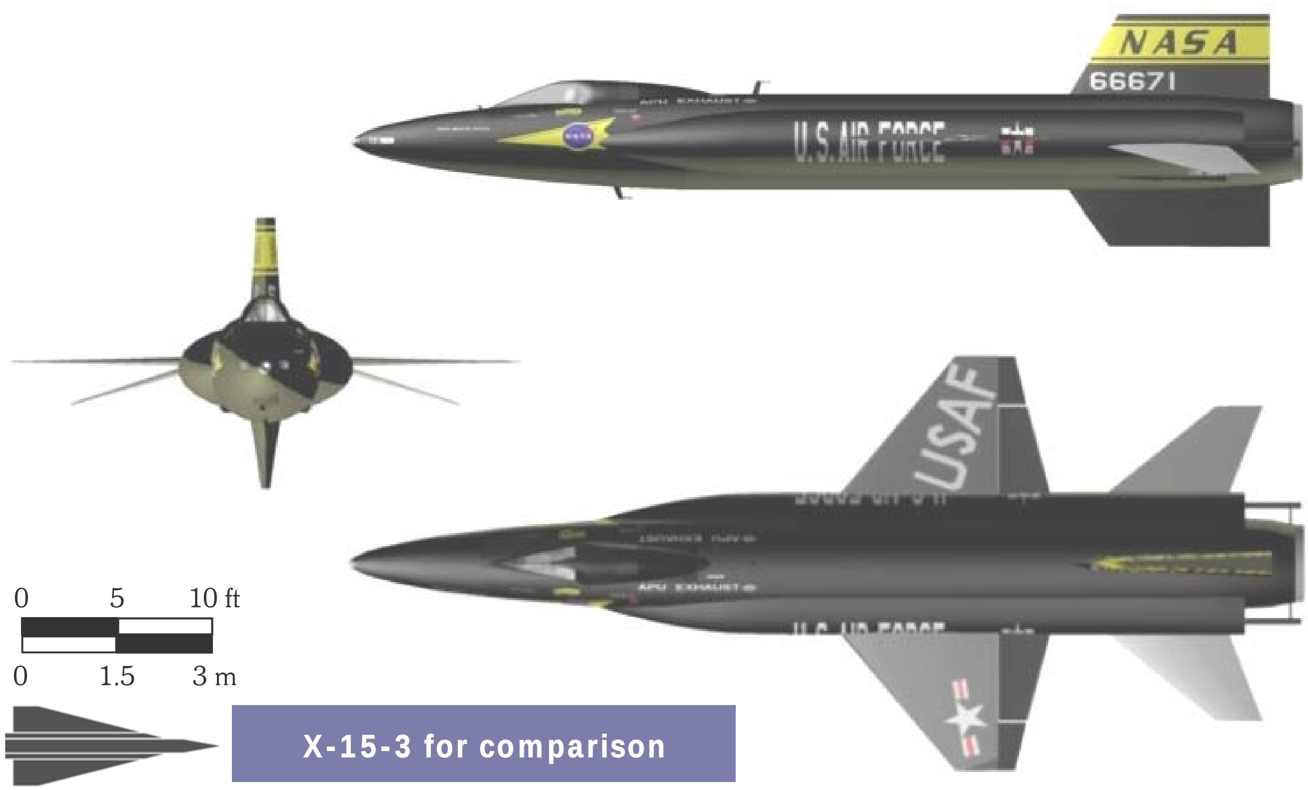
X-15Δ-1 THREE-VEIW



X-15Δ-2 THREE-VIEW



X-15Δ-3 THREE-VIEW



X-15-3 for comparison

B-52 Stratofortress

Launch System — Section II

DESCRIPTION

The B-52 carrier ship serial number 20003 (Balls 3), used as a launcher for the original X-15, was altered slightly to serve as the launcher for the initial X-15Δ flights. The first aircraft in the X-15Δ series, the X-15Δ-1, has a wingspan matching the original X-15 permitting it to be mounted on a launch pylon below the B-52 carrier ship's wing, between the fuselage and inboard engine nacelle, in the same launch configuration as the original X-15. The B-52 can launch the X-15Δ-1 from an altitude of 45,000 feet (13.7 km) and a speed of 500 mph (223 m/sec), also identical to the original X-15 aircraft.

B-52 CUSTOM KEY COMMANDS

[J]	Launch X-15 from B-52 carrier
[G]	Extend/retract landing gear

B-52 PRE-LAUNCH PROCEDURES

Launch scenario begins with the B-52 carrier ship cruising at the launch speed of 500 mph (223 m/sec) and altitude of 45,000 feet (13.7 km).

- Jump to the B-52 cockpit [F1]. Verify the cockpit instrument settings:
- HUD set to surface mode
- Surface MFD open on the RIGHT side;
- Map MFD open on the LEFT side with target set for Edwards.

CAUTION

The Surface MFD will be ON throughout the flight. It will obstruct your view during final approach if it is open on the left side (assuming a typical left-turn approach to landing).

- Establish a precise heading toward Edwards using the triangular pointer on the Surface HUD ribbon compass.

X-15Δ-1 WITHOUT DROP TANKS

Launch

- Without drop tanks, Delta 1 launch takes place at 932 miles (1,500 km) from Edwards Air Force Base [J]
- Immediately turn off the reaction control system [CTRL] + [/]numpad

CAUTION

Spacecraft2 defaults to rotation RCS when a new ship is launched. Failure to turn off the RCS will limit the X-15Δ's atmospheric flight performance and waste fuel.

- Ignite engine at full throttle and lock it on [+]numpad + [CTRL]
- Pitch up *gently*, maintaining a 12° angle of attack (AoA) throughout the pitch-up maneuver, to a climb of +20°.
- Keep the direction indicator on the +20°. The prograde marker will rise up to a point just below the direction indicator. At about 49,200 feet (15 km) altitude, and a speed of mach 1.6 (470 m/s), you may let go of the stick and fly "hands-off" for several seconds.
- Flying hands-off, the aircraft will continue to pitch up slowly. Re-set the Map MFD target to Edwards. (Target setting was lost when X-15Δ-1 was launched.)
- At 65,600 feet (20 km) altitude begin pitching down, maintaining AoA of –2° to –2.5° during the pitch-down maneuver

- Achieve 0° pitch (level flight) at 131,200 feet (39 to 41 km) altitude.

WARNING

Leveling off at lower altitude, in denser atmosphere, will result in overheating. Leveling off at higher altitudes will result in insufficient lift causing the aircraft to drop and accelerate excessively during cruising flight, again resulting in overheating.

- Engine burnout occurs at about the time 0° pitch is achieved. Top speed at burnout should be about mach 7.

Cruise Flight

- Level cruise flight can continue for several minutes, "hands-off". Altitude will increase and decrease gently as the aircraft skims along the upper atmosphere. Time warp can be increased to 10X during cruise flight [T]
- As needed, reduce time warp to normal [R] and make gentle courses corrections toward target base.
- At 435 miles (700 km) from base begin checking altitude and speed against Speed Brake Table on page 1-3. Extend and retract speed brakes as needed [K].
- Aim for the north edge of Rogers Dry Lake to allow room for turning into the High Key Point, aligned with main lakebed runway on heading 172°, 5 km altitude above and 1.5 km north of runway.
- Flight time from launch to High Key Point is about 20 minutes

Landing

- At High Key Point turn off the Map MFD [L Shif] + [Q]
- Bank left 45° and adjust pitch to maintain a speed of 230 knots (115 to 120 m/sec).
- Turn 360° while descending to runway.
- Flare-out begins at 195 knots (100 m/sec) and tochdown at 175 knots (90 m/sec). Maximum vertical speed at touchdown is 10 feet per second (3 m/sec).

X-15Δ-1 WITH DROP TANKS

The additional fuel provided by the external drop tanks allows the X-15Δ-1 to accelerate to mach 8. The additional speed requires a higher cruise altitude to prevent overheating.

- With drop tanks, Delta 1 launch takes place at 1,180 miles (1,900 km) from Edwards Air Force Base [J]
- Immediately turn off the reaction control system [CTRL] + [/]numpad
- Ignite engine at full throttle and lock it on [+]numpad + [CTRL]
- Pitch up, maintaining a 12° AoA throughout the pitch-up maneuver, to a climb of +20°.
- Hold +20° pitch. At about 49,200 feet (15 km) altitude, and a speed of mach 1.6 (470 m/s), you may let go of the stick and fly "hands-off" for several seconds
- Shift to external view [F1] and drop external fuel tanks [L Shift]+[3]numpad
- At 68,900 feet (21 km) altitude begin pitching down, maintaining AoA of –2° to –2.5° during the pitch-down maneuver
- Achieve 0° pitch (level flight) at 134,500 feet (40 to 42 km) altitude.
- Re-set the Map MFD target to Edwards.
- Cruise hands-off for several minutes. Time warp can be increased to 10X during cruise flight [T]
- Flight time from launch to High Key Point is about 30 minutes

Sustained Hypersonic Flight

Experiment with throttling down to 5-10% thrust to maintain speed of mach 6. See how this effects total flight distance.

B-70 Valkyrie

Launch System Section III

DESCRIPTION

The B-70 Valkyrie was designed as a long-range strategic bomber capable of cruising mach 3 at 70,000 feet (885 m/sec at 21.3 km). The idea of a mach 3 bomber was conceived in the mid-1950s - a time when nuclear warheads were growing heavier and a high-flying, supersonic manned bomber was believed to be the only weapon capable of penetrating Soviet air space and targeting the weapon with accuracy. The rapid development of warhead miniaturization along with the intercontinental ballistic missile, and Soviet development of surface-to-air missiles, rendered the mach 3 bomber obsolete before its development was completed. Only three B-70 Valkyries were constructed. They currently serve as supersonic research aircraft and as launchers for the X-15Δ (see Introduction, page ii)

The Valkyrie's main wing has a delta planeform with multiple elevons providing pitch and roll control. The wing is positioned to take advantage of the pressure field behind the supersonic shock wave generated by the lower fuselage enclosing the engines. This "compression lift" effect allows the aircraft to fly at a lower angle of attack, reducing drag at supersonic speeds and increasing range. Small canard wings provide trim control with a further reduction in drag. Lateral control is provided by twin vertical stabilizers. The main wing tips fold down to increase lateral stability at supersonic speeds. (Contrary to popular report, the folding wingtips contribute little to the compression lift effect.) The windscreen and upper surface of the nose move in concert. This "ramp nose" provides a smooth forward surface at supersonic speeds and increases forward visibility at slower speeds during in-air refueling and landing.

The Valkyrie has a maximum takeoff weight of 542,000 pounds (245,850 kg), length of 189 feet (57.6 m) and wingspan of 105 feet (32 m). The Aircraft has six General Electric YJ93-GE-3 turbojet engines with published sea level afterburner thrust of 28,800 lbf each.

NOTE

The B-70 maximum payload weight is 20,000 pounds (9,072 kg). The X-15Δ has takeoff weights of 42,500 to 46,950 pounds(19,300 to 21,300 kg). Therefore, when launching an X-15Δ, the B-70 carries a 70% fuel load.

B-70 CUSTOM KEY COMMANDS

[J]	Launch X-15 from B-70 carrier
[G]	Extend/retract landing gear
[K]	Deploy drag chutes
[LShift]+[0]numpad	Raise/lower nose ramp
[LShift]+[1]numpad	25° wing tips
[LShift]+[2]numpad	65° wing tips

NOTE

Key commands 1 and 2 are ADDITIVE and must be done 1-2, and then 2-1 to prevent "animation mangle"

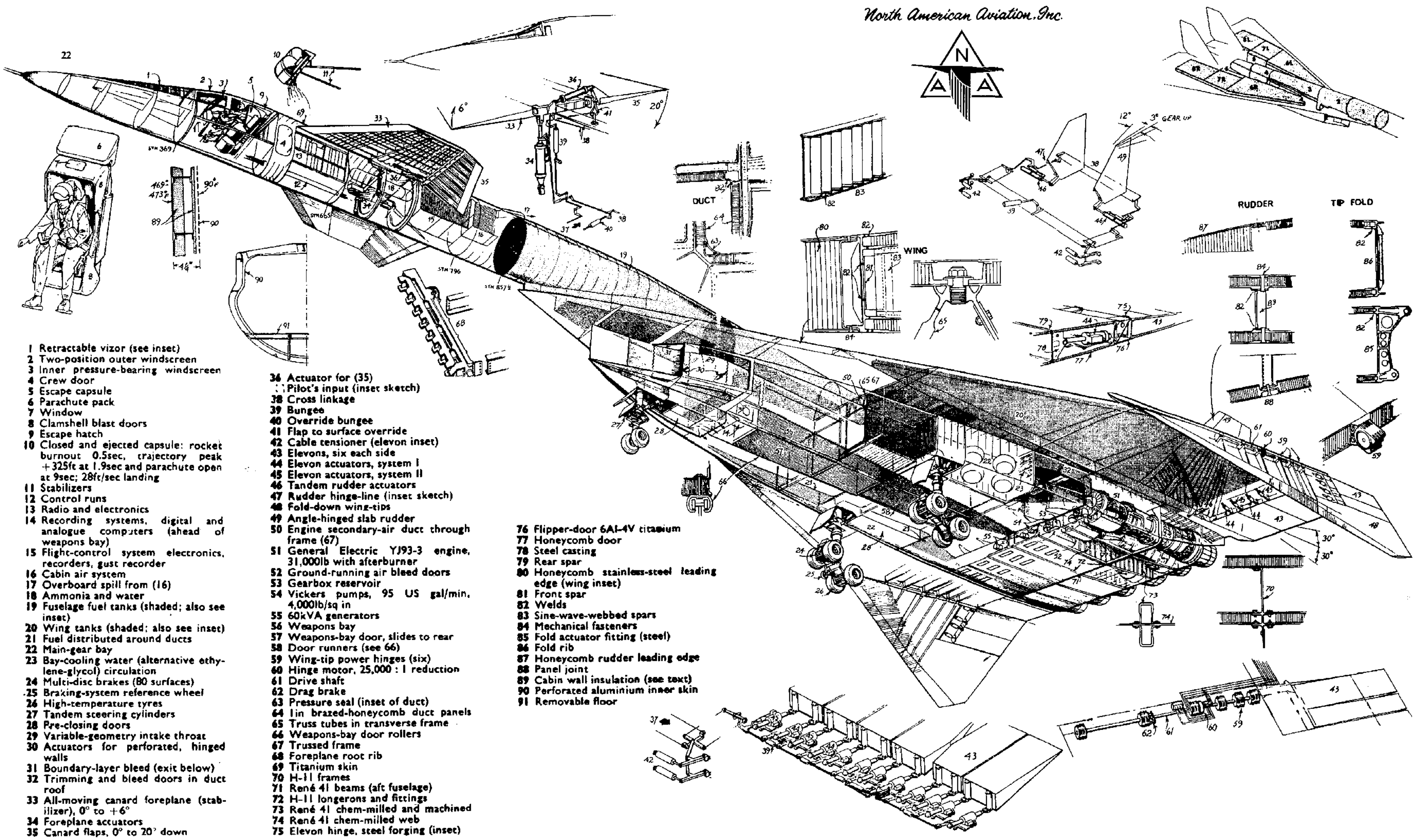
B-70 FLIGHT PROCEDURES

Following describes a Delta 2 flight from KSC to Edwards Air Force Base. Open the scenario "X-15D-2 Takeoff from KSC."

Pre-flight

- Jump to the B-70 cockpit [F1]. Verify the cockpit instrument settings:
- HUD set to surface mode
- Surface MFD open on the RIGHT side
- Map MFD open on the LEFT side with target set to Cap Canaveral

B-70 Valkyrie Cut-Away



1 Retractable vizor (see inset)
2 Two-position outer windscreen
3 Inner pressure-bearing windscreen
4 Crew door
5 Escape capsule
6 Parachute pack
7 Window
8 Clamshell blast doors
9 Escape hatch
10 Closed and ejected capsule: rocket burnout 0.5sec, trajectory peak +325ft at 1.9sec and parachute open at 9sec; 28ft/sec landing
11 Stabilizers
12 Control runs
13 Radio and electronics
14 Recording systems, digital and analogue computers (ahead of weapons bay)
15 Flight-control system electronics, recorders, gust recorder
16 Cabin air system
17 Overboard spill from (16)
18 Ammonia and water
19 Fuselage fuel tanks (shaded; also see inset)
20 Wing tanks (shaded; also see inset)
21 Fuel distributed around ducts
22 Main-gear bay
23 Bay-cooling water (alternative ethylene-glycol) circulation
24 Multi-disc brakes (80 surfaces)
25 Braking-system reference wheel
26 High-temperature tyres
27 Tandem steering cylinders
28 Pre-closing doors
29 Variable-geometry intake throat
30 Actuators for perforated, hinged walls
31 Boundary-layer bleed (exit below)
32 Trimming and bleed doors in duct roof
33 All-moving canard foreplane (stabilizer), 0° to +6°
34 Foreplane actuators
35 Canard flaps, 0° to 20° down
36 Actuator for (35)
37 Pilot's input (inset sketch)
38 Cross linkage
39 Bungee
40 Override bungee
41 Flap to surface override
42 Cable tensioner (elevon inset)
43 Elevons, six each side
44 Elevon actuators, system I
45 Elevon actuators, system II
46 Tandem rudder actuators
47 Rudder hinge-line (inset sketch)
48 Fold-down wing-tips
49 Angle-hinged slab rudder
50 Engine secondary-air duct through frame (67)
51 General Electric YJ93-3 engine, 31,000lb with afterburner
52 Ground-running air bleed doors
53 Gearbox reservoir
54 Vickers pumps, 95 US gal/min, 4,000lb/sq in
55 60kVA generators
56 Weapons bay
57 Weapons-bay door, slides to rear
58 Door runners (see 66)
59 Wing-tip power hinges (six)
60 Hinge motor, 25,000 : 1 reduction
61 Drive shaft
62 Drag brake
63 Pressure seal (inset of duct)
64 1in brazed-honeycomb duct panels
65 Truss tubes in transverse frame
66 Weapons-bay door rollers
67 Trussed frame
68 Foreplane root rib
69 Titanium skin
70 H-11 frames
71 René 41 beams (aft fuselage)
72 H-11 longerons and fittings
73 René 41 chem-milled and machined
74 René 41 chem-milled web
75 Elevon hinge, steel forging (inset)
76 Flipper-door 6Al-4V titanium
77 Honeycomb door
78 Steel casting
79 Rear spar
80 Honeycomb stainless-steel leading edge (wing inset)
81 Front spar
82 Welds
83 Sine-wave-webbed spars
84 Mechanical fasteners
85 Fold actuator fitting (steel)
86 Fold rib
87 Honeycomb rudder leading edge
88 Panel joint
89 Cabin wall insulation (see text)
90 Perforated aluminium inner skin
91 Removable floor

Takeoff

- Throttle up B-70 engines to 100% thrust [CTRL] + [+]numpad
- At 165 knots (85 m/sec) begin pitch up, slowly rotating the aircraft to +8° angle of attack. The Valkyrie will become airborne at 180 knots (93 m/sec).
- Retract landing gear [G]
- Climb to 6,000 feet (1.8 km) and turn right to heading 90°. Raise nose ramp for supersonic flight [L Shift] + [0]numpad
- Continue climbing and accelerating at full throttle to 70,000 feet (21.3 km).
- At mach 1 lower wingtips to 25° [LShift]+[1]numpad At mach 2.0 lower wingtips to 65° [LShift]+[2]numpad
- Continue level flight to 150 miles (240 km) away from KSC.
- Set Map MFD target to Edwards and turn right toward target base. Use triangular marker on Surface HUD ribbon compass to set precise heading.
- Adjust altitude and throttle to hold 70,000 feet (21.3 km), mach 3 (885 m/sec) and 0 m/sec acceleration.

Launch Delta 2

- At 2,240 miles from Edwards (3,600 km) launch X-15Δ-2 [J]
- Turn off RCS [CTRL] + [/]numpad
- Ignite engine and at full throttle and lock it on [+]numpad + [CTRL]
- Pitch up to +20°, maintaining 12° AoA throughout pitch-up maneuver.
- At 95,100 feet (29 km) begin pitching down, maintaining a -2° to -2.5° AoA, to level flight at 144,400 feet (43 to 45 km)
- Shut down engine at 5% fuel remaining [*]numpad Maximum speed will be about mach 10.

Cruise Flight

- Level cruise flight can continue "hands-off". Altitude will increase and decrease gently as the aircraft skims along the upper atmosphere.
- Open the equipment bay doors and start collecting data [LShift] + [2]

Land B-70

- Jump back to B-70 cockpit [F3]
- Set Map MFD target to KSC and turn left to return to KSC
- Open Com/Nav MFD on left and set NAV1 to 112.70 and NAV2 to 134.20
- Open HSI MFD (see Orbiter docs for instrument landing)
- Throttle down to about 25% to reduce speed and altitude.
- At mach 2.0 raise wingtips to 25° [LShift]+[2]numpad At mach 1 raise wingtips to 0° [LShift]+[1]numpad
- Lower nose ramp [LShift]+[0]numpad
- Lower landing gear [G]
- Land at main KSC runway and deploy drag chute after touchdown [K]

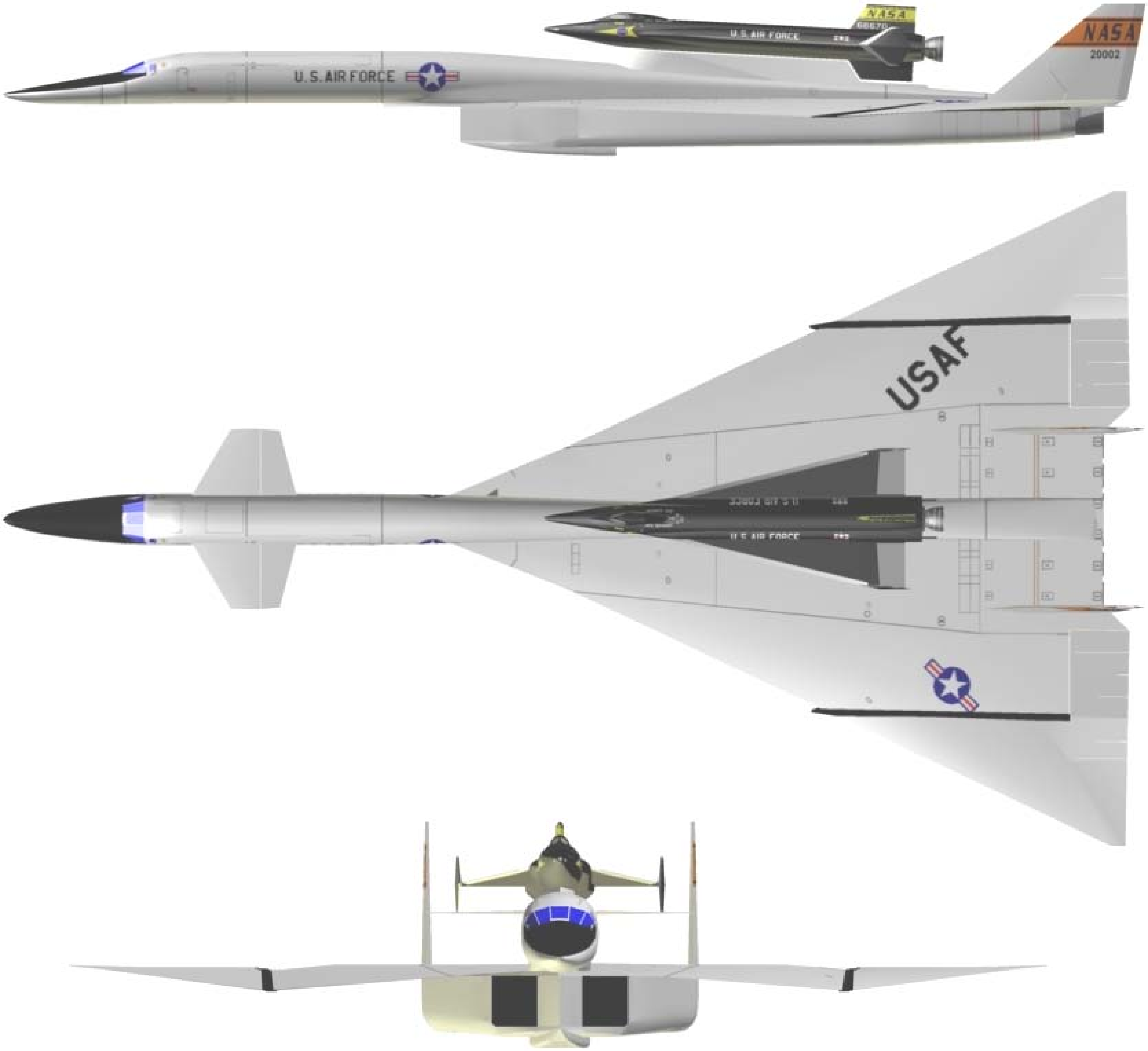
Land Delta 2

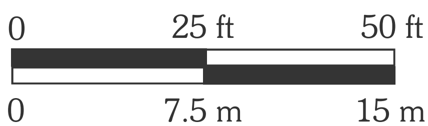
- Jump back to X-15Δ-2 cockpit [F3]
- Time warp can be increased to 10X during cruise flight [T]
- As needed, reduce time warp [R] to normal to make gentle courses corrections toward target base.
- Close equipment bay doors [LShift] + [2]
- Landing the Delta 2 is the same as Delta 1. See page 2-2 for landing X-15Δs

B-70 LAUNCH OF DELTA 1

Launching the Delta 1 from the Valkyrie is similar to the Delta 2 with the following exceptions:

- Launch at 2,600 km from Edwards
- Begin pitching down from 20° climb at an altitude of 27 km
- Hold level flight at 42 to 44 km altitude until engine burnout. Maximum speed about mach 9.





B-70 Valkyrie with X-15D-1

Titan IIIc

Launch System **Section IV**

DESCRIPTION

Development of the Titan family of rockets began in 1955 as a two-stage, silo launched ICBM. The initial Titan I, fueled with liquid oxygen and RP-1 (kerosene), was replaced by the Titan II fueled with Aerozine 50 and dinitrogen tetroxide. These hypergolic propellants can be stored at normal temperatures and pressures allowing the rocket to stand ready for an extended time. The Titan II was adapted for use as a space exploration booster and "man rated" for Project Gemini. Titan III development began in 1961 as a booster for especially heavy payloads (in particular, the cancelled X-20 and Manned Orbiting Laboratory). The IIIc version made its first flight on June 18, 1965.

The Titan IIIc consists of a hypergolic liquid fueled core and two strap-on solid fuel boosters. The boosters are designated stage 0 and develop a total thrust of 2,624,000 lbf (11,672 kN) each. The core Stage 1 has two LR87 engines with 1,048,000 lbf (4,660 kN) total thrust. Stage 2 has a single LR91 engine with 102,000 lbf (454 kN) thrust. Stage 3, called the Titan Transtage, has two Aerojet AJ-10-138 engines, total thrust of 31,800 lbf (142 kN).

The Titan IIIc can deliver a payload of 28,900 pounds (13,100 kg) to low Earth orbit. Because the X-15Δ weighs over 46,000 pounds it must use its own 83,000 lbf engine to complete the boost to orbit. Refer to CVEL Titan documentation for further information on the Titan rocket family.

CVEL TITAN CUSTOM KEY COMMANDS

[U] Set new autopilot launch azimuth, overrides azimuth specified in scenario file.
[O] Start autopilot
[J] Jettison next stage or payload. (Staging is automatic when previous stage fuel is exhausted.)
[CTRL]+[E] Launch abort separates X-15Δ from lower stages.

FLIGHT PROCEDURES

Following describes the first Delta 2 orbital flight. Launch procedure for the Delta 3 is identical.

LAUNCH AND ORBIT INSERTION

CVEL Titan add-on includes a simple launch autopilot - refer to CVEL Titan documentation. However, the autopilot does not work well with the "overweight" X-15Δ payload. Orbit can be achieved more efficiently (using less X-15Δ fuel) by flying the launch manually. This requires making pitch changes at pricise "mission elapsed time" (MET). Use a stop watch or other convenient timer, or the MET timer provided with Orbiter Sound.

Pre-flight

- Prior to starting Orbiter, open the Orbiter Sound Configuration program (SoundConfig.exe) and check the box for the T+ 300 second counter in the "More options" section on lower right area of the screen.
- Start Orbiter and open the scenario "X-15D-2 First Orbital Flight."
- Jump to the X-15Δ-2 cockpit [F1]
- Verify the cockpit instrument settings:
  - HUD set to surface mode [H]
  - Surface MFD on right side [RShift] + [S]
  - RCS mode set to Rotation [/]numpad
  - Orbit MFD on left side [LShift] + [O] with the following settings:
    Projection = Ship [LShfit]+[P]
    Distance Display = Altitude [LShfit]+[D]
    Frame = Equator [LShift]+[F]

Launch

- Jump to exterior view for liftoff [F1]
- Ignite the Titan IIIc boosters [+]numpad
- Counter for Mission Elapsed Time (MET) should appear in the lower left corner of screen.
- As MET approaches 20 seconds jump back to cockpit view [F1]
- At MET +20 (or +25) seconds begin making pitch adjustments according to the table below [8]numpad or [2]numpad Launch heading is 90°
- Adjustments in yaw may be needed, especially after staging [1]numpad and [3]numpad
- Maintain 90° heading with yaw thrusters. Use roll thrusters as needed to keep the Surface HUD pitch ladder vertical

NOTE

The Titan boosters do not have attitude control jets, steering is done by thrust vectoring. Therefore, the "kill rotation" command [5]numpad will not function. Rotational "damping" is provided, which nulls the rates to a degree, but some counter-thrust must be applied end pitch, yaw and roll maneuvers. Use 10% attitude "thrust" to make fine adjustments by holding down [CTRL] key while pressing numpad keys. "Kill rotataion" command is functional with the Titan Transtage, and with the X-15Δ.

TITAN IIIc LAUNCH PROFILES

100 Mile Orbit (160 km)	210 Mile Orbit (340 km)	Orbital altitude when launching at 90° azimuth
MET +0	MET +0	Launch
MET +20	MET +25	Pitch to 80°
MET +40	MET +50	Pitch to 70°
MET +60	MET +75	Pitch to 60°
MET +80	MET +100 Stage 0 Jet.	Pitch to 50°
MET +100 Stage 0 Jet.	MET +125	Pitch to 40°
MET +120	MET +150	Pitch to 30°
MET +140	MET +175	Pitch to 20°
MET +160	MET +200	Pitch to 10°
Continue on table at right		

Maintain 10° pitch through jettison of Stage 1, and through most of Stage 2. Vertical Speed (VS) will be positive but decreasing. As VS passes through 25m/sec, begin pitching up to achieve zero VS and zero vertical acceleration (VACC). Continue adjusting pitch to maintain zero VS and VACC. (On 210 mile orbit launch profile VS remains positive throughout stage 2 burn.)
At Transtage ignition pitch to 30° and maintain 30° throughout the burn. (this applies to both launch profiles.) Vertical speed and altitude will decrease but horizontal acceleration continues.
After Transtage jettison, ignite X-15Δ main engine and lock on at full throttle [+] numpad + [CTRL]. Maintain 30° pitch. VS will still be negative but increasing. As VS passes through -50 m/sec begin pitching down to achive zero VS and zero VACC. As the Orbit MFD indicates perigee rising rapidly to earth's surface, reduce thrust to 50% [CTRL]+[-]numpad When orbit eccentricty reaches zero shut down main engine [*]numpad

Notes:

- Indications of pitch "up" and "down" in these tables are relative to the horizon.

ORBITAL FLIGHT OPERATIONS

After X-15Δ main engine shutdown:

- Turn off aerodynamic control surfaces [ALT]+[/]numpad
- Set HUD to Orbit mode [H]
- Turn X-15Δ prograde, then lock spaceplane into prograde attitude **[**

CAUTION

Using the "attitude keys" (**[ ] ; '**) to turn the X-15Δ will waste fuel. Make turns manually with short bursts from the RCS thrusters. Use attitude keys only to lock in the attitude.

- Turn on Translation RCS [/]numpad
- Use Z-axis thrusters [9]numpad and [6]numpad (and main engine if needed) to achieve a circular orbit at 160 km altitude. On a 90° launch azimuth, it is possible to achieve orbit with 45% of X-15Δ fuel remaining.
- Open Map MFD on right, set target for Edwards. A 90° launch azimuth from KSC results in a orbital inclination of about 29° (relative to equator) Edwards AFB lies at 34.92° N To land at Edwards, orbital inclination must be increased to at least 35°. Increasing inclination a bit more, say 36°, is helpful. To change orbital inclination refer to Orbiter documentation, and the following:

Changing Orbit Inclination

At Ascending Node

- Normal thrust raises inclination
- Anti-normal thrust lowers inclination

At Descending Node

- Normal thrust lowers inclination
- Anti-normal thrust raises inclination

Changing Longitude of Ascending Node

At "Crest" (high point on Map MFD)

- Normal thrust moves LAN to the east
- Anti-normal thrust moves LAN to the west

At "Trough" (low point on Map MFD)

- Normal thrust moves LAN to the west
- Anti-normal thrust moves LAN to the east

WARNING

A minimum 10% fuel level is needed for retrofire and reentry attitude control. A 15% fuel level is recommended.

REENTRY AND LANDING

Retrofire

Verify the following conditions:

- Edwards AFB is in alignment with the X-15Δ orbital track.
- Orbit at 160km, eccentricity close to zero
- Map MFD open on left, target Edwards
- Surface MFD open on right

- As the X-15Δ passes over east Africa turn spaceplane retrograde, then lock retrograde attitude **]**
- When range to Edwards is 15,000 km (15.00M) throttle up main engine to about 7% thrust [CTRL]+[+]numpad As a guide, use the fuel indicator located directly above the thrust indicator. For example, if fuel remaining is 15% the thrust bar should advance half the length of the fuel bar.

NOTE

From higher orbits perform retrofire at a greater distance from target base.

- Watch the Map MFD. The red portion of the orbital track is below the earth's surface. When the west (entry) end of the red line advances onto Edwards shut down main engine [*]numpad
- Use translation thrusters to adjust red "entry" point as close to Edwards as possible
- Turn prograde, then lock prograde attitude **[**

Reentry

Begin reentry maneuvers by verifying instrument settings:

- HUD set to Surface mode
- Map MFD open on left, target Edwards
- Surface MFD open on right

- Turn on aerodynamic control surfaces [ALT]+[/]numpad Switch to external view [F1] and make a visual check of surfaces.

(Reentry continued next page)

(Reentry continued)

- Unlock prograde attitude [
- Roll to level, center up prograde marker and kill rotation [*]numpad
- At 100 km altitude pitch up to 52° AoA
- At 95km altitude aerodynamic pressure will begin effecting spaceplane pitch. Turn on killrot [5]numpad

NOTE

Reentry attitude is maintained by applying constant stick pressure. Killrot will remain on and active throughout reentry, acting as an inertia damper, making it easier to manually maintain proper reentry attitude.

- Vertical speed will be negative, but approaching zero as aerodynamic lift increases.
- When vertical speed reaches -50 m/sec adjust pitch to hold vertical acceleration at zero, and vertical speed at -50 m/sec.
- With a steady hand, *and the killrot "damper" active*, time warp can be increased to 10X. Vertical speed may be allowed to vary *momentarily* from -40 to -60 m/sec without harm. Be prepared to return quickly to normal 1X time warp to steady up the spaceplane as needed.
- Occasionally switch to an external view [F1] Throughout the reentry there should be no apparent ionization. Visible "flames" indicate overheating during an X-15Δ reentry. Deceleration forces should not exceed 3g.

- At 45 to 48 km altitude speed should be down to mach 10. This is the same condition achieved during a X-15Δ flight launched from the B-70 Valkyrie
- Pitch down to level flight. Watch the altimeter's Apogee indicator. Pitch down further, as needed, to keep the AP below 49 km.
- Turn off RCS [CTRL]+[/]numpad

WARNING

Rebounding to an altitude of 50 km or more may result in excessive heating when the spaceplane looses lift, accelerates, and again reenters the lower atmosphere.

Approach and Landing

- Use the triangular marker on the surface HUD ribbon compass to make gentle course corrections toward Edwards
- Refer to Speed Brake Table on page 1-3. Extend and retract brakes as needed [K]
- Approach Edwards and land on main lakebed runway as described in Section I

LAUNCH ALTERNATIVE

Launching directly into an orbit with a predetermined inclination (relative to Earth's equator) must take into account the effects of Earth's rotation. Use this formula to calculate a launch azimuth:

$$\text{Launch Azimuth} = \sin^{-1}\left(\frac{\cos\ \text{Target Inclination}}{\cos\ \text{Launch Latitude}}\right)$$

Example:
Launch from KSC, latitude 28.52°, to an orbital inclination of 36°, suitable for landing at Edwards AFB:

$$\text{Launch Azimuth} = \sin^{-1}\left(\frac{\cos\ 36.00°}{\cos\ 28.52°}\right)$$

$$\text{Launch Azimuth} = \sin^{-1}\left(\frac{0.809017}{0.878650}\right)$$

$$\text{Launch Azimuth} = \sin^{-1}\left(\ 0.92075\ \right)$$

Launch Azimuth = 67.04°

See Skylab, Section 5, for description of launching to an alternate azimuth.

Skylab

Space Station

Section V

INTRODUCTTION

The Skylab scenarios are the one aspect of pure fantasy in the X-15Δ add-on. Well before Skylab development began the real-life X-15 program ended, and all hopes of a Delta follow-on were dropped. But the dates of our imagined X-15Δ timeline overlap those of the real-life Skylab. So it seemed logical that the two vehicles should meet. The Skylab space station (using an open source mesh) is included with the X-15Δ add-on, and there are two launch scenarios for rendezvous and mooring with Skylab:

The Skylab 4 scenario imagines the X-15Δ-3 visiting Skylab while the last crew still occupies the station. To run this scenario you must first perform a complete installation of the Project Apollo - NASSP add-on into your X-15Δ directory. (Project Apollo - NASSP is currently available at www.sourceforge.net/projects/nassp) The Skylab 4 scenario uses only the Apollo NASSP Command Service Module, and has it already docked to Skylab, but a partial installation of NASSP is not practical due to the complexity of the add-on.

In the Skylab 5 scenario the X-15Δ-3 visits the station sometime after the Skylab 4 crew has left. Further add-ons are not required to run this scenario because there is no Apollo CSM docked to the unoccupied station. This scenario envisions EVA transfer of the X-15Δ-3 crew to Skylab through its main docking port.

We leave further exploration of Skylab/X-15Δ operations to the imagination and creativity of the Orbiter community. With a proven re-useable crew shuttle for Skylab, and the cost of the historical STS program avoided or postponed, perhaps the means of sustaining Skylab's orbit would have been implemented before its actual demise in July, 1979. Perhaps Skylab could have gone on to become the foundation of a space station that might still be in operation today.

DESCRIPTION

Skylab is part of the Apollo Applications Program seeking long term uses for surplus Apollo program hardware. Constructed from a modified S-IVB booster, the unmanned Skylab was launched into low earth orbit by a two-stage Saturn V rocket on May 14, 1973. The space station was severely damaged during launch, losing a combination micrometeoroid/solar radiation shield, and one of its two main solar panels. The first three-man crew was launched by a Saturn 1B rocket on May 25, 1973 and made extensive repairs to the station. An improved sun screen was added by the second crew. The station crews provide data on the physiological effects of long-term space flight, perform experiments in a microgravity environment, and make astronomical and earth science observations. Skylab orbits at a perigee of 268.4 miles (431.8 km) and apogee of 269.4 miles (433.5 km) with an inclination of 50 degrees.

The X-15 Delta program uses the Skylab space station as a rendezvous target for pilot training. The X-15Δ-3 has been retrofitted with a "mooring mast" that can engage the Skylab's number 2 docking port and keep the two spacecraft securely joined. (The loss of the Skylab's solar panel provides the clearance needed to make an X-15Δ mooring possible.) It is expected that the X-15Δ-3 crew can transfer to Skylab by EVA through the station's number one docking port, or through the Command Module main hatch if the station is occupied.

LAUNCH AND ORBIT INSERTION

The following description of launch, orbit insertion and rendezvous uses Orbiter's standard MFDs and HUDs.

Pre-Flight

Jump to cockpit view [F1] and verify the instrument settings:

- RCS mode, Rotation. HUD mode, Surface.
- Map MFD open on left, targets set to Canaveral and X-15Skylab. Note orbital track just east of Canaveral and Skylab passing nearby
- Orbit MFD on right with the these settings:
  - Projection = Ship [RShift] + [P]
  - Frame = Equator [RShift] + [F]
  - Data = Altitude [RSshift] + [D]

Launch
- Open Surface MFD on left [LShift] + [S]
- Skylab 4 scenario launches December 19, 1973 at 13:55:00 UT
- Skylab 5 scenario launches April 5, 1974 at 11:20:00 UT

- Launch azimuth will be 47°. Use the 210 mile orbit launch profile on page 4-2
- Ignite Titan IIIc [+]numpad
- From MET +10 to +25 roll right about 40° [6]numpad

NOTE

The roll maneuver will be approximate because the Surface MFD and HUD will not return reliable heading information at a 90° pitch.

- At MET +25 pitch down to 80° [8]numpad, then...
- Correct heading to 47° using 10% yaw thrust [CTRL]+[1]numpad or [CTRL]+[3]numpad, then...
- Roll as needed to bring the surface HUD pitch ladder vertical [4]numpad or [6]numpad
- At MET +50 pitch down to 70° and repeat yaw and roll maneuvers as needed to establish 47° heading and vertical pitch ladder.
- Continue following 210 mile orbit launch profile shown on page 4-2. Make adjustments as needed to maintain 47° heading and vertical HUD pitch ladder. Use the Surface HUD ribbon compass to maintain a precise heading.
- At engine shut down orbit eccentricity should be near zero, altitude about 196 miles (315 km) and fuel remaining 28%
- Set Orbit MFD target to Skylab [LShift] + [T] Verify that X-15Δ is orbiting below and behind Skylab.

Orbital Plane Alignment
- Open Alignment MFD on left [LShift] + [A]
- Set target for "X-15Skylab" [LShift] + [T]
- Relative inclination should not exceed 1.25°
- Use main engine at about 10% thrust to align orbits:
  At ascending node thrust Anti-normal.
  At descending note thrust Normal.
- Use translation RCS to fine tune alignment:
  Relative inclination = 0°, and
  Ship Position line and Node line form a right angle.
- Repeat alignment procedure at next node crossing if needed.

RENDEZVOUS

Transfer Orbit Insertion (TOI)
- Open Transfer MFD on right [RShift] + [X]
- Activate hypothetical transfer orbit (HTO) mode [RShift] + [X] (again)
- Set target to 'X-15Skylab" [RShift] + [T]
  Solid green line = X-15Δ current position.
  Solid yellow line = Skylab current position.
  Dotted green line = X-15Δ eject position.
  Message "No Intersect" appears.
- Increase Dv [RShift]+[=] just until two lines appear (use the minimum Dv possible):
  Solid gay line = X-15Δ intercept position (where X-15Δ will intercept Skylab's orbit).
  Dotted yellow line = Skylab intercept position (where Skylab will be when X-15Δ intercepts Skylab's orbit).
- Rotate the eject line [RShift] + [<] or [>] until the two intercept lines overlap. If the intercept lines will not overlap wait for the X-15Δ to draw closer to Skylab and try again. When the lines overlap compare the TLi (location of intercept line) shown for X-15Δ and Skylab. Adjust eject line further to minimize the difference between the two TLi figures.
- Turn X-15Δ prograde, then lock spaceplane into prograde attitude **[**
- When DTe (Δ time to eject) = 5 seconds throttle up main engine to 5% thrust [CTRL] + [+]numpad
- When Dv reaches zero shut down main engine [*]
- Fine tune Dv to zero with 10% RCS thrust [CTRL] + [6]numpad or [9]numpad
- Turn off Transfer MFD [RShift] + [Q]

Mid-course Correction (MCC)
- Close MFD on right [RShift] + [Q]
- Set HUD mode to Docking [H]
- Open Nav/Comm MFD on left [LShift]+ [C]
- Set Nav1 to Skylab's transponder frequency 111.10 [LShift] + [=] and **]**

- Replace NavCom MFD with Docking MFD on left [LShift] + [D]
- Slave Docking MFD to Nav1 frequency [LShift] + [N] Docking MFD will receive signals from Skylab's transponder when the distance closes to 100km
- *Perform MCC 1 at 40km distance to Skylab*:
- Turn toward Skylab in direction indicated by Docking HUD. From a prograde attitude this should be a right yaw. Docking HUD will mark Skylab with a square target box. The HUD's retrograde crosshairs should be close by.
- Aim the X-15Δ at the retrograde crosshairs and kill rotation [5]numpad
- Turn on translation RCS [/]numpad
- "Drive" the retrograde crosshairs into the target box by firing X-axis RCS thrusters [1]numpad or [3]numpad
- Fire Y-axis thrusters to drive the crosshairs "up" or "down" as needed. Adjustment should be very minor if the orbits were properly aligned prior to TOI.
- *Perform MCC 2 at 20km distance to Skylab*.

Braking Phase

At 10km distance to Skylab the closing velocity should be 20 m/sec. Closing velocity will most likely be higher and "braking" will be required.

- If closing velocity is fairly close to 20 m/sec aim the X-15Δ at the Docking HUD retrograde crosshairs and fire Z-axis translation thrusters [6]numpad or [9]numpad to achieve CVEL of 20 m/sec at a DST of 10km.
- If closing velocity is significantly greater than 20 m/sec (which is most likely) turn the X-15Δ to aim at the Docking HUD ***prograde*** marker and ignite main engine at minimal thrust [CTRL] + [+]numpad
- Shut down main engine when closing velocity reaches 20 m/sec [*]numpad
- Fine tune closing velocity with Z-axis thrusters as needed.
- Turn X-15Δ back to aim at Skylab
- As X-15Δ closes on Skylab use Z-axis thrusters to decrease the closing velocity as follows:

DST	CVEL	DST	CVEL
2000m	9m/sec	150m	1.5m/sec
1000	6	50	0
500	3		

- Maintain station-keeping at 50m distance until lighting conditions are favorable for mooring.

MOORING

Skylab's Multiple Docking Adapter (MDA) is located on the space station's main axis "below" the Apollo Telescope Mount (ATM) which has a "windmill" solar panel array. The MDA has two docking ports. The main port is located on Skylab's main axis and is used by the Command Service Module. The side port is located on Skylab's ventral (bottom) side, opposite the ATM. The X-15Δ-3 has a "mooring grapple" that extends up from the dorsal (top) side of the spaceplane. The X-15Δ will approach Skylab from below and translate "up" the spaceplane's Y axis to engage the grapple with the space station's ventral docking port.

- Jump to Skylab [F3] Kill its rotation [*]numpad
- Jump back to X-15Δ-3 [F3]
- Open the Docking MFD on the left [LShift] + [D] and set to visual mode [LShift] + [V]
- Extend the mooring grapple [LShift] + [3]
- Approach Skylab from the side opposite the main solar panel, and several meters "below" the space station. (The X-15Δ's main axis at a right angle to Skylab's main axis)
- Position the mooring mast below the ventral side docking port.
- Using the Docking MFD to guide the approach, thrust up to engage the mooring mast into the docking port.

CAST-OFF AND REENTRY

- Set RCS for translation [/]numpad
- Cast off from Skylab [CTRL] + [D]
- Thrust "down" [8]numpad
- Stow mooring grapple [LShift] + [3]
- See page 4-3 for reentry procedures

LAUNCH FOR SKYLAB 5

In the Skylab 5 scenario the X-15Δ-3 at launch lags further behind Skylab. Launching into a 100 mile orbit will allow the X-15Δ-3 to catch up to Skylab quicker.

Installation

Requirements

Appendix

GENERAL

The ***X-15Δ*** is a "stand alone" Spacecraft2-based add-on for Orbiter. Previous installation of the orignal Project***X-15*** add-on (simulating the real-life X-15) is not required. However, prior experience with installing and flying the original Project***X-15*** will be very benificial. ***X-15Δ*** can be flown "as is" with most of the scenarios provided using only the System Requiements (basic Orbiter and Spacecraft2) and no other add-ons. The orbital flight scenarios require installing the CVEL Titan add-on.

The ***X-15Δ*** flight experience is greatly enhanced by the optional add-ons. The default installation for several of these add-ons create uniquely named configurations for system Sol, planet Earth and bases Canaveral and Edwards. This permits installing these various add-ons into a single Orbiter folder, without over-writing previously installed configurations, but it also places each add-on in its own parallel, mutually exclusive "universe." To make these various add-ons work together they must be placed in the same universe, defined by single configuration files for Sol, Earth, Canveral and Edwards. These config files must then be edited to call up the necessary mesh and texture files for each add-on. This makes installing these add-ons a little more challenging. To make this process easier ***X-15Δ*** installation includes alternate configurations that you can use to bring the add-ons into system SOL.

The X-15 is a research aircraft. This is an opportunity to experiment and learn.

Install these programs in a new, empty folder, in the order shown. Install the programs one at a time, then start Orbiter and run appropriate scenarios to test each installation before proceeding to the next. This will make problem solving much easier. Each program comes with its own documentation and installation instructions which you should review.

Unless noted otherwise, all programs can be found at Orbithanger.com

In these instructions FOLDER names are shown in all upper case, File names appear in upper and lower case.

REQUIRED PROGRAMS

Orbiter Space Flight Simulator (050116 Base and 050216 Patch) by Martin Schweiger. Start with a fresh installation of Orbiter in a new folder devoted to the ***X-15Δ*** add-on. (If you set up the previous Project***X-15*** add-on in this way, you may install ***X-15Δ*** in that same Project***X-15*** folder.) The following instructions assume you are starting with Canveral and Edwards as they come with Orbiter 2005, unaltered by other add-ons.

Spacecraft2 by Vinka (available at: http://users.swing.be/vinka/) Note that the older release, Spaccraft.dll, will not work. The required files are included with ***X-15Δ***:
CONFIG\Spacecraft2.cfg
MODULES\Spacecraft2.dll
Downloading the program is recommended for the documentation and test scenarios.

CVEL Titans v1.1 by Erik Anderson (Sputnik). Copy the contents of the .zip file to your Orbiter X-15Δ directory, preserving the directory structure.

(Required Programs continue next page)

X-15Δ by Greg Burch (GregBurch) and Scott Conklin (Usonian) Released in four .zip file packages:

Pack 0 Flight Manual
Pack 1 Delta 1 and B-52 "Balls 3", Spacecraft2 files, alternate base configs.
Pack 2 Delta 2 and B-70 Valkyrie.
Pack 3 Delta 3, and Skylab.

Copy the contents of each .zip file to your Orbiter X-15Δ directory, preserving the directory structure. Packs are "additive" (packs 2 & 3 using material from a previous pack) so install them in the order shown. Pack 1 contains customized configuration files for Edwards and Canaveral which are used with the optional add-ons as explained below.
(Thanks to Cyrus E. Phillips V for photo from National Air and Space Museum of Apollo AGM DSKY used on X-15Δ panel.)

Skylab included with the ***X-15Δ*** installation, configuration by Scott Conklin, "open source" mesh by John Graves (missleman01) & Sean Evans (Nighthawke). The rendezvous procedure in Section V is adapted from the LM lunar rendezvous described in John Dunn's outdated but still excellent 2003 NASSP Apollo Tutorial (available at www.jdkbph.com)

OPTIONAL PROGRAMS

OrbiterSound 3.0 by Daniel Polli (DanSteph)(available at: www.orbiter.dansteph.com)
In addition to the heightened drama of engine sounds and cabin fans this program provides a T+300 second timer useful for manual control during Titan launches, and altitude call-outs useful and realistic during landings. Installation is easy from a self-extracting file.

Edwards Air Force Base Upgrades
Prior to performing any of the Edwards upgrade you must first correct the location of Edwards on planet Earth (the Orbiter program has it wrong).

1. Using Windows Notepad (or other appropriate plain text editor) open this file: CONFIG\Earth.cfg
2. Under the heading SURFACE_BASE change the Edwards line to read:
`Edwards: -117.838620 +34.918400`
3. Save the edited file and make sure your editor does not change the file extension. The file name must remain Earth.cfg

A Basic (Almost Stupid) EAFB Upgrade (included with ***X-15Δ*** install) adds the two paved runways and several lakebed runways to Orbiter's simple Edwards configuration. No downloads required, low impact on memory.

1. Using Notepad, open the file CONFIG\EdwardsRUNWAYS.cfg
2. Perform a "Saveas" and type in Edwards.cfg to overwrite the existing file.
3. Open CONFIG\Base.cfg and below "Runway1" add this line: "RunwayDirt1" This new runway texture is included with ***X-15Δ*** .

This procedure replaces Edwards.cfg while preserving EdwardsRUNWAY.cfg The ***X-15Δ*** install includes a backup copy of the original Orbiter Edwards.cfg file (named EdwardsORBITER.cfg) so you can restore the original configuration if needed.

Edited Edwards AFB by McWgogs. (download file name EdwardsAFBedit.rar) depicts Rogers Dry Lake, hangars and the paved runways.

1. Download the .rar file extractor from www.rarlab.com/download (free trial copy).
2. Extract EdwardsAFBedit.rar to your Orbiter X-15Δ directory, preserving the directory structure.

The McWgog add-on installs an appropriate CONFIG\Edwards.cfg file. The ***X-15Δ*** install includes a backup copy of this configuration file (named EdwardsMCWGOG-1.cfg) so you can restore it later if needed.

Edwards AFB Upgrade 1.2 by McWgogs. (download file name EdwardsAFB_1.2.zip) extends the textures to add a 600 square mile area around Rogers Dry Lake.

1. Install the Edited Edwards AFB add-on prior to installing this add-on.
2. Extract Edwardsedit2.zip and copy the files to the TEXTURES directory in your X-15Δ.

The add-on includes two sets of texture files, for low resolution or high resolution.

3. Using Notepad, edit the Edwards.cfg file as described in the add-on readme file, or...
4. Using Notepad, open the backup copy provided with the X-15Δ install (named CONFIG\EdwardsMcWGOG-2.cfg) Perform a "Saveas" and type in Edwards.cfg to over write the existing file.

A final wrinkle to this McWgog add-on is ***Edwards Upgrade 1.2 - Revisited*** (download file name Edwardsedt2.zip) provides the same texture files as Edwards Upgrade 1.2, but the appearance is altered to better blend with the Level 9 Earth Textures by Jim Williams. It uses the same Edwards.cfg file (or the backup EdwardsMcWGOG-2.cfg)

Launch Complex 39 and Edwards AFB by Damir Gulesich (Slat) (download file name LC39-EAFB_v2.17.zip) provides taxi ways and markings for lakebed runways. The real-life lakebed runways are marked with an asphalt compound each year.

1. Install the Edited Edwards AFB and the Edwards AFB Upgrade 1.2 (or Upgrade 1.2 - Revisited) add-ons by McWgog prior to installing Slat's add-on. The Slat add-on uses the McWgog textures
2. Extract ONLY the following files from LC39-EAFB_v2.17.zip to the corresponding folders in you X15Δ directory:
   MESHES / STSedwards.msh
   TEXTURES/edw1.dds
   TEXTURES/edw2.dds
   TEXTURESedw3.dds
3. Using Notepad, open the file named CONFIG/EdwardsSLAT.cfg included with the ***X-15Δ*** install. Perform a Saveas and type in Edwards.cfg to overwrite the existing file.

When using this add-on with ***X-15Δ***, do NOT extract the entire add-on .zip file. It will overwrite your Canaveral configuration, and it will create a new system called SolSTS. The ***X-15Δ*** add-on is configured to operate only in system Sol. Do NOT use the Edwards.cfg file that comes with v2.17 of this add-on. It contains an extraneous semicolon blanking out one of the Rogers Dry Lake textures and it will likely create a CONFIGSTS folder.

Kennedy Spaceflight Center Upgrades
The ***X-15Δ*** add-on includes Titan launch scenarios that permit launching the Deltas from either Launch Complex 39B that comes with Orbiter, or from the Titan Launch Complex 40-41 add-on by Kev33. The X-15Δ was never built, so it is not possible to say which facility would be used to assemble and launch the vehicle - good arguments can be made for either LC40-41 or LC39. The Kev33 add-on has a high polygon count, so the LC-39 launch scenario is provided for "low-end" computers. The Earth_1975 add-on includes a simpler LC-40-41 and there are many LC-39 upgrades available. The Titan/X-15Δ launch scenarios can be edited to place the rocket on any launch pad anywhere. The critical lines to edit are POS (position) which establishes latitude and longitude of the rocket stack, PADBIAS which moves the entire rocket stack up or down to place it on the launch table, and HEADING which will rotate the rocket around its Z axis on the launch table. Refer to the CVEL Titan documentation for complete details.

Launch Complex 39 Simply start the appropriate scenario installed with X-15Δ. No editing of Canveral.cfg is required. Whatever upgrades you made to Edwards AFB you will be effective, providing a target for reentry and a place to land.

Launch Complex 40 and 41 by Kev Shanow (Kev33) (download file name K-LC-40-41.zip) Depicts the launch pads, umbilical towers, assembly buildings and related roadways.

1. Extract ONLY the MESHES and TEXTURE files to the corresponding folders in you X15Δ directory.
3. Using Notepad, open the file named CONFIG\CanaveralKEV33.cfg included with the ***X-15Δ*** install. Perform a Saveas and type in Canaveral.cfg to overwrite the existing file.

When using the Kev33 add-on with ***X-15Δ***, do NOT extract the CONFIG files. They create a new system called Sol_K40-41. Also, the configuration file for Canaveral (K40-41_Canaveral.cfg) does not include the long STS runway needed for B-70 Valkyrie takeoff.