READ ME BEFORE ENTERING THE SPACE SHUTTLE Flight Deck

Commander's Reference Manual

Rev 4.0

30 YEARS OF SPACE SHUTTLE MISSIONS

'…the space conquest continues…'

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Special thanks to Dr. Raimondo Fortezza
of MARS® **srl**, Italy for his support of the ISS texturing design

For a more in-depth reading and reference, we recommend the NASA official Space Shuttle Manual as the ultimate source for the Space Shuttle operations. The Space Shuttle Manual is accessible online at the official NASA website at www.nasa.gov and other sources.

This manual is suitable for SSM2007 version 5.20 and higher, and it supersedes any previous versions of the manual.
Always visit the official SSM2007 website and download the latest manuals and Missions/Features Packs

Introduction

Thank you for accepting the challenge of becoming a (virtual) Space Shuttle Astronaut.

We will not waste precious time in telling the story of the Space Shuttle – we are confident that if you purchased this simulator you are already interested in Space Exploration and you may even know a thing or two (or much more) about the Space Shuttle, the Hubble, the International Space Station and other achievements owed to the excellent record of the STS program.

Before getting into the really interesting stuff, we'd like to remind you that there is a huge amount of information at the official NASA website - at www.nasa.gov - regarding the Space Shuttle, its history, its achievements and its missions.

That information includes the very comprehensive document named 'Shuttle Crew Operations Manual' and it is updated for 2003 – in other words it is very recent. Although we borrowed some of the graphics, we do not intend to parrot it or copy entire sections and present that to you as our manual. Besides, how can we compete with a 40MB/1190 pages worth of information from the team that built and operates the actual Space Shuttle program? However if you want to learn more, we do recommend at least browsing through that document once.

Our Commander's Reference Manual is first and foremost a guide to how the SSM2007™ works, how to operate its interface and other information critical for a successful and enjoyable Space Shuttle Mission 2007™ experience.

NOTE: *some of the functions, features and controls are true for the simulator updated with the latest Service Pack. The Service Packs are released periodically and are available for free on our official website. We strongly recommend updating the simulator to the latest Service Pack as they always contain new features, missions, changes or fixes which are reflected in this manual.*

The Space Shuttle Mission 2007™

So what exactly does SSM2007™ have to offer?

When we have started this project we decided that the scope of this simulator should be to offer a Space Shuttle experience as close as possible to the real thing, while keeping in mind the limitations imposed by the mainstream PC hardware and the target audience (you).

In plain English, we wanted this mission simulator to be able to run well on a wide range of hardware configurations and appeal to all ages and educational backgrounds – you do not really need a hot-rod PC or to be a "rocket scientist" to enjoy it!

This means that we had to leave out certain realities like the possibility of failure and emergency operations that the real crew trains for, but fortunately it seldom has to apply in real life. Also some of the operations are simplified and automated (like the robotic arm of the ISS).

We also left out certain activities such as various scientific experiments and tasks which are performed by specialized crew members.

Since its maiden launch in April 12th 1981, The Space Shuttle has seen many improvements to a degree that today some of the systems are dramatically different (and improved) from the original ones. Some of these modifications are also reflected by the technology used in the cockpit. We decided that we will not go all the way and we will not simulate all the Space Shuttle "variants". Basically what you get now is the modern MFD-based flight deck of today's Space Shuttles and not the old-style mechanical gauges. We thought that for the sake of simplicity and user-friendliness we should make the simulator as enjoyable and as non-intimidating as possible. Forcing you to learn several cockpit variants would have certainly put an undesirable stress which could have resulted in having the simulator shelved after the first 15 minutes or so.

So we did leave out several items which purists may disagree with, but if you relax and ponder a bit, you're not getting a bad deal after all: what we do offer is the opportunity to perform many operations the real Space Shuttle Commander and other crew members do during the various missions.

You do get to press buttons, turn knobs, use the RMS, perform EVA - Extravehicular Activities, dock, deploy and capture satellites, service the Hubble and build the ISS. Of course, in the visual world that we live in, all this would not mean much without those cool views from space. We have invested in the best 1km/pixel, 15m/pixel and 1m/pixel Satellite Imagery you can get today and licensed it from TerraMetrics Inc. – the company which provides Satellite Imagery for Google Earth™ and for a multitude of other critical applications.

We offer extensive viewing options, including a free-floating camera that allows you to admire the view from infinite points of view. Now you can take shots of that difficult docking that you've just completed and win bragging points.

We decided to offer for now a set of the most exciting and representative historical missions and we plan to periodically release new missions, until we cover all the historical missions to date. Visit our website regularly and you will definitely be rewarded with some very exciting add-ons.

As you see, with all that has been simplified in this SSM2007™ release, there is still much to do! We are confident that by playing with SSM2007™ you will learn a lot and understand the magnitude of the STS Program achievements.

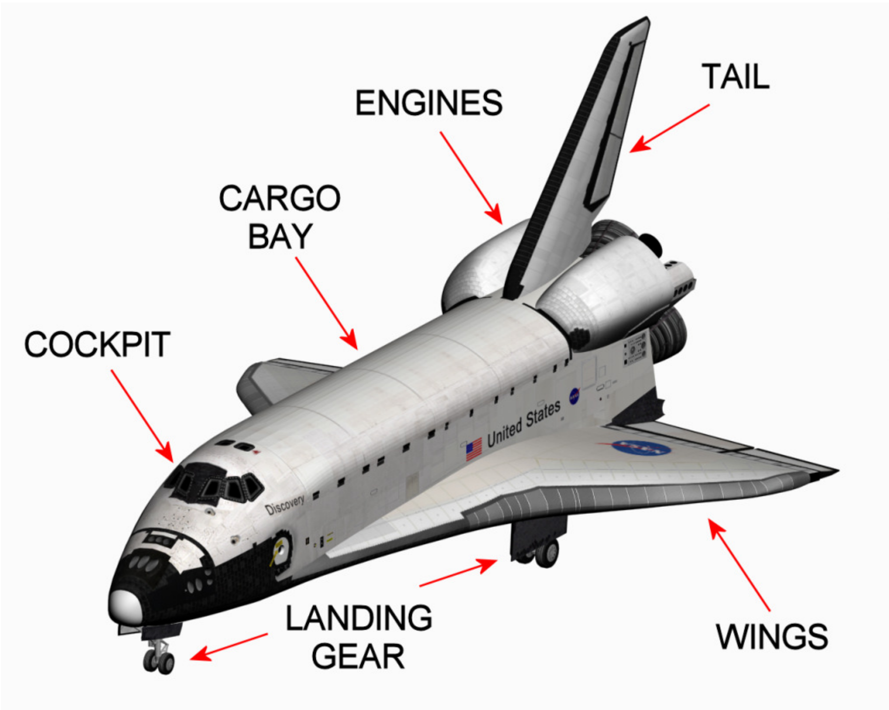
We have plans to follow through with additional SSM versions with cool features that will offer you the opportunity of learning more about what mankind has achieved in Earth Orbit operations during the last decades.

Stay tuned and visit the official Space Shuttle Mission 2007™ website at www.space-shuttle-mission.com for updated information.

A brief anatomy of the Space Shuttle

From outside, the Space Shuttle is not dramatically different from most aircraft, but as we shall see, it is much more sophisticated than that.

It is enough for now however to identify several key elements that make the Space Shuttle what it is – the most complex re-usable space ship to be successfully used for the last 25 years in over a hundred missions whose results have been shaping the way we think about traveling, exploring, living and working in space.



The **Cockpit** (or **Flight Deck**) is the place where the Space Shuttle crew spends most of its time. Its environment is protected from the outside extremes of the space (radiation, temperature, lack of breathable air) by a sophisticated and highly reliable life-support system. The Astronauts can therefore work most of the time without any special protective space suit. Instead they wear light clothing which allows them to work comfortably within the cockpit space.

The cockpit consists of the main flight deck where the Astronauts perform Space Shuttle-related operations, and the lower deck where we can find most of the auxiliary equipment for additional outer-space tasks – experiments etc.

The **Cargo Bay** is where the mission-specific cargo is located. Access to the Cargo Bay is by opening the two large upper bay doors and from the cockpit through a pressurized airlock.

The three **Main Engines** are located at the rear part of the Shuttle. They supply additional thrust during the lift-off stage.

When returning to Earth Atmosphere, the Space Shuttle behaves like a big glider. The lift and stability are provided by its delta-shaped **Wings** and the **Tail**. While in Earth Atmosphere the engines are inoperative so the landing phase is largely one-shot process, requiring a precise computer controlled system and a highly skilled pilot.

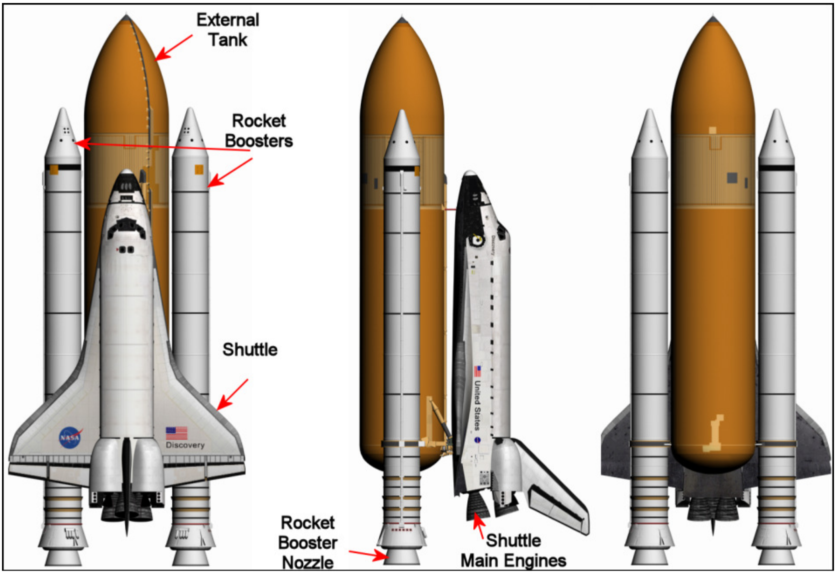
Once the Space Shuttle is close to the runway threshold, the pilot deploys the **Landing Gear** which consists of two rear wheels and a **Nose Wheel**. During a normal landing, the pilot performs a "flare-up" procedure by slightly raising the Space Shuttle nose in order to bleed off the speed and gently lower it on the runway. The rear wheels touch the ground first followed by the nose wheel. At this point the pilot gains directional control which allows for keeping the Shuttle on the runway center. Due to its size and inertia, in order to stop the Shuttle run the Pilot uses the **air brakes**, deploys a small **braking parachute** which is jettisoned as the speed is reduced, and applies the **wheel brakes** which finally bring the Space Shuttle to a complete stop.

The Space Shuttle is a complex platform which changes "shape" and handling parameters several times during its mission.

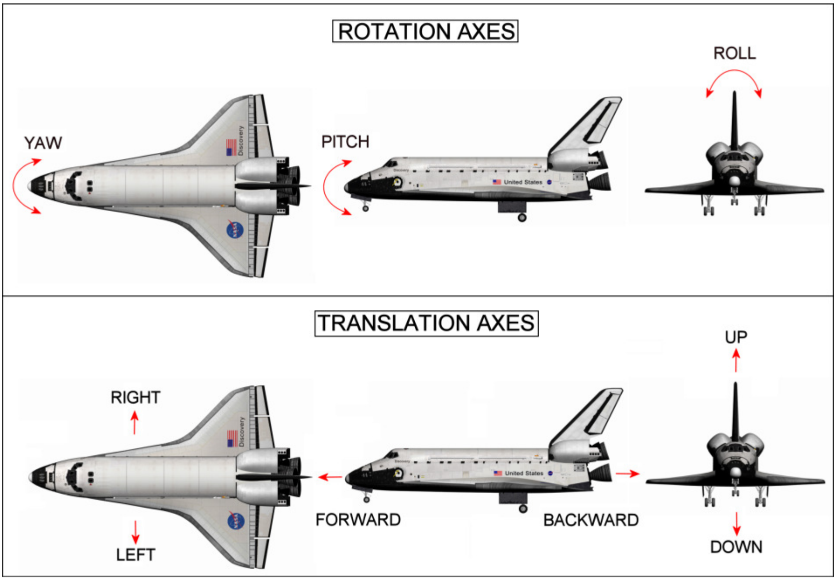
During **launch**, the Space Shuttle is attached to two Solid fuel Rocket Boosters (**SRB**) and a liquid fuel External Tank. The Rocket Boosters assist the Space Shuttle in escaping the Earth gravitational field to a position which enables its own Main Engines to continue the orbital insertion phase.

After fulfilling their task, the **Rocket Boosters** are separated from the Shuttle and they fall into the ocean, to be retrieved later and re-used in one of the next flights.

The **External Tank** supplies the Main Engines with Liquid Hydrogen and Oxygen during the Orbital Insertion phase. After it completes this task the External Tank is jettisoned too and disintegrates as it falls into the Indian or Pacific Ocean – depending on Shuttle's Orbit Insertion trajectory – and away from known shipping lanes.



In **orbit** and throughout the remainder of the mission until the re-entry phase, the Space Shuttle can be maneuvered manually with the joystick or automatically by the Guidance and Navigation Computer, by selectively activating its Rocket Control System which consists of 44 micro-rockets placed at specific points around the Space Shuttle body. The RCS enables the Space Shuttle to move in six degrees of freedom around three Rotation and three Translation Axes.

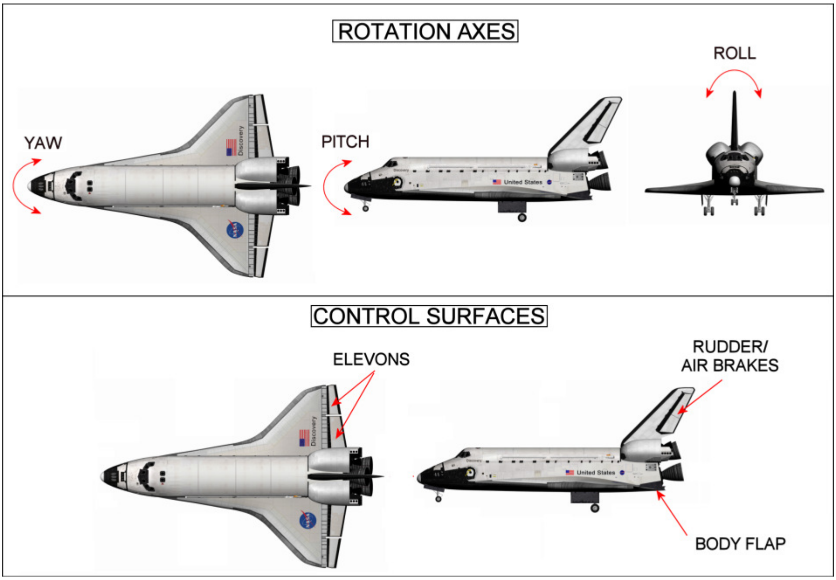


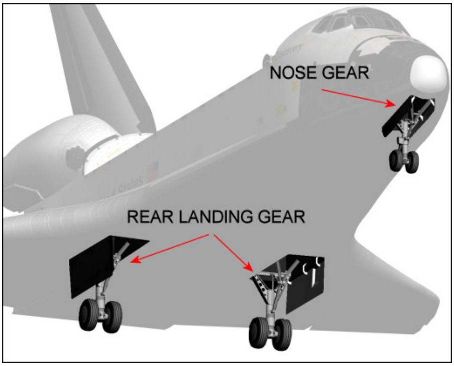
When activating these rockets manually, make sure you allow for inertia – in other words, use small bursts for a precise movement and avoid overshooting. This will offer a better control of the Space Shuttle attitude, and also conserves precious fuel.

After **re-entry** and during **approach** and **landing**, the Space Shuttle is in the Earth Atmosphere and the RCS is disabled. From this point onward, the attitude control of the Space Shuttle is performed with the control surfaces, the Shuttle practically being a big glider. These surfaces – Rudder and Elevons (which are a combination of Elevators and Ailerons) - can be controlled automatically by the Auto Pilot (recommended) until the Shuttle is switched to manual mode, as it comes down below 1Mach, before the final approach and landing phase. At this point, the Commander and Pilot can use the joystick to control Pitch, Roll and Yaw to land the Space Shuttle manually.

In addition we have the Body Flap which is a special control surface used for Pitch trim and which doubles as a Main Engines thermal protection surface during the re-entry phase.

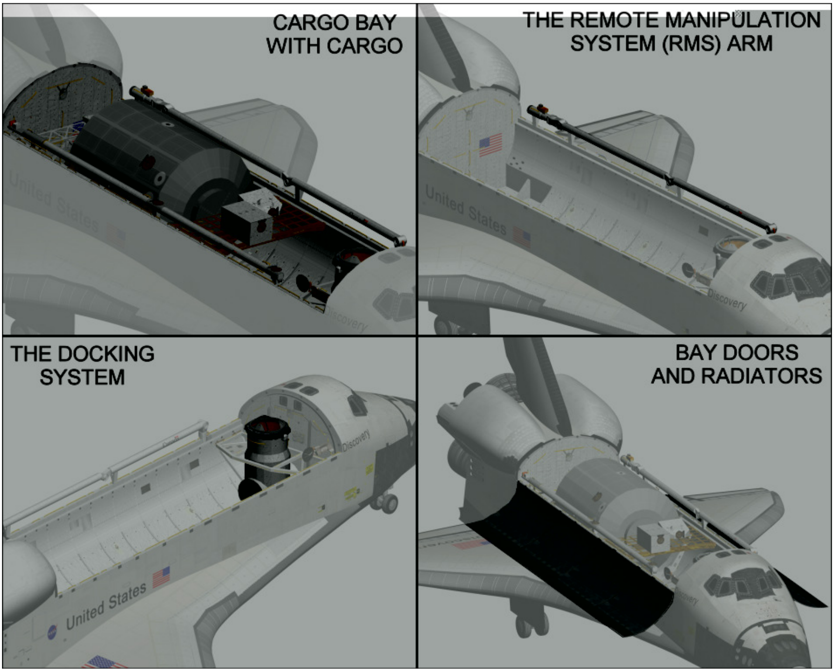
Last, we have the airbrake system which is activated by "splitting" the Rudder surface into two sections.





During landing, the Pilot lowers the landing gear which is comprised of two rear and one nose wheel. *Please refer to the* ***Controlling the Space Shuttle with the Keyboard*** *and* ***Controlling the Space Shuttle with the Joystick*** *sections of this manual, for a full list and description of the user interface relevant to the control of the Space Shuttle attitude.*

The Space Shuttle **mission** is to haul cargo in orbit around Earth, for a variety of tasks such as performing experiments, launching satellites, maintenance and building and re-supplying the ISS.



As a result, most of the Space Shuttle body volume is occupied by a spacious **cargo bay** equipped with its own "crane" (**Remote Manipulation System**) and **pressurized docking system**. The cargo is protected by the **bay doors** which can be closed and opened in space.

The cargo bay doors also protect the **radiators**. The radiators are deployable panels which when stowed, are flush with the cargo bay doors and when deployed, they separate from the cargo bay doors in an upward position. Their deployment and stowing operations are part of the tasks performed by Astronauts in space. The radiators allow for an efficient temperature control of the Space Shuttle crew and equipment space.

The **crew cockpit** is separated by the cargo bay and equipped with a crew life-support system allowing the Astronauts to work inside the cockpit without wearing a space suit. While in space, the Astronauts can don the space suit, leave the cockpit and access the cargo bay by a special airlock which usually is also a part of a sophisticated and pressurized docking system.

Space Shuttle Mission Profile

Each Space Shuttle mission consists of very precise, predefined phases which ensure a successful completion, culminating with a safe return to Earth.

Almost all the mission phases are fully automated under computer control. On board the Space Shuttle there are a total of five identical **General Purpose Computers** (GPC) manufactured by IBM. Each GPC consists of a CPU, memory and I/O and is connected to hundreds of sensors.

The GPCs are controlled by a special Operating System and are capable of running mission-specific programs for navigation, control tasks etc. There are three GPC Major Functions:

GNC – Guidance Navigation and Control: specific software required for launch, ascent to orbit, maneuvering in orbit, entry, and landing.

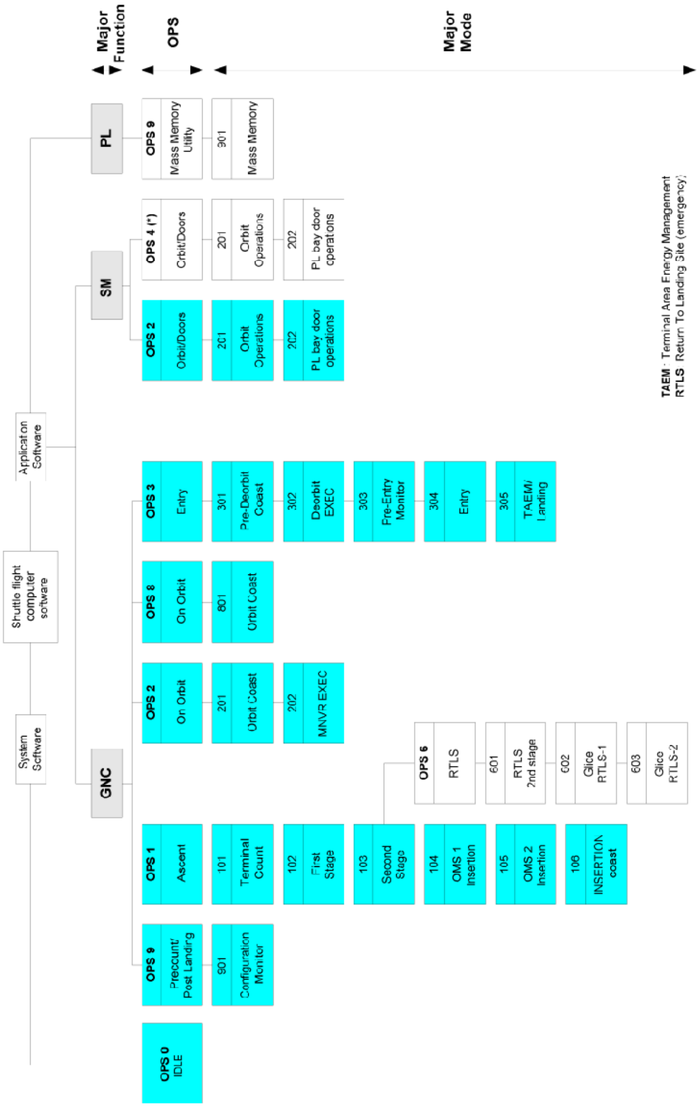
SM – Systems Management: tasks that monitor various orbiter systems, such as life support, thermal control, communications, and payload operations.

PL – Payload: this function currently contains mass memory utility software. The PL major function is usually unsupported in flight, which means that none of the GPCs are loaded with PL software. The PL function is only used in vehicle preparation at KSC.

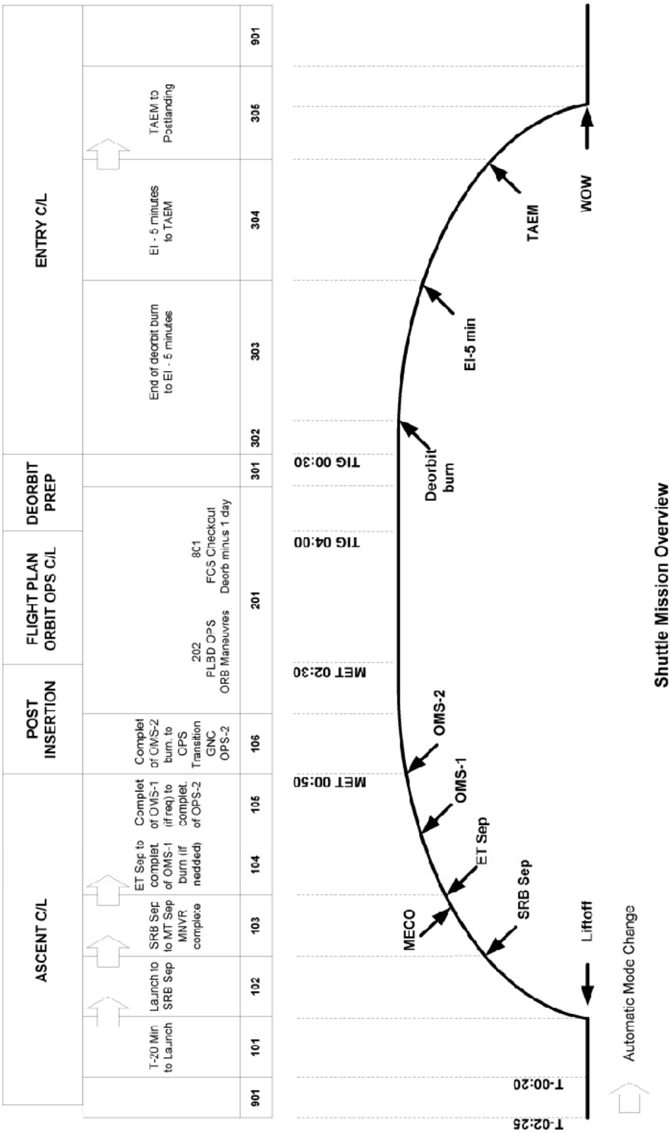
Major functions are divided into mission phase oriented blocks called Operational Sequences (OPS). The OPS Specialist function (SPEC) is a block of displays associated with operational sequences, and it enables the crew to monitor and modify parameters. DISP are display modes associated with OPSs and are for monitoring purposes only.

Not all GPC modes, OPS, SPEC and DISP modes are simulated in SSM2007™ but we provide enough to assist you in finishing all the missions successfully and keep you busy with the Multi Function Displays (MFD). Please refer to the following chart for the GPC modes map and their relevance to SSM2007™ (in BLUE).

The SSM2007™ GPC Functions and Modes



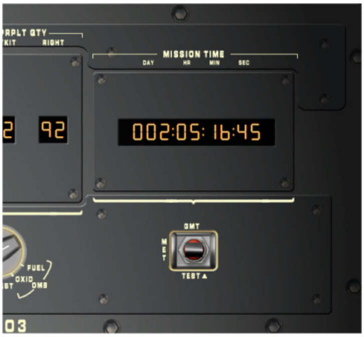
The Space Shuttle Mission Profile

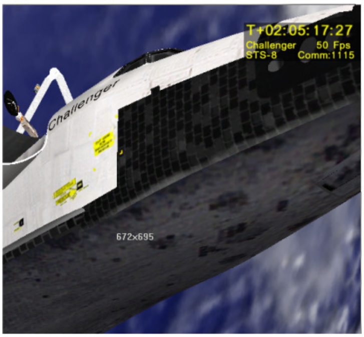


The Space Shuttle Mission Phases

For more details about the various systems, please refer to the comprehensive NASA Space Shuttle Manual. Although you will be instructed (and helped) to perform all the necessary operations, a full explanation of the Space Shuttle systems functions and structure is beyond the scope of this manual.

Throughout the manual and within the simulator itself, time is represented as MM:SS:TT, HH:MM:SS or DD:HH:MM:SS, where DD stands for "days", HH for "hours", MM – "minutes", SS-"seconds" and TT-"tenths of a second". During a mission time is measured as relative time before liftoff - "T minus" or "T-", and time after liftoff – "T plus" or "T+".





This time can also be viewed on the Mission Elapsed Time (MET) indicator on the upper right part of the simulator screen which displays time in the

DD:HH:MM:SS format. The "T+" times can be also seen on the upper right section of every GPC CRT display in any mode and on the upper O3 and the aft A4 panels which display it in the full DD:HH:MM:SS format.

The Ascent Phase

T-20 minutes to Launch (MM 101)

The time format for this section is MM:SS:TT.

(T-20:00:00)
The crew turns on GPC #5 and puts it in mode OPS 101.

(T-16:00:00)
Helium is transferred to the Main Engines.

(T-15:00:00)
Mission Control cycles the ABORT light on the F6 panel.

(T-07:30:00)
The Launch Tower Crew Access Bridge is retracted.
(T-06:30:00)
The crew prepares the Auxiliary Power Unit (APU).

(T-05:00:00)
Crew starts to load the APU fuel while monitoring the pressure. The APU is started shortly afterwards.

(T-04:30:00)
The Space Shuttle is fully independent now. All the external links are disconnected and all its operations are under GPC control.

(T-03:55:00)
The aerodynamic control surfaces are moved into the neutral position.

(T-03:03:00)
Engine nozzles are gimbaled into the neutral position.

(T-02:55:00)
The Main Tank Oxygen ventilation is closed as pressure starts to build up in the Liquid Oxygen tank.

(T-01:55:00)
The Main Tank Hydrogen ventilation is closed as pressure starts to build up in the Liquid Hydrogen tank.

(T-00:25:00)
The APU and countdown are now under GPC control.

(T-00:12:00)
The Shuttle is under full GPC control.

(T-00:06:60)
The GPC starts the Shuttle Main Engines. The sequence is Engine #1 and then Engine #2 and #3 with a 120 millisecond delay.

(T-00:00:00)
The SRB engines are fired and the Space Shuttle enters the Ascent phase.

Launch to SRB Separation (MM-102)

As the Space Shuttle clears the Launch Tower, it rotates into a "back-flip" position which stays for the duration of the Ascent Phase. This phase is fully automatic and under GPC control. There is no need to perform any manual control activities unless there is an emergency. The crew monitors the various readings and follows specific checklists.

Please note that the times have switched to "T+" as the liftoff process has started the mission counters.

(T+00:06:50)
Space Shuttle clears the Launch Tower.

(T+00:11:00)
The Space Shuttle performs the Roll maneuver.

(T+00:45:00)
The Main Engines are automatically throttled back to 60% to reduce the dynamic pressure on the Space Shuttle.

(T+01:05:00)
The main Engines are throttled up to approx. 104%.

(T+02:00:00)
The SRB engines stop working.

(T+02:05:00)
SRBs are disconnected and separated from the Space Shuttle. They fall back to Earth to be collected from the ocean, refurbished and re-used in one of the future Shuttle flights.

GPC automatically enters the OPS-103 mode.

SRB Separation to MT Separation Complete (MM-103)

(T+04:20:00)
Mission Control sends a "Negative Return" message. This means that it is not possible to abort the mission and perform a RTLS.

(T+06:30:00)
Ascent angle is adjusted in preparation for the Main Tank separation.

(T+07:00:00)
At this mark, the Space Shuttle can reach orbit even in event of failure of two of its Main Engines.

(T+07:40:00)
Main Engines are throttled back until the acceleration is reduced to less than 3G.

(T+08:30:00)
Main Engines are throttled back to 68%.

(T+08:38:00)
Main Engines Cut Off (MECO).

(T+08:55:00)
Main Tank is disconnected and separated from the Space Shuttle.

GPC automatically enters the OPS-104 mode.

ET Separation Complete to OMS-1 Burn (MM-104)

(T+09:00:00)
The crew manually maneuvers the Space Shuttle into the correct attitude as a preparation for OMS-1.

(T+10:40:00)
The crew initiates the OMS-1 process by entering the necessary parameters in the GPC.

(T+12:30:00)
The crew shuts down the APU and changes the GPC mode to OPS-105.

Complete of OMS-1 to Complete of OMS-2 (MM-105)

(T+45:55:00)
The crew initiates the OMS-2 process by entering the necessary parameters in the GPC. After this point the Space shuttle is in low orbit around Earth, preparing for final Orbit Insertion.

The Post Insertion Phase

Complete of OMS-2 to GPC mode OPS-2 (MM-106)

(T+50:00:00)
The crew changes the GPC mode to OPS-106.

(T+02:30:00:00)
At this point, the Post Insertion Phase is completed and the crew prepares for its mission in orbit.

Flight Plan, Orbit OPS Phase

ORB Maneuvers (MM-201)

This phase is mission-specific. The crew may be required to launch, service or capture satellites, perform experiments or dock with the ISS.

The Deorb Preparations Phase

DEORB minus 1 day

Somewhere after completing the mission objectives, the crew prepares the Space Shuttle for it's to return to Earth. Usually this comprises of stowing the RMS and other various equipment, closing the bay doors, etc.

(TIG-04:00:00:00)
Time to Deorbit Ignition (TIG) is four hours and counting. There are now four hours before the Space Shuttle fires its OMS engines to slow it down towards the de-orbit point.

Crew at Deorb and Landing posts (MM-301)

(TIG-01:00:00:00)
Donning the special G-suits, the crew takes position in the crew seats. The GPC is switched to OPS-301 mode.

(TIG-00:40:00:00)
The crew prepares for slowing down the Space Shuttle. The slowdown is performed by firing the OMS engines against the direction of flight. The crew checks the OMS engines.

The Entry Phase

(TIG-00:30:00:00)
DEORB Preparations Complete.

(TIG-00:25:00:00)
The crew prepares the APU for activation.

Confirm Deorbit and Landing process (MM-302)

(TIG-00:20:00:00)
The crew loads the OPS-302 mode into the GPC. Mission Control confirms the Deorbit and Landing processes.

(TIG-00:15:00:00)
The crew manually maneuvers the Space Shuttle so that its aft points towards the direction of flight.

(TIG-00:03:00:00)
The APU is started.

(TIG-00:02:00:00)
The crew arms the OMS and the Digital Auto Pilot (DAP) in preparation for the Deorbit burn.

End of Deorbit Burn to EI-5 minutes (MM-303)

(TIG-00:00:00:00)
The DAP fires the OMS engines and slows down the Space Shuttle enough to allow it's orbit to decay slowly. The Space Shuttle is now one hour away from landing.

(L-52:00:00)
The Space Shuttle is manually maneuvered with the nose pointing into the direction of flight. The GPC is put in the OPS-303 mode.

(L-50:00:00)
General switches status check before entering the Atmosphere.

(L-41:00:00)

The crew is performing a check of the Aerodynamic Control Surfaces, Hydraulic System.

(L-40:00:00)
At this point, the residual Forward RCS fuel is emptied in space.

EI-5 minutes to TAEM (MM-304)

(L-35:00:00)
The crew activates the G-suits and the GPC is put in the OPS-304 mode as a preparation for entering the Earth Atmosphere.

(L-30:00:00)
The Space Shuttle is at an altitude of 400,000ft and speeding at approximately 17,000kts at the Earth Atmosphere Interface on a decaying orbit.

(L-25:00:00)
The OMS controls are inhibited and the Space Shuttle loses communications as it enters the Earth Atmosphere and a halo of plasma begins to engulf its body.

(L-20:00:00)
At this point, the Space Shuttle body temperature is at its maximum, the thermal tiles protecting it from burning in the upper Atmosphere. The Space Shuttle is at an altitude of approx. 230,000ft and flying at 15,000kts

(L-15:00:00)
The Autopilot begins a series of rolling and banking to increase drag, manage lift and rate of descent and generally point the Shuttle towards the HAC. If these maneuvers cause the shuttle to veer too far off course, the Autopilot will initiate a roll reversal maneuver. A combination of these maneuvers appears as a series of "S" turns.

(L-12:00:00)
The Space Shuttle is at 120,000ft and flying at 8,000kts. The Shuttle regains communications with the Mission Control.

(L-10:00:00)
The Shuttle deploys the Air Brakes to the 100% position.

(L-07:00:00)
The Space Shuttle is at an altitude of 90,000ft flying at a supersonic speed of 3.3 Mach. The Air Brakes are moved to the 65% position.

(L-05:30:00)
The altitude is now 83,000ft and speed 2.5 Mach. The Pilot begins the HAC interception in preparation for the final approach and landing, using the SPEC 50 horizontal attitude display mode.

(L-03:00:00)
At 50,000ft and at a speed of 1 Mach, the lateral stabilizing RCS engines are inhibited and the Aerodynamic Control Surfaces (elevons, rudder and flap) become active. At this stage, the Space Shuttle becomes a big, heavy glider and the Commander takes over the control of the Shuttle.

TAEM to WOW Phase (MM-305)

(L-02:00:00)
At around 10,000ft and 400kt, the Space Shuttle is aligned roughly with the landing runway. At this point, the GPC moves automatically to the OPS-305. Using the HUD and the automatic landing system instrumentation the Commander will gently guide the Shuttle towards the runway threshold. Remember, there are no engines – the Shuttle is just a big, heavy glider so the only control you will have is over the Shuttle attitude which ultimately controls the energy and lift.

(L-00:30:00)
At about 2000' and 350kts, the glide angle is reduced to 1.5 degrees. Listen to the guidance cues coming from the tower.

(L-00:17:00)
At about 600' the pilot begins a flare-up maneuver in preparation for touchdown. Please note the approach speed – it should be around 250kts.

(L-00:12:00)
At 200' the landing gear is lowered. The optimal landing speed is around 200kts.

(L-00:00:00)
The main landing gear is the first to touch down followed by the nose gear which slowly descends on the runway until it touches the runway (Weight on Wheel). At this point, the pilot deploys the braking chute and applies brakes.

WOW to Post Landing Phase (MM-901)

(L+01:00:00)
The Shuttle rolling speed is brought to below 60kts at which point the pilot jettisons the braking chute.

(L+02:00:00)
The Shuttle is brought to a complete stop.

(L+04:00:00)
The pilot performs the shutdown procedure which goes on for about 30'. After the completion of the shutdown procedure, the crew opens the hatch and begins exiting the Space Shuttle.

Mission Control Center

SSM2007™ offers an option to monitor the mission progress from the comfort of the **Mission Control Center** (MCC). Press **F11** during any mission phase to access the MCC screen.

As in real life, the MCC provides a visual display of the Shuttle and space objects orbits and location, including a synthesized view (or real-time video link) from the Shuttle.

The bottom screens show mission, dynamic and communications information. Currently the MCC screen is only an information screen. In the future we plan to develop it into a more interactive part of the simulation process.

You can leave the MCC at any time by pressing F1.

Mission Control Center View

Entering the Flight Deck

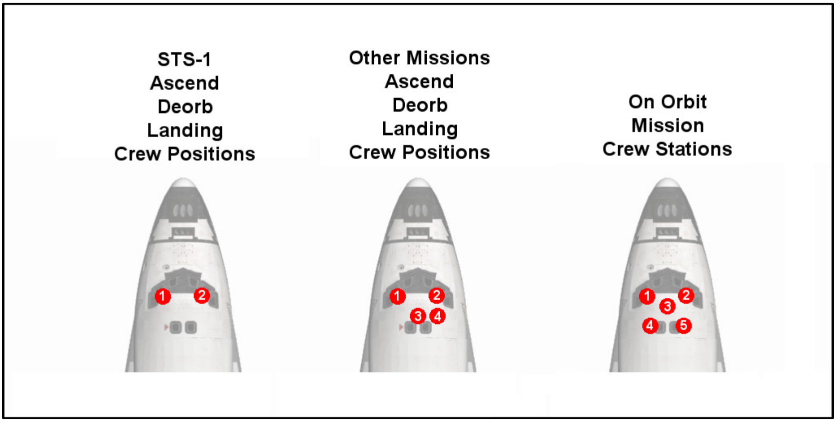
Crew Positions

Space Shuttle Mission 2007™ features a **3D Virtual Flight Deck** (3DVFD) which allows you to access panels and look through the flight deck windows. We are seriously considering increasing the 3DVFD functionality by adding "active controls" so that you may operate some of the knobs, switches etc. from within the 3D view without the need to access the zoomed-in, 2D detailed panels. This will certainly happen in future versions of SSM2007™.

For now, the 3DVFD features active MFDs and other auxiliary displays (MET, MON1, etc.). The active displays change in real-time enabling you to monitor the system status without the need to select the relevant panels.

Press **F3** to enter the 3D Virtual Cockpit. By doing so you will find yourself positioned at the last accessed "crew station". The first time you enter the 3DVC you will be seated in the Commander's Seat.

Press **F4** to move on to then next station. You will find yourself sitting in the Pilot's Seat. Pressing F4 repeatedly while in 3DVFD view will rotate you through all the available Crew Stations, including the Mid-deck.



3DVS Crew Stations

The availability of the Crew Stations depends on the Space Shuttle Mission phase:

- During **Ascend**, **Deorb** and **Land** Phases, there are four positions available (only two for STS-1): Commander, Pilot, Crew 1 and Crew 2 behind the Commander and Pilot stations.
- During **On Orbit** Phase, there are five available positions: Commander, Pilot, "jump seat", AFT1 and AFT2.
- STS-130, **Cupola** view, after **Cupola** installation, while docked

The "jump seat", AFT1 and AFT2 positions have a 360 deg field of view. The Commander, Pilot, Crew 1 and Crew 2 positions have a limited Point of view – simulating the anatomic limits.

The initial position of the Commander, Pilot and "jump seat" stations is facing towards the front of the Shuttle, while the AFT1 and AFT2 are facing aft, through the aft windows. These are also the ideal locations to look through the upper windows. This is where you will spend most of the time during RMS and Docking operations.

Position #3 is special in the sense that it puts the Astronaut in a “free-floating” mode. In this mode you are free to float inside the Shuttle flight-deck through the stairs to the mid-deck, and if the mission warrants it, float through the hatch and airlock to other places. Use the EVA controls to move around.

While in 3DVFD use the mouse to look around and the **Mouse Wheel** to **Zoom-in** or **Zoom-out** and improve the readability of the gauges or panels.

Right-Click once in order to enter **Panel-Selection Mode**.

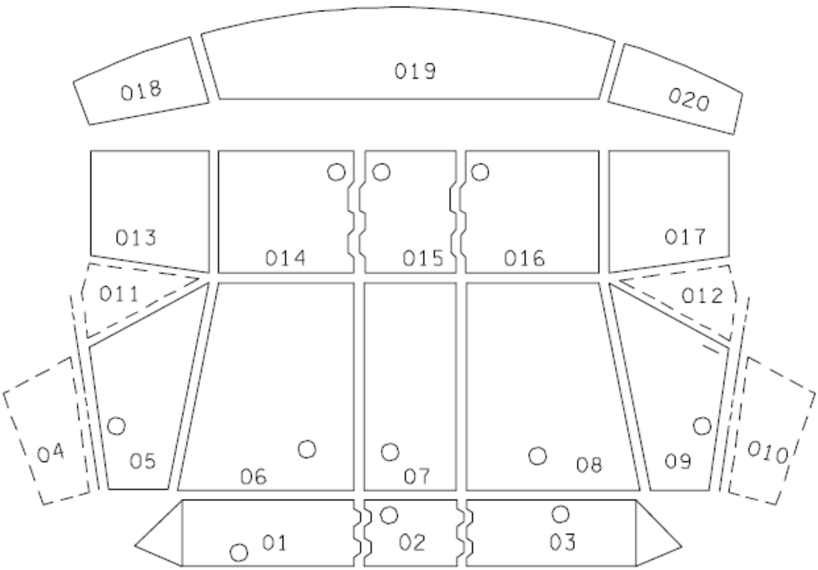
The current 3D point of view will freeze. Move the mouse around and you will notice that as the mouse cursor hovers, it will highlight certain panels. If you click on one of these highlighted panels, you will zoom-in into the 2D detail view mode where you will be able to press the buttons, rotate the knobs and play with the switches. You may press F3 at any time to go back into the 3DVFD view, select other panels or just look around.

SSM2007™ always remembers the last accessed panel and you can return there instantly by pressing **F2**.

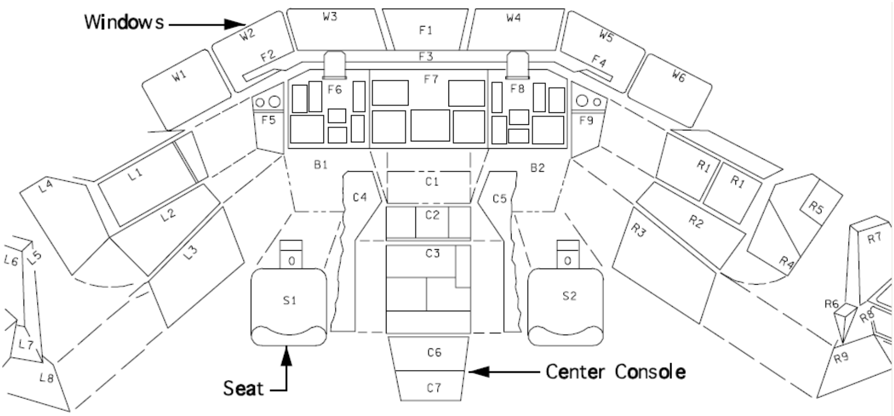
Panels

The Space Shuttle systems are controlled by vast array of switches, knobs, buttons and keyboards arranged on panels which surround the flight deck.

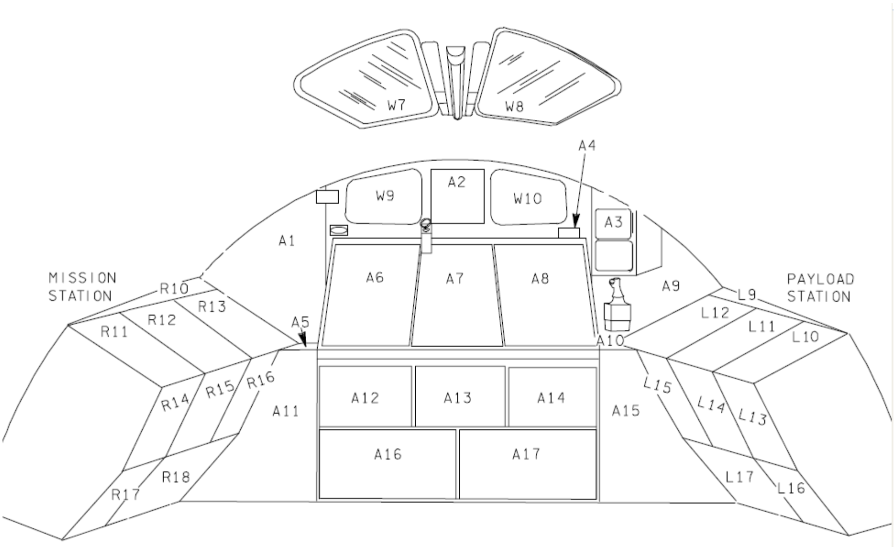
They are referenced by IDs, engraved on each panel. The IDs are made by a letter and a number, or a sequence of letter, number and letter. The first letter indicates where the panel is located – Front, Left, Right, Aft or Overhead. The number is sequential, numbered from top to bottom, forward to aft. The last optional letter is used to indicate whether we talk about the Upper or Lower part of a particularly large panel. So IDs can go like L1 meaning the Left panel number 1, or A6U, meaning the Upper section of the A panel number 6. Please refer to the excellent panel guides below, taken straight from NASA's original **Shuttle Crew Operations Manual** (SCOM) which can be downloaded at **www.nasa.gov**.



The Cockpit Overhead Section



The Cockpit Front Section



The Cockpit Aft Section

Selecting a panel

Once you enter the 3D Virtual Flight Deck, you can look around from any crew station you chose by moving the mouse (or using TrackIR™). You can zoom in a specific area and read labels or MFD or HUD information.

If you chose to select a panel, once you see it, you right click. This puts you in "panel selection" mode. You may exit this mode by right-clicking again. In this mode, the view is frozen to the moment you right clicked, and now you can move the mouse over the panels in sight. As you hover over the panels, you will notice that some will show a yellow overlay. That means that they are selectable and that you can further zoom in to operate the knobs.

Left click on the selected panel and you will be moved into the 2D panel view where all the knobs, buttons, keyboards, etc. are active. This is the main system operation mode.

Selecting a panel

Controlling the 3D Cockpit Lighting

Cockpit lighting is very flexible and covers separate controls for instrument panels, CDR and PLT seats, ambient lighting etc. SSM2007 currently offers the option to control the ambient lighting of the cockpit, but it also takes into account the external light which comes from the Sun.

Light is controlled by the rotary LEFT/RIGHT SEAT/CNTR CNBL FLOOD on panels O6 and O9. Both rotaries influence the ambient light so you may use any one of them.

The Cockpit Light Control

Multi Function Displays

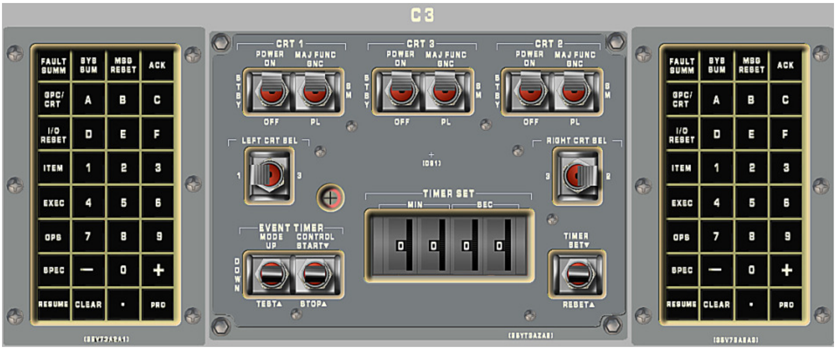
The **Multi Function Displays** (MFDs), also known as **Multifunction Electronics Display Subsystems** (MEDS) are a set of "D-size" (6.71 x 6.71 inches) flat-screen displays manufactured by Honeywell (with FDS screens from Philips, Netherlands).

These displays are used by the crew to monitor and control the GPC. The MFDs displayed content is selectable either manually or automatically and it presents status, alerts and information for navigation, guidance, system management and diagnosis purposes.

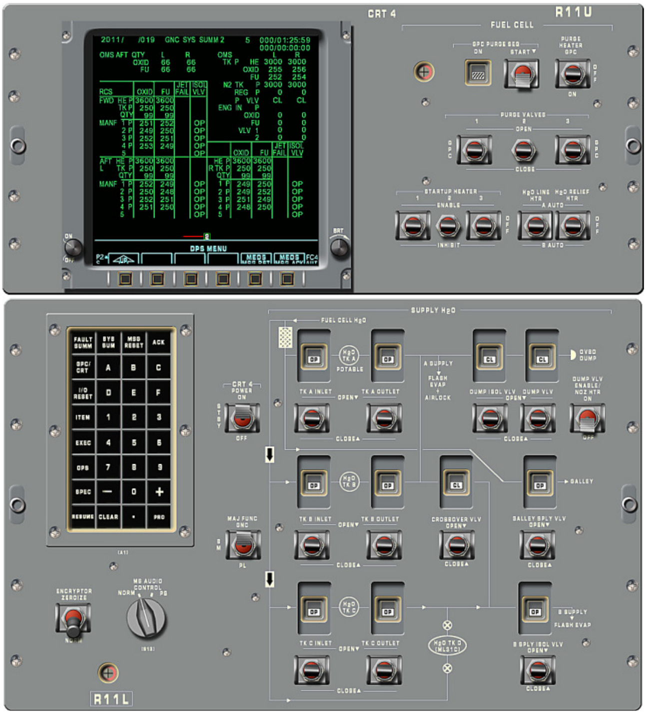
SSM2007™ emulates many of the display modes and uses the GPC quite extensively during a mission; therefore you will need a very good understanding of the various display modes and conventions used by the MFDs.

The MFDs are located on the Front Panels and on the Right Aft Panel. The Front Panels hold a cluster of nine MFDs while the Right Aft panel has a single MFD. The crew controls the GPC via the keypads. The Commander and Pilot keypads can be accessed in the 2D mode either directly or, when they are out of view (but still while the Front Panels are visible), by toggling them with the LEFT (Commander) or RIGHT (Pilot) SHIFT keys respectively. You cannot have both keypads on screen at the same time.

Front Panels Overview



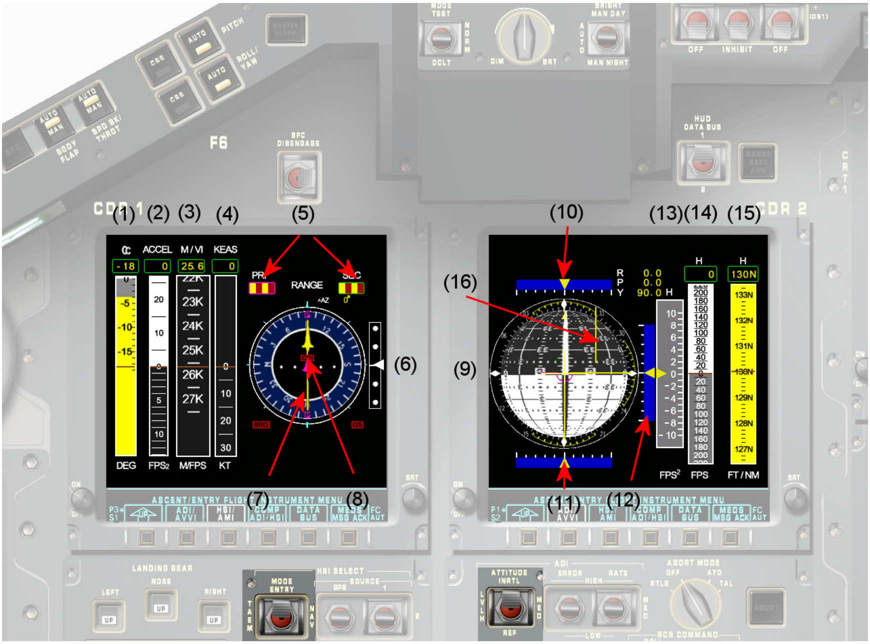
Center Front Keyboards



Right Aft MFD + associated Keyboard

The HSI/ADI Displays

The Space Shuttle Bay main attitude and navigation instruments are the ADI and Horizontal Situation Indicator (HSI) on the left and Attitude Direction Indicator (ADI) on the right.



Commander Front panel with the HIS and ADI displays

Some of their operation modes depend on whether the Shuttle is on Orbit or during approach or landing.

The HSI gauge mode is controlled by the Mode Switch which can be ENTRY (approach) used for the entry phase, or TAEM.

The ADI gauge is controlled by the ATTITUDE switch which selects two modes: LV/LH – for reference to Earth, INRTL – for reference to a specific point in space, usually a star (this mode is used on Orbit) or REF. The REF mode is used as a marker for the last position, in case we need to return to it later on after performing a maneuver.

Let's examine the various symbols displayed by these two instruments:

HSI Symbology:

1. **Alpha** – Angle of Attack from -18 to +60 degrees
2. **Acceleration** – 50-100 ft/sec2
3. **Mach Number** – 0 – 4,000ft/sec and Mach
4. **Estimated Air Speed** – 0-500kts
5. **Range** – Primary (left) and Secondary (right) in miles.
6. **Glide Slope Indicator** – deviation from glide slope
7. **Course Pointer –** bearing to runway in degrees
8. **Course Deviation –** deviation from course/runway centerline

ADI Symbology:

9. **The "Artificial Horizon" Ball –** shows Shuttle attitude to a reference system.
10. **Roll Rate Pointer –** rate of roll
11. **Yaw Rate Pointer –** rate of yaw
12. **Pitch Rate Pointe –** rate of pitch
13. **Altitude Acceleration Rate –** in fps2
14. **Vertical Speed –** in fps
15. **Altitude –** in ft/nautical miles
16. **Yaw/Pitch/Roll Error Needles –** show the deviation from a desired position. In order to get to the desired position, "fly" the Shuttle towards the needles.

Crew Alert and Warning Systems

The Space Shuttle has a series of Crew Alert and Warning Systems (CAWS). Some of them are simulated in SSM2007. Some alerts are advisory only and they occur as part of the normal Shuttle operations, but some are critical and must be addressed immediately.

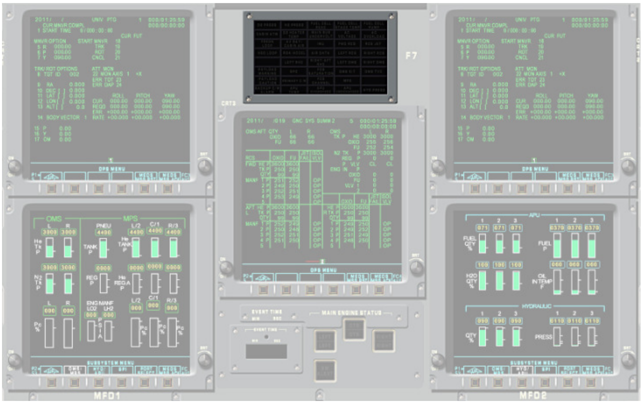
When an alert light is on, an alarm beep-beep is heard continuously. When a fire or smoke is detected, a siren also starts sounding. Usually, alert lights go off after the situation is corrected.

The alarm beep can be turned off by pressing the MASTER ALARM button on the Front Panel.

The Master Alarm button

Front Panel

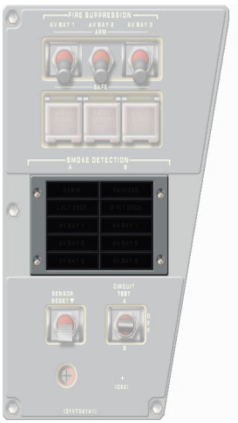
The primary CAWS is located on the front center panel and it consists of several annunciator lights.



Front Panel CAWS

Left Panel

The Fire alarm annunciator lights are located on the Left (L1) panel together with the Fire Suppression System.

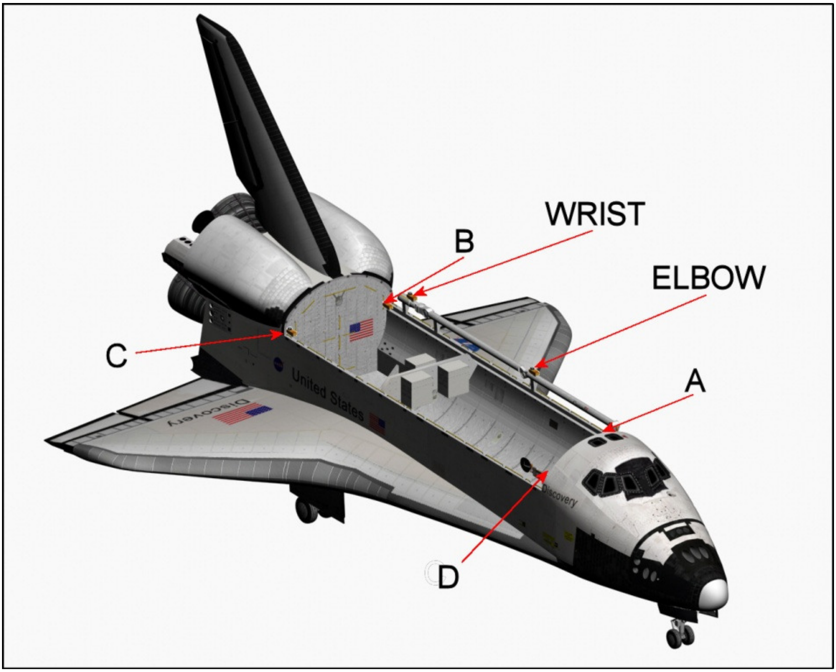


Fire Suppression System CAWS

Bay Lighting and CCTV Systems

Floodlights and CCTV

The Space Shuttle Bay is illuminated by a series of powerful floodlights and monitored by a set of video cameras that allow for uninterrupted activities regardless whether the Shuttle is on the "day" or "night" side of Earth.



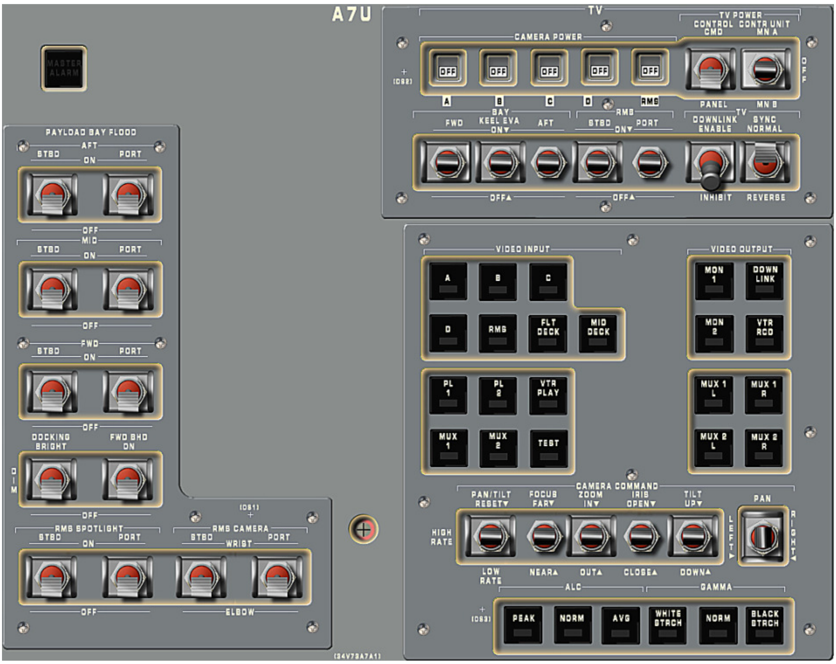
CCTV locations

The Bay Lighting and **Closed Circuit TV** (CCTV) systems are controlled and monitored from Panel **A7U**. In SSM2007™, all lights and bay CCTVs are fully operational and can be turned on and off at any time.

Please note that another CCTV is mounted inside the docking system. That special CCTV is used during the docking operations. The Input linked to that camera is **PL1**. Another special CCTV link is **PL2** which is connected to the OBSS camera used for thermal tiles inspection.

The video signals coming from the CCTV are managed from the same panel (**A7U**) and routed to various video systems, but in SSM2007, the video can be routed only to **MON1** and **MON2** (monitor #1 and #2) which are located on the Aft Left section of the flight deck. In order to route a video signal, you first have to select the monitor by pressing the MON1 or MON2 on the VIDEO OUTPUT buttons group, and then the CCTV from the VIDEO INPUT buttons group.

Additional controls enable the Astronauts to adjust the positions and zoom factor of each camera independently: Tilt (Up and Down), Pan (Left and Right) and Zoom (In and Out) are fully simulated, while Iris, Focus and the special ALC and Gamma are not.



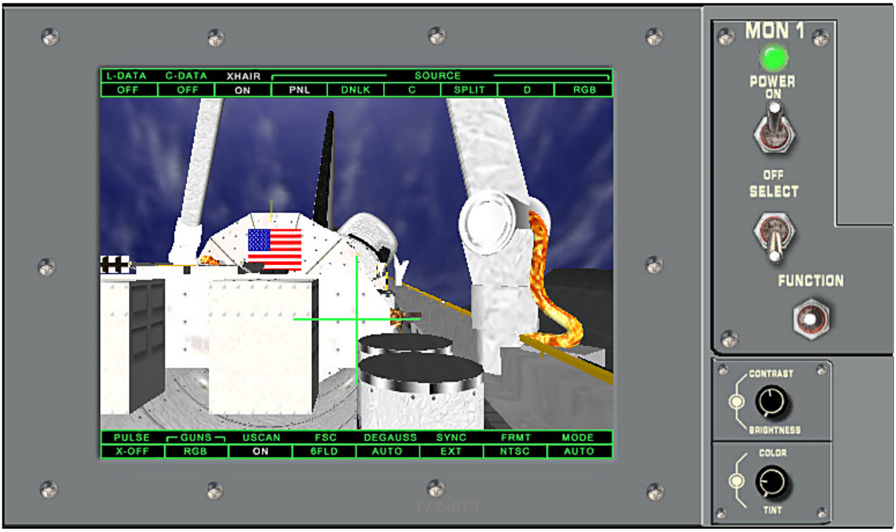
Panel A7U – Lighting, CCTV control

We recommend that you play with the various CCTV and lighting combinations and make yourself acquainted with the system – you will need this knowledge in each and every mission for operating the RMS and docking. SSM2007™ simulates cameras A, B, C, D, RMS Wrist, RMS Elbow and PL1 and the video signal can be routed only to MON1.

The Video Monitor (MON1 or 2)

As explained above, the video signals coming from the CCTVs are routed to the MON1 and MON2.

The MON1 and MON2 Power On/Off switches can be seen and operated in 2D panels view, and are always at the upper right side of the Aft panels, regardless how much you scroll them either side. Also once turned on, the monitors will hold their position so basically you may scroll the panels behind while not losing sight of the video image. This is important during RMS and docking procedures.



MON 1

The only active monitor control at this time is the "targeting" reticule which is a big green cross in the center of the screen. This reticule overlay assists in targeting the correct attitude for docking, or for capturing the grappling points, depending on the nature of the mission.

If you use the CCTV system only for looking around the cargo bay, you may not need the reticule overlay and you may want to hide it. This is done by using the Select and Function switches. Please note that only the XHAIR function is simulated at this time.

The monitors can be also seen in the 3D Flight Deck view. The image is displayed in real time and can be used to perform RMS operations and dockings just as in the real Space Shuttle. While docking, you may also want to look up through the upper aft windows.

The 3D view of MON1 and MON2

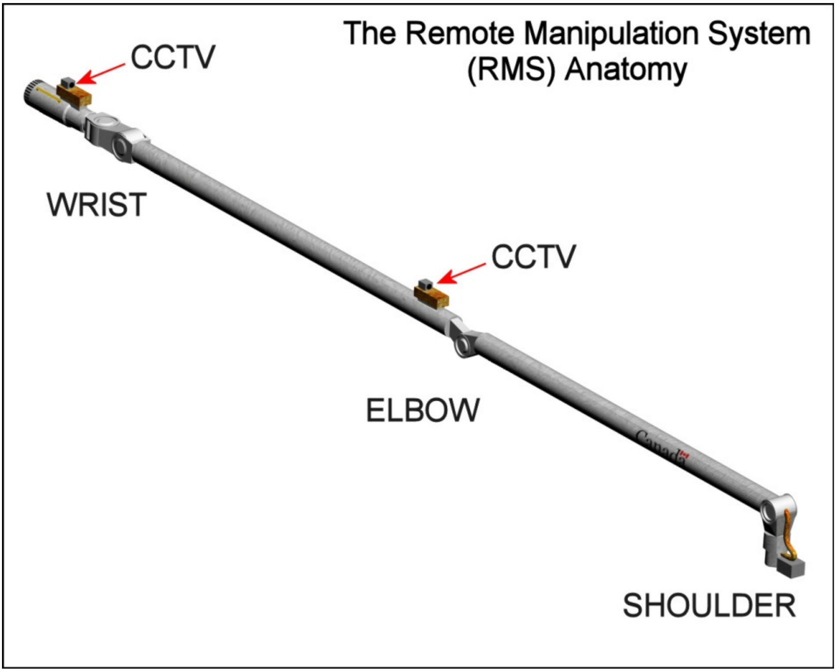
The Remote Manipulator System (RMS)

The RMS is used to manipulate the cargo and assist the Astronauts while performing EVA missions.

There is a provision for two RMSes on the Space Shuttle but only the Port one has been ever installed and used.

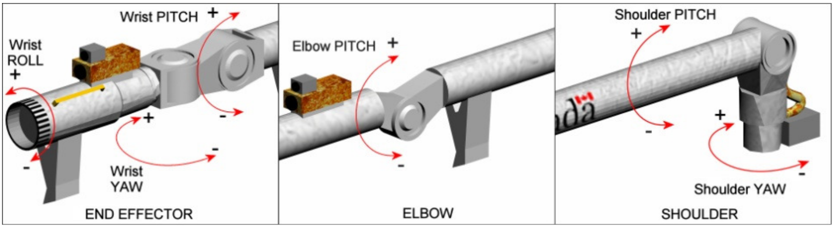
Anatomy

The RMS has several rotation axes and can be controlled from the Space Shuttle cockpit via the computer and joystick.



The RMS

The RMS arms can be rotated around these axes and the End Effector can capture and hold a variety of cargo by means of specialized grapples.

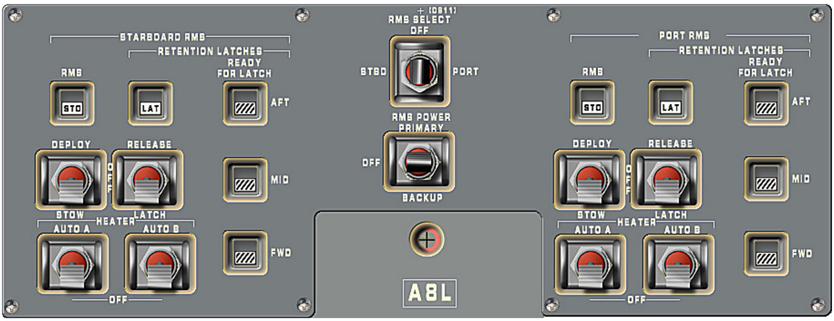


The RMS degrees of freedom

During lift-off, the RMS is stowed in a special position to protect it from vibrations and acceleration. Before returning to Earth, there is no need to return the RMS to the special stow position which was necessary for the launch phase.

The RMS control panels

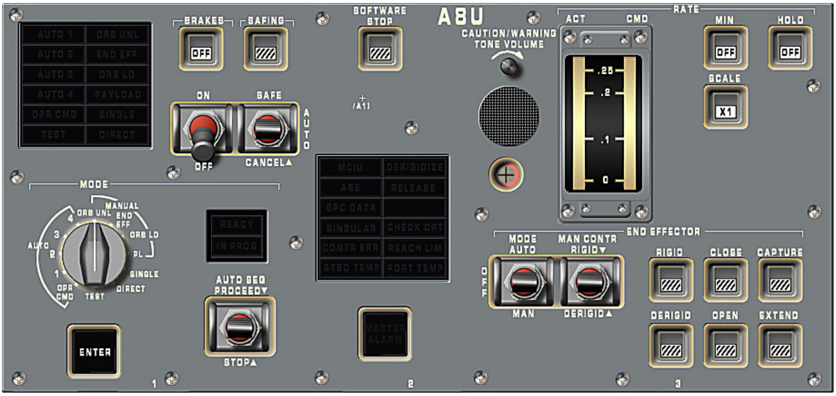
All the RMS controls are located on the A8 Aft Right panel located under the cockpit port aft window.



The A8L panel: RMS powering-up and deployment

The Lower part of the A8 panel (A8L) controls the selection, powering up, deployment and unlatch of the RMS while in orbit. Although we have power-up controls for two RMSes, the Shuttle has only the port RMS installed, therefore all the RMS procedures refer to the port RMS only.

After the Columbia disaster, the Starboard RMS empty position has been occupied by an extension boom which, in conjunction with the RMS, is used to inspect the thermal tiles for possible damage sustained during the launch phase.

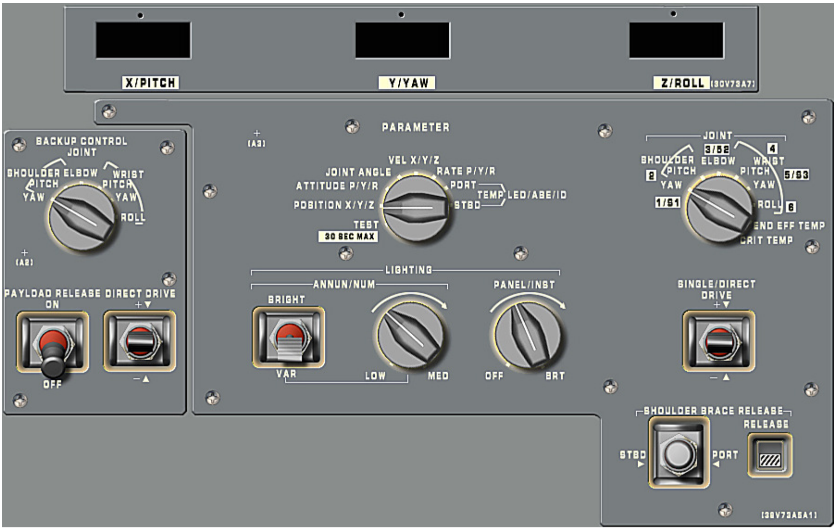


The A8U panel: RMS and End Effector modes

The upper part of the A8 panel (A8U) controls the various operation modes of the RMS and its End Effector together with the breaks, safing, operation rate switches and gauges.

The four AUTO modes are pre-programmed for each relevant mission. You can also take manual control of the RMS by selecting the ORB UNLATCH, SINGLE or DIRECT modes and use the joystick or the procedure described below. After selecting a mode with the mode knob, you need to activate it by pressing the A8 "ENTER" button (NOT the keyboard ENTER key). The mode activation is reflected by the Mode Annunciator panel lights right above the mode selection knob. SSM2007™ does not simulate the AUTO modes.

The End Effector can work in Automatic and Manual modes. The End Effector status is reflected by the associated six status annunciator lights. A successful grapple is indicated by a lighted CAPTURE light. During a capture or release process, the lights change status to show the various process progress. You can use the keyboard ENTER and “NumPad 5” keys to respectively capture or release a grapple.



The A8 middle section: RMS position control

The middle section of A8 (technically part of the A8U panel) is where we will spend most of the time while operating the RMS. Here we also have three digital displays which display 3D positional and angular RMS data.

The type of control and positional display are selected by the PARAMETER knob. For example, when we select the "Joint Angle" position, then we control the angle of the selected axis, and the X/Pitch digital display show the values in degrees.

We use the JOINT knob to select the axis (or joint) we wish to control. The various positions of this knob are self-explanatory.

In order to change the value we have selected (for example the angular position of a joint), we use the SINGLE/DIRECT DRIVE switch. We move the switch to '+' to increase the value and to '-' to reduce the value. This switch spring-returns to the middle (not active) position automatically so in order to have a continuous motion, we have to keep it pressed in the desired position.

It takes some time until the RMS motion picks up or slows down. This is due to the RMS inertia, so be patient and careful as you maneuver the RMS especially when you have grappled an expensive cargo such as a satellite or an Astronaut. The actual rate of motion can be seen on the vertical linear ACT gauge on the A8U panel.

IMPORTANT: special PARAMETER rotary modes are **ATTITUDE P/Y/R** which shows the End Effector rotational attitude in degrees, and **POSITION X/Y/Z** which shows the EE absolute coordinates referred to the Shuttle coordinates system. These values are displayed on the X/Y/Z digital readouts when the JOINT rotary is set at any position within the WRIST range. You will use these modes extensively when you need to accurately place the End Effector at a specific position for EVA, grapple or hand over items from the Shuttle to the ISS RMS for example.

If the RMS seems not to move, you should check the ACT gauge. The ACT gauge would most certainly show a small "jump" but will not reach full rate despite the continuous press on the SINGLE/DIRECT DRIVE switch. This may indicate that the RMS is stuck due to some obstacle it met during the operation. Usually you can "un-stuck" it by moving it back to the previous position.

The RMS will stop moving also when it tries to reach a position which is not consistent with the RMS manufacturer specs – for example an extreme angle. The "REACH LIM" light from the A8U panel will indicate this situation. In this case, as before, you will need to move the RMS to a different position.

Another control mode, and the one used most in all the mission is ORBIT UNLATCH mode where you can use the Shuttle AFT stick (or related keyboard commands) to control the RMS and move it precisely, quickly and smoothly to the desired position. Make sure that the Flight Controller is disabled and that control is passed to the RMS. If you forget to transfer the joystick control to the RMS, you will activate the RCS and change the Shuttle Attitude. This may result in scrapping the mission or worse, as you may damage it or the intended target (Hubble, satellites, ISS) in the process. To switch the joystick control to the RMS you will have to switch the FLT CNTRLR POWER switch on the AFT LEFT A6U panel to ON. In order to return the joystick control to the RCS, you will have to switch the FLT CNTRLR POWER switch on the Commander FRONT LEFT (F6) panel to ON.

The RMS was tested in space for the first time during the STS-2 mission. In SSM 2007, STS-8 is an excellent opportunity to practice the RMS operation.

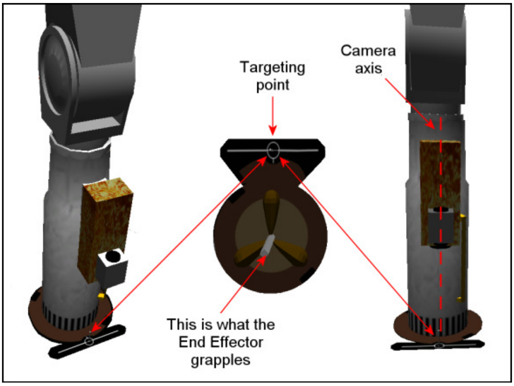
The RMS operation is the same throughout the missions so once you pick it up, its use becomes almost instinctive. The exact operation sequences are explained in detail during the missions and in the checklists, however commanding the "art" of cargo manipulation with the RMS, requires practice.

ⓘ ***Hint:*** *pressing the "**R**" (**RATE HOLD**) key on the keyboard maintains the rate at which the RMS moves. This is very useful when you want to maintain a constant motion rate and perform a precise grapple or hand-over maneuver such as in STS-116.*

How to grapple

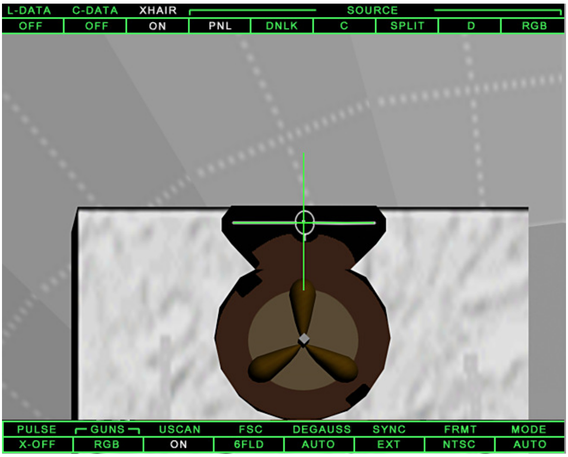
In real life, the RMS operator can use the views from the Closed Circuit TV (CCTV) system – more about it later - and the aft windows in order to position the RMS and its End Effector correctly. You have all these available to you in SSM 2007, including the external view and free floating camera, a tool inexistent in real life except for the case the crew have an EV Astronaut helping them.

The Grappling Point is a hardened device installed on the object that is to be manipulated by the RMS. The Grappling Point has a special shape, its upper part being used for targeting the End Effector and the central part for capturing.



The correct End Effector attitude over a Grappling Point

Please note that the End Effector must be in the correct angular attitude and X/Y/Z position in order to perform a successful capture.



Correct End-Effector Attitude over a Grappling Point as seen through the End Effector Camera

The CCTV End Effector (EE) view is sent from a camera mounted on the EE. The camera also has a spot light which can be turned on in case you need to perform operations while the Shuttle is on the "night-side" of Earth. The CCTV monitor has a crosshairs display which allows you to target the

EE for a correct grapple. The EE has to be aligned with, and rotated perfectly at the Grapple Point so that the crosshairs are right on top of the target and the grapple point itself, below the crosshairs.

Once you have positioned the EE approximately above the Grappling Point, <u>refer to the ATTITUDE and POSITION coordinates in the **checklist**</u> to position the EE correctly. A correct grapple will happen only when the **ATTITUDE P/Y/R** <u>and</u> **POSITION X/Y/Z** are correct within several tenths of degrees and inches respectively. <u>In order to read these values, you will alternate the PARAMETER rotary between ATTITIDE and POSITION while the JOINT rotary at the WRIST Pitch, Yaw or Roll.</u>

Grappling can be tricky so please be patient!

Achieving Mission Orbit

Once outside of the major part of the atmosphere, the Space Shuttle is on an orbit around Earth. Orbits are always elliptical. There are two positions on our orbit that are especially important: the farthest point from Earth's center (**Apogee**) and the nearest point to Earth's center (**Perigee**). The nearer you get to the mass center (center of the Earth) the faster you travel on orbit and the farther you get from the center of Earth, the slower you go. If you want to know more about it, read about “Kepler Laws” in corresponding books.

During the launch phase, the initial orbit characteristics depend on launch parameters, among them thrust and weight. It is quite possible that after MECO your Perigee is still inside the atmosphere or even "inside" Earth. This would lead to a premature re-entry of the Shuttle thus missing the on-orbit mission phase. It is necessary therefore to "raise" the Perigee to stay in a stable orbit around Earth and prevent the Shuttle from prematurely deorbiting and returning to Earth.

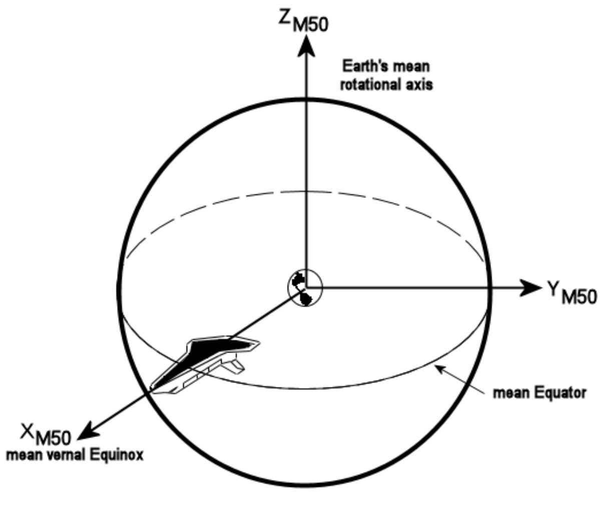
The Shuttle crew can raise the Perigee by increasing the velocity at Apogee. If you add enough velocity you can get to a higher orbit, thus changing the former Perigee to a new Apogee. To make the orbit circular you should add some speed at your new Apogee, so that it is just the same as your Perigee.

At this point the **Orbital Maneuvering System** (**OMS**) gets into the game because the Shuttle cannot use the Main Engines anymore. To reach your first stable orbit around Earth after MECO, the Shuttle uses the thrust of the OMS. It burns fuel, so these maneuvers are called “OMS burns”. If you need a few of them, the burns get numbered 1, 2 etc. These first orbits are usually lower than the rendezvous target orbit (or mission orbit), but because you are lower, you are traveling faster. This fact could be used to catch up with the ISS (or other rendezvous target). A number of correction burns (**NC** = Nominal Correction) will match your orbit gradually to that of the rendezvous target. Next, you have to make sure that both the Shuttle and the rendezvous target are at the same position on orbit, otherwise you may be at the same altitude but too far ahead or behind. If you are behind, you cannot simply accelerate to catch up without gaining altitude again. The final phase of the rendezvous (explained in another section of this manual) is a bit tricky to calculate and perform, but that's what computers and radars are for.

If you want to land, you need to lower your Perigee in a way that you will end inside the atmosphere: this means that the Shuttle has to be slowed down at Apogee. That is why the Shuttle makes its Deorbit burn with the nozzles of the OMS facing against the direction of movement.

A precise Shuttle alignment (Pitch, Roll and Yaw) is mandatory for all on orbit burns. This alignment is computed by the Shuttle on-board computers (and the MCC team). The attitude can be achieved either by manually controlling the Shuttle until the attitude matches the required values, or can be controlled automatically by the on-board computers.

The M50 Reference System



The M50 Reference Frame

The on-orbit attitude is defined in a special reference frame (coordinates system) called **M50** – see figure above. The line-of-sight data from two stars are used to determine the current **Inertial Measurement Units** (IMU) orientation with respect to the **M50** reference frame. This star-based alignment is obtained by the Shuttle's **Star Trackers**.

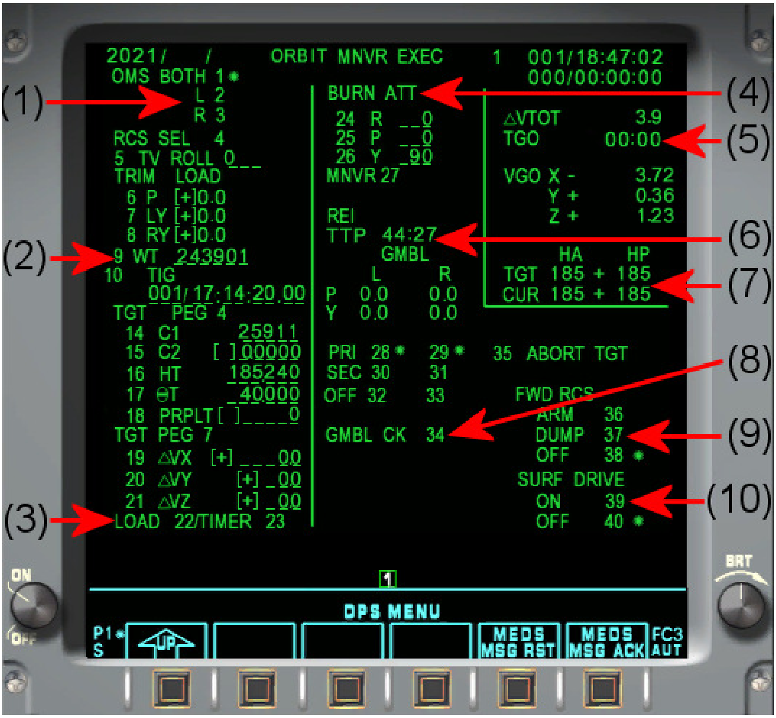
The M50 coordinates system is used to establish and maintain the inertial position and velocity of the Shuttle during all on-orbit phases. The X Axis points toward the mean *vernal Equinox* of the year 1950. *Vernal Equinox* is the apparent point on the celestial sphere where the Sun crosses the Earth's Equator on its Northward journey. The Z Axis points along Earth's mean rotational axis of the year 1950 with the positive direction toward the North Pole. The Y Axis completes the Right-handed system. All axes are perpendicular to each other. This is a reference frame with its origin at the Earth's center, but it is completely independent of Earth's rotation. Remember, that the Shuttle keeps its alignment, no matter where it is on orbit. It is aligned relative to M50 (which is fixed) and NOT relative to Earth.

During landing, it makes sense to leave the M50 reference frame and change to the Local Vertical/Local Horizontal (LV/LH) coordinate system. The LV/LH mode shows the Shuttle attitude relative to the Earth's surface. In LV/LH mode, the ADI works like any other aircraft "artificial horizon". More about this mode can be found in the chapter dealing with the Shuttle landing phase.

The GNC hardware and software provides the crew with information necessary to navigate and align the Shuttle. Additionally it accepts inputs (Items) by the crew. The most important GNC displays associated with the OMS/NC together with their more important parameters are shown below. More information can be obtained by reading the official **NASA Shuttle Crew Operations Manual** (**SCOM**).

XX MNVR YY (Maneuvering Display)

This is where the most critical Shuttle attitude and OMS/NC burn parameters and targets are shown and selected. Please take the time to learn them as you will need to verify and interact with this mode in every mission during Orbit Insertion, Rendezvous and Deorb phases. The XX and YY designate which mission phase the MNVR display references to. For simplicity, we are showing below a screenshot of the ORBIT MNVR EXEC major GPC mode.



ORBIT MNVR EXEC GPC display

1. **OMS Selector**: Item 1-3 chooses which OMS engine you want to use, Item 4 chooses the back end RCS in case both OMS are not functional.

2. **Weight**: **WT** shows the weight of the Shuttle in Pounds (lb). During a burn this is constantly updated. WT can be changed by ground uplink or by the crew (Item 9) but LOAD (Item 22) must be executed in order for the new weight to be recognized.

3. If **LOAD** flashes, new data needs to be loaded by ITEM 22 EXEC. Execution of Item 23 shows the countdown to the next burn in the upper right corner.

4. **BURN ATT** shows the loaded Roll (R), Pitch (P) and Yaw (Y) angles in degrees relative to the M50 reference system described above. The crew may enter a desired attitude by using Items 24, 25, 26. Item 27 (MNVR) initiates an automated maneuver to the attitude parameters if **DAP AUTO** is selected. It may be required that the crew performs final manual adjustments to match the exact RPY parameters (more about it in the UNIV PTG section below).

5. **ΔVTOT** shows the guidance prediction of the total change in velocity of the maneuver in Feet per Second. **TGO** is the time to go in mm:ss until the burn ends.

6. **REI** indicates the Shuttle range from **EI** (Entry Interface) to the landing site (in OPS 3 only). Time to next Perigee (**TTP**) or next Apogee (**TTA**), whichever is closer, is shown in OPS 1+2. In OPS 3 the time to EI is shown as **TFF**. REI and TFF are not computed for Perigees above 55 nm.

7. The targeted (**TGT**) and current (**CUR**) altitude of the apogee (**HA**) and perigee (**HP**) are shown in nautical miles.

8. **GMBL CK**: Item 34 initiates a gimbals check of the Main Engines nozzles.

9. **FWD RCS**: Items 36-38 control the dump of the forward RCS propellants.

10. **SURF DRIVE**: the initiation (Item 39) and termination (Item 40) of a flight control surface drive is provided in OPS 3 only. A ‘*’ is displayed next to the selected item number. The reason for this drive is thermal conditioning of the hydraulic fluids that are used to move the control surfaces.

UNIV PTG (Universal Pointing or OPS 2011)

This is where the crew can monitor and control the Shuttle attitude with a higher precision than with the standard ORBIT MNVR EXEC (OPS 2021).

UNIV PTG (OPS 2011) GNC Display

1. **MNVR OPTION** allows the crew to enter attitude parameters by using Item 5, 6, 7 down to a precision of 0.01 degree.

2. **START MNVR** (Item 18) executes the movement of the shuttle to the new attitude.

3. **TRK** (Item 19) executes a track of the target defined in the S-TRK / COAS CNTL (SPEC 22) star or target tracking setup page. This function will point the Shuttle docking assembly towards the center of the tracked target. If the mission includes a rendezvous, you will be requested to access the SPEC 22 and select the correct target by the mission comms.

4. **CNCL** (Item 21) stops the motion and keeps the current attitude.

5. **ROLL, PITCH** and **YAW** columns show the respective RPY values for all three axes. The **CUR** row shows the current attitude. **REQD** shows the required attitude (as entered in Items 5, 6 and 7). **ERR** shows how far the CUR is from the REQD attitude (error delta). **RATE** shows the rate of attitude change in degrees per minute.

By using the UNIV PTG (OPS 2011) mode, the crew can align the Shuttle with a precision of 0.01 degrees. Sometimes you are required to manually move the Shuttle to a certain attitude. If the mission does not move ahead, it is quite possible that the Shuttle is not at the required attitude yet. Switch to this GPC mode (OPS 201 PRO) and notice that the ERR values are not Zero. Adjust the Shuttle attitude until all the ERR values are Zero and the mission control will give the green light to move on with the mission.

The UNIV PTG TRK (ITEM 19) function is especially useful for rendezvous, docking, and undocking operations. For example, TORVA and TORF/TORS are much easier to perform with the aid of the UNIV PTG TRK activated.

More information about this display can be obtained from the official **NASA Shuttle Crew Operations Manual** (**SCOM**).

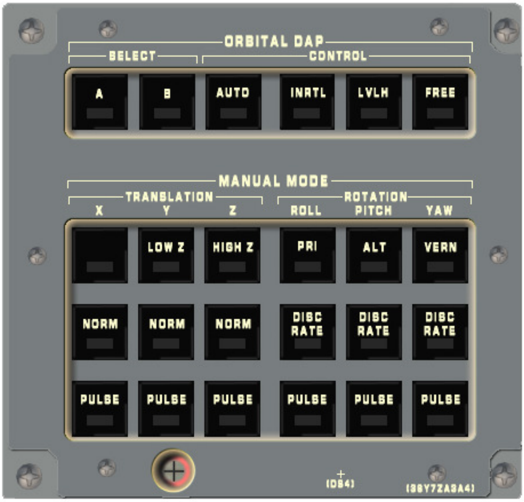
Using the Digital Auto Pilot (DAP)

What does the DAP do?

The **Digital Auto Pilot** controls the movement of the Shuttle with the OMS engines and the RCS jets. The DAP consists of several modules which are in charge of controlling different Space Shuttle mission phases.
The Orbital DAP is fully functional only during the On-Orbit phase. It is not operational during Ascent or Reentry.

Using the ORBITAL DAP to set the attitude

The **ORBITAL DAP** controls are available on the Center (C3) and AFT (A6U) panels.



The Orbital DAP Controls

The **SELECT** (A or B) buttons toggle the DAP between two possible configurations which can be accessed via the DAP CONFIG display (SPEC 20).
The **CONTROL** buttons toggle between four modes: **AUTO**, **INTRL**, **LVLH** and **FREE**.

1. **AUTO** controls the attitude by universal pointing (UNIV PTG) and the DAP will rotate the Shuttle about the shortest angle to the required attitude.
2. **INRTL** results in an inertial (M50) attitude hold.
3. **LVLH** maintains the Shuttle attitude relative to Earth. The ROTATION DISC RATE buttons must be active (lit) for INRTL or LVLH to hold the attitude. If the ROTATION PULSE buttons were lit because of usage in AUTO or FREE mode, switching to INRTL or LVLH selects DISC RATE automatically.
4. **FREE** switches the DAP to free drift. In this mode the ROTATION PULSE buttons will be lighted.

MANUAL MODE TRANSLATION:

1. If **LOW Z** is selected, no upward-firing RCS are used. This mode is used to protect other hardware (e.g. ISS) when the Shuttle is operating in close proximity.
2. If **HIGH Z** is selected the Shuttle uses all the up-firing RCS.
3. If **NORM** is selected will fire the RCS continuously for as long as the THC is moved.
4. If **PULSE** is selected, the RSC will fire once by moving the THC out of detent.
5. Normally, the upper row buttons are not lighted. In this case the default number of up-firing jets are used.

MANUAL MODE ROTATION:

1. In **PRI** (primary mode) one or more of the primary RCS jets will be fired continuously. This mode is not used for RMS or payload operations.
2. **ALT** (alternate mode) still uses the primary RCS but the usage is controlled by the DAP CONFIG display.
3. In **VERN**, the DAP uses the six vernier RCS jets (low thrust) to control the Shuttle attitude more precisely and gently.
4. In **DISC RATE**, when moving the RHC out of detent, the RCS will fire according to the **ROT RATE** parameters in the DAP CONFIG display.
5. **PULSE** mode produces one RCS pulse each time the THC is moved out of detent. Keeping the THC in detent means that the DAP is in free drift mode for that axis. The easiest way to stop any rotation is to switch to AUTO or INRTL. To use either DISC RATE or PULSE, the DAP must not be in AUTO mode.

DAP CONFIG Page (OPS 201 SPEC 20)

This page is accessible while on orbit and allows for presetting various DAP parameters which are active during automatic DAP control and during manual ops.

The DAP CONFIG page

For example, the Vernier rotation rate VERN ROT RATE (ITEM 23, 43 and 63) presets the rotation rate around any axis when the DAP is in VERNIER mode to anything between 0.0020 and 2.000 deg/min, while PRI ROT RATE (ITEM 10, 30 and 50) between 0.0500 and 2.0000 deg/min. You should select the correct DAP mode and value according to the maneuver you need to perform. If you want to rotate while tracking, the rotation rate should match the relative motion between the Space Shuttle and the tracked target.

ⓘ ***Hint:*** *For TORVA maneuvers for example, you could select a VERN ROT RATE (ITEM 23 or 43) value of 0.1000 as required at Step 7 of the "Terminal Phase PM and TORVA" checklist, then set the DAP in AUTO mode, set the UNIV PTG to TRK (ITEM 19) and use the manual translation commands only to perform the TORVA maneuver while the Shuttle points towards the ISS automatically. When you reach the V-BAR, you can cancel the auto tracking and continue the manual translation along the V-BAR until the docking maneuver is completed. Same goes for TORF (Fly Around). Please note that this is not a standard TORVA or TORF procedure, but it can be used by novices to reduce workload by eliminating the need to control the Shuttle pitch axis while translating.*

For manual non-TRK ops, you can select different values in order to turn faster for better timing, or slower, for better precision and control. Please note that you can preset values for both DAP A and DAP B and prepare for future maneuvers in advance. After you preset the necessary values, you switch between DAP A and DAP B by pressing the SELECT A or B push buttons on the ORBITAL DAP control panel. This saves precious time when you have to act according to a preset time line and on a tight schedule.

You can switch to this page any time while in OPS 202 main mode, by selecting OPS 201 (UNIV PTG) and then SPEC 20. You can return to UNIV PTG (OPS 201 mode) by pressing RESUME. You can leave UNIV PTG mode by re-selecting OPS 202 (ORB MNVR EXEC).

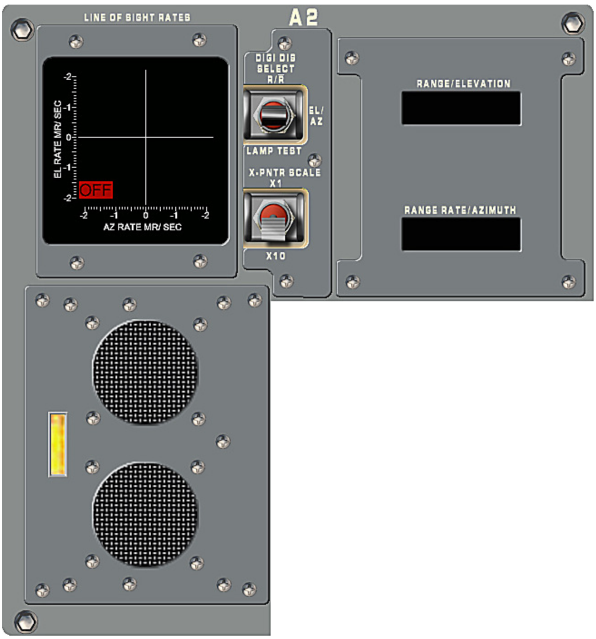
More information about this display can be obtained from the official **NASA Shuttle Crew Operations Manual** (**SCOM**) and associated material.

Rendezvous & Docking

The Line of Sight Indicator

Before reaching the actual docking or rendezvous mission stage, the Space Shuttle must "find" the rendezvous target which is somewhere in orbit, around Earth. Initially, the Space Shuttle mission will place you roughly within visual range, close to the target, but from there on, you must steer it accurately and safely up to the docking position. This is a fully manual procedure which needs practice – lots of it!

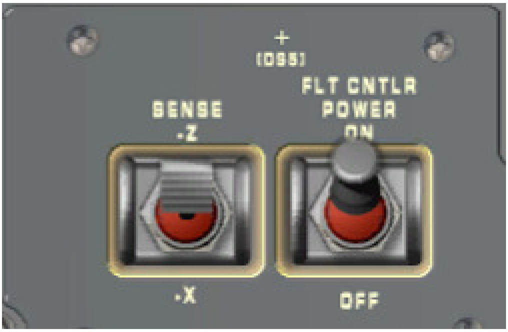
Tracking is achieved by using a very sophisticated guidance system – the Line-of-Sight Indicator. The LOS system alternates between two modes – Azimuth/Elevation (horizontal/vertical) and Range/Range (center-axis distance) which show the 3D positional data relative to the target.



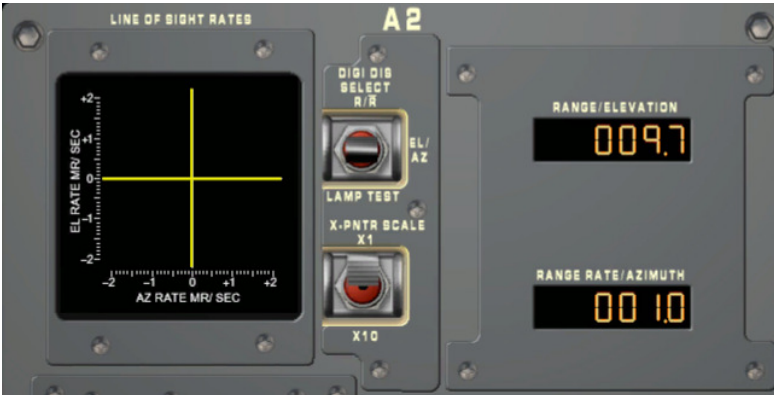
The Line-of-Sight Indicator Panel

The rendezvous starts in a distance of about 45000 ft (13,5 km) from the target. The first thing is to align the Shuttle's body axes with those of your target (see the attached drawings about the axes).

Even if you cannot see the target yet, the navigational systems of the Shuttle "know" where it is in relation to your axes. Rendezvous and dockings are done by looking out of the overhead windows. Imagine you are facing the aft panels and now you look up and through the overhead windows. That is your working position until you are docked. Your line-of-sight is now into the – (minus) Z direction. –Z is now forward, -Y is right and +X is up. To adapt the RCS thrusters to this situation you must switch on the FLT CNTRL Power on the left side of the A6U panel and flip the SENSE switch to –Z. If you use your translational thrusters now while looking out the described way, everything moves the way you want it, without the need to re-think about the axes.



Now the A2 panel comes into play. In the center of panel A2 you see two switches. The upper one (DIGI DIS SELECT) selects the digital display on the right side. If the switch is in the R/R position the digital displays on the right show the Range (distance) in feet and the approach Rate - velocity in feet per second - relative to the target. A negative Rate means that you are closing in. The switch in the EL/AZ position selects the Elevation (up/down) and the Azimuth (left/right) indication in degrees. Positive numbers mean up and right respectively. The example below shows your target 9.7 degrees up and 1.0 degree to the right in relation to your line-of-sight (-Z axis).

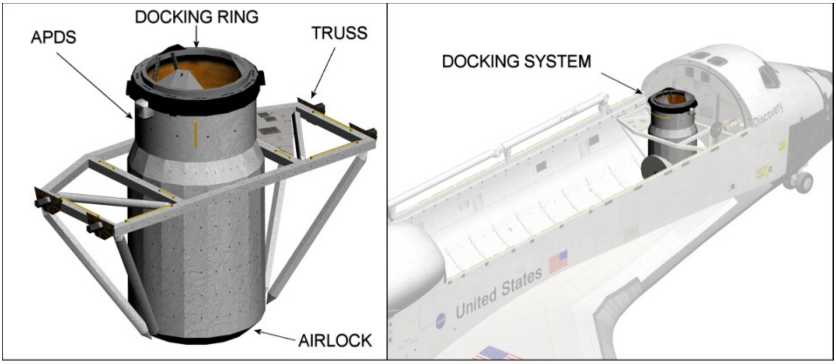


The lower switch (X-PNTR SCALE) alters the sensitivity of the left analog indicator. The moving bars show angular rates of the target in Millie-Radians per Second. In other words, they show the virtual movement of the target relative to your line-of-sight. If both reticules stay centered for some time while you are reducing the distance, it means that you are drifting exactly towards the target.

During the approach, align and docking maneuvers, be prepared to constantly switch between the Range/Range-Rate and Azimuth/Elevation modes, while moving to the X1 sensitivity mode as you get closer.

The Docking System

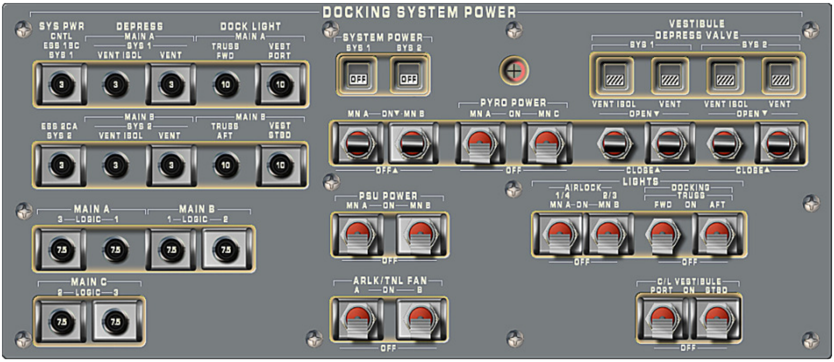
The Space Shuttle Docking System is called "Androgynous Peripheral Docking System" or APDS, and is located on top of a structure which consists of the External Airlock and Truss Assembly. This unit is located in the forward section of the Shuttle Cargo Bay. The APDS uses a Capture Ring to capture, dynamically stabilize, align and finalize the connection between the Space Shuttle and the ISS or any other dockable object. The strange name of the Docking System comes from the fact that its coupling mechanism is identical to the docking target, i.e. there are no "male" and "female" couplings. This simple yet extremely effective mechanism was designed and manufactured by "RSC Energia" – a Russian company.



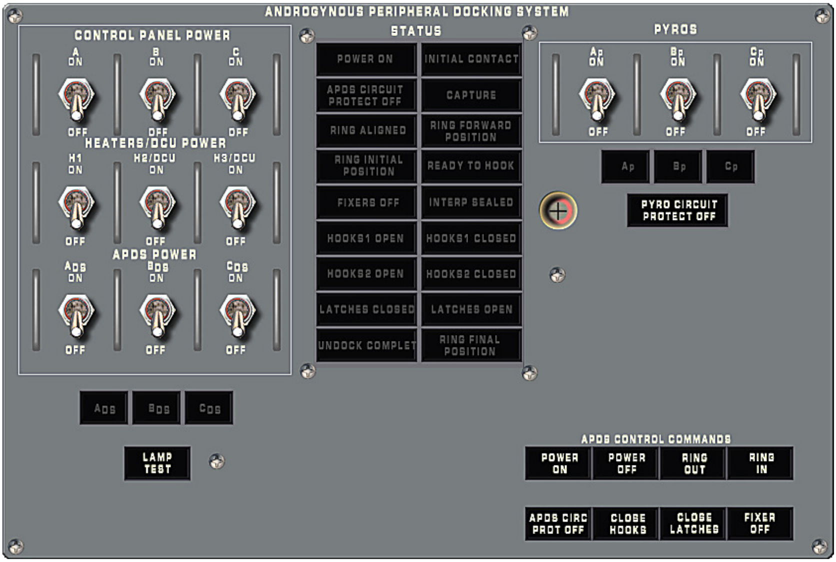
The Space Shuttle Docking System

The APDS is controlled via AFT panels which manage the Docking System Power Supply, APDS Control Commands, Status Indicators and Keypad. The Status Indicators will show the docking stage, ring status, ring movement, capture, latches etc.

During docking, you will be instructed to press specific keys and switches and watch the indicators according to the docking protocol, until you achieve a successful capture.



The Docking System Power Panel



The APDS Control Panel

Please note that when you eventually need to undock, you must press the UNDOCK COMPLETE annunciator light on the APDS STATUS panel, which is also a button. The APDS COMMANDS does NOT have an "undock" function.

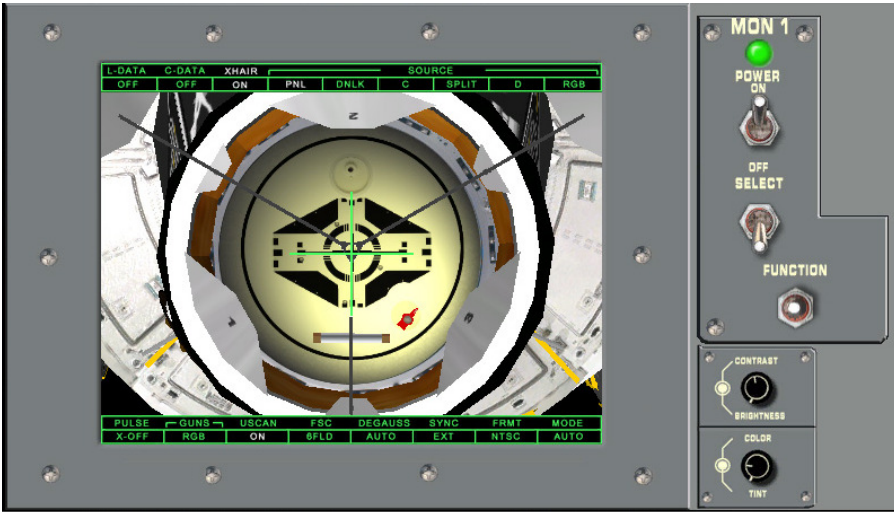
Monitoring the Docking Process

Before docking you will be performing a series of manual maneuvers using the RCS with the aim of aligning the Space Shuttle with the ISS PMA and approach it towards a successful docking.

The entire process can be monitored visually using the PL1 camera located inside the Docking System (Select PL1 on the CCTV control panel).

The goal is to aim the monitor reticule with the entry hatch target while approaching the ISS PMA slowly until the APDS Status Indicators indicate that the Docking Ring has made contact. After a correct contact has been made, the process is automatic until the Shuttle and the ISS are rigidly connected to each other to enable Airlock pressurization.

Do not forget to turn on the Docking Lights (on the bay lights control panel) if you perform the docking maneuver at "night".



A correct alignment with the ISS PMA

How to dock

There are few moments that will give you as much satisfaction as a performing a successful docking. The maneuver is not that difficult if executed in the correct order and with a good amount of patience and perseverance. During each mission you will be instructed what to do at every step of the Docking process but that will not replace the needed practice to maneuver the Space Shuttle manually. **Watch your PITCH and ROLL too!** An incorrect attitude will lead to a failed docking and possibly to serious damage to the APDS, ruining the mission.

The first goal will be to bring the Shuttle exactly underneath your target. This means, Elevation and Azimuth should show zero because your target is then exactly in front of you when you look through the overhead windows.

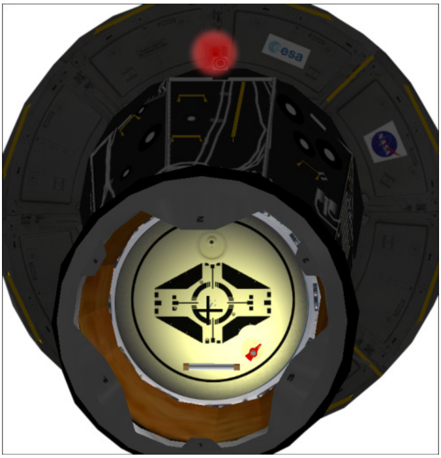
You are now on the so called R-BAR, an imaginary (radial) line that connects the target with the center of the earth. Some approach procedures will be performed along the R-BAR, others will lead you along the V-BAR – the Velocity Vector of the target. If you stay on the R-BAR you will approach the target from below.

The maneuver of moving from a R-BAR approach to V-BAR is called TORVA (Twice Orbital Rate R-BAR to V-BAR Approach). You have to fly a quarter circle from below the target to a position in front of the target – just like overtaking the target from below. It requires a pitch maneuver to stay in visual contact with the target and to align both docking ports. You can also use the Docking System CCTV to have a visual of the target.

In order to initiate a TORVA maneuver, you will have to increase your speed a bit (UP translation!). A higher velocity will lead to a higher Apogee. Thus, you will cross the orbit of the higher flying target. During the altitude gain keep the docking port of the target in the center of the camera image. You must pitch the Shuttle to keep the ISS centered in the upper aft view. For a manual approach it is a good idea to set the DAP control mode to FREE during the pitch. Keep an eye on your distance to the target. You can control it with some gentle forward/backward translational thrusts. When your pitch angle is 90° switch the DAP back to LVLH or INRTL - whatever you need- to stabilize the attitude. When you arrive at the V-VBAR your distance to the target should not be closer than 300 feet. Once on the V-BAR, stay on it and start your final approach for docking by translating SLOWLY along the V-BAR, constantly monitoring the ISS PMA targeting markings with the CCTV crosshairs, until you achieve a correct dock. Watch your approach speed and alignment. If you are coming in too fast, or are severely misaligned, you may damage the ISS/Shuttle PMA and ruin the mission. *Do not exceed an approach speed of -0.10 fps during the last 50' or so, with an ideal proximity speed of -0.01 fps during the last 3'*.

The ISS PMA has a set of four LED light which indicate the status of the ISS attitude control system mode: the Attitude Control System Modding Indicators (ACSMI). The ACSMI LEDs are off when they are not in use, they are steady when the ISS is under ACS command, and flashing at 5Hz when the ISS is in FREE FLOATING mode.

The ISS will be put in FREE FLOATING mode during docking and undocking to prevent the Shuttle attitude control and the ISS ACS from "fighting" while in contact and possibly damage the ISS PMA or Shuttle docking assembly. The ACSMI LEDs are also a great guide during night docking ops.

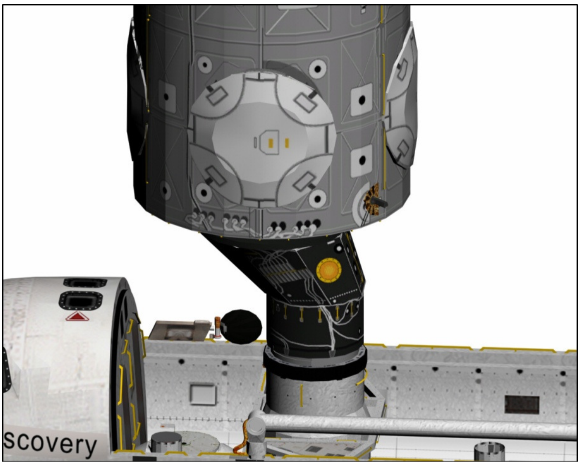


The ACSMI LED lighting "above" the PMA

After undocking it is common to do a Fly-Around procedure or TORF (Twice Orbital Rate Fly-Around). You initiate the TORF after you put at least 400 ft between you and the ISS. You begin by a small translational thrust into +X direction (UP) so that the Shuttle will drift into a higher orbit above the ISS. Keep the approximate center of the ISS within the Shuttle Docking System CCTV crosshairs by pitching the Shuttle just like you did during TORVA (DAP in FREE). Allow the distance to increase to about 600 feet, and then stabilize it by using some forward/backward thrust. When the Shuttle is underneath of the ISS, on the upper part of the R-BAR, switch the DAP control mode back to LVLH to stabilize the attitude. From here on you will take your front seat again. That means, you will switch on the FLT CNTRL power on the front panel which will put back the RCS thrusters into the normal Z mode: “front” now means looking through the front windows again. An OMS separation burn will end your visit at the ISS.

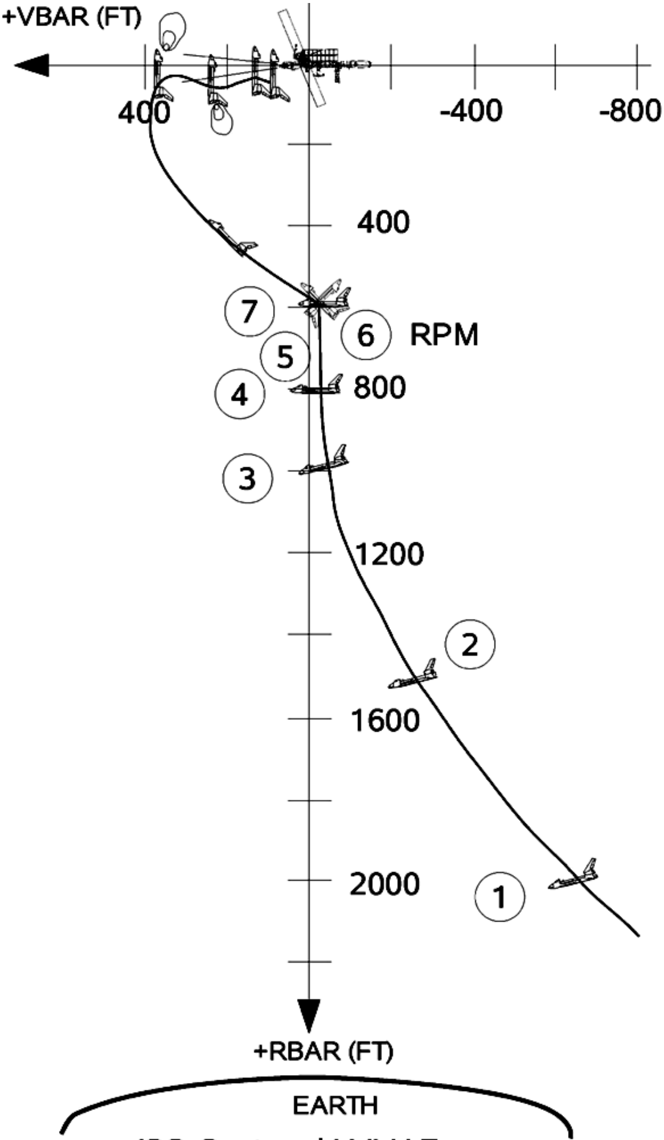
Everything described above needs a lot of practice and a good understanding of the involved systems. Please refer to the drawings and general checklists below for a better understanding of the procedure, attitudes and flight path.

Don’t expect it to work your way at the very first try. Make a save before starting the maneuvers and practice again and again. That is the way the real astronauts do it on the ground before they fly the mission. At the beginning you may use the external view to find your way in 3D but later on, the challenge is to use only what is available to the astronauts: the Line-of-Sight System, the CCTV and of course the windows.



The Space Shuttle docked with the Unity Module

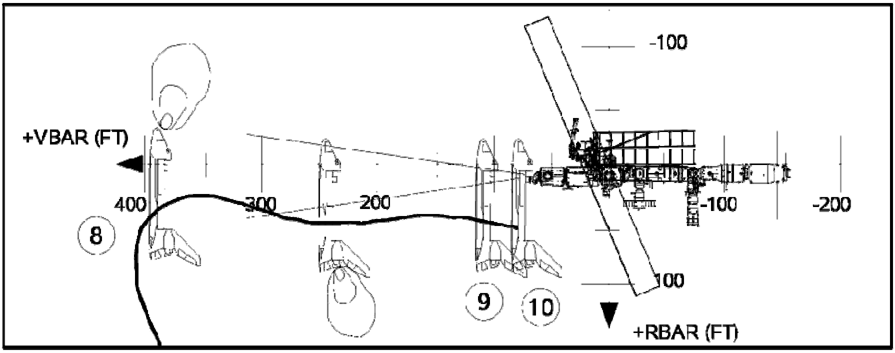
Terminal Phase, RPM and TORVA



ISS-Centered LVLH Frame

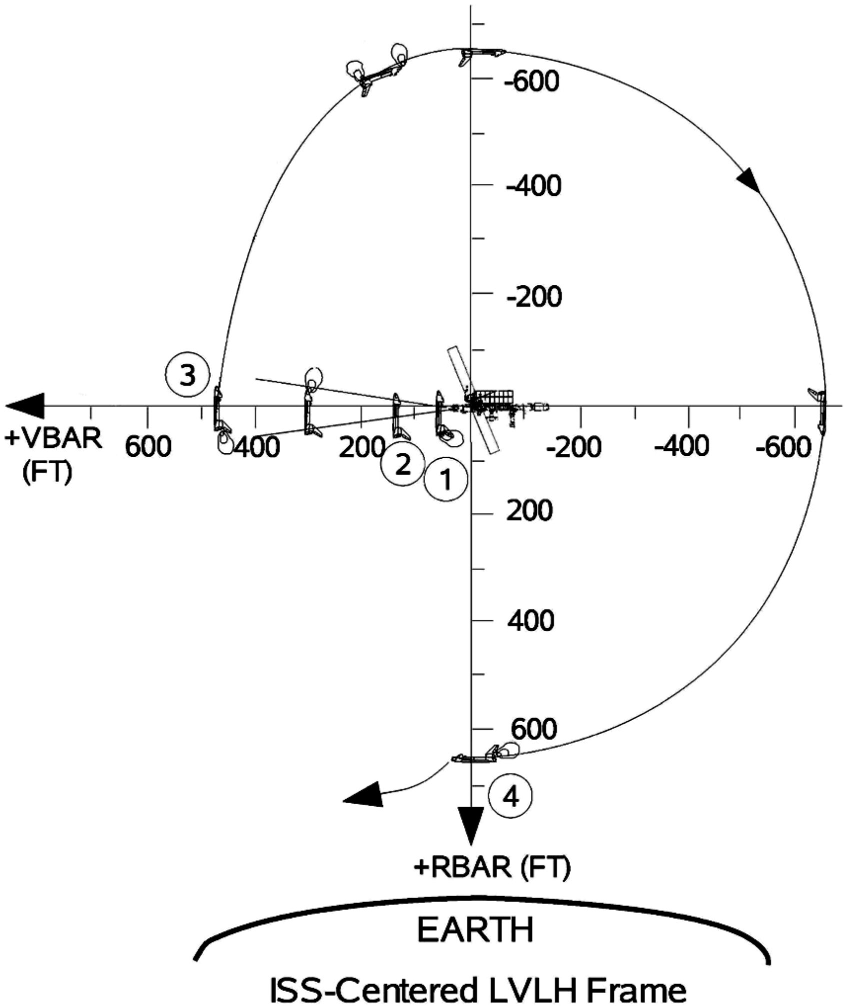
	Time to docking	Range (ft) CG - CG	Rdot (fps)	EVENT
1	D-1:37	2000	-3.0	Maneuver to RBAR (ADI on LVLH)
	D-1:35	1700	-2.4	MONITOR SETUP: TV INPUT : PL1 TV OUTPUT : MON 1 ON XHAIR : ON
2	D-1:33	1500	-2.1	
3	D-1:28	1000	-1.7	**Verify DAP settings:** Control LVLH, Translation to LOW Z, Rotation to VERN, PITCH, ROLL & YAW to DISC RATE. Once aligned set Y&Z translation to PULSE
4	D-1:27	900	-1.1	
		800	-0.9	
		700	-0.6	
		650	-0.4	
5	D-1:18	620	0.0	Station Keep till sunrise if required
6	D-1:04	620-580		***RPM (if required):*** DAP control to FREE, PITCH to DISC RATE. X&Z translations to NORM. PITCH +0.7 DEG/S When pitch nears 0 at the end of the RPM. Stabilize on pitch=0 (LVLH) with DAP on LVLH. Initiate TORVA on clearance (reduce pitch rate to 0.1 Deg/s and follow step 7)
7	D-0:53	600-500		***Initiate TORVA:*** DAP control to FREE, PITCH to DISC RATE. PITCH +0.1 DEG/S Perform 2Sec +X RADIAL BURN USE GREEN XHAIR TO ACQUIRE AND TRACK ISS's CG. USE +X PULSES AS REQ'D TO NULL TARGET MOTION IN CAMERA (Do not get closer than 320ft until established on VBAR) **VBAR attitude R = 0 P = 90 Y = 0 (ADI on LVLH)**

V-BAR Approach



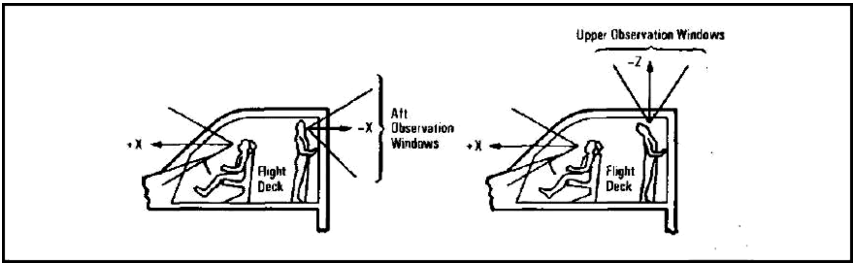
	Time to docking	Range (ft) DP - DP	Rdot (fps)	EVENT
8	D-0:39	320 (386-CG)	-0.2	***VBAR Arrival:*** -X PULSES AS REQ'D TO NULL TARGET MOTION ***Once On VBAR:*** Set DAP Control to LVLH Translation to LOW Z, Rotation to VERN PITCH, ROLL & YAW to DISC RATE. Translations Z to NORM, X & Y to PULSE
	D-0:22	110 (176-CG)	-0.15	
	D-0:18	75 (141-CG)	-0.10	
9	D-0:10	30 (96-CG)	-0.00	Station-keep if required
10	D-0:00	0 (66-CG)	-0.10	Docking

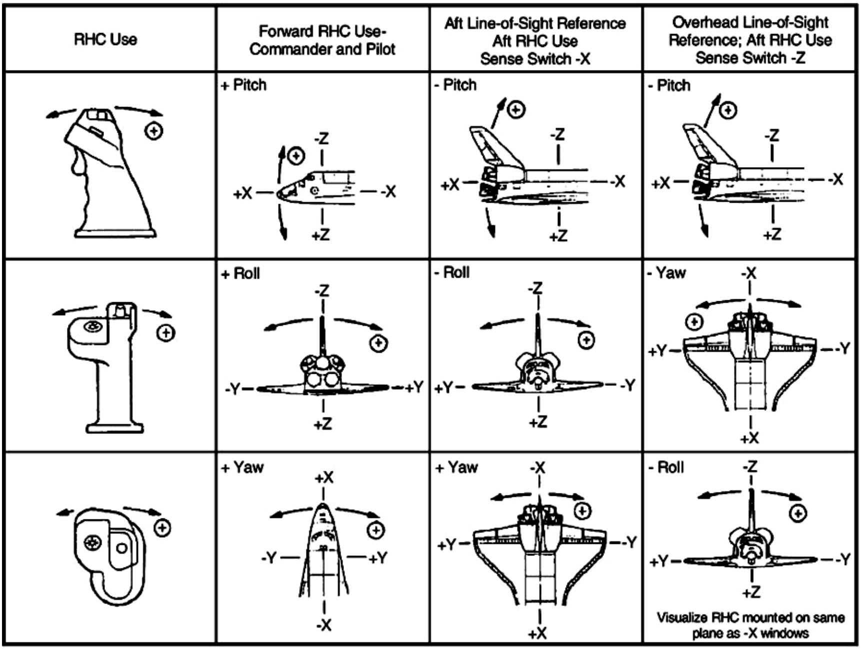
Undocking, TORS/TORF & Final Separation

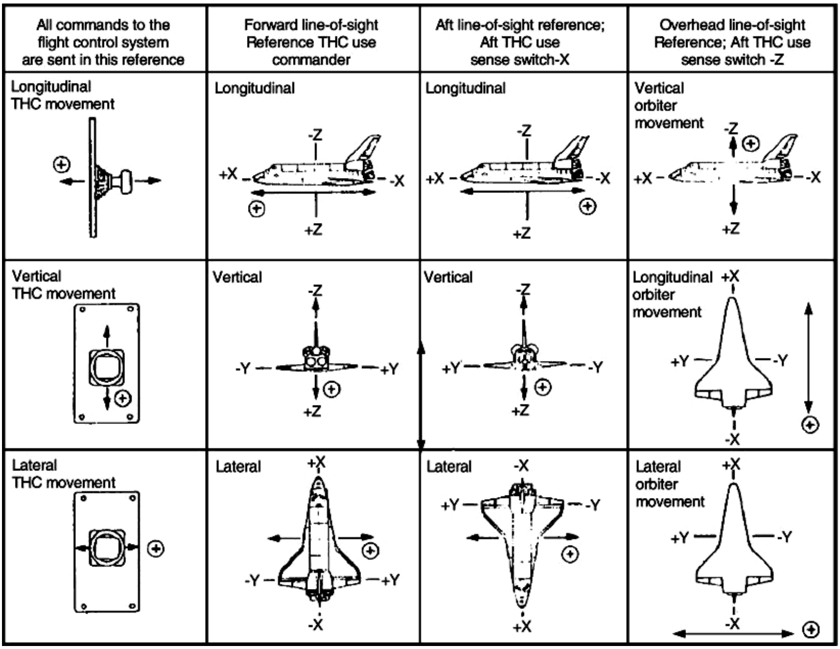


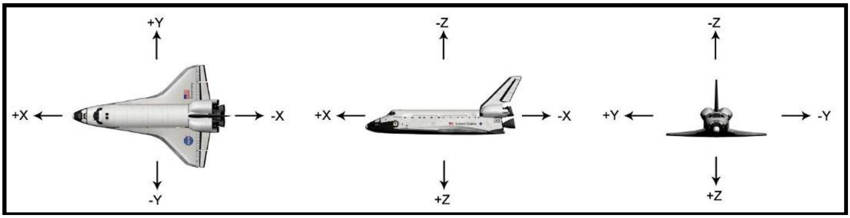
	UnDock ET (h:mm)	Range (ft) DP - DP	EVENT
	-0:03	0 (66-CG)	**Set ADPS and DAP For Undocking** Verify AFT FLT CNTLR POWER - ON; SENSE: –Z Set DAP: Control to LVLH, Translation to LOW Z, Rotation to VERN. Translations Z to NORM, Y&X to PULSE
1	0:00	0 2	**Undocking** Verify: RMS POWER to OFF;
	0:01		Perform Burns at 10 Sec intervals to build opening rate of 0.15 fps
	>0:03	>30 (96-CG)	Perform Burns at 10 Sec intervals to build opening rate of 0.2 fps
2	0:07	75 (141-CG)	Select PL1 Camera to MON1, MON1 - ON
3	0:29	>400 (CG-CG)	*Fly around:* **(station keep till sunrise if necessary)** 1/4 Lap TORS between 400 and 600 ft (CG-CG); Null opening rate outside 600ft; Perform 1/2 Lap TORF between 600 and 700 ft Set DAP: Control - LVLH , PITCH - DISC RATE; Translations X&Z to NORM, Y to PULSE; Pitch up +0.1 Deg/sec. When ISS is center OH window Initiate TORS with +X radial burns (2 sec burns on 15 sec interval). Maintain ISS on center of OH with +/-X burns to 600ft. on 600ft null closure with –Z burns. Maintain ISS on OH with -/+X burns while keeping RDOT on 0 with –Z burns. On last 1/4 lap Allow range to open to 700ft, compensate for ISS drift with +X burns.
4	0:57	>750 (CG-CG)	*Stabilize on ATT P=0, Y=0, R=0 (ADI on LVLH)* Set DAP to LVLH, Translation to NORM Z; All Rotation to DISC RATE. All Translations to NORM. *OMS SEP:* 3.0 fps +X burn.

Shuttle Axis and Maneuvering Reference Charts






All commands to the flight control system are sent in this reference
Forward line-of-sight Reference THC use commander
Aft line-of-sight reference; Aft THC use sense switch-X
Overhead line-of-sight Reference; Aft THC use sense switch -Z
Longitudinal THC movement
Longitudinal
-Z
+X
-X
+Z
Longitudinal
Vertical orbiter movement
Vertical THC movement
Vertical
-Y
+Y
Vertical
Longitudinal orbiter movement
Lateral THC movement
Lateral
+X
-X
Lateral
Lateral orbiter movement


+Y
+X
-X
-Y
-Z
+X
-X
+Z
-Z
+Y
-Y
+Z

Extra Vehicular Activity (EVA)

Exiting the Shuttle

Occasionally, you will be expected to perform **Extra Vehicular Activities** (EVA), such as assembling systems and servicing satellites. When the mission moves on, at some point you will be notified that EVA 1 and/or EVA 2 are ready for action. That means that one or more Astronauts, (called EVA1 etc.) have exited the airlock and are waiting for you to guide them to complete the mission goals.

You can do this either from Third Person (God) View, or actually becoming one of the Astronauts and seeing the world through their eyes by switching to First Person View.

In order to select an EVA Astronaut, we press **F1** repeatedly, until the Astronaut ID appears in the upper right MET window. Pressing F1 repeatedly will rotate us through Shuttle, EVA1, EVA2, and other relevant space objects (such as ISS, Hubble, etc.) if available.

Once you have selected your EVA, you may press **F3** (cockpit view). This will bring you into the First Person View mode. If you have TrackIR™ installed on your system and you have activated it already, you will be able to literally look around naturally, while you move.

Moving in Space

In reality, the Astronauts "crawl" around by holding onto rails or by attaching themselves to the RMS or some other structure. They are all secured to the structure they service with a "tether-line".

Earlier missions used a **Manned Maneuvering Unit** (MMU) which resembles a big "chair" equipped with mini-jets and some auxiliary tools. In SSM2007 it is simulated in **STS-41C**. Give it a try.

The MMU has been used until 1984 when it was retired from use. Today the Astronauts performing EVA are equipped with the **Simplified Aid for EVA Rescue** (SAFER) a much smaller system whose main purpose is to allow the Astronauts to return to the safety of the Space Shuttle in case they find themselves drifting in space without the tether-line.

In our simulation, we will be moving around a bit more freely than Astronauts really do. When performing EVA, use small and controlled commands. If you are not careful you may find yourself floating away from the safety of the Shuttle or banging yourself on various structures around you.

Be aware of your own size. Plan your path - seeing something does not mean that you can get there by going directly to it. Until you get the hang of it, you can use F1 (Third Person View) to estimate the best path to the goal, then go into F3 (First Person View) to move towards it.

Please refer to the “Controlling the Astronaut during EVA and in free-float mode” chapter to learn the commands needed for controlling the Astronaut in this mode.

The Space Helmet HUD

In F3 (First Person View mode), you can move your "head" around by moving the mouse, but you are limited by the helmet field of view. We have provided a mini-HUD (non-existent in the real helmets) to assist you in centering your view after looking around. Your head points straight ahead when the dot is within the circle.

Before moving, make sure that your head faces forward; otherwise you will NOT be moving in the direction your head points.

You can exit the First Person View mode by pressing F1 again.

Reentry

Deorbit

After finishing the on-orbit mission, the Shuttle crew begins the necessary operation for a safe return home. The first phase is the **Deorb Phase**. In preparation for Deorb, the Shuttle changes attitude so that its rear faces the on-orbit motion direction and fires the OMS engines, slowing down and thus reducing the orbit Perigee point towards the Earth atmosphere interface. This maneuver is performed under full GPC control and initiated by the crew by accessing GPC Major Mode 301 onward. The Shuttle then is repositioned towards the original Orbit motion direction and its pitch adjusted for a correct re-entry attitude.

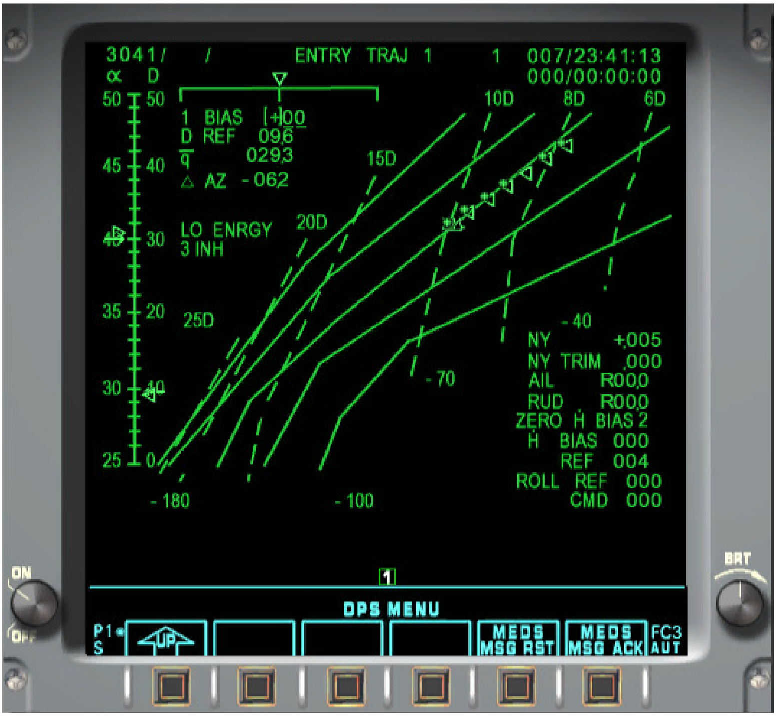
After the necessary preparations have been completed, the crew monitors the systems until, and through the Deorb and re-Entry phases which are under full automatic control of the GPC.

The re-entry starts at the **Entry Interface** (EI) at an altitude of 400,000ft, and the nominal AoA automatically assumed by the Shuttle is 40°.

This high AoA is needed to produce enough drag to slow down the Shuttle in preparation for Approach and Landing, and to position the Shuttle belly which is protected by the heat-resistant tiles, into the airstream, while also protecting the upper part of the Shuttle (payload doors, tail, cockpit) from the plasma which appears during the re-entry phase as a result of the extreme friction with the air particles. Later through the re-entry phase, the AoA is reduced gradually and at around Mach 5 the Shuttle becomes a fast, heavy glider, with an AoA closer to “real” aircraft.

Re-Entry GPC displays

The GPC Major Mode 304 provides the crew with 5 trajectory displays, marked **Entry Traj 1** to **5**. These are used to monitor the flight parameters while approaching and going through Earth's atmosphere. The Shuttle comes in with excessive energy which is dissipated as heat due to friction with air particles in the atmosphere. The "art" of de-orbiting is to modulate the different flight parameters towards a safe touch down at the desired point (runway). This process is mostly controlled by the GPC, leaving the **Approach** and **Landing** phase under manual control of the Shuttle Commander or of the Pilot.



Entry Traj 1 display

The **Entry Trajectory** displays consist of scales, readings, moving symbols and some background guidance curves. The **Traj 1-3** Y-axis shows the relative velocity [ft/s] of the Shuttle. In **Traj 4-5**, the Y-axis represents the energy/weight (E/W) ratio. The X-axis is the range to waypoint (WP) 2 via WP 1. WP1 is the tangential HAC intercept point (see "**Landing the Shuttle**" section below). WP2 is 1000ft past the threshold of the selected runway. Basically the X-axis shows the distance still to fly. In **Traj 1** this range is shown from 800 (left) to 3800 (right) nautical miles (NM). **Traj 2** shows it from 425 to 1300 NM and Traj 3 from 315 to 800 NM. The axis is non-linear.

The left side scale shows two of the most critical deorb/re-entry parameters:

- **Angle of Attack** (AoA or alpha (α)) in Degrees
- **Drag acceleration** (**D**) in ft/s^2. The ⊳ symbol shows the actual number and → symbol shows the nominal/reference.

The horizontal line at the top is called **phugoid bank scale**. In simple terms it shows how much is left until the referenced bank angle is reached. **Item 1** allows an entry to bias the reference drag *(not supported in SSM2007 yet)*.

- **D_{ref}** is the reference drag acceleration. This is the amount of drag that is necessary to keep the vehicle on the nominal trajectory.
- $\overline{\mathbf{q}}$ is the readout of the dynamic pressure in lb/ft^2.
- **DELAZ** , or **Δ AZ,** shows the Heading error relative to WP1.
- **Item 3** enables low-energy guidance. *(not supported in SSM2007 yet)*
- **NY** shows the lateral acceleration from -0.99 to +0.99 g.

Below NY you will find some DAP-related parameters:

- **$\dot{\mathrm{H}}$ REF** is the readout for the guidance computed reference altitude rate in ft/s. This should equal $\dot{\mathrm{H}}$ on the primary flight display if on the nominal trajectory.

- $\dot{H}$ BIAS in ft/s is a guidance computed correction term for the altitude rate. It can be reset by executing **Item 2.** *(not supported in SSM2007 yet)*.
- **ROLL REF** is the calculated reference **Roll Angle** to maintain the drag profile. Rolls and Roll Reversals are necessary to decrease upcoming lift and to maintain or even increase the drag level.
- **ROLL CMD** is the calculated Roll Angle that goes to the DAP.

The Trajectory (Traj) displays have four moving indicators:

- **The Shuttle Symbol** represents the actual velocity/range data.
- The ∇ shows the Shuttle path history.
- **The Guidance Symbol :** if moves in front of the **Shuttle Symbol** it indicates that the actual drag is lower than $\mathbf{D_{ref}}$. If it is behind the **Shuttle Symbol**, the drag is higher than $\mathbf{D_{ref}}$. The crew must observe if the **Shuttle Symbol** follows the nominal guidance curves and if it does not, the crew may consider taking over manually, pending a relevant **MCC** decision.
- The • shows the history of the guidance symbol

The Traj displays contain two type of guidance curves: The solid lines represent **Velocity** versus **Range** guide and the dashed ones are lines of constant drag acceleration. In **Traj 1** the <u>third</u> solid line from the left is the nominal guideline. In **Traj 2-5** the nominal line is the <u>second</u> from left. Flying constantly above this line will result in overshooting the target (runway) and vice versa. The dashed lines show the **Drag Acceleration** required at different combinations of range and velocity. The corresponding drag number is at the top of the dashed lines.
The negative numbers at the bottom show the **Altitude Rate ($\dot{H}$)** on the nominal line. In the image, the **Shuttle Symbol** is on the nominal line and above -70. That means the descent rate should be 70 ft/s in this situation. All subsequent Trajectory displays are similar to this one and can be interpreted the same way.

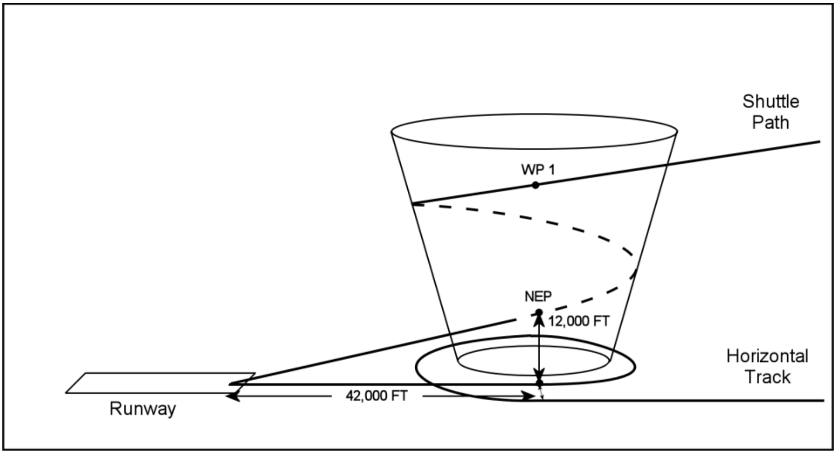
Landing the Shuttle

Approach

After passing through the Deorbit Phase, the Shuttle is basically brought to the correct initial approach point by its own Autopilot down to 80,000ft when the crew assumes manual command of the Shuttle, and using the control surfaces brings the Shuttle to the **Heading Alignment Cone** (or HAC). HAC interception begins at approx 50,000ft.

The HAC

When viewed in 3D, a Heading Alignment Cone depicts an imaginary cone that, when projected on the Earth, lies tangentially to the extended runway centerline. The Shuttle intercepts the HAC at Waypoint 1 (WP1) at about 34,000ft, and glides around the cone until it reaches the Entry Point.



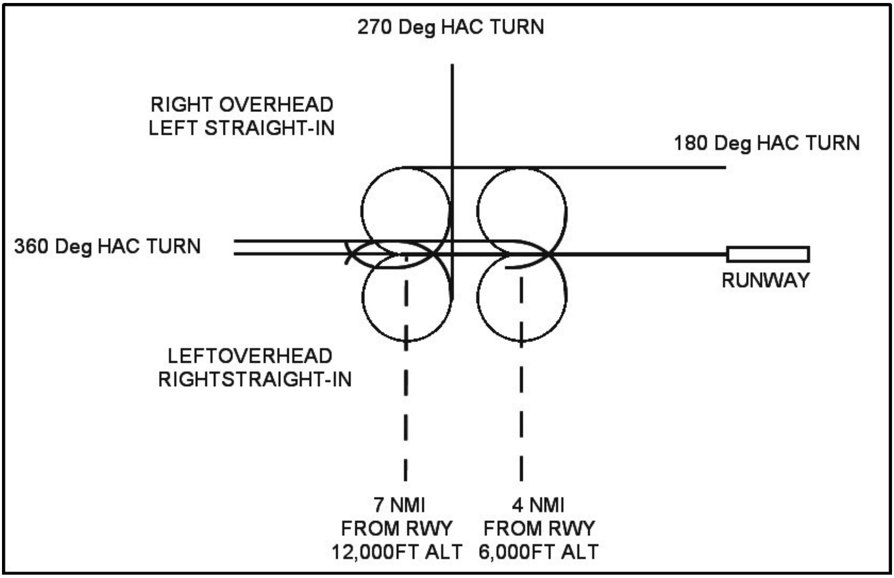
Flying the HAC

When the Shuttle reaches the Nominal Entry Point (NEP) the runway is straight in front of the Shuttle. At this point the Shuttle is within nominal parameters for a safe landing.

In simple terms, if you fly the Shuttle on the HAC you will eventually find yourself heading straight onto the runway center line. Flying the HAC is assisted by several guidance displays, the most prominent being the Heads Up Display (HUD).

In our case, it is easier to remember that once you get manual control, you should intercept the HAC at an altitude of approx 34,000', and then fly along it monitoring speed, altitude and energy (along the glide slope) until you have the runway in sight. At that point you should be at approx 12,000ft AGL.

HAC interception point (WP1) depends on the entry trajectory. The Shuttle may be required to intercept the HAC at 270, 180 or 90 degree points.



This is performed using GPC mode OPS 305 and display mode SPEC 50 on one of the MFDs, which monitors the horizontal Shuttle position relative to the HAC and the HUD indicators (diamond, center reticule, pitch ladder, speed and altitude ladders etc.). Please refer to the chapters below explaining the HUD symbology, the HIS and ADI and how they assist during approach and landing. You should also listen to the Tower and to your Pilot as they provide you calls and instructions.

In addition to the SPEC 50 Horizontal Situation display, you should pay attention to the Vertical Situation MFD modes which show the vertical position of the Shuttle relative to the ideal glide path - more about them in the following chapters.

After you are aligned with the runway you will notice that the runway is marked with a computer-generated overlay that makes finding and following it much easier – especially at low visibility. Fly towards it while monitoring the speed, altitude, and following the correct glide slope towards the touchdown point. At an altitude of about 2,000ft you should begin a pre-flare maneuver raising the Shuttle pitch a bit followed by a flare-up at about 500ft Above Ground Level (AGL) and Landing Gear deployment at around 300ft AGL, which further reduces the Shuttle speed as it gently touches down on the runway. The speed at this point should not exceed 240 Knots.

You touch down with the main landing gear (the rear gear) and then push the Shuttle nose gently towards the tarmac. When you hear the "weight on the nose wheel" message you start applying the brakes and can also steer the Shuttle along the runway and keep the center line. Braking is assisted by a Braking Chute which is released after touchdown. The Braking Chute is jettisoned as the Shuttle speed falls below approximately 60 Knots.

We recommend that you refer to the online NASA Official Space Shuttle Manual and other resources for a more thorough explanation of how to land a Space Shuttle.

The HSI/ADI Displays during Landing

The Space Shuttle Bay main attitude and navigation instruments are the ADI and Horizontal Situation Indicator (HSI) on the left and Attitude Direction Indicator (ADI) on the right.

Commander Front panel with the HIS and ADI displays

During approach and landing, the HSI displays the range and Shuttle position relative to the runway. The HSI has a rotating needle showing the bearing to the runway. During the final landing phase, the middle section of the needle shows where the runway centerline is relative to the Shuttle. If you want to be on the right horizontal approach path, then the main needle must point straight up and it's middle section must be fully merged with the needle. To the right of the rotating needle, you can notice a vertical bar with a needle moving vertically. This needle shows the relative position of the glide path to the Shuttle. When the needle is in the middle, then the Shuttle is on the correct glide path.

In order to achieve the best approach path during final, you should "fly towards the needles" until they are centered, and hold that until the very last moments on the flight when you will rely more on your eyes than on instruments.

During approach and landing, the ADI behaves like a regular "artificial horizon" showing the horizon position relative to the Shuttle. When the "ball" is tilted to the right then you should roll the Shuttle to the right if you want to reach a horizontal position. If the ball moves down, then you should "push" the stick to lower the nose if you want to level the Shuttle. Please note that if the Shuttle nose points up, the Shuttle does not necessarily go up - it may still "fall" despite the nose-up position.

In a similar manner, if the Shuttle points to the left or right, it does not necessarily fly left or right, especially if you have the “winds” option activated (chapter “ACTION/Options”). Crosswinds make for some difficult landings so in this case, you will need to apply rudders and compensate with the yoke to correct the flight path and attitude, landing with what pilots call a “crab angle” (or other techniques used for cross-landings). Basically you will have to fly the Shuttle “into the wind” to compensate for the wind component which “pushes” it the other way, but still holding it aligned with the glide slope and runway center line (keep the guidance diamond into the VV). A few seconds before touchdown, you will have to quickly align the Shuttle nose with the runway center line to achieve a correct landing and prevent it from running off the runway or worse. As you can see, landing with crosswinds can be challenging, therefore we do NOT recommend turning on the “winds” option until you are very good at landing the Shuttle without crosswinds.

In order to fully understand the Shuttle’s attitude and motion, you also have to refer to the Vertical Speed and Indicated Air Speed readings.

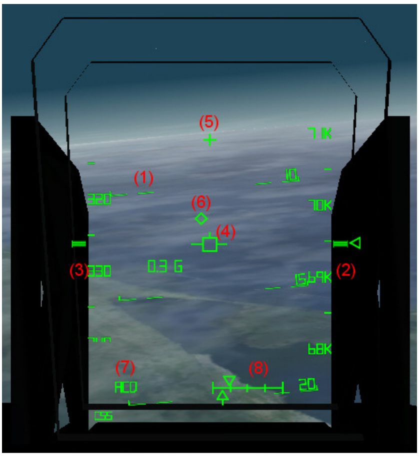
If you have played with a flight simulator or if you are a real pilot all these terms and gauges must be very familiar to you already. If you are neither, then you must practice a lot in order to get it right, however, the HUD and Vertical Situation MFD displays will also help you with the particular task of landing the Shuttle. Please move on to the next section to see how.

The HUD

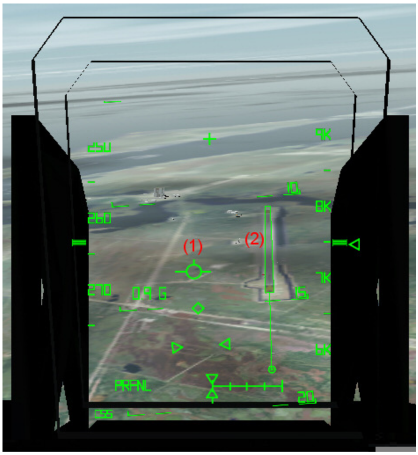
SSM2007™ can be fully operated with a keyboard and mouse but it will also benefit greatly from adding a joystick. HAC interception is easily done by using various guidance aids, the most important being the Heads Up Display (HUD). SSM2007 has a 2D HUD and a 3D HUD. The 3D HUD is a replica of the 2D HUD and is targeted to the more experienced pilots who have mastered the SSM2007 interface and landing, and prefer to land in a full Virtual Reality environment. Please note that the 3D HUD is collimated and it simulates this effect very realistically. This may confuse you initially, but once you get used to it, you will appreciate its advantages. The 2D HUD has an easier (if unrealistic) point of view. We recommend this mode to the novice pilots until they master the Shuttle control during landing.

The HUD consists of several computer-generated elements and symbols which are projected on an optical collimator allowing the Pilot to see both the HUD indicators and the outside view – just as in modern fighter aircraft. In SSM we cover two main HUD modes: before WOW (Weight on Wheels) and after WOW.

These indicators help the pilot fly the Shuttle towards a safe approach and landing:



HUD prior to TAEM



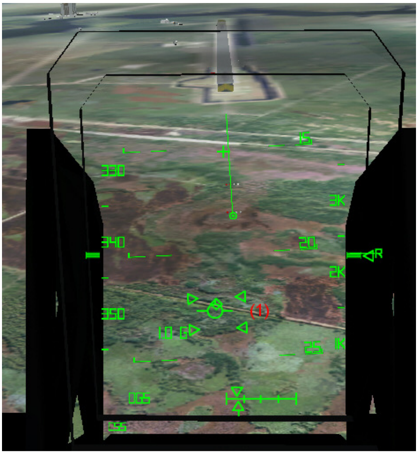
HUD during TAEM/final

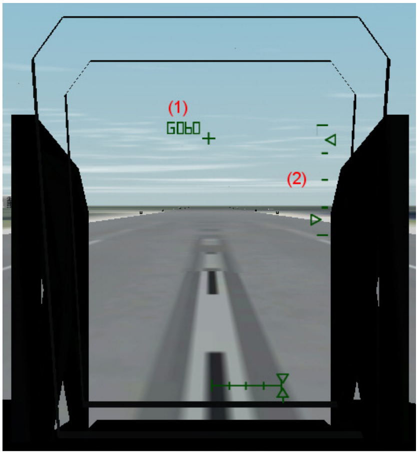
The HUD symbology in the prior to TAEM/final:

1. **The Attitude Reference** – represents the current Shuttle Pitch and Roll angles.
2. **The Altitude Tape** – displays the wheel altitude above ground as reported by the NAV.
3. **The Airspeed Tape** – This is the Shuttle Estimate Air Speed (EAS) in knots and has an upper limit of 500kts.
4. **FD** – the Flight Director is the squared-shape symbol which is stationary until TAEM prefinal, when it becomes uncaged and changes into the Velocity Vector (below).
5. **The Boresight** – represents an extension of the Shuttle body X-axis.
6. **The Guidance** – is a diamond-shaped symbol and it shows what path the Shuttle must follow to comply with the guidance-derived solution. Keep the diamond in the center of the FD/VV and you will be in for a safe landing.
7. **Lower Left Window** – is used to display guidance mode before WOW.
8. **Air Brakes** – showing the commanded and actual Air Brakes status.

The HUD symbology during TAEM/final:

1. **Velocity Vector (VV)** – the Velocity Vector shows the direction the Shuttle flies to. This is not necessarily the direction the Shuttle points to, <u>especially when crosswinds are present</u>. When the VV and the guidance diamond are overlaid, the Shuttle is on the nominal path for landing.
2. **Runway Overlay** – is a rectangular representation of the runway. This symbol is indispensable during low visibility/night landing and it shows the crew where the runway is supposed to be, helping in the final visual approach. It has an “aiming” line with two small circles serving as aims for steep or shallow approach targets.


HUD below 3,000’ during final


HUD after touchdown

The HUD symbology below approximately 3,000’ during final:

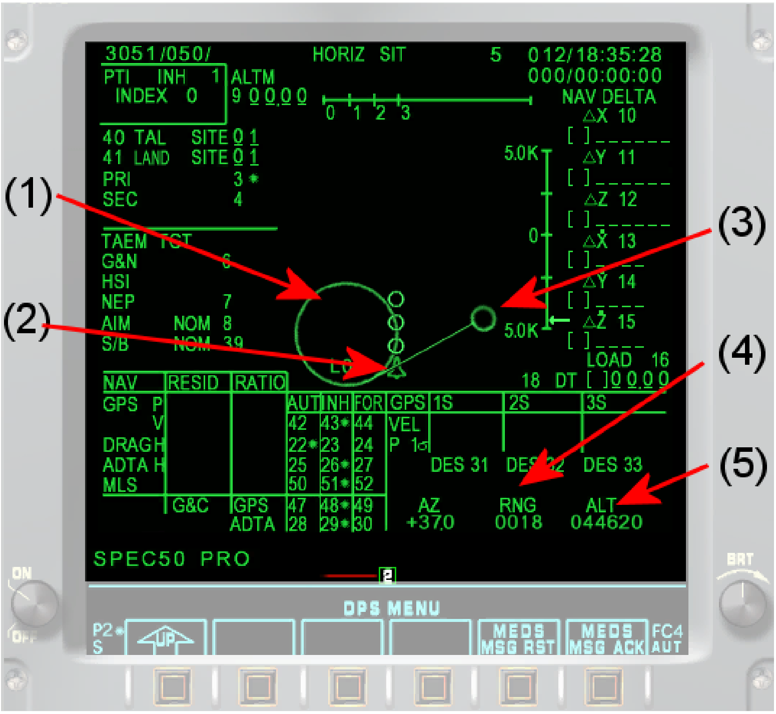
1. **Flare-up Indicators** – Indicate the direction and rate of the flare-up for a correct touch-down.

The HUD symbology after touchdown:

1. **Ground Speed** – self explanatory.
2. **Deceleration Rate** – represents the commanded and actual deceleration (as a result of using the Wheel Brakes).

The Spec 50 (HORIZ SIT) display

This is a special Horizontal Situation display which shows the Shuttle from above, in its final approach phase of HAC interception until landing.



The SPEC 50 (HORIZ SIT)display mode

Let’s examine some of the data available in the SPEC 50 display:

1. **HAC Symbol** – moves according to the relative Shuttle position
2. **Shuttle Symbol** – fixed at the MFD bottom
3. **Runway Threshold** – small circle representing the touchdown point
4. **Range** – range in miles to the landing point
5. **Altitude** – Altitude Above Ground Level

While not active, the HAC symbol is caged at the MFD bottom and flashes. When it becomes active, it shows the Shuttle position relative to the HAC.

The Vertical Situation Display

The Vertical Situation Display is a special display mode which can be seen on the front panel MFDs. This special mode is automatically selected during reentry and is on until touchdown.

During approach we have two important modes: VERT SIT 1 and VERT SIT 2.

The VERT SIT 1 mode is displayed from 80,000' down to 30,000', when it transitions to VERT SIT 2 which is displayed until touchdown. Both displays show the vertical glide path corridor. Generally, for a safe landing you will want to keep the Shuttle between the top and bottom lines.

The VERT SIT 1 Display Mode

The VERT SIT 2 Display Mode

During landing, you should keep your eyes on the I, ADI displays on HUD, HORIZ DISP (HAC) and VERT SIT 1/2 displays.

Yes, this is not so easy, but you can use the 3D Virtual cockpit display and keep all these displays within visual range y zooming in/out and rotating your view in such a way that you keep everything under control. Try to keep the 2D HUD only for the final when you start to be aligned with the runway.

The SSM2007 User Interface

SSM2007™ can be fully operated with a keyboard and mouse but it will also benefit from adding a joystick.

The Main Screen

Please refer to the Quick Start Manual for explanations regarding the activation of SSM2007™. The activation screen will appear for as long as the simulator is not activated by entering the Activation Key sent to you via email during the activation/purchasing process.

After the activation process is completed, this screen will be replaced by the SSM2007™ Main Screen with the main menu interface. While you are in the Main Screen, the menus behave in the standard way and you can select various options with the mouse.

The Main Menu

ACTION

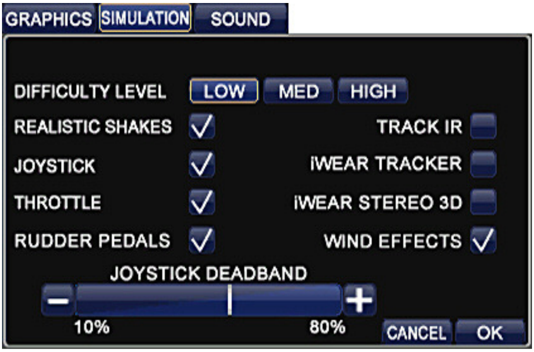
Options

The options window provides control for Graphics, Simulation and Sound.

GRAPHICS

Option	Description
Earth Detail	Controls the texture quality of the Earth and clouds. Select High only if you have a relatively powerful 3D acceleration graphics card.
Launch 3D detail	Controls the complexity of KSC and EAFB scenery. Impacts performance.
Cloud Coverage	Several options to fit your taste. No real impact on performance except for on very weak systems.
Cloud Shadows	Clouds cast shadow on Earth and that is visible from Space. Impacts performance.
Misc. Shadows	Shadows cast by scenery etc.
Launch Smoke Amount	The higher the amount, the more strain on the CPU. Impacts performance.
Complex Lighting	Controls the number of light sources. It may be necessary to reduce the setting for weak graphic accelerator cards.

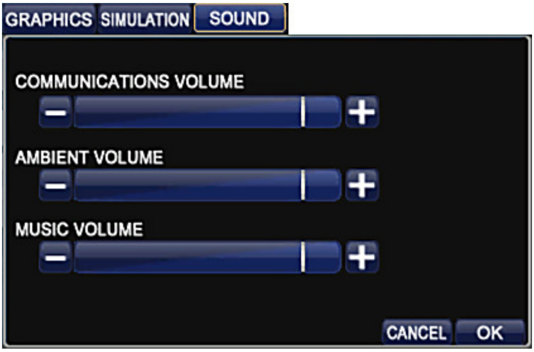
Generally, the higher the settings, the more you strain your hardware, so if you do not get a smooth simulation, you may want to consider reducing some of the settings in this panel.



SIMULATION

Option	Description
Difficulty Level	**LOW:** full text and arrows help. **MED:** full text help **HIGH**: brief text help
Realistic Shakes	During liftoff, deorb, landing etc. there are induced shakes that may bother you. You can turn them on or off here.
Joystick	Self explanatory
Throttle	Self explanatory
Rudder Pedals	Self explanatory
Joystick Dead Band	Self explanatory
TrackIR (*)	Select to activate TrackIR support
iWEAR Tracker (*)	Selects the Vuzix iWear VR920 HMD head tracking.
iWear Stereo 3D (*)	Activates the Vuzix iWear VR920 Stereoscopy support. Please refer to the iWear VR920 manual regarding the correct setup, calibration and other product-specific issues.
Wind	Activates cross winds generation during landing (landing is more difficult and realistic). Listen to the voice comms for weather information.

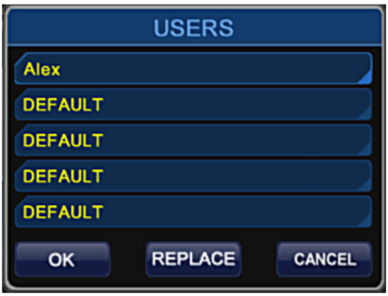
ⓘ ***IMPORTANT*****:** you may have to apply the latest SSM2007 Service Pack in order to gain access to the special hardware support such as TrackIR: Pro, TripleHead2Go and iWear VR920 Stereoscopic HMD.



SOUND

Option	Description
Communications	Self explanatory
Ambient	Self explanatory
Music	Self explanatory

User
SSM2007™ keeps Achievement Records and separate save files for up to five different users. In order to define a new user, select one of the free slots and type in your name. Form that moment on, everything you do and save will be assigned to your name.



MISSIONS

This is where you select your mission. Near each mission you can notice a number of stars. Missions with one star are the easiest and with three stars are the most demanding, usually requiring many hours of work in space – even with the Time Skip option. We recommend you start with the easier missions and as you gain confidence and proficiency, move to the more difficult ones.

The basic set of missions covers missions spanning from STS-1 to STS-117. Since SSM2007 launch, many new missions have been released and new ones are under development – the MISSIONS menu will reflect this and show all the available missions. Please make sure to visit the official SSM2007 website and watch for news about new Mission Packs.

Mission Briefing Screen

After selecting a mission from the main screen, you will move to the Mission Briefing Screen. This screen is divided into several sections: Mission Name and Patch, Crew, Mission Highlights, Payload and Flight Summary.

The menu at the bottom left will allow you to access the mission either form the very beginning or some intermediary point:

Option	Description
T-00:00:01:50	The very beginning of the mission. If you select this option and finish the mission this will be noted in the Astronaut Achievement board.
T-00:00:00:12	12 seconds to liftoff.
On Orbit	Puts the Shuttle in Orbit and ready for moving on with the mission.
Deorbit	The Shuttle has finished the assigned mission and preparing to return to Earth
Landing	The Shuttle approaches the landing field (KSC or EAFB). It is at 80,000ft and approaching the HAC.
Load	Load a previously-saved situation
MAIN MENU	Cancel the mission and return to the main screen.

The Main 3D Screen

After selecting a mission entry point or loading a previously-saved situation, you will move to the main simulation screen:

The screen is divided into three main sections:

- The optional Mission Event Timer (MET) in the upper right corner, displaying the MET, mission and Space Shuttle name, frame per second display and a communications code. Here, SSM will also display the “NO GO”, “RUNNING” and “COMM” indicators.
- The main 3D display – this is where the action is.
- The bottom communications transcript. This is where you will be receiving detailed instructions on how to move on with the mission. Read this carefully if you want to complete the mission successfully.

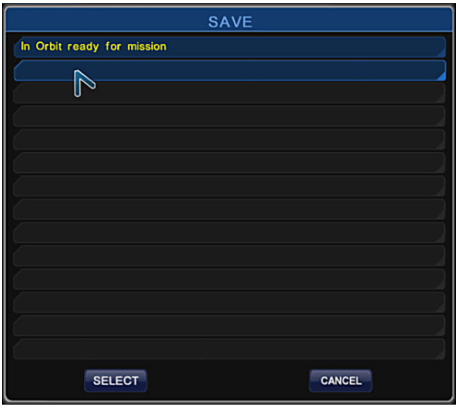
The Main 3D Screen Menu

When in the Main 3D Screen, **right-click** to display the 3D Simulation Screen Menu. This menu offers options which are relevant only during the simulation. While the menu is active, you cannot rotate the point of view with the mouse. Instead, the cursor can select menu items. Right Click again to return to 3D Simulation mode and return the point of view Mouse control.

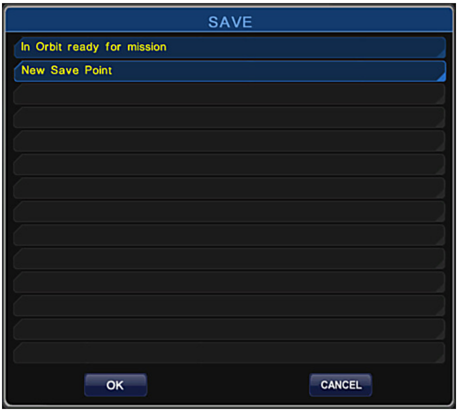
The 3D Simulation Screen Menu consists of three sections: ACTION, VIEW and PANEL. The Action menu controls various mission-specific tasks, the View menu allows you to select the preferred camera view and the Panel menu enables you to jump to the desired panel. Please note that most of the menu options have keyboard shortcuts.

Saving a situation

The Save Window allows you to save up to 14 situations per mission. The correct procedure for saving is to click on a Save Slot, press the “SELECT” button, enter the situation name, press ENTER and then click the “OK” button. Please follow the images below for a visual description of the saving process:



Click on the desired save slot and press the SELECT button



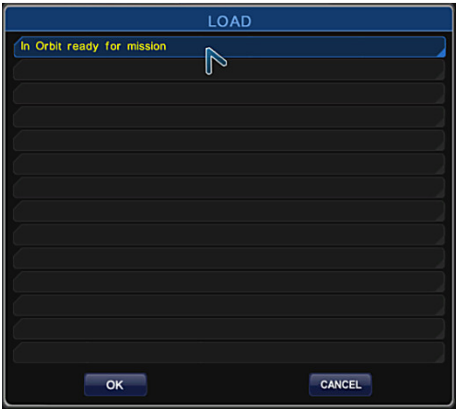
Write the situation name, press ENTER and click the OK button

Loading a situation

Each mission can have up to 14 save/load points per Astronaut so different people can play the game and have their own separate saved situations for each mission. We believe that this is more than enough.

You can load a situation from both the Mission Briefing Screen and from the 3D Simulation Screen Menu.

Once in the Load window, click on the save slot that contains the situation you want to load, and then press the OK button. Please refer to the image below for a visual description of the Loading process:



Click on a saved situation slot and press the OK button

Space Shuttle Mission Commands

General Keyboard Commands:

Key	Function
F1	*Simulation External View*
F2	*View last accessed Panel*
F3	*Virtual Cockpit mode*
F4	*Move to the next Crew Station in Virtual Cockpit mode*
F5	*View/Hide messages window*
F6/F7	*Commander/Pilot 2D HUD display*
F8	*KSCVAB Press area view of the Shuttle launches*
F11	*Show Orbital View – similar to NASA Mission Control wall-sized display showing the orbit, the Space Shuttle location, a synthesized 3D view of the Shuttle and other relevant information.*
T	*Time acceleration mode. In this mode time passes faster allowing you to arrive faster to the next mission point. In this mode you will notice that everything is moving much faster. In addition, a flashing indicator will appear at the top right part of the screen indicating that the Time Skip mode is activated.*
P	*Pause on/off. This will stop or un-pause the simulation. A flashing indicator will appear at the top right part of the screen indicating that the simulator is paused.*
F	*Free Floating Camera mode. In this mode you can use the mouse and the translate keys to move the view at any point in space around the Space Shuttle or any object selectable with the F1 key. This is more powerful than the F1 view as the F1 view is limited by a sphere centered on the object. This mode is free from this limitation and allows you to position yourself for taking better screenshots of that cool docking or Earth viewed from Space.*

Key	Function
CTRL-F	*Reset Free Floating Camera position*
Num PgUp/PGDn	*Zoom in/out in Simulation External view*
H	*"Help": scrolls the current panel to the next button to be pressed. First, you must be on the correct panel for this to work. You have 10 grace Help points until you lose the right to get a mission patch.*
SHIFT-H	*Show remaining Help points before the mission patch right is revoked. This key will toggle the FPS/Help points visible in the MET window.*
SHIFT-C	*In multiple screen configurations (TripleHead2Go and nView) this key will position the menus and various screens, to the center or to the left screen. The change is instant and is active both in static screens – main menu, MCC, Briefing Screen, etc. and in 3D views.*
M	*Toggle in-game Music on/off*
I	*If you have activated your TrackIR software, you may toggle between TrackIR and Mouse navigation in the 3D Virtual Flight Deck or EVA first-person-view.*
A, S	*Vuzix™ iWear VR920 eye separation calibration. SSM2007 remembers the setting for each camera (F1, F3, F8, F)*
LEFT/RIGHT SHIFT	*Toggle the Commander/Pilot keypads respectively in 2D Front Panel View when the 2D keypads are out of view. Active in 2D view only.*

Mouse Functions:

Mouse	Function
Left Click	*Select menu item, select panel, press button on/off, move a switch in the upper position, rotate a knob counter-clockwise*
Right Click	*Toggle menu/view mode in Simulation External view, move a switch in the down position, rotate a knob clockwise, exit save/load screen*
Zoom wheel	*Zoom in/out in Simulation External view*
Movement	*Rotate view in Simulation External view and Virtual Cockpit, scroll flight deck 2D panels.*

Controlling the Space Shuttle with the Keyboard:

During its mission the Space Shuttle shall need to be controlled manually in order to perform various maneuvers:

- Approaching a satellite or the International Space Station (ISS), docking and changing attitude.
- Gliding control during the approach, final and landing phase of the mission

In space, the Space Shuttle uses the Reaction Control System (RCS) which consists of 44 micro-rocket engines. These engines are placed at specific locations around the Shuttle body, and by firing them selectively (manually or automatically) they enable precise translational and rotational control of the Space Shuttle. While in Simulation External View you will notice the jets plumes from the relevant RCS engines as the Space Shuttle changes attitude during manual or automatic control.

The RCS engines can be controlled with the joystick and the **Numeric Pad**.

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<tr><td>Num
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ROLL RGT</td></tr>
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TRANS DN</td><td rowspan="2">Enter</td></tr>
<tr><td colspan="2">0
YAW LEFT</td><td>Del
YAW RGT</td></tr>
</table>

While in Earth Atmosphere the RSC are disabled and control switches to the aerodynamic control surfaces – rudder and elevons. In this mode, the Space Shuttle is basically a glider. In this mode, only the Rotation Commands and the Miscellaneous commands work.

Key	Function
Num +	*Air Brakes Open*
Num -	*Air Brakes Close*
D	*De-clutter HUD*
G	*Press once to ARM and again to Deploy the Landing Gear*
C	*Press once to ARM and again to Deploy the Braking Chute*
J	*Jettison Braking Chute*
B	*Wheel Brake: hold to brake, release to release brakes. Hold while steering with the pedals to apply Differential Brakes until nose wheel touches down.*
Num Delete/ Num Page Down	*Steer Left/Right – active only after the Nose Landing Gear has touched the runway and you hear the message "Weight on the Nose Wheel".*
Num 5	*End Effector Release Grapple*
ENTER	*End Effector Grapple*

ⓘ ***Note:*** *if you have a programmable joystick, you may want to assign some of the keyboard commands to the joystick programmable buttons. One of the more critical phases during a Space Shuttle mission is landing, where events happen in quick succession and timing and precision are critical. We recommend that you assign the following commands to the Joystick programmable buttons:*

1. *(D) Declutter HUD*
2. *(G) Gear Arm/Deploy*
3. *(C) Chute Arm/Deploy*
4. *(J) Jettison Chute*
5. *(B) Wheel Brakes*
6. *(F3) for 3D cockpit view)*
7. *(F6) for 2D HUD view, until you get comfortable using the 3D view*

Controlling the Space Shuttle with the Joystick:

Joystick	Rotation Commands
Forward	*Pitch down*
Backward	*Pitch up*
Left	*Roll left*
Right	*Roll right*
Rudder Left	*Yaw Left*
Rudder Rgt	*Yaw Right*
Throttle	*Air Brakes*

In order to translate the Shuttle, you must press and hold the **FIRE** button while you move the joystick.

Joystick	Translation Commands
FIRE + Forward	*Translate forward*
FIRE+ Backward	*Translate backward*
FIRE+ Left	*Translate to the left*
FIRE + Right	*Translate to the right*
FIRE+ Throttle Up	*Translate up*
FIRE+Throttle Dn	*Translate down*

WARNING: *whatever you do, make sure that if you intend to control the Shuttle attitude, you must enable the Flight Control. If you fail to do so, you may move the RMS instead and damage the Shuttle, payload or other object in the RMS proximity such as the Hubble, ISS etc.*

Controlling the RMS with the Keyboard (ORB/UNL):

Num Lock	/ *SHLDR YAW LEFT*	+ *SHLDR YAW RGT*	- *STRETCH ARM*
7	8 *WRIST PITCH DN*	9 *Translate EE UP*	+ *RETRACT ARM*
4 *WRIST ROLL LFT*	5 *UNGRAPPLE*	6 *WRIST ROLL RGT*	
1	2 *WRIST PITCH UP*	3 *Translate EE DOWN*	Enter *GRAPPLE*
0 *WRIST YAW LFT*		Del *WRIST YAW RGT*	

Please note that you may press two keys at the same time and obtain a more complex motion. You are encouraged to experiment.

Controlling the RMS with the Joystick:

Joystick	Function
Forward	*End Effector Pitch down*
Backward	*End Effector Pitch up*
Left	*End Effector Roll left*
Right	*End Effector Roll right*
FIRE + Forward	*Translate the End Effector Forward*
FIRE + Backward	*Translate the End Effector Backward*
FIRE + Left	*Shoulder Yaw Left*
FIRE + Right	*Shoulder Yaw Left*

WARNING: *whatever you do, make sure that if you intend to control the RMS, you enable the AFT Joystick by turning the Flight Control OFF. If you fail to do so, you may change the Shuttle attitude instead, and damage the Shuttle in case it is in close proximity to another object (Hubble, ISS, etc.).*

RMS Rate Hold

Pressing the “R” (RATE HOLD) key on the keyboard maintains the rate at which the RMS moves. This is very useful when you want to maintain a constant motion rate instead of ramping up the motion speed which happens when you move the RMS without Rate Hold activated.

Controlling the Astronaut during EVA and in free-float mode:

During its mission the Astronaut may need to be controlled manually in order to perform various tasks:

- Inside the Shuttle for moving from the flight-deck through the stairs to the mid-deck and through the airlock hatch etc.
- Outside the Shuttle for performing EVA missions.

The controls for free-floating inside the Shuttle, during EVA with or without the MMU are identical to those for controlling the Space Shuttle attitude with the RCS. Don’t worry, when you are in first-person mode (free-float or EVA) these controls are automatically assigned to the Astronaut motion and have no influence on the Shuttle. While in this mode, you can use the mouse to rotate your head and look around. Please note that the direction of movement is not necessarily the direction one you’re looking at. Use the EVA mini HUD to orientate yourself.

<table>
<tr><td>Num Lock</td><td>/
TRANS LFT</td><td>*
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<tr><td>7</td><td>8
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ROLL LFT</td><td>5</td><td>6
ROLL RGT</td></tr>
<tr><td>1</td><td>2
PITCH UP</td><td>3
TRANS DN</td><td rowspan="2">Enter</td></tr>
<tr><td colspan="2">0
YAW LEFT</td><td>Del
YAW RGT</td></tr>
</table>

Appendix A

The Ares 1-X Test Launch

The Ares 1-X launch is not a real Space Shuttle mission in the traditional sense but nevertheless, the SSM2007 team felt that it was a necessary addition to the Space Shuttle Mission Simulator because it is a significant NASA step towards a new LEO and Interplanetary Transport System.

The Constellation program, of which Ares 1 is part of, marks the effort for a transition from the arguably the highly successful STS program to more reliable, efficient and flexible systems that can take humans and cargo beyond Moon, and for the first time, to another planet – Mars.

This “mission” is a relevant homage to these efforts, which in a sense are also a replacement of the STS program, which we simulate.

The unmanned **Ares 1-X TEST LAUNCH** mission does not really need any kind of user interaction. You have two entry points – **one hour**, and **five minutes** before liftoff (which is different from MET T:-01:00:00 and T-:00:05:00 respectively). This explains the MET “frozen” at T:00:04:00.

Actually, we start the simulation about a few hours into the four-minute hold, and one hour (or five minutes) away from TZ – liftoff time. During this last four-minute hold, weather and triboelectrification limitations forced NASA to postpone the actual launch several times, until the final go-ahead was given for a launch at 11:30AM EST.

This mission shows that the SSM2007 is not only a Shuttle Mission platform, but it can also quite easily become much more. This is a forward-looking statement – a commitment if you what - about what we are capable of, when, and if the need arises.

The **Ares 1-X TEST LAUNCH** mission sports a few firsts: we show the actual SRB splash-down into the ocean, and we use real NASA comms, providing a new and more immersive experience.

There are also a few changes to the commands and menu structure, which is specific to this “mission”:

- **F2** moves the view to a Simulated Upper Stage camera, looking down, along the Ares 1-X body. You can use this from liftoff onwards.
- **F3** switches to a set of KSC fixed NASA observer cameras “slideshow”. If you do nothing, you will be presented with a view similar to NASATV.
- With **F4** you can “flip” between the fixed KSC cams.
- **F1** has the same functionality as before, but after separation, it allows you to switch between the SRB and the Simulated Upper Stage views.
- The **F** (free cam) has the same functionality as before. Use it for taking cool screen shots or videos.
- Various menu options have been removed – there is no “SAVE”, QUICK SAVE” or “LOAD” in the main menu, and no “ON ORBIT”, “LANDING” on the Briefing Screen.

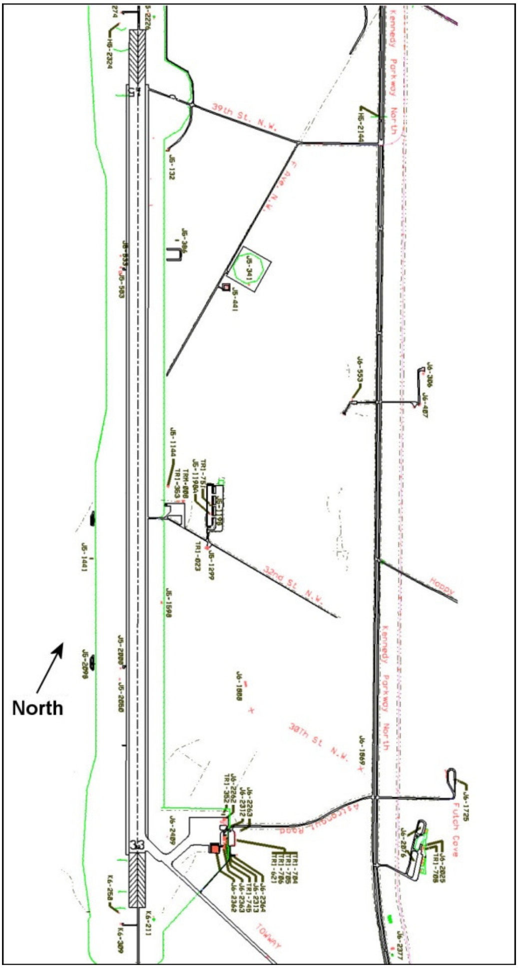
We recommend you watch the entire launch sequence from one hour before launch and at least 6 minutes after liftoff, while listening to the comms and to the cool background music.

When the mission is over, you will get the message which tells you that you can leave the mission at any time.

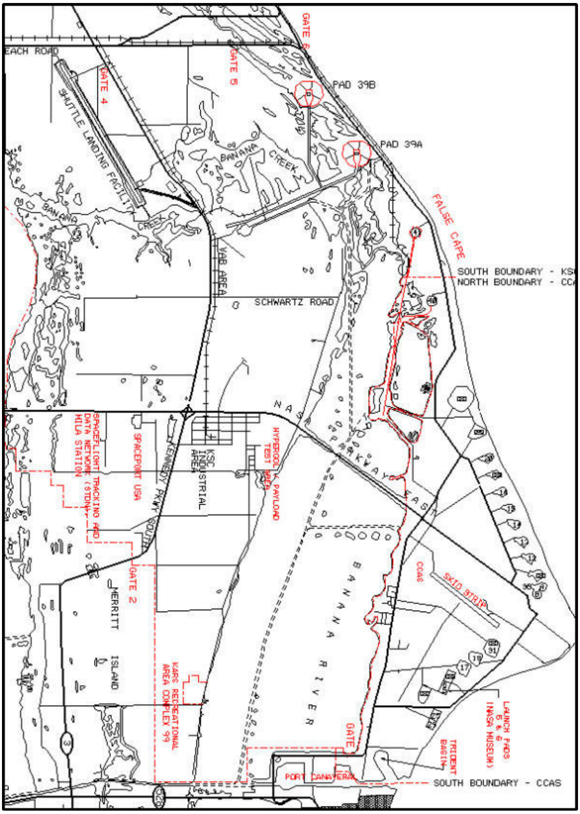
Enjoy Ares 1-X for what it is: a nice diversion from the “standard” SSM2007 mission addons, a new perspective of the Ares 1-X test launch and a sign of things to come.

Appendix B

KSC Shuttle Landing Facility maps



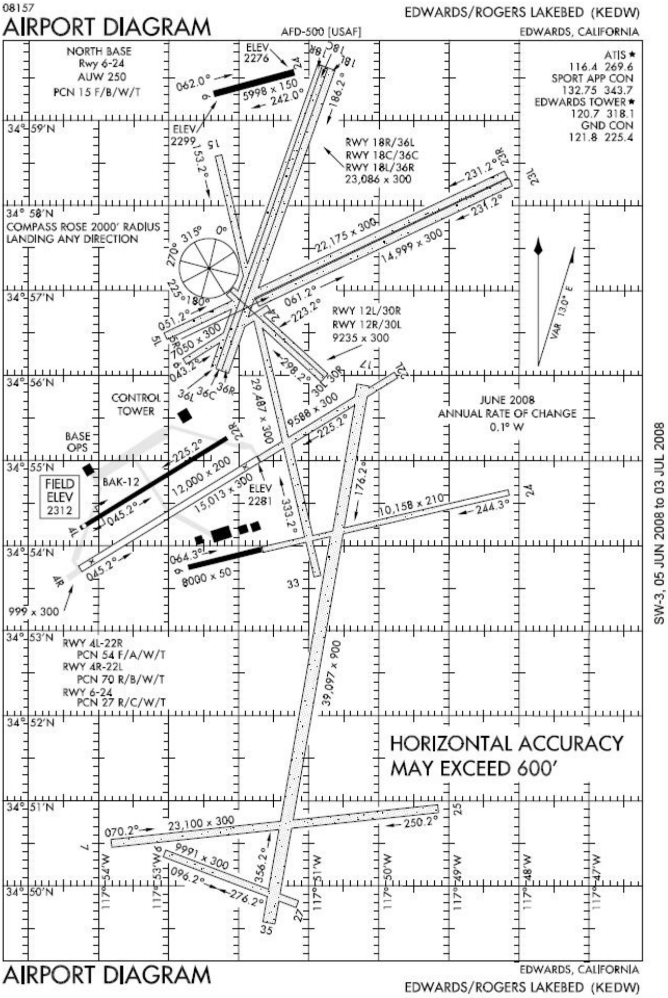
KSC Runway 15/33


GATE 6
EACH ROAD
GATE 4
GATE 5
PAD 39B
PAD 39A
SHUTTLE LANDING FACILITY
BANANA
CREEK
BANANA CREEK
FALSE CAPE
SOUTH BOUNDARY - KS
NORTH BOUNDARY - CC
VAB AREA
SCHWARTZ ROAD
N A S A PARKWAY EAST
SPACEFLIGHT TRACKING AND DATA NETWORK (STDN) MILA STATION
SPACEPORT USA
KENNEDY PKWY SOUTH
KSC INDUSTRIAL AREA
HYPERGOL TEST AREA
PAYLOAD
GATE 2
MERRITT ISLAND
KARS RECREATIONAL AREA COMPLEX 99
B A N A N A R I V E R
CCAS
SKID STRIP
LAUNCH PADS 5 & 6 (NASA MUSEUM)
TRIDENT BASIN
GATE
PORT CANAVERAL
SOUTH BOUNDARY - CCAS

KSC Area Map

Appendix C

Edwards Air Force Base Airport Diagram



Usually the Space Shuttle lands on RWY23 or 22

Appendix D

Manual Changes from Version 3.9

Chapter	Changes/Notes
Crew Positions	Added Cupola view crew station
Bay Lighting and CCTV Systems	Changed to reflect the addition of OBSS video feed

Appendix E

Useful references

1. **NASA SCOM**: SSM2007 is realistic enough to allow virtual Astronauts to make good use of the real NASA **Shuttle Crew Operations Manual** (SCOM). This manual is available on the Internet, but it is quite elusive. You may want to do a thorough search for it and as a last resort, try to purchase a DVD with all the important original documentation. This DVD can be purchased online at select eCommerce distributors such as Amazon.
2. '**NASA Space Flight**'(NSF) website is the most authoritative Space Shuttle source on the net, outside NASA. The "inner sanctum" of NSF is the L2 forum access which requires a paid registration. The L2 access level gives you the deepest access to original unclassified NASA documents on the Internet. NSF also has a professional forum frequented by active and ex-NASA, Lockheed, USAF etc. staff that are ready to help and discuss any Space-related subject. NSF is at www.nasaspaceflight.com

SSM2007 on the Web

1. **The Official SSM2007 Community** *accessible to legal and registered users only,* from the main SSM2007 website: www.space-shuttle-mission.com
2. **The SSM2007 Ground Crew Twitter:** http://twitter.com/ssm2007 for the latest news-flash inside information.
3. **The SSM2007 Ground Crew Blog:** http://ssm2007.blogspot.com/ for more detailed inside information and activities.
4. **The SSM2007 Facebook:** http://www.facebook.com/exciting.simulations
5. **The unofficial SSM2007 Wiki**. It has been founded and largely maintained by a veteran SSM2007 guru and Beta Tester “Uri-Ba”. Other gurus and Beta Testers occasionally chime in and add their own input and updates. The SSM2007 Wiki contains information complementary to this manual and the official site.
   The Wiki is at: http://wiki.ssm-fans.info/
6. **The unofficial SSM2007 fans portal:** http://portal.ssm-fans.info/ founded and maintained by SSM2007 veterans “Marvx”, “Uri-Ba” and “Cthulhus”

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Lorinczi Alexander

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Additional Programming: Ilan Papini

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Toine Mercier
XP Concept (UI)
Jehl Xavier (Splash Screen)
George Winnard (Mid-deck)
TerraMetrics Inc.

SFX consultant

Marc Mackin

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Rainer “Christra” Christiansen (Achieving Orbit, DAP, Deorb, LOS, RNDZ)
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KSC Friends

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