Space Shuttle Ultra

Version 1.XX Rev. A

SSU Operations Manual

June 15, 2011

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 `http://www.nasa.gov/centers/johnson/news/flightdatafiles/index.html`, and provide a good reference for other procedures.

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). While reading these are not required at this time (all pertinent information is provided in SSU documents) eventually when systems are fully simulated, we will point users to these documents for information deeper than a basic summery of the system.

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 custum mission creation. Separate documents will be provided for developers who would like to create a SSU compatible payloads and scenarios.

This document is formated 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 CELL2 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.

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1 GENERAL DESCRIPTION

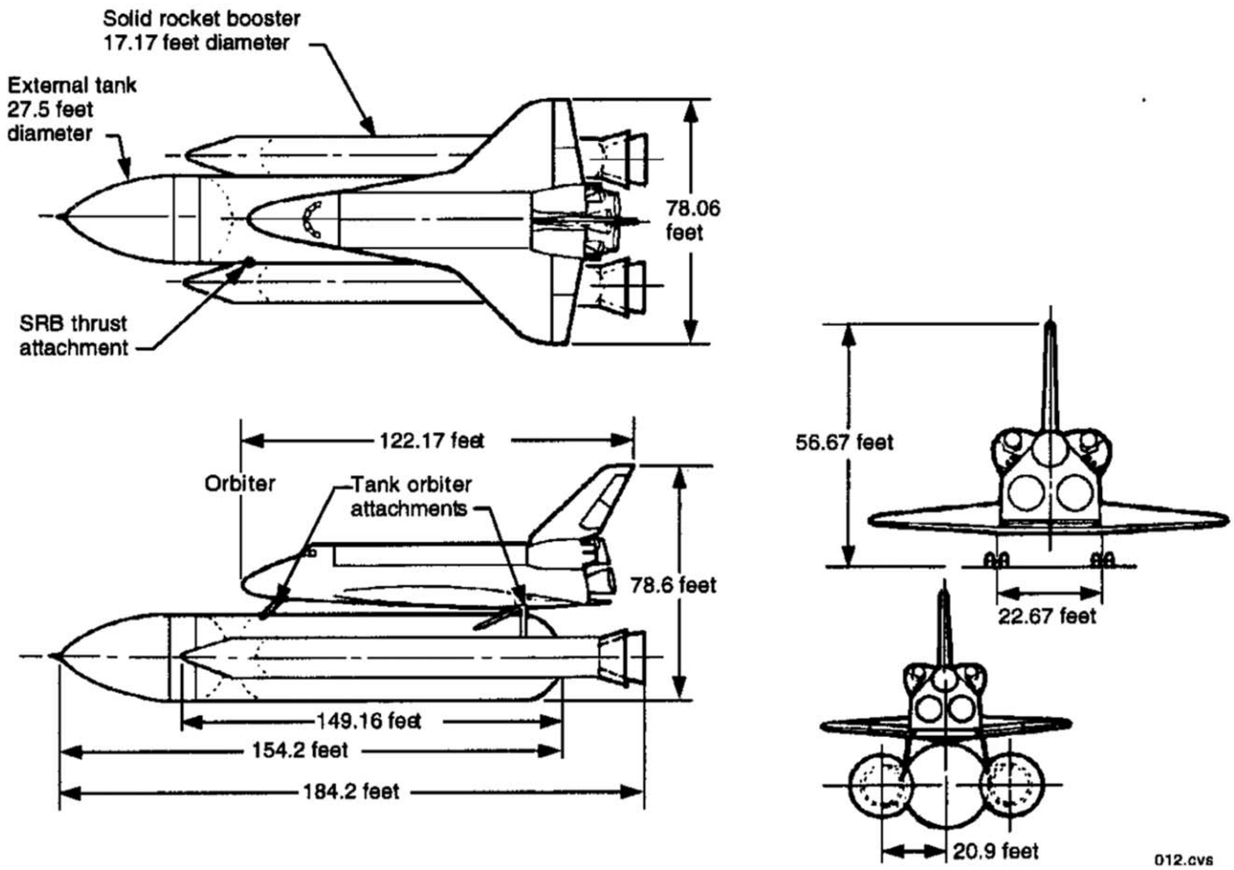
CONTENTS

The section provides general background information about the obiter, its configuration and coordinate system, the nominal mission profile, and general procedures followed during a shuttle mission. It also briefly discusses components, such as the external tank and solid rocket, that are not included in the next section on orbiter systems.

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.

1.1 OVERVIEW

CONTENTS



Space Shuttle Statistics

Space Shuttle Overview

The space shuttle system consists of four primary elements: an orbiter spacecraft, two solid rocket boosters (SRBs), and external tank (ET) to house fuel and oxidizer, and three space shuttle main engines (SSMEs). The shuttle can transport payloads into near Earth orbit 100 to 312 nm (185 to 577 km) above the Earth. Payloads are carried in a bay 15 feet in diameter and 60 feet long. Major system requirements are that the orbiter and the two SRBs be reusable.

The orbiter has carries a flight crew of up to eight persons. The nominal mission is 4 to 16 days in space. The crew compartment has a shirtsleeve environment, and the acceleration load is never greater than 3 g's. In its return to Earth, the orbiter has a crossrange maneuvering capability of about 1,100 nm.

Nominal Mission Profile

SSU has reached a point of development that almost a full mission profile can be simulated. Continued development of Entry, from Entry Interface (EI) to terminal area energy management (TAEM), will see implementation of the entry guidance and displays that will aid in executing reentry but for now it must be done manually with limited instrumentation.

Launch

In launch configuration, the orbiter and two SRBs are attached to the ET in a vertical (nose-up) position on the launch pad.

The three SSMEs, fed liquid hydrogen fuel and liquid oxygen oxidizer from the ET, are ignited first ∼T-6 seconds. Once proper operation and thrust level has been varified, a signal is sent at T-0 seconds to the SRBs which ignite and the stack is released from the launch pad.

After approximately 2 minutes into the ascent phase, the two SRBs have consumed their propellant and are jettisoned from the ET. This is triggered by a separation signal from the orbiter.

The orbiter and ET continue on to orbit while the SRBs begin to descend back to Earth. At a predetermined altitude, parachutes are deployed and the boosters spashdown in the ocean. The boosters are recovered and reused.

After approximately 8 and a half minutes after launch, the three main engines undergo main engine cutoff (or MECO), and the ET is jettisoned on command from the orbiter.

The forward and aft reaction control system (RCS) jets provide attitude control, translate the orbiter away from the ET at separation, and maneuver the orbiter to burn attitude prior to the orbital maneuvering system (OMS) burn. The ET continues on a ballistic trajectory and enters the atmosphere, where it disintegrates.

Orbit Insertion and Circularization

The nominal ascent profile, referred to as “direct insertion," places the vehicle in a temporary elliptical orbit at MECO. 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.

In cases of severe performance problems during the ascent, the vehicle may find itself well short of the expected MECO velocity, and even suborbital. In such cases, the crew performs what is call an “OMS 1” burn, which raises the orbit to a safe altitude. They then perform an OMS 2 burn to stabilize that orbit.

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. This ascent profile was used for the first ten missions, STS-1 though STS-41B.

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 planed, but not flown, missions are planed to be simulated with SSU including shuttle-Centaur flights and posible Vandenberg missions.

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.

Entry

Orbiter reentry is normally controlled automatically through the entry guidance program from entry interface (EI) through TAEM, to $\sim$ mach 2, where the CDR takes control of the orbiter. This autopilot has yet to be simulated in SSU but manual entry is possible with third party addons that provide more situational awareness then what is currently provided. A detailed description of reentry procedures will be included later in this document.

TAEM

TAEM (terminal area energy management) guidance steers the orbiter to one of two heading alignment cones (HAC), which are located to and on either side of the runway centerline on the approch end. Again, the guidance that would aid the CDR or PLT during this phase of the flight has yet to be implemented but is still posible without it. Detailed desriptions will be included later in this document.

Landing

Approach and landing easily performed without TAEM guidance. After runway acqusition on rollout from the HAC one can visually fly the orbiter to runway. Detailed desriptions of final approach and landing will be included later in this document.

Launch and Landing sites

During the Shuttle program, The Kennedy Space Center (KSC) in Florida was used for all shuttle launches. Currently in SSU that is also true. Eventually, SSU hopes to simulate West Coast shuttle operations based at Vandenberg Air Force Base as it was originaly planned until the Challenger accident in 1986. Shuttle landings occur at KSC, also, as well as at Edwards Air Force Base in California. Contingency landing sites are also provided in the event the orbiter must return to Earth in an emergency.

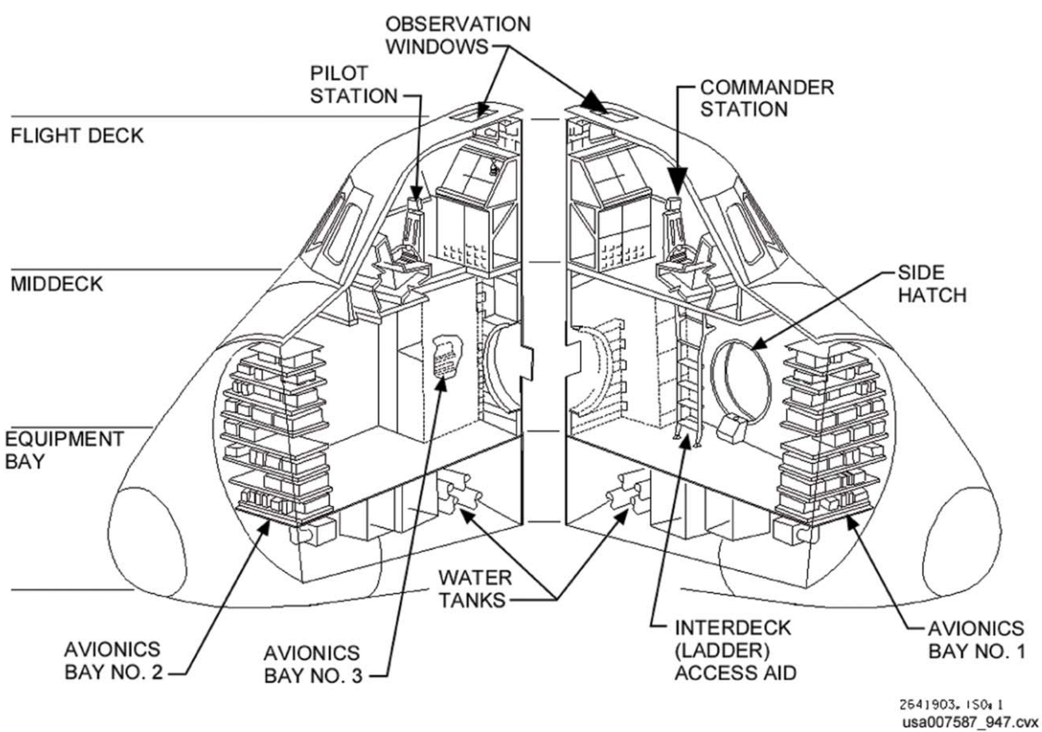
NOTE

KSC is currently the only base that is included with SSU. Eventually Edwards, White Sands, VAFB, and the abort landing sites will be included.

A 035° azimuth launch places the spacecraft in an orbital inclination of 57°, which means the spacecraft in its orbital trajectories around Earth will never exceed an an Earth latitude higher or lower than 57° north or south of the equator. A launch path from KSC at an azimuth of 090° (due east from KSC) will place the spacecraft in an orbital inclination of 28.5°.
These two azimuths, 035° and 090°, represent the current launch limits from KSC. Any azimuth angles further north or south would launch the spacecraft over a habitable land mass, adversely affect safety provisions for abort or vehicle separation conditions, or present the undesirable possibility that the SRB or external tank could land on inhabited territory.

Shuttle Location Codes

Orbiter location codes enable crewmembers to locate displays and controls, stowage comparments 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 to the degree that location coding must be followed. Soon panels in the middeck will be simulated and at that time the middeck location coding will be included in this manual.



Crew Cabin (Cutaway View)

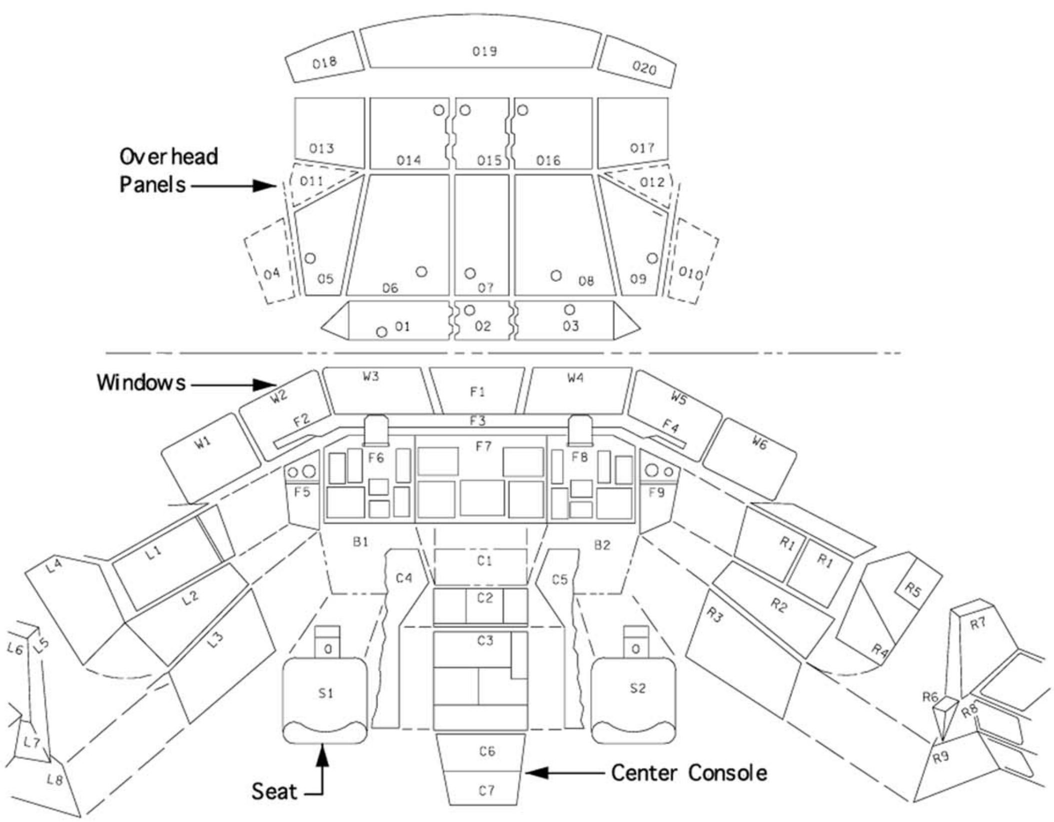
Flight Deck Location Codes

SURFACES	GENERAL NUMBERING PHILOSOPHY
L - Left R - Right C - Center console	• Numbered from the 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	• The forward windows are numbered left to right (W1 through W6) facing forward • The overhead windows are numbered left to right (W7 and W8) facing aft • The aft windows are numbered left to right (W9 and W10) facing aft
S - Seats	• The CDR's seat is S1 and the PLT's seat is S2

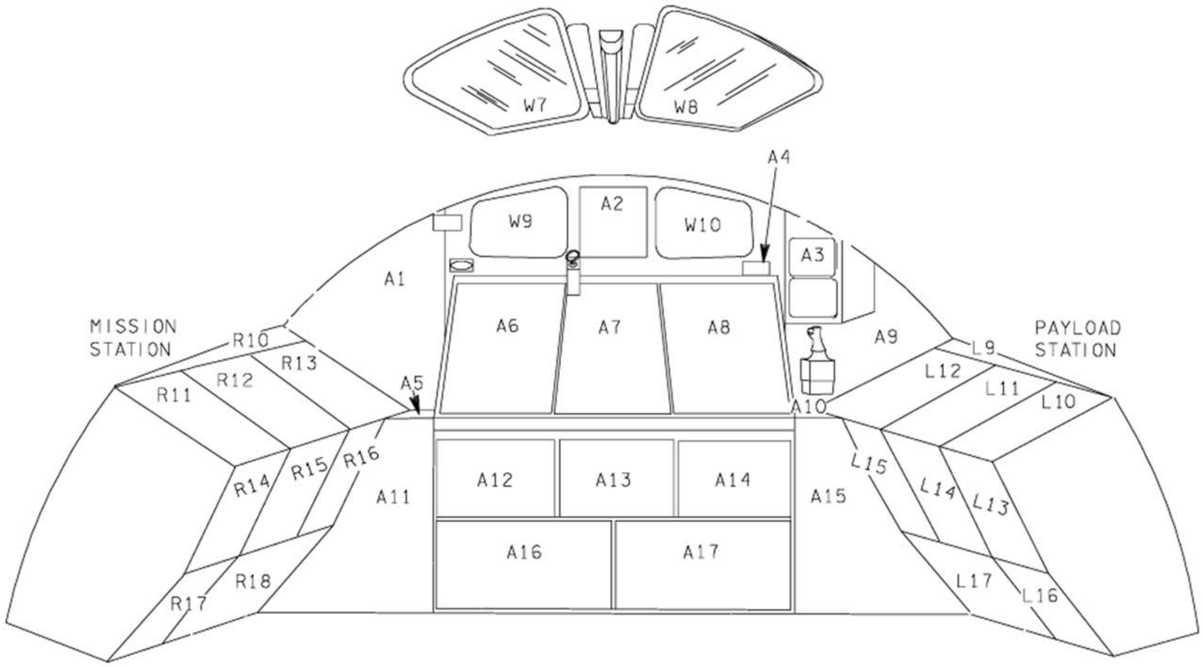
A flight deck location code consists of two or three alphanumeric characters. The first character is the first letter of a flight dect surface as addressed while sitting in the commander/pilot seats. The characters are:

L	-	Left
R	-	Right
F	-	Forward
A	-	Aft
C	-	Center Console
O	-	Overhead
S	-	Seats
W	-	Window

The second and third characters are numerics identifying the relative location of componets on each flight deck surface. The numbering system philosophy is summerized in the table above.



Flight Deck Location Codes (1 of 2)



Flight Deck Location Codes (2 of 2)

1.2 ORBITER AND SSU

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SSU Keyboard Commands

The ultimate goal of SSU is to provide a complete simulation of the Space Shuttle. This means that most of the imput is done with in-simulation controls (ie. 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
Ctrl+B - toggle fully open/close speedbrake
comma - open speedbrake by 5 percent
period - close speedbrake by 5 percent
B - turn off launch autopilot
C - toggle automatic throttling

Alternate Translation Commands (valid only in 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

Camera Views

SSU includes the four payload bay cameras and the docking port centerline camera. Also, the new payload camera control panel is available. To access it, press Ctrl+Space, then select Payload camera operations. To rotate a camera, select it with the Camera radio button, then use the rotation controls to pan the camera.

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).

The table below 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
CDR	Port Workstation	PLT	ODS	MS1
PLT	CDR	Stbd Workstation	ODS	MS2
MS1	Port Workstation	MS2	CDR	ODS
MS2	MS1	Stbd Workstation	PLT	ODS
Port Workstation	RMS Station	CDR	ODS	Middeck
Stbd Workstation	PLT	Aft Pilot	ODS	Aft Workstation
Aft Workstation	Stbd Workstation	Port Workstation	RMS Station	MS1
Aft Pilot	stbd Workstation	RMS Station	ODS	Aft Workstation
RMS Station	Aft Pilot	Port Station	ODS	Aft Workstation
RMS EE	RMS Elbow	-	-	RMS Station
RMS Elbow	-	RMS EE	-	RMS Station
PLB Camera A	PLB Camera D	PLB Camera B	RMS EE	ODS
PLB Camera D	PLB Camera C	PLB Camera A	RMS EE	ODS
PLB Camera B	PLB Camera A	PLB Camera C	RMS EE	ODS
PLB Camera C	PLB Camera B	PLB Camera D	RMS EE	ODS
ODS	-	-	PLB Camera D	Aft Pilot

Payload Operations Overview

1.3 Components Overview

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4 MISSION FILES

5 SCENARIO FILES