Space Shuttle Ultra

Version 5.0

SSU Operations Manual

April 19, 2017

The Space Shuttle had a 30 year run like none other. Four times I was blessed with the opportunity to travel to space aboard this marvelous spacecraft. There has never been a vehicle quite like it: a reusable spacecraft, with the beauty of an airplane, the capacity to carry eight astronauts to space and a 60-foot payload bay. The Shuttle's three-decade long run was nothing short of remarkable.

Charles F. Bolden Jr. - NASA Administrator, 2015

PREFACE

Space Shuttle Ultra (SSU) is an addon for Orbiter Space Flight Simulator (http://orbit.medphys.ucl.ac.uk/). The purpose of this addon is to fully simulate the NASA's Space Transportation System Program. Currently only a few elements have been completed and work on others is ongoing.

The basis for this addon was the Space Shuttle Deluxe but through adding additional subsystems and taking full advantage of the 2016 version of Orbiter, the current SSU has few similarities to the original Deluxe. Currently, SSU simulates a number of systems, displays, and procedures of the real shuttle and can be used along with real NASA Flight Data File (FDF) checklists to complete tasks. These checklists can be found at the NASA Flight Data Files web page (http://www.nasa.gov/centers/johnson/news/flightdatafiles/index.html), and provide a good reference for other procedures. The NASA Flight Data Files site includes checklists for all missions after STS-107, as well as generic checklists.

Additional documentation containing background information about the shuttle and its systems can be found at http://sourceforge.net/projects/shuttleultra/files/References/.

Other good NASA references are the Shuttle Crew Operations Manual (SCOM), the DPS Dictionary, and the various Workbooks and Handbooks that are available on the Internet (these can also be found at the above link).

This document contains the condensed material taken from various NASA documents as well and Orbiter and SSU specific information. The goal of this document is to provide a typical Orbiter User the information need to perform basic SSU flights as well as to aid in basic custom mission creation. Separate documents will be provided for developers who would like to create a SSU compatible payloads and scenarios.

This document is formatted to look the same as the SCOM to facilitate changing from one document to the other. Additional information or clarification is presented in three formats: notes, cautions, and warnings. Notes provide amplifying information of a general nature. Cautions provide information and instructions necessary to prevent hardware damage or malfunction (not yet simulated). Warnings provide information and instructions necessary to ensure crew safety (also not simulated). The formats in which this material appears are illustrated below.

NOTE
A barberpole APU/HYD READY TO START talkback will not inhibit a start.

CAUTION

After an APU auto shutdown, the APU FUEL TK VLV switch must be taken to CLOSE prior to inhibiting auto shutdown logic. Failure to do so can allow the fuel tank isolation valves to reopen and flow fuel to an APU gas generator bed that is above the temperature limits for safe restart.

WARNING

The FUEL CELL REAC switches on panel R1 are in a vertical column with FUEL CELL 1 REAC on top, FUEL CELL 3 REAC in the middle, and FUEL CELL 2 REAC on the bottom. This was done to allow the schematic to be placed on the panel. Because the switches are not in numerical order, it is possible to inadvertently close the wrong fuel cell reactant valve when shutting down a fuel cell.

Contents

1 INSTALLATION INSTRUCTIONS

SSU requires the following addons to be installed:

1. OrbiterSound 4.0 (`http://orbiter.dansteph.com/index.php?disp=d`)
2. Antelope Valley scenery pack (`http://orbit.medphys.ucl.ac.uk/mirrors/orbiter_radio/tex_mirror.html`)

Install the "SSU_Font_A" and "SSU_Font_B" fonts, located in the Orbiter base directory, by opening it and selecting install. After installation the files can be deleted.
The following lines need to be added to the list of textures of the "<orbiter_installation>\Config\Base.cfg" file:
→ SSU\NOR1735tex
→ SSU\NOR2305tex
Using the D3D9 graphics client is strongly recommended (although not required). The *Disable near clip plane compatibility mode* option in the D3D9 Advanced Setup dialog (Orbiter Launchpad → Video → Advanced) should be checked.
If you encounter the error "msvcp120.dll is missing" you need to download the Microsoft Visual C++ Redistributable for Visual Studio 2013.
The displays in SSU require the MFD resolution of 512 x 512 (Orbiter Launchpad → Extra → Instruments and panels → MFD parameter configuration → MFD texture size).

WARNING

The SSU installation overwrites the default Earth.cfg file.

2 GENERAL DESCRIPTION

Contents

The section provides general background information about the orbiter, its configuration and coordinate system, the nominal mission profile, and general procedures followed during a shuttle mission.
Also included in this section is keyboard commands for SSU but will not include standard Orbiter keyboard commands. See Orbiter.pdf for standard Orbiter keyboard commands.

2.1 Overview

Contents

2.1.1 Nominal Mission Profile

SSU has reached a point of development that almost a full mission profile can be simulated.

Launch

The launch is controlled by autopilot. The autopilot targets a set of desired parameters defined in the mission file (altitude, velocity and inclination) at main engine cutoff (MECO). After MECO, the ET is jettisoned and the +Z RCS thrusters are automatically fired to translate the orbiter away from the ET.

Procedures for this phase of the mission can be found in the NASA Ascent Checklist.

Orbit Insertion and Circularization

The nominal ascent profile, referred to as "direct insertion," places the vehicle in a temporary elliptical orbit at MECO, with the perigee in the Earth's atmosphere. Orbital altitudes can very depending on mission requirements. The crew performs an OMS burn, designated as "OMS 2", to stabilize the orbit. This burn can add anywhere between 200 to 550 fps to the vehicle's orbital velocity, as necessary.
When simulating early missions with SSU, the orbiter will perform what was known as a "standard insertion". This will place the orbiter in a heads down suborbital orbit at MECO and will require an OMS 1 burn to raise the apogee, followed by an OMS 2 burn. This ascent profile was used for the first ten missions, STS-1 though STS-41B.
After ET separation (and before the OMS 2 burn), the ET umbilical doors are closed.

Procedures for this phase of the mission can be found in the NASA Ascent Checklist.

WARNING

Scenario saving during the launch phase (MM102, 103 and 104) is currently not supported by SSU.

Orbit

On orbit, the forward and aft RCS jets provide attitude control of the orbiter, as well as any minor translation maneuvers along a given axis. The OMS engines are used to perform orbital transfers, such as those done to rendezvous with the International Space Station (ISS). Mission objectives while in orbit has ranged from ISS assembly and logistics, payload deployment and retrieval, to scientific experiments. Also several planned, but not flown, missions are able be simulated with SSU including Shuttle-Centaur flights and Vandenberg missions.
The procedures needed on orbit differ significantly based on the mission objectives. Checklists for STS-114 and subsequent missions can be found at the Flight Data Files page. The Orbit Operations Checklist, Orbit Pocket Checklist and PDRS Operations Checklist (all available at the Flight Data Files page) contain generic information for operations that are frequently performed (i.e. OMS burns).

During the last full day on-orbit (the day before the planned deorbit burn), the FCS checkout and RCS hotfire tests are performed. Procedures for these tests can be found in the Orbit Operations Checklist.

Deorbit

At the completion of orbital operations, the RCS is used to orient the orbiter in a tail-first attitude. The two OMS engines are burned to lower the orbit such that the vehicle enters the atmosphere at a specific altitude and range from the landing site. The deorbit burn usually decreases the vehicle's orbital velocity anywhere from 200 to 550 fps, depending on orbital altitude. When the deorbit burn is complete, the RCS is used to rotate the orbiter's nose forward for entry. The RCS jets are used for attitude control until atmospheric density is sufficient for the pitch, roll, and yaw aerodynamic control surfaces to become effective.

Procedures for deorbit prep and the deorbit burn are in the Deorbit Prep Checklist and the Entry Checklist. Mission-specific details are in the Entry Flight Supplement.

Entry

In real life, reentry is normally controlled automatically by the Aerojet Digital Autopilot (DAP) from entry interface (EI) through Terminal Area Energy Management

(TAEM), to ∼ Mach 1, where the CDR takes control of the orbiter. SSU has a fully functioning entry autopilot which provides guidance and control from EI to 2000 ft (the start of the preflare). It is also possible to fly the shuttle manually. The speedbrake is usually controlled automatically throughout entry, but can be controlled manually. See Section 2.2.3 for more details. The Heads-Up Display (HUD) becomes active at Mach 2.5. Guidance commands are displayed on the HUD from Mach 2.5 until the start of the final flare phase.

The landing gear are automatically armed at 2000 ft and deployed at 300 ft. In real life, this is done manually by the PLT.

Procedures for entry and found in the Entry Checklist. Mission-specific details are in the Entry Flight Supplement.

2.1.2 Shuttle Coordinate Frame

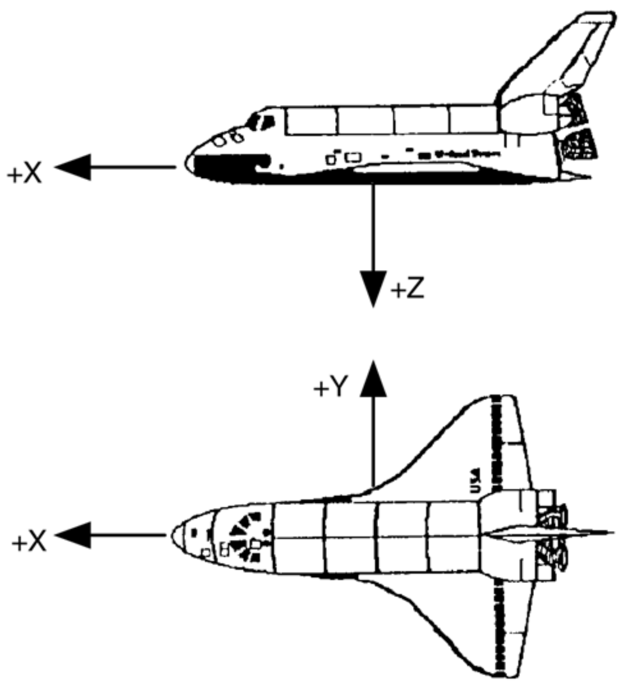


Figure 1: Body Axis Coordinate System (image from SCOM)

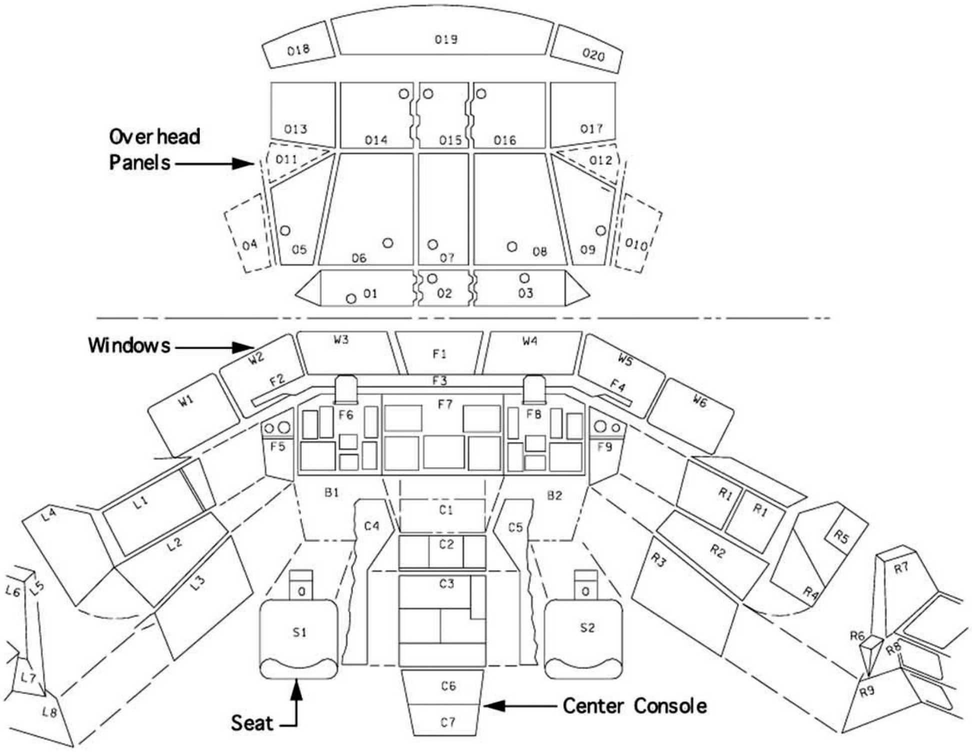
Figure 1 shows the shuttle Body Axis Coordinate system. This coordinate system is used in the NASA documents and checklists, as well as this manual. It should be noted that the Body Axis Coordinate frame is different from the normal Orbitersim frame.

2.1.3 Shuttle Location Codes

Orbiter location codes enable crewmembers to locate displays and controls, stowage compartments and lockers, access panels, and wall-mounted equipment in the orbiter crew compartments. The crew compartments are the flight deck, middeck, and airlock. Because of compartment functions and geometry, each has a unique location coding format.
Currently SSU only simulates the flight deck panels. Eventually panels in the middeck will be simulated and at that time the middeck location coding will be included in this manual.
A flight deck location code consists of two or three alphanumeric characters. The first character is the first letter of a flight deck surface as addressed while sitting in the commander/pilot seats. The second and third characters are numbers identifying the relative location of components on each flight deck surface. Table 1 lists the surfaces and the numbering philosophy for each surface. Figures 2 and 3 show the flight deck panels and their location codes.

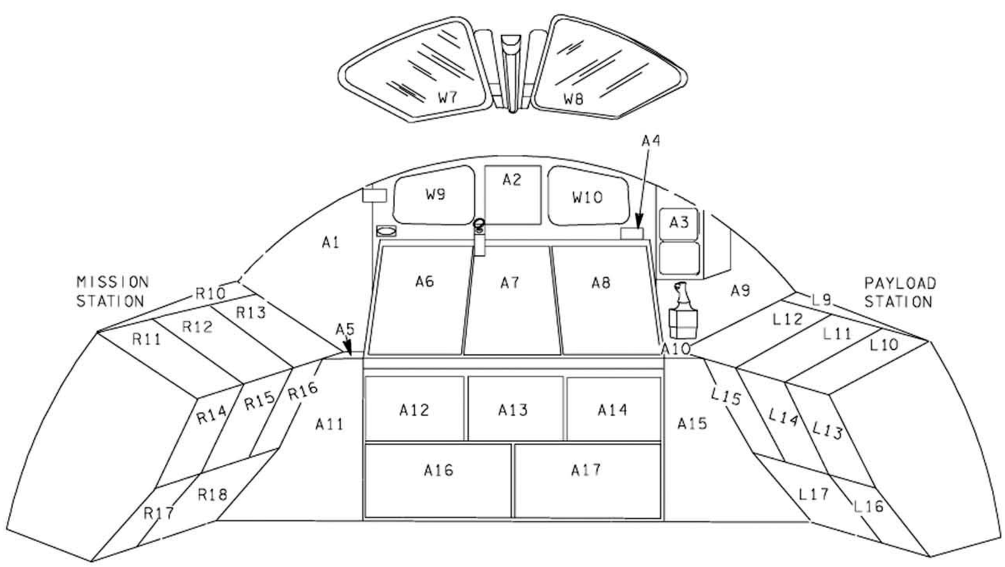
SURFACES	NUMBERING PHILOSOPHY
L - Left R - Right C - Center Console	Numbered from top to bottom, forward to aft
O - Overhead	Numbered from left to right, forward to aft
F - Forward A - Aft	Numbered left to right, top to bottom (facing the surface)
W - Windows	**Forward** (W1 through W6): numbered left to right facing forward **Overhead** (W7 & W8): numbered left to right facing aft **Aft** (W9 & W10): numbered left to right facing aft
S - Seats	CDR seat is S1 and PLT seat is S2

Table 1: Flight Deck Numbering scheme



Flight Deck Location Codes (1 of 2)

Figure 2



Flight Deck Location Codes (2 of 2)

Figure 3

2.2 Orbiter and SSU

Contents

2.2.1 SSU Keyboard Commands

The ultimate goal of SSU is to provide a complete simulation of the Space Shuttle. This means that most of the input is done with in-simulation controls (i.e. cockpit switches, GNC keyboards, and dialog windows). This results in very few keyboard commands to operate the shuttle.

General

Ctrl+A - toggle between controlling RCS thrusters and RMS motion
Ctrl+G - arm landing gear
G - deploy landing gear
Comma - left brake
Period - right brake

RMS

Ctrl+Enter - grapple
Ctrl+Backspace - release
Ctrl+O - toggle between Coarse and and Vern rates

2.2.2 Rotational Hand Controller / Translational Hand Controller

The regular Orbitersim thruster control commands (either keyboard or joystick) are used to simulate the Rotational Hand Controller (RHC) & Translational Hand Controller (THC). When controlling the RCS thrusters, the appropriate *FLT CNTLR PWR* switch must be on for RHC/THC inputs to be used. There are no such restrictions when controlling the RMS (although the RMS needs to be powered on before it can move).

The RHCs on the real shuttle have a "soft stop" and a "hard stop" (the mechanical limit of movement). Moving the RHC out of detent (up to the soft stop) will command either a constant rotation rate or a pulse of RCS firings to change the rotation rate by a specified amount (depending on whether *DISC RATE* or *PULSE* has been selected). Moving the RHC past the soft stop will result in continuous thruster firings in the appropriate axis. In SSU, a thruster command of <75% is considered to be within the soft stop; a thruster command of >75% is treated as RHC deflection beyond the soft stop. When using keyboard controls, the normal keyboard controls are equivalent to full RHC deflection, while holding down the Ctrl key is equivalent to deflection within the soft stop. The THC (and the RMS controls) does not have this idea of a soft stop. When *NORM* is selected in a translational axis, the thrusters will fire continuously if the THC is moved out of detent. When *PULSE* is selected, the thrusters will fire to provide a specified ΔV (the TRAN PLS rate specified on the SPEC 20 DAP CONFIG display). When controlling the RMS, the commanded rotation/translation rates are always directly proportional to the RHC/THC deflection.

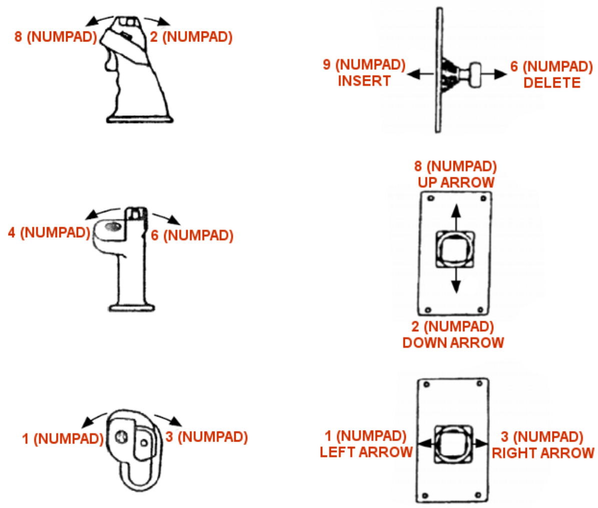


Figure 4: RHC/THC key mapping

2.2.3 Speedbrake/Thrust Controller

The Speedbrake/Thrust Controller (SBTC) controls both SSME throttling during ascent and the speedbrake setting during entry. In Orbiter, the SBTC is controlled in 5% intervals, in the forward direction by the numpad *Subtract* key, and in the aft direction via the numpad *Add* key. The takeover switch, used to initiate manual control of the SSME throttle or speedbrake settings, is simulated by the *Minus* key. The appropriate *FLT CNTLR PWR* switch must be on for the SBTC to be active. Each SBTC is animated so the user can tell what setting is being commanded. During ascent, a full aft SBTC position corresponds to 67% SSME throttle; full forward SBTC position corresponds to 104.5% (109% during some abort cases) SSME throttle. During entry, full aft SBTC position corresponds to the speedbrake being **fully open**; full forward SBTC position corresponds to the speedbrake being commanded **fully closed**.

Ascent

During ascent, SSME throttling is usually controlled by autopilot; in this case, the *AUTO* portion of the *SPD BK/THROT* PBIs on Panel F2 & Panel F4 is lit, and **THRTL: Auto** is displayed in the A/E PFD display. To takeover manual control of the SSME throttle command, press the SBTC takeover switch and move the SBTC to match the current SSME auto command (displayed in the Ascent Traj displays. When the SBTC takeover switch is pressed both *AUTO* PBIs will go out, indicating a manual takeover is in progress, but not completed. When the SBTC-commanded SSME throttle setting matches the auto command within 4%, the PLT *SBD BK/THROT MAN* PBI will be lit and **THRTL: Man** appears in the A/E PFD display, indicating that the SSME throttle is now under manual control. To return to auto SSME throttle control, press either *SBD BK/THROT MAN* PBI. A manual MECO can be commanded by pressing the NUMPAD * key (in real life, this is done by simultaneously pressing all 3 *MAIN ENGINE SHUT DOWN* push buttons on Panel C3; this is not possible in Orbiter).

Entry

The speedbrake is usually controlled automatically throughout entry, with the *AUTO* portion of the *SPD BK/THROT* PBIs on Panel F2 & Panel F4 is lit, and **SB: Auto** is displayed in the A/E PFD display. To take over manual control of the speedbrake press the SBTC takeover switch; the speedbrake will immediately move to the position commanded by the SBTC, the *AUTO* portion of the *SPD BK/THROT* PBIs will go out and the *MAN* PBI will be lit on either the CDR or PLT position (depending on what SBTC takeover switch was last pressed). Pressing the either *SPD BK/THROT* PBI, will put the speedbrake into *AUTO* mode again.

2.2.4 Rudder Pedal Transducer Assembly

The Rudder Pedal Transducer Assembly (RPTA) allows the rudder during the later part of reentry, as well as nose wheel steering during rollout. The RPTA also contains the brake pedals, which in addition to braking provide another means of lateral control during rollout. The appropriate *FLT CNTLR PWR* switch must be on for the RPTA to be active. Although the rudder is automatically controlled, manual control is available when the P/Y channel is in CSS.

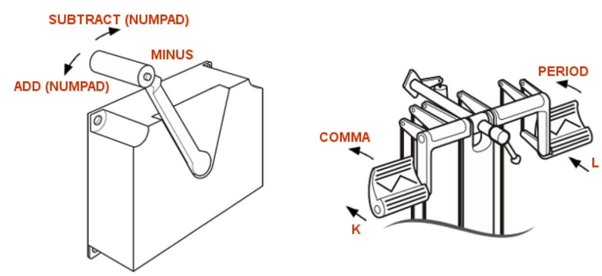


Figure 5: SBTC/RPTA key mapping

2.2.5 Camera Views

SSU includes the four payload bay cameras and the docking port centerline camera. The PLB cameras are controlled via their switches on panel A7U on the flight deck and are no longer controlled with a dialog window.

In the PLB camera VC views, the cameras can be rotated using Alt+Arrow Key.

2.2.6 Navigating the Virtual Cockpit

Changing between Virtual Cockpit (VC) views is identical to the system used in the default Atlantis but with several more positions around the cockpit that we call stations. You can switch between different stations using the Ctrl+Arrow key combination (See Chart below for all combinations.) The Commander (CDR) Station is the front left seat on the flight deck, while the Pilot (PLT) station is the right seat (while looking forward).

Table 2 is set up to show the different ways to move about the crew module. The first column is the camera position you are in and the other columns show the views you can change to using the Ctrl+Arrow key combination at the top of the table. For additional assistance in navigating the views, the name of the view is shown for a few seconds at the top of the screen during the simulation. The names in the table are identical to those that appear on-screen.
In addition, each station has lean positions (Alt Gr+Arrow key) which allow better positioning to reach a specific panel or window.

Cockpit View	**Left**	**Right**	**Up**	**Down**
Commander Seat	CDR - L4	Pilot Seat	PLB Camera A *or* ODS Camera[c]	MS Seat
Pilot Seat	Commander Seat	Pilot - R4	PLB Camera D *or* ODS Camera[c]	MS2/FE Seat
CDR - L4	Port Workstation	Commander Seat	PLB Camera D *or* ODS Camera[c]	MS Seat
Pilot - R4	Pilot Seat	Stbd Work Station	PLB Camera D *or* ODS Camera[c]	MS2/FE Seat
MS Seat	Port Workstation	MS2/FE Seat	Commander Seat	PLB Camera A *or* ODS Camera[c]
MS2/FE Seat	MS Seat	Stbd Work Station	Pilot Seat	PLB Camera A *or* ODS Camera[c]
Port Work Station	RMS Work Station	Commander Seat	PLB Camera A *or* ODS Camera[c]	Mid Deck
Stbd Work Station	Pilot Seat	Aft Pilot Station	PLB Camera D *or* ODS Camera[c]	Aft Work Station
Aft Work Station	Stbd Work Station	Port Workstation	RMS Work Station	MS Seat
Aft Pilot Station	Stbd Work Station	RMS Work Station	PLB Camera D *or* ODS Camera[c]	Aft Work Station
RMS Work Station	Aft Pilot Station	Port Work Station	PLB Camera A *or* ODS Camera[c]	Aft Work Station
RMS EE[a]	RMS Elbow	-	-	RMS Work Station
RMS Elbow[a]	-	RMS EE	-	RMS Work Station
PLB Camera A	PLB Camera D	PLB Camera B	RMS EE[a,c]	RMS Work Station *or* ODS Camera[c]
PLB Camera B	PLB Camera A	PLB Camera C	RMS EE[a,c]	RMS Work Station *or* ODS Camera[c]
PLB Camera C	PLB Camera B	PLB Camera D	RMS EE[a,c]	Aft Pilot Station *or* ODS Camera[c]
PLB Camera D	PLB Camera C	PLB Camera A	RMS EE[a,c]	Aft Pilot Station *or* ODS Camera[c]
ODS Camera[c]	-	-	PLB Camera A	Aft Pilot Station
Mid Deck	-	-	Port Work Station	External Airlock[b]
External Airlock[b]	-	-	Mid Deck	ODS Camera[c]

[a] only when RMS is installed
[b] only when External Airlock is installed
[c] only when ODS is installed

Table 2: VC navigation

2.3 Payload Operations Overview

Payloads are attached through standard Orbiter attachment points. Figure 6 below will assist in visualizing the available attachment locations. The image on the left show the attachment locations without the ODS and the image on the rights shows the attachment locations with the ODS. Attachments 5 thru 11 are located just below the payload bay liner, so to have a correct vertical positioning of the payload, the attachment coordinates of the payload must be in its keel pin. Attachments 12 thru 19 are located on the side wall of the payload bay, just below the sill.
If the payload is one that is deployed and later put back into the bay (example: MPLM), be sure to take note of the SRMS joint angles and orbiter XYZ coordinates displayed on panel A8U. The mission file entries to define the payload attachment positions are defined in Section 6 of this manual. The scenario file entries needed to add payloads to SSU are covered in Section 7 of this manual.

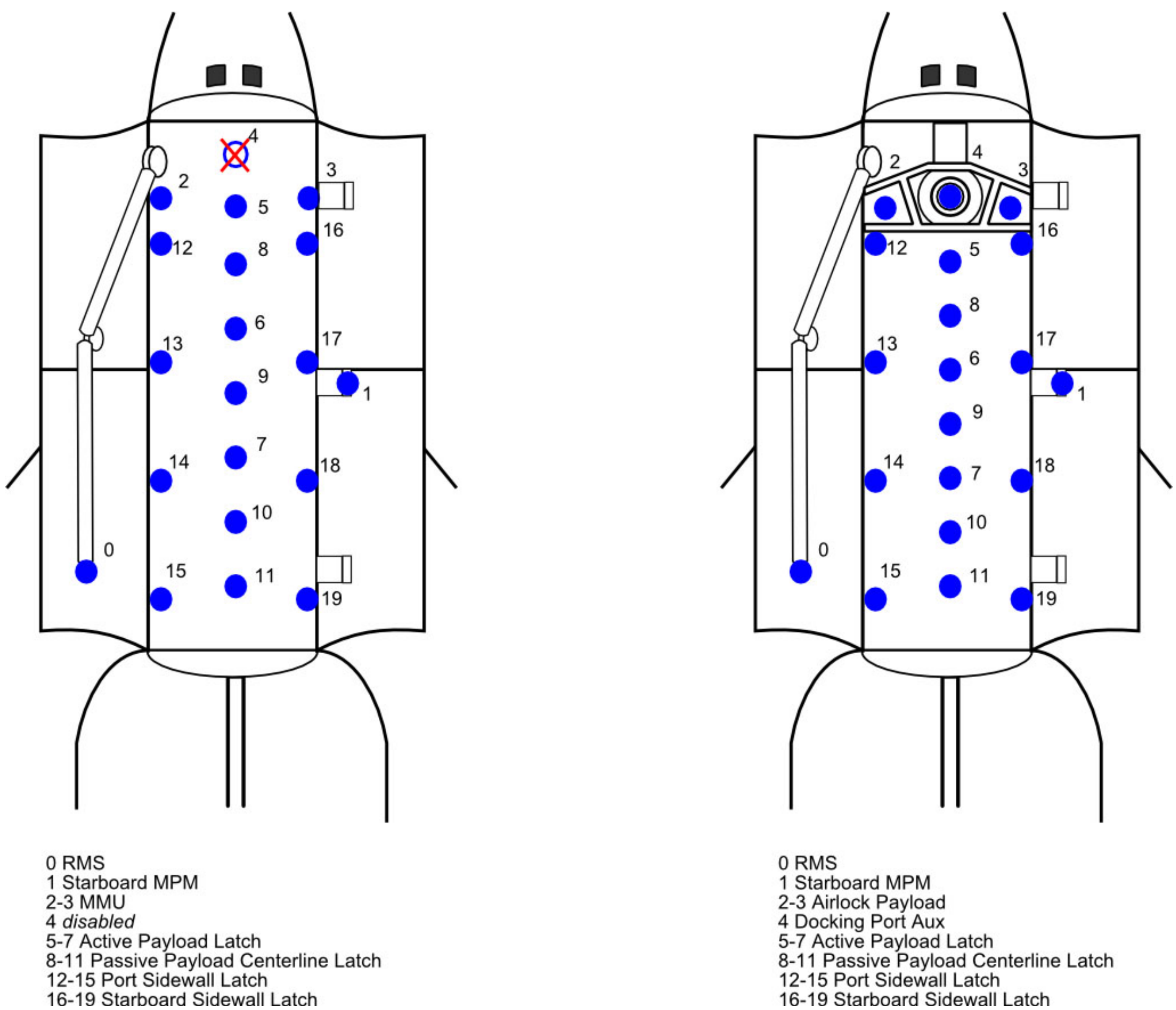


Figure 6: SSU attachment locations

2.4 Extra Vehicular Activities and Docking Operations Overview

Extra Vehicular Activity (EVA), or spacewalk, is used on some missions for work outside the shuttle, either for retrieving a satellite or most recently, for the assembly of the ISS. Independently of mission tasks, all missions have contingency EVA capability for manual payload bay door closure. EVA requires the use of an airlock, which on the shuttle can be located inside the middeck (Internal Airlock), or outside on the payload bay (External Airlock). EVA is currently not supported by SSU.
For missions requiring docking with the ISS or Mir, the orbiter need to be fitted with the Orbiter Docking System (ODS). The ODS is mounted on top of the External Airlock, and is controlled by buttons on panel A7L, allowing ODS powerup and docking ring extension and retraction.

WARNING

A future version of SSU will introduce changes to the docking port format. In addition to the docking port, there must exist an child attachment, in the same location, with the id ”APAS” to achieve soft-docking. Without the attachment, docking will not be possible.

For missions requiring the ODS to be located aft of its normal position (e.g. STS-88), the Tunnel Adapter Assembly (TAA) is positioned between the External Airlock and the forward bulkhead, effectively acting as a spacer. The TAA must also be used on missions carrying the Spacelab or the SpaceHAB modules. It must be placed at the forward end of the tunnel to provide a way in/out of the airlock during an EVA.
The mission file entries to define the ODS, External Airlock and TAA are defined in Section 6 of this manual.

3 SSU SYSTEMS

Contents

This section discusses in greater detail each of the space shuttle systems that are currently simulated.

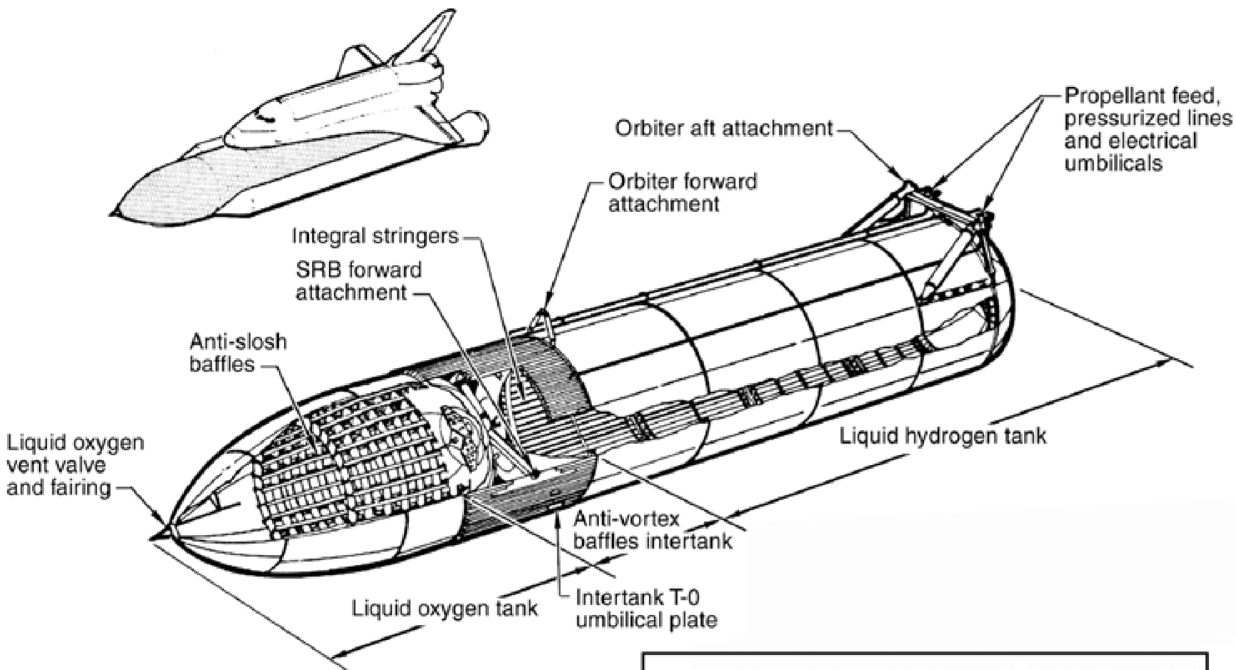
These are not meant to provide all information about the real orbiter system but to provide a working knowledge required to understand what is happening in the simulation. For full, detailed reading, each subsection provides references to relevant sections in the Shuttle Crew Operations Manual (SCOM) and should be read for a better understanding for that system.

3.1 External Tank (ET)

Contents

3.1.1 Description

The External Tank (ET) holds the liquid hydrogen and liquid oxygen propellants for the Main Propulsion System, and serves as a backbone for the whole space shuttle vehicle.
There are 3 versions of ETs:
⇒ Standard Weight Tank (SWT), the original ET to which can be added a cover of Fire Retardant Latex (FRL) paint;
⇒ Light Weight Tank (LWT), lighter weight ET resulting from structural changes;
⇒ Super Light Weight Tank (SLWT), further weight reductions to improve payload capability.
The scenario file entries needed to define the ET vessel are covered in Section 7 of this manual.



Length	153.8	feet
Diameter	27.6	feet
Average gross lift-off weight (SLWT)	1,658,217	pounds
Inert weight (SLWT)	58,500	pounds
Liquid oxygen maximum	1,376,240	pounds
	144,857	gallons
Liquid hydrogen maximum	230,302	gallons
	389,770	gallons
Average total LO2/H2	532,776	gallons
Burn rate (104%)	64,957	gallons/min
	1,083	gallons/sec

(all weights/rates are approximate)

Figure 7: External Tank

3.2 Solid Rocket Boosters (SRB)

Contents

3.2.1 Description

The Solid Rocket Boosters (SRB) are solid propellant rockets that provide thrust during the early phases of the launch. The main component of the SRB is the Solid Rocket Motor (SRM).
There are 4 types of SRMs:
⇒ Standard Performance Motor (SPM), the original SRM (not yet available in SSU);
⇒ High Performance Motor (HPM), upgrade to the SPM;
⇒ Filament Wound Case (FWC), lighter case SRM planned to be used from SLC-6;
⇒ Redesigned Solid Rocket Motor (RSRM), developed in response to the Challenger accident.
The scenario file entries needed to define the SRB vessels are covered in Section 7 of this manual.

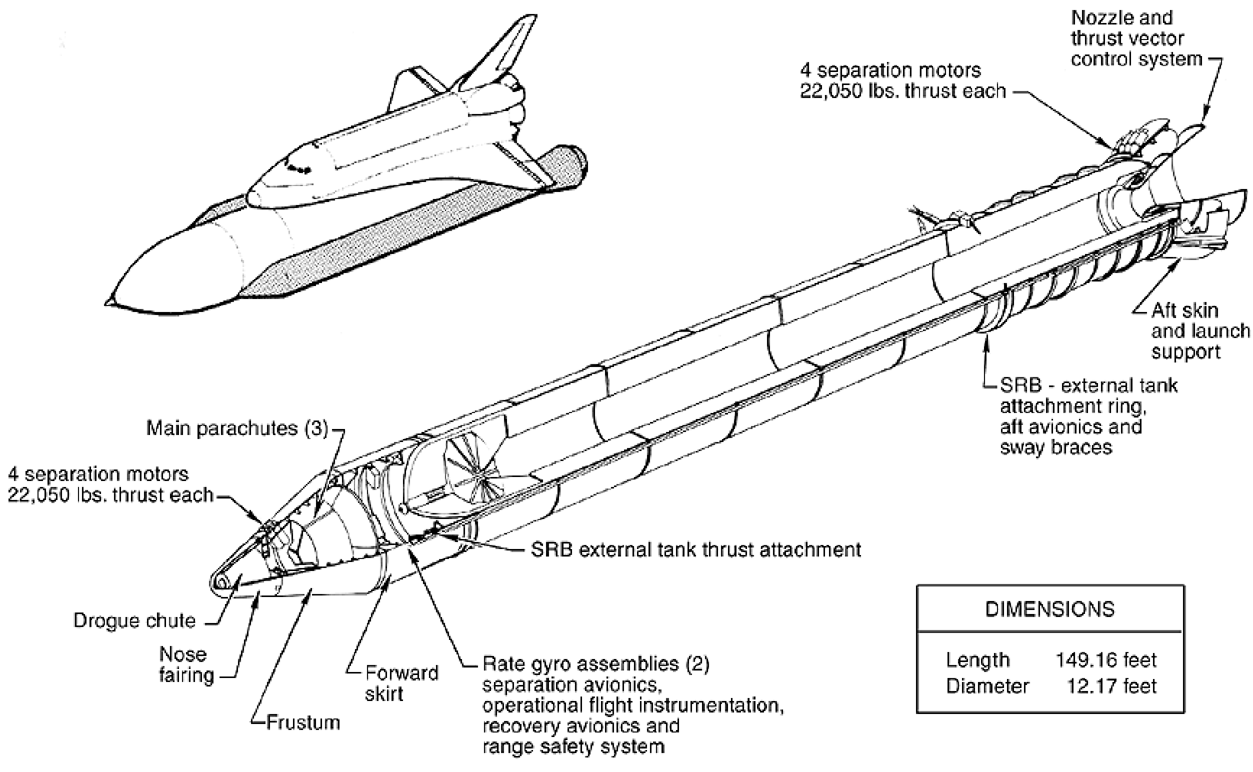


Figure 8: Solid Rocket Booster

3.3 Auxiliary Power Unit/Hydraulics (APU/HYD)

Contents

3.3.1 Description

The orbiter has three independent hydraulic systems. Each system provides hydraulic pressure during launch and entry to control the SSMEs, the Orbiter's aerosurfaces, and other systems. The APUs are started 5 minutes before launch and shut down shortly after MECO. The day before entry, a single APU is started for the FCS checkout. A single APU is started 5 minutes before the deorbit burn (this is done to ensure at least 1 APU is functioning before committing to entry). The remaining APUs are started 13 minutes before Entry Interface. All 3 APUs are shut down after landing.

3.4 Main Propulsion System (MPS)

Contents

3.4.1 Description

The Main Propulsion System (MPS) is composed of the External Tank that holds the propellants, 3 Space Shuttle Main Engines (SSME) that provide thrust during the whole launch, and propellant manifolds to carry the propellants from the tanks to the engines.

3.4.2 Space Shuttle Main Engines (SSME)

The SSMEs are high performance liquid propellant rocket engines located in the aft compartment of the orbiter. They can operate between 67% and 109% of their rated thrust (370000lbs), and are throttled down temporarily early in the ascent to reduce aerodynamic loads on the vehicle, and then again late in the ascent to keep the acceleration under 3g.

3.4.3 MPS Dump

Following MECO and ET separation, the MPS Dump is automatically started to vent remaining MPS propellants from the engines and the manifolds. Liquid oxygen is vented thru the SSMEs and the liquid hydrogen is vented thru the backup LH2 dump valves and thru the fill and drain valves located on the port sidewall of the orbiter.

3.5 Remote Manipulator System (RMS)

Contents

3.5.1 Description

To deploy and retrieve payloads from the Payload Bay the OV has a Canadian-built robotic arm know as the Remote Manipulator System (RMS). It has 6 joints allowing motion similar to the human arm. The End Effector (EE), located at the tip of the RMS, allows it to grapple payloads. The RMS can be moved in a single-joint mode, or moved along the axes of the OV or of the End Effector, thus allowing flexibility in its operation.

WARNING

The ”Position” and ”Attitude” parameters displayed on panel A8U refer to the position and attitude of the End Effector in the OV reference frame, identified in the PDRS checklists as ”PL ID 0”. Other ”PL ID”s are currently not supported by SSU, so those coordinates will not be usable but the joint angles are always usable.

The RMS is positioned on the port side of the Payload Bay, mounted on the Manipulator Positioning Mechanisms (MPM) that must be rolled out prior to RMS usage.

3.6 Data Processing System (DPS)

Contents

The DPS consists of the shuttle's General Purpose Computers (GPCs), associated systems, and the software run by the GPCs. The 11 MDUs (Multifunction Display Units) are also part of the DPS.

3.6.1 GPCs

The real shuttle has 5 identical computers. Up to 4 of the 5 GPCs run the Primary Avionics Software System (PASS). The remaining computer runs the Backup Flight System (BFS). The PASS software is further divided into 3 Major Functions: *GNC* (Guidance, Navigation & Control), *SM* (Systems Management) and *PL* (Payload) software. The *GNC* software is responsible for controlling the orbiter during flight. During critical phases of flight, such as launch and entry, multiple GPCs will run the PASS *GNC* software simultaneously; this provides redundancy if one of the GPCs fails. The *SM* software monitors various orbiter systems. The *PL* software is not used during flight. The BFS was written separately from the PASS, and implements a subset of the PASS *GNC* functions. The BFS is meant to be used in the event of a PASS failure.

The *GNC* major function is divided into multiple OPS. Each OPS represents a different phase of flight. OPS 1 is used for launch, OPS 2 is used on-orbit, and OPS 3 is used for deorbit and entry. The GPC only has enough memory to store one OPS at a time, so the PASS software is divided into multiple memory configurations. Each memory configuration contains one OPS (except for MC 1, which is used during launch, and contains both OPS 1 (launch) and OPS 6 (RTLS)). To change from one OPS to another, the appropriate memory configuration has to be loaded onto the GPCs. Each OPS is further divided into Major Modes, which relate to specific phases of the mission. For example, OPS 2 (on-orbit) has 2 Major Modes: MM 201 (orbit coast) and MM 202 (Mnvr Exec). MM 202 is used for performing OMS burn, while MM 201 is used otherwise.
At the moment, SSU only simulates the PASS *GNC* software. Also, loading different memory configurations into the GPCs is not simulated. SSU assumes only one GPC is running, and does not simulate multiple GPCs performing the same operations as part of a redundant set.

3.6.2 Multifunction Display Units (MDUs)

The shuttle originally had 4 CRT displays, and multiple analog instruments. The CRTs allowed the crew to interact with the shuttle computers, while the analog instruments displayed subsystem status and flight instruments. Starting with STS-101, the analog instruments were replaced with the MDUs. The shuttle has 11 MDUs: CDR 1 and 2 on panel F6; CRT 1, 2, and 3, and MFD 1 and 2 on panel F7; PLT 1 and 2 on panel F8; CRT 4 on panel R11; and AFD 1 in the aft station. In real life, the MDUs display either DPS displays, flight instrument displays, or subsystem status displays. The flight instruments and subsystem status displays replace the analog instruments, while the DPS displays are almost identical to the CRT displays.

In SSU, each MDU is an Orbitersim MFD. CRT MFD, which is part of SSU, simulates the shuttle MEDS displays. In the future, SSU will only display accurate displays in the MDU; some displays have not been implemented yet, and so Orbitersim MFD equivalents have to be used. Section 12 describes the DPS displays that have been implemented so far. The 3 subsystem status displays (*OMS/MPS*, *APU/HYD* and *SPI*) have been implemented in CRT MFD. The flight instrument displays are only partially implemented. All displays in the Ascent/Entry Primary Flight Display are working except for the ADI and HSI.

3.7 DPS Displays

Contents

The NASA DPS Dictionary describes each display in detail. This section lists the displays that have been implemented so far and describes the differences between the real shuttle and the SSU implementation.

3.7.1 ASCENT TRAJ

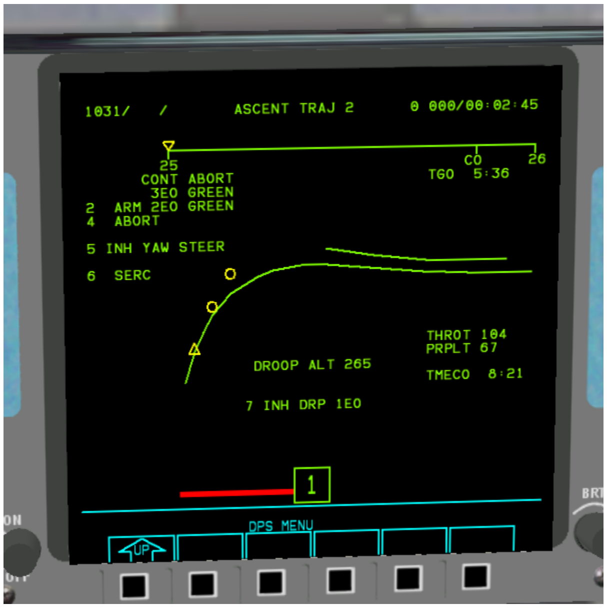


Figure 9: ASCENT TRAJ display

This display is used in MM 102 and MM 103 to monitor the vehicle's trajectory during ascent. The DROOP ALT digital output is not being driven. The ITEMs on this display are related to abort options and are not supported by SSU.

3.7.2 UNIV PTG

This display is used in MM 201, and is used to control the attitude of the orbiter. Most of the functions in this display have been implemented. ITEM 8 (TGT ID) only supports an entry of 2 at the moment, and ITEMS 9-13 are not supported. ITEM 20 (TRK) is not supported. Finally, ITEMs 22-24 (which affect how the attitude error is displayed) are not implemented.

3.7.3 OMS MNVR EXEC

This display is used in MM 104 (OMS 1 MNVR EXEC), MM 105 (OMS 2 MNVR EXEC), MM 106 (OMS 2 MNVR COAST), MM 202 (ORBIT MNVR EXEC), MM 301 (DEORB MNVR COAST), MM 302 (DEORB MNVR EXEC) and MM303 (DEORB MNVR COAST). It is used mainly to perform OMS engine burns to change the shuttle's orbit. This display is almost completely implemented in SSU. ITEMs 28-40 (OMS gimbal check, FWD RCS dump and SURF DRIVE) have not been implemented yet.

3.7.4 DAP CONFIG

This display is used in MM 201 and MM 202, and control the Digital Autopilot (DAP) settings. In real life, there are 15 DAP A configurations and 15 DAP B configurations; at any time, 1 DAP A and 1 DAP B configuration is active, and the crew selects between DAP A and B using the PBIs on Panels C3 and A6. In SSU, there is only 1 DAP A configuration and 1 DAP B configuration. As a result, ITEMS 1 and 2 (which select the active DAP A & B configuration) are not implemented. Also ITEMs 3 and 4 (which, in real life, select a DAP configuration and load it into the EDIT column) simply select between loading DAP A and DAP B into the EDIT column.

3.7.5 ORBIT TGT

This display is used in MM 201 and MM 202 to compute rendezvous burns. In real life, the state vectors for the rendezvous target are uploaded from Mission Control. In SSU, the name of the target vessel is specified in the scenario file. The real-life ORBIT TGT display can load rendezvous targets by specifying a TGT NO (ITEM 1); in SSU, each parameter has to be set individually. SSU doesn't support the EL parameter (ITEM 6), which allows the burn TIG to be computed to match a desired elevation angle; instead, the TIG must be specified. SSU can only be used to compute the T1 burn (ITEM 28), and not the T2 burn. In real life, the T2 burn computations are not used.

SITE	Location	PRI RWY	SEC RWY
1	KSC	KSC 15	KSC 33
3	Moron	MRN 20	MRN 02
13	Moron	MRN 20	MRN 02
20	St. John's International	YYT 29	YYT 11
21	Gander	YQX 21	YQX 31
22	Banjul	BYD 32	BYD 14
23	Lajes	LAJ 15	LAJ 33
24	Vandenberg AFB	VBG 30	VBG 12
26	Shannon	INN 06	INN 24
29	Istres	FMI 33	FMI 15
32	Diego Garcia	JDG 31	JDG 13
33	RAAF Amberley/Tindall	AMB 15	PTN 14
36	Bermuda	BDA 30	BDA 12
38	Easter Island	EIP 28	EIP 10
39	Hao Atoll	HAO 12	HAO 30
42	White Sands	NOR 17	NOR 23
43	White Sands	NOR 05	NOR 35
45	Edwards AFB	EDW 22	EDW 04

Table 3: Landing Site Table

3.7.6 ENTRY TRAJ

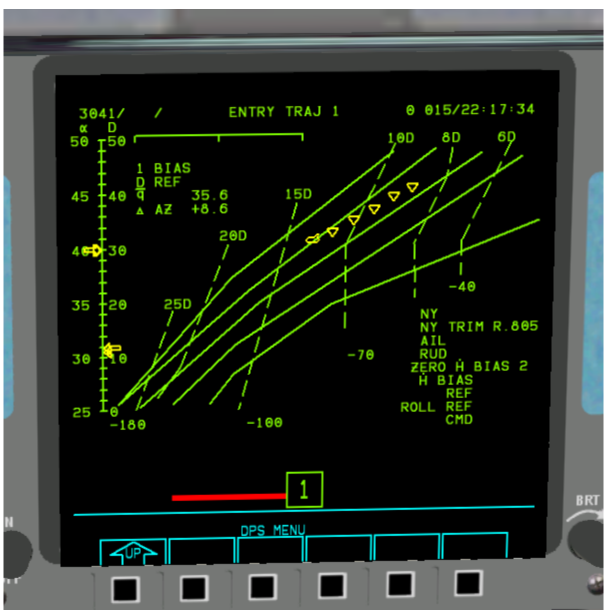


Figure 10: ENTRY TRAJ display

These displays are used during entry to monitor the vehicle's trajectory. Currently the only digital outputs being driven are the q-bar, delta-AZ and NY outputs. The guidance box and trailers are not displayed, the phugoid scale is not driven and no item entries are supported.

3.7.7 VERT SIT

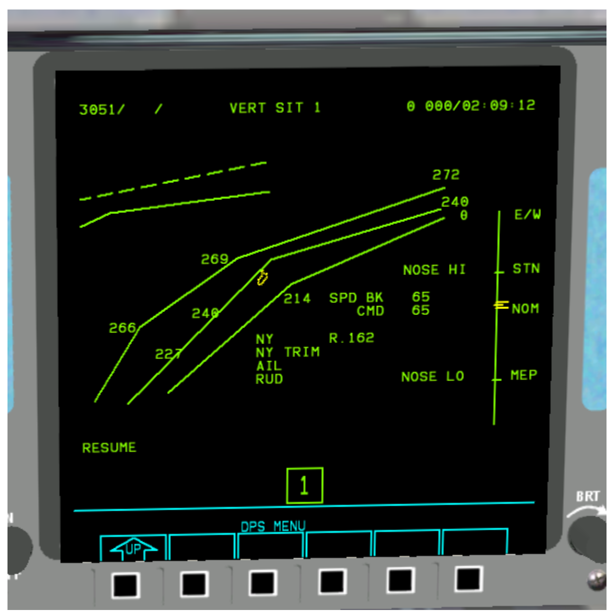


Figure 11: VERT SIT display

These displays are used during TAEM to monitor the vehicle's trajectory. Currently the only digital outputs being driven are the SPD BK, SPD BK CMD and NY outputs. The Theta scale and the E/W scale are not driven.

3.7.8 HORIZ SIT

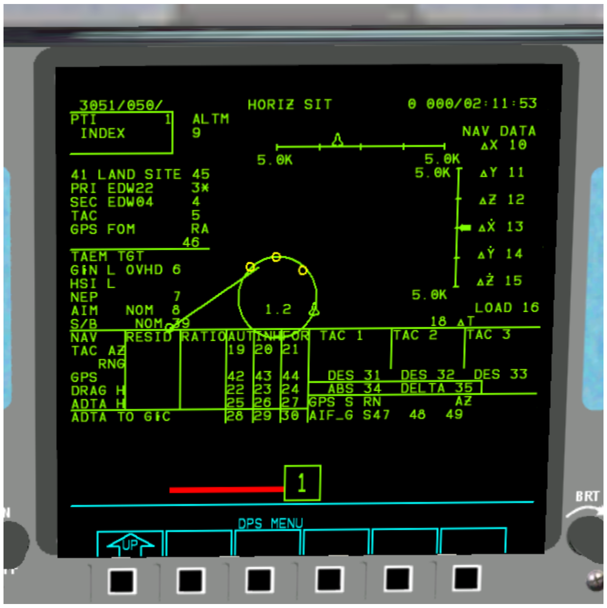


Figure 12: HORIZ SIT display

This display is used during deorbit and entry to specify the landing site and monitor the position of the shuttle relative to the HAC and the runway. The HORIZ SIT display in SSU is simplified compared to the real life version. Currently the vertical error scale is not driven prior to A/L interface, and only ITEMs 3, 4, 6, 8, 39 and 41 are supported. ITEM 41 selects the landing site, ITEMs 3 and 4 switch between the primary and secondary runway. ITEM 6 switches between a straight-in and overhead approach, ITEM 8 switches the aim point between nominal and close, and ITEM 39 switches between nominal, short and ELS (Emergency Landing Site) speedbrake configurations for final approach. These parameters all affect the entry autopilot, so they should be set before Entry Interface (EI). Table 3 shows the list of landing sites currently supported by SSU.

3.8 MEDS Displays

Contents

3.8.1 A/E PFD

Figure 13: A/E PFD

The Ascent/Entry Primary Flight Director display shows several parameters relevant to Ascent and Entry. Currently the attitude error needles are not properly driven, so they are not to be trusted. The ADI is operating in LVLH mode only with yaw zeroed, so the ADI ATT switches have no effect. During TAEM, and up until A/L interface, the vertical position error is not being driven, and the heading error is not being driven. The HSI is missing all the bearing pointers, and during launch it is not referenced from the target plane. The X-Trk value is not being driven.

3.8.2 ORBIT PFD

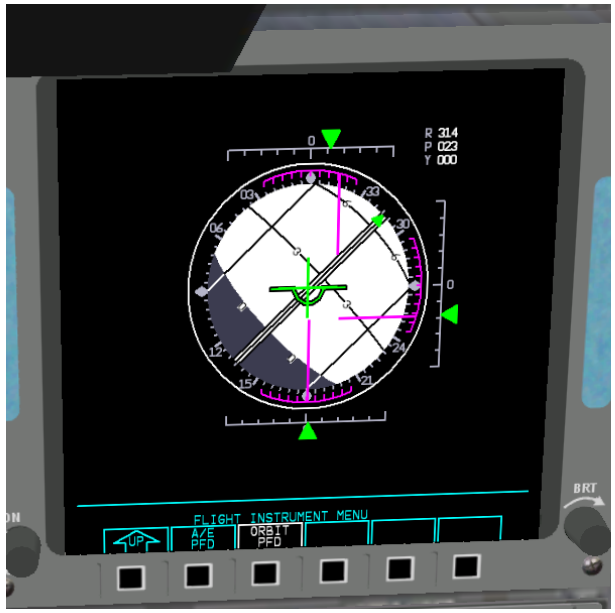


Figure 14: Orbit PFD

The Orbit Primary Flight Director is used for on-orbit display of vehicle attitude. Currently the attitude error needles currently are not being driven properly, so they are not to be trusted. The ADI currently operates only in the LVLH mode with yaw zeroed, so the ADI ATT switches have no effect.

3.8.3 OMS/MPS

Figure 15: OMS/MPS display

The OMS/MPS display provides information about various pressures in the OMS and MPS systems. The OMS He TK P and N2 TK P meters are not driven.

3.8.4 APU/HYD

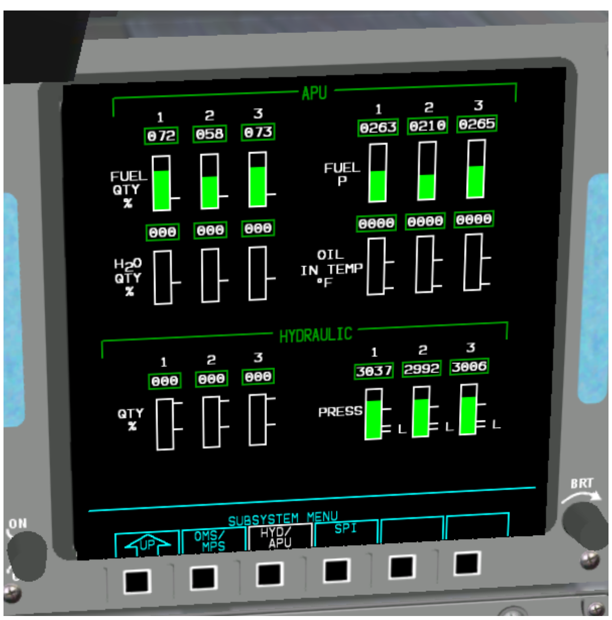


Figure 16: APU/HYD display

The APU/HYD display shows pressures, quantities and temperatures related to the hydraulic system. The APU H2O QTY %, OIL IN TEMP °F and HYDRAULIC QTY % meters are not driven.

3.8.5 SPI

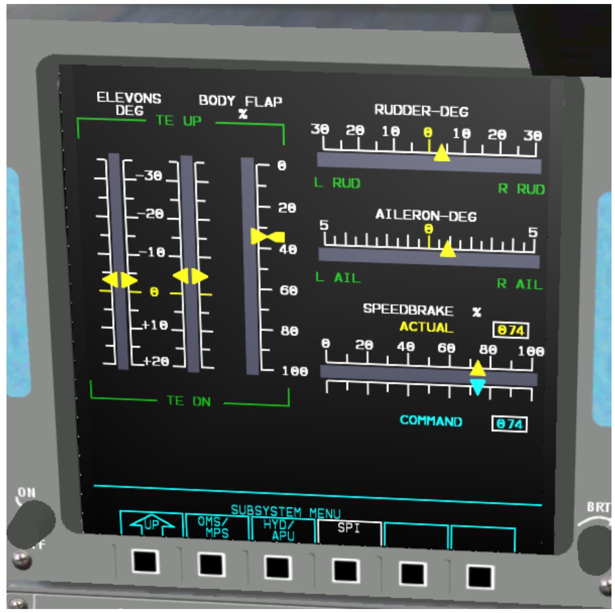


Figure 17: SPI display

The SPI display shows the position of the orbiter's aerosurfaces. The BODY FLAP % indicator is non-functional.

3.9 Launch Pads

SSU can be launched from 2 launch pads: Launch Complex 39 (LC39) at the Kennedy Space Center in Florida, or Space Launch Complex 6 (SLC-6) at the Vandenberg Air Force Base in California.

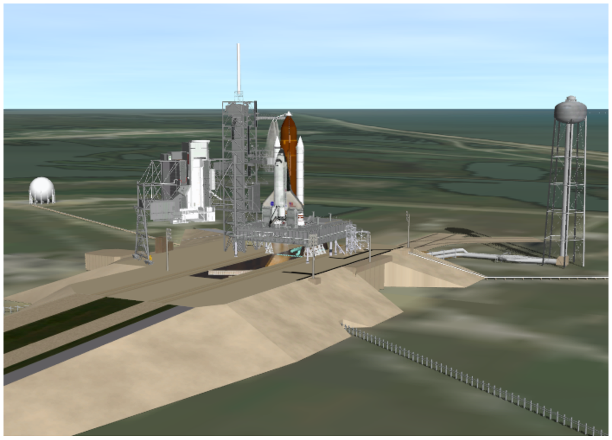


Figure 18: Launch Complex 39

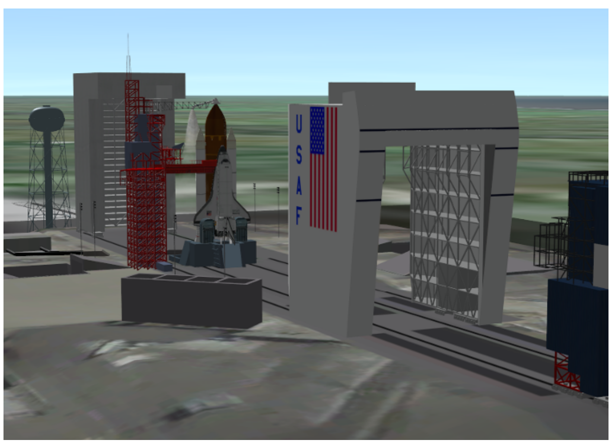


Figure 19: Space Launch Complex 6

Most pad structures are controlled automatically during the countdown, but manual control is available for all of them via a dialog window which is opened by the keys Ctrl+Space.
The scenario file entries needed to define the launch pad vessels are covered in Section 7 of this manual.

4 UPPER STAGES

Contents

Currently SSU supports the 2 biggest and more powerful Space Shuttle upper stages: the Centaur and the Inertial Upper Stage. These 2 upper stages allow the Space Shuttle Ultra add-on to launch payloads to anywhere from GEO to the depths of the Solar System.

4.1 Centaur

Contents

4.1.1 Description

In the 1980s, NASA modified the Centaur upper stage with the intent to use it aboard the Space Shuttle to increase the payload capability of space probes and GEO satellites.

Two versions were developed: the Centaur G version was primarily for GEO satellite deployment missions, and the larger, more powerful Centaur G Prime for interplanetary payloads. In the aftermath of the Challenger accident, the Centaur was no longer considered safe enough to be used by the Space Shuttle, and so it was abandoned.

Thrust is provided by 2 RL-10 engines, and the Attitude Control System (ACS) allows 3-axis control of the stage, and also translation in the +Z direction (forward).

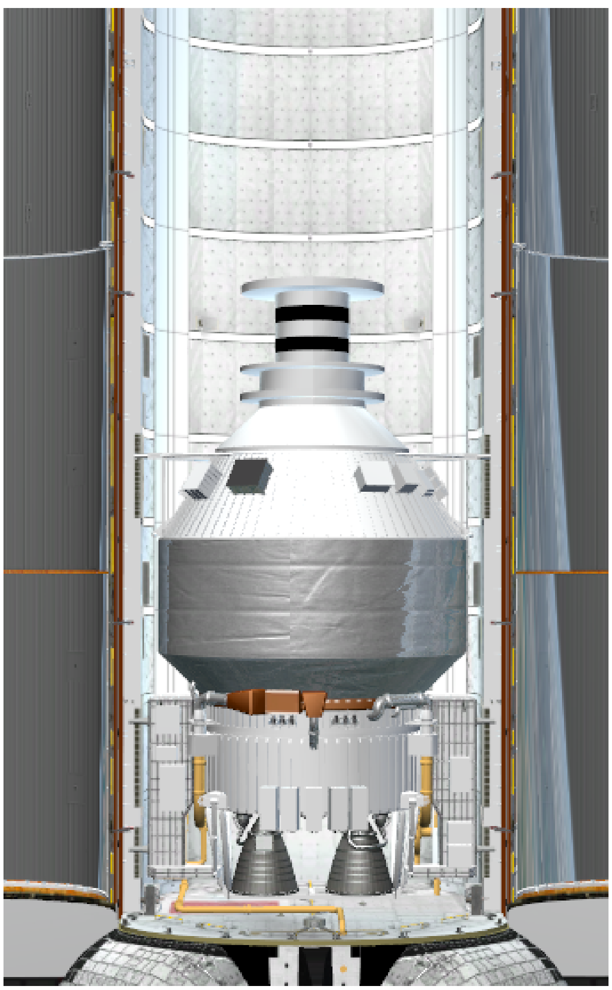


Figure 20: Centaur G installed in the payload bay with SSU_DemoSat

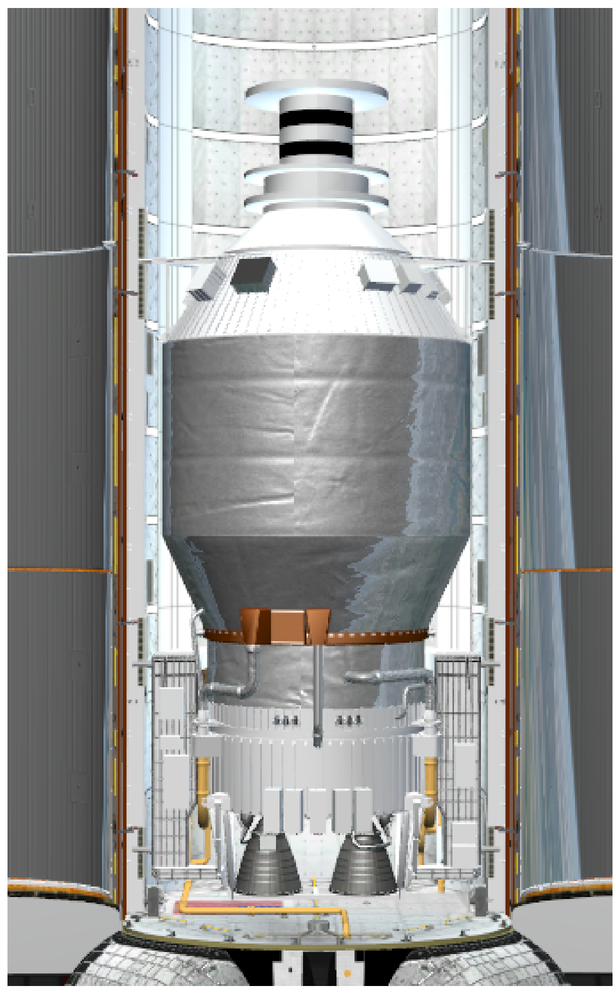


Figure 21: Centaur G Prime installed in the payload bay with SSU_DemoSat

4.1.2 Performance

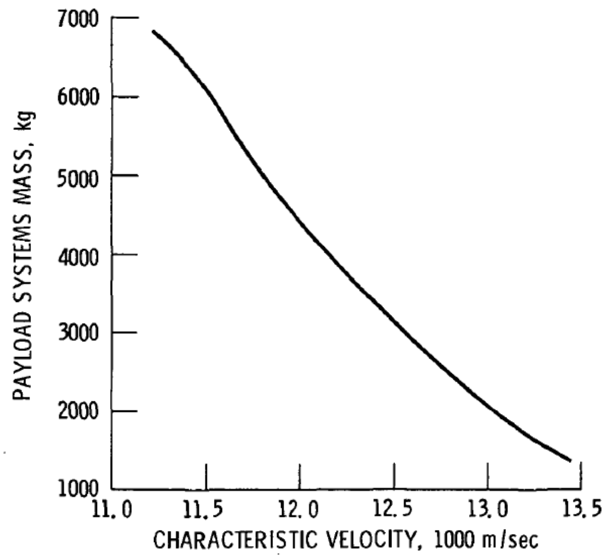


Figure 22: Centaur G payload capability for an Earth-escape trajectory

Although the Centaur G is suited for GEO satellite missions, it is also capable of launching spacecraft into Earth-escape trajectories. A plot of payload mass versus characteristic velocity achievable with the Centaur G in shown in figure 22.

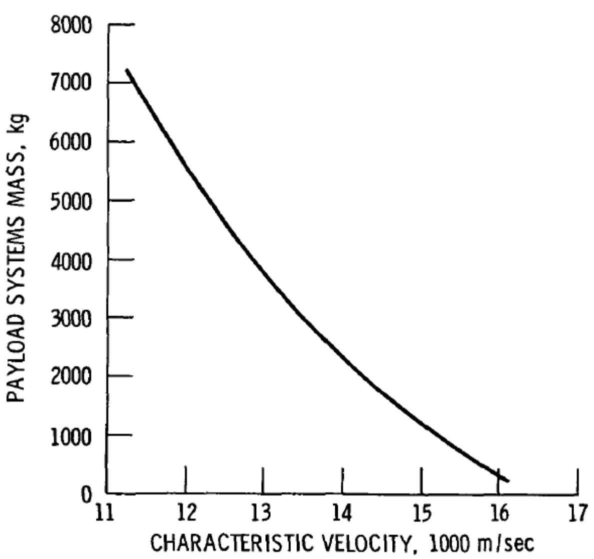


Figure 23: Centaur G Prime payload capability for an Earth-escape trajectory

The greater propellant capability of the Centaur G Prime gives it the performance needed to launch heavy spacecraft to other planets. A plot of payload mass versus characteristic velocity achievable with the Centaur G Prime in shown in figure 23.
Figure 24 shows the allowable payload envelope for both Centaur versions. The higher performance of the Centaur G Prime comes at a cost in allowable payload volume.

4.1.3 Centaur Integrated Support Structure

The Centaur Integrated Support Structure (CISS) is the interface between the Centaur stage and the orbiter vehicle. Before Centaur deployment, the CISS provides the Centaur with fluid connections for propellant loading and dumping, electrical power and communications, and serves to secure it inside the payload bay. The CISS has a tilt table, to which the Centaur is attached, allowing it to be raised above the payload bay for deployment.

4.1.4 Deployment

The deployment sequence is similar for both Centaur versions, and is controlled by panel L12U. A checklist is available in section 5.
Inhibits are placed on the operation of the ACS and of the RL-10 engines, as to protect the orbiter vehicle. At deployment, timers are started to remove those inhibits. The status of those timers is displayed in the SSU_Centaur MFD (Ctrl+T), as well as the remaining ACS propellant.

4.1.5 Autonomous flight control

After separation from the CISS and the engine inhibits have been removed, the Centaur is controlled by using the standard Orbiter keys. The "+" key is used to initiate the start sequence for the RL-10 engines. The start sequence is a 270-second chill-down of the RL-10s concurrent with a propellant settling burn by the forward-thrusting ACS. After the chill-down is complete, RL-10 ignition occurs automatically. After the start sequence is initiated, the time remaining until ignition is shown in the SSU_Centaur MFD. Currently there are no restrictions on the number of times the RL-10 engines can be started. The "-" key is used to shutdown the engines once the desired ΔV has been achieved. During RL-10 burns the attitude in completely controlled by gimballing the engine nozzles.

WARNING

Engine gimballing is much more powerful than the ACS, so it must be used carefully so the stage is not put into a tumble that might be impossible for the ACS to correct after the burn.

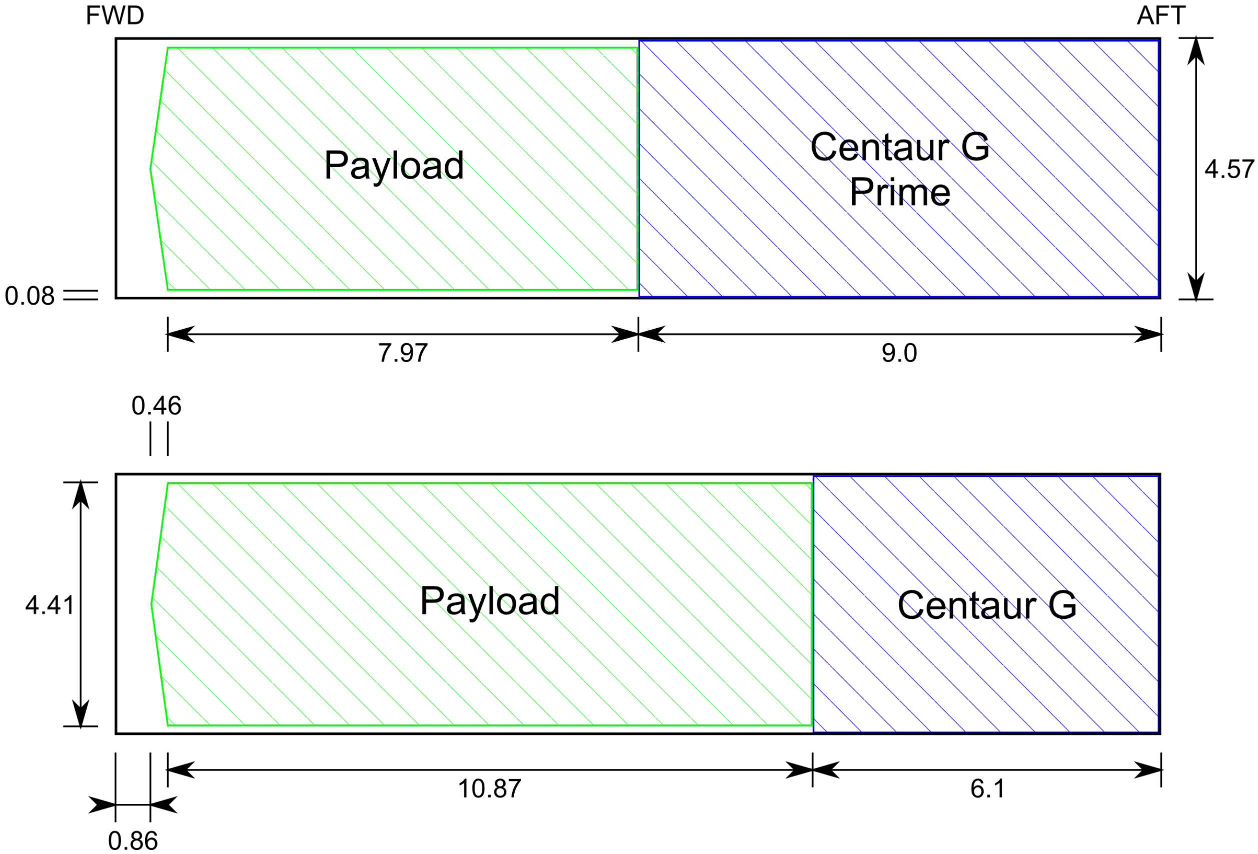


Figure 24: Centaur G and G Prime payload envelope (dimensions in meters)

Manual command for the engine gimbal is available and when there is no user input, the rates will be automatically nulled. After all the necessary burns are performed, payload separation is done by pressing the "Ctrl+J" key combination.

4.1.6 Payload Interface

The connection between the Centaur and its payload is done using a payload adapter. Its exclusive purpose is to interface the payload with the Centaur and is considered a part of the payload, even though on payload deployment the adapter remains with the Centaur.
The payload adapter is specified in the Centaur vessel section of the scenario file (section 7). For Centaur payload developers, the payload adapter must be 2.74 meters in diameter at the Centaur end, to correctly interface with the stage. The payload adapter can be a solid tapered cone as shown in figures 20 and 21 or a grid structure. SSU includes a demonstration payload adapter for interfacing the Centaur with SSU_DemoSat.

4.2 Inertial Upper Stage

Contents

4.2.1 Description

The Inertial Upper Stage, or IUS, is a 2-stage solid propellant vehicle used in several Space Shuttle missions to boost satellites into GEO and space probes into Earth escape trajectories.

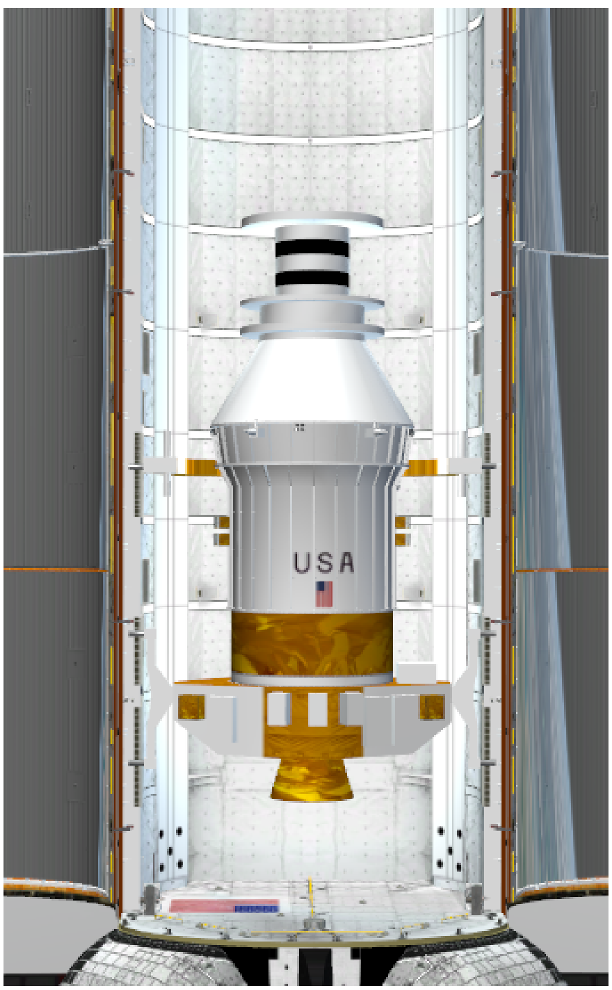


Figure 25: Inertial Upper Stage installed in the payload bay with SSU_DemoSat

Thrust is provided by one Solid Rocket Motor (SRM) in each stage, and the Reaction Control System (RCS) allows 3-axis control of the stage, and also translation in the +Z direction (forward).

4.2.2 Configuration

The IUS can be installed in the payload bay in 2 possible positions: the forward position or the aft position (for large payloads). The position choice is defined in the mission file (section 6).
The standard IUS configuration features 2 RCS tanks each with 55Kg of propellant. An additional tank can be used, for a total of 3, or only one tank can be used to reduce mass. In addition to the standard 2 omni-directional antennas in the 2^{nd} stage, a further 2 can be added, for a total of 4. Due to the nature of the solid propellant motors, fine control of the ΔV is impossible during the burn, so the propellant quantity must be carefully set. Both SRMs have the capability to be offloaded up to 50%.
The number of RCS tanks, omni-directional antennas and SRM propellant offload quantity are controlled by scenario file parameters (section 7).

4.2.3 Performance

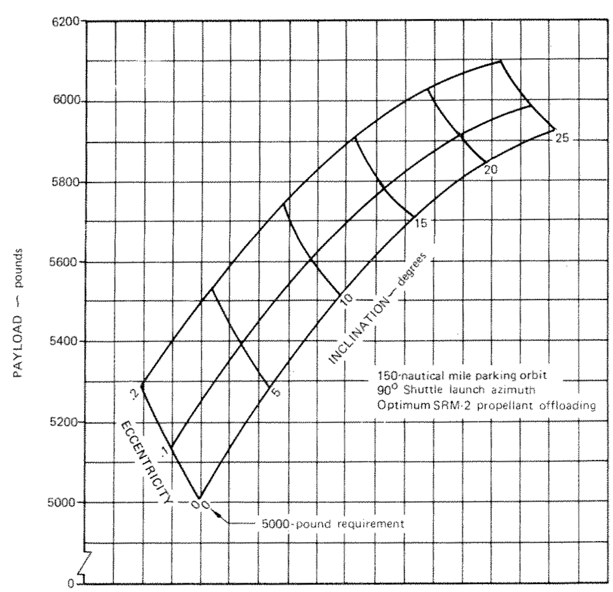


Figure 26: IUS payload capability to GEO

Specially suited for GEO missions, the IUS was designed to insert a 5000-pound (2268 Kg) payload into geostationary orbit. It can however launch heavier payloads at the expense of final orbit eccentricity and/or inclination. The relationship between payload mass and the corresponding achievable orbital parameters for a GEO mission is shown in figure 26.

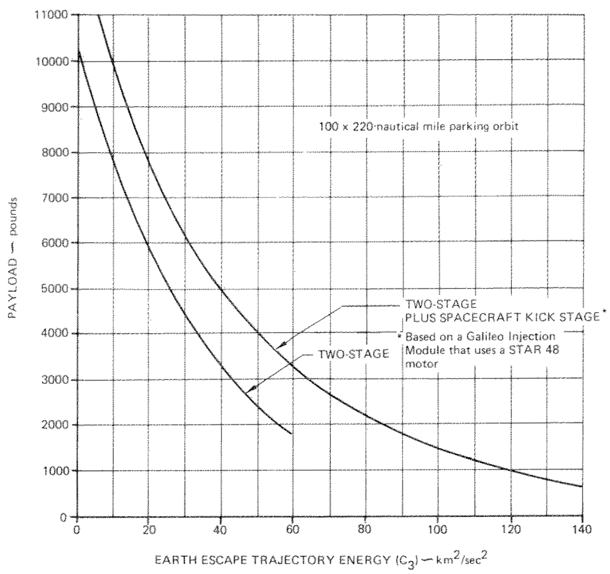


Figure 27: IUS payload capability for an Earth-escape trajectory

Although designed for Earth-orbit missions, the IUS can also inject spacecrafts into low-energy Earth-escape trajectories. More capability can be obtained by including an additional stage in the spacecraft. The payload capability of the IUS versus C3 energy is presented in figure 27.

Figure 28 shows the allowable payload envelope for both IUS positions. While the aft IUS position allows a payload with greater volume to be carried, it should only be used when necessary due to orbiter vehicle c.g. concerns.

4.2.4 Airborne Support Equipment

The Airborne Support Equipment (ASE) is the interface between the IUS and the orbiter vehicle. Before IUS deployment, the ASE provides the IUS with electrical power and communications, and serves to secure it inside the payload bay. The ASE has a tilt table, to which the IUS is attached, allowing it to be raised above the payload bay for deployment. The ASE also has a boom-mounted IUS umbilical, that must be released before IUS deployment.

4.2.5 Deployment

The IUS deployment sequence is controlled by panel L10.
TODO
Inhibits are placed on the operation of the RCS and of the 1^{st} stage motor, as to protect the orbiter vehicle. At deployment, timers are started to remove those inhibits. The status of those timers is displayed in the SSU_IUS MFD (Ctrl+T), as well as the remaining RCS propellant.

4.2.6 Autonomous flight control

After separation from the ASE and the engine inhibits have been removed, the IUS is controlled by using the standard Orbiter keys. The "+" key is used to ignite the SRMs. During SRM burns the attitude in the pitch and yaw axis is controlled by gimballing the engine nozzle, while roll remains under RCS control.

WARNING
Engine gimballing is much more powerful than the RCS, so it must be used carefully so the stage is not put into a tumble that might be impossible for the RCS to correct after the burn.

Manual command for the engine gimbal is available and when there is no user input, the rates will be automatically nulled. Once ignited, the SRMs will burn to depletion.
After 1^{st} stage burnout, its separation is done by pressing the "Ctrl+G" key combination. After 1^{st} stage separation, the Extendable Exit Cone in the 2^{nd} stage will automatically deploy.
At the end of each SRM burn, the RCS can be used for velocity fine tuning.
After all the burns are performed, payload separation is done by pressing the "Ctrl+J" key combination.

4.2.7 Payload Interface

The connection between the IUS and its payload is done using a payload adapter. Its exclusive purpose is to interface the payload with the IUS and is considered a part of the payload, even though on payload deployment the adapter remains with the IUS.
The payload adapter is specified in the IUS vessel section of the scenario file (section 7). For IUS payload developers, the payload adapter must be 2.89 meters in diameter at the IUS end, to correctly interface with the stage. The payload adapter can be a solid tapered cone as shown in figure 25 or a grid structure. SSU includes a demonstration payload adapter for interfacing

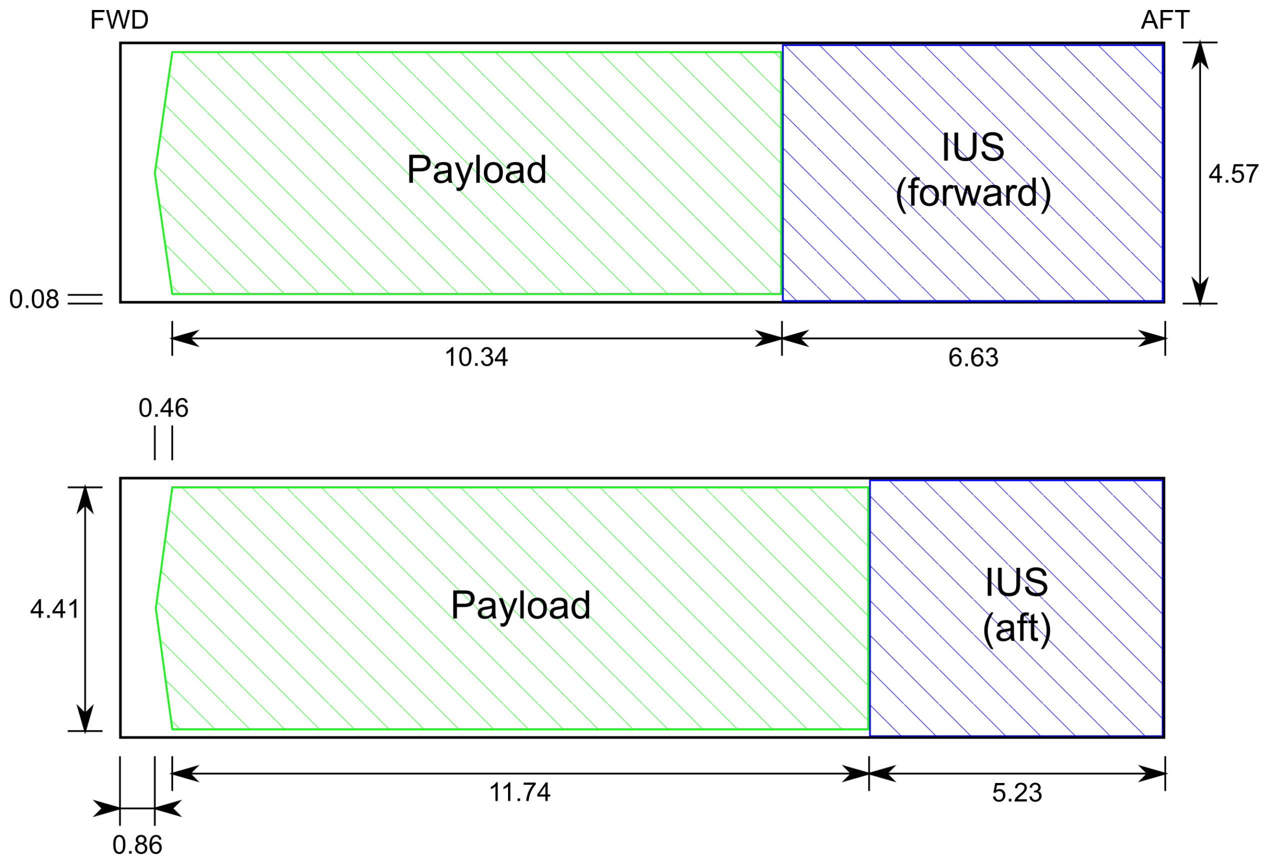


Figure 28: IUS payload envelope (dimensions in meters)

the IUS with SSU_DemoSat.

5 FLIGHT DATA FILES

Contents

In this section, checklists are provided for some activities.

5.1 Centaur Deploy Procedures

Panel and CISS activation

L12U SSP PRI(BKUP) PWR – ON
MECH PRI(BKUP) PWR – ON (mom)
✓MECH PRI(BKUP) PWR tb – gray

Raise Tilt Table

L12U LOGIC PRI(BKUP) PWR – ON (mom)
DA PRI(BKUP) ROT – UP (mom)
✓DA PRI(BKUP) ROT tb – bp

✓DA PRI(BKUP) ROT tb – gray (after ~5:00)
LOGIC PRI(BKUP) PWR – OFF (mom)

Centaur deploy

L12U SUPERZIP* PRI(BKUP) – ARM
✓SUPERZIP* PRI(BKUP) tb – gray

SUPERZIP* PRI(BKUP) – FIRE (mom)

SUPERZIP* PRI(BKUP) – SAFE
✓SUPERZIP* PRI(BKUP) tb – bp

Lower Tilt Table

L12U LOGIC PRI(BKUP) PWR – ON (mom)
DA PRI(BKUP) ROT – DN (mom)
✓DA PRI(BKUP) ROT tb – bp

✓DA PRI(BKUP) ROT tb – gray (after ~5:00)
LOGIC PRI(BKUP) PWR – OFF (mom)

Panel and CISS deactivation

L12U MECH PRI(BKUP) PWR – OFF (mom)
✓MECH PRI(BKUP) PWR tb – bp
SSP PRI(BKUP) PWR – OFF

5.2 IUS Deploy Procedures

6 MISSION FILES

Contents

6.1 General

Space Shuttle Ultra uses the mission file to specify several parameters about the vehicle and the mission. Mission files are declared in the scenario file with the entry ”MISSION” followed by the name of the mission file, and must be placed in the directory ”<orbiter_installation>\Missions\SSU”.
Parameter values are specified by having the parameter name, followed by the equal sign and then the value. Parameters not specified in the mission file will use a hardcoded default value. Here is an example mission file for simulation of mission STS-107:

Name=STS-107
Orbiter=Columbia
OrbiterTexture=Columbia_8thmod
TargetInc=39.000000
TargetLAN=0.000000
MECOAlt=105564.000000
MECOVel=7882.719007
MECOFPA=0.827612
PerformRollToHeadsUp=TRUE
OMSAssistEnable=TRUE
OMSAssistDuration=102.000000
MaxSSMEThrust=104.5
ThrottleDown=843.333
ThrottleUp=1154.266
UseRMS=FALSE
UseKUBand=TRUE
UseSTBDMPM=FALSE
UseODS=FALSE
UseExtAL=FALSE
UseTAA=TRUE
AftTAA=FALSE
HasBulkheadFloodlights=TRUE
HasDragChute=TRUE
Bridgerails=2,3,7,9,11
SILTS=TRUE
LogSSMEData=FALSE
UseCISS=FALSE
CISS_GPrime=TRUE
UseASE_IUS=FALSE
ASE_IUS_AftLocation=FALSE
InternalPRSDTankSets=5
HasEDOKit=TRUE
EDOPallets=1

The SSU installation already has some mission files for the included scenarios.

6.2 Parameter List

Option Name	Type	Description	Default
Name	String	Mission name	-
Orbiter	String	Orbiter name (also determines orbiter vehicle empty mass and default texture), valid values: ”Columbia”, ”Challenger”, ”Discovery”, ”Atlantis”, ”Endeavour”	Atlantis
OrbiterTexture	String	Orbiter texture name (located in ”<orbiter_installation>\Textures\SSU”). Currently available textures for each Orbiter: Columbia: $\Rightarrow$ ”Columbia_original”, ”Columbia_8thmod” Challenger: $\Rightarrow$ ”Challenger_original” Discovery: $\Rightarrow$ ”Discovery_original”, ”Discovery_9thmod” Endeavour: $\Rightarrow$ ”Endeavour_original”, ”Endeavour_3rdmod” Atlantis: $\Rightarrow$ ”Atlantis_original”, ”Atlantis_5thmod”	(the last on each Orbiter list)
LOMSPodTexture	String	Name of left OMS pod texture (located in ”<orbiter_installation>\Textures\SSU”)	-
ROMSPodTexture	String	Name of right OMS pod texture (located in ”<orbiter_installation>\Textures\SSU”)	-
TargetInc	Number	Target inclination for MECO (deg)	28.5
MECOAlt	Number	Target altitude for MECO (m)	105564
MECOVel	Number	Target velocity for MECO (m/s)	7869.635088
MECOFPA	Number	Target flight path angle for MECO (deg)	0.747083
PerformRollToHeadsUp	Boolean	Roll to heads up is performed	FALSE
OMSAssistEnable	Boolean	OMS assist burn is performed	FALSE
OMSAssistDuration	Number	OMS assist burn duration (seconds)	102
MaxSSMEThrust	Number	Maximum SSME throttles commanded by GPC (%)	104.5
ThrottleDown	Number	1^{st} stage SSME throttle down velocity (fps)	792
ThrottleUp	Number	1^{st} stage SSME throttle up velocity (fps)	1304
UseRMS	Boolean	RMS is installed	FALSE
UseKUBand	Boolean	KU-Band antenna is installed	FALSE
UseSTBDMPM	Boolean	Starboard MPMs are installed	FALSE
UseODS	Boolean	ODS is installed	FALSE
UseExtAL	Boolean	OV has external airlock	FALSE
UseTAA	Boolean	Tunnel Adapter Assembly is installed	FALSE
AftTAA	Boolean	Tunnel Adapter Assembly is installed aft of the External Airlock	FALSE
HasBulkheadFloodlights	Boolean	Forward bulkhead floodlight and docking light are installed (Discovery and Endeavour only, always installed on others)	TRUE
HasDragChute	Boolean	OV has drag chute	FALSE

Bridgerails	Comma-separated numbers	Comma-separated list of numbers indicating which bridgerails are present. Each number in list should be between 0 and 12 inclusive	-
PayloadZPos<N>	Number	The Z coordinate (in the Orbitersim frame) of payload attachment point N. N = 5-7 $\rightarrow$ Centerline active attachment N = 8-11 $\rightarrow$ Centerline passive attachment N = 12-15 $\rightarrow$ Port attachment N = 16-19 $\rightarrow$ Starboard attachment	-
SILTS	Boolean	SILTS pod (Columbia only)	FALSE
LogSSMEData	Boolean	Enables SSME data logging	FALSE
UseCISS	Boolean	CISS is installed	FALSE
CISS_GPrime	Boolean	CISS installed is for Centaur G Prime	TRUE
UseASE_IUS	Boolean	ASE for the IUS is installed (is TRUE, the UseCISS parameter is ignored)	FALSE
ASE_IUS_AftLocation	Boolean	ASE for the IUS is installed in the aft position	FALSE
InternalPRSDTankSets	Number	Number of Internal PRSD Tank Sets (min 2, max 5)	5
HasEDOKit	Boolean	EDO hardware is installed in the OV (Columbia and Endeavour only)	FALSE
EDOPallets	Number	Number of EDO pallets installed in the PLB (Columbia and Endeavour only, max 1 for Columbia, 2 for Endeavour)	0

Table 4: Mission File Parameters

7 SCENARIO FILES

Contents

Space Shuttle Ultra uses the scenario file to define the state of the associated vessels. The next sections will provide an list of available parameters (in addition to the default Orbiter ones) for each SSU vessel.

7.1 Space Shuttle Ultra orbiter Parameter List

Space Shuttle Ultra orbiter vessel. Versions available:
SpaceShuttleUltra

TODO

7.2 External Tank Parameter List

External Tank vessel. Versions available:
ET_SWT → the original External Tank
ET_LWT → the Light Weight External Tank
ET_SLWT → the Super-Light Weight External Tank

PRPLEVEL 0:0.996000 → propellant level
ATTACHED 0:20,Atlantis → attachment to *SpaceShuttleUltra* vessel
FRL → add Fire Retardant Latex paint (only for *ET_SWT*)

7.3 Solid Rocket Booster Parameter List

Solid Rocket Booster vessel. Versions available:
SSU_LSRB and *SSU_RSRB* → SRB with the High Performance Motor SRM
SSU_LSRB_FWC and *SSU_RSRB_FWC* → SRB with the Filament Wound Case SRM
SSU_LSRB_RSRM and *SSU_RSRB_RSRM* → SRB with the Redesigned SRM

ATTACHED 0:21,Atlantis → attachment to *SpaceShuttleUltra* vessel (only for *SSU_LSRB* or *SSU_LSRB_FWC* or *SSU_LSRB_RSRM*)
ATTACHED 0:22,Atlantis → attachment to *SpaceShuttleUltra* vessel (only for *SSU_RSRB* or *SSU_RSRB_FWC* or *SSU_RSRB_RSRM*)
PRPLEVEL 1:1.000000 → propellant level
SECTION_COUNT → not used

7.4 Launch Control Center Parameter List

Launch Control Center vessel. Versions available:
SSU_LCC

LAUNCH_MJD → MJD of launch
PAD_NAME → name of the *SSU_Pad* or *SSU_Pad1985* or *SSU_SLC6* vessel
SHUTTLE_NAME → name of *SpaceShuttleUltra* vessel

7.5 Launch Complex 39 Parameter List

Launch Complex 39 vessel. Versions available:
SSU_Pad → the Launch Complex 39 for more recent launches
SSU_Pad1985 → the Launch Complex 39 for the early launches

ACCESS_ARM → animation state for the OAA
GVA → animation state for the GO2 Vent Arm
VENTHOOD → animation state for the GO2 Vent Hood
FSS_OWP → animation state for the FSS mounted OWP (only for *SSU_Pad*)
RSS_OWP → animation state for the RSS mounted OWP (only for *SSU_Pad*)
RBUS → animation state for the RBUS (only for *SSU_Pad1985*)
RSS → animation state for the RSS
FSS_GH2 → animation state for the GH2 Vent Arm
FSS_IAA → animation state for the Intertank Access Arm
EAST_SRB_SFD → animation state for the East SRB Side Flame Deflector
WEST_SRB_SFD → animation state for the West SRB Side Flame Deflector
SHUTTLE → name of *SpaceShuttleUltra* vessel

7.6 Mobile Launcher Platform Parameter List

Mobile Launcher Platform vessel. Versions available:
SSU_MLP

ATTACHED 0:0,LC39A → attachment to the *SSU_Pad* or *SSU_Pad1985* vessels
T0_UMB → animation state for the T0 umbilical

7.7 Space Launch Complex 6 Parameter List

Space Launch Complex 6 vessel. Versions available:
SSU_SLC6

ACCESS_ARM → animation state for the OAA
VENT_ARM → animation state for the GO2 Vent Arm
VENT_HOOD → animation state for the GO2 Vent Hood
GH2_VENTLINE → animation state for the GH2 Vent Arm
IAA → animation state for the Intertank Access Arm
T0_UMB → animation state for the T0 umbilical
PCR → animation state for the Payload Changeout

Room
SAB → animation state for the Shuttle Assembly Building
SABDoor → animation state for the Shuttle Assembly Building Door
MST → animation state for the Mobile Service Structure

7.8 Centaur G Parameter List

Centaur G vessel. Versions available:
SSU_CentaurG → optimized for GEO missions
SSU_CentaurGPrime → optimized for Earth-escape missions

ADAPTER_MESH → defines the path and filename of the mesh file of the adapter
ADAPTER_OFFSET → defines the offset between the Centaur and the payload in meters (effectively the height of the adapter)
ADAPTER_MASS → defines the mass of the adapter in kilograms

7.9 Inertial Upper Stage Parameter List

Inertial Upper Stage vessel. Versions available:
SSU_IUS

STAGE2 → is present, the 1st stage has been jettisoned
EEC → animation state for the Extendable Exit Cone
LOAD_STAGE1 → controls 1st stage SRM propellant load (range is between 0.5 (50% offload) and 1.0 (0% offload))
LOAD_STAGE2 → controls 2nd stage SRM propellant load (range is between 0.5 (50% offload) and 1.0 (0% offload))
RCS_TANKS → defines number of RCS tanks present (default is 2, range is between 1 and 3)
FOUR_ANTENNAS → if present, 4 omni-directional antennas will be shown, as opposed to the default 2 antennas
ADAPTER_MESH → defines the path and filename of the mesh file of the adapter
ADAPTER_OFFSET → defines the offset between the IUS and the payload in meters (effectively the height of the adapter)
ADAPTER_MASS → defines the mass of the adapter in kilograms

8 CHANGE LOG

Major changes from SSU 4.2

→ updated SSU to run in Orbiter 2016
→ integrated CRTMFD into the SpaceShuttleUltra vessel
→ moved HUD outputs in IUS and Centaur into own MFDs
→ extensive overhaul of the CRTMFD displays: corrected MDU screen aspect ratio, all displays reworked and converted to 512x512 resolution, separate code for MOGE and D3D9, added fonts, improved resource allocation, blue hue in the background, added brightness control
→ improved CRT keyboard data entry
→ improved memory cleanup on exit
→ updated all 7-segment displays to the "UV system"
→ updated all talkbacks to the "UV system"
→ improved VC mesh performance
→ corrected position of White Sands surface base
→ added manual control capability during ascent
→ added FCS lights checkout in MM801
→ improved RHC, THC and SBTC simulation and added RPTA
→ fixed pad lights glare
→ changed IUS and Centaur engine gimbal to be rate command
→ fixed several RMS issues
→ improved HUD symbols
→ corrected PLBD animation
→ fixed left elevon and rudderspeedbrake animations
→ finished ADI ball meshtexture for D3D9
→ added initial PDRS implementation (allows configuration of number of tank sets, but tank mass remains constant during the mission)
→ added capability to display EDO pallet in payload bay
→ added RMS master alarm, triggered when reach limits are exceeded
→ corrected GVA retraction time
→ improved ODS panel power logic
→ updated existing, and added all remaining, PBIs and lights to the "UV system"
→ corrected scenarios
→ corrected forward bulkhead hatch cover position
→ corrected Orbiter mesh

9 ACRONYM LIST

ACS	Attitude Control System
APU	Auxiliary Power Unit
BFS	Backup Flight System
CDR	Commander
CISS	Centaur Integrated Support Structure
CRT	Cathode Ray Tube
DAP	Digital Autopilot
DPS	Data Processing System
EE	End Effector
EEC	Extendable Exit Cone
EI	Entry Interface
ET	External Tank
EVA	Extra Vehicular Activity
FCS	Flight Control System
FE	Flight Engineer
FRL	Fire Retardant Latex
FWC	Filament Wound Case
GNC	Guidance, Navigation and Control
GPC	General Purpose Computer
HPM	High Performance Motor
HUD	Heads-Up Display
IUS	Inertial Upper Stage
LC	Launch Complex
LWT	Light Weight Tank
MDU	Multifunction Display Unit
MECO	Main Engine Cutoff
MM	Major Mode
MPM	Manipulator Positioning Mechanism
MPS	Main Propulsion System
MS	Mission Specialist
OAA	Orbiter Access Arm
OBSS	Orbiter Boom Sensor System
ODS	Orbiter Docking System
OMS	Orbital Maneuvering System
OV	Orbiter Vehicle
PASS	Primary Avionics Software System
PBI	Push-Button Indicator
PCR	Payload Changeout Room
PDRS	Payload Deploy and Retrieval System
PFD	Primary Flight Director
PLB	Payload Bay
PLBD	Payload Bay Door
PLT	Pilot
RBUS	Rolling-Beam Umbilical System
RCS	Reaction Control System
RHC	Rotational Hand Controller
RMS	Remote Manipulator System
RPTA	Rudder Pedal Transducer Assembly
RSRM	Redesigned Solid Rocket Motor
SAB	Shuttle Assembly Building
SBTC	Speedbrake/Thrust Controller

SCOM	Shuttle Crew Operations Manual
SILTS	Shuttle Infrared Leeside Temperature Sensing
SLC	Space Launch Complex
SLWT	Super Light Weight Tank
SM	Systems Management
SPM	Standard Performance Motor
SRB	Solid Rocket Booster
SRM	Solid Rocket Motor
SSME	Space Shuttle Main Engine
SSU	Space Shuttle Ultra
STS	Space Transportation System
SWT	Standard Weight Tank
TAEM	Terminal Area Energy Management
THC	Translational Hand Controller
TTA	Tunnel Adapter Assembly
VAB	Vehicle Assembly Building
VC	Virtual Cockpit

10 CREDITS

Space Shuttle Ultra was originally based on Space Shuttle Deluxe. Large parts of the launch autopilot were copied (with minor modifications) from PEG MFD. Some of the attitude control code was derived from Attitude MFD V3. SSU also uses the KOST library. Vandenberg base uses part of VandenbergAFB-2006 (`http://www.orbithangar.com/searchid.php?ID=2380`) by Usonian.

This addon is open-source and is released under the GNU GPL.