XR Flight Operations Manual

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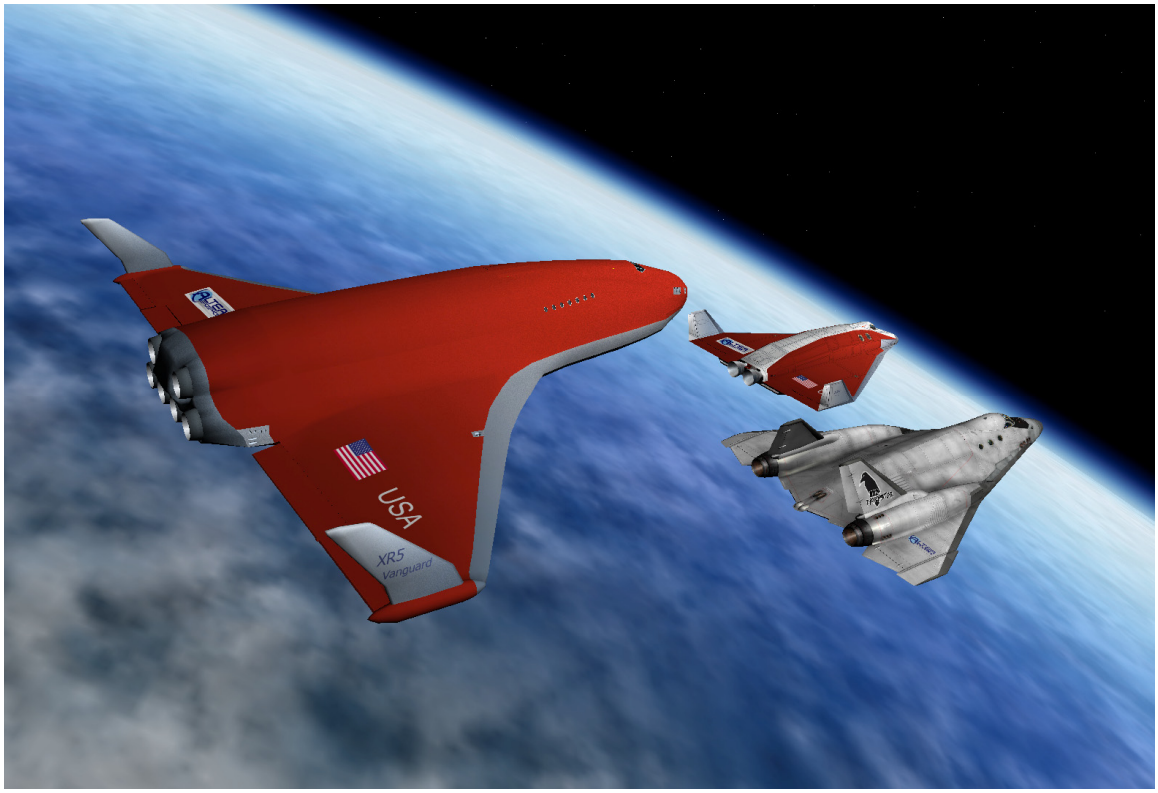

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The Future Is Now.

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Don Gallagher	3D mesh tweaks, hover doors, SCRAM doors

XR5 Vanguard Development Team

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Thanks to Greg Burch for kindly granting me permission to use his excellent high-polygon astronaut meshes.

Thanks to Frying Tiger on the Orbiter Forum for developing the original DeltaGlider-S mesh and virtual cockpit upon which the XR1 is based.

Copyright

Summary

Welcome to the Future.

The **DG-XR1**, **XR5 Vanguard**, and **XR2 Ravenstar** are cutting-edge spacecraft for Orbiter that are the products of over 60,000 lines of C++ code and over 3000 hours of work (the equivalent of 16 months of full-time eight-hours-a-day five-days-a-week), all of which was done on evenings and weekends. In addition, Russell Hicks, who created the Vanguard's mesh and internal textures, and Steve Tyler, who developed the XR2's mesh and textures, both have hundreds of hours of work invested.

All XR vessels are built on a common framework and share similar internal systems. Highlights include three (XR1), four (XR2), or five (XR5) 2D instrument panels that natively support 1280-, 1600-, and 1920-pixel-wide resolutions, high-performance Altea Aerospace SCRAM engines, complex damage simulation, custom sound effects, over 250 voice callouts performed by voice actress Sally Beaumont, and highly precise autopilots just to name a few. In addition, the XR2 and XR5 include a payload bay with full payload support via a custom panel.

XR vessels are designed to be *pilot's ships*, and with all the realism settings set to maximum the ships are significantly more challenging to fly efficiently (and *safely*) than the default DeltaGlider; i.e., pilot workload is higher. However, each vessel is fully configurable via its configuration file (e.g., `Config\XR5VanguardPrefs.cfg`), and with all the realism settings disabled each vessel is just as forgiving to fly as the default DeltaGlider. The configuration file also features a custom *CHEATCODES* section that allows the user to directly set certain ship's values such as maximum engine thrust, fuel capacity, ship mass, etc.

Features

If you are a veteran XR pilot you will find most of all three ships' systems familiar. However, the Vanguard is many times larger than the XR1/XR2 and the flight characteristics are completely different – particularly if you are carrying a heavy payload.

All XR vessels include:

- **2D instrument panel native support for 1280-, 1600-, and 1920-pixel-wide video modes.** To load one of the wide-panel modes, set `2DPanelWidth` in your ship's configuration file (e.g., `Config\XR5VanguardPrefs.cfg`). The main panel is low-profile in the center for maximum visibility.
- 279 unique sound effects and voice callouts; callouts performed by voice actress Sally Beaumont.
- Rotating wheels animation.

- The crew is configured by default to use all of the default UMMu meshes as well as all four of Greg Burch's high-polygon astronaut meshes. Meshes are configurable via each ship's configuration file.

- Altea Aerospace SCRAM engines operable up to ~mach 17 (XR1) or ~mach 20 (XR2/XR5).

- Extensive refueling/resupply support via the lower instrument panel. Also disabled Orbiter's automatic (and instant) refueling of the ship when touching down on a landing pad or when loading a scenario where the ship is landed on a pad.

- Many instrument panel gauges, including:
    - Fuel display showing Main, RCS, and SCRAM fuel remaining.
    - Engine display showing 1) main engine efficiency (affected by atmospheric pressure), 2) main, hover, and SCRAM thrust levels, and 3) acceleration along all three axes in Gs and meters-per-second.

  The G scale automatically switches its range as necessary, providing accurate information for low, moderate, and high-G situations. This gauge shows the force pulling on the ship, so as the ship accelerates into orbit you can watch the Y axis Gs go down from one to zero. X = lateral (left-right), Y = vertical (up-down), Z = ship acc (front-back).

- Reworked TSFC ("Thrust-Specific Fuel Consumption") screen showing main engine and hover engine efficiency (affected by atmospheric pressure). Rocket engines are most efficient when operating in a vacuum.

- Dynamic Pressure and Static Pressure gauges; useful for optimizing your ascent when using the SCRAM engines.

- Slope gauge showing ascent/descent slope.

- AOA and Slip gauges.

- SCRAM Diffuser Temperature gauge which allows the pilot to monitor when the SCRAM engines reach the edge of their performance envelope.

- *Multi-Display-Area* (MDA) screen that has ten different modes, showing:
    - Mode 0: Airspeed Hold Autopilot
    - Mode 1: Descent Hold / Auto-Land Autopilot
    - Mode 2: Attitude Hold Autopilot
    - Mode 3: Temperature Display for hull and coolant
    - Mode 4: Systems Status Display #1
    - Mode 5: Systems Status Display #2
    - Mode 6: Systems Status Display #3
    - Mode 7: Systems Status Display #4
    - Mode 8: Systems Status Display #5
    - Mode 9: Reentry Systems Check

- Two configurable pop-up HUDs. The secondary HUD has five modes and is fully configurable for data, color, and transparency. The tertiary HUD shows

status and warning messages and is configurable for color and transparency only.

- A new configuration file in your `C:\Orbiter\config` directory for each vessel named `DeltaGliderXR1Prefs.cfg`, `XR5VanguardPrefs.cfg`, or `XR2RavenstarPrefs.cfg` for the XR1, XR5, and XR2, respectively. This file allows you to configure many ship settings, including flight settings, disabling/enabling a given damage type, pop-up HUD colors and fields, etc. Read the detailed comments in each file for details.

- The parser that reads each ship's configuration file is robust and will not cause Orbiter to crash if some invalid data is encountered. If some invalid data is encountered, the parser will log any errors to `DeltaGliderXR1.log/XR5Vanguard.log/XR2Ravenstar.log` in the main Orbiter startup directory and blink an alert message at the bottom on the screen.

- Full reentry heating and damage support. Hull temperature readouts are displayed by mode 3 on the MDA screen, and may be switched between Kelvin, Fahrenheit, and Celsius by clicking the blue block on the touch screen.

- Realistic fuzzy logic hull overheating support: the ship is not instantly destroyed when a hull surface exceeds maximum temperature; this is discussed in detail in the *Reentry* section later in this document.

- Master Warning System with an alarm tone and a warning light panel. Full support for audio warnings is also implemented.

- Highly-precise and efficient *Attitude Hold* autopilot that holds a set pitch/AOA and bank while neutralizing yaw (i.e., *yaw dampening*); typically used to hold pitch and bank during reentry and to hold attitude in an atmosphere.

- In an atmosphere the *Attitude Hold* autopilot holds attitude using three methods simultaneously: 1) elevator trim, 2) a *center-of-gravity shift* feature that works by pumping fuel forward or aft, and 3) RCS jets. The combination of these three methods allows the ship to hold a rock-solid reentry attitude even under time acceleration. It is also extremely efficient and requires very little RCS fuel. *Attitude Hold* requires APU power in order to drive the center-of-gravity pumps and elevator trim.

- Efficient *Descent Hold/Auto-Land* autopilot to hold a descent or ascent rate; engaging auto-land mode will land the ship in a hover efficiently and smoothly every time.

- Efficient *Airspeed Hold* autopilot to hold a given airspeed within 0.1 meter-per-second. Useful during atmospheric flight and when taxiing. *Airspeed Hold* may be enabled alongside (i.e., simultaneously with) any other autopilot mode.

- `[CHEATCODES]` support in the configuration file that allows you to directly set certain ship values such as the ship's mass, max engine thrust, fuel tank

- Full damage and crash simulation, including gear collapse based on touchdown vertical speed and ship mass.

- New sound effects including altitude callouts, mach callouts, warning callouts, damage and failure callouts, and docking distance callouts. Docking distance callouts are synced to a NAV IDS or XPDR frequency, with the closest active IDS frequency taking precedence over any active XPDR frequency.

- DATA HUD to show custom keyboard shortcuts; activated via ALT-SPACE or via a button on the main instrument panel.

- Thruster translation/rotation and on/off controls (normally *NUMPAD-/* and *CTRL-NUMPAD-/*) are now compatible with Joy2Key. Joy2Key has a bug where it cannot recognize *NUMPAD-/*, so the new **/** and **CTRL-/** keys do the same thing as their NUMPAD counterparts now. This means you can now assign translation/rotation switching to a joystick button.

- Reworked ambient sound effects (stock OrbiterSound plays them way too often).

- Updated sound for the SCRAM engines; note that engine volume is based on *fuel flow* (i.e., the resulting combustion) -- *not necessarily on the throttle setting.*

- Configurable refresh rates for the secondary HUD and MDA screen; this improves performance at high frame rates.

- Auxiliary Power Unit (APU) that powers the ship's hydraulic systems; the APU must be running in order for hydraulic systems to operate. Depending on the config file setting the APU has limited fuel, so manage it carefully.

- Airlock pressurization/depressurization.

- EVA support via DanSteph's excellent *Universal Mmu (UMmu)*.

- High-polygon astronaut meshes developed by Greg Burch; used with permission.

- Astronaut mesh is easily configurable; users can use Greg Burch's high-polygon astronaut meshes, the standard bulky astronaut meshes included with UMmu, or any other custom astronaut mesh. (The XR2 also includes two new meshes: Lee and Kara.)
- Supports crew member transfers while docked to another UMmu-enabled ship.
- Custom autopilots *Attitude Hold, Descent Hold,* and *Airspeed Hold* save and reload their state to/from the scenario file. This means you can now save your scenario even while reentering or auto-landing and then reload and continue without a hitch.

XR1-Only Features

- A fully active virtual cockpit (VC); you may switch between cockpit modes by pressing F8.

XR2-Only Features

- A *static* virtual cockpit (VC); you may switch between cockpit modes by pressing F8. Note that the next version of the XR2, the *XR2 Ravenstar Mk II*, will have a fully active virtual cockpit.

- Hull heating visual effects.

XR2/XR5-Only Features

- Full payload support that supports any payload module (i.e., vessel) that exists in Orbiter that can fit in the payload bay. The Vanguard can carry up to 432 metric tons of payload, whereas the XR2's recommended payload limit is 10.8 metric tons.

- A payload instrument panel to manage grappling/deploying payload.

- Support for auxiliary fuel and LOX tank payload modules attached in the payload bay. If attached, bay tanks will drain *first* in flight and fill *last* when ship is resupplied.

XR5-Only Features

- Nose wheel steering animation.

- Independent front/rear gear compression animation on takeoffs and landings: the gear compresses two meters as the ship touches down or lifts off. You can best see this by lifting off at Brighton Beach using the Descent Hold autopilot and watching from an external view. If you lift off at KSC and raise the nose you can see the nose gear decompress first as the nose comes up, and the rear gear will decompress when the ship lifts off.

- A crew elevator to allow the crew to EVA while landed. Crew may EVA/ingress via either the top-mounted docking port or the crew elevator -- the active EVA port is selected via a switch on the upper panel. <u>This also means that you can now EVA/ingress via the crew elevator even while the ship is docked to a station or another vessel</u>. Elevator deployment requires APU power.

- A top-mounted docking port that includes a docking camera panel view.

- An *RCS Config* mode that switches between standard and docking RCS configurations: in RCS docking configuration, two things happen: 1) power to the RCS jets is reduced to 40% of normal to allow for precise control of the ship while docking, and 2) the control axes for the RCS jets are switched so that when you are looking along the docking port centerline camera you can use the RCS Rotation and Translation keys just as though you were looking along the nose with a nosecone docking port; i.e., it will feel "normal." For

example, pressing NUMPAD-6 in translation mode will move the ship forward along the Z axis in *normal* RCS mode, but it will move the ship up along the Y axis in *docking* RCS mode. The hotkey to toggle RCS normal/docking mode is ALT-J.

Requirements

- Orbiter Patch 1 (Orbiter P1 060926) or newer. Older Orbiter releases are not compatible.

- OrbiterSound 3.5 or newer; a link to the latest OrbiterSound may be found on my Web Page. Although you may fly XR vessels without OrbiterSound installed, OrbiterSound is highly recommended.

- Universal MMU (UMmu) 1.5 or newer is *mandatory*; you cannot fly an XR vessel unless UMmu 1.5 or newer is installed. A link to the latest UMmu may be found on my Web Page.

- *Optional but recommended:* STS-121 Orbiter Sound Pack #1. This is my STS-121 Sound Pack #1 for Orbiter that features CAPCOM Canadian Astronaut Julie Payette and the STS-121 crew during their twelve-day mission. These files were extracted from raw MPEG-2 video files downloaded from my TIVO and then downmixed to 48KHz, 16-bit mono. Set your Orbiter radio frequency setting to 217.121.

  You can also download this and other custom Orbiter sound packs from my Web Page.

- *Optional:* XR Vessels support pluggable custom third-party skins; refer to my Web Page for list of custom skins available for each ship.

Installation

This section details how to install and configure you XR vessel. Note that each XR vessel is an *Orbiter add-on*, and requires that Orbiter be installed first.

1. Install Orbiter P1 060929 or newer. Older versions of Orbiter are NOT SUPPORTED by XR vessels.

2. Install OrbiterSound 3.5 or newer if not already installed. (A link to the latest version may be found on my Web Page.)

3. Install Universal Mmu if it is not already installed. (A link to the latest version may be found on my Web Page.)

4. *Optional:* Install STS-121 Orbiter Sound Pack #1.

5. If you are upgrading from a previous version of your XR vessel, be sure to back up your vessel's configuration file (e.g., `C:\Orbiter\config\XR5VanguardPrefs.cfg`) file if you customized it. Do not simply copy your original configuration file over the new one installed by the XR vessel's zip file; the new configuration file contains new settings not present in older configuration file versions.

6. Unzip the XR vessel's distribution file into your `C:\Orbiter` directory.

7. If you are upgrading a previous version of your XR vessel, merge your settings back into the new configuration file using your favorite text editor.

8. Bring up Orbiter to display the Orbiter Launchpad.

9. Click the *Modules* tab.

10. Click *OrbiterSound* in the *Inactive modules* window and click the `<== Activate Selected` button.

11. Go into the *Video* tab and set the screen resolution to your taste. **NOTE:** remember that XR vessels support 1280-, 1600-, and 1920-pixel-wide 2D panels. If your display supports it, a width of 1920 pixels is recommended; e.g., 1920x1200, 1920x900, etc. Note that the screen *height* in pixels is not critical since the panels are only about 640 pixels high. If you are running in a window, a resolution of 1926x1200, 1606x1200 or 1286x1024 is recommended to allow room for the borders, although window *height* is not critical. XR Vessels load the 1280-pixel-wide 2D panels by default: if you want to use one of the wide-screen panel modes instead, edit your configuration file and set `2DPanelWidth`. Note that each XR vessel will auto-select the optimum panel resolution based on your video mode and panel scale settings in the Orbiter Launchpad when the next Orbiter core patch version is released: a new API call is being added to the Orbiter core to support this feature. For now, however, you will need to set the 2D panel resolution manually.

    If you are running full-screen, it is recommended that you click the "Disable Vertical Sync" checkbox so your full-screen framerate can run at full speed: the higher the framerate, the more accurate the simulation is. If the scanline tearing that can occur with vsync disabled bothers you, enable vertical sync again by unchecking *Disable Vertical Sync*. Note, however, that limiting the framerate will also reduce the accuracy of the simulation.

    In addition, ensure that *Color Depth (bpp)* is set to 32 instead of 16: running in 16-bit color mode may produce odd colors on the screen and is not recommended. If you are running in a window, set your desktop to 24- or 32-bit color rather than 16-bit.

    Note: you should also click the *Always Enumerate Devices* checkbox to ensure that the video modes in the full-screen drop-down list are accurate.

12. You may adjust the *Panel Scale* value in the *Parameters* tab as necessary to stretch the instrument panels. An *MFD refresh* value of something below 0.5

is recommended (0.1 is a good place to start; if you see a noticeable framerate hit with 0.1, try upping the value slightly).

13. If you have a joystick, go into the *Joystick* tab and configure it. Be sure to also run Joy2Key if you have it installed. (Remember that you can now configure Joy2Key for / and CTRL-/ for RCS changes.)

14. Review and edit your XR vessel's configuration file (e.g., `C:\Orbiter\config\XR5VanguardPrefs.cfg`) and configure the settings to your liking. The file is fully commented, and each XR vessel allows extensive configuration of its settings.

That's it. Now boot up Orbiter and load one of the XR scenarios installed under the `C:\Orbiter\Scenarios` folder (e.g., `Scenarios\XR2 Ravenstar`). (If you installed STS-121 Orbiter Sound Pack #1, set your Orbiter radio frequency setting to 217.121.)

Refer to later sections in this manual for details on how to fly your XR vessel. Welcome aboard!

The screenshots below compare the Vanguard's 1280-, 1600-, and 1920-pixel-wide main panels. Remember that you may enable one of the new wide-screen 2D instrument panel modes by editing your vessel's configuration file and setting 2DPanelWidth.

1920x1200 Screenshot Showing the Vanguard's Optional 1920-pixel-wide 2D Main Instrument Panel.

1600x1200 Screenshot Showing the Vanguard's Optional 1600-pixel-wide 2D Main Instrument Panel.

1280x1024 Screenshot Showing the Vanguard's Default 1280-pixel-wide 2D Main Instrument Panel.

Pre-Flight Setup

At a minimum, review and edit your vessel's configuration file (e.g., `C:\Orbiter\config\XR5VanguardPrefs.cfg`*) and configure the settings to your liking. The file is fully commented, and each XR vessel allows extensive configuration of its settings.*

Note that you do not need to exit the Orbiter Launchpad in order for your edits to take effect; the configuration file is read every time a new vessel is created; i.e., each time a scenario loads.

XR vessels are high-performance spacecraft for Orbiter, however they share many common controls with standard Orbiter vessels: Orbiter's default controls, such as virtual cockpit, throttle, and view controls are unchanged from the DeltaGlider ship

included with Orbiter. You may refer to the DeltaGlider-S documentation included with Orbiter for details about standard flight and view controls: The file is `C:\Orbiter\Doc\DeltaGlider.pdf`.

This *XR-Class Flight Operations Manual* focuses on the new features of XR vessels rather than repeating information that is common to all Orbiter ships.

Configuring Damage Simulation

By default each XR vessel is installed with all damage settings *enabled*, which means that it is now quite possible to destroy your ship if you don't watch what you're doing. However, damage detection and simulation is fully configurable via your vessel's configuration file, and you are free to turn any particular damage type on or off as desired (*hull heating, hard landings, crashes, etc.*) If you turn off *all* damage settings, you will find your XR vessel to be as forgiving as the default DeltaGlider that is included with the Orbiter core. This allows novice pilots to "ease into" realistic flight gradually as they progress.

For more adventurous pilots, XR vessels also include a *CHEATCODES* section in their config files that allows users to directly set certain ship parameters such as ship mass, fuel capacity, engine thrust, etc. *Note that these values are not range-checked in any way.* Please be aware that although setting a *CHEATCODE* value incorrectly will not harm your Orbiter installation, it *could* cause Orbiter to CTD *(Crash-To-Desktop)*. Refer to the comments in you vessel's configuration file for more information.

Flying your XR Vessel

Note: as stated in the standard Orbiter documentation, you may switch between different instrument panels (upper, main, lower) using the CTRL-UP and CTRL-DOWN keys. For more information about standard Orbiter flight keys and additional ship controls, refer to the standard `C:\Orbiter\Doc\DeltaGlider.pdf` and `C:\Orbiter\Doc\Orbiter.pdf` files installed with Orbiter.

Although not required, the key to efficiently flying you XR vessel into LEO ("Low-Earth Orbit") is to use your air-breathing SCRAM engines for as long as possible before using your main engines for orbit insertion. A SCRAMJET is a variant of the conventional RAMJET engine. Unlike jet engines, RAMJET engines have no compressor to compress the incoming air -- air is "rammed" into the diffuser where it is compressed and ignited with injected fuel. As such, SCRAM engines are ineffective at low velocities or even high velocities if the atmosphere is too thin.

If you fly too low you will waste fuel by generating excessive heat, possibly even damaging the ship if hull temperatures get too high. On the other hand, if you fly too high you will decrease SCRAM engine thrust and efficiency because there will be insufficient oxygen being rammed into the SCRAM intakes. The key to efficient flight is to gradually increase altitude as velocity increases, keeping dynamic pressure high enough to feed the SCRAM engines but low enough to not create excessive drag and heat.

To track your SCRAM engine efficiency, refer to the SCRAM TSFC/Fuel Flow gauge on the main panel; for TSFC, lower values are better.

SCRAM TSFC and Fuel Flow Gauge on the Main Panel

Similarly, when firing the main engines you may refer to the TSFC (*Thrust-Specific Fuel Consumption*) gauge on the *MAIN/HOVER* display on the lower panel to show how much fuel is consumed to produce a given amount of thrust: lower values are better.

Main/Hover TSFC and Fuel Flow Gauge on the Lower Panel

The white horizontal line on the TSFC gauge shows the TSFC of the main and hover engines in a vacuum; i.e., it is the *maximum efficiency* line. The two fuel flow gauges to the right of the TSFC show the fuel flow rates of the *main* and *hover* engines, respectively, in kilograms-per-second.

A key gauge to watch during SCRAM ascent is the *Dynamic Pressure* gauge on the main panel.

Dynamic Pressure Gauge showing pressure in kilopascals

Try to keep the dynamic pressure between 8 and 20 kPa (*kilopascals)* initially, depending on velocity. This will supply the SCRAM engines enough oxygen without the ship being too low in the atmosphere and generating excessive heat, which wastes fuel. If you fly your ascent correctly you should be able to reach mach 17-20 before the engines reach their operational limit and you shut down the SCRAM engines and switch to the main engines for orbit insertion.

Another important gauge to watch during SCRAM ascent is the *SCRAM Diffuser Temp* gauge; this shows the temperature of the diffuser in each engine where the incoming air is compressed before it is combined with SCRAM fuel and ignited.

SCRAM Diffuser Temperature Gauge

The diffuser chamber walls are cooled by the cryogenic SCRAM fuel right before it is injected; the operational limit of the engines is 8000 degrees Kelvin. Since the SCRAM engine is a RAMJET variant, the speed of the ship determines the temperature of the compressed air in the diffuser. As you approach thermal limits the temperature of the compressed freestream approaches the temperature of the ignited fuel/air mixture, and so the thrust produced (and therefore engine efficiency) is reduced. Once the engines reach their thermal limit they are unable to accelerate the ship any further; at that point you should shut down the SCRAM engines and switch to the main engines.

WARNING: Remember to close the SCRAM doors (CTRL-G, or use the switch on the upper panel) before you engage the main engines! Otherwise the diffuser temperature may exceed 8000K, which will overheat and likely damage the SCRAM

engines. Excessively overheating the SCRAM engines may cause an explosion and destroy the ship![1]

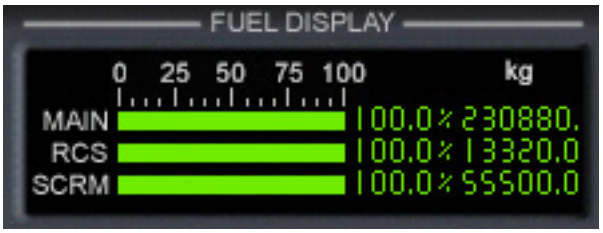
To monitor your engine thrust and efficiency plus the G forces active on your ship, refer to the *Engine Display* on the main panel (shown below). The top line shows a gauge from 0-100. The green bars below it indicate 0-100% engine thrust for the Main, Hover, and SCRAM engines, respectively. The green arrow on the *Effic* Line shows your current main and hover engine efficiency; rocket engines are less efficient when flying in an atmosphere, and so you will see the arrow move to the right toward 100% efficiency as dynamic pressure decreases during ascent in an atmosphere[2].

Engine Display Gauge Landed on Earth

The bottom part of the panel shows the G forces currently active on your ship. Orbiter uses a left-hand coordinate system, and so the X axis shows acceleration along the left-right axis (side-to-side), Y shows vertical acceleration (up-down), and Z shows forward/backward acceleration. A green arrow indicates positive acceleration (*right* for X axis, *up* for Y axis, and *forward* for Z axis), and red arrow indicates a negative acceleration (i.e., "deceleration").

To monitor the fuel quantity remaining in your Main, RCS, and SCRAM tanks refer to the *Fuel Display* as shown below:

[1] Remember that SCRAM engine heat damage may be disabled in the `XR5VanguardPrefs.cfg` file if desired; in that case the gauge will continue to display the diffuser temperature, but exceeding the limits will not damage the ship.
[2] You may disable this realism feature by setting `EnableATMThrustReduction=0` in your `XR5VanguardPrefs.cfg` file.



Fuel Display Gauge with Full Tanks on the Vanguard

Structural and Thermal Limits

This section details the structural and thermal limits of each XR vessel; remember that you can disable any or all of these limits by editing your vessels configuration file (e.g., `XR5VanguardPrefs.cfg`).

XR Structural and Thermal Limits

Description	DG-XR1	XR2 Ravenstar	XR5 Vanguard
Max positive wing load	17000 N/m^2	17000 N/m^2	17000 N/m^2
Max negative wing load	11000 N/m^2	11000 N/m^2	11000 N/m^2
Max dynamic pressure (absolute)	150 kPa	150 kPa	150 kPa
Landing Gear Energy Absorption Limit	8.04e+4 $\frac{kg}{m/s^2}$	1.29e+5 $\frac{kg}{m/s^2}$	2.57e+6 $\frac{kg}{m/s^2}$
Max touchdown descent rate, max load (full fuel, full cargo)	3.1 m/s	2.8 m/s	2.6 m/s
Max touchdown descent rate, typical load (33% fuel, 75% cargo)	5.8 m/s	4.2 m/s	3.5 m/s
Crew Survivability Limit (max vertical impact velocity)	39 m/s	39 m/s	39 m/s
Max bank at touchdown	15 degrees	15 degrees	15 degrees
Max pitch at touchdown	16 degrees	16 degrees	16 degrees
Max dynamic pressure: Crew Elevator deployed	N/A	N/A	9 kPa
Max dynamic pressure: Radiator Deployed	16 kPa	16 kPa	16 kPa
Max dynamic pressure: Cabin Hatch deployed	20 kPa	20 kPa	20 kPa
Max dynamic pressure: Docking Port/Nosecone open	32 kPa	32 kPa	32 kPa
Max dynamic pressure: Payload Doors open	N/A	36 kPa	36 kPa
Max dynamic pressure: Landing Gear deployed	39 kPa	39 kPa	39 kPa
Max dynamic pressure: Retro Doors deployed	41 kPa	41 kPa	41 kPa
Hull Thermal Failure at temperature limit (single surface)	~8 seconds (typical)	~8 seconds (typical)	~8 seconds (typical)

Max surface heating: NOSECONE	2840 C (5144 F)	2840 C (5144 F)	2840 C (5144 F)
Max surface heating: WINGS	2380 C (4316 F)	2380 C (4316 F)	2380 C (4316 F)
Max surface heating: COCKPIT	1490 C (2714 F)	1490 C (2714 F)	1490 C (2714 F)
Max surface heating: TOP HULL	1210 C (2210 F)	1210 C (2210 F)	1210 C (2210 F)

Notes:

- Depending on the ship's mass, exceeding the max descent rate at touchdown will collapse the landing gear and damage the hover engines, and may injure or kill the crew; exceeding the limit by too much will destroy the ship.

- Exceeding a surface's dynamic pressure limits will overload that surface's hydraulics causing them to fail. **WARNING: AN OPEN (DEPLOYED) SURFACE SEVERELY COMPROMISES THAT SURFACE'S HEAT RESISTANCE.**

- The high-strength SCRAM and Hover doors do not have a dynamic pressure limit (except for the hull's absolute dynamic pressure limit, of course); however, the hover doors must be CLOSED during reentry in order to prevent the inner hull from overheating. Similarly, you must close the SCRAM doors for high-mach (> mach 17-20) upper atmospheric flight.

- If a hull surface overheats, typical failure occurs within eight seconds at temperature limit; failure probability increases by overtempRatio^2 as hull temperature increases.

- **WARNING: If a door is open on a surface, that surface's thermal limit is much lower: 480 C**

Custom Shortcut Keys

This section lists the custom shortcut keys defined by XR Vessels. Note that the standard Orbiter shortcut keys are not listed here; please refer to the standard documentation bundled with the Orbiter core distribution for details about standard shortcut keys.

Note that not all keys are applicable to all ships; for example, the XR1 does not have a payload bay, and so payload keys are not applicable to that vessel.

XR Vessel Custom Shortcut Keys

ALT-,	Shift center-of-gravity aft.
ALT-.	Shift center-of-gravity forward
ALT-M	Re-center center-of-gravity

ALT-U	Deploy selected payload
CTRL-ALT-U	Deploy all payload
ALT-G	Grapple selected payload
CTRL-ALT-G	Grapple all payload
ALT-J	Toggle DOCKING/NORMAL RCS config (*XR5 only*)
CTRL-E	Toggle crew elevator (*XR5 only*)
CTRL-U	Toggle payload bay doors
F1	Toggle exterior view
ALT-SPACE (hold)	Show DATA HUD (XR custom keyboard shortcuts)
CTRL-A	Auxiliary Power Unit (APU); supplies hydraulic power
CTRL-B	Airbrake
CTRL-Z	Radiator
CTRL-K	Nose Cone / Docking Port
CTRL-\	Retro doors (opening = low-pitched beep, closing = high-pitched beep)
CTRL-G	SCRAM doors (opening = low-pitched beep, closing = high-pitched beep)
CTRL-V	Hover doors (opening = low-pitched beep, closing = high-pitched beep)
CTRL-O	Outer airlock
CTRL-Y	Cabin hatch
G	Gear
CTRL-W	Reset MWS Warning Light and Alarm (you can also click the blinking MWS light)
L	Toggle Attitude Hold / Auto-Land autopilot; replaces stock LEVEL HORIZON autopilot.
A	Toggle Descent Hold autopilot; replaces stock HOVER HOLD ALT autopilot.
ALT-S	Toggle Airspeed Hold autopilot; note that Airspeed Hold may be engaged simultaneously alongside (i.e., independently of) any other autopilot.
CTRL-= or ALT-NUMPAD+	Increase SCRAM throttle
CTRL-- or ALT-NUMPAD-	Decrease SCRAM throttle
ALT-=	Small increase SCRAM throttle (1/10th normal)
ALT--	Small decrease SCRAM throttle (1/10th normal)
CTRL-BACKSPACE or ALT-NUMPAD*	Kill SCRAM thrust
SHIFT-NUMPAD_INS	Small increase hover throttle (1/10th normal)
SHIFT-NUMPAD_DEL	Small decrease small hover throttle (1/10th normal)
CTRL-NUMPAD*	Kill hover thrust
CTRL-.	Increase elevator trim level
CTRL-,	Decrease elevator trim level
SPACE	Disengage autopilot
/	Same as NUMPAD "/"; workaround for Joy2Key bug.
CTRL-/	Same as NUMPAD "CTRL-/"; workaround for Joy2Key bug.
ALT-/	Same as NUMPAD "ALT-/"; workaround for Joy2Key bug.
ALT-X	Increase HUD brightness
ALT-Z	Decrease HUD brightness
ALT-H	Change HUD color
CTRL-X	Toggle secondary HUD on/off
CTRL-[1-5]	Switch to secondary HUD mode [1-5] (also turns on HUD in that mode)
CTRL-T	Toggle tertiary HUD on/off

[0-9]	Switch to MultiDisplayArea Mode #(0-9)
D	Next MultiDisplayArea Mode
ALT-D	Previous MultiDisplayArea Mode
ALT-P	Main engines gimbal up (nose up)
ALT-L	Main engines gimbal right (nose left)
ALT-;	Main engines gimbal down (nose down)
ALT-'	Main engines gimbal left (nose right)
ALT-0	Re-center main engines gimbal controls

Notes:

- "CTRL-", "CTRL=", and BACKSPACE on the main keyboard are recommend for controlling the SCRAM throttle; those keys are easier to use than the ALT-NUMPAD keys when flying with a joystick.

When one of the three custom autopilot modes is engaged, certain autopilot-specific keys become activated. The following sections list each of the three custom autopilot modes and the keys used by each.

XR Attitude Hold Shortcut Keys

L	Toggle *Attitude Hold* on or off
CTRL-L	Engage *Attitude Hold* and sync to current attitude
NUMPAD2	Increment pitch/AOA hold by 2.5 degrees
NUMPAD8	Decrement pitch/AOA hold by 2.5 degrees
ALT-NUMPAD2	Increment pitch/AOA hold by 0.5 degree
ALT-NUMPAD8	Decrement pitch/AOA hold by 0.5 degree
NUMPAD6	Increment bank hold by 5 degrees
NUMPAD4	Decrement bank hold by 5 degrees
CTRL-NUMPAD3	Zero bank (reset bank to level)
CTRL-NUMPAD7	Zero pitch (reset pitch to level)
CTRL-NUMPAD1	Zero both (reset bank and pitch to level)
NUMPAD9	Toggle between *AOA Hold* and *Pitch Hold* modes.

XR Descent Hold Shortcut Keys

A	Toggle *Descent Hold* on or off
CTRL-NUMPAD2	Decrease descent rate 2.5 m/s
CTRL-NUMPAD8	Increase descent rate 2.5 m/s
NUMPAD2	Decrease descent rate 0.5 m/s
NUMPAD8	Increase descent rate 0.5 m/s
ALT-NUMPAD2	Decrease descent rate 0.1 m/s
ALT-NUMPAD8	Increase descent rate 0.1 m/s
NUMPAD0	Engage AUTO-LAND mode (efficient, gentle auto-touchdown using hover engines)

NUMPAD.	Engage HOVER mode (hold altitude)

XR Airspeed Hold Shortcut Keys

S	Toggle *Airspeed Hold* on or off
CTRL-NUMPAD+	Increase rate 25 m/s
CTRL-NUMPAD-	Decrease rate 25 m/s
NUMPAD+	Increase rate 5 m/s
NUMPAD-	Decrease rate 5 m/s
SHIFT-NUMPAD+	Increase rate 1 m/s
SHIFT-NUMPAD-	Decrease rate 1 m/s
ALT-NUMPAD+	Increase rate 0.1 m/s
ALT-NUMPAD-	Decrease rate 0.1 m/s
NUMPAD_ENTER	Hold current airspeed (also useful after NUMPAD* to hold a lower speed; i.e., "resume")
NUMPAD*	Reset rate to 0 m/s (i.e., "coast")

Center-of-Gravity Shifting

XR Vessels use center-of-gravity shifting and elevator trim in addition to RCS jets to manage the ship's pitch during reentry and atmospheric flight. If the *Attitude Hold* or *Descent Hold* autopilot is engaged the computer will control COG shifting automatically. If you want to manage COG shifting yourself, ensure that the *Attitude Hold* and *Descent Hold* autopilots are disengaged.

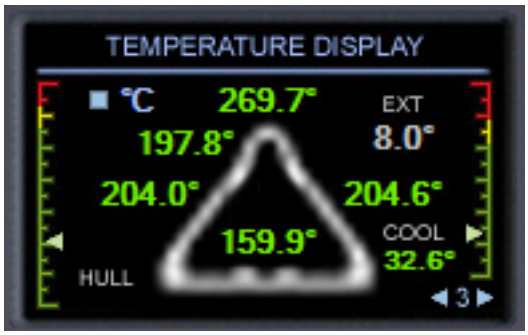
If *Attitude Hold* or *Descent Hold* is engaged, the flight computer will use COG shifting in conjunction with elevator trim and RCS jets to maintain attitude, which allows the ship to hold a stable reentry profile even under time acceleration. Also, it is extremely efficient and uses very little RCS fuel. Attitude Hold also performs well in atmospheric flight (for example, during SCRAM ascent). The ship is also very stable when transitioning from conventional flight to hover while Descent Hold is engaged.

Note that the pumps that pump fuel forward or aft for COG shifting require a lot of power, and therefore the APU must be active in order for them to operate. The APU must be active in order for the elevator trim to operate as well. If the APU is offline and *Attitude Hold* or *Descent Hold* is engaged in an atmosphere, by default the ship will auto-start the APU so that COG shifting and elevator trim control can occur. If you want to disable this feature, set `APUAutostartForCOGShift=0` in your vessel's preference file.

Center-of-Gravity Controls on the Main Panel

Using the Multi-Display-Area (MDA)

XR vessels are equipped with a touch-screen *Multi-Display-Area (MDA)* in the lower center of the main panel. This panel supports 10 different modes (0-9), with each mode having its own touch-screen virtual buttons and other information. The picture below lists MDA Mode #3:



MDA Mode 3 (Temperature Display)

Notice the solid light blue areas on the screen: those areas are touch-sensitive. You can use the blue arrows on either side of the **3** in the lower-right corner to step to the next or previous MDA mode. You can also select an MDA mode *directly* by via the keys 0-9, and you can step to the next or previous MDA mode by using the **D** and **ALT-D** keys, respectively.

The other interactive area on the above MDA screen is the solid blue block next to the °C indicator: clicking it will switch the display between Celsius, Fahrenheit, and Kelvin temperature scales. Except for the blue navigation arrows in the lower-right corner, the interactive areas for each MDA mode are different; you will find each MDA mode detailed in its relevant section later in this manual.

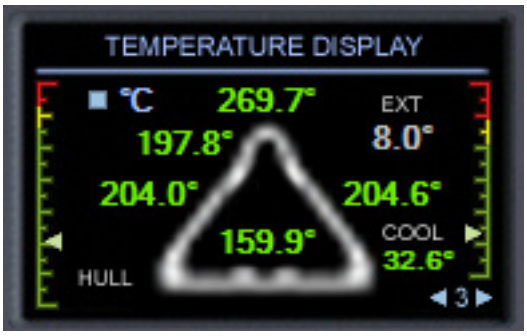
Walkthrough: Launch from KSC to Low-Earth-Orbit

Here is walkthrough detailing how to fly your XR vessel from Kennedy Space Center efficiently into LEO *(Low-Earth-Orbit)*:

1. In the Orbiter Launchpad, select your vessel's *Ready for takeoff to ISS* scenario in your vessel's scenario folder (e.g., *XR5 Vanguard*). You are lined up on the runway at KSC.

2. Ensure that the APU (*Auxiliary Power Unit*) is powered on (it is controlled by the APU button or CTRL-A). The APU powers your hydraulic systems. Also ensure that the *AF CTRL* switch is set to *ON*; if you forget to do this and you are taking off in an atmosphere, a warning callout occurs.

3. If you will be taking off immediately, skip this step. Otherwise, if you want to wait for more than a few minutes before taking off, enable e*xternal cooling* via the switch on the lower panel to keep the ship's internal systems cool. You can monitor the internal coolant temperature on the lower panel or on the main panel on the MDA screen, mode 3 (it should currently be displayed by default). You should also shut down your APU (CTRL-A, or click the button on the panel) so you don't waste any APU fuel. If you want to conserve onboard oxygen as well, open the cabin hatch via CTRL-Y or the switch on the upper panel.



Multi-Display-Area (MDA) Mode #3

The right-hand gauge shows the ship's internal coolant temperature: 32.6 degrees Centigrade. The remainder of the display shows external hull temperatures, which are discussed later.

4. Once you reach your takeoff time, power up the APU again, close the cabin hatch, and disable external cooling via the switch on the lower panel. Also double-check that *AF CTRL* is set to *ON*. You will need to keep the APU online until you reach about 75 km altitude and switch to RCS jets for attitude control.

5. Ready for takeoff! Push the main engines to full power. You will notice the Y axis G meter fluctuating as you roll down the runway; this is normal.

6. The computer will call out *100 knots*, then *V1* (which is *Takeoff Decision Speed*), and finally *Rotate:* pull up when *Rotate* is called out and press ALT-S to engage Airspeed Hold, or throttle back to about 40% manually. As the ship goes airborne, by default the computer will call out *Wheels Up*, which is a pilot term that means "the wheels are off the ground." It does *not* mean that the gear has been retracted. *NOTE: you can change or disable the liftoff and touchdown callouts by editing your vessel's configuration file; refer to the* `LiftoffCallout` *and* `TouchdownCallout` *properties in the file for details.*

7. Once you are airborne raise the gear with **G**. Turn smoothly to 136 degrees (or whatever your ascent heading is), level out, press SPACE BAR to disengage Airspeed Hold, and push the main engines to full power. Pitch up to about 70 degrees. **Do not engage the SCRAM engines yet!** As you accelerate you will hear a sonic boom as you pass through Mach 1 unless you have disabled the sonic boom sound in your vessel's configuration file.

8. Once you approach 24-28 km altitude, level out smoothly and begin to accelerate to Mach 3.5 (XR1/XR2) or 4.5 (XR5) and open the SCRAM doors if they are not already open (CTRL-G, or use the switch on the upper panel) Adjust the elevator trim controls to maintain level flight (*CTRL-.* and *CTRL-,* or *INS* and *DEL*). Once you reach your target velocity, push the SCRAM engines to full power and gradually throttle back the main engines until they are shut down. Keep an eye on the thrust generated by the SCRAM engines; if you throttle back the main engines too soon the SCRAM engines will not be able to accelerate the ship by themselves. Adjust the elevator trim controls to maintain about +100 m/s *(meters-per-second)* ascent. If you want to you may engage the *Attitude Hold* autopilot at this point (**CTRL-L**) to maintain a smooth ascent profile.

9. As you accelerate uphill keep an eye on the *Dynamic Pressure* gauge: it should read about 35 kPa at 24 km at Mach 4. Adjust your climb rate via elevator trim to gradually decrease dynamic pressure until it reaches ~10 kPa at 40 km altitude. Then adjust elevator trim or Attitude Hold settings to maintain 10kPa. *Note: you may need to adjust your ascent profile somewhat depending on the vessel you are flying and its payload mass.*

10. When the sky becomes dark switch your secondary HUD mode to mode 2 (press the **2** Secondary HUD button or press *CTRL-2* on the keyboard). This will switch to a transparent HUD with different data fields useful during ascent. Remember that you can customize each of the five secondary HUD modes via your vessel's configuration file.

Default Secondary HUD Mode 3

By default the five secondary HUD modes are configured for (1) reentry, (2) ascent, (3) atmospheric flight, (4) docking, and (5) on-orbit operations. You may customize all five secondary HUD modes by specifying which data fields to display for each mode as well as the color and transparency settings for each mode in your XR vessel's configuration file (e.g., `XR5VanguardPrefs.cfg`*).*

11. You will notice the fuel flow and, correspondingly, the thrust for the SCRAM engines increase as velocity increases up until the fuel flow reaches the maximum flow rate. The flow rate determines the maximum amount of fuel the engine can burn, and therefore the maximum thrust the engine can produce.

12. You will also notice as speed increases the SCRAM TSFC (*Thrust-Specific Fuel Consumption*) will go down, which means the engines are being more efficient. As speed increases beyond Mach 7-9, however, engine efficiency will gradually decrease. This is normal and is due to a combination of two factors: 1) the shape and design of the engines, and 2) the decreasing delta between the compressed freestream temperature and the SCRAM burner temperature as velocity increases.

13. Use elevator trim (*CTRL-,* and *CTRL-.* or *INS* and *DEL*) to maintain a smooth, gradual ascent as you accelerate. Adjust ascent rate to keep dynamic pressure around 10 kPa. Try to fly smoothly by making small adjustments to the elevator trim. As your velocity and altitude increase, adjust your ascent rate to keep lowering dynamic pressure gradually below 10 kPa down to about 4 kPa. For optimum efficiency you want to have enough oxygen for the SCRAM engines to operate at peak thrust but still have minimum air resistance.

XR2 Ravenstar on SCRAM Ascent

14. If you fly your ascent correctly (and assuming no payload), at about 60 km you should reach mach 20+ before the SCRAM engines approach their thermal limit or run out of fuel, with ~60% main fuel remaining (with the default fuel ISP settings). You may want to keep a few percent of your SCRAM fuel in reserve in case you need it later during reentry if you are short of the base by a few hundred kilometers. If that occurs, remember to engage the SCRAM engines at velocities greater than mach 4, and preferably about mach 7-9; below mach 4 the TSFC is much higher because the engines make much less thrust for a given amount of fuel. The engines operate at peak efficiency around mach 7-9.

15. Once you shut down the SCRAM engines, **close the scram doors!** (*CTRL-G*, or use the switch on the upper panel.) If you don't do this and you engage the main engines, the SCRAM engines will begin to overheat because the temperature of the diffuser (which compresses the incoming air) is directly proportional on the velocity of the freestream. Overheating the SCRAM engines may damage them or even destroy the ship if you overheat them too much!

16. After you close the SCRAM doors, push the main engines to full power and pitch up about 10 degrees initially. Then adjust pitch to enter your desired orbit as you ascend smoothly. Once your apoapsis altitude (ApA on the Orbiter MFD) reaches 200 km, shut down the main engines. Note that you are not in orbit yet, but you have to wait until you reach apoapsis (the "high point" of your orbit) before burning your main engines again to raise your periapsis (the "low point" of your orbit).

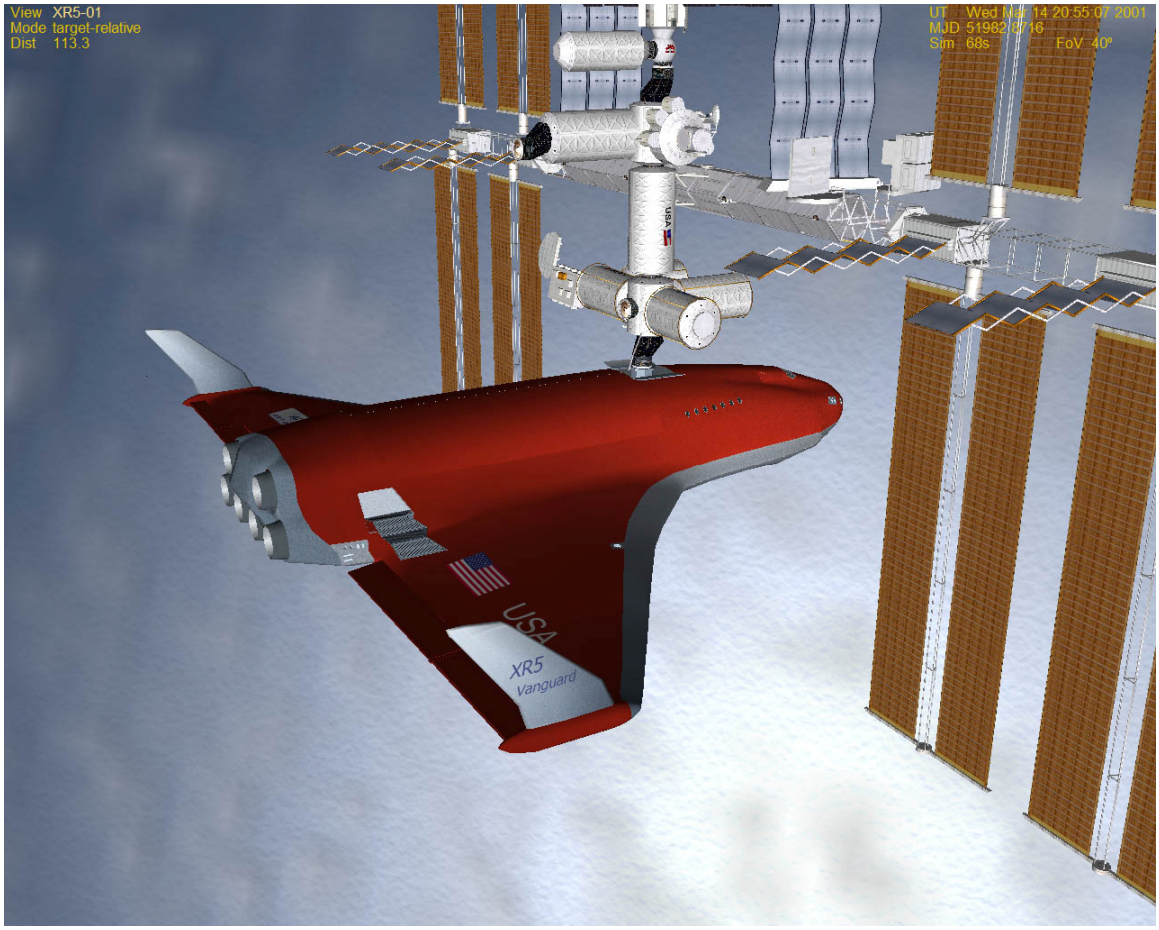
17. Deploy the radiator (*CTRL-Z*, or use the green button the main panel or the switch on the upper panel) and re-center the elevator trim (*CTRL-.* or click on the elevator trim area on the panel). Once the radiator is fully deployed the green *RAD DEPLOY* light will come on. Switch *AF CTRL* to *OFF* and shut down the APU to conserve its fuel (*CTRL-A*, or click the APU button).

18. It will take up to 45 minutes in real-time to reach your apoapsis (which is the point where your vertical speed goes from positive to zero to negative). You can use accelerated time (**T** and **R** keys) to speed up the process.

19. As you approach apoapsis, engage the PROGRADE autopilot (**[** key, or use the *Prograde* autopilot button on the main panel) and engage the main engines gradually *just before* you reach apoapsis: this will raise the low point of your orbit. Be careful to not engage your main engines too soon or you will raise your *apoapsis* (the *high* point of your orbit) as well, which is not what you want! Once your periapsis (PeA on your Orbit MFD) reaches 200 km, cut your main engines.

At this point if you've done everything correctly you should be in a stable 200x200 km orbit. Congratulations, you have achieved orbit!

Or you can just forget finesse and run the main and SCRAM engines simultaneously during ascent and accelerate at 3-5 Gs…



XR5 Vanguard Docked at the ISS

Fuel and Oxygen Consumables Management

XR vessels support built-in refueling when you are docked with any vessel or landed on any planet or moon; no fuel MFD or other add-on is necessary. Refueling and LOX *(Liquid Oxygen)* resupply settings are fully configurable via you're your vessel's configuration file (e.g., `XR5VanguardPrefs.cfg`); the default configuration is to allow MAIN fuel refueling and LOX resupply when docked with any vessel or landed on any planet or moon, but you may only resupply SCRAM and APU fuel when landed on Earth (since you only need significant amounts of SCRAM and APU fuel when in an atmosphere). You may change any of this behavior as desired by editing the config file.

To refuel or resupply you must be landed or docked and your XR configuration settings must be set to allow refueling and/or LOX resupply for your location. For example, you could configure your vessel to only allow refueling on the **ground** and *never* while **docked**.

Replenishing Fuel and LOX Tanks

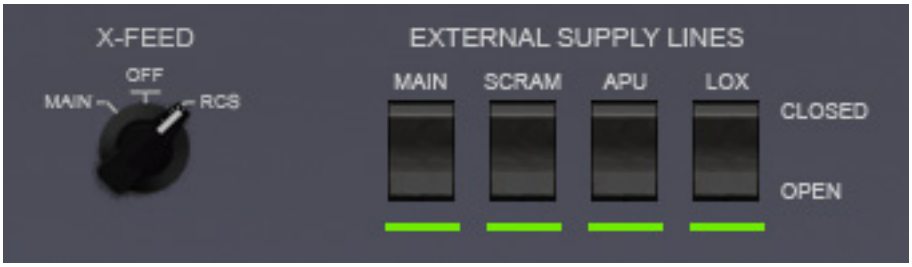
1. After docking (or landing and coming to a full stop), switch to the lower panel and open the fuel and/or LOX hatches depending on whether you want to resupply fuel, LOX, or both.

Ship Mass Display and Resupply Hatch Switches

2. You will hear the external fuel and/or LOX hatches open, followed by a thump when the external lines connect and magnetically lock. You will see pressure build on the *EXTERNAL LINE PRESSURE* gauges. When pressure reaches nominal for each line the green light below the gauge will come on.

All Supply Lines Green!

3. At this point there is pressure in the fuel lines, so refer to the *EXTERNAL SUPPLY LINES* switches on the lower left-center of the panel. Click the *MAIN/SCRAM/APU/LOX* switches as desired to feed consumables to that tank (picture is below). To resupply the RCS tank, set the *X-FEED* switch to *RCS* to cross-feed fuel in the main tank to the RCS tank.



Resupply in progress; filling RCS tanks as well.

Hint: If you are low on main engine fuel during a mission and have some RCS fuel to spare, you can cross-feed RCS fuel over into the main tank by setting the X-FEED switch to MAIN and cross-feeding fuel until only a small amount of RCS fuel remains. However, be sure to keep enough RCS fuel in reserve to finish the mission!

Hint: You can dump fuel and/or LOX [usually done only before reentry to lighten the ship] by holding down the dump button below the main gauge. Note that you must HOLD the button down to initiate the fuel dump. Tap the button again to halt the fuel dump.

Fuel Dump Button

Note: Main/RCS Engine Fuel, SCRAM Fuel, and APU Fuel are not compatible. Fuel may only cross-feed between the MAIN and RCS tanks.

4. When you flip the switch for a supply line you will see the line pressure drop and fluctuate slightly as fuel or LOX flows into the tank; this is normal. Note that line pressure will be *higher* when refueling on the ground than when refueling while docked; line pressure affects the speed at which the tank fills, so refueling will take longer when docked than when on the ground.

5. You can monitor the ship's mass as fuel or LOX is loaded via the *SHIP MASS* display on the lower panel. Refueling continues until you close the supply line via its switch, close the fuel or LOX hatch, or move the ship with thrusters (which disconnects the lines). Each supply line switch will also automatically close when the tank it feeds is full. The only exception to this is when the main tank is full but is still cross-feeding into the RCS tank; at that point refueling will continue until the RCS tank is also full, at which point the main supply line feed will close automatically.

6. When you are finished resupplying, close the fuel and LOX hatches; you are now ready for takeoff!

Note that the ship will switch over to external Oxygen (O_2) when you are 1) docked with both airlocks open, or 2) landed on Earth with both airlock doors or the crew hatch open. It is a good idea to do this whenever possible because it will help to conserve your onboard oxygen supply.

XR2/XR5 Only: Using Payload Bay Fuel/LOX Tanks

XR vessels that have a payload bay can also attach and use auxiliary fuel and/or LOX tanks in the payload bay. There are three types of consumables tanks available:

1. Main fuel bay tank
2. SCRAM fuel bay tank
3. LOX bay tank

These tanks vary by XR vessel, but they all function in the same way: when bay tanks are attached, your fuel/LOX gauges are updated to reflect the increased fuel load, and bay tanks will drain before your internal tanks. Some additional notes:

- If you attach a non-empty bay tank, fuel from the bay tank will fill the main tank.

- Each bay tank's fuel/LOX load is preserved in the scenario file.

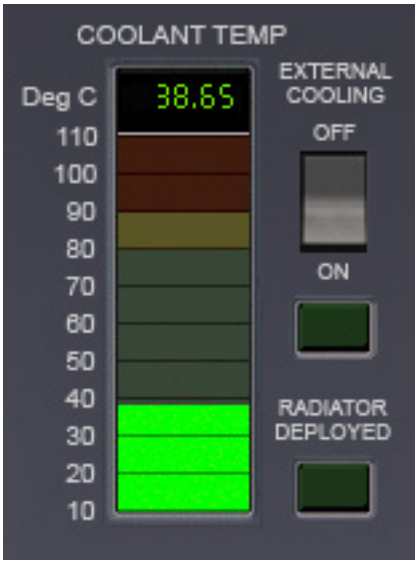
- If you dump consumables from your ship with bay tanks attached, the *bay* tanks drain first.

- If you resupply consumables with bay tanks attached, the ship's *internal* tanks fill first and then any *bay* tanks.

Coolant Temperature Management

XR vessels' internal electronics and computers are cooled via a liquid cooling system. The coolant reserves are able to absorb a certain amount of heat, but this heat must eventually be dissipated away from the ship via the radiator or a ground-based or station-based external cooling system. If not, the internal computers and systems will overheat and fail, causing the computers which regulate environmental systems to fail as well. Once this occurs cabin oxygen will no longer be replenished and the crew will lose consciousness or even die if cabin oxygen levels fall below about 10%.

To manage coolant temperature it is important to deploy the radiator as soon as possible after reaching orbit. If you are landed or docked you may also enable the external cooling system, which works by connecting an external coolant line from a ground- or station-based cooling system. External cooling is somewhat more efficient than the radiator, and if you are landed or docked you may also enable *both* systems simultaneously to cool the ship at more than twice the rate of the radiator alone. External cooling is activated via a switch on the lower panel.



Coolant Temperature Gauge

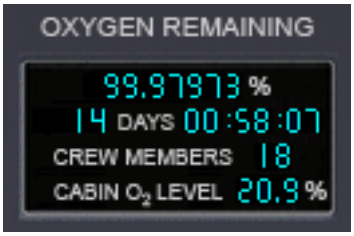
Note: running the APU will increase heat generation by several percent (as well as burn APU fuel), so be sure to shut down the APU when you don't need it.

Be sure not to deploy the radiator in flight in an atmosphere because excessive dynamic pressure may damage it, rendering it unable to cool the ship any further. *If that happens, land immediately because once the internal systems overheat cabin oxygen flow will fail!* Once you land, open the crew hatch or both airlock doors to replenish oxygen levels in the cabin, and enable external cooling to cool the ship's systems.

You can monitor coolant temperatures on the main panel via the *Temperature Display* MDA screen (described earlier), or you may refer to the *COOLANT TEMP* gauge on the lower panel as shown above. If coolant temperature reaches **80C** you will hear a warning message. If coolant temperature reaches approximately **90C** internal systems may fail; failure will typically occur within 20 seconds, although it may vary. Once the system overheats, the MDA screen, MFDs, HUDs, and environmental systems will fail. *At this point you must deploy the radiator ASAP because you only have a few minutes before oxygen levels fall too low and the crew becomes unconscious and dies shortly thereafter.*

Note that coolant management may be configured or disabled via the config file.

You can monitor the cabin oxygen levels via the *OXYGEN REMAINING* screen on the lower panel.



O_2 Remaining Display

Oxygen time remaining is of course proportional to the number of crew members onboard the ship.

APU Fuel Management

The APU (*Auxiliary Power Unit*) provides hydraulic power to the ship. It powers flight control systems, doors, radiator deployment, etc. You will normally only run the APU during takeoff and landing in an atmosphere, reentry, or you will run it for a short time when you need to open or close an airlock door or the payload bay doors.

Unless APU fuel consumption is disabled via the *APUFuelBurnRate* setting in the ship's config file, the APU has limited fuel so be efficient with its use and don't leave it running when you don't need it.

If you attempt to take off in an atmosphere with the APU off you will hear a warning callout from the computer.

Because the APU is the sole source of hydraulic power on XR vessels, the APU must be running in order for these systems to operate:

- Airlock Ladder
- Docking Port/Nosecone
- Outer Airlock Door
- Inner Airlock Door
- Airbrake
- Cabin Hatch
- Radiator
- Retro Doors
- Landing Gear
- Payload Bay Doors
- Crew Elevator
- Flight Control Surfaces (elevons, rudder, elevator trim, etc.)
- Wheel Brakes

Nominal APU startup/shutdown time is 2.5 seconds.

As a safety feature, if you leave the APU running for more than 60 seconds with no load on it (i.e., without using it) you will hear a warning callout from the computer. This warning interval may be changed or eliminated via the *APUIdleRuntimeCallouts*

in your vessel's configuration file. Note that if *APUFuelBurnRate=0* (unlimited), APU idle warning callouts are automatically disabled.

Also note that, by default, the APU will automatically shut down whenever you switch focus to another vessel *unless* an XR autopilot that requires APU power is engaged. If desired, you may disable auto-APU shutdown by setting *APUAutoShutdown=0* in your vessel's configuration file.

You may activate the APU via *CTRL-A* or via the APU button present on the ship's 2D instrument panels.

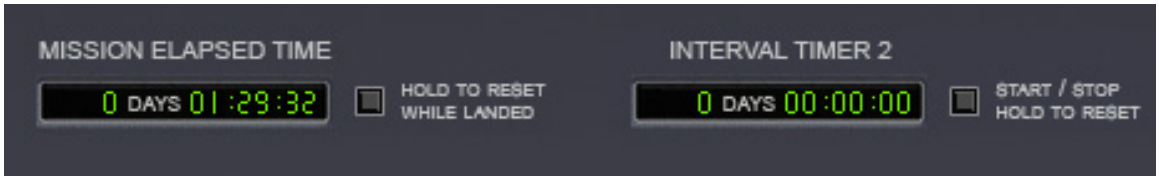
APU Button and Fuel Gauge

M.E.T. and Interval Timers

XR vessels feature a *Mission-Elapsed-Time* (MET) timer plus two manual interval timers. The MET timer will start automatically once the ship goes "wheels-up", meaning "at liftoff". The MET timer will run until you land again and manually reset it by holding down the reset button. Note that you may only reset the MET timer while landed – you may *not* reset it merely while docked to another vessel or while in flight. Once it is reset it will start again automatically at liftoff.

The two interval timers are similar to the MET timer except that they may be started, stopped, or reset anywhere at any time. The first interval timer is on the upper panel and the second interval timer is on the lower panel; these timers run independently of each other.

Upper Panel Timer Displays



Lower Panel Timer Displays

Damage and Warning Display

This section details the damage and warning displays in XR vessels. First and foremost, there is a warning display on the main panel in addition to a *Master Warning System (MWS)* light that alerts you to a problem. This panel varies slightly between XR vessels, but it functions similarly on all XR vessels.

XR5 Vanguard Master Warning System Indicator Lights

The MWS panel is present on both the main and lower instrument panels. To silence the audible alarm, press *CTRL-W* or click the MWS button/light. Hold down the *MWS TEST* button to test the warning indicator lights.

Also note that the APU button will blink steadily if the APU is low on fuel.

The indicator warning lights refer to the following systems (listed from top-left to lower-right):

XR5 Vanguard Master Warning System Indicator Lights

`Elev`	Crew Elevator
`Bay`	Payload Bay Doors
`main`	Main Engines
`hovr`	Hover Engines
`scrm`	SCRAM Engines

rtro	Retro Engines
lwng	Left Wing
rwng	Right Wing
lail	Left Aileron
rail	Right Aileron
gear	Landing Gear
Dock	Docking Port
rdor	Retro Doors
htch	Cabin Hatch
rad	Radiator
airb	Airbrake
rcs	Reaction Control System (14 jets)
htmp	Hull Temperature
Mfuel	Main Fuel
Rfuel	RCS Fuel
lox	Liquid Oxygen (O_2)
dynp	Dynamic Pressure
cool	Coolant Temperature

To obtain more specific information about damaged systems, use the five *Systems Status* MDA modes (modes 5-8).

MDA Mode 4 (Systems Status Display #1)

Attitude Hold Autopilot

XR vessels include a highly accurate and efficient *ATTITUDE HOLD* autopilot that can hold a given pitch or AOA (*Angle of Attack)* and bank setting while neutralizing yaw via a *yaw dampener*. It is MDA mode 2; use the MDA arrows and click the *Engage* button, or use **L** to engage it via the keyboard (more on this later). This high-precision autopilot replaces the stock *Level Horizon* autopilot.

Note that ATTITUDE HOLD may be used at any time, not just for reentry. For example, it is useful to hold 87.5 degrees pitch while you are braking with the hover engines approaching a landing site in a vacuum (for example, at Brighton Beach). In

addition, some pilots like to use ATTITUDE HOLD during SCRAM ascent to hold a given pitch and/or bank.

The autopilot constantly neutralizes yaw while it is engaged; however, you may "nudge" the ship's yaw using the joystick rudder or the *NUMPAD1*/*NUMPAD3* keys; the yaw dampener will momentarily disengage whenever the pilot manually induces yaw, and automatically reengage when the pilot stops inducing yaw.

There are two different modes to hold the ship along the Y axis: *Pitch Hold* and *AOA Hold*. In *Pitch* mode the autopilot will hold a set pitch. Conversely, in *AOA* mode the autopilot will hold a given *Angle of Attack*. Typically you will only use *AOA* mode when reentering in an atmosphere and use *Pitch* mode the rest of the time. You may toggle between modes by clicking the blue block in the top-right corner of the screen, or you may use *NUMPAD9* when the autopilot is engaged.

ATTITUDE HOLD Autopilot Engaged in Pitch Mode

NOTE: except during reentry, if you engage ATTITUDE HOLD during atmospheric flight be sure to engage Pitch mode to hold a given pitch rather than AOA mode to hold a given angle of attack: in atmospheric flight the ship's angle of attack will constantly decrease (this is normal!), and so AOA mode will cause the ship to constantly increase pitch trying to maintain the set angle of attack. You should only engage AOA mode for reentry!

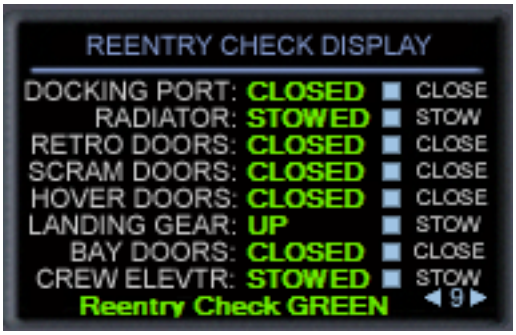
The *Zero Pitch, Zero Bank,* and *Zero Both* buttons will reset pitch, bank, and *both axes* to zero, respectively. (Note that *Zero Pitch* will read *Zero AOA* if AOA mode is engaged.) The *Sync* button will automatically update the bank and pitch/AOA target values to the ship's current values; i.e., it will "sync" the autopilot settings to the ship's current attitude. The shortcut key to engage ATTITUDE HOLD and automatically sync to (i.e., "hold") your current attitude is *CTRL-L*. "L" by itself toggles ATTITUDE HOLD normally.

Note: unlike the CTRL-L shortcut key, the Sync *button on the MDA screen will not automatically engage the autopilot; therefore, you will normally only use the* Sync *MDA button before engaging the autopilot. If you want to immediately "lock" the ship in its current attitude, use CTRL-L instead.*

One final note about *Sync*: the pitch/AOA and bank limits for sync mode are 60 degrees; do not engage *Sync* beyond those limits. If you do, the ship will attempt to engage attitude hold at the 60-degree boundary.

Reentry Walkthrough

Before you reach the atmosphere during reentry, be sure that the radiator is retracted and all doors are closed! Bring up MDA MODE 9 (*Reentry Systems Check*) by pressing **9**, or use the MDA arrows. Close any doors flagged by the reentry check. Once all systems show GREEN you are ready for reentry!

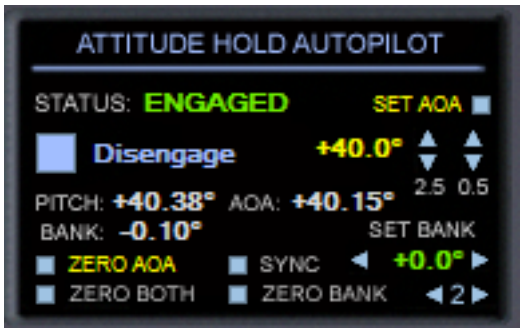


MDA Mode 9 (Reentry Systems Check) on the XR5 Vanguard

Before reaching entry interface, turn PROGRADE to ensure your ship is aligned with the ship's velocity vector and then switch to the *Attitude Hold* MDA screen (mode 2) by pressing **2** on the keyboard or using the MDA screen arrows. Ensure that AOA Mode is engaged (the top-right should read *SET AOA*), and then set your desired AOA; typically you will initially set 40 degrees AOA and 0 degrees bank. Engage the ATTITUDE HOLD autopilot with **L** or by clicking the *Engage* button on the touch screen. Be sure you have enough APU fuel remaining to reach your landing site! The APU must remain online to power the center-of-gravity shift pumps and flight control surfaces.

Once Attitude Hold is engaged you may change your AOA in 2.5- or 0.5-degree increments by clicking the pitch arrows on the MDA screen or via the *NUMAPAD8, NUMPAD2, ALT-NUMPAD8* and *ALT-NUMPAD2* keys. You may change your bank in 5-degree increments by clicking the bank arrows or via the *NUMPAD4* and *NUMPAD6* KEYS. Refer to the *Custom Shortcut Keys* section earlier in this document for a detailed list of autopilot mode keys.

Note: You may also hold down the mouse button on the pitch/AOA and bank arrows to rapidly scroll the pitch and bank rates. The ship's current pitch, AOA, and bank are displayed on the MDA screen.



ATTITUDE HOLD Autopilot Engaged in AOA Mode

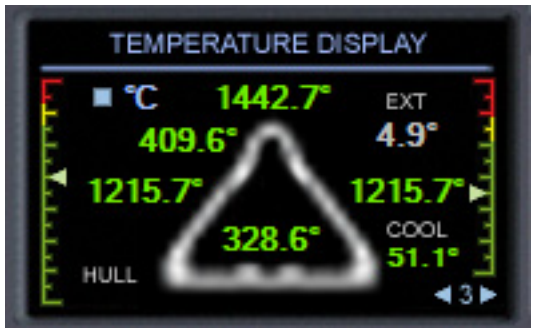
With bank set to 0 degrees you can hold a maximum pitch of +/- 87.5 degrees; with bank set to non-zero, you can hold a maximum pitch of +/- 60 degrees. Similarly, with pitch set to 0 degrees you can hold a maximum bank of 75 degrees; with pitch set to non-zero, you can hold a maximum bank of 60 degrees.

A NOTE ABOUT TIME ACCELERATION:

With a decent frame rate (60 fps or higher) you should be able to run the *ATTITUDE HOLD* autopilot at 100x in space and 4x in an atmosphere, even during reentry: great care was taken to make the autopilot as fuel-efficient and stable as possible. If you attempt to engage time acceleration at 1000x in space or 100x in at atmosphere, the autopilot will switch to SUSPENDED status (this will be shown on the MDA screen); it will automatically re-engage when you switch back to a lower time acceleration again.

As you reenter the atmosphere you should typically hold 35-45 degrees AOA. NOTE: be sure your ship's mass is not too great -- if the ship is too heavy you will likely overheat your hull! Use the fuel and/or LOX dump buttons on the lower panel to lighten your ship if necessary. For a nominal one-degree-slope reentry and assuming a normal payload your fuel mass should be under 50%, although it is possible to "baby the ship down" with a higher ship mass if you expertly vary your pitch to reduce the rate of aero-braking.

As you enter the denser part of the atmosphere keep an eye on your hull temperatures! The vertical gauge on the left side of the *Temperature MDA* screen (mode 3) is especially useful because it shows you exactly how close your hottest surface is (percentage-wise) to going over-temp. This makes it easy to see exactly how close you are to overheating your hull. If the indicator reaches the top, one of your hull surface temps is over maximum and you will shortly damage or even destroy your ship!



Temperature Display (MDA Mode 3)

From top-to-bottom and left-to-right, the hull temperatures displayed are:

- NOSECONE
- COCKPIT (i.e., Cabin hatch)
- LEFT WING
- RIGHT WING
- TOP HULL

The *EXT* value shows the temperature outside the ship, which may be either atmospheric temperature or temperature in vacuum.

If you exceed the maximum safe temperature on one or more of your hull surfaces the hull begins to weaken and will fail, on average, within about eight seconds if hull temperatures are not reduced below maximum. Note that the higher you are over-temp the faster the hull will (on average) fail, and overheating more than one surface will increase the chances of hull failure proportionally.

Note: It is theoretically possible to breach the hull anytime you are over-temp -- there is no hard-coded "minimum time" or "maximum time". Typically you will have about eight seconds if you are right on the threshold and only have one surface that is over-temp; however, the average time-to-breach will be lower if you are significantly over-temp (percentage-wise) for a given surface. Also, the more surfaces you have over-temp the more likely that one of them will breach. For example, if you have four surfaces over-temp instead of just one, your ship will have four times as many chances for a hull breach than if only one surface is over-temp (assuming each surface is percentage-wise equally over-temp). Furthermore, 200 degrees C over-temp on the *wings* is only 8.4% over maximum, but 200 degrees C over-temp on the *cockpit* is 13.4% over maximum. The more you are over-temp on a surface, the higher your odds of a hull breach on that surface: being just slightly over-temp is less likely to cause a hull breach, but it is still possible at any time when you are over-temp.

Temperature readouts are displayed as follows:

GREEN	OK
YELLOW	temp >= 80% of maximum sustained temperature
RED	temp >= 90% of maximum sustained temperature
WHITE	**OVER-TEMP! The hull will likely fail within a few seconds if heat**

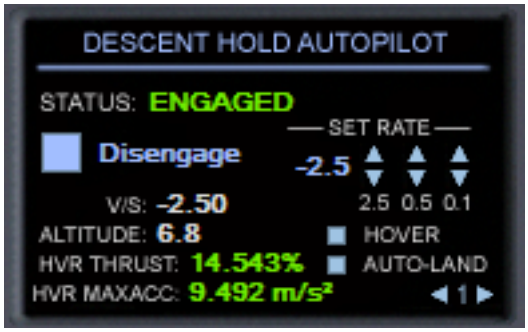
	is not reduced. The hotter the hull gets, the more likely it is to fail.

Remember to keep an eye on your internal coolant temperature as well, which is the gauge on the right-hand side of the display. (This was detailed earlier in the *Walkthrough: Launch from KSC to Low-Earth-Orbit* section.)

Descent Hold Autopilot (Hovering and Landing)

XR vessels include a highly accurate and efficient *DESCENT HOLD / AUTO-LAND* autopilot that can hover or hold a specified ascent or descent rate within 1/100th of a meter-per-second (0.01 m/s). It is MDA mode 1; use the MDA arrows and click the *Engage* button, or use **A** to engage it via the keyboard. This high-precision autopilot replaces the stock *Hover Hold Altitude* autopilot.

NOTE: before engaging the DESCENT HOLD autopilot, be sure that the hover doors are open: if the hover doors are closed or if you close them with the hover engines running, the hover engines will shut down and the DESCENT HOLD autopilot will disengage. You can toggle the hover doors with CTRL-V or by using the switch on the upper panel.



DESCENT HOLD Autopilot Engaged

You will notice there are three sets of *SET RATE* arrows labeled 2.5, 0.5, and 0.1. Clicking these will adjust the configured ascent/descent rate by 2.5, 0.5, and 0.1 meters-per-second, respectively. You can set any rate between -990 m/s and +990 m/s.

Also notice the *HOVER* and *AUTO-LAND* buttons: *HOVER* will reset the rate to 0.0 m/s, and *AUTO-LAND* will switch to auto-landing mode to efficiently and smoothly land your ship. If you attempt to engage *DESCENT HOLD* but the ship is too heavy for the hover engines to maintain the requested ascent or descent rate you will immediately receive a warning message stating that there is insufficient hover thrust available. For example, you will get this message if you attempt to lift off from Earth using *Realistic* hover engine settings (this is set in the config file) with more than about 50% fuel remaining.

The shortcut keys to set the ascent/descent rate are detailed in the *Custom Shortcut Keys* section earlier in this document; for example *CTRL-NUMPAD2* will decrease the

descent rate by 0.1 m/s, *NUMPAD2* by itself will decrease it by 0.5 m/s, and *ALT-NUMPAD2* will decrease it by 2.5 m/s. Refer to the *Custom Shortcut Keys* section earlier in this document for a detailed list of autopilot mode keys.

Once you are hovering over your target landing site and you want to auto-land, you can either land the ship yourself by setting the descent rate or you can engage auto-land mode at any point to have the autopilot land the ship efficiently and smoothly. Once the wheels touch down the autopilot will automatically disengage and shut down the hover engines, whether or not auto-land mode is engaged. To auto-land, click the *AUTO-LAND* button on the MDA screen or press *NUMPAD0* when the autopilot is engaged. Press *NUMPAD0* again to disengage auto-land and revert to hover mode. You can also use *NUMPAD.* (numpad-dot) to engage hover mode at any time.

There are four values of interest displayed on the *Descent Hold* MDA screen:

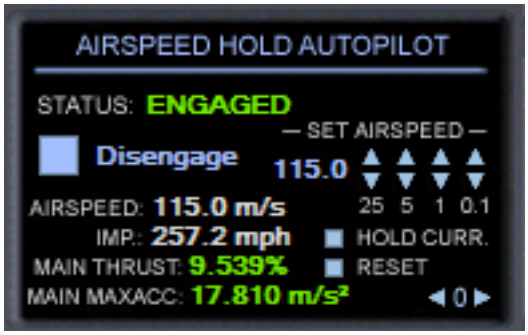
V/S	Shows vertical speed in meters-per-second.
ALTITUDE	Shows altitude in meters with 1/10th-meter resolution.
HVR THRUST	Shows the current hover engine thrust level from 0% to 100%.
HVR MAXACC	Shows the maximum acceleration that the hover engines can provide to the ship; i.e., it is the maximum braking force that the hover engines can provide. If this is < 0 it means the ship is too heavy to hover!

A NOTE ABOUT TIME ACCELERATION:

With a decent frame rate (~60 fps) you should be able to run the *DESCENT HOLD* autopilot at 100x in space and 10x in an atmosphere; you can even *AUTO-LAND* at up to ~80x time acceleration (the exact value depends on your frame rate rate). If you attempt to engage time acceleration at 1000x in space or 100x in at atmosphere, the autopilot will switch to *SUSPENDED* status (this will be shown on the MDA screen); it will automatically re-engage when you switch back to a lower time acceleration setting.

Airspeed Hold Autopilot

XR vessels include a highly accurate and efficient *AIRSPEED HOLD* autopilot that can hold a given airspeed to within 0.1 meter-per-second in atmospheric flight or while taxiing. It is MDA mode 0; use the MDA arrows and click the *Engage* button, or use **ALT-S** to engage/disengage it via the keyboard.



AIRSPEED HOLD Autopilot Engaged

You will notice there are four sets of *SET AIRSPEED* arrows labeled 25, 5, 1, and 0.1. Clicking these will adjust your set airspeed by 25, 5, 1, and 0.1 meter(s)-per-second, respectively. You can set any positive target velocity; however, depending on atmospheric drag and/or gravity the engines will not necessarily be able to reach the target airspeed. If the engines are unable to accelerate the ship any further a warning callout will sound.

Also notice the *HOLD CURRENT* and *RESET* buttons: *HOLD CURRENT* will set the target airspeed to your current airspeed, and RESET will reset the target airspeed to zero (i.e., the ship will "coast"). You can also use *NUMPAD_ENTER* to automatically engage *HOLD CURRENT*, *and NUMPAD** to reset the target airspeed to zero.

If the target airspeed is zero and you engage the *Airspeed Hold* autopilot, the system will automatically engage and hold your current airspeed.

Note that the autopilot will never apply RETRO thrust: this is a design decision in the interests of efficiency; *Airspeed Hold* is designed to be used in an atmosphere or while taxiing. However, you may engage it in a vacuum if you want to accelerate smoothly and precisely to the indicated speed -- provided that you are facing in the direction of the ship's velocity vector (i.e., *prograde*).

The shortcut keys to set the target airspeed are detailed in the *Custom Shortcut Keys* section earlier in this document; for example *CTRL-NUMPAD+* will increase the target airspeed by 25 m/s, *NUMPAD+* by itself will increase it by 5 m/s, *SHIFT-NUMPAD+* will increase it by 1 m/s, and *ALT-NUMPAD+* will increase it by 0.1 m/s (useful while taxiing). *NUMPAD-* performs the inverse of *NUMPAD+*. Refer to the *Custom Shortcut Keys* section earlier in this document for a detailed list of autopilot mode keys.

There are four values of interest displayed on the *Airspeed Hold* MDA screen:

AIRSPEED	Shows current airspeed in meters-per-second.
IMP	Shows current airspeed in Imperial miles-per-hour.
MAIN THRUST	Shows the current main engine thrust level from 0% to 100%.
MAIN MAXACC	Shows the maximum acceleration that the main engines can provide to the ship; if atmospheric drag and/or gravity drag is too high the engines will not be able to accelerate the ship any further and a warning callout will sound.

The *Airspeed Hold* autopilot will automatically disengage when you touch down, so you don't need to worry about disengaging it if you use it during final approach.

Airspeed Hold is particularly useful during final approach when landing in an atmosphere:

1. Set *Airspeed Hold* to maintain about 110-130 meters-per-second, depending on your ship's mass.

2. Fly the ship to a smooth touchdown on the runway without touching the throttle.

3. Apply the brakes by holding the **.** (period) and **,** (comma) keys.

A NOTE ABOUT TIME ACCELERATION:

You should be run the *Airspeed Hold* autopilot between 10x and 100x in an atmosphere, depending on your frame rate. If you attempt to engage time acceleration at > 100x the autopilot will switch to *SUSPENDED* status (this will be shown on the MDA screen); it will automatically re-engage when you switch back to a lower time acceleration setting.

EVA and Airlock Operations

XR vessels track their crew members and support astronaut EVAs via DanSteph's excellent *Universal MMU (UMmu)* add-on. It is possible for any ship using this add-on to perform EVAs and to transfer crew members to/from another ship that supports UMmu, even if the ships were written by different authors. Please refer to the UMmu documentation bundled with the UMmu add-on for details about operating an astronaut during EVA operations; this section details how to initiate EVAs and crew transfers with an XR vessel.

Note: UMmu stores crew member data in the scenario file; however, you may define each default crew member's name, age, rank, and 3D mesh by editing the [PASSENGER#] sections in your preference file. These defaults are only used if passenger data is not present in the scenario file; i.e., if the vessel was created dynamically via the scenario editor or another add-on.

Configuring an Astronaut Mesh

UMmu supports pluggable astronaut meshes for EVA, which means that you can use your own custom astronaut meshes for EVAs if you want to. In addition to the standard UMmu astronaut meshes, all XR vessels include four different high-polygon astronaut meshes developed by Greg Burch (used with permission): two male and two female astronaut meshes are included. You may configure which mesh to use for each of your crew members by editing your vessel's configuration file; refer to the comments in the file for details.

Note: the XR2 Ravenstar also includes two custom astronauts named Lee *and* Kara*; refer to the XR2RavenstarPrefs.cfg file for details.*

The 3D mesh defined for each crew member in your vessel's config file is linked to each crew member via the `XI#` "Misc ID" UMmu values stored with each crew member. For example:

```
UMMUCREW XI0-Michael_Samuel-37-72-68
UMMUCREW XI1-Nikita_Simone-29-72-68
```

Each crew member created by the XR vessel is stored with a prefix of "XI" followed by a number. This number is what links a given crew member to a given mesh defined in the configuration file. For example, XI0 links to [PASSENGER0], XI1 links to [PASSENGER1], etc. Therefore, any crew members who are added to the ship who do not have an "XI" UMmu misc ID prefix will use the default UMmu mesh. This naming scheme is necessary because UMmu does not track a crew member's mesh separately, and so the UMmu "Misc ID" field must be used.

Refer to the comments at the top of your vessel's config file for details about how to edit the default [PASSENGER#] settings.

Important: Note that although a crew member's *mesh* is always controlled via the config file, data about the crew members actually on-board (name, age, etc.) is stored *in each scenario file* when the scenario is saved and restored when the scenario is loaded. This is because crew members may enter or leave the ship at any time. Therefore, if crew member data is defined in a given scenario file, that data will override any values in your vessel's configuration file. If you want to "reset" the crew in a given scenario to the default crew members defined in your vessel's configuration file, edit your scenario file(s) and delete the following line:

```
XRUMMU_CREW_DATA_VALID 1
```

If that line is not present (or has a value of zero), it causes the ship to ignore any UMmu data in that scenario and re-load a default crew using crew values in the vessel's configuration file (e.g., `XR2RavenstarPrefs.cfg`).

Performing an EVA

XR5 Only:
The Vanguard includes a crew elevator as well as a docking port: both may be used for EVAs. Normally you will EVA via the crew elevator only when the ship is landed, but it is also useful to EVA via the crew elevator when the ship is docked to a station or another vessel (i.e., when the docking port is occupied). To select which EVA port is active, use the switch on the upper panel:

XR5 Vanguard's Crew and EVA Display on the Upper Panel

All XR Vessels:
Perform the following steps to conduct an EVA:

Note: in reality you would first open the inner airlock door and send your EVA astronauts into the airlock before performing these steps; however, in the interests of playability XR vessels do not require (enforce) this because it can become tedious when performing multiple EVAs.

1. Switch to the upper panel (*CTRL-UP*).

2. Turn on the APU if it is not running; the APU must be running to power the airlock doors and the docking port or crew elevator.

3. *XR5 only:* Select either *Docking Port* or *Crew Elevator* via the *Active EVA Port* switch: only one of the two may be active for ingress/egress at one time.

4. *XR5 only:* If deploying via the elevator, deploy the crew elevator via CTRL-E or the switch on the upper panel and skip to step 8. Otherwise, continue to the next step.

5. Close the inner and outer airlock doors and deploy the docking port / open the nosecone (CTRL-K, or use the switch on the upper panel).

6. Depressurize the airlock chamber with the switch on the upper panel; wait until the airlock is complete depressurized. It is now safe to open the outer airlock door.

XR5 Vanguard Airlock Controls on the Upper Panel

7. Open the outer airlock door with the switch on the upper panel.

A note regarding the OVERRIDE INTERLOCK button: since it is dangerous to open the outer airlock door when there is a pressure differential between the airlock chamber and the external atmosphere (or lack thereof), the computer locks one or both of the airlock doors whenever a pressure mismatch is detected. However, you may override this safety via the OVERRIDE INTERLOCK button; once that is armed, the outer door and/or inner doors may be opened even if there is a pressure mismatch.

WARNING: you could decompress the ship and kill the crew if you accidentally open both airlock doors to vacuum! Therefore, it is recommended that the OVERRIDE INTERLOCK buttons remain <u>disarmed</u> (off).

The same principles and warnings apply to the Crew Hatch OVERRIDE INTERLOCK button.

8. Using the EVA touch-screen display, select the crew member you want to EVA and touch the *EVA* button.

XR5 Vanguard's EVA Touch-Screen Display

9. Repeat Step 8 for any additional crew members you want to EVA.

Warning: do not EVA your <u>last</u> crew member or there will be no one left on board to pilot the ship! This would be a dangerous thing to do on-orbit!

If you *do* EVA your final crew member, however, one of the crew can still reenter the ship and pilot it. Note that any one of your crew can pilot the XR vessel -- it does necessarily not have to be the Commander. This behavior is by design in order to enhance playability. However, you may configure the ship to require that only the pilot or co-pilot may pilot the ship by setting `RequirePilotForShipControl=1` in your ship's config file.

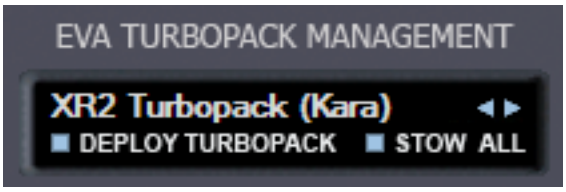
Reentering the Ship after an EVA is Complete

These instructions are specific to UMmu and are detailed in the Universal Mmu Documentation; however, as of this writing all you need to do is maneuver the astronaut within one meter of the open airlock (or crew elevator, if that is active) and press 'E' to reenter the ship.

Turbopack Management

XR vessels include UMmu *turbopacks* on-board. Turbopacks may be used by astronauts on EVA to perform short-distance flights while outside the ship. For full details about turbopacks and how to operate them, refer to the UMmu documentation. As of this writing, however, you can place a turbopack on your astronaut's back by maneuvering up to it and pressing 'B' to attach the turbopack to your back. Press 'B' again to drop the turbopack.

To deploy a turbopack, you must have the airlock and outer airlock door configured the same as for an EVA. The reason is that an astronaut must ingress/egress the ship in order to deploy or stow a turbopack.



Turbopack Management Screen on the XR2's Lower Panel

To deploy or stow a turbopack:

1. Open the nosecone/crew elevator/docking port.

2. Switch to the lower panel and locate the *Eva Turbopack Management* screen on the lower-left.

3. For ships that support multiple turbopack types (e.g., the XR2), select the desired turbopack to deploy via the blue arrows.

4. Click the blue *Deploy Turbopack* block to deploy the selected turbopack; it will appear a few meters forward of the active EVA port.

5. To stow all turbopacks near the ship (even those currently attached to an EVA crew member), click the blue *Stow All* block. All turbopacks in range (about 25 meters) will be stowed inside the ship.

Kara Wearing her XR2 Turbopack at Brighton Beach

Transferring Crew Members While Docked

UMmu supports direct crew member transfers while docked to another UMmu-enabled vessel. To transfer a crew member to a docked vessel, simply open the outer airlock doors on both ships and use the EVA button as you normally would; the crew member will be transferred to the other ship -- provided there is room on board! Note that you do not need to open the inner airlock door; it is assumed that the transferring crew member will automatically open or close that door himself as necessary. (Of course, in the interests of realism you are still free to open the inner airlock doors if you want to.)

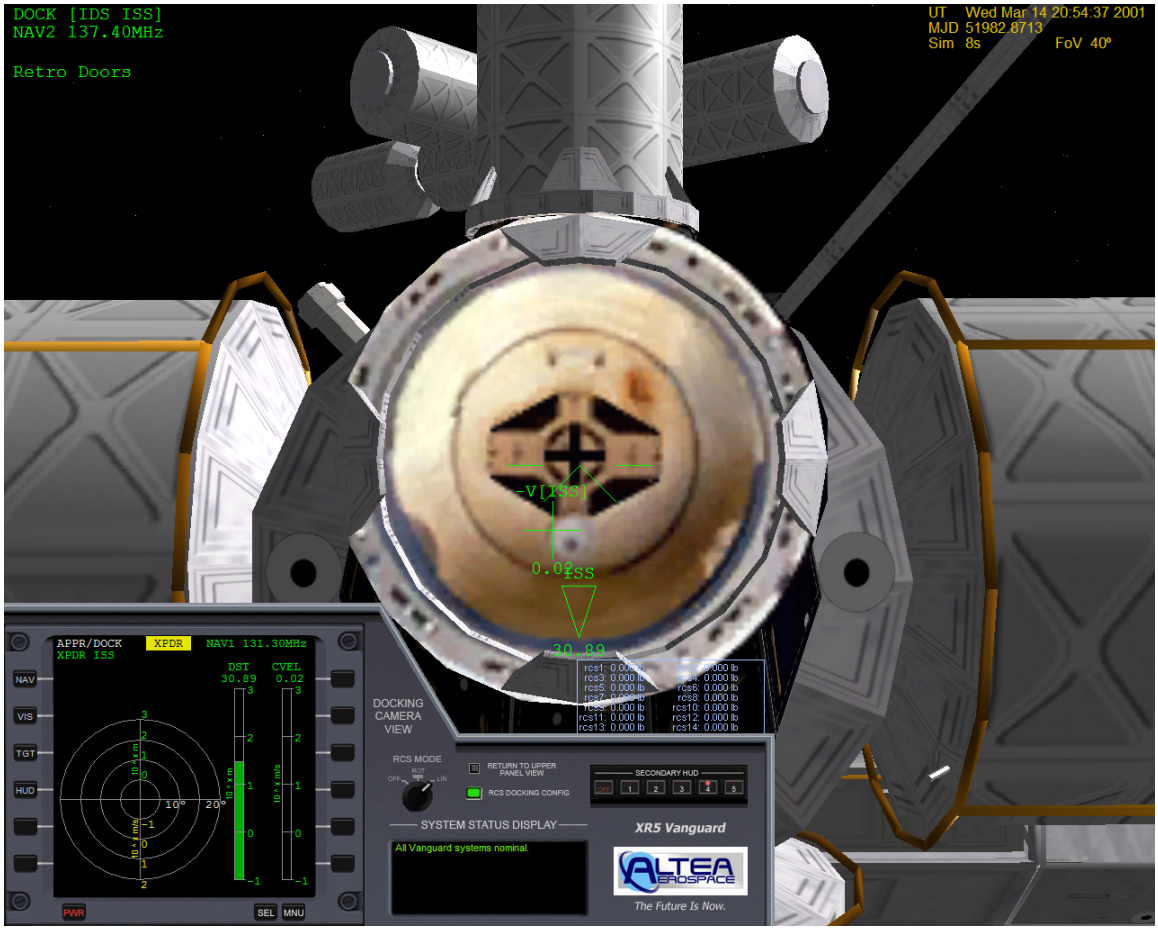
WARNING: unless you are docked in the atmosphere, *remember to close the outer airlock doors on both ships before undocking!* If both the inner and outer airlock doors are open, violent decompression will result and kill the crew!

Bailing Out During an Emergency

If you EVA the crew while in atmospheric flight, the crew will bail out and their parachutes will auto-deploy. Note that you only have two hours of air available, so be careful where you bail out!

Using the Docking Camera (XR5 Only)

The Vanguard features a *docking camera and instrument panel* that makes docking with stations and other vessels much easier than it is for other Orbiter vessels with a top-mounted docking port. Here is a screenshot of the docking camera view with the Vanguard on final docking approach to the ISS:



Docking Camera View of Final Approach to the ISS

You can access the docking panel by pressing CTRL-UP from the upper panel view (i.e., press CTRL-UP *twice* from the main panel), or you can use the *Switch to Docking Camera View* button on the upper panel. The docking camera is mounted directly along the centerline of the Vanguard's docking port.

In addition to the docking camera, the Vanguard can switch the RCS jets into *docking configuration*. This is controlled via the *RCS Docking Config* button/light on the main panel and the docking camera panel, or you can use the ALT-J hotkey. Clicking the button toggles the RCS configuration between *Normal* and *Docking* modes: in normal mode the RCS jets operate normally. In *docking* mode, however, two changes occur: 1) power to the RCS jets is reduced to 40% of normal to allow for precise control of the ship while docking, and 2) the control axes for the RCS jets are switched so that when you are looking along the docking port centerline camera you can use the RCS Rotation and Translation keys just as though you were looking along the *nosecone* with a *nosecone* docking port; i.e., it will feel "normal." For example, pressing NUMPAD6 in translation mode will move the ship forward along the Z axis in *normal* RCS mode, but it will move the ship up along the Y axis in *docking* RCS mode.

As you approach the docking port you have tuned in your docking MFD you will hear distance callouts from the computer as you approach. After docking port contact you may open your inner and outer airlock doors to use the station's oxygen supply in order to conserve onboard oxygen if you wish. If you want to EVA the crew, you can use the crew elevator and take a spacewalk around the station. Refer to the chapter titled *Performing an EVA* for details.

Payload Management (XR2/XR5 Only)

The XR2 Ravenstar and XR5 Vanguard feature cutting-edge payload support that makes it easy (and fun!) to transport cargo from one place to another in the solar system. The XR5 Vanguard is designed to carry up to 432,000 kg (432 metric tons) of payload, and while the XR2 Ravenstar is primarily designed as a "luxury Learjet" craft, it can carry up to 10.8 metric tons of cargo. It is possible to carry a heavier payload, but that would exceed the vessel's maximum rated load and so it is not recommended.

To display the payload camera/instrument panel view, press CTRL-LEFT from the upper panel view or use the *Switch to Payload Camera View* button on the upper panel. Once you are in the payload camera view you may switch back to the upper panel via the *Return to Upper Panel View* button on the left side, or you may press one of the following hotkeys:

- CTRL-UP = Switch to Docking Camera view (XR5 only)
- CTRL-RIGHT = Switch to Upper Panel view
- CTRL-DOWN = Switch to Main Panel view

Any Orbiter vessel/payload module that can fit in the XR vessel's payload bay can be latched into the bay, transported, and deployed either in orbit or while landed at a surface base (or anywhere else you land).

XR5 Vanguard Only:

For the Vanguard, payload is managed by attaching cargo modules into one or more of the Vanguard's 36 bay slots, each of which is the size of a standard shipping container: 2.43 meters wide (X), 2.59 meters high (Y), and 6.09 meters long (Z). When a cargo module is attached in the bay it occupies one or more bay slots depending on its size. For example, if a cargo module is 3.0 meters wide it will occupy two bay slots *across* in the bay (X dimension) because it is wider than a single slot (2.4 meters). The only exceptions to this are the center slots in the Vanguard's bay: they are slightly wider than standard bay slots, and measure 3.65 meters wide instead of 2.43 meters wide. With our example here, a payload module that is 3.0 meters wide would only occupy *one* center slot, but *two* normal slots (assuming the payload module is less than or equal to one slot in length [Z dimension], of course).

The Vanguard has a total of 36 bay slots across a total of three levels in the bay: level one contains 20 slots, level two contains 12 slots, and level three contains 4 slots.

A good scenario to use to see how payload management works is the *In Orbit With Payload* scenario in the *XR5 Vanguard* scenario folder.

XR2 Ravenstar Only:

The XR2 includes three payload bay slots: the forward slot (slot #1) is designed to carry the CHM (*Crew Habitat Module*), which contains living space for the crew. The two aft slots (2 & 3) are the same size and are designed primarily to carry auxiliary main fuel/SCRAM fuel/LOX, although other custom payloads may be attached as well.

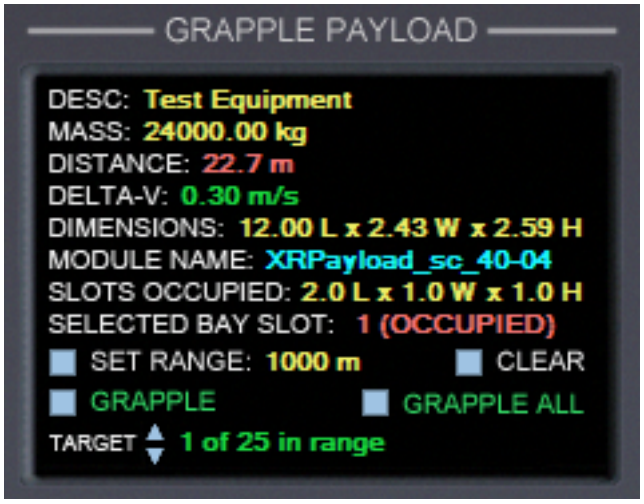
Slot #1's dimensions are 3.452 meters wide (X), 2.418 meters high (Y), and 2.060 meters long (Z). This is designed to carry the CHM; other payloads are not recommended because then the crew would have very limited living space.

Slot #2 and #3 are 3.452 meters wide (X), 2.128 meters high (Y), and 1.454 meters long (Z).

Note that all XR payloads are interchangeable between different ships *provided* that the payload will fit in the bay.

Grappling Payloads

The XR payload management system makes it easy to load or unload cargo modules in orbit or while landed. To grapple ("load") an existing cargo module, you must first select a grapple target that is within a certain distance of your ship. To do that, you should first refer to the *Grapple Payload* touch-screen: you will see a *Set Range* button and a value in meters. This setting determines the maximum range that payload will be shown in the *Target* list just below the button. The default is 50 meters, but you may step through different ranges to make it easier to find your desired payload module by filtering out payload modules that are farther away. Next, click on the blue *Target* up/down arrows to step through all cargo modules in range: the targeted module's information will be displayed on the screen and its thumbnail will be displayed on the *Target Payload* screen on the right.



Grapple Payload Touch-Screen

Once you find the module you want to grapple you need to select an empty bay slot into which the payload will be attached: click on a square in the *Select Bay Slot* touch-screen. For the Vanguard, you may switch between payload bay slot levels (1-3) by clicking the *LEVEL* button on the bottom of the touch screen.

XR5 Vanguard's Select Bay Slot Touch-Screen

Bay slot block border colors are as follows:

Block Border Color	**Indicates**
Orange	The selected slot is occupied.
Cyan	The selected slot is empty.
Green	Unselected slot is occupied, and a payload module is attached in that slot. This is also called the *primary* slot for the occupying payload module, since it is the slot

	into which the payload module was originally attached.
Gray	Unselected Slot is occupied, but the payload module occupying it is attached in an adjacent slot. Gray slots cannot be selected: to deploy payload that is occupying a gray slot you must select that payload's *primary* slot instead (which will be green).

Once you have selected a free slot and you have maneuvered within grappling range of your targeted module you are ready to grapple the payload into the bay. In order to grapple your targeted module, however, the following conditions must be met:

1. The module must be within grappling range, which by default is about 22.0 meters[3] from the center of the vessel to the center of the payload module while in orbit, or 400 meters[4] while landed.

2. The ship must be within 0.5 meter-per-second delta-V to the cargo module.

3. You must have selected an empty bay slot that has enough free slots surrounding it for the module to fit (if the module is larger than one slot).

If you click the *GRAPPLE* button and any of the above conditions are not met, an error callout will occur and a detailed error message will be displayed. Note that you can also use the *GRAPPLE ALL* button to automatically grapple all targets in range into the bay, starting at the lowest free slot number and working upwards. The largest payloads in range are automatically grappled *first* in order to make the most efficient use of space.

You may also use the ALT-G hotkey to grapple a single target or CTRL-ALT-G to *grapple all*.

Once the target is grappled you will see your ship's mass increase accordingly, and the selected bay slot will automatically increment to the next-higher free slot. This allows you to quickly grapple successive modules without having to keep selecting another free slot. This is particularly useful if you are in an external view and are using the ALT-G hotkey to grapple cargo while landed.

Note that the grappling procedure is the same whether you are in orbit or landed.

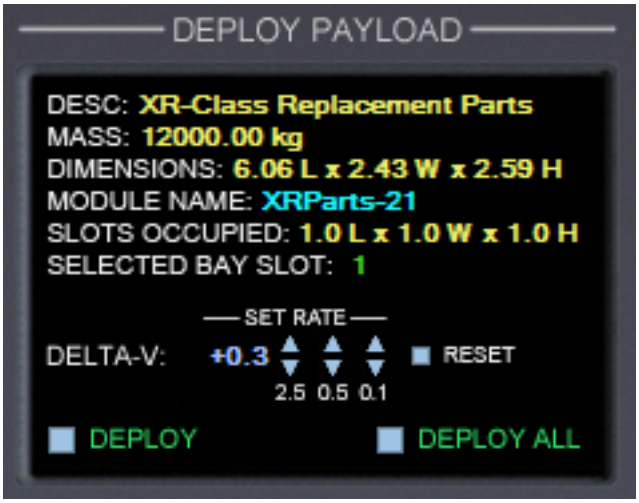
If you grapple a consumables tank (main fuel/SCRAM fuel/LOX) your ship's consumables gauges will reflect the updated quantity. Remember that bay tanks drain *first* and fill *last*. For more information, refer back to the section titled *Using Payload Bay Fuel/LOX Tanks*.

[3] The maximum grapple distance while in orbit may be altered by setting the `PayloadGrappleRangeOrbit` CHEATCODE setting in your vessel's configuration file (e.g., `XR5VanguardPrefs.cfg`).
[4] The maximum grapple distance while landed may be altered by setting the `PayloadGrappleRangeLanded` CHEATCODE setting in your vessel's configuration file (e.g., `XR5VanguardPrefs.cfg`).

Deploying Payloads

Deploying a payload that is attached in the bay is, for the most part, the reverse of grappling a payload. You must first select a bay slot that contains the cargo module you want to deploy: this slot will be green before you select it and will turn orange when you click on it. As before, use the *LEVEL* button (if applicable) on the *Select Bay Slot* touch-screen to select the bay level of your target payload, then click the bay slot itself to select it.

The *Deploy Payload* touch-screen will display details about the attached payload you have selected (i.e., the payload slot that is highlighted in orange on the *Select Bay Slot* screen). If you are in orbit the touch-screen will display a delta-V setting and arrows as shown below:

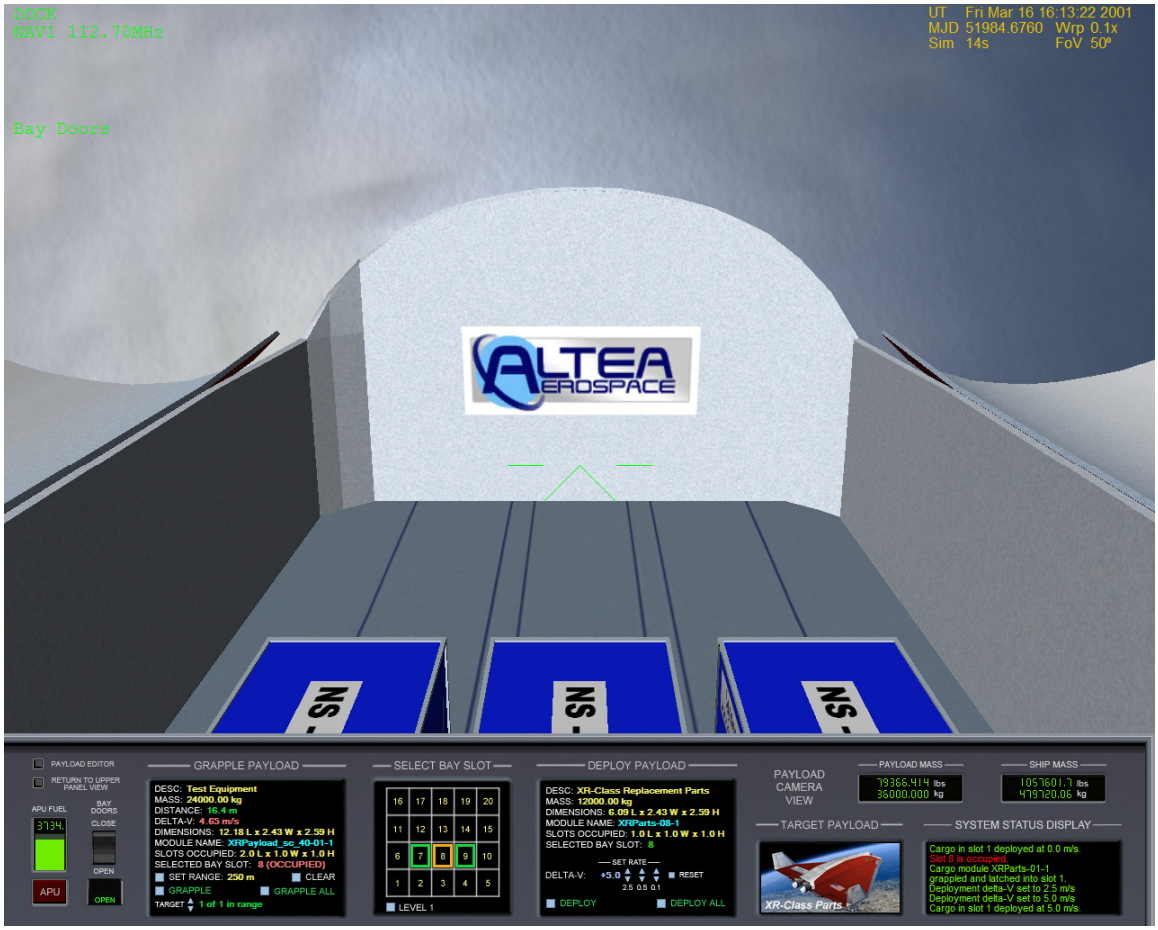


Deploy Payload Screen in Orbit

In addition, your selected payload's thumbnail will be displayed on the *Target Payload* screen.

Before you click *DEPLOY* to deploy your selected payload you should first set your desired *delta-V* for it: this is the velocity at which the payload module will be "pushed away from the ship." The default value is 0.2 meter-per-second, which should be fine in most cases. As with other XR-class touch screens, in addition to clicking the delta-V arrows you can also *hold down your mouse button* on the arrows to change the values quickly. Click *Reset* to reset the delta-V to zero.

Once you have set your desired delta-V, press *DEPLOY* to deploy your selected payload module at the requested delta-V. (You may also use the ALT-U hotkey to deploy the selected module). As it is deployed you will see your ship's mass decrease accordingly. If you want to deploy *everything in the bay simultaneously* using the same delta-V, use the *DEPLOY ALL* button or press the CTRL-ALT-U hotkey.

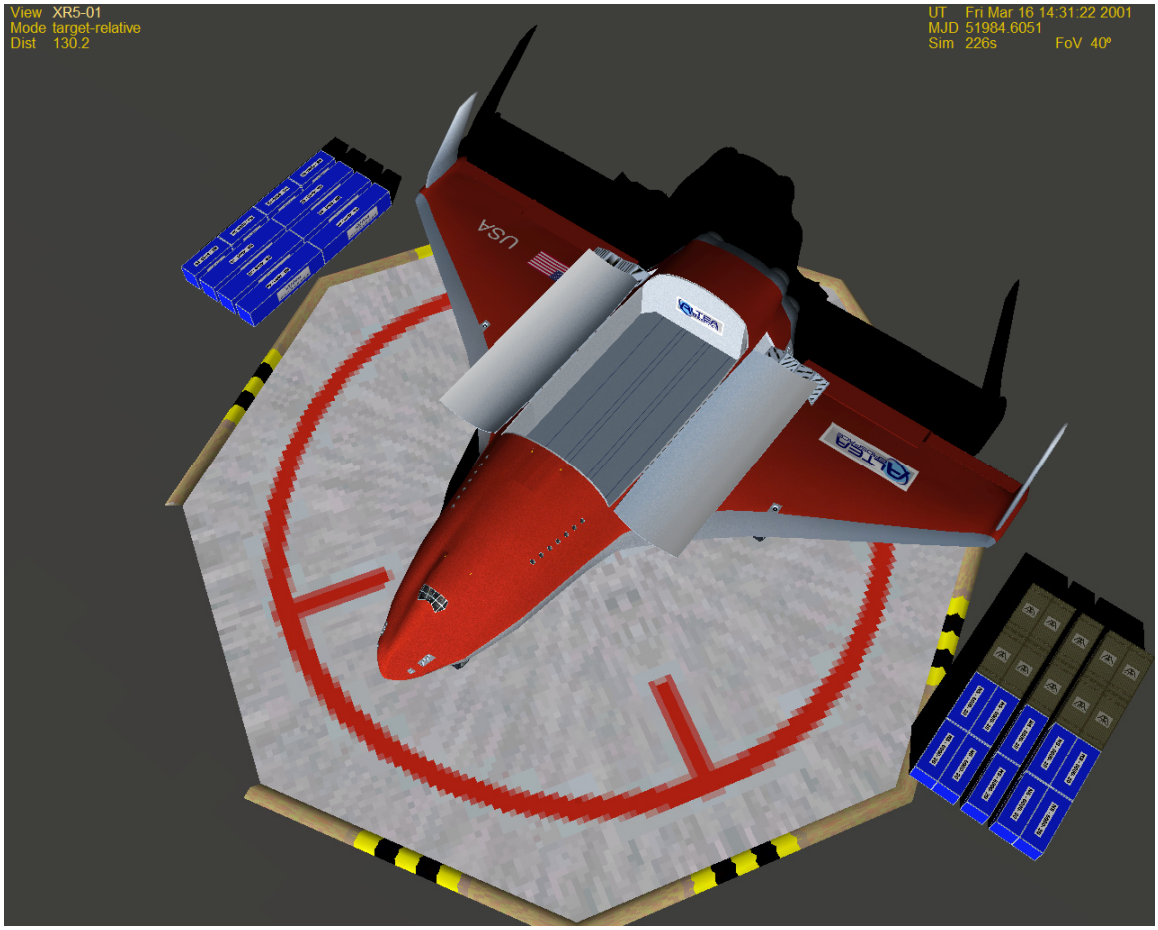


XR5 Vanguard Payload Camera View with both Deploy and Grapple Targets Selected

Note: in the interests of playability, the ship allows you to deploy cargo from any slot even if there is cargo in a slot above it, "blocking" it. This was a design decision so that it would not be tedious to deploy a cargo first that you accidentally grappled into a level-one slot before you launched. You are still free, of course, to always deploy top-level cargo modules first so that lower-level modules will not be "blocked", but in the interests of playability XR vessels do not enforce this.

Deploying payload modules while landed is exactly the same as deploying in orbit *except* that there is no delta-V component: the payload in each slot is automatically deployed to a fixed location adjacent to the ship based on its slot location. The ship-relative coordinates to which the payload will be unloaded (i.e., "deployed") are shown on the screen in place of the delta-V selection arrows.

Here is a screenshot showing a full payload bay deployed (i.e., unloaded) at Brighton Beach on the Moon:



XR5 Full Payload Bay Unloaded at Brighton Beach on the Moon

A Note Regarding Payload Mass

Your vessel's total mass is continuously updated each frame by scanning the total mass of each payload module/vessel attached in the payload bay and adding it to the normal vessel mass. This means, for example, that if you have any payload modules attached in the bay that are venting mass or burning consumables (like a bay fuel tank) you will see that reflected in real-time on the Payload Mass *and* Ship Mass *displays. i.e., if any of your cargos' masses change, it will be reflected in real-time by the XR vessel as well.*

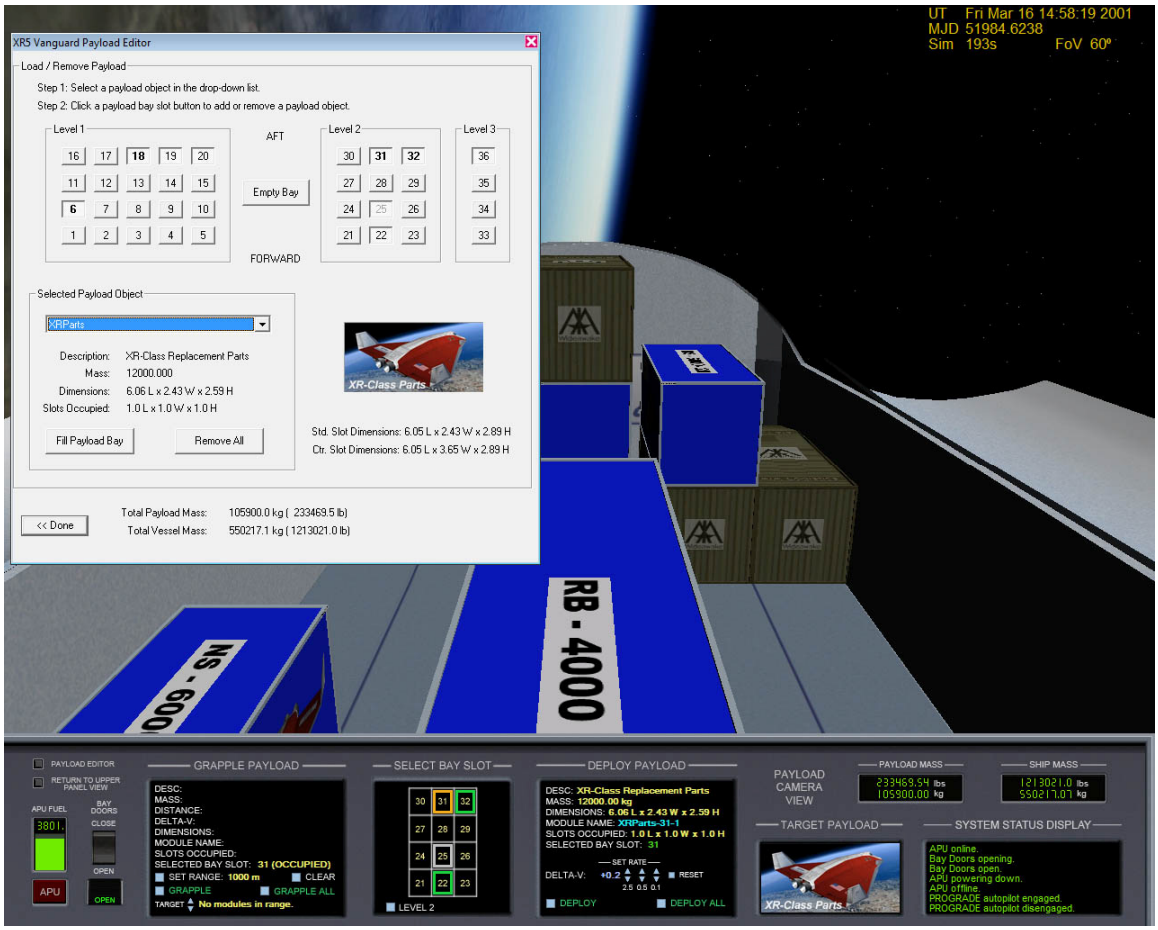
Using the Payload Editor

XR vessels make it easy to create/delete cargo modules via the Payload Editor dialog; this is useful for creating new scenarios where you want to start with cargo in the bay, or where you want to change the cargo that is in your bay at any time. Note that you do not need to use the payload editor in order to grapple or unload

cargo: is only necessary if you want to *create new* payload modules in the bay or *delete existing* payload modules from the bay.

You may bring up the Payload Editor via Orbiter's scenario editor (CTRL-F4 -> Scenario Editor -> Edit -> Payload Editor), the *Payload Editor* button on the payload panel, or you can use the ALT-B hotkey to toggle the Payload Editor dialog on/off. Note that your mouse cursor must be *off the dialog* in order for the ALT-B hotkey to *close* the window again: the reason is that the Orbiter core traps keystrokes sent to child dialogs, and so ALT-B can only work if the main Orbiter window has the focus. Alternatively, you can instead click the "<< Done" button to close the Payload Editor dialog.

Below is a screenshot of the Vanguard's payload panel with the Payload Editor dialog displayed.



XR5's Payload Bay Camera and Instrument Panel View with the Payload Editor Displayed.

When you bring up the editor, notice the *Selected Payload Object* drop-down list. This list contains all of the XR-payload-enabled cargo modules installed in Orbiter's `Config\Vessel` directory. When you select a module type, its description, mass,

dimensions, and number of slots occupied are displayed right below its type name, and a thumbnail bitmap is displayed in the right. Some XR cargo modules may not have a custom thumbnail defined, in which case a default *Altea Aerospace* thumbnail will be displayed.

Also, when you select a module type any existing modules of that type that are attached in the bay are highlighted in bold. Click on a slot number in the dialog to add or remove a module from that bay slot. If the module will not fit in the bay slot, an error beep will sound.

Notice in the screenshot above that some of the slot buttons are disabled: that indicates that the slot is occupied by a cargo module that is attached in an *adjacent* slot and the cargo module is too big to fit into a single slot. Note that the Vanguard's centerline slots in the bay are slightly wider than the normal bay slots, so there may be certain payload modules that occupy *two* normal slots but only *one* centerline slot.

Creating Your Own Payload Module

An XR-class payload-capable ship can carry *any vessel or module in Orbiter that can fit in its cargo bay*. All this is required to make an existing Orbiter vessel or cargo module compatible with all XR-class vessels are a few additional lines in the vessel's configuration file. Note that most users will not need to read this section or deal with custom cargo modules: this section is intended for use by developers who want to create their own custom cargo modules or modify existing cargo modules or vessels to be compatible with XR-class payload systems.

When Orbiter loads and the first XR ship instance is created, it scans the `C:\Orbiter\Config\Vessels` directory and parses all *.cfg files in it. Each .cfg file that is compatible with the XR Payload System is parsed and cached in a static, shared, vessel-wide cache for efficiency: scanning and parsing many configuration files is relatively expensive, and therefore the files are only scanned and parsed *once* for each XR vessel class. This means that if you install a new cargo module while Orbiter is running (which is unlikely anyway) you will need to bounce Orbiter before XR vessels can see it; in practical terms, however, this limitation is a non-issue.

The best way to create your own custom payload modules is to view an existing XR payload module's data section, copy it to your *new* module's .cfg file, and modify it as necessary. Below is a sample XR-payload-enabled vessel file named *XRParts.cfg;* this is installed with the Vanguard distribution to `C:\Orbiter\Config\Vessels\XRParts.cfg`. Other payload-enabled XR vessels include their own payload modules as well. Read the detailed comments in the payload .cfg file for instructions on how to create your own payload modules.

```
; === Configuration file for standard 20-ft XR Payload Cargo container
===
; Copyright 2007 Douglas Beachy
```

```
; http://www.dougsorbiterpage.com
;*****************************************************************
**************
; NOTE: the vessel's 'ClassName' *must match the name of the config
file* so that
; the XR vessels can locate the .cfg file in Orbiter's config directory
in order to
; parse the XR-payload-specfic data in it.
; For example, XRParts.cfg must contain 'ClassName=XRParts'.
;*****************************************************************
**************
ClassName = XRParts
MeshName = XRPayload\XRParts
Size = 3.867
Mass = 12000 ; empty mass [kg] (max mass each for full load of 36
containers)
MaxFuel = 0  ; max fuel mass [kg]
Isp = 0        ; fuel specific impulse [m/s]
MaxMainThrust = 0
MaxRetroThrust = 0
MaxHoverThrust = 0
MaxAttitudeThrust = 0
CameraOffset = 0.0 .0 0.0
CW = 0.194 0.189 0.470
LiftFactor = 0.0
CrossSections = 7.060448  7.060448  14.769404
EnableFocus = true
TouchdownPoints = 0 -1.296 3.024  -1.217 -1.296 -3.024    1.217 -1.296
-3.024

;-------------------------------------------------
; XR Payload custom parameters
;-------------------------------------------------

; REQUIRED: must be set to 'true' for this vessel to be dockable in an
XR-class payload bay.
XRPayloadEnabled = true

; cosmetic description; 127 chars MAX., but 40 chars or less
recommended
Description = XR-Class Replacement Parts

; Dimensions in meters: X (width) Y (height) Z(length).  This also
determines how many standard payload slots are occupied.
Dimensions = 2.43 2.59 6.09

; attachment point index (0-n) that should be used for grappling in the
bay; default=0
AttachmentPointIndex = 0

; (OPTIONAL) Offset in meters from the center of the primary payload
slot to the center of this payload's mass (X,Y,Z).
; If this is not set, the default is [0 0 0].  These coordinates are
necessary so that the collision detection code can know the
; origin point (the "centerpoint") of the payload mass in order to
determine how many slots this payload module will occupy.
```

```
; If you adjust your attachment point coordinates to center this module
in its primary payload slot, these coordinates
; should be [0 0 0] (the default).  If your payload  is attached off-
center in the slot along any axis, as will be the case
; if your payload occupies more than one slot, you will need to adjust
these coordinates accordingly.
; For example, if your payload's center-of-mass is 0.3 meter below the
centerpoint of its primary slot, this
; value should be 0 -0.3 0.  As another example, if your payload is two
slots long, one slot wide, and one slot high,
; this value should  be set to 0 0 -3.048: the reason is that the
center-of-mass of a 40-foot-long container is 3.048 meters
; (1/2 slot) AFT of the ceterpoint of the primary slot (the forward of
the two slots it occupies).
PrimarySlotCenterOfMassOffset = 0 0 0

; (OPTIONAL) If this is not specified, a default thumbnail is used.
; Path relative to Orbiter config directory (e.g., "C:\Orbiter\Config")
to the bitmap thumbnail image for this payload.
; This is displayed on the payload panel when this cargo is selected.
; This should point to a 24-bit-color bitmap that is 154x77 pixels in
size.
; NOTE: do not use pure white (255,255,255) in your custom thumbnail
bitmaps because that color is rendered
; as transparent when a bitmap is rendered on the panel.
ThumbnailPath = Vessels\XR1_Spare_Parts_Thumbnail.bmp

; (OPTIONAL): List of Orbiter vessel classnames for which an
'ExplicitAttachmentSlots' property is defined.
; VesselsWithExplicitAttachmentSlotsDefined = XR5Vanguard

; (OPTIONAL): These are optional parameters that only need to be
defined for a given ship class if you have a
; large or specially-shaped payload.  If no explicit attachment slots
are defined, the ship will compute
; which slots are valid for this payload based on its dimensions and
the location of its attachment point.
; If explicit attachment points *are* defined here they will override
any calculations made by
; the ship as to whether this object will fit in the bay when attached
to a given slot.  However,
; they do *not* override checks as to whether this object will fit
alongside *other payload* in the
; cargo bay.  Most payload objects will not need to define this value.
;
; Format is: <parent vessel classname>_ExplicitAttachmentSlots = # # #
...
;XR5Vanguard_ExplicitAttachmentSlots = 3 8 13 18 22 25 28 31 33 34 35
36  ; center slots on all three levels only for testing

; (OPTIONAL) Defines a delta to be applied to this vessel when it is
deployed on the ground.  This is useful
; when the payload vessel defines touchdown points that are below the
ground when the vessel is deployed.
; For example, '0.0 2.0 0.0' would deploy the vessel to 2.0 meters
*higher* than normal when this payload
; is deployed while landed.
```

```
;GroundDeploymentAdjustment = 0 0 0

;--------------------------------------------------

; === Attachment specs ===
; NOTE: a payload object's attachment point should be set for the
CENTER of the bay slot into which it is
; attached.  Each standard slot is exactly 2.4384 wide (X), 2.5908 high
(Y), 6.096 long (Z).  Some XR-class
; ships, such as the XR5 Vanguard, have some slots that are wider as
well.
; WARNING: attachment *direction* must be (0 1 0) and attachment
*rotation* must be (0 0 1)!  The bay
; collision detection code expects this.
; Note: only *one* BEGIN_ATTACHMENT/END_ATTACHMENT block may be present
in any vessel's .cfg file.
; If you have multiple attachment points, you must declare them all in
a single block.
BEGIN_ATTACHMENT
P 0 0 0   0 1 0   0 0 1   XRCARGO
END_ATTACHMENT
```

Publishing Your Payload Module

After you have created your new payload module and tested it, please consider publishing it to make it available for other XR pilots as well. If want to host your new payload module on your own Web site, I would be happy to link to your page from the *Payload* section on my Web page at http://www.dougsorbiterpage.com. If you prefer, I would also be happy to host your new payload module on my Web page, crediting you as the author. If you would like me to link to your page or host your payload on my page, please drop me an email at dougb@dougsorbiterpage.com.

XR2-01_Bay/XR5-01_Bay Vessel Saved in Scenario Files

A note regarding the XR2-01_Bay/XR5-01_Bay vessels you will see in saved Ravenstar and Vanguard scenarios: this is an invisible phantom vessel attached behind the XR vessel's payload bay to force Orbiter to render the payload bay even when no cargo is present. If you delete the vessel from the scenario file no harm is done: the XR vessel will recreate it automatically when the scenario loads. Do not delete the phantom vessel in-game, however, or the cargo bay will no longer be rendered in the payload camera view unless there is at least one payload module in close proximity to the bay. This is an Orbiter core limitation.

Installing and Using a Custom Skin

XR vessels support any number of custom skins so long as each skin installed to its own subdirectory under %*ORBITER_ROOT*%`\Textures\{SHIPNAME}>\Skins`. If the custom skin was created with an XR Skin Pack, you should be able to install the skin simply by unzipping the skin's zip file into your Orbiter root directory; refer to the `readme.txt` file in the skin's zip file for details.

If you want to create a new custom skin for your favorite vessel you should download corresponding XR vessel's paint kit available on my Orbiter page (http://www.dougsorbiterpage.com). It contains detailed instructions on how to create, test, and release your new skin; it also contains the default vessel exterior textures in PSD and BMP format that you can use as a starting point.

More information is available in the paint kits, but for example, to install your own Vanguard custom skin, deploy your custom texture files to a new `C:\Orbiter\Textures\XR5Vanguard\Skins\Foobar` directory. Once the files are installed, set the skin directory name in the scenario file as follows:

SKIN **Foobar**

…where **Foobar** is the directory name under `C:\Orbiter\Textures\XR5Vanguard\Skins`; e.g., `C:\Orbiter\Textures\XR5Vanguard\Skins\Foobar\`. Each Vanguard ship defined in the scenario may use a different or the same skin. If the *SKIN* property is not set, the default skin is used.

Submitting a Feature Request or Bug Report

Before submitting a bug report, please check my Web page for updates and other information: http://www.dougsorbiterpage.com It is possible that a newer version of the ship is available, and I can only work on bugs that are present in the latest ship version.

If you have a question about an XR vessel, please post your request to the Orbiter *Addon Support and Bugs* forum here:
http://orbiter-forum.com/forumdisplay.php?f=51

NOTE: if you are defining any [CHEATCODE] values in your vessel's config file it is quite possible that one of your CHEATCODE values is causing the problem; please re-test the problem after commenting out all [CHEATCODE] values.

If the bug is a simple typo in the documentation or something trivial like that, please email me directly at dougb@dougsorbiterpage.com.

For non-trivial bugs please write up a bug report as specified below and post it to the Orbiter *Addon Support and Bugs* forum here:
http://orbiter-forum.com/forumdisplay.php?f=51

Please include the following information in your bug report:

1. The XR vessel name and version you are using; this can be found in your `C:\Orbiter\SHIPNAME.log (e.g., XR5Vanguard.log)` file.

2. The Orbiter version you are using.

3. Whether the bug occurs in a clean Orbiter installation (i.e., with only *Orbiter*, *OrbiterSound*, *UMmu*, and the *XR vessel* installed). Your bug is more likely to be fixed (or at least fixed *sooner*) if the problem occurs in a clean Orbiter installation.

4. The exact steps to reproduce the bug. If the bug is not reproducible, please be as specific as possible about what you were doing when the bug occurred. Note that if a bug is reproducible it is more likely to be fixed.

5. The complete contents of a scenario file to reproduce the bug. Remember to enclose your scenario file text in **[code]** and **[/code]** tags when constructing your post on the Orbiter forum.

You may reach me on the Orbiter forums as dbeachy1.

Appendix A: Notes

- *Altea* in *Altea Aerospace* is pronounced ***all-TEE-uh***.

- For a more realistic challenge, edit your ship's config file and make the following change:

    - **MainFuelISP=1** (sets main fuel burn rate to REALISTIC – suitable for ISS or LEO only)

- If you are an expert pilot and looking for a real challenge, make the following changes:

    - **MainFuelISP=0** (sets main fuel burn rate to EXPERT – ISS Only w/expert use of SCRAM engines and expert deorbit/landing)
    - **APUFuelBurnRate=5** (sets APU fuel burn rate to EXPERT)

  Now take off using the default *Ready for takeoff to ISS* scenario, dock with the ISS, and deorbit to KSC. If you fly it perfectly you should be able to land back at KSC without refueling. Good luck!

- You may alter or even delete any of an XR vessel's custom speech callouts and sound effects by editing or deleting the wav files in the `C:\Orbiter\Sound\SHIPNAME` (e.g., `XR5Vanguard`) directory: if a callout or sound effect is missing it is simply not played – it is not an error. This allows pilots to change or remove any callouts or sound effects they don't like. Note that you may also enable/disable different types of callouts by editing your ship's configuration file.

Appendix B: Technical Data

Note: engine thrust data assumes the vessel is configured for Realistic *(the default) settings in the configuration file.*

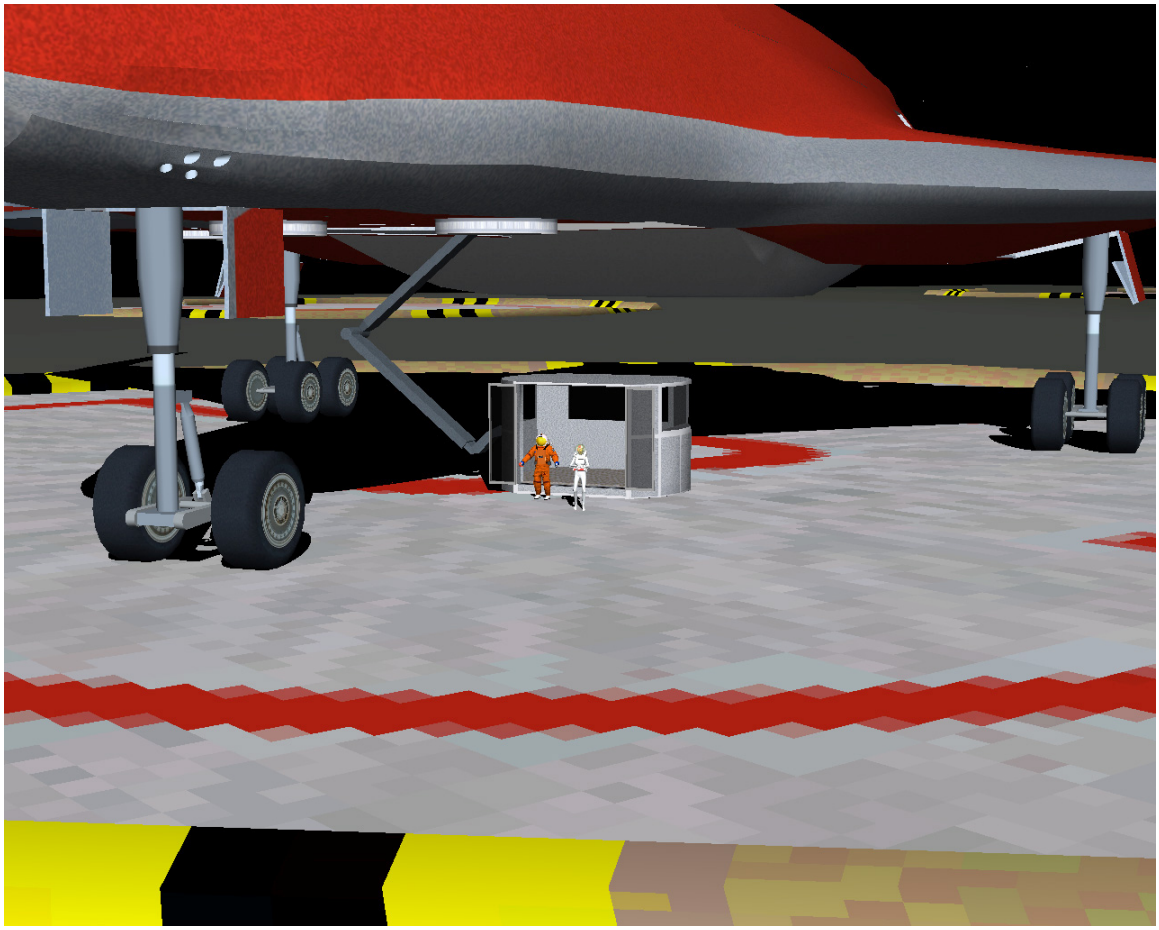
XR Technical Specifications

Description	DG-XR1	XR2 Ravenstar	XR5 Vanguard
Max positive wing load	17000 N/m^2	17000 N/m^2	17000 N/m^2
Max negative wing load	11000 N/m^2	11000 N/m^2	11000 N/m^2
Max dynamic pressure (absolute)	150 kPa	150 kPa	150 kPa
Landing Gear Energy Absorption Limit	8.04e+4 kg m/s^2	1.29e+5 kg m/s^2	2.57e+6 kg m/s^2
Max touchdown descent rate, max load (full fuel, full cargo)	3.1 m/s	2.8 m/s	2.6 m/s
Max touchdown descent rate, typical load (33% fuel, 75% cargo)	5.8 m/s	4.2 m/s	3.5 m/s
Crew Survivability Limit (max vertical impact velocity)	39 m/s	39 m/s	39 m/s
Max bank at touchdown	15 degrees	15 degrees	15 degrees
Max pitch at touchdown	16 degrees	16 degrees	16 degrees
Max dynamic pressure: Crew Elevator deployed	N/A	N/A	9 kPa
Max dynamic pressure: Radiator Deployed	16 kPa	16 kPa	16 kPa
Max dynamic pressure: Cabin Hatch deployed	20 kPa	20 kPa	20 kPa
Max dynamic pressure: Docking Port/Nosecone open	32 kPa	32 kPa	32 kPa
Max dynamic pressure: Payload Doors open	N/A	36 kPa	36 kPa
Max dynamic pressure: Landing Gear deployed	39 kPa	39 kPa	39 kPa
Max dynamic pressure: Retro Doors deployed	41 kPa	41 kPa	41 kPa
Hull Thermal Failure at temperature limit (single surface)	~8 seconds (typical)	~8 seconds (typical)	~8 seconds (typical)
Max surface heating: NOSECONE	2840 C (5144 F)	2840 C (5144 F)	2840 C (5144 F)
Max surface heating: WINGS	2380 C (4316 F)	2380 C (4316 F)	2380 C (4316 F)
Max surface heating: COCKPIT	1490 C (2714 F)	1490 C (2714 F)	1490 C (2714 F)
Max surface heating: TOP HULL	1210 C (2210 F)	1210 C (2210 F)	1210 C (2210 F)

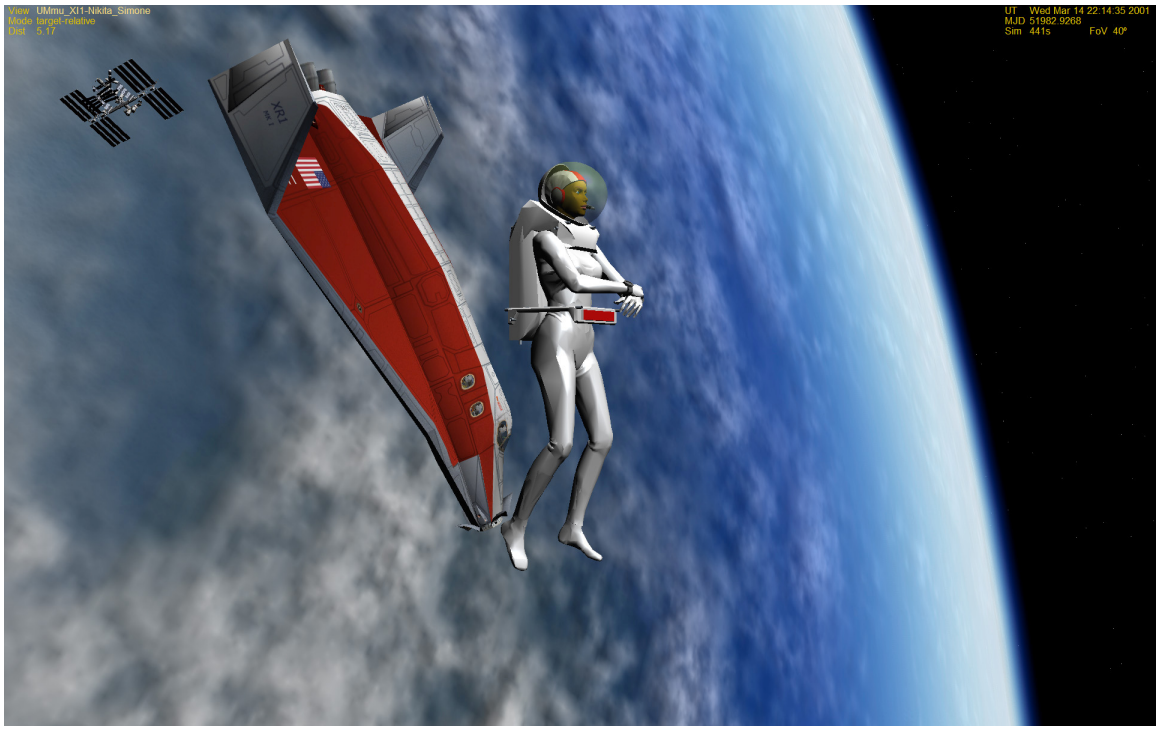
Empty Mass	12,000 kg	16,080 kg	266,400 kg
Main Fuel Mass	10,400 kg	13,396 kg	230,880 kg
RCS Fuel Mass	600 kg	804 kg	13,320 kg
SCRAM Fuel Mass	2,500 kg	3,350 kg	55,500 kg
APU Fuel Mass	200 kg	268 kg	4,440 kg
LOX Mass [5] *(see footnote)*	65 kg (7 days) to 3389 kg (5 years)	182 kg (7 days) to 47,438 kg (5 years)	234 kg (7 days) to 60,991 kg (5 years)
Fully Loaded Mass w/14-day LOX and full crew complement (no cargo)	26,254 kg	35,748 kg	572,225 kg
Length	17.76 meters	29.91 meters	60.34 meters
Wingspan	17.86 meters	18.95 meters	76.67 meters
Rear Gear Track	6.82 meters	7.48 meters	35.61 meters
Payload Bay Capacity	N/A	3 custom payload slots (approx. 30 cubic meters)	36 Standard Cargo slots (approx. 2,500 cubic meters)
Maximum Payload Mass	N/A	10,795 kg (max recommended)	432,000 kg (max recommended)
Main Engine Thrust in Vacuum	192 kN x 2 384 kN total	302 kN x 2 605 kN total	1,420 kN x 6 8,524 kN total
Hover Engine Thrust in Vacuum	88 kN x 3 264 kN total	208 kN x 2 415 kN total	977 kN x 6 5,860 kN total
Maximum SCRAM Engine Thrust	~160 kN x 2 ~320 kN total	~350 kN x 2 ~700 kN total	~5,250 kN x 2 ~10,500 kN total
Retro Engine Thrust in Vacuum	40.8 kN x 2 81.6 kN total	64.2 kN x 2 129 kN total	905 kN x 2 1,811 kN total
SCRAM Diffuser Thermal Limit	8000° Kelvin	8000° Kelvin	8000° Kelvin
APU Runtime ("low" *APUFuelBurnRate* default setting)	~110 minutes	~110 minutes	~110 minutes
APU Startup/Shutdown time	2.5 seconds (nominal)	2.5 seconds (nominal)	2.5 seconds (nominal)
Principal Moments of Inertia (PMI)	15.5 / 22.1 / 7.77	32.04 / 42.56 / 13.17	317.35 / 305.08 / 219.45
Cross Sections	55.13 / 190.53 / 26.41	77.46 / 238.98 / 30.14	543.82 / 1962.75 / 330.97
Center of Mass (in meters)	0.0, -0.07, -0.50	0.0, 0.41, -2.05	0.0, 10.45, -4.66
Crew Complement	5	14	18
Gear deployment time	6.7 seconds	6.7 seconds	6.7 seconds
Docking Port / Nosecone deployment time	20.0 seconds	20.0 seconds	20.0 seconds
Crew Elevator deployment time	N/A	N/A	35.0 seconds
Airlock doors opening time	10.0 seconds	10.0 seconds	10.0 seconds

[5] The maximum LOX listed here assumes that *LOXConsumptionRate* in the config file is set to its default of **AUTO**; the amount of LOX loaded will be higher if *LOXConsumptionRate* is changed. For example, if *LOXConsumptionRate* is set to *Realistic*, the actual LOX loaded for a five-year mission would be 16,942 kg (37,350 pounds).

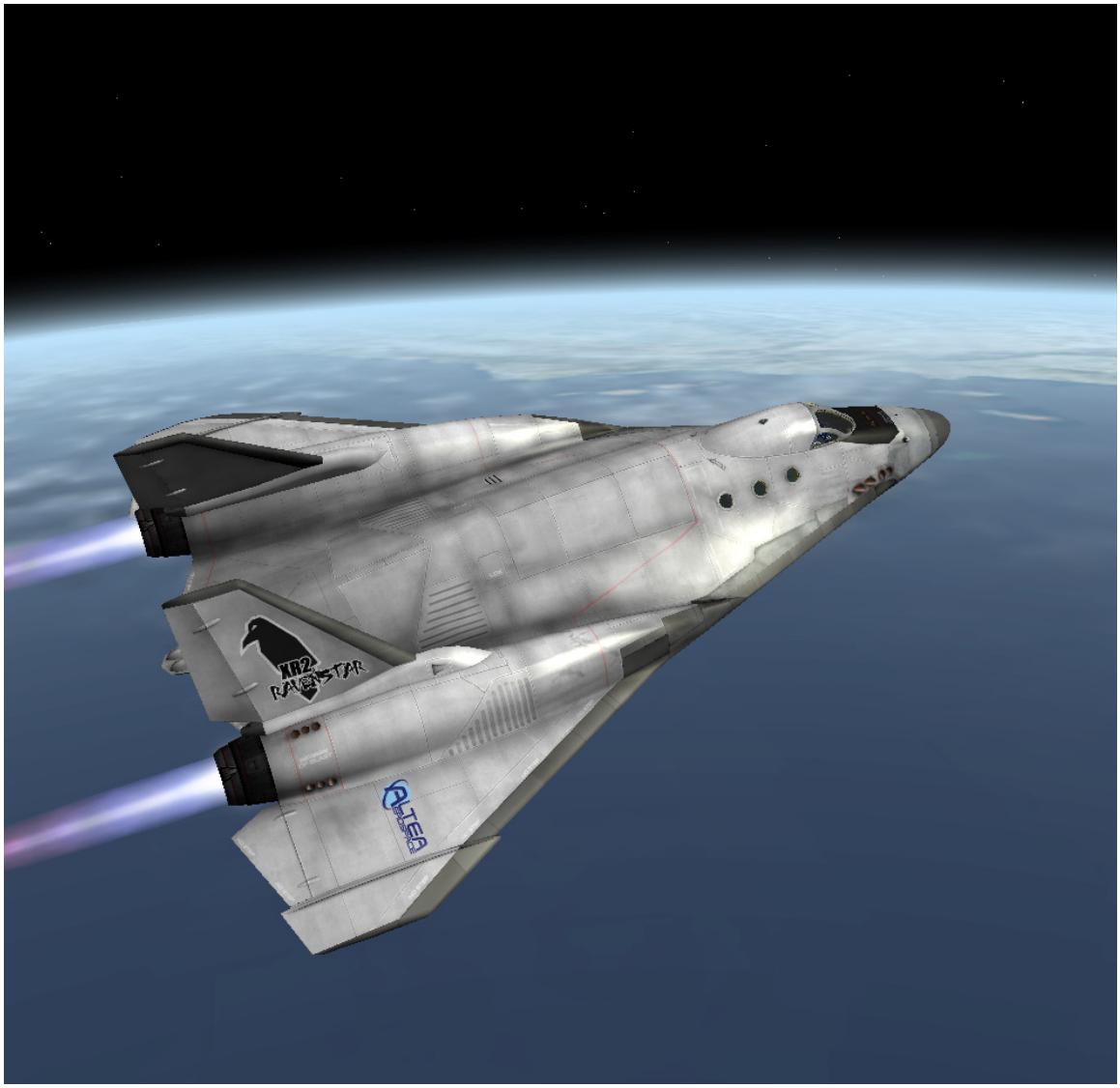
Airlock chamber pressurization time	28.0 seconds (vacuum to 14.7 psi)	28.0 seconds (vacuum to 14.7 psi)	28.0 seconds (vacuum to 14.7 psi)
Radiator deployment time	32.0 seconds	32.0 seconds	32.0 seconds
Airbrake deployment time	3.3 seconds	3.3 seconds	3.3 seconds
Payload Bay Doors opening time	N/A	22.0 seconds	35.0 seconds
Crew Hatch opening time	6.6 seconds	6.6 seconds	6.6 seconds
Retro Doors opening time	3.3 seconds	3.3 seconds	3.3 seconds
Hover Doors opening time	5.0 seconds	5.0 seconds	5.0 seconds
SCRAM Doors opening time	3.0 seconds	3.0 seconds	3.0 seconds
Main Refueling Line Pressure	22.2 psi nominal, 30 psi max	22.2 psi nominal, 30 psi max	22.2 psi nominal, 30 psi max
SCRAM Refueling Line Pressure	15.6 psi nominal, 21 psi max	15.6 psi nominal, 21 psi max	15.6 psi nominal, 21 psi max
APU Refueling Line Pressure	4.5 psi nominal, 6 psi max	4.5 psi nominal, 6 psi max	4.5 psi nominal, 6 psi max
LOX Resupply Line Pressure	11.1 psi nominal, 15.0 psi max	11.1 psi nominal, 15.0 psi max	11.1 psi nominal, 15.0 psi max
Resupply Line Pressurization Time	5.0 seconds (nominal)	5.0 seconds (nominal)	5.0 seconds (nominal)
Internal Coolant Temperature	32.2 C nominal, 89 C max	32.2 C nominal, 89 C max	32.2 C nominal, 89 C max
Transponder (XPDR) Frequency	117.65 MHz	118.05 MHz	117.75 MHz
Docking Port (IDS) Frequency	117.95 MHz	118.15 MHz	117.85 MHz
Gear Compression	N/A	N/A	0.95 meter
Wheelbrake Force	100 kN	134 kN	2,220 kN



XR5: Nikita Simone and John Sheppard at Brighton Beach on the Moon



XR1: Nikita on EVA



XR2 Ravenstar Leaving Orbit

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