# SPACE SHUTTLE ULTRA

VERSION 1.XX REV. B

# SSU Operations Manual

August 8, 2015

# PREFACE

Space Shuttle Ultra (SSU) is an addon for Orbiter Space Flight Simulator. 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 2010 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.

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. KSC hires tiles (`http://www.orbithangar.com/searchid.php?ID=5583`)
3. Vandenberg AFB (`http://www.orbithangar.com/searchid.php?ID=2380`)

CRT MFD needs to be enabled (Orbiter Launchpad → Modules → check *CRT* box).

Using the D3D9 graphics client is strongly recommended (although not required). The *Enable geometry instancing* option in the D3D9 Advanced Setup dialog (Orbiter Launchpad → Video → Advanced) should be unchecked.

# 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.

**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.

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 $\sim$ 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

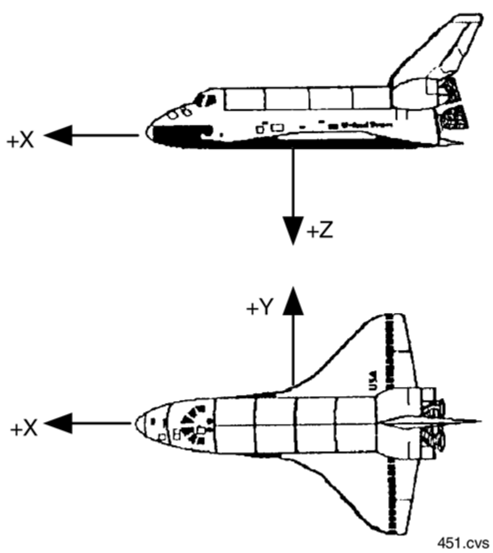



Figure 1: Body Axis Coordinate System (image from SCOM)

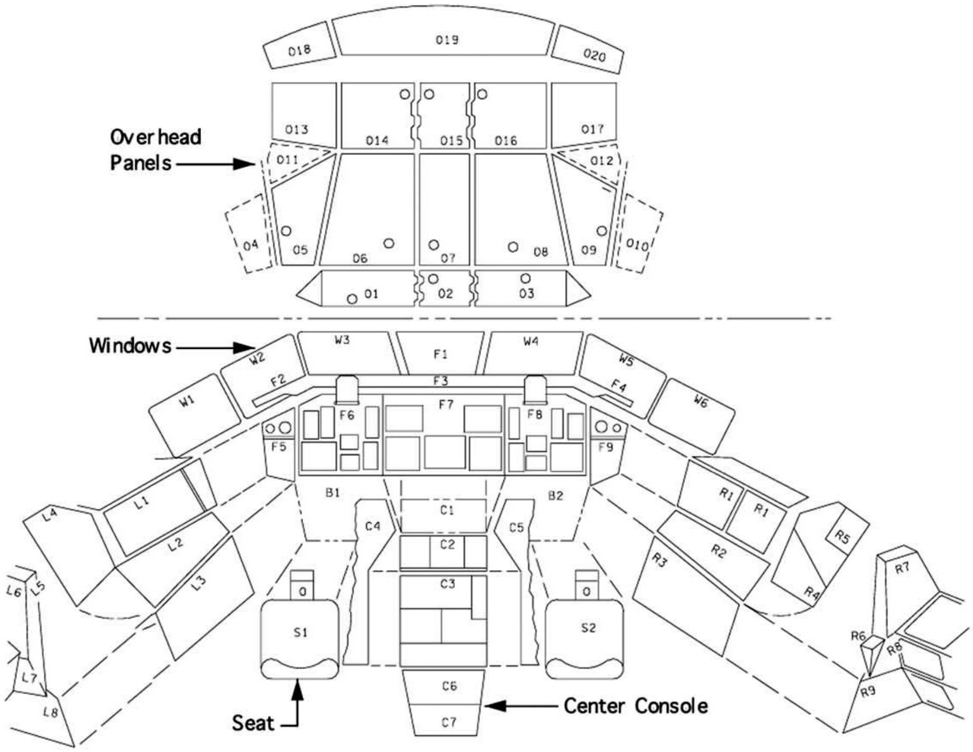
Figure 1 shows the shuttle Body Axis Coordinate system. This coordinate system is used in the NASA documents and checklists, as well as this manual. It should be noted that the Body Axis Coordinate frame is different from the normal Orbitersim frame.

### 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.

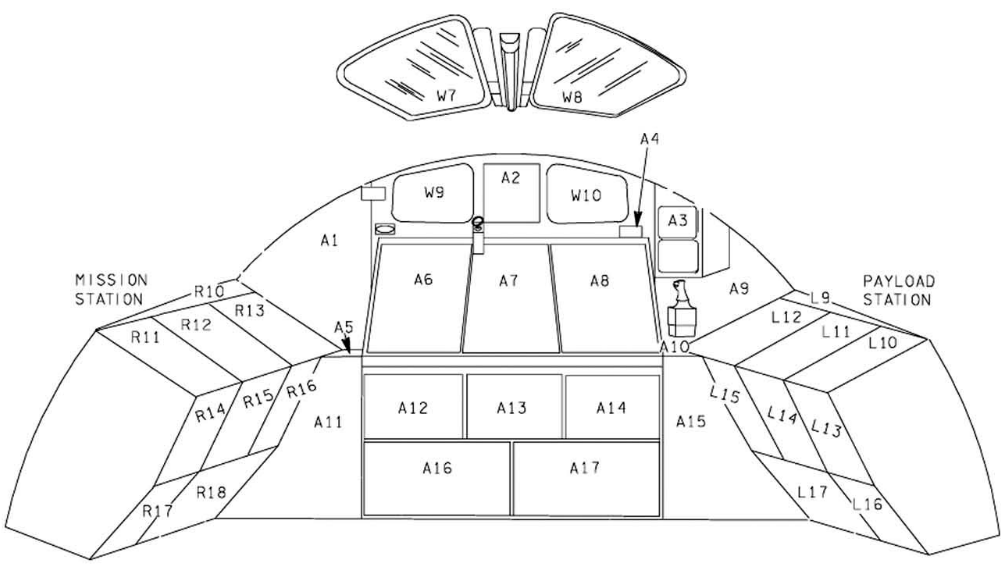
| SURFACES | NUMBERING PHILOSOPHY |
|---|---|
| L - Left<br>R - Right<br>C - Center Console | Numbered from top to bottom, forward to aft |
| O - Overhead | Numbered from left to right, forward to aft |
| F - Forward<br>A - Aft | Numbered left to right, top to bottom (facing the surface) |
| W - Windows | **Forward** (W1 through W6): numbered left to right facing forward<br>**Overhead** (W7 & W8): numbered left to right facing aft<br>**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 - open speedbrake by 5 percent
period - close speedbrake by 5 percent

**Alternate Translation Commands (valid only if RCS is in Rot mode)**
Left/Right Arrow - left/right translation (equivalent to 1/3 on Numpad)
Up/Down Arrow - up/down translation (equivalent to 8/2 on Numpad)
Insert/Delete - forward/aft translation (equivalent to 9/6 on Numpad)

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

### 2.2.2 RHC/THC

The regular Orbitersim thruster control commands (either keyboard or joystick) are used to simulate the RHC & 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 $\Delta$V (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.

### 2.2.3 Speedbrake/Thrust Controller

On the real shuttle, the Speedbrake/Thrust Controller (SBTC) controls both SSME throttling during ascent and the speedbrake during entry. In Orbiter, the SBTC is simulated using the main engine key controls. The Orbitersim throttle setting is mapped to the SBTC range. During ascent, 0% Orbitersim main thrust corresponds to 67% SSME throttle; 100% Orbitersim main thrust corresponds to 104.5% (109% during some abort cases) SSME thrust. During entry, 0% Orbitersim main thrust corresponds to the speedbrake being **fully open**; 100% Orbitersim main thrust 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. To takeover manual control, move the SBTC (by changing the Orbitersim main engine throttle) to match the current autopilot command. At this point, both *AUTO* PBIs will go out and the PLT *SBD BK/THROT MAN* PBI will be lit (the CDR PBI will not be lit; in real life, only the PLT SBTC can be used during ascent, although SSU allows the SBTC to be used from both CDR and PLT seats). 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* pushbuttons on Panel C3; this is not possible in Orbiter).

#### Entry

The speedbrake is usually controlled automatically throughout entry. To take over manual control move the SBTC; the speedbrake will immediately move to the position commanded by the SBTC and 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 the current VC position). Pressing the *SPD BK/THROT* PBI will put the speedbrake into *AUTO* mode again.

### 2.2.4 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.

#### 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.

| Cockpit View | Left | Right | Up | Down |
|---|---|---|---|---|
| Commander Seat | CDR - L4 | Pilot Seat | ODS Camera | MS Seat |
| Pilot Seat | Commander Seat | Pilot - R4 | ODS Camera | MS2/FE Seat |
| CDR - L4 | Port Workstation | Commander Seat | ODS Camera | MS Seat |
| Pilot - R4 | Pilot Seat | Stbd Workstation | ODS Camera | MS2/FE Seat |
| MS Seat | Port Workstation | MS2/FE Seat | Commander Seat | ODS Camera |
| MS2/FE Seat | MS Seat | Stbd Workstation | Pilot Seat | ODS Camera |
| Port Workstation | RMS Work Station | Commander Seat | ODS Camera | Middeck |
| Stbd Workstation | Pilot Seat | Aft Pilot Station | ODS Camera | Aft Workstation |
| Aft Workstation | Stbd Workstation | Port Workstation | RMS Work Station | MS Seat |
| Aft Pilot Station | Stbd Workstation | RMS Work Station | ODS Camera | Aft Workstation |
| RMS Work Station | Aft Pilot Station | Port Station | ODS Camera | Aft Workstation |
| RMS EE | RMS Elbow | - | - | RMS Work Station |
| RMS Elbow | - | RMS EE | - | RMS Work Station |
| PLB Camera A | PLB Camera D | PLB Camera B | RMS EE | ODS Camera |
| PLB Camera D | PLB Camera C | PLB Camera A | RMS EE | ODS Camera |
| PLB Camera B | PLB Camera A | PLB Camera C | RMS EE | ODS Camera |
| PLB Camera C | PLB Camera B | PLB Camera D | RMS EE | ODS Camera |
| ODS Camera | - | - | PLB Camera D | Aft Pilot Station |

Table 2: VC navigation

## 2.3 Payload Operations Overview

Payloads are attached through standard Orbiter attachment points. Figure 4 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.

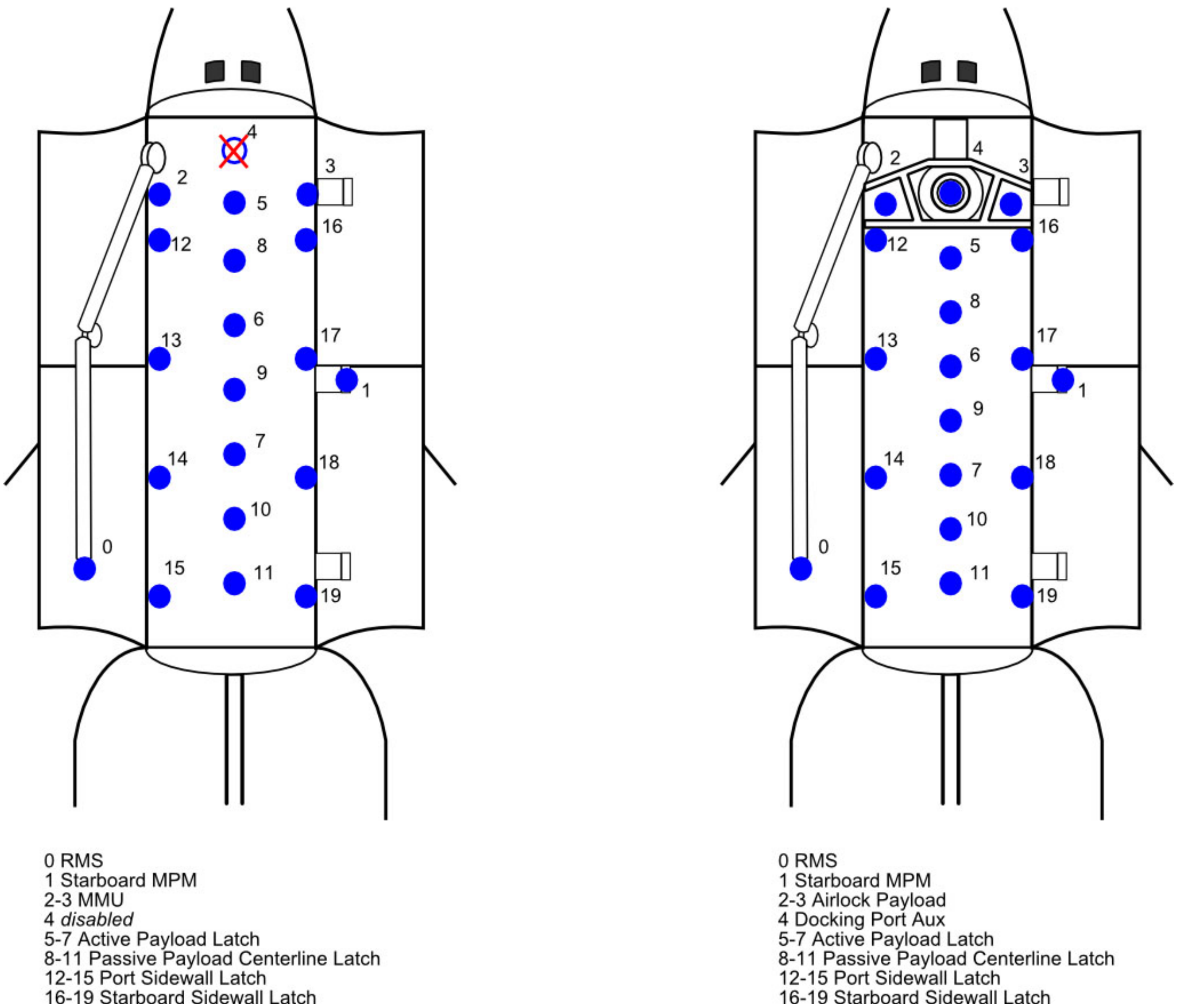



Figure 4: SSU attachment locations

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 5 of this manual. The scenario file entries needed to add payloads to SSU are covered in Section 6 of this manual.

# 3 SSU SYSTEMS

**Contents**



This section discusses in greater detail each of the orbiter systems that are currently simulated. The subsections are organized alphabetically, with detailed internal table of contents provided for each.

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 Auxiliary Power Unit/Hydraulics (APU/HYD)

### Contents



### 3.1.1 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.

## 3.2 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.

### 3.2.1 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.

### 3.2.2 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; MFD 1 and 2 on panel F7; PLT 1 and 2 on panel F8; CRT 4 on panel R12; 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 8 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.

## 3.3 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.

### 3.3.1 ASCENT TRAJ


Figure 5: 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.

### 3.3.2 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.

### 3.3.3 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.

### 3.3.4 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.

### 3.3.5 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 |
| 23 | Lajes | LAJ 15 | LAJ 33 |
| 24 | Vandenberg AFB | VBG 30 | VBG 12 |
| 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 |
| 45 | Edwards AFB | EDW 22 | EDW 04 |

Table 3: Landing Site Table

### 3.3.6 ENTRY TRAJ


Figure 6: 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.

### 3.3.7 VERT SIT


Figure 7: 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.

### 3.3.8 HORIZ SIT

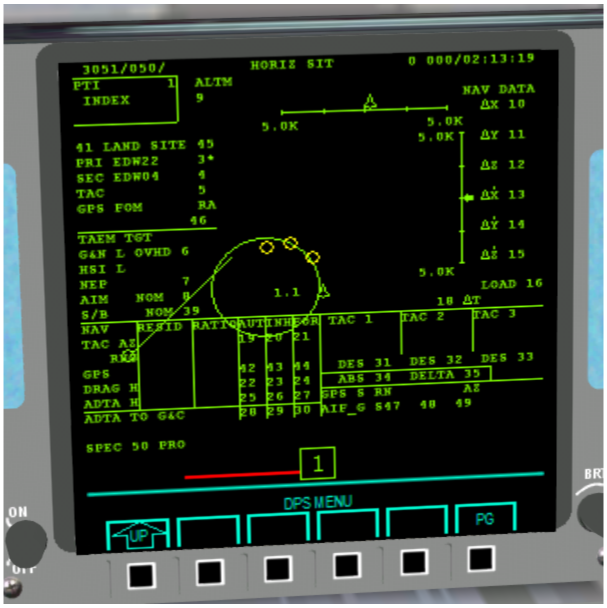



Figure 8: HORIZ SIT display

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.

## 3.4 MEDS Displays

**Contents**



### 3.4.1 A/E PFD


Figure 9: A/E PFD

The A/E PFD 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. OMS/MPS 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.

### 3.4.2 ORBIT PFD


Figure 10: Orbit PFD

The Orbit PFD 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.

### 3.4.3 OMS/MPS


Figure 11: 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.

### 3.4.4 APU/HYD

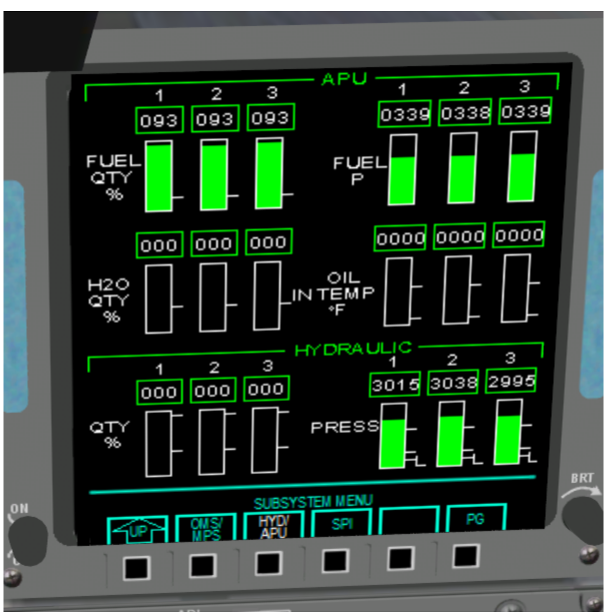



Figure 12: APU/HYD display

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.

### 3.4.5 SPI

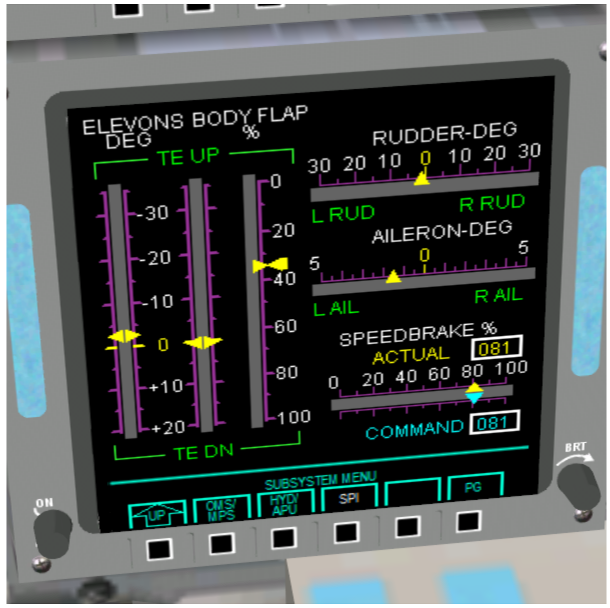



Figure 13: SPI display

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

# 4 FLIGHT DATA FILES

# 5 MISSION FILES

# 6 SCENARIO FILES

# 7 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.

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

DISCLAIMER: The SSU team is not responsible for any crashes or other problems caused by this addon. Use at your own risk.