TUTORIAL

FLYING SPACE SHUTTLE

Reaching ISS
and returning home

BY JOSÉ PABLO LUNA SÁNCHEZ. 2009.

Version 1.2

SOME IMPORTANT NOTES

These instructions are based on David413's Shuttle Fleet version 3.9.4 addon for Orbiter Space Flight Simulator. I haven't had a chance to test other versions of Shuttle Fleet. Version 3.9.4 is the latest stable version I have tested.

Latest versions may change the way of operation, so see documentation that comes with the respective addons.

As a matter of notation actions that you need to perform are colored in red and separated by ">". Actions could be to press a key, or a button, or select an option, or to type text.

Example:

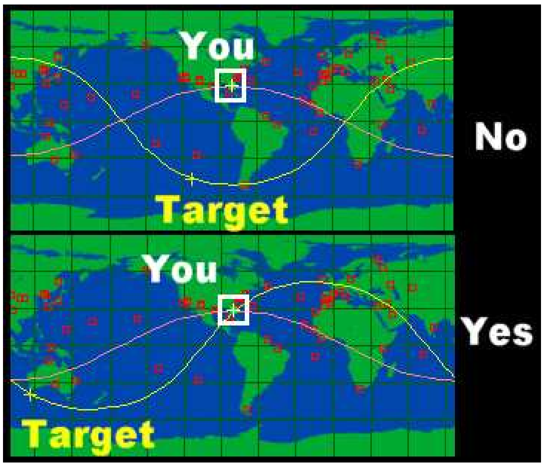
> PWR > GPC > OPS > 1 > Enter key
>
> In this example you need to press PWR button, then select the option that corresponds to GPC, then OPS button, then type 1 and hit Enter Key. How do you know? Well, you will see the screen and I bet you will know what to do.

This tutorial is not aimed at beginners who do not master the basic concepts of ascent, orbits and docking. How do you know if you are ready? If you got to take a Delta Glider and take off and rendezvous and dock with space station, then you may be ready to use this tutorial.

If you find any typos or problems, be sure that it was not intentional. I have had to use hours from my sleep to make it.

This tutorial is work in progress. Right know it covers from take off to ISS docking and how to get back home.

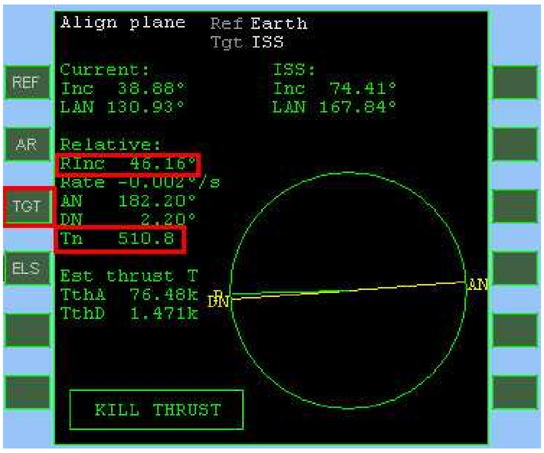
LAUNCH WINDOW



Launch window takes place when the orbit of our target is almost on top of the launch platform.

Earth rotates, so target orbit will move. As you may imagine, there are two moments every day when you may launch.

You may use Align MFD to estimate the proper moment for launch.

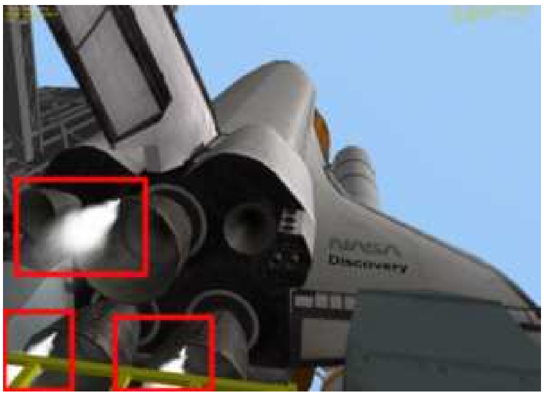


Ascent lasts about 8.5 minutes (about 510 seconds). Select your target TGT > Spacecraft > ISS and as a rule of thumb you may need to wait until Tn (Time to node) is 510 or smaller.

RInc (Relative Inclination) may help you to estimate your approximate launch heading. As a rule of thumb it will be either 90 + Rinc or 90 – Rinc but if you need more accuracy, you may need math.

Launch heading is preset by the scenario that you started and if you might want to change it, you may want to edit your scenario.

OXYGEN PURGE

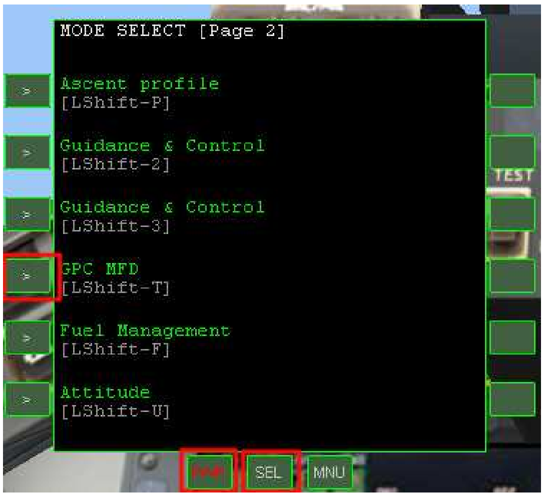


Press CTRL X to start oxygen purge to keep pipes cold.

David413 shuttle does not simulate inner systems. This purge is merely visual.

SETTING UP GPC

GPC stands for General Purpose Computer.



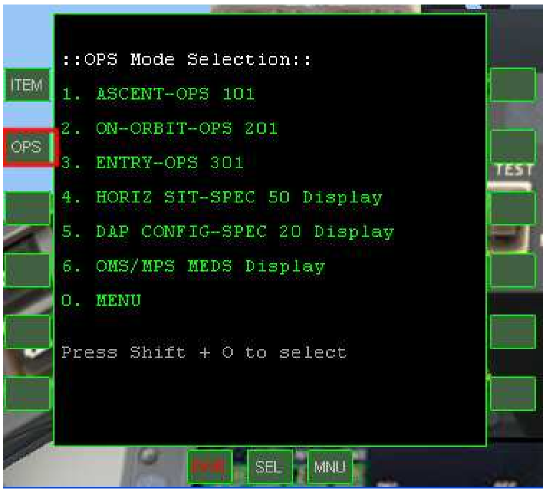
Press F1 to get into the craft.

Press 5 to take commander (CDR) seat.

Press H to activate Head Up Display.

Set up your GPC by pressing
PWR > GPC > OPS > 1 > Enter key

You may like to know that David413 GPC works with 2 basic types of commands: OPS and ITEM.



Every order that you give to the computer involves the use of both, command and a number.

In the real space shuttle you would have a numeric keypad with all numbers and OPS and ITEM buttons.

Since in this simulator you do not have a keypad, you have MFD buttons to accomplish that.

You just have got to setup OPS 1 program.

FINAL COUNTDOWN

Autopilot is activated by default. If you wish to deactivate it, press B key.

Notice that if you turn it down, you may not be able to turn it on again.

It looks like we are ready to take off. Isn't it exciting? You are now ready for your first flight as a pilot of a Space Shuttle.

To start countdown, use GPC to select ITEM 777. It will reset countdown to minus 10 seconds.

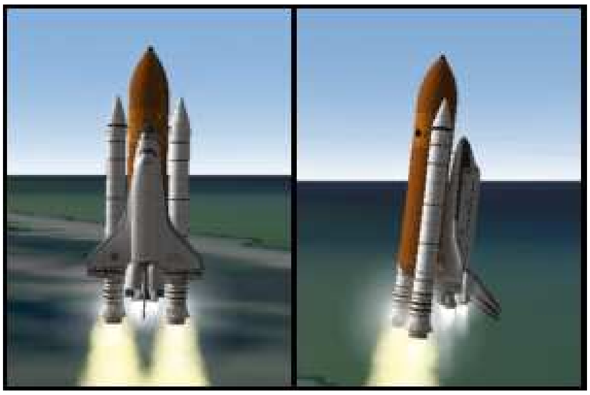
Wait until countdown reaches zero and your craft will take off automatically.

BLAST OFF

In real life you might see Space Shuttle Main Engines (SSME for short) igniting and producing a white/transparent flame at minus 4 seconds.

After countdown reaches zero you might see the craft taking off.

ROLL MANEUVER



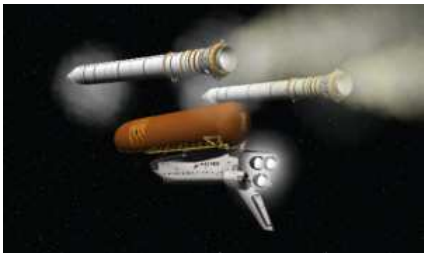
Roll maneuver is very critical for the success of your mission, as the top of the orbiter points at the heading that will determine the inclination of your orbit.

Making the roll maneuver manually could be very difficult, so you might want to let autopilot to conduct the maneuver.

ASCENT

There are two types of ascent profiles which will be explained later:

- Direct insertion
- OMS-1 required



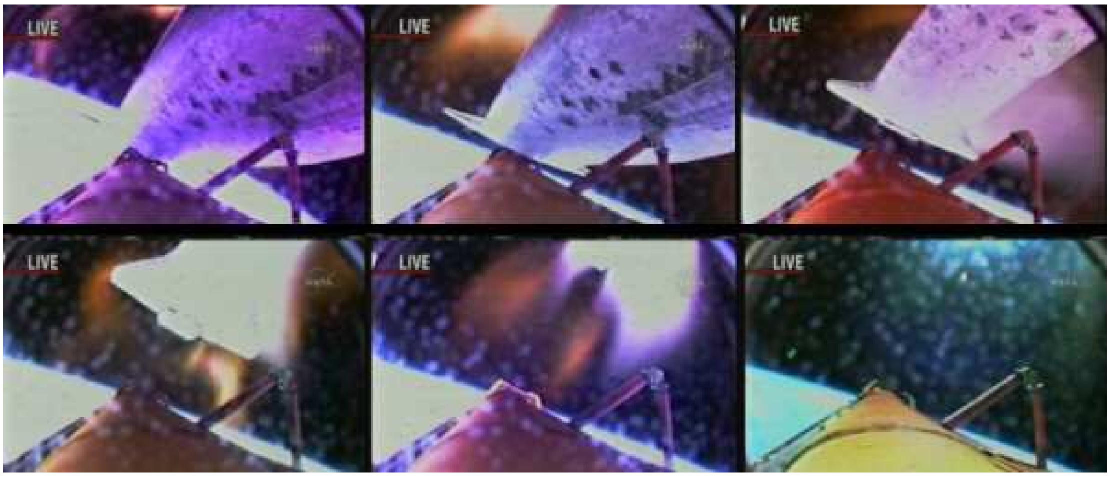
After 2 minutes of flight, the Solid Rocket Boosters (SRB) will detach from the craft at an approximate altitude of 43km above sea level. This point is designated as SRB SEP.

The SRBs fall into the ocean with parachutes and they are recovered, repaired and reused.

After about 8 minutes of flight, when apoapsis has been set and the craft has reached a certain velocity, it comes the time to turn of the SSMEs that use fuel from the External Tank (ET).

The moment when SSMEs are turned off is known as Main Engine Cut-Off (MECO).

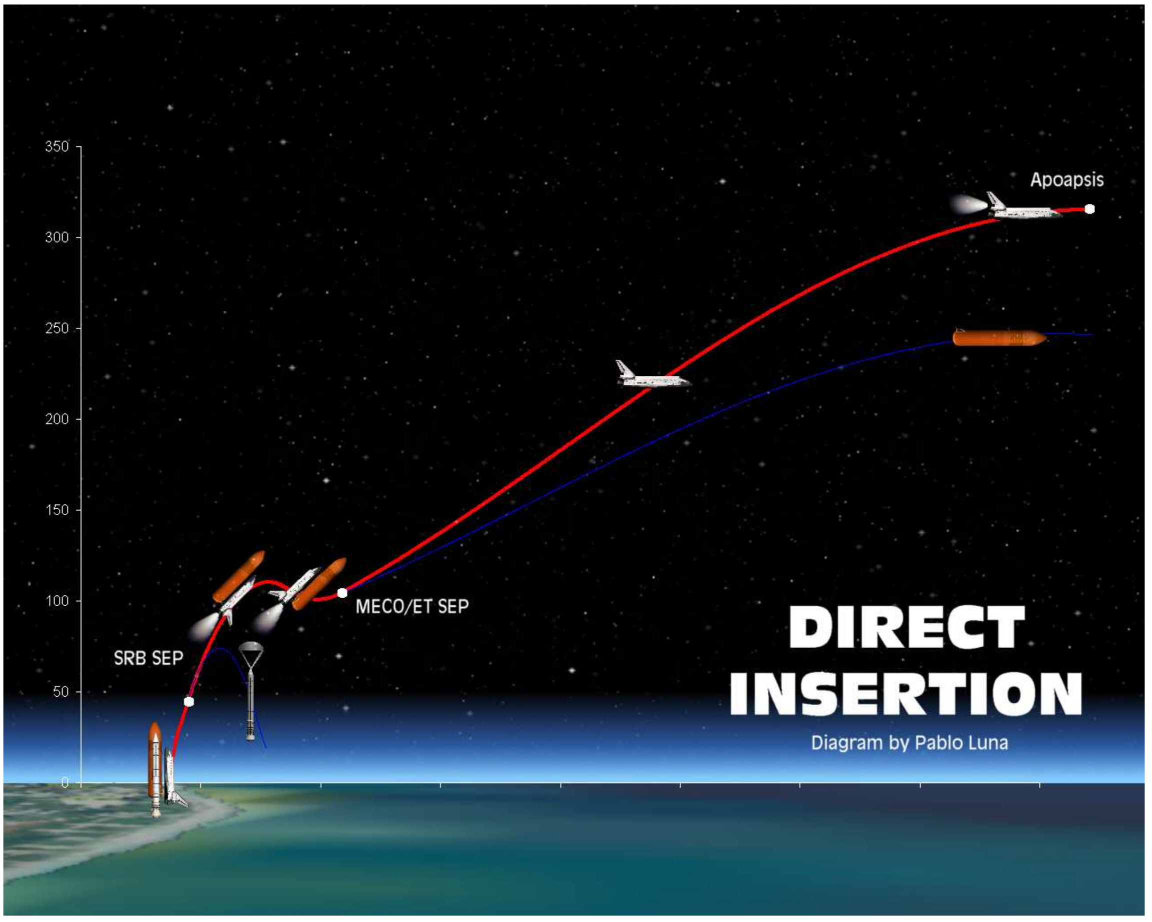
After MECO, the orbiter detaches from the ET and it is known as ET SEP.



After ET SEP the orbiter will perform a roll maneuver so the upper windows point towards ET, in order to inspect it and take pictures to analyze damage during ascent.

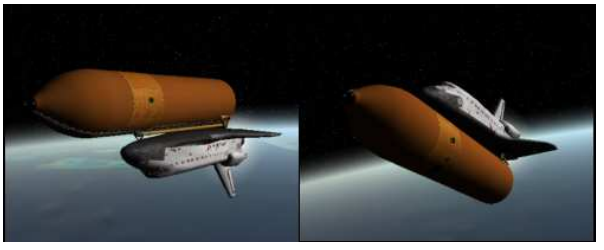
Those pictures will be analyzed by ground personnel.

DIRECT INSERTION PROFILE



In the direct ascent the craft will conduct a roll maneuver before MECO.

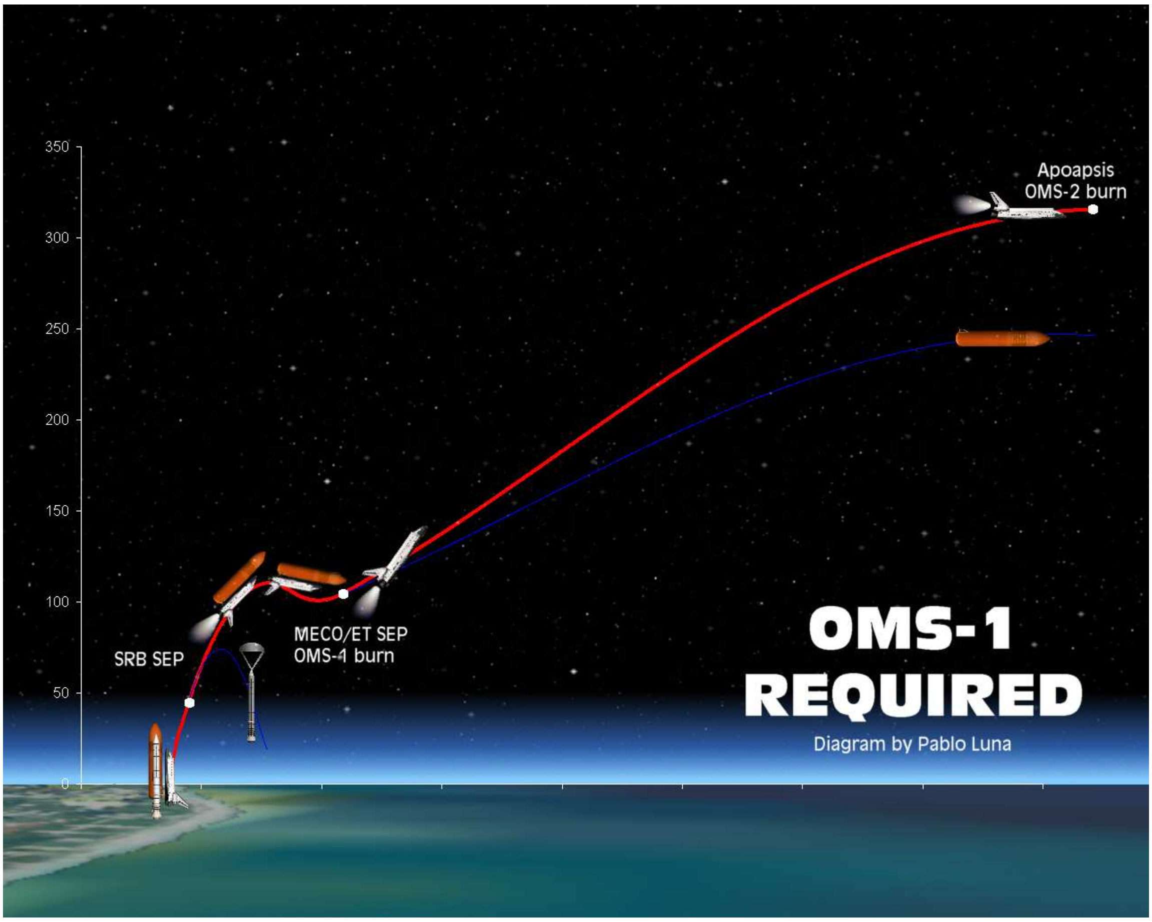
This maneuver allows the shuttle to raise the apoapsis (highest point of the trajectory) before MECO.



This will make a better use of the fuel contained in the External Tank (ET) and allows the ship to move from ground control to satellite control.

As the craft reaches apoapsis, it starts a prograde burn to circularize orbit.

OMS-1 REQUIRED PROFILE



In this profile the craft remains inverted during MECO and ET SEP. After ET SEP, the orbiter will conduct an OMS-1 burn to raise apoapsis, and as it gets close to apoapsis a prograde OMS-2 burn takes place to circularize the orbit.

CONFIGURING ASCENT PROFILE AND HEADING

Unfortunately, to configure the ascent profile you need to edit your scenario with notepad, before running Orbiter.

If it reads **`PROFILE 0`** it will use direct insertion.
If it reads **`PROFILE 1`** then it will use OMS-1 required.

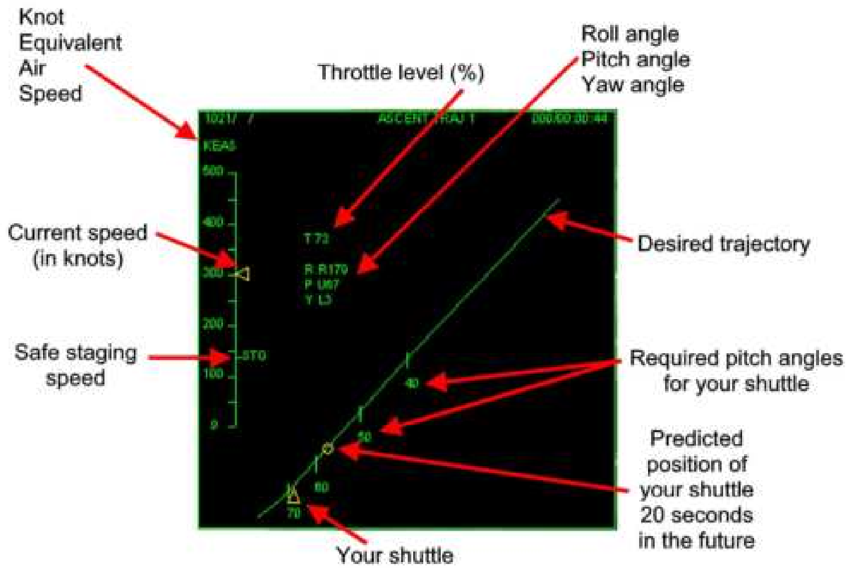
You also may read something like **`TGT_HEADING 42 228`** which means a heading of 42 (0 is north, 90 is east and 180 is south) and an target apoapsis altitude of 228 km. Edit your scenario before starting Orbiter.

GPC DURING ASCENT

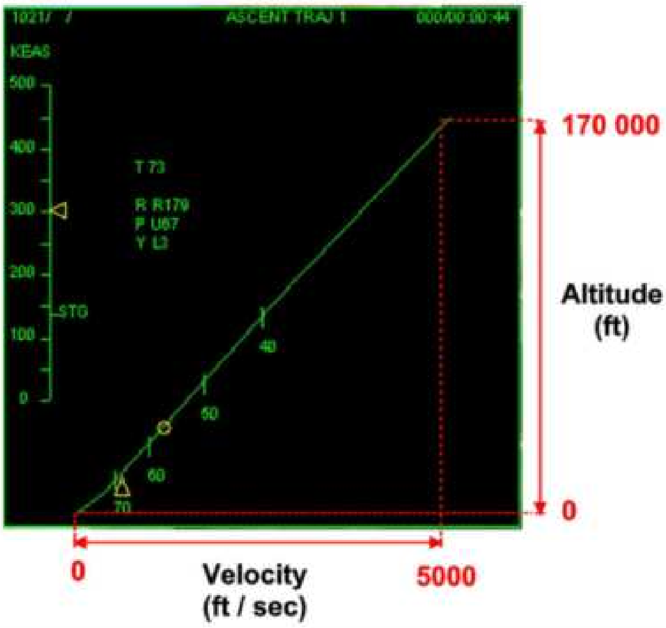
Ascent is composed by 2 stages.

STAGE 1

During stage 1 of the ascent (before SRB SEP), trajectory appears as a straight line, but do not be fooled by it.



Real trajectory is not a straight line. This line is a graphic that compares altitude and velocity.



Your goal is to keep the yellow ball of the predicted position along the line. You only need to pitch up or down.

Once you reach the end of stage 1, you need to switch to stage 2 by selecting ITEM 15 in your GPC.

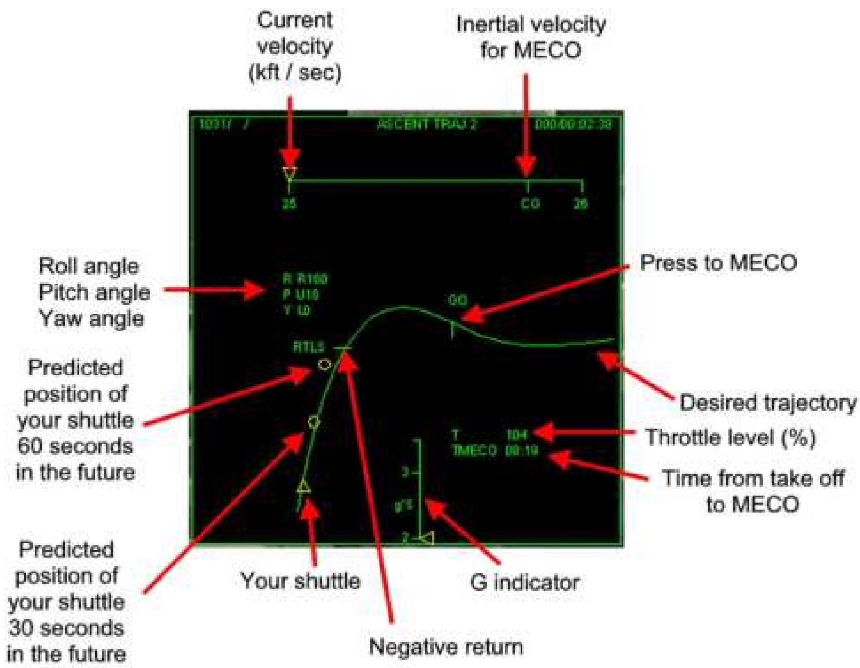
STAGE 2

This stage is tricky.

The GO marker indicates "press to MECO" which means something like "we are almost MECO".

The CO marker in the upper ruler indicates when the inertial velocity for MECO has been reached.

RTLS marker indicates that you can't go back to launch site if you need to abort the mission.



CONTROLLING PITCH

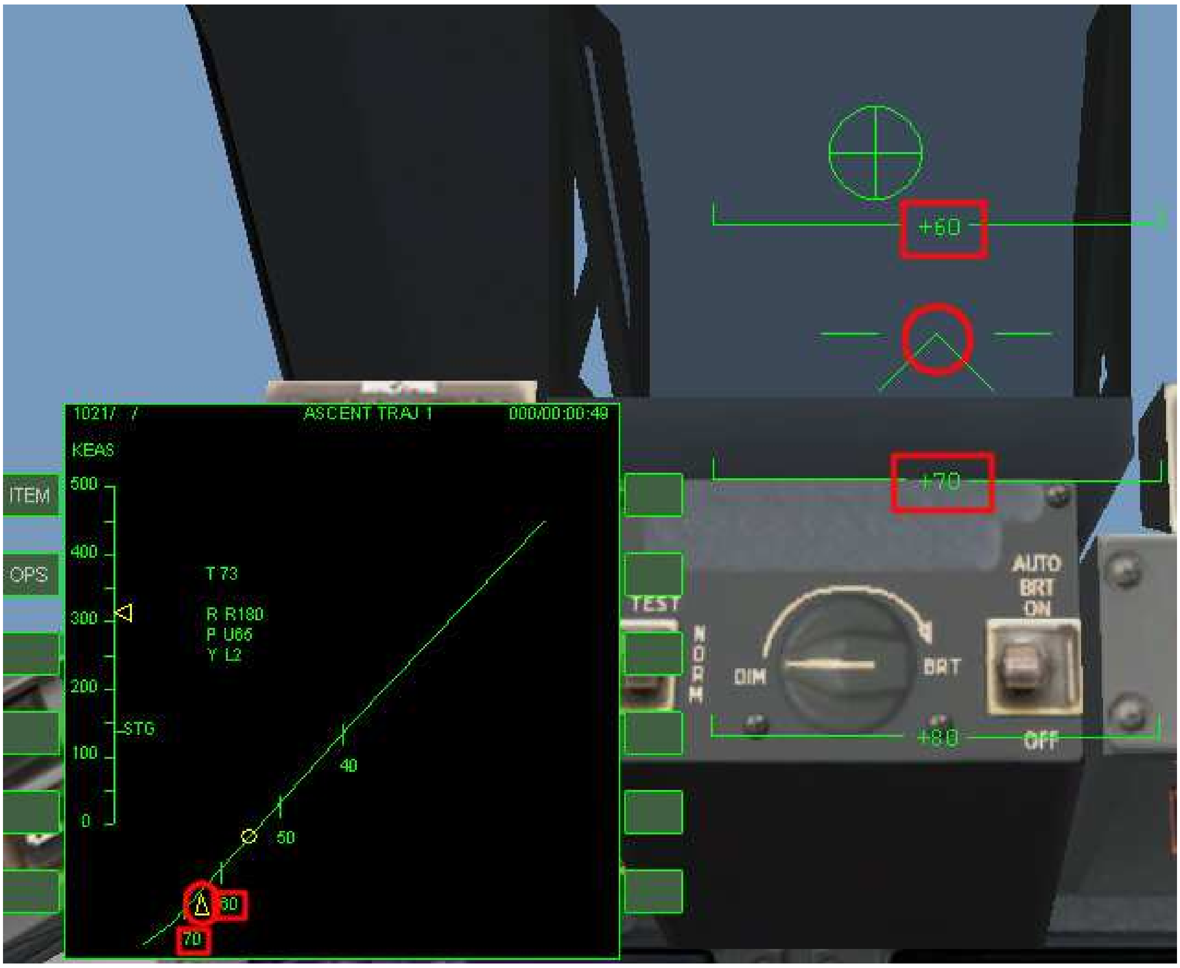
You may wonder how to control pitch. 0 means your nose is aligned with horizont. 90 means you go straight up.

So pitch is an angle measured from horizont. This angle can be seen in your Head-Up Display (HUD).

In this example, you can see how it looks from inside and outside. Notice HUD shows the smaller number above and bigger numbers below. It happens because you fly inverted.

Use keypad 2 and 8 to control your pitch angle. Notice how GPC also has markers that indicate the pitch angle you should have at a certain moment. Maintaining the right pitch is very tricky.

This is why you may like the autopilot to fly for you, if you are a newbie. The autopilot will take you to MECO and ET SEP.



ADJUSTING ORBIT

Select Guidance & Control MFD (the one that reads “RShift 2”) after MECO and ET SEP.

Guidance & Control MFD is an old addon and it does not respond very well when you change seats inside your craft, so do not change seats when using it.

Guidance & Control MFD has 4 displays:

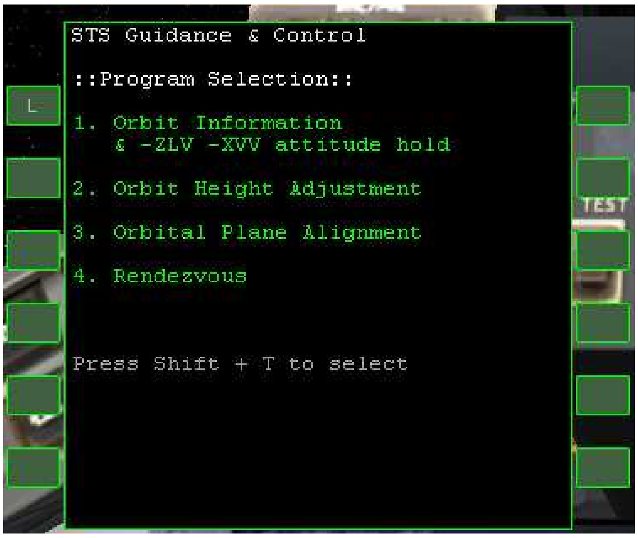
- **ORBIT INFORMATION & –ZLV –XVV ATITUDE HOLD:** Orbit info and set fixed vessel attitude.
- **ORBIT HEIGHT ADJUSTMENT:** It will adjust orbit apoapsis and periapsis.
- **ORBITAL PLANE ALIGNMENT:** It will conduct orbit alignment maneuvers.
- **RENDEZVOUS:** It allows synchronization and final approach maneuvers.

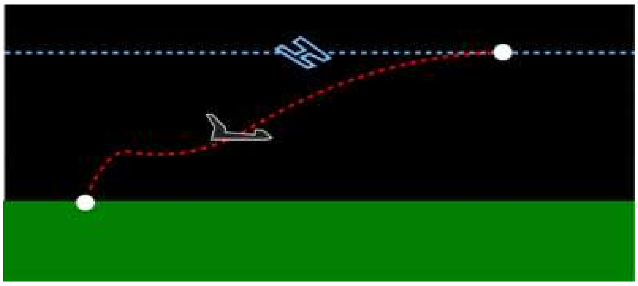
If you use Guidance & Control MFD you need to take off after your target has passed above you.

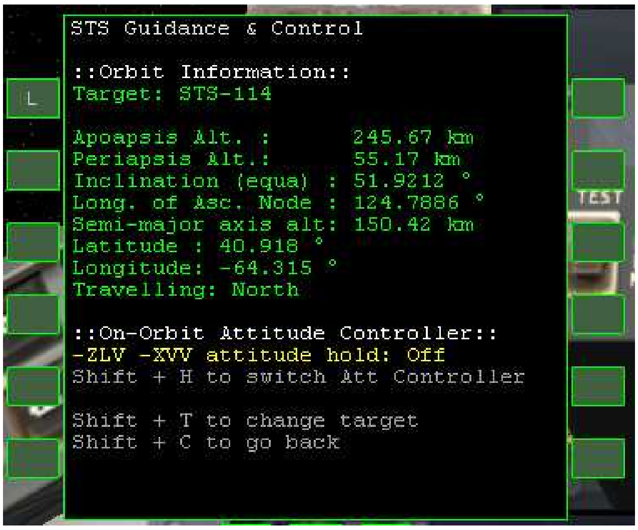
So you will be approaching from behind and below.

Select L > 1 > Enter key.

Check that Apoapsis Alt is between 243 and 267 km. Our next step is to circularize our orbit.





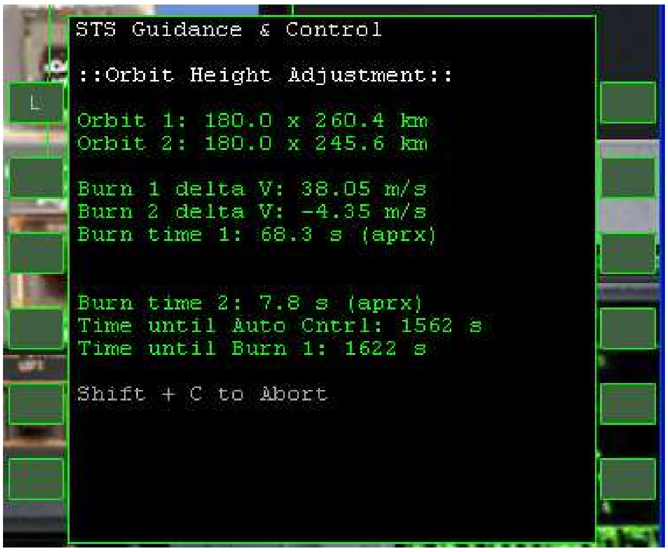


Press Shift C to come back to the main screen, if needed.

Select L > 2 > Enter key.

Press Shift T > 1800 2456 > Enter key. This will set periapsis at 180.0 km and apoapsis at 245.6 km.

A periapsis above 150 km allows us not to fall back to Earth and an apoapsis below target altitude allows us to travel faster than our target, due to Kepler laws.



Now wait until Guidance & Control MFD performs the orbit circularization burns.

If you accelerate time, try not to set it above 100X.

You will see these figures:

- **BURN DELTA V:**
  Desired velocity minus current velocity
- **BURN TIME:**
  Time it takes, with engines at full thrust, to achieve Delta V.
- **TIME UNTIL AUTO CNTRL:**
  Time to activate autopilot that moves the craft to achieve the proper attitude. It is a countdown.
- **TIME UNTIL BURN:**
  Time to start the burn. It is a countdown.

Open Cargo Bay Doors

During the ascent, the craft gets hot, so as soon as orbit is reached, opening cargo bay doors and deploying the radiators is of utmost importance to prevent overheating.

Press K to open cargo bay doors. Once doors are completely open, deploy radiator with CTRL L.

You might not want the sun to heat your radiators, so you might want to fly inverted, so radiators point towards Earth. David413 shuttle does not simulate overheating but you might maneuver for the sake of realism.

Deploy Antenna

Now it is time to deploy the Ku Band antenna that is located inside the cargo bay.

Press CTRL U.

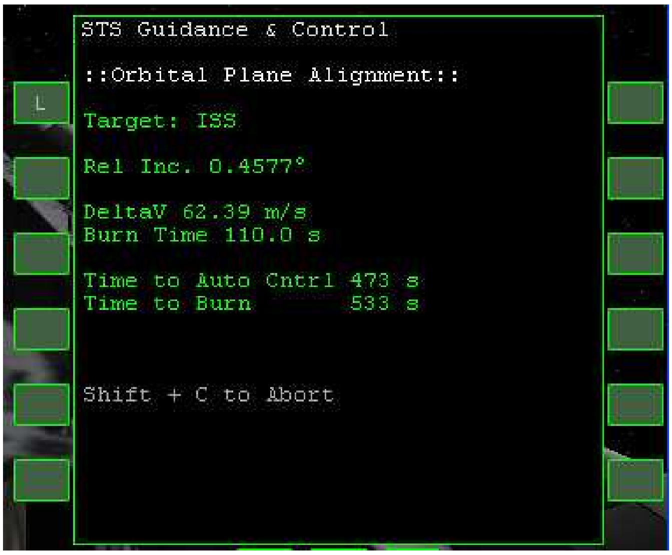
PLANE ALIGNMENT

It is time to use Guidance & Control MFD again.

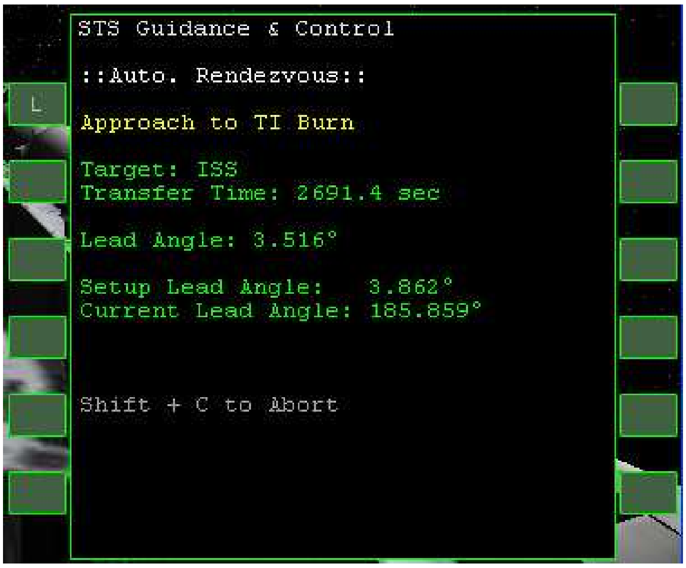
Select Shift C to go back to main MFD menu, if needed.
Select L > 3 > Enter key.
Then Shift T > ISS > Enter key.
This will align your orbit with ISS orbit.

You will see these figures:

- **TARGET:**
  The name of your target
- **REL. INC.:**
  (Relative inclination) Angle between your orbit and target orbit. This manuver consumes lots of fuel, so it is very important that ascent could provide almost no relative inclination.
- **DELTA V:**
  Desired velocity minus current velocity
- **BURN TIME:**
  Time it takes, with engines at full thrust, to achieve Delta V.
- **TIME UNTIL AUTO CNTRL:**
  Time to activate autopilot that moves the craft to achieve the proper attitude. It is a countdown.
- **TIME UNTIL BURN:**
  Time to start the burn. It is a countdown.



COURSE CORRECTION AND RENDEZVOUS



Select Shift C to go back to main MFD menu, if needed.
Select L > 4 > Enter key.
Then Shift T > ISS > Enter key.

Accelerate time (or wait a lot if you wish) until **Setup Lead Angle** is similar to **Current Lead Angle**. As they become similar, bring back time to normal. You may go around Earth several times during this maneuver.

Let the autopilot do the job for you. It will perform CCB (Course Correction Burn) and a Rendezvous Burn. After this process ends, you will find yourself very close to the station.

You will see these figures:

- **SETUP LEAD ANGLE:**
  Desired angle between you and and your target, measured from the center of planet Earth.
- **CURRENT LEAD ANGLE:**
  Current angle between you and and your target.

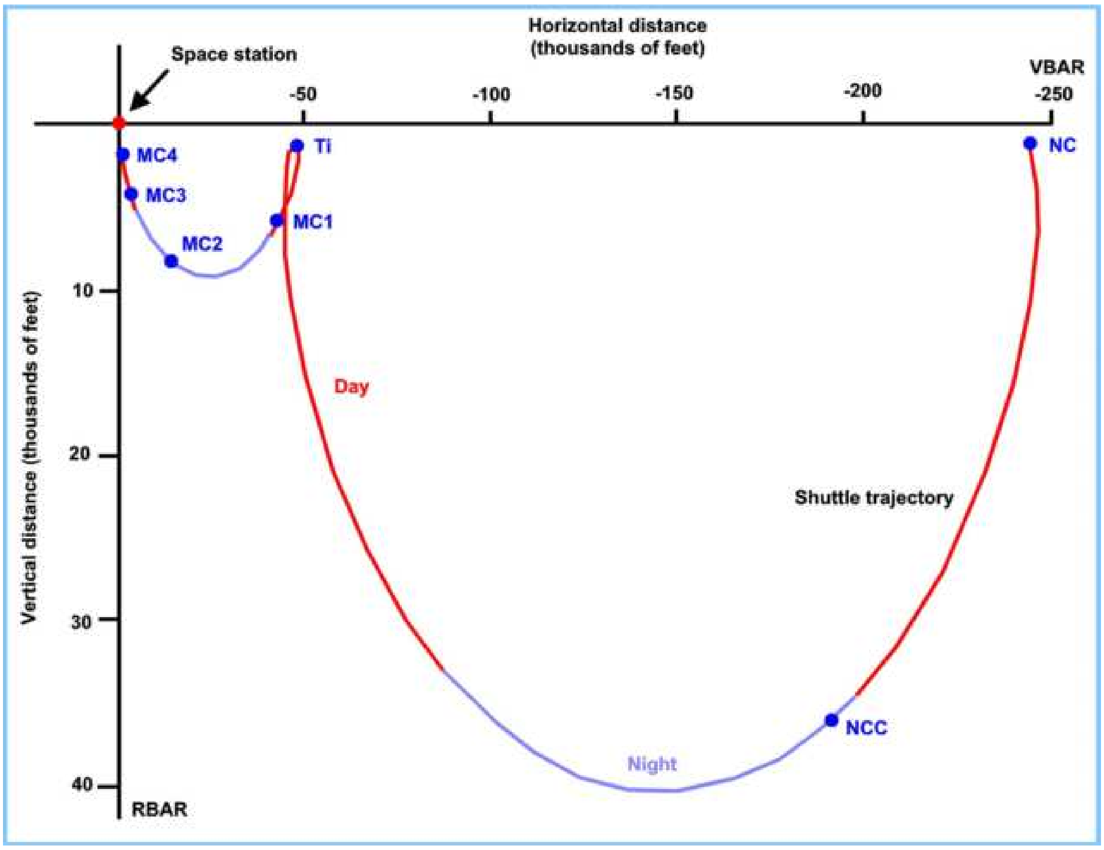
After autopilot ends, you will know exactly how to dock, if you already practiced with a Delta Glider.

You may use CTRL Z to see through the space shuttle ODS (docking port) or use 7 key to see through the top windows from the cockpit.

UNDERSTANDING COURSE CORRECTION AND RENDEZVOUS

Fortunately for you, Guidance & Control MFD does all the hard work for you. The following image shows the trajectory of the shuttle in terms of vertical and horizontal distance, as if Earth was flat and both shuttle and station were flying over it.

RENDEZVOUS PROFILE

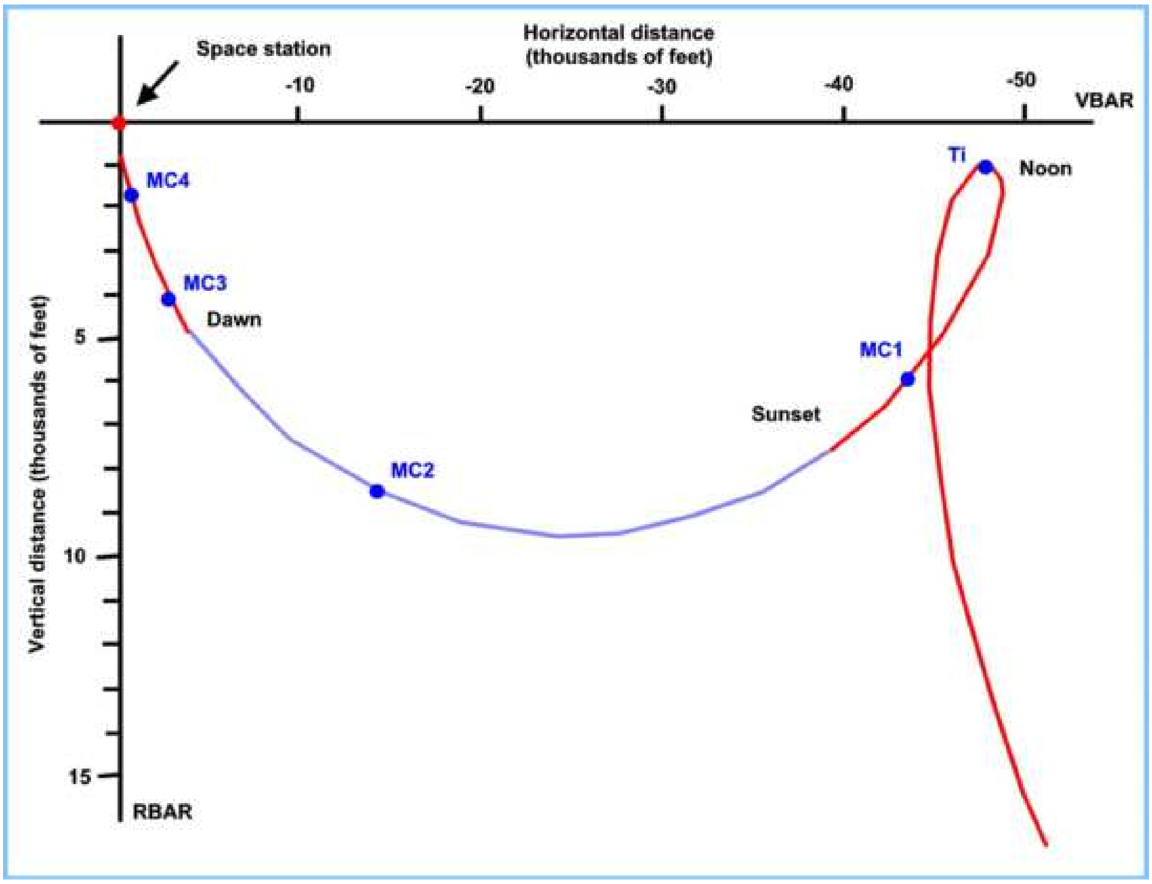


Burns that need to be performed in a real mission:

- **NC** (encounter) It allows to be at a certain distance from target in the future.
- **NH** (encounter height adjustment) It allows to have a certain difference of altitude in the future.
- **NPC** (encounter plane change) It aligns target and shuttle orbits.
- **NCC** (encounter corrective combination) It is the first of a series of burns to start encounter sequence. Using GPS and star scanning phase and altitude error margin can be removed to reach the right point for Ti burn. This burn could be understood as orbit synchronization.
- **TI** (encounter terminal initialization) Second burn of encounter that uses radar mostly to place orbiter in intercention trajectory after one orbit.
- **MC-1, MC-2, MC-3** and **MC-4** (Course correction burns): They use star scanning and GPS to eliminate sources of error in post-Ti trajectory in preparation to manual approach operations.

ORBT POST TI PROFILE

After Ti you have ORBT (Optimized RBar Targeting Technique). It outs your craft close, behind and below the station.

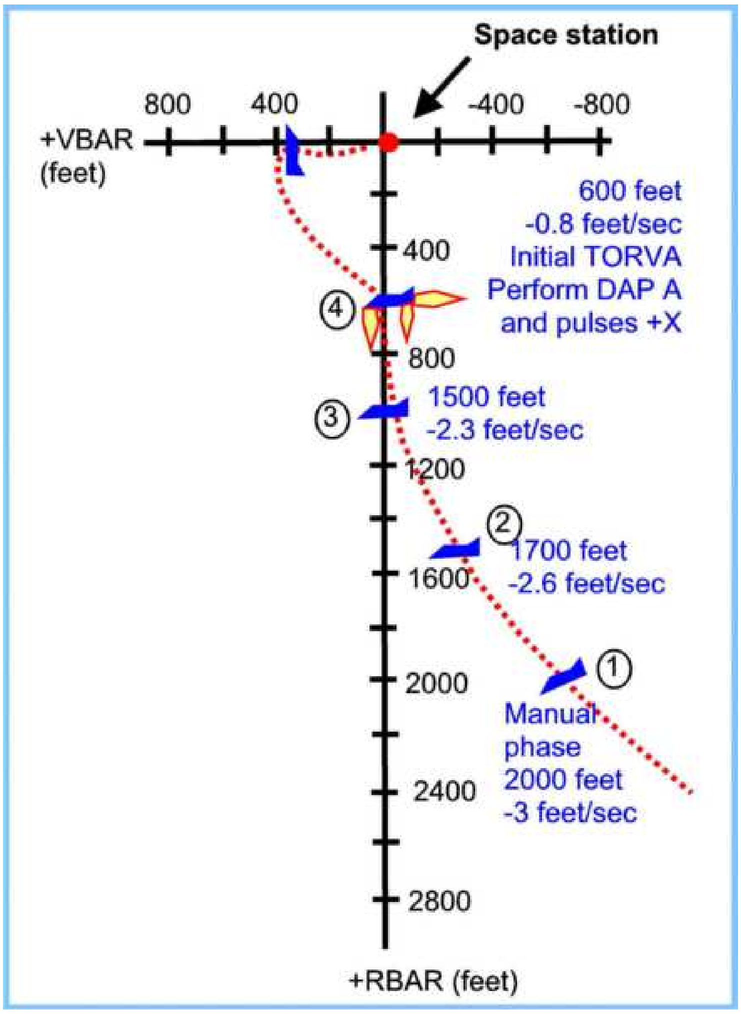


TERMINAL PHASE, TORVA AND VBAR APPROACH

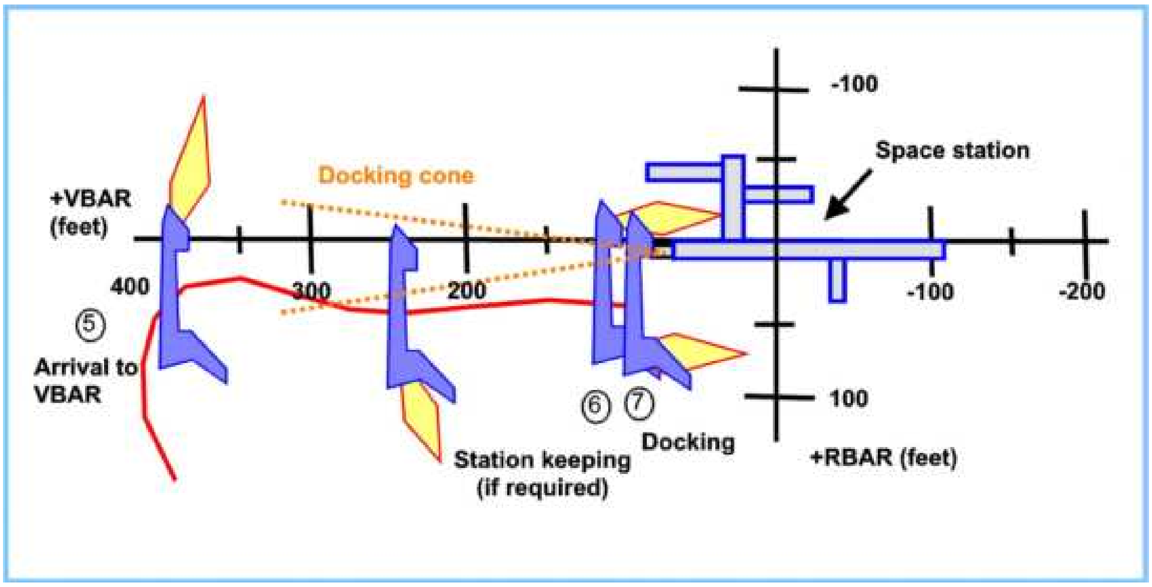
After MC-4 burn you are in a trajectory that will place you about 1000 feet below the station. There you will perform **TORVA** (Twice Orbital Rate Vbar Approach) which is a technical way to say "put your craft in front of the station" where the docking port is just in front of you at the same altitude for the final approach and docking along the +VBAR axis.

Notice NASA already calculated relative velocity, which can be seen with Docking MFD. You may see that this diagram has yellow-red flames. It indicates that a burn must be performed there.

David413's addon includes a playback where you can see how it works.



VBAR APPROACH



This maneuver is about placing ODS along the VBAR axis to dock with space station. Once you start this maneuver you may use Docking MFD, since you will be inside the docking cone and you have a signal coming from the docking port.

When the shuttle is inside the docking cone, put the shuttle pointing the nose upwards (using HUD in surface mode using H key).

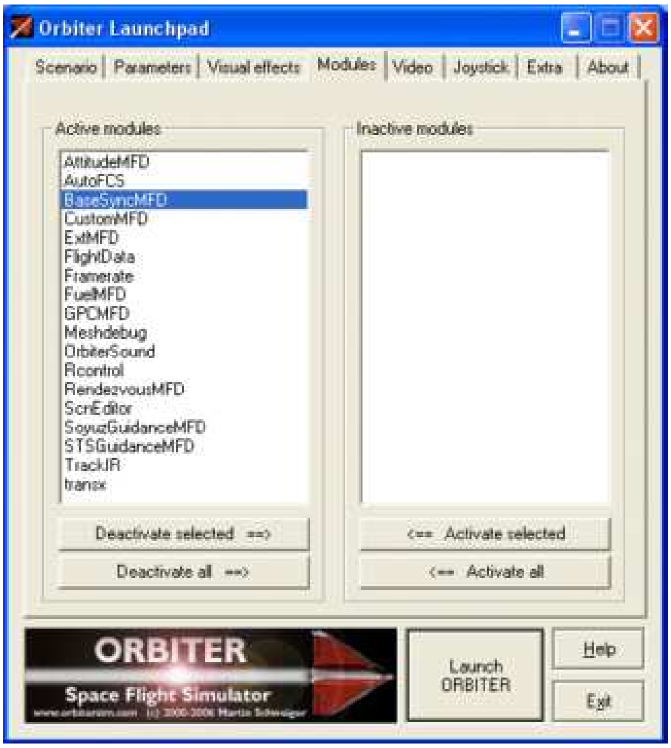
Use keypad 9 with RCS in translation mode to stop ascent (as seen in step 5 in the diagram).
Approach at 0.5 meters per second (watch Docking MFD).
When close to station (step 6, less than 100 feet) bring relative velocity to 0.
Use RCS to approach at 0.1 meters per second in translation mode.

Notice your craft is pointing towards zenith and the docking port points prograde. If station had docking port with a different attitude, steps would be completely different.

DEORBIT AND ENTRY

Atmospheric entry poses a true challenge, so Mike Norman made AutoFCS (Auto Flight Control System) that allows automated deorbit and entry.

To use AutoFCS you must be aligned with base, because AutoFCS has problems if you are not aligned. To align your craft you are going to need **BaseSyncMFD**.



Once you install BaseSyncMFD you may need to activate it in the Orbiter Launchpad.

Before aligning with base, you need to have a very light ship. It means that you must get rid of as much weight as you can. Orbit alignment consumes lots of fuel, and it consumes more if your craft is heavier. Your fuel supply is very limited.

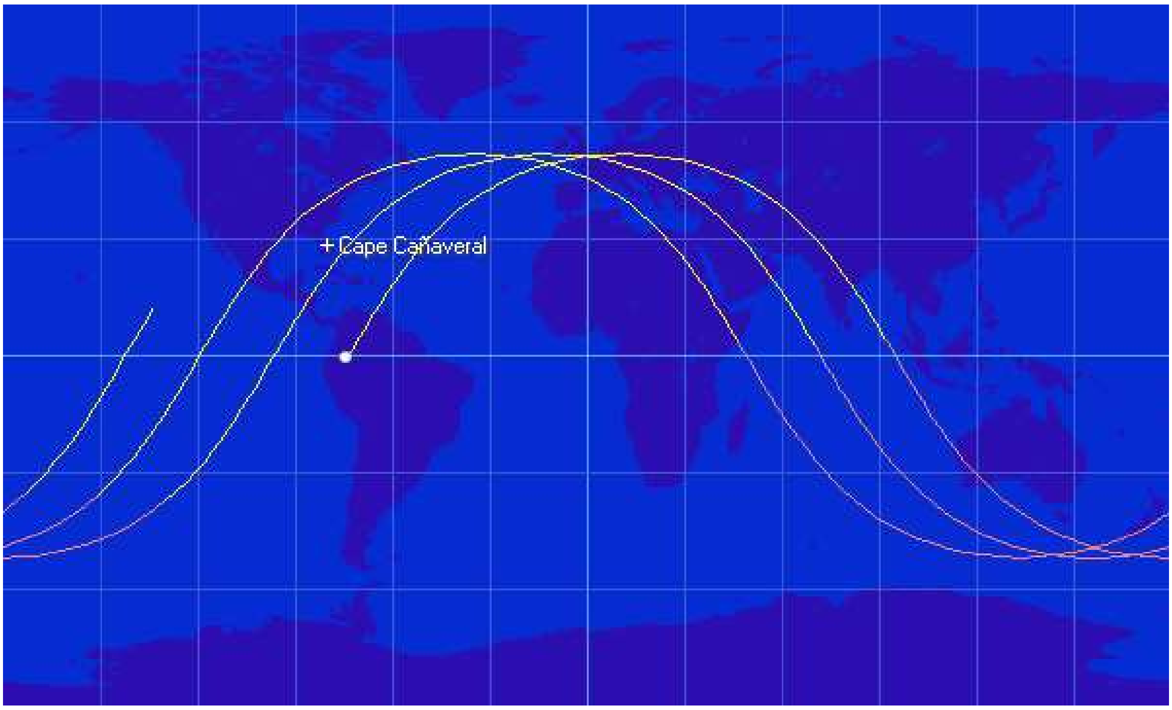
There are some tasks you need to do before deorbiting.

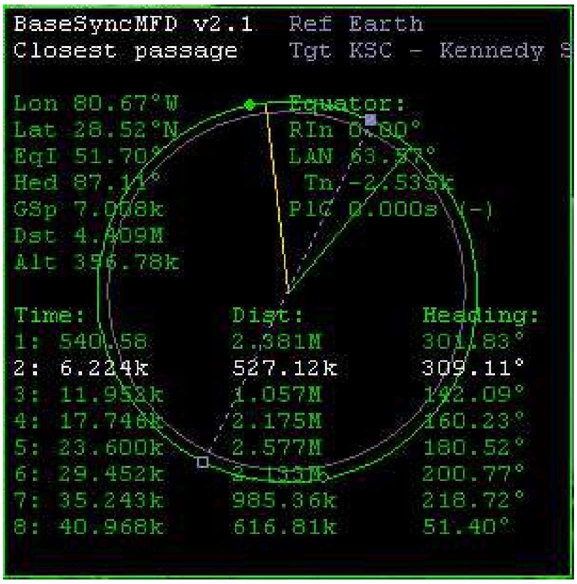
Select CTRL SPACE > Stow to stow the arm.
Once the arm is stowed, press CTRL X to move the RMS to stowed position.
Select CTRL U to stow the Ku Band antenna.
Select CTRL L to stow the radiator.
Close payload bay doors with K.

Select BaseSync MFD and Map MFD.
Select TGT in BaseSync MFD
Type the name of a base and press Enter.
You may select a base in Map MFD if you are unsure about the name of the base you want.

ALIGNING WITH LANDING BASE

Our ship orbits Earth and Earth rotates, so we never pass over the same point twice.





We need to pass over the landing site in the near future, which means that the closest pass in a certain orbit will be near zero. Closest pass is exactly what BaseSync calls "Dist". It has 3 columns but we only need 2:

TIME:

Time to closest pass in seconds

DIST:

Distance to base (closest pass).

In this example 527 km as closest pass is too far away, so we need to pick another base. We might spend all of our fuel to align. Alignment to such best closest pass (highlighted distance in the MFD) near zero is very fuel consuming.

Every line represents one orbit. So you know how many orbits you need to reach the closest pass.

Your best moment to align orbit with base (orbit alignment) is when your craft is 90 degrees away from target base.

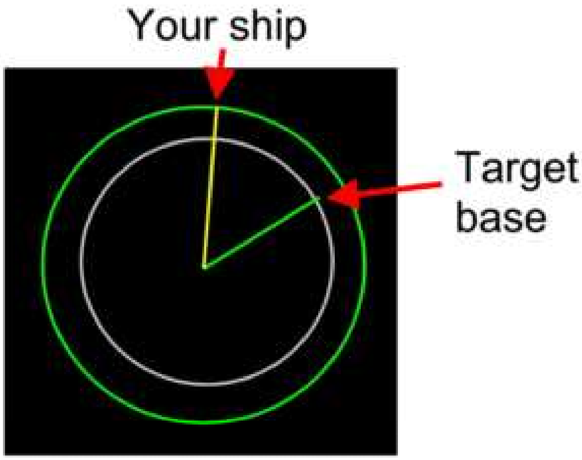
When we are 90 degrees away, we might need to orient our craft using Normal or Antinormal autopilot to make the alignment burn.

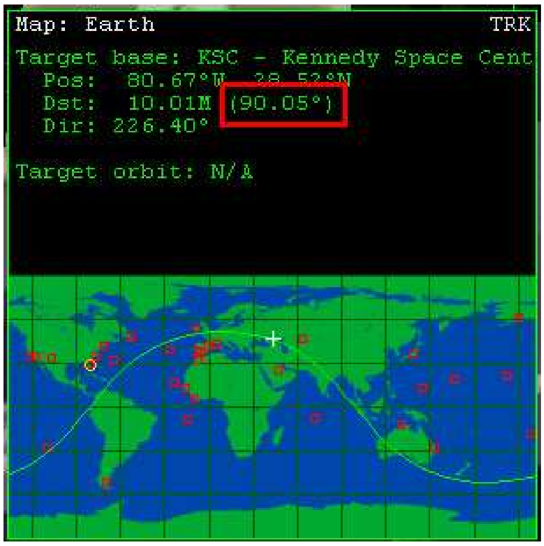
The goal is to make the closest pass to become zero.

You also may use Map MFD to know how many degrees away you are from base.

Notice that a deorbit burn might take place very far away from you base (normally, orbinauts start deorbiting at 180 degrees from base). The closest you are to your base (smaller angle), means that your descent will be more steep and you would burn during entry in real life.

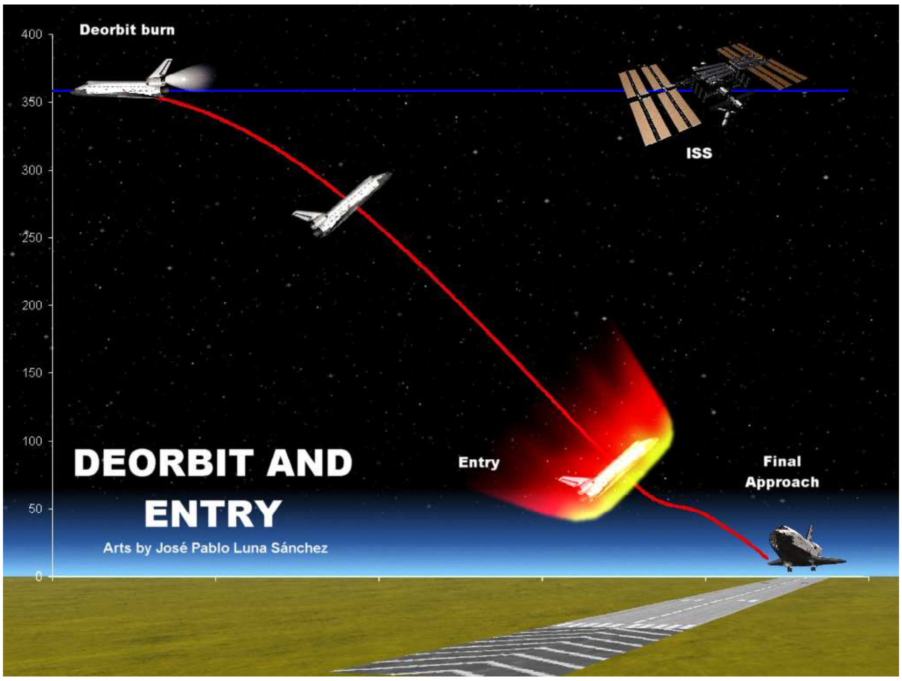
Fortunately, David413's addon does not simulate damage.



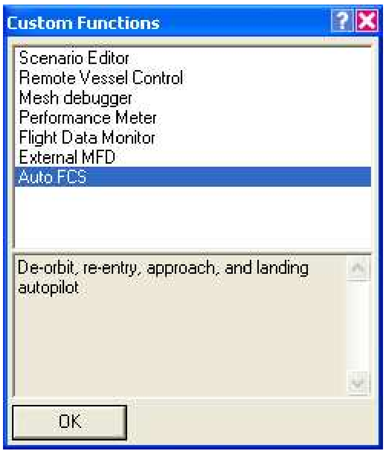


Warning! AutoFCS does not like when you are not almost perfectly aligned with your base.

DEORBIT BURN

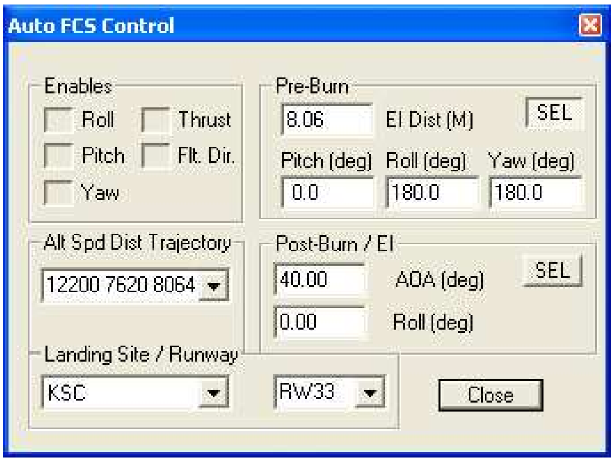


Deorbit is the process of lowering periapsis inside the atmosphere, using a retrograde burn, so we start the descent. Once you touch the atmosphere you start EI (Entry interfase) where you will perform an aerobrake maneuver to put the point of impact right on the landing site.

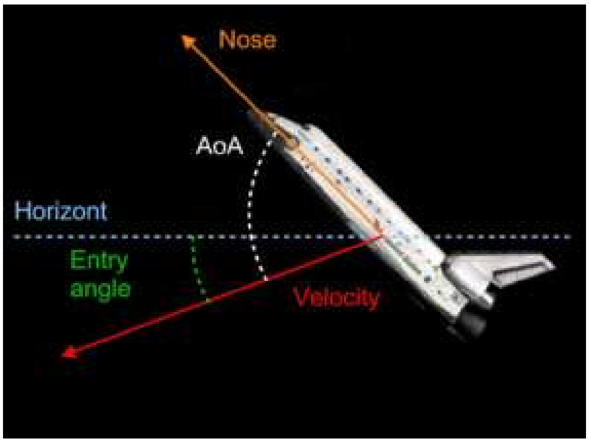


Once you deorbit you will have a glider. If you were on the ground and you used your OMS engines, you would not even move your craft. Also, RCS and OMS engines are optimized to work in vacuum, it is unlikely that something would come out of the exhaust due to atmospheric pressure. Do not rely on your engines.

To conduct the deorbit, align with your base first.
Select F4 > Custom > AutoFCS.
Select a Landing Site/Runway.
Press Pre-Burn SEL button.
Wait until AutoFCS performs deorbit burn. Do not close AutoFCS.



ENTRY INTERFASE

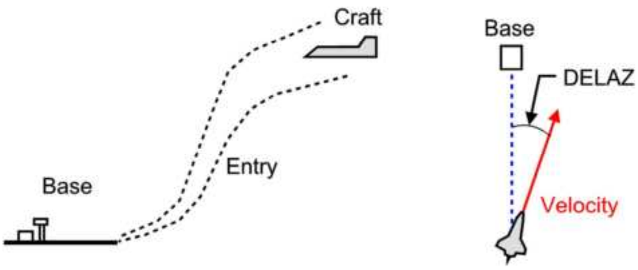


During Entry we maintain a certain angle of attack (AoA) and deorbit burn provides an entry angle.

This angle provides aerobraking capability but also some lift that could bounce our craft back to space.

This is why at some point during the descent the “S-turn” maneuver is conducted.

Such a maneuver uses velocity as axis of rotation, so the ship will move sideways, altering its path towards one side, and then it rotates to the other side to compensate and realign with base.



S-Turns will cause changes in the DELAZ (Delta Azumit) angle, and would make the craft to lose energy so it does not bounce back to space.

The entry path is similar to the shape of a horn or some sort of a cone.

Once deorbit finishes, press the Post-Burn/EI SEL button in AutoFCS and do not close AutoFCS.

AutoFCS does not like you to change seats.

You may toggle cockpit and external views at most.

Warning! Do not deactivate AutoFCS. Do not make mistakes when using it. Attach to the procedure described here. Once you press SEL, become a passive observer, unless you want to take control. AutoFCS will land your craft.

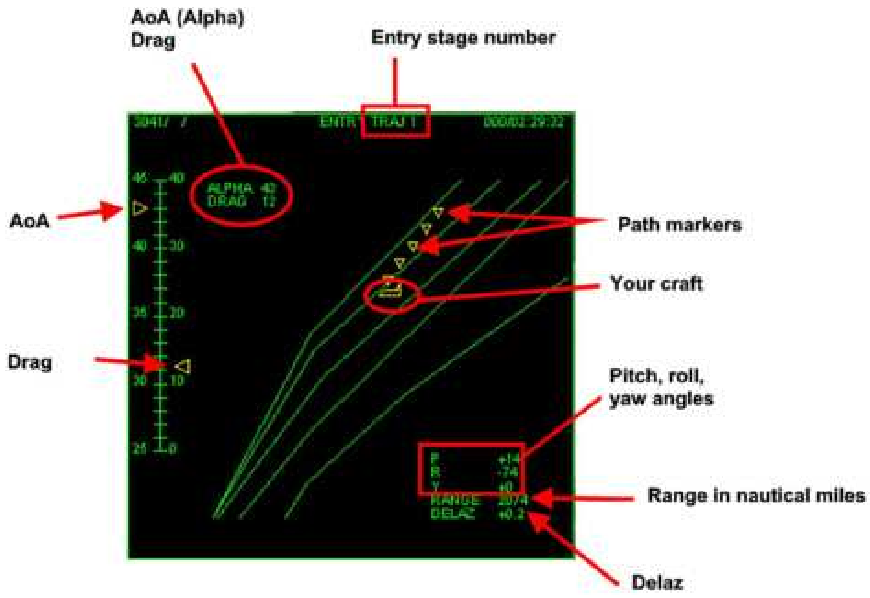
Problem: Ok. So you made a mistake…
Solution: Exit Orbiter and run the **(Current state).scn** scenario. Now start AutoFCS and do it right this time.

Turn on GPC MFD again. Select OPS > 3 which is the entry display.

GPC OPS 3 display will show portions of the entry cone.

Those portions will change automatically to reflect the different stages of your descent.

The goal is to keep the ship inside the cone. Fortunately, AutoFCS will do the hard work for you.



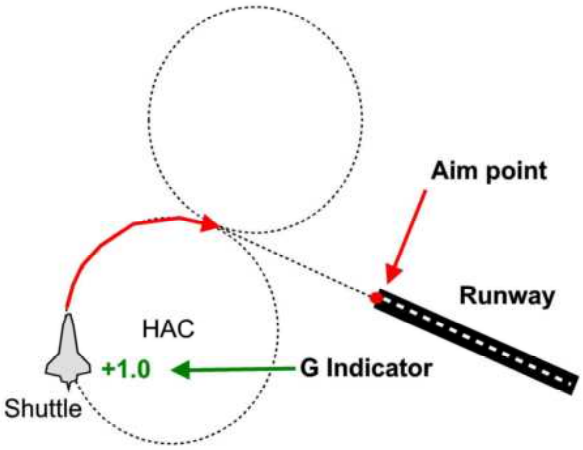
After the last stage, it is time for the final approach.

FINAL APPROACH

Once OPS 3 display comes to its last stage it becomes time to work on our final approach, known as TAEM Interfase.

- Select OPS > 4 in one MFD and turn on Surface MFD in the other.
- Select landing site and runway with ITEM 41, ITEM 3 and ITEM 4.
- Select CTRL G to arm landing gear and CTRL , to arm airbrake.
- Align with HAC and maintain trajectory to land (if AutoFCS is not active).
- Deploy landing gear G and airbrake Shift 9 a few seconds before landing.
- Approach runway and land.

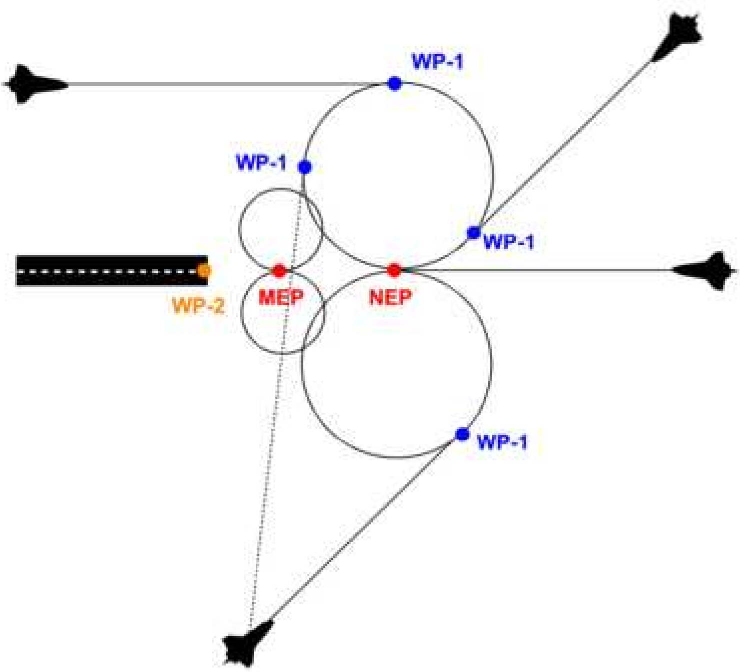
Unlike OPS 3 which reflected a vertical situation, OPS 4 reflect a horizontal situation as if you could see things from above.



HAC stands for Heading Alignment Cylinder and it helps you to be perfectly aligned with runway as you intercept the cylinder and start turning around it.

You have several HAC depending on how much energy you have left for your gliding.

Managing energy means that you exchange altitude for speed and vice versa. Depending on available energy you might want to select NEP or MEP points when selecting a HAC.



Fortunately for you, all these work is conducted by AutoFCS until the moment of landing.

In OPS 4 display you can customize your landing preferences by selecting an item number.

- ITEM 3 Select primary runway (PRI)
- ITEM 4 Select secondary runway (SEC)
- ITEM 6 Toggle HAC geometry
- ITEM 7 Toggle SEP/NEP.

How do you practice the final approach if you want to fly it yourself?
Try the stock Tutorials/Atlantis final approach.
This will teach you about the final moments of landing.

Now that you understand the complexity of such flights, you understand why NASA personnel do not feel it is time to celebrate until the shuttle has completely stopped.

UNDERSTANDING SHUTTLE FLEET SCENARIOS

If you are going to create your own custom scenarios you need code for:

- LC-39A or LC-39B launch platform
- Space shuttle
- Payload (optional)
- Space station (optional)
- Other objects (optional)

PAYLOAD

This example belongs to a stock Leonardo MPLM station module.

```
Leonardo_mplm:Leonardo_mplm
  STATUS Orbiting Earth
  RPOS 4290806.57 4227079.81 -2076328.22
  RVEL 261.566 -124.513 287.046
  AROT 116.16 - 42.34 - 150.19
  ATTACHED 0:0,STS-47
  NAVFREQ 0 0
  XPDR 2
End
```

`ATTACHED 0:0,STS-47` stands for "attached to point 0 of a craft called STS-47". It means that one craft in the scenario must have such a name STS-47, and the craft comes BEFORE this payload that makes reference to it.

Notice that this module has **`XPDR`** (transponder frequency) which allows to detect the object in the distance, but there is no **`IDS`** frequency, so you might need to dock on visual, without the help of Docking MFD. To use docking MFD an IDS frequency must be added to each docking port.

Other parameters for payloads may vary, so you might need to rip scenario code from scenarios that come with module or payload addons. However, the ATTACHED line must be added manually.

SPACE STATIONS

ISS fleet addon by David413 comes with several stages of ISS and other authors like Greg Burch and Mustard have made nice addons. You might like to rip the code from their scenarios to add it to your scenario. Just take care about specifying that they are **`Orbiting`**, or you may find them on the ground.

UNDERSTANDING SHUTTLE CODE

Let's analyze this example of shuttle code:

```
STS-47:Shuttle
STATUS Landed Earth
  POS -80.6242555 28.6191222
  HEADING 0
  PRPLEVEL 0:1.000 1:1.000 2:1.000 3:1.000
  NAVFREQ 0 0
  CONFIGURATION 0
  OV- 105
  ORIGINAL
  RMSARM
  ODS
  CARGODOOR 0 0.0000
  KUBAND 0 0.0000
  PRADIATOR 0 0.0000
  SRADIATOR 0 0.0000
  PAYLOAD_MASS 5000
  ARM_STATUS 0.5000 0.0151 0.0162 0.5000 0.5000 0.5000
  SAT_OFS_X 0.000
  SAT_OFS_Y -2.2
  SAT_OFS_Z 1.2
  PROFILE 0
  CALLOUT
  GRAVITY
  OMS
  TGT_HEADING 42 228
  XPDR 0
  IDS 0:1 100
End
```

STS-47 is the name of the ship. It is a custom name.
Shuttle is the name of the cfg file in the config directory that is used for this craft.
STATUS indicates if it is **Landed** or **Orbiting** and in this case the reference planet is **Earth**.
POS indicates longitude and latitude where the craft is.
Heading 0 indicates how the craft is oriented at the launch site.
PRPLEVEL refers to fuel levels for different tanks.
Configuration 0 refers to staging:

- Configuration 0: Orbiter + ET + SRB + Engines off
- Configuration 1: Orbiter + ET + SRB + Engines on
- Configuration 2: Orbiter + ET
- Configuration 3: Orbiter

`OV- 105` refers to the ID code of the shuttle:

- OV- 99 Challenger
- OV- 101 Enterprise
- OV- 102 Columbia
- OV- 103 Discovery
- OV- 104 Atlantis
- OV- 105 Endeavour
- OV- 106 Constitution (fictional)
- OV- 107 Intrepid (fictional)
- OV- 108 Constitution (fictional)

`ORIGINAL` refers to the paint scheme.
Paint scheme may be `ORIGINAL` (not available for Challenger and fictional shuttles), `MID102` (for Columbia only) or it could be just omitted for a default paint scheme.

`ODS` refers to a docking port installed in the payload bay. Not available for Columbia, Challenger and fictional shuttles.

`RMSARM` refers to an RMS installed in your craft. It is supported by all shuttles.
`PAYLOAD_MASS 5000` adds extra weight to simulate a payload.
`GRAVITY` allows to simulate gravity gradient effect.
`OMS` refers to STS guidance enabled for rendezvous.
`CALLOUT` enables altitude and airspeed callouts.
`TGT_HEADING 42 228` refers to a launch heading of 42 and a target apoapsis of 228 km above sea level, and it is used by the launch autopilot.

LAUNCH PAD

This example belongs to a remarkable shuttle pad made by Kev Shanow.

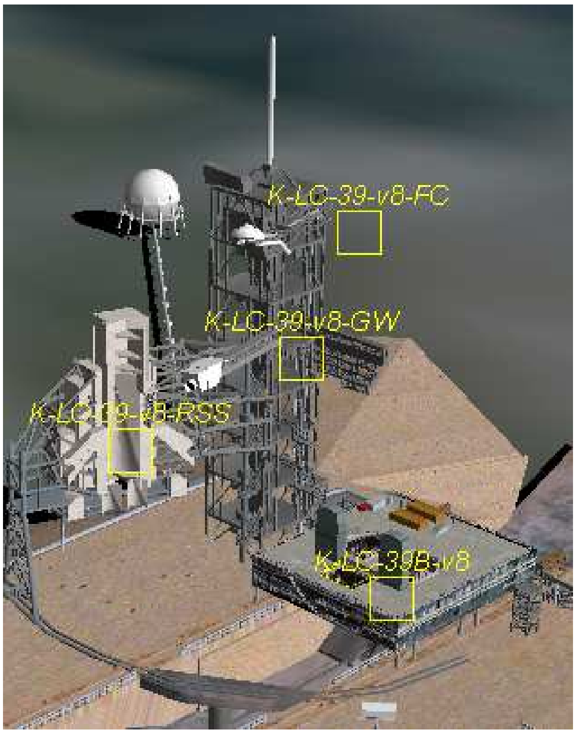
```
K-LC-39B-v8:Spacecraft\Spacecraft2
  STATUS Landed Earth
  POS -80.6242555 28.6191222
  HEADING 0
  PRPLEVEL 0:1.000
  NAVFREQ 94 481
  CONFIGURATION 1
  CURRENT_PAYLOAD 0
End
K-LC-39-v8-FC:Spacecraft\Spacecraft2
  STATUS Landed Earth
  POS -80.62489 28.6196921
  HEADING 53.44
  PRPLEVEL 0:1.000
  NAVFREQ 94 481
  CONFIGURATION 1
  CURRENT_PAYLOAD 0
  SEQ 0 2 0.900000
End
K-LC-39-v8-GW:Spacecraft\Spacecraft2
  STATUS Landed Earth
  POS -80.6249203 28.6195964
  HEADING 355.53
  PRPLEVEL 0:1.000
  NAVFREQ 94 481
  CONFIGURATION 1
  CURRENT_PAYLOAD 0
  SEQ 0 2 0.900000
End
K-LC-39-v8-RSS:Spacecraft\Spacecraft2
  STATUS Landed Earth
  POS -80.625153 28.6194108
  HEADING 359.72
  PRPLEVEL 0:1.000
  NAVFREQ 94 481
  CONFIGURATION 1
  CURRENT_PAYLOAD 0
  SEQ 0 -2 0.000000
End
```

As you may notice it is composed by many pieces:

K-LC-39B-v8:Spacecraft\Spacecraft2
Main launch pad.
K-LC-39-v8-FC:Spacecraft\Spacecraft2
FCC (Fuel Cap).
K-LC-39-v8-GW:Spacecraft\Spacecraft2
GW (Gateway).
K-LC-39-v8-RSS:Spacecraft\Spacecraft2
RSS.

FCC, GW and RSS are mobile pieces.

Kev has made many versions of his addon, so scenario code must be ripped from his scenarios, if you intend to use them.



ROBOTIC ARMS

Shuttle Fleet addon includes robotic arms:

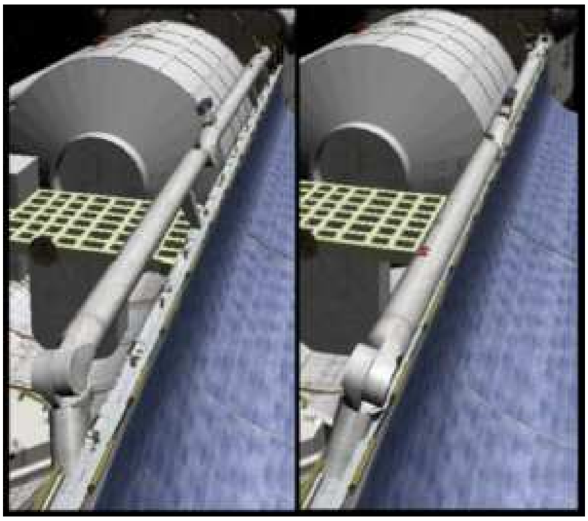
- **RMS** (Remote Manipulator System): It is located in the port (left) side of the payload bay.
- **OBSS** (Orbiter Boom Sensor System): It is located in the starboard (right) side of the payload bay. It is an extension for the RMS, so the RMS must graple one end of the OBSS in order to use it as extension.
- **SSRMS** (Space station Remote Manipulator System): It is an arm of the ISS.

All arms have a shoulder, elbow and wrist, as well as a grapple point.

Why do you need such arms?

- To inspect shuttle heat shield.
- To assemble a space station or place modules.
- To release or retrieve satellites.

DEPLOYING / LATCHING RMS



If you want to use the RMS you first must deploy it.

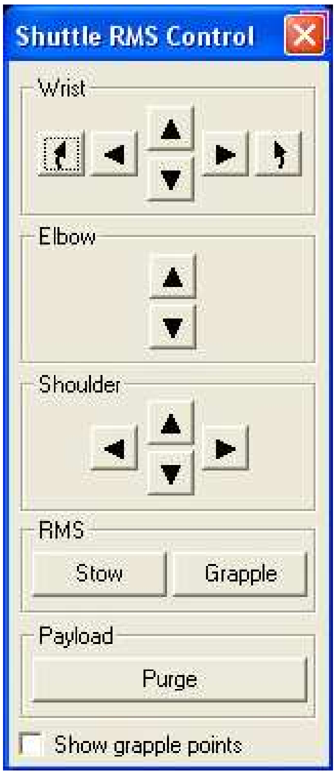
Press CTRL X to deploy or CTRL X again to latch.

The arm can be in two possible positions:

- Latched (left picture)
- Deployed (right picture).

The arm will take about 34 seconds to move from one position to another.

OPERATING RMS WITH SHUTTLE RMS PANEL



Press CTRL SPACEBAR to display the Shuttle RMS control panel.

There are several buttons:

- **Arrows:** RMS movement is slow, you need to keep the button pressed.

- **Stow:** It will extend the arm when you do not need it anymore. Once extended you may make the arm to be latched.

- **Grapple/Release:** It will allow you to attach/detach objects to the arm. The object needs to have an arm compatible grapple point.

To move the RMS with this panel, RMS must be deployed. If arm is latched you may not be able to use the RMS.

If you need a visual aid, check the “Show grapple points” checkbox.

OPERATING RMS USING ANGLES

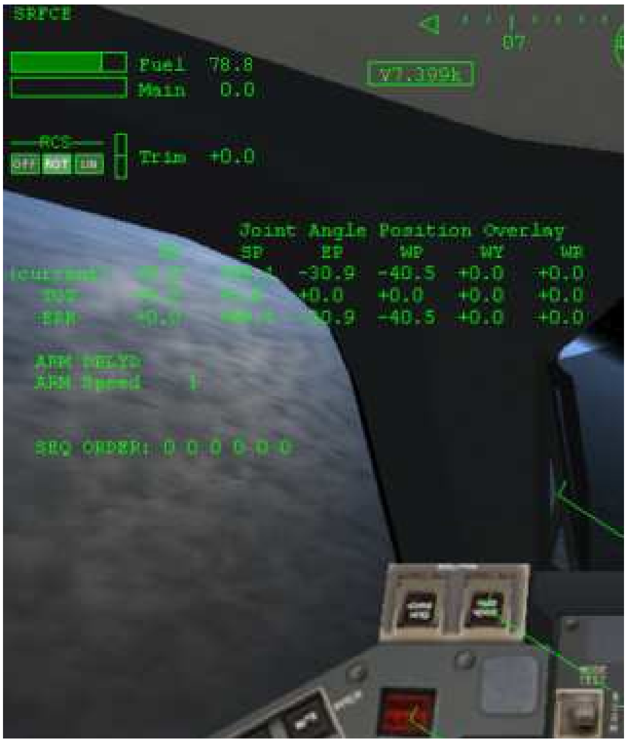
Using angles is far more complex, less intuitive but more accurate than using the RMS control panel. To operate the RMS you need to display RMS data.

DISPLAY RMS DATA

Press SHIFT J to display RMS data.

Columns:

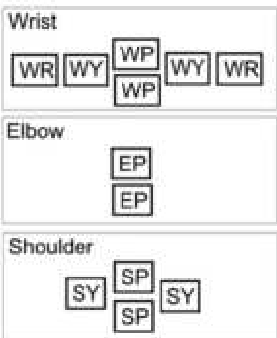
- **SY**: Shoulder Yaw. Values go from -180 to +180 degrees.
- **SP** : Shoulder pitch. Values go from -2 to +145 degrees.
- **EP** : Elbow pitch. Values go from -160 to +2 degrees.
- **WP** : Wrist Pitch. Values go from -120 to +120 degrees.
- **WY**: Wrist Yaw. Values go from -120 to +120 degrees.
- **WR** : Wrist Roll. Values go from -447 to +447 degrees.



Rows:

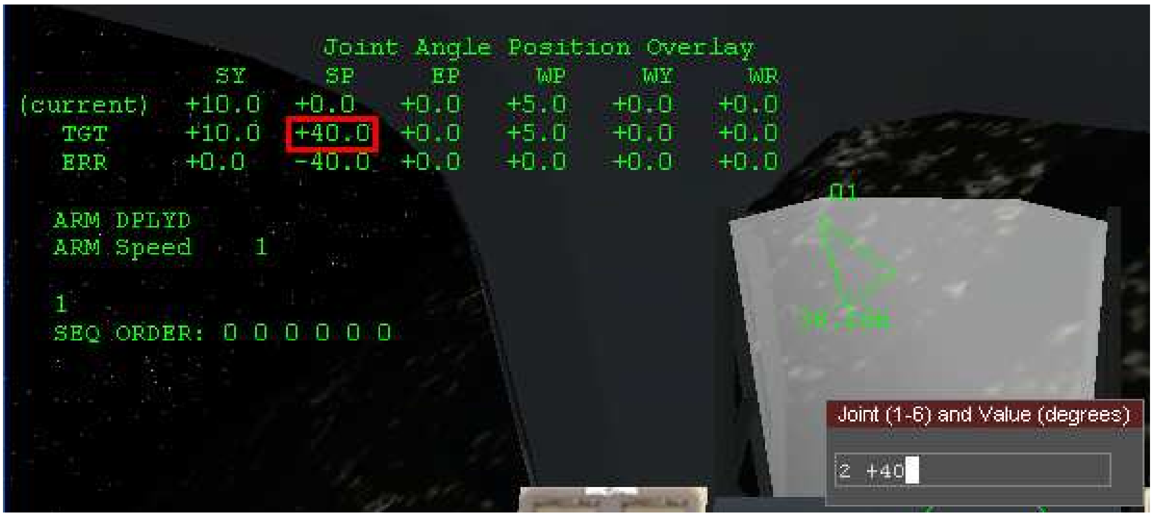
- **Current**: current position.
- **TGT**: (Target position) Desired position. You may store up to 4 RMS positions using CTRL 1 to CTRL 4, and retrieve them with SHIFT A to SHIFT D.
- **ERR**: (Error) Diference between current and TGT positions.

RMS control panel equivalent:



HOW TO INPUT TARGET POSITION

- Press CTRL 6.
- Input joint number and desires angle value, and press Enter key.



In this example, it sets a target value +40 for joint 2.

Joints are:

1. SY
2. SP
3. EP
4. WP
5. WY
6. WR

HOW TO MOVE ARM TO TARGET POSITION

- Press Shift F.
- Specify the sequence of the joints that will be moved and press Enter.

For example, if you enter **1423** it means target position will be reached in the following order: SY (1), WP (4), SP (2), EP (3).

Notice arm must be deployed before moving to target position.

ADJUSTING SPEED OF ARM MOVEMENT

- Press S

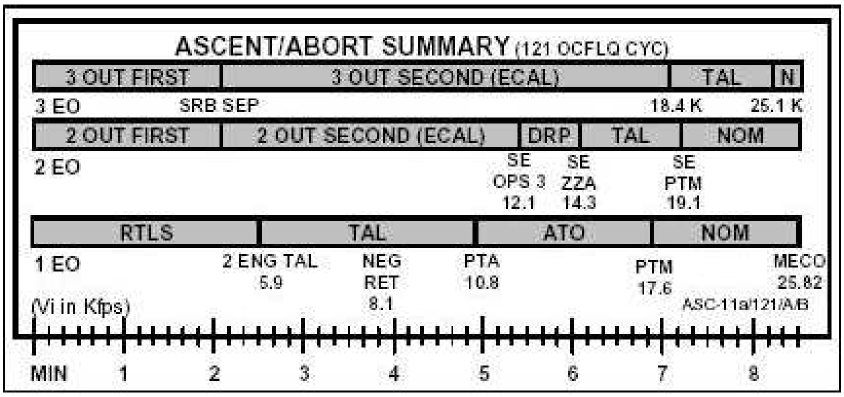
OPERATING SSRMS

Orbiter considers SSRMS as a vessel attached to ISS, so you need to press F3 to switch to that vessel and then you may operate SSRMS just like RMS:

- **CTRL 1** to **CTRL 4** Store arm current position in memory slots 1 to 4.
- **SHIFT A** to **SHIFT D** Retrieve arm positions from memory as target position.
- **CTRL 6** modify specific target position values.
- **S** change velocity of arm.
- **SHIFT F** to specify the sequence of joints to move to pass from current to target position.

ABORTING A MISSION

This is the cue card that the commander (CMDR) has attached to the cockpit panel.



Before starting to explain abort missions here you have some acronym you need to understand the cue card:

- **ENG**: Engine.
- **EO**: Engine out. Number of engines that failed.
- **NEG RET**: Negative return. The vessel is so high and far away that it can't return to the launch site.
- **NOM**: Nominal.
- **PTA**: Press to ATO.
- **PTM**: Press to MECO.
- **MECO**: Main engine cut-off. When the three SSMEs are shut down.
- **SSME**: Space Shuttle Main Engine.
- **SE**: System element.
- **SEP**: Separación
- **SRB**: Solid Rocket Booster (Cohete de combustible sólido).
- **ZZA**: Zaragoza. If you look at the ***Landing Site Table.pdf*** that comes with Shuttle Fleet you may see the acronym for different bases around the world.

Cue card has 3 grey bars and a timeline below. It indicates the failure mode during ascent:

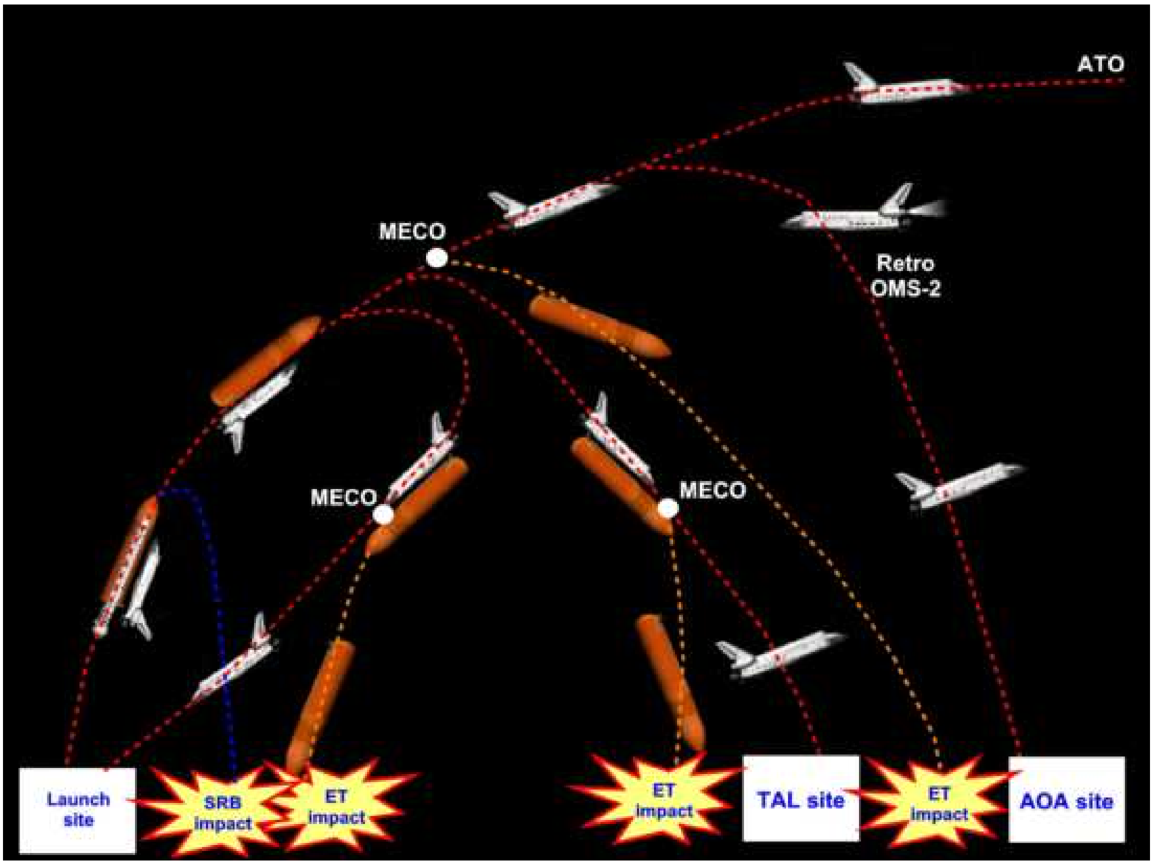
- **1 EO**: 1 SSME is out.
- **2 EO**: 2 SSMEs are out.
- **3 EO**: 3 SSME are out.

Acronyms also have a number below, indicating velocity in kilofeet per second. For example PTA has 10.8 below. For those who are used to meters per second it will be hard to familiarize with these figures.

1 kilofeet per second is equivalent to 304.8 meters per second, which is almost Mach 1, the speed of sound.

ABORT MISSION MODES

- **RTLS**: Return to Launch Site. It happens after SRB SEP. The vessel will not fly inverted and returns to base with ET attached to it, then dives and drops ET and then it glides to the runway.
- **TAL**: Transatlantic Abort Landing. The craft will crosso the Atlantic and will land at a base designated as TAL. It takes place before ET SEP and before MECO. There is a file called ***TAL Tutorial.pdf*** that you may like to read.
- **ATO**: Abort to Orbit. The craft will try to reach LEO and stay there. An orbit with periapsis of 100 km above sea level is considered safe for 24 hours.
- **AOA**: Abort Once Around. You land after MECO, but before entering orbit. When you return you will have an entry interface as if you came from orbit.



CONFIGURING FAILURES

Let's take a look at the scenario code for the shuttle:

```
Discovery:Shuttle
STATUS Landed Earth
  POS -80.6242555 28.6191222
  HEADING 0
  PRPLEVEL 0:1.000 1:1.000 2:1.000 3:1.000
  NAVFREQ 0 0
  CONFIGURATION 0
  OV- 103
  CARGODOOR 0 0.0000
  KUBAND 0 0.0000
  PRADIATOR 0 0.0000
  SRADIATOR 0 0.0000
  PAYLOAD_MASS 0
  ARM_STATUS 0.5000 0.0151 0.0162 0.5000 0.5000 0.5000
  SAT_OFS_X 0.000
  SAT_OFS_Y -2.2
  SAT_OFS_Z 1.2
  PROFILE 0
  TGT_HEADING 42 228
  ENGINE_FAIL 75 2 150
  XPDR 0
  IDS 0:1 100
End
```

The line that refers to the failure is this:

```
ENGINE_FAIL 75 2 150
```

It means this:

- The probability of failure is 75%.
- It will use failure mode 2 (see shuttle fleet documentation for failure modes).
- Failure will occur at MET (Mission Elapsed Time) 150 seconds after take off.

By editing a scenario with notepad you may fly a mission where you may need to abort.