North American Aviation, Inc.

X-15

FLIGHT MANUAL

International Airport, Los Angeles 45, California

LOS ANGELES DIVISION

Project**X-15**
Version 1.0 — September, 2005
Version 2.0 — July, 2006

TABLE OF CONTENTS

IMPORTANT NOTE

Project**X-15** v2.0 is not a patch for v1.0. Do not install ProjectX-15 v2.0 within an Orbiter folder already occupied by an earlier release of ProjectX-15 or X-15 Delta.

ABOUT THIS MANUAL

A high resolution .pdf copy of the actual 1962 *X-15 Flight Utility Manual* can be found at www.sierrafoot.org/x-15/documents/documents.html In the interest of heightened historical accuracy (and just for fun) the X-15 Flight Manual for Orbiter 2006 attempts to maintain the 1950s "feel" of the original by using similar typeface, formatting and graphics. The illustrations are in black and white. The text is in present tense, where reasonable, as though the X-15s are in active service.

Given the "space age" subject matter, it is startling how "antique" the original manual looks — underscoring the fact that North American Aviation was selected to design and build the X-15 over fifty years ago, on September 30, 1955.

SYSTEM REQUIERMENTS AND RECOMMENDATIONS

Required:
Orbiter (060504) by Martin Schweiger
Spacecraft3 by Vinka

Recommended Add-ons:
Orbiter High Res Earth Textures
Orbiter Sound by Daniel Polli (DanSteph)

See Section III for detailed credits, program installation and sources.

SPECIAL THANKS

John Shanow (Kev33) whose groundbreaking K-X-15 furnished the inspiration for Project**X15**

AUTHORS

Greg Burch (GregBurch)
Aircraft mesh and animations.

Scott Conklin (Usonian)
Flight performance and manual.

SPECIAL CONTRIBUTORS

Friedrich Kastner-Masilko (Face)
For creating the ReleaseMFD, permitting us to launch the X-15 from within the X-15 Cockpit

Damir Gulesich (Slat)
For permission to use his 2005 Edwards base mesh providing lake bed runway markings and taxiways for Edwards AFB

Description

SECTION I

AIRPLANE

The X-15 is a single-place research airplane, specifically designed to obtain data on flight at extremely high altitudes and speeds and on the physiological and psychological effects of such flight conditions on the pilot. Built by North American Aviation, Inc, the airplane has an inertial all-attitude (gyro-stabilized platform) flight data system and is powered by one XLR99 liquid propellant rocket engine [initially two XLR-11s]. The 25-1/2 degree sweptback wing has hydraulically operated flaps on the inboard trailing edge of each wing panel. All aerodynamic control surfaces are actuated by irreversible hydraulic systems. The horizontal stabilizer has a 15-degree cathedral. The two sections move simultaneously for pitch control, differentially for roll control, and in compound for pitch-roll control. The upper and lower vertical stabilizers are in two sections, a movable outer span for yaw control and a fixed section adjacent to the fuselage. The lower movable section (ventral) is jettisonable for landing. Each fixed section incorporates a split-flap speed brake. For changes in airplane attitude relative to flight trajectory at altitudes where aerodynamic controls are relatively ineffective, the airplane incorporates a ballistic control system, wherein the metered release of gas through small rockets in the nose and wing causes the airplane to move about each axis as required. Two auxiliary power units drive the airplane hydraulic pumps and AC electrical generators. Fuel for the rocket engine is carried internally. The airplane is not designed for normal ground take-off, but is air-launched by a B-52 Airplane. The landing gear consists of a dual-wheel nose gear and two main landing skids. The gear is lowered in flight by gravity and air loads.

NOTE

The foregoing description is from the 1962 *X-15 Flight Utility Manual*. The meshes, animations and flight configurations for Project**X-15** strive to conform with this description. (Spacecraft3.dll provides flap animation, but due to a software bug the flaps produce no aerodynamic effect. The overall flight and landing performance is not badly compromised.)

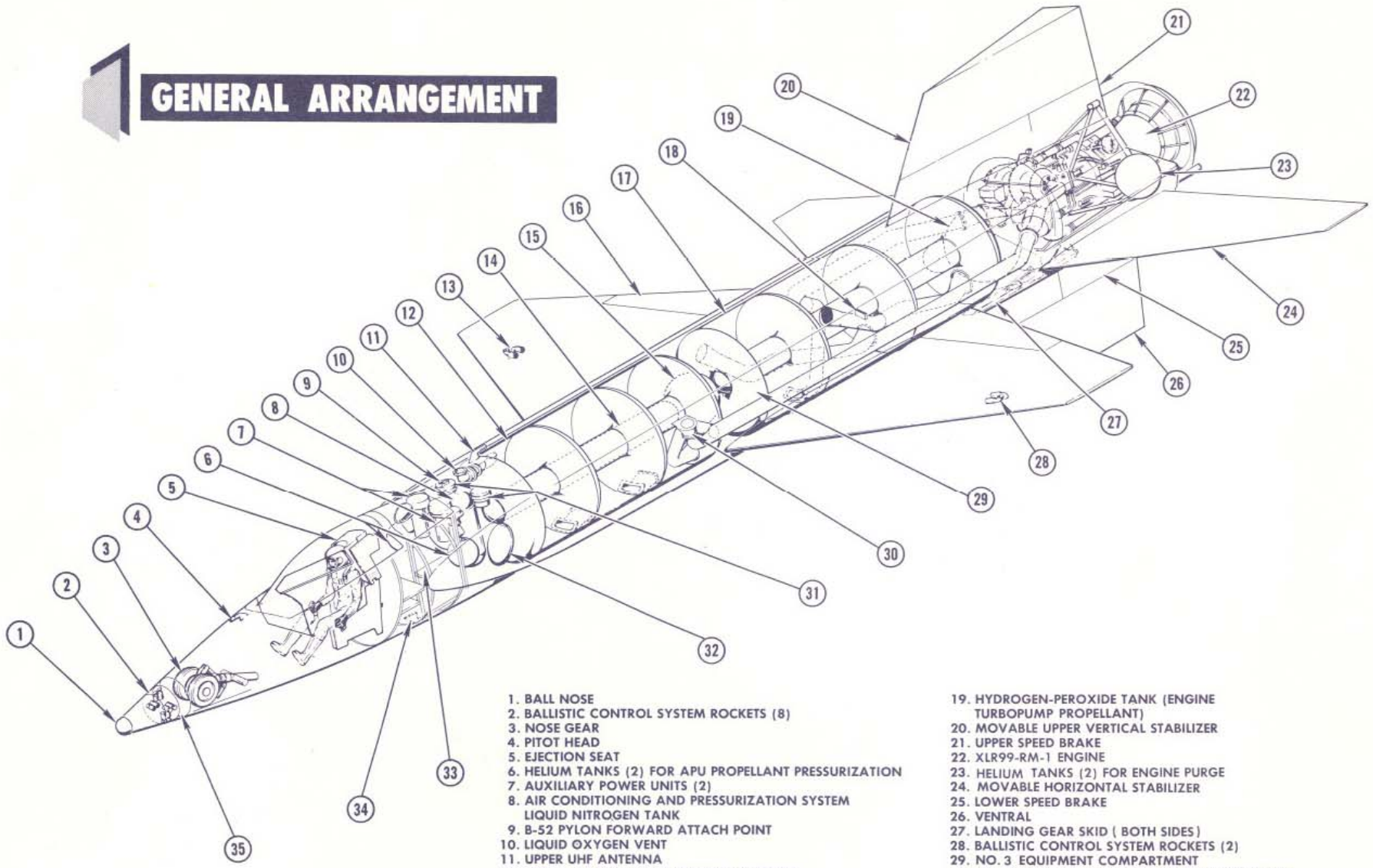
ENGINES

Development of the XLR-99 engine lagged behind the rest of the aircraft. In the interim, to keep the program alive and test out the airframe and other systems, two smaller XLR-11 motors were installed. This X-15 simulation includes configurations for flying with either engine.

The two XLR-11s produce a combined total thrust of 16,000 lbf (36 kN). They are fueled with alcohol and liquid oxygen. Each engine has four exhaust nozzles. The eight nozzles can be fired individually, and through various combinations provide a crude form of throttle control. At full thrust (all eight nozzles burning) the XLR-11 will run for about 260 seconds.

The XLR-99 is rated at 57,000 lbf thrust (254 kN) and is fueled with anhydrous ammonia and liquid oxygen. It provides true throttle control from 40% to 100% thrust. At 100% thrust the XLR-99 will burn for about 85 seconds.

GENERAL ARRANGEMENT



1. BALL NOSE
2. BALLISTIC CONTROL SYSTEM ROCKETS (8)
3. NOSE GEAR
4. PITOT HEAD
5. EJECTION SEAT
6. HELIUM TANKS (2) FOR APU PROPELLANT PRESSURIZATION
7. AUXILIARY POWER UNITS (2)
8. AIR CONDITIONING AND PRESSURIZATION SYSTEM LIQUID NITROGEN TANK
9. B-52 PYLON FORWARD ATTACH POINT
10. LIQUID OXYGEN VENT
11. UPPER UHF ANTENNA
12. LIQUID OXYGEN TANK (ENGINE OXIDIZER)
13. BALLISTIC CONTROL SYSTEM ROCKETS (2)
14. HELIUM TANK (FOR ENGINE PROPELLANT PRESSURIZATION)
15. HELIUM TANK FOR PRESSURIZATION CONTROL, ENGINE CONTROL, AND ENGINE HYDROGEN PEROXIDE PRESSURIZATION
16. RIGHT-HAND WING FLAP
17. AMMONIA TANK
18. B-52 PYLON REAR ATTACH POINT (BOTH SIDES)
19. HYDROGEN-PEROXIDE TANK (ENGINE TURBOPUMP PROPELLANT)
20. MOVABLE UPPER VERTICAL STABILIZER
21. UPPER SPEED BRAKE
22. XLR99-RM-1 ENGINE
23. HELIUM TANKS (2) FOR ENGINE PURGE
24. MOVABLE HORIZONTAL STABILIZER
25. LOWER SPEED BRAKE
26. VENTRAL
27. LANDING GEAR SKID (BOTH SIDES)
28. BALLISTIC CONTROL SYSTEM ROCKETS (2)
29. NO. 3 EQUIPMENT COMPARTMENT
30. LIQUID OXYGEN TANK (ENGINE OXIDIZER) FILLER
31. HYDRAULIC SYSTEM RESERVOIRS (2)
32. HYDROGEN-PEROXIDE TANKS (2) APU AND BALLISTIC CONTROL SYSTEMS PROPELLANT
33. NO. 2 EQUIPMENT COMPARTMENT
34. LOWER UHF ANTENNA
35. NO. 1 EQUIPMENT COMPARTMENT

X-15-1-00-1B

SPECIFICATIONS

Fuselage

Length:	49.33'
Max. Diameter:	4.5'
Center of Gravity:	341.7"

Wing

Airfoil:	Modified NACA 66005
Root section:	5%
Span:	22.36'
Area:	200 sf (incl. 94.98 sf in fuselage)
Aspect Ratio:	2.50
Wing cord:	10.27'
Root chord:	14.91'
Tip chord:	2.98'
Lead sweep:	25.5°
Flap area:	8.30 sf
Flap defection:	-40°

Horizontal Stabilizer

Airfoil:	Modified NACA 66005
Root section:	5%
Span:	18.08'
Area:	51.76 sf
Aspect Ratio:	2.81
Root chord:	7.02'
Tip chord:	2.10'
Lead sweep:	45.0°
Deflection:	+15/-45

Dorsal Stabilizer

Airfoil:	10° wedge
Area:	41.25 sf
Lead sweep:	52.0°
Rudder deflection:	±30°

Ventral Stabilizer

Airfoil:	10° wedge
Area:	33.75 sf
Lead sweep:	52.0°

Weights

	X-15	X15A-2
Empty:	15,200 lb	17,000 lb
Fuel weight:	16,700	32,250
Pilot & equip:	1,000	1,000
Total:	32,900	50,250

Three X-15 aircraft were constructed. The X-15-1 and X-15-2 flew initially with the XLR-11 engine, the X-15-3 flew only with the XLR-99. The aircraft exceeded the program design altitude of 250,000 feet (76.2 km), but the maximum speed fell just short of the specified 6,600 feet per second (2011 m/sec) -- mach 6 . This shortfall was expected because the as-built weight of the X-15s exceeded the initial design weight.

On November 9, 1962 the X-15-2 rolled over and was heavily damaged during an emergency landing at Mud Lake. (The pilot, Jack MacKay, was seriously injured, but recovered and went on to make an additional 22 X-15 flights.) The re-built X-15A-2 was modified to test hypersonic air-breathing engine systems. The fuselage was lengthened by inserting a 29 inch (0.74m) long section to provide additional camera ports, and space for a liquid hydrogen tank to fuel a ram jet mounted under the tail. The redesigned ship could also carry external fuel tanks, increasing engine burn time from 90 to 150 seconds and, it was hoped, increase top speed to 8,000 fps (2,438 m/sec) -- mach 7. A working ram jet was never flown. Top speed achieved was 6,629 fps (2,020 m/sec).

The first powered X-15 flight took place September 7, 1959. The three ships made a total of 199 flights. The program ended December 20, 1967.

Summary of Record Flights

Configuration	Altitude	Speed
Program Objectives	250,000 ft 76.2 km	6,600 fps 2012 m/sec
XLR-11	133,000 ft 40.54 km 12 Aug 60	3,337 fps 1,017 m/sec 7 Feb 61
XLR-99	354,200 ft 107.96 km 22 Aug 63	6,019 fps 1,834 m/sec 27 Jun 62
X-15A-2 XLR-99 with External Tanks. Manual engine shut-down at 140.7 seconds		6,629 fps 2021 m/sec 3 Oct 67

ORBITER CONFIGURATIONS

Appearance

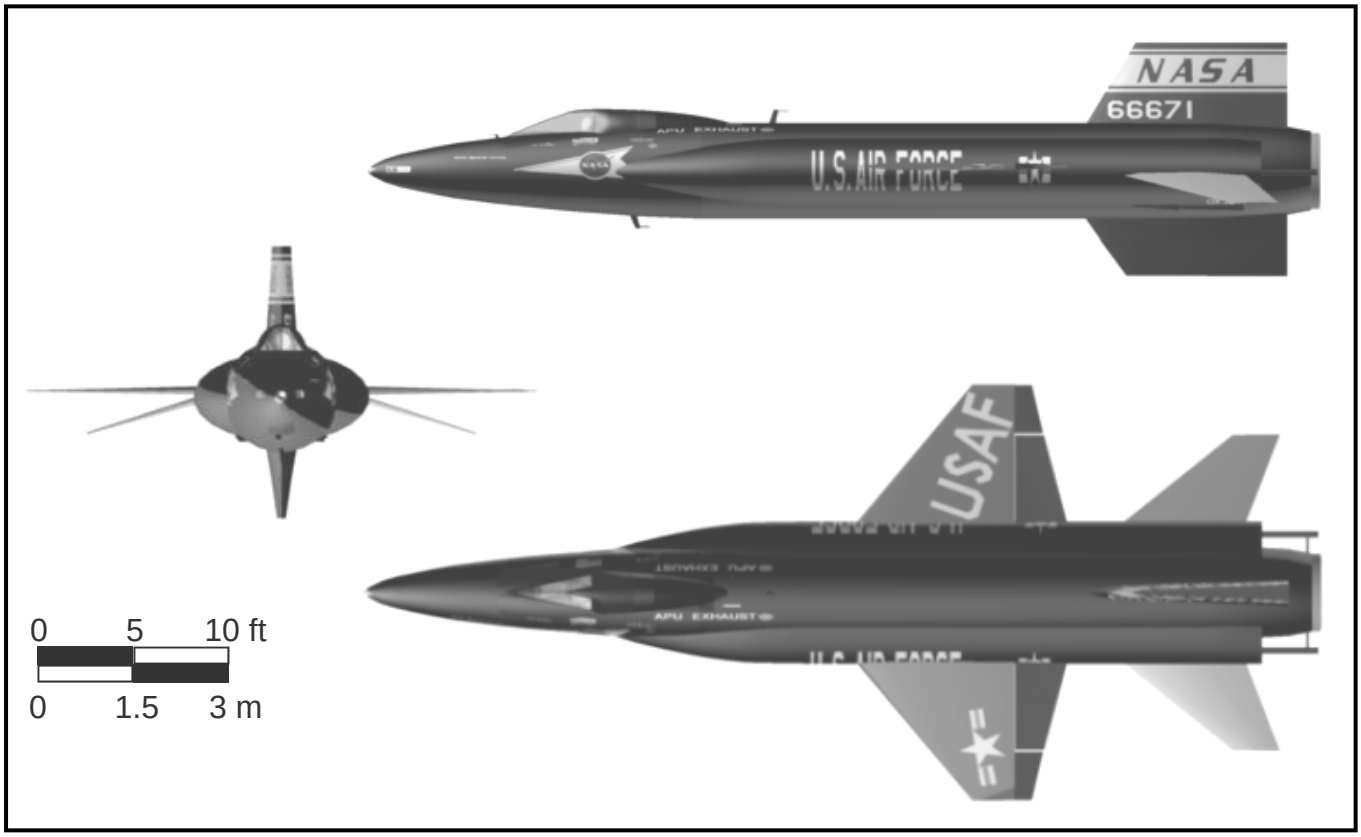
There were variations, both significant and subtle, among the three aircraft, and across the 199 flights made during the X-15 program. The four aircraft models included with the Project**X15** add-on are intended to be representative of the way the planes looked at various major milestones during the eight years that the X-15s flew.

The X-15-1 is shown with the XLR-11 motor, serial number 66670 on the dorsal stabilizer, and the original X-15 instrument panel. The X-15-3 (66672) is shown with the XLR-99 engine and the final instrument panel. The X-15A-2, (66671), is shown both with and without external fuel tanks, in its initial black finish, with some test areas of red ablative coating. The fourth model shows the X-15A-2 with full, white ablative coating, external fuel tanks and dummy ramjet as it appeared for its record setting speed flight.

Project**X15** also includes the B-52 carrier ships, "Balls 3" and "Balls 8" (serial numbers 20003 and 20008). Balls 3 appears in October 1959 colors. Balls 8 appears as it did for the October 3, 1967 speed record flight.

Performance

Spacecraft3 provides full access to the aerodynamic modeling potential of Orbiter 2006. Weight, engine thrust, wing area and aspect ratio of each craft is accurately configured. The lift vs. AoA profile, base drag and wave drag are taken from a contemporaneous technical paper based on in-flight measurements. (See Section III for sources.) To the greatest extent possible, the X-15 configuration files match the real-life specifications, resulting in historically accurate performance.



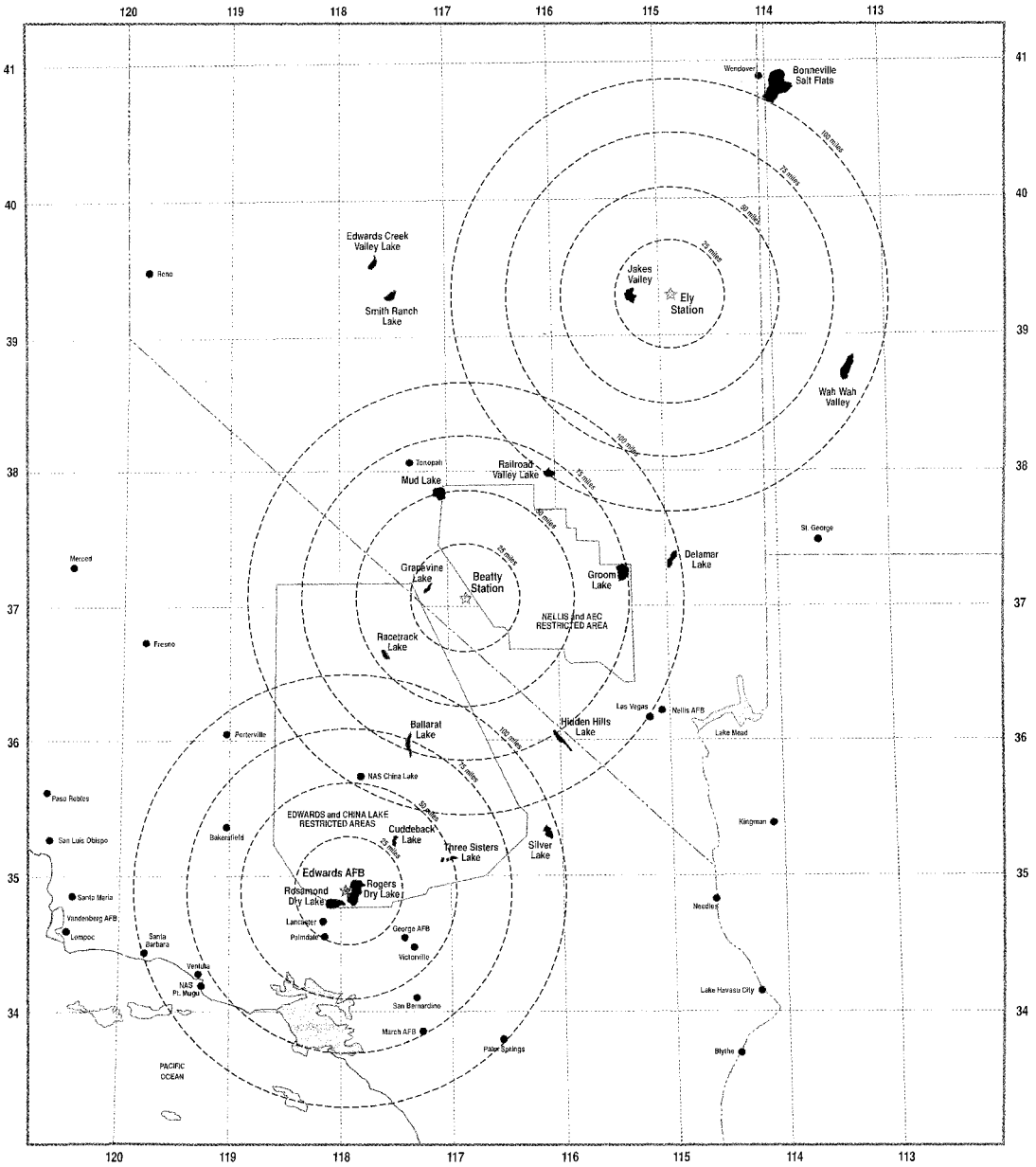
Three View of X-15-3

HIGH ALTITUDE FLIGHT RANGE

The High Altitude Flight Range was developed to support the X-15 and to establish safe flight paths away from populated areas. The High Range has three stations - Ely, Beatty and Edwards - furnishing radar tracking, radio communications, and telemetry recording. The High Range also includes a variety of small dry lakes for emergency landings. All X-15 flights were planned to begin above one of these small lakes - the launch lake - and end on the main runway at Rogers Dry Lake.

HISTORICAL NOTE

Out of 199 X-15 flights there were ten emergency landings at alternate dry lakes. Most landings at Rogers Dry Lake came within 2,000 feet (615 meters) of the planned touch-downed point, although Neil Armstrong once missed by 12 miles (19 km). Although landing on a marked runway is preferred, a landing anywhere on a dry lake bed is survivable. ProjectX-15 v2.0 includes surface tiles for Rogers Dry Lake, and for all of those High Range lakes that were used as launch lakes, and where emergency landings actually took place.



High Altitude Flight Range

Flight Operations SECTION II

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. Key commands apply to all X-15 aircraft unless otherwise noted.

Custom Key Command Summary

[J] Jettison ventral fin[1]
Jettison external fuel tanks [2]

[K] Extend/retract speed brakes

[G] Extend/retract landing gear

[L Shift] + [0]numpad
Lower/Raise flaps[3]

[L Shift] + [1]numpad
Open/close canopy

[L Shift] + [2]numpad
Open/close skylight hatch[4]

[L Shift] + [3]numpad
Open/Close eyelid window cover [5]

[CTRL] + [F3]
Shift focus between aircraft[6]

[1] Jettison ramjet on X-15A-2 with full ablative coating.
[2] Only on X-15A-2 with external tanks.
[3] Flaps are animated but have no aerodynamic effect due to a Spacecraft3 bug.
[4] Not available on X-15 with XLR-11.
[5] X-15A-2 with full ablative coating.
[6] After shifting focus once by the conventional method - [F3], click the on-screen window - you can quickly "toggle" between the current vessel focus and the previous vessel focus with this key command.

X-15 aircraft support dynamic virtual cockpit views. Use the mouse to “turn your head” as described in the Orbiter documentation.

PRE-FLIGHT REQUIREMENTS

Installation See Section III of this manual for add-on installation details.

Attachment and the ReleaseMFD
ProjectX-15 v2.0 uses the ATTACHMENT feature now supported by Spacecraft3. When joined by ATTACHMENT, both the "parent" B-52 carrier ship, and the "child" X-15 ship, are fully initialized when a scenario is loaded. This allows the user to change focus with the [F3] key between the two ships while the ships are still attached. Once the flight path of the B-52 is properly trimmed, the user can jump into the X-15 cockpit, complete launch preparations, and then release the X-15. This greatly enhances the realism of the launch.

Spacecraft3 supports detachment of the "child" ship only when the focus is on the "parent" ship. But ProjectX15 includes a simple MFD tool that permits a remote release while the focus is on the child ship.

Before loading an X-15 scenario you MUST click on the Modules tab of the Orbiter Launch Pad window and activate ONE of the following:

Release-Mouse OR Release-ShiftD

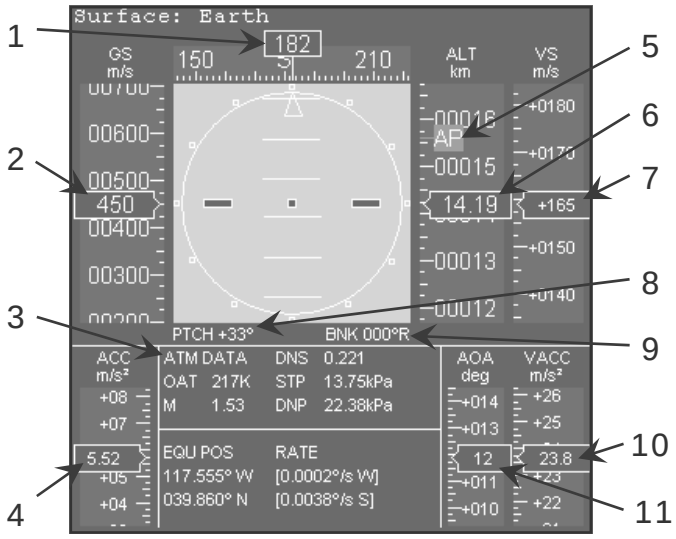
Do not activate both Release MFDs

Release-Mouse releases the X-15 from the carrier ship with a mouse click on the MFD screen button. Release-ShiftD releases the X-15 with a [Shift]+[D] key command. Release-ShiftD permits releasing the X-15 from an external view of the aircraft.

MFD Adjustments
Reducing the size of the MFDs and making them transparent will improve cockpit visibility. Click on the Parameters tab in the Orbiter Launch Pad window to make adjustments.

INSTRUMENTATION

Project X-15 uses Standard SurfaceHUD, MapMFD and SurfaceMFD. (ReleaseMFD is included with the ProjectX-15 installation.)



SurfaceMFD

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 True Air Speed (TAS)

3 Atmospheric Data:
OAT - Outside Air Temperature (Degrees Kelvin)
M - Mach Number
DNS - Atmospheric Density
STP - Static Pressure
DNP - Dynamic Pressure

4 Prograde Acceleration - 1G = 9.75 m/sec^2, 2G ~ 20 m/sec^2, 3G ~ 30 m/sec^2 , etc.

5 Apogee Marker

6 Altitude

7 Vertical Speed

8 Pitch - Also read from Surface HUD, angular difference between horizon and direction ("nose") indicator.

9 Bank indicator

10 Vertical Acceleration - See G force note above.

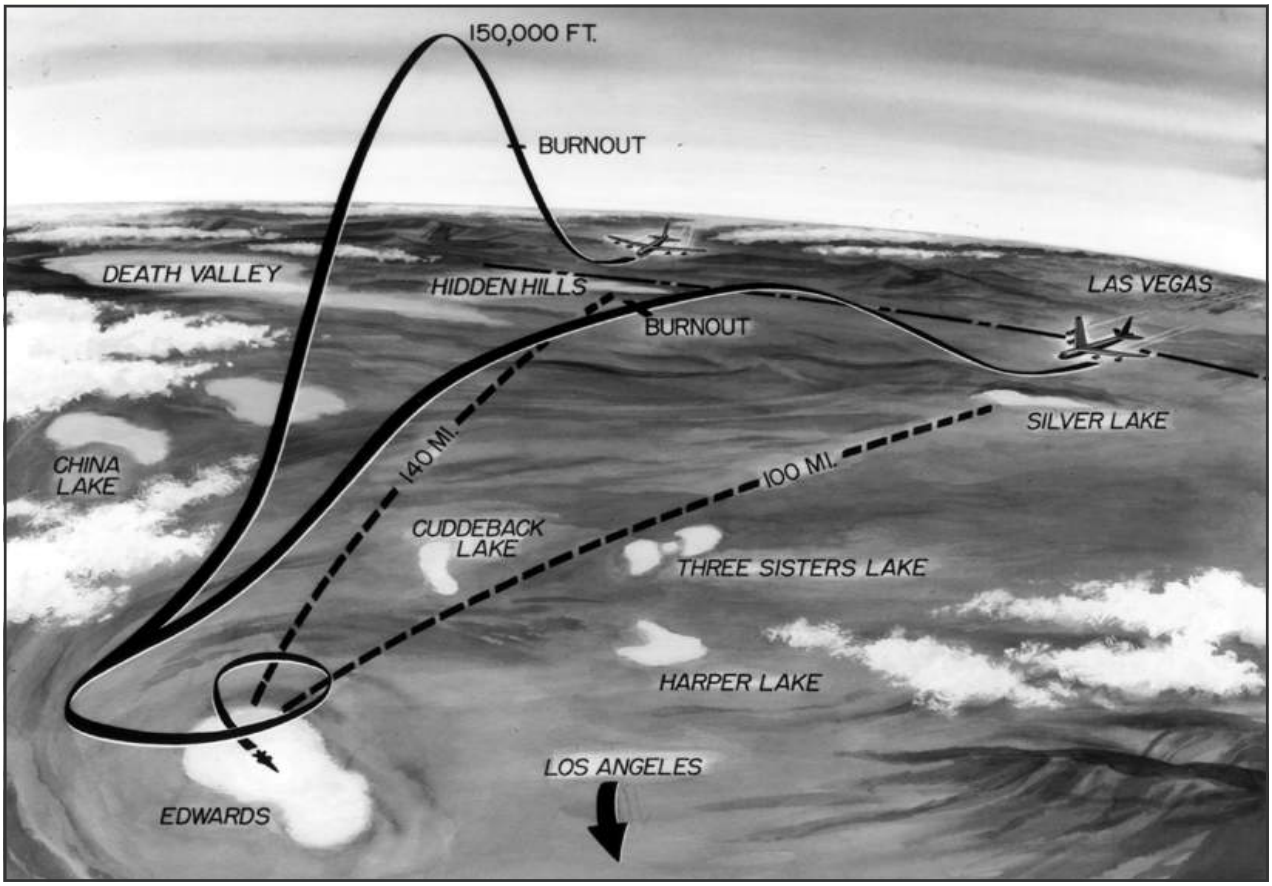
11 Angle of Attack - Angular difference between aircraft pitch and direction of air stream flow, which can be more simply regarded as the prograde direction of travel. On the Surface HUD, this would be angular difference between the Direction indicator and the Prograde indicator. Understanding the difference between Pitch and Angle of Attack is important for proper flight operations.

FLIGHT PROFILES

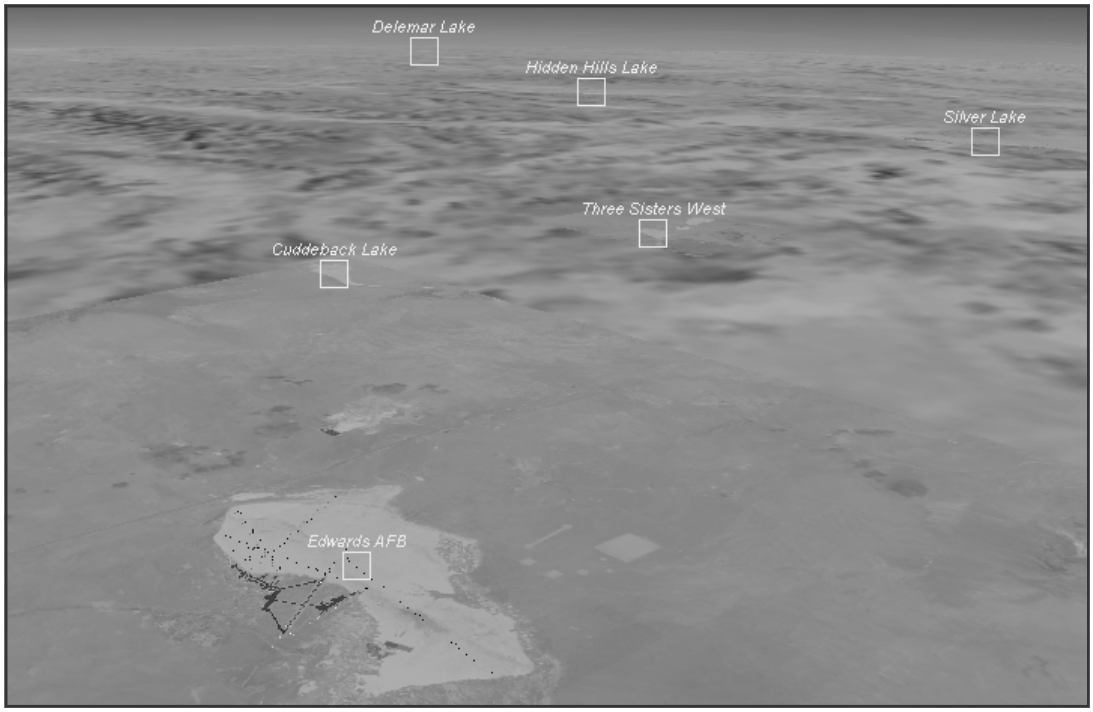
X-15 flights generally conform to one of two flight profiles: An altitude mission or a speed mission. (Refer to Figure on page 2-3.) All flights follow a straight-line course, beginning with an air bourn launch from a B-52 carrier ship, aimed at Edwards AFB, and a landing on the bed of Rogers Dry Lake. Powered flight is brief — the XLR-99 burns 80 to 120 seconds (depending on throttle setting), the XLR-11 burns for 260± seconds with all eight chambers ignited. The remaining 8 minutes of flight is a ballistic trajectory, followed by a dead-stick glide. A reaction control system provides attitude control at high altitude. Minor course corrections can be made during the early part of the powered flight, and during the glide following the re-entry pull-out; normally, major course changes are not made. Flights are planned with plenty of excess energy to reach Rogers Dry Lake. Speed brakes are deployed to adjust the glide distance. The nominal landing approach is a 360° left turn from an altitude of 28,900 feet (8.8 km). Flight distances vary from 100 to 300 miles (160 to 480 km). A variety of smaller dry lakes, near the launch point and along the flight path, serve as emergency landing fields. Rogers Dry Lake and the emergency lakes have runways “drawn” on the surface of the lake bed with an asphalt compound that is reapplied annually. ProjectX-15 v.2.0 includes surface tiles and runway markings for Rogers Dry Lake and for most of the emergency lakes. The surface tiles appear best with Orbiter’s Level 10 high resolution Earth textures.

HISTORICAL NOTE

Each X-15 flight was carefully planned and simulated. A complex mission, filled with test procedures and exacting altitude and velocity requirements, would last only 8 to 10 minutes. But such a flight could be preceded by 30 to 40 hours of simulator time! You should anticipate making several attempts before completing a satisfactory flight.



Typical X-15 flight profiles, for altitude and speed missions, from a contemporary illustration



Orbiter screen shot showing Edwards AFB and surroundings, including some of the High Range lake beds available for emergency landings.

ALTITUDE MISSION

The scenario "Launch X-15 (XLR-99) for Altitude" recreates the X-15 program's record altitude mission, August 22, 1963. This is a good introduction to flying the X-15. The launch lake is Smith Ranch, directly north of Edwards. You will be flying due south so you will find it relatively easy to align your approach with the main lake bed runway at Edwards which is on a heading of 189°.

NOTE

The runway headings are changed from ProjectX-15 v1.0. Orbiter instruments show true headings. Airport diagrams provide magnetic headings. Apparently, the separate Edwards AFB add-ons, used in conjunction with v1.0, had their surface tiles and runways rotated to correspond with the magnetic headings shown on the diagrams. The new surface tiles and runways included with ProjectX-15 are rotated to true headings.

Pre-Launch

Launch scenario opens with the B-52 carrier ship cruising at the launch speed of 500 mph (223m/sec) and altitude of 45,000 feet (13.7 km). Range to Edwards is about 550 km. Smith Ranch, the launch lake for this mission, is visible 50 km ahead.

NOTE

Launch lake and launch distance for each scenario are noted in the description window of the Orbiter Launch Pad.

Jump to the B-52 cockpit [F1]. Your launch heading should be 180° and the direction to Edwards will be 182° to 183°.

- Correct the B-52 carrier ship's course as needed to establish 180° heading for launch. Turn the B-52 by banking, and by using the rudder keys [1]numpad and [3]numpad
- Use the trim keys, [Insert] and [Delete], and throttle keys [CTRL] + [+]numpad or [-]numpad to establish correct launch altitude and speed, with zero horizontal and vertical acceleration.

Jump to the X-15 cockpit [F3].
Verify the X-15 instrument settings:

- Set the RCS mode to OFF

NOTE

Leaving the RCS on at launch and during powered flight will waste fuel and limit overall aircraft performance.

- HUD set to surface mode;
- Surface MFD open on the RIGHT side;
- Map MFD open on the LEFT side with target set for Edwards.

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).

Maintain a precise launch heading. Launch takes place at a distance of 310 miles (500 km). Return to the B-52 cockpit as needed to make course corrections
You can quickly shift between cockpits by pressing [CTRL]+[F3] without opening, clicking and closing the on-screen window.

Return to the X-15 cockpit for launch.

Launch

- As you near the launch distance of 310 miles (500 km), bring up the Release MFD on the left (replacing the MapMFD for now) by pushing the SEL button and then the Release button from the MFDs listed. The ReleaseMFD screen will display the word ATTACHED.
- Release the X-15 by pressing the on-screen REL button, or pressing [LShift]+[D], depending on which version of the ReleaseMFD you activated (see page 2-10).
- The ReleaseMFD screen will display FREE as you drop away from the carrier ship.

(Continued on page 2-5)

- Ignite the engine at full throttle and lock it on [+]numpad + [CTRL]
- Pitch up *gently*, maintaining a 12° angle of attack throughout the pitch-up maneuver, to a climb of +45°.
- Watch the SurfaceHUD and keep the Direction Indicator on +45°. The Prograde Marker will settle below that point.
- Use the TRIM keys, [Insert] and [Delete] to hold the +45° pitch angle. You can take you hands off the joy stick, adjust your MFD or [F1] to enjoy an external view.
- Bring up the MapMFD on the Left (replacing the ReleaseMFD).
- Small course corrections can be made during the early stages of powered flight.
- When fuel level reaches 5% shut down the engine [*]numpad. The reserve fuel is for the RCS.

HISTORICAL NOTE

On the actual flight, the engine was kept running until burn out. (RCS was a separate system with its own fuel.) But to achieve a realistic altitude you should still shut down with 5% remaining fuel. On most X-15 flights the engine was shut down manually to achieve precise velocity and altitude.

Ballistic Flight

With the engine shut down the X-15 will continue climbing.

- Adjust trim setting to 0 [Insert] or [Delete]
- Turn on the RCS (or "ballistic control system", as it was called) with the on-screen buttons, or key command [CTRL] + [/]numpad
- Maintain a prograde attitude using RCS system. Enjoy the view as you top out near the record altitude of 354,200 feet (107.96 km).
- Open the skylight hatch to expose experiments and camera. [L Shift] + [2]numpad
- After passing apogee, close the skylight hatch. [L Shift] + [2]numpad

If your launch heading was correct you should be aimed at the east edge (left side) of Rogers Dry Lake, although during ballistic flight you can do nothing to alter your course.

Re-entry, Pull-out and Glide

- Use RCS to assume and hold an 15° to 20° angle of attack. 18° AoA is about ideal.
- The X-15-3 has a conventional Stability Augmentation System (SAS), providing dampers for the aerodynamic control surfaces about all three axes. An Adaptive Flight Control System (AFCS) provides additional stability augmentation by blending aerodynamic surfaces and reaction control jets. You can simulate the damping effect of the SAS and AFCS by activating KillRot as you pass through about 175,000 feet (53 km) altitude. Leave KillRot on to run continuously.
- Continue holding 18° AoA. [F1] to an external view. There should be no visible flames during the rentry.
- As you descend into the thicker atmosphere your lift will increase, angle of attack will decrease, and you can begin pitching up to level.
- Level off at 70,000 feet (21.3 km)
- Extend speed brakes [K]
- Turn OFF the AFCS (discontinue KillRot), and turn OFF the RCS.
- Refer to the Speed Brake Table on page 2-6. Quickly assess your altitude, distance to Edwards, and speed. You should still have more speed than needed to reach Edwards.
- Decelerate to an appropriate speed by extending and retracting speed brakes [K].

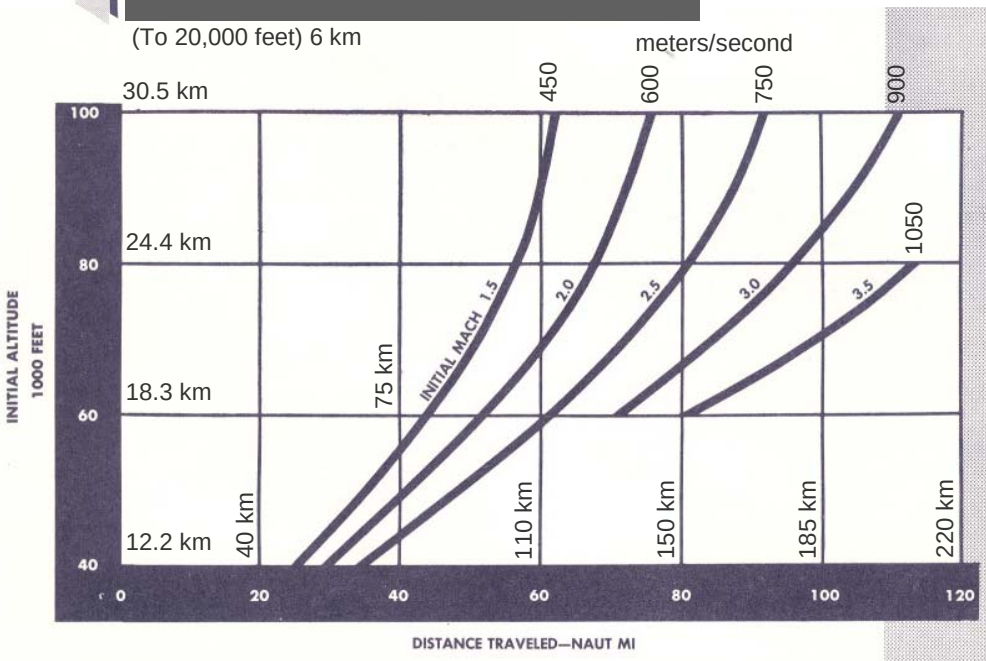
Do not decelerate all at once. Reserve some speed for making course corrections towards Edwards and for runway alignment. Repeat application of speed brakes as needed.

- Use trim keys to maintain a level attitude during the glide - SurfaceHUD direction indicator on 0° pitch. The prograde marker will sink as you decelerate. The maximum angle of attack during glide flight is 15°. When that limit is reached let the nose drop to maintain 15° AoA.

(Continued on page 2-7)

MAXIMUM GLIDE DISTANCE

(To 20,000 feet) 6 km



EXAMPLE: From 80,000 feet at Mach 2, 465 seconds will be required to descend to 20,000 feet and 68 nautical miles will be traveled.

X-15-1-00-12A

NOTE
This table appears in the original X-15 Flight Manual. (Metric units added.)

It provides maximum glide distance from an initial altitude and speed down to an altitude of 20,000 feet (6 km)

SPEED BRAKE TABLES

(To 30,000 feet) 9 km

Altitude = 33km						
Distance to Base (km)	40	75	110	150	185	220
Set Speed (m/sec)		150	425	650	825	975

Altitude = 27 km						
Distance to Base (km)	40	75	110	150	185	220
Set Speed (m/sec)		200	500	750	950	1100

Altitude = 21 km						
Distance to Base (km)	40	75	110	150	185	220
Set Speed (m/sec)		400	750	1050		

Altitude = 15 km						
Distance to Base (km)	40	75	110	150	185	220
Set Speed (m/sec)	275	600				

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

NOTE
These tables are based on the information above.

They provide maximum glide distance from an initial altitude and speed down to an altitude of 9 km — the landing pattern High Key Point.

Landing

The figure on page 2-9 shows a typical landing pattern, with a 360° left turn from a High Key point located 2 miles short of the runway and offset about a mile to the right. In practice, each X-15 pilot worked out his own marks for making the 360° final turn. A few pilots preferred a right turn. This manual describes an easier-to-find High Key Point located directly off the end of the runway with no offset. Edwards AFB is centered on a point near the north end of the main lakebed runway, so the SurfaceHUD and the MapMFD will direct you to the High Key Point described here.

- After re-entry and pullout, make course corrections toward the east side (left side) of Rogers Dry Lake. In addition to banking into a turn with the joy stick, the "yaw" keys [1]numpad and [3]numpad can be used as rudder pedals to assist in turning.
- If your launch heading was correct, your approach to the east edge of Rogers Dry Lake should be on a heading of about 180° and your course corrections will be minimal.
- Watch the triangular shaped “direction-to-base” marker on the SurfaceHUD’s ribbon compass (at the top of your screen). As your flight path takes you east of Edwards the base marker will move to the right.
- As the base marker approaches 189° make a gentle right turn towrd the base. The main lakebed runway is on a heading of 189°. The center of the base is located near the runway. So when your your heading and the direction to the base are both 189° you are aligned with the main runway. Perfect alignment is not necessary.
- On a flight path roughly aligned with the runway, when the Map MFD shows a distance to Edwards of about 4 to 5 km you are at the High Key Point. Your altitude at High Key point should be 8.8 km.
- Upon reaching the High Key Point turn off your Map MFD.
- Bank 45 degrees left and turn 360 degrees while dropping to the runway.
- Maintain a speed of 300 knots (154m/sec)

Do not allow angle of attack to exceed 15 degrees. If forward momentum is lost, dive to pick up speed and retrieve the prograde marker, then level off and make the best landing possible.

- At 8,200 feet (2.5 km) altitude jettison the ventral fin [J]
- At 3,500 feet (1.1 km) altitude lower the flaps [LShift]+[0]numpad (This has no aerodynamic effect due to a Spacecraft3 bug, but it looks cool.)
- At 3,000 feet (900m) drop landing gear [G] and begin flare out.
- At touchdown at a speed of 200 knots (103m/sec), 10 feet/sec (3 m/sec) maximum vertical speed and 10° maximum angle of attack.
- Extend speed brakes to shorten your rollout [K]
- Open the canopy [L Shift] + [1]numpad
- Open the equipment bay [Lshift]+[2]numpad

NOTE

Flights originating from other launch lakes approach Edwards from a more easterly direction. Aim these flights a north of Edwards to permit a left turn into the High Key Point, on a heading of 189° for the main lakebed runway.

SPEED MISSION

Speed missions are launched closer to Edwards. The launch procedures are identical to the altitude mission, except that the climb is +30°. At an altitude of 70,000 feet (21.3 km) begin pitching forward to level off at 100,000 to 110,000 feet (30.5 to 33.5 km). Shut down the engine when fuel level reaches 5% (for historically accurate velocity) or allow the engine to burn out. Aerodynamic control surfaces remain effective at these lower altitudes. The ballistic control system is not used on speed missions.

X-15A-2 Flights

The X-15A-2 flew initially without external tanks to test out the new systems and airframe. Envelope expansion flights followed, which tested the external tanks and various ablative coatings. The X-15 was originally designed to handle heating from atmospheric friction at speeds of Mach 6, at an altitude of 100,000 feet (30.5 km). To fly at the planned speed of Mach 8 the X-15A-2 received a spray-applied ablative coating. Initial flights with small test patches of the ablator revealed that the eroding material would deposit on the aircraft's windscreen. It was anticipated that the windscreen would be completely obscured during a maximum speed flight with a full ablative coating. An "eyelid" cover was installed over the left windscreen to protect the glass. A flight would begin with the left windscreen covered and a clear view out the right. As maximum speed was reached the right windscreen would be completely obscured by eroding ablator. The pilot would continue the flight guided by instruments and radio calls from ground controllers. When the speed dropped below Mach 2 (610 m/sec) the eyelid cover was opened to provide a clear (though somewhat restricted) view for a left turn approach and landing.

With external fuel tanks attached, the X-15A-2 flies speed mission only. External fuel tanks increase the XLR-99 engine burn time to 150± seconds, but the tanks and extra fuel add significantly to the launch weight. The scenario Launch X-15A-2 for Speed recreates the programs maximum speed flight of October 3, 1967

- Note the launch lake and launch distance in the description sections of the Orbiter Launch Pad window.
- Trim the B-52 carrier ship flight path as required to maintain launch heading, altitude and speed.
- Launch the X-15 in the usual manner using the ReleaseMFD
- Maintain a 12° AoA, the aircraft will fly level (or even loose altitude) for several seconds before gaining speed and lift to begin the climb.
- Maintaining the 12° AoA, pitch up to a climb of +32°.
- Using the trim keys [Insert] and [Delete] maintain a pitch of +32°.
- Jettison the external tanks when fuel level drops to 65% [J]
- At an altitude of 70,000 feet (21.3 km) pitch forward, maintaining a -2° AoA.
- Level off at 100,000 to 110,000 feet (30.5 to 33.5 km)
- Shut down the engine at **6%** fuel remaining [*]

HISTROICAL NOTE

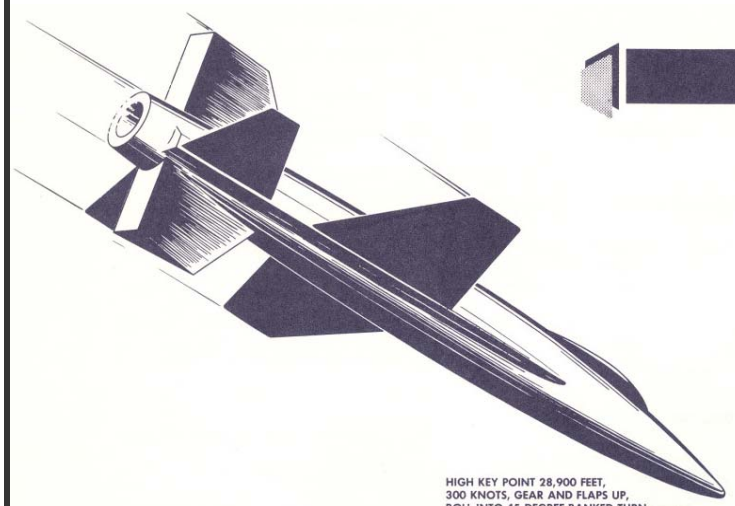
The speed record set on October 3, 1967 was actually a buildup flight with manual engine shutdown occurring at 141 seconds. The X-15 program was terminated before the X-15A-2 could be flown with a full 150 seconds for thrust to engine burnout. The as-built aircraft exceeded its design weight, so the target speed of mach 8 could have been achieved. Try flying a mission to burnout and see what maximum speed you can attain,

- Extend speed brakes at apogee [K]. Refer to the speed brake tables on page 2-6
- Project**X15** cannot duplicate the progressive obscuring of the windscreen, but the eyelid hatch is included. When speed drops below Mach 2 (610 m/sec) open the eyelid
  [L Shift] + [3]numpad
- Align with the runway at High Key Point and land in the usual manner.

XLR-11 Flights

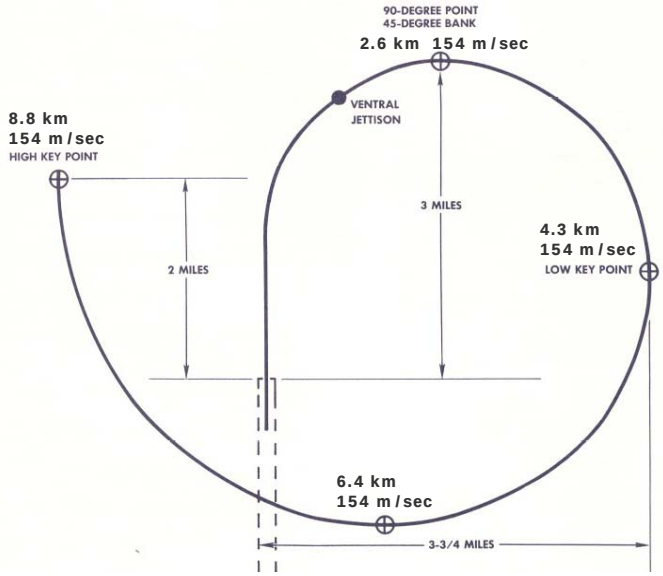
Flying with the XLR-11 is somewhat different. The engine burns longer and the thrust is much lower. The ballistic phase on altitude missions is very short or non-existent. Because the thrust is low for the aircraft weight, you must fly a very tight profile to get maximum performance out of the XLR-11.

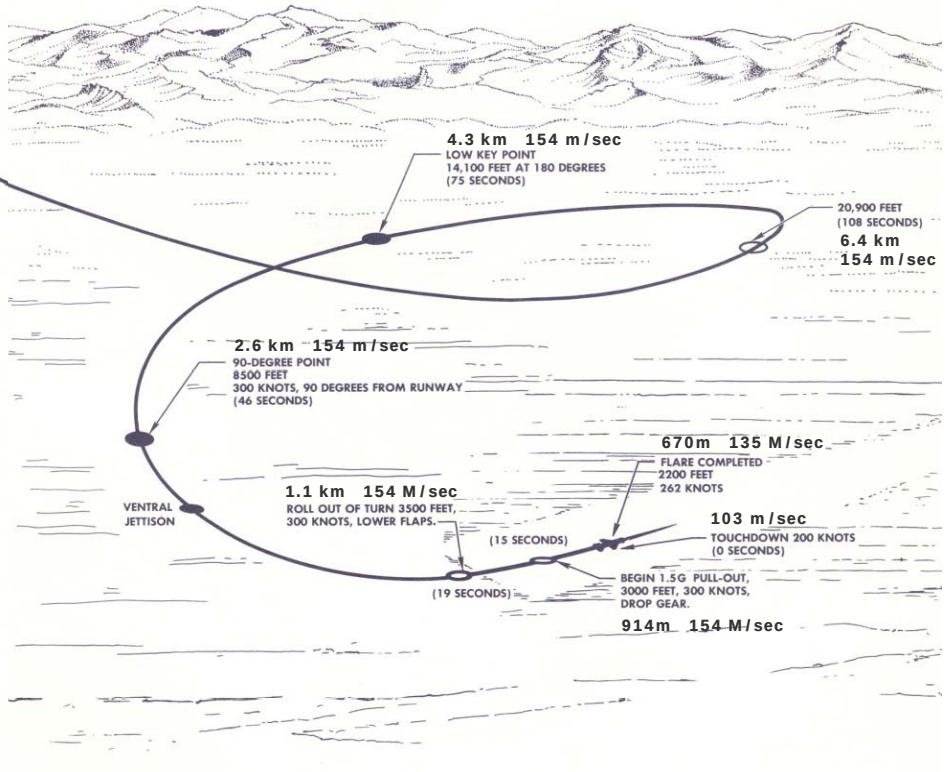
LANDING PATTERN (TYPICAL)



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.

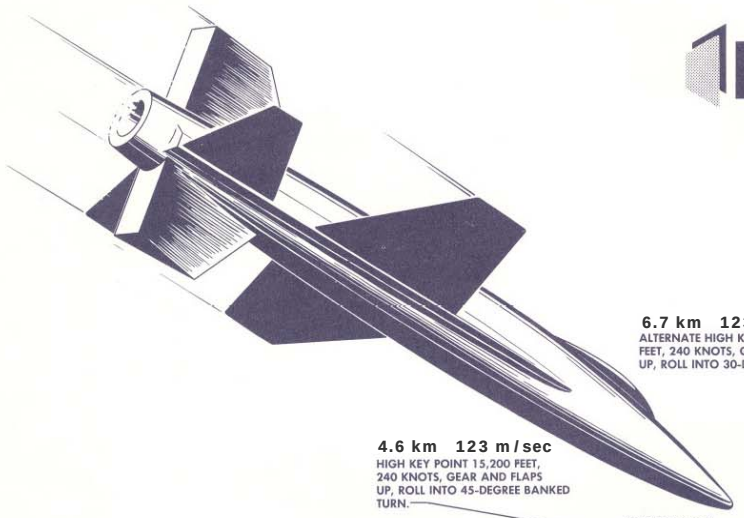


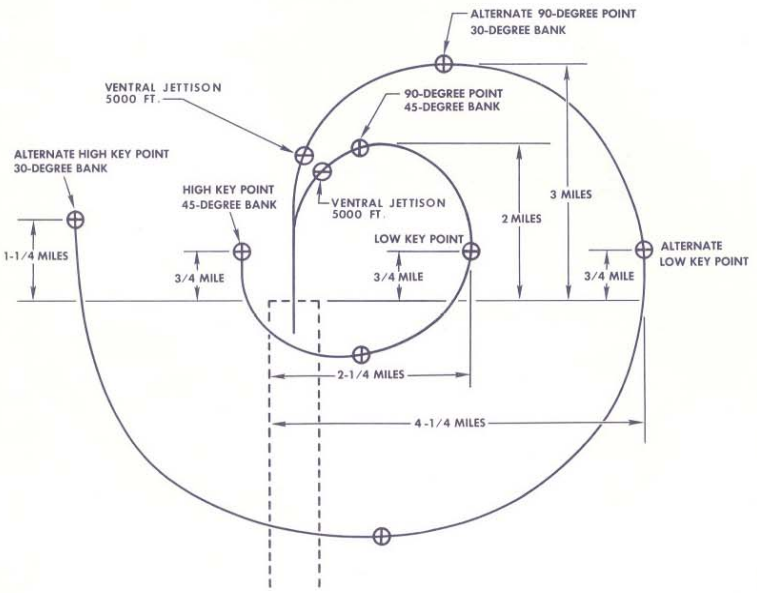


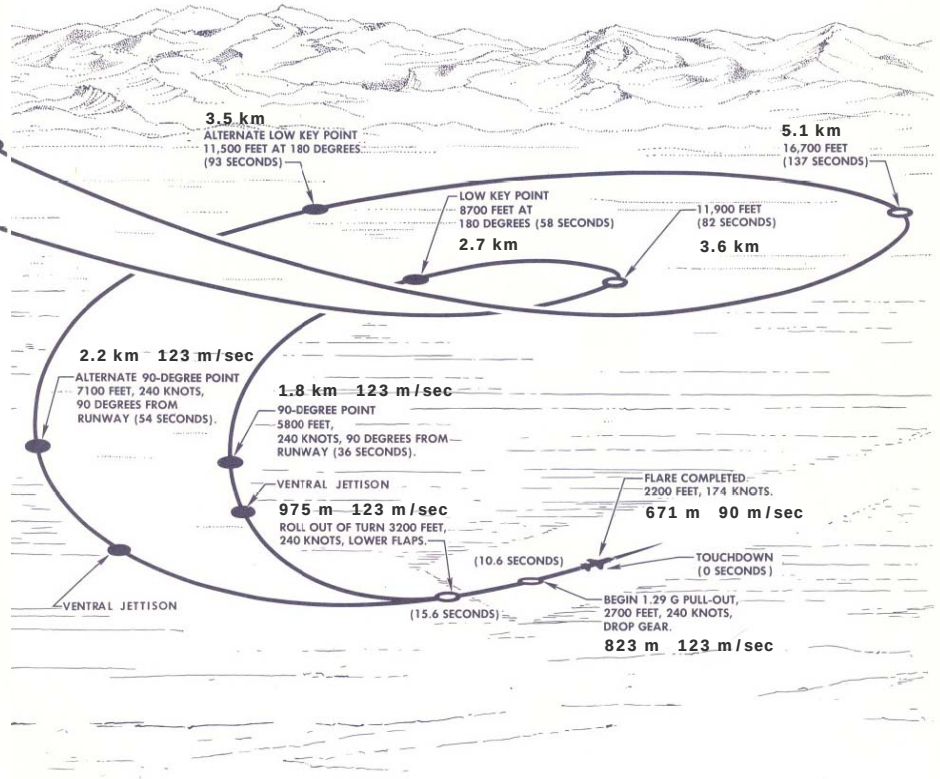
LANDING PATTERN (LOW SPEED—LOW ALTITUDE)

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-15-1-00-11B

X-15-1-00-10C

Installation & Sources

SECTION III

DESCRIPTION

ProjectX-15 v2.0 is a complete, stand-alone add-on for use with Orbiter 2006 and Spacecraft3. Version 2.0 is NOT a patch for any of the previous releases of ProjectX-15. Do not install ProjectX-15 v2.0 within an Orbiter folder already occupied by an earlier release of ProjectX-15 or X-15 Delta.

ProjectX-15 v2.0 includes models, scenarios and manuals for the Historical X-15, and for the proposed (but never built) X-15 Delta. Also included are new surface tiles of Edwards AFB

REQUIRED PROGRAMS

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. Install the programs in the order shown.

Orbiter Space Flight Simulator (Base) (Orbiter060504_base) by Martin Schweiger.
Start with a clean installation of Orbiter 2006 that does not contain previous versions of ProjectX-15.

Spacecraft3 by Vinka (available at: http://users.swing.be/vinka/)
The required files are included with the installation of ProjectX-15 v2.0

CONFIG\SPACECRAFT\Spacecraft3.cfg
MODULES\Spacecraft3.dll

Downloading the entire Spacecraft3 program is recommended for the documentation and test scenarios. Note that older releases, Spacecraft and Spacecraft2, will not work with ProjectX-15 v2.0.

ProjectX-15 v2.0 by Greg Burch (GregBurch) and Scott Conklin (Usonian)

Copy the contents of the release .zip files into your Orbiter folder. Preserve the directory structure.

ProjectX-15 v2.0 includes a custom MFD for launching the X-15. See page 2-1 for detailed instructions to activate the MFD. We are very grateful to Friedrich Kastner-Masilko (Face) for creating this vital tool, and allowing us to make it a part of ProjectX-15.

We also thank Damir Gulesich (Slat) for permitting us to include the Edwards mesh from his LC39-EAFBv2.17 add-on. The mesh provides runway markings for Rogers Dry Lake and paved taxiways for Edwards.

Note that Face's ReleaseMFD and Slat's mesh are *included within* ProjectX-15 v2.0. No separate downloads are required.

OPTIONAL PROGRAMS

These add-ons are not required, but they are very highly recommended:

Orbiter High Resolution Earth Textures (Earth060504_L10) by Martin Schweiger.
ProjectX-15 v2.0 includes new surface tiles for Edwards AFB, Rogers Dry Lake and several of the emergency landing lakes. The tile colors are adjusted to blend with Orbiter's Level 10 Earth Textures.

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 altitude call-outs which are useful and historically realistic during landings.

Flight Instruments MFD v0.9 (FlightInstMFD09.zip) by David Henderson. For the historical X-15 purist, this MFD gives flight information in Imperial units - feet and knots.

Fuel Management MFD by Trevor Johns. Permits venting fuel to better simulate emergency landings.

PRIMARY SOURCES

Hypersonic: The Story of the North American X-15 by Denis Jenkins & Tony Landis, Specialty Press, 2003 An excellent, detailed and very complete history of the X-15 program from conception through the last flight. This book is the primary source for historical and technical information on the X-15s, the B-52 carriers, and the High Range. This is also the source for the aircraft model textures.

X-15 Flight Utility Manual, North American Aviation, Inc., 1962. The primary source for manual illustrations, graphics and cover.

Summary of Full-Scale Lift and Drag Characteristics of the X-15 Airplane, Edwin J. Saltzman & Darwin J. Garringer, NASA, 1966. The source for the X-15 lift profile, and drag coefficients.

http://www.geocities.com/bobandrepont/spacepdf.htm This site has hundreds of technical papers in .pdf form regarding all aspects of manned space flight, from the earliest X-planes to the International Space Station.

www.sierrafoot.org/x-15/x-15.html The X-15 Flight Utility Manual can be found here, along with several other technical documents. This site also provides links to other good sites including:

www.dfrc.nasa.gov/gallery/index.html
(video clips)

jpcolliat.free.fr/x15/index.html
(French language)

http://www.aerospaceweb.org/question/list.shtml
This site is a very good primer on aerodynamics.