ORBITER

Nasaís Apollo Space Simulation Project (N.A.S.S.P) V 5.0

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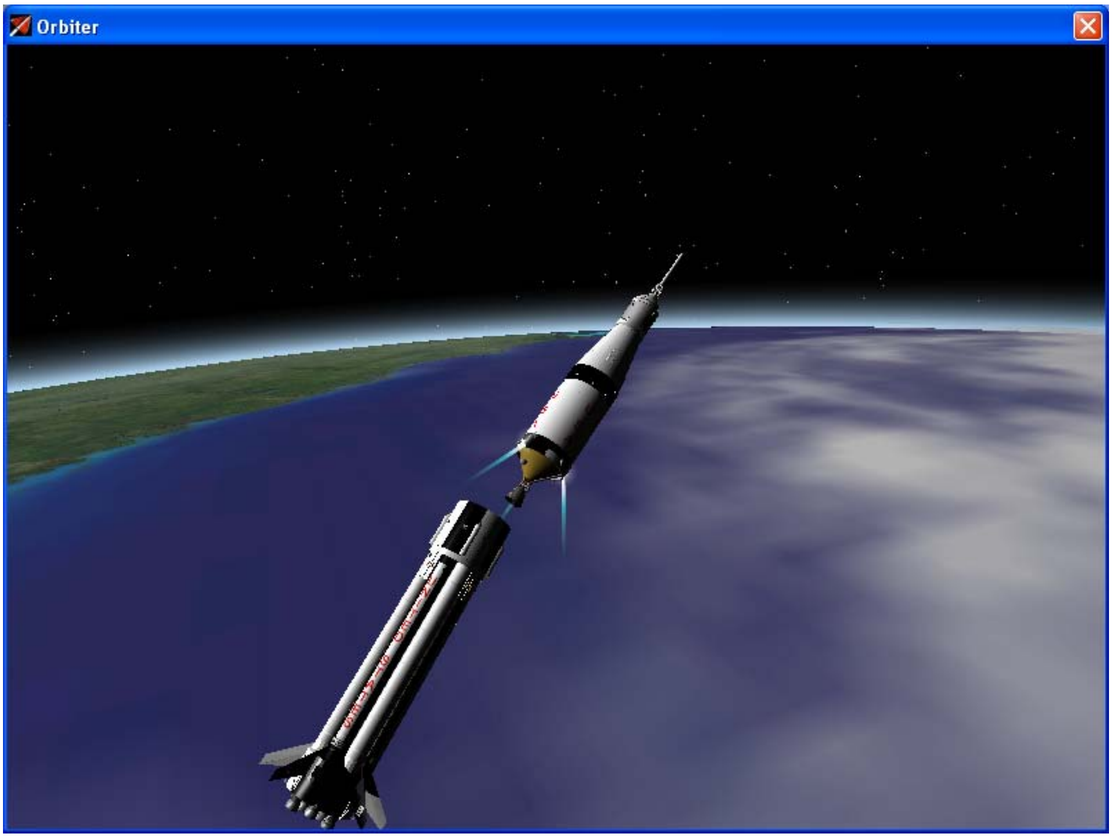
Sotfware ADD-On to :

ORBITER © Martin Schweiger
martins@medphys.ucl.ac.uk
www.medphys.ucl.ac.uk/~martins/orbit/orbit.html



1) Copyright

2) A little history

A little word before credits. I started NASSP add-on development as a personnal hobby. But now NASSP has more than 2 years of existence.

In the beginning I started to code Saturn 1B Apollo from Dealer McDOPEís Saturn 1B (that still exist on his own).

Second part was to release Saturn V and LEM vehicle, itís been done based as other Apollo add-on went on project stops.

As it may be confusing for most users, letís be clear, THERE IS NO NASSP DEV Team.

NASSP add-on has finally been launched and now more belongís to Orbiterís community.
This package does include lot of work from various people, some I know, some I donít, all this stuff had been included in one package for userís convenience only due to public request
It is very important to me that all of you understand that alll those materials arenít not mine.
Several people worked hard to offer community magnificent piece of art. I only had integrated them for userís pleasure.
So please read the credits section that goes under.

I also had to make some choices, as I have too much materials. TomPA did a great work on my CM meshes but I did not conserve it as P64 offered me to use AFPP meshes.

3) Credits

3D Design :
- Apollo CM and SM outstanding mesh developped by P64
- LM Vessel: ArtWork Design RODION
- Lunar Vehicle Rover and astronaut meshes by rodion
- New exhaust textures from the Atlantis_Mod Team for most engine (except S1B/S1C that uses orbiter default SRB engine)
- Saturn V and Saturn 1B meshes design by TomPA.

2D design :

Regarding panel, functionnal design is mine, but the outstanding bitmap are from P64 (mine was really ugly).

Some idea are also from Manabu Hanafusa (P64)himself.

A great thankís to his outstanding work...

Coding :

- Autopilot code based on Gemini samples - Entire brand new logic from me

- Lots of function of mercury Panel and engine gimbaling from Mercury sample code, special thanks to Rob Conley for sharing his great work.
- Panel Horizon routine from Deltaglider sample, needle code from mercury.
- some routine from Atlantis MOD (Richard Craig engine control enhancement).
- Exhaust texture from Atlantis_Mod.

Re-coding

This section is very particular since one man as completly rewritten NASSP Code, using C++ classes techniques and making S1B and S5 engine share lots of code.
More than this, Mark Grant (Movieman), added lot of functions and modified other so that NASSP_COSTAM is no more exactly NASSP.

Maintaining different version of NASSP having different features would be difficult and would lead user to complication. As pleasure is the most important thing in this venture, I restarted from NASSP_COSTAM .015 (courtesy of Mark).

Doní t ask me question about DSKY module, Mark is the author of all Dsky functions so refer to his included doc for Dsky operations.

Other people that gave valuable contribution :

Orbiter Fan
CaptJoel
AcSoft
Brad Hodges
MatzFab

I apologize for all those I have forgot in this list.

And above all Martin Schweiger for giving us Orbiter...

4) Contents

5) Introduction

This Manual is not an accurate tutorial but it explains who now does works Apolloís Internal System. It Also explain a bit upon different kind of mission completion.

Mainly Apollo was designed to go to the Moon, it has also been used for Earth orbit mission. Main changes in version 5.0 is that NASSP now have both launcher released in a single package with the same functionnality level. A new panel, for Apollo Docking operation, fully implemented in both normal and illuminated version.

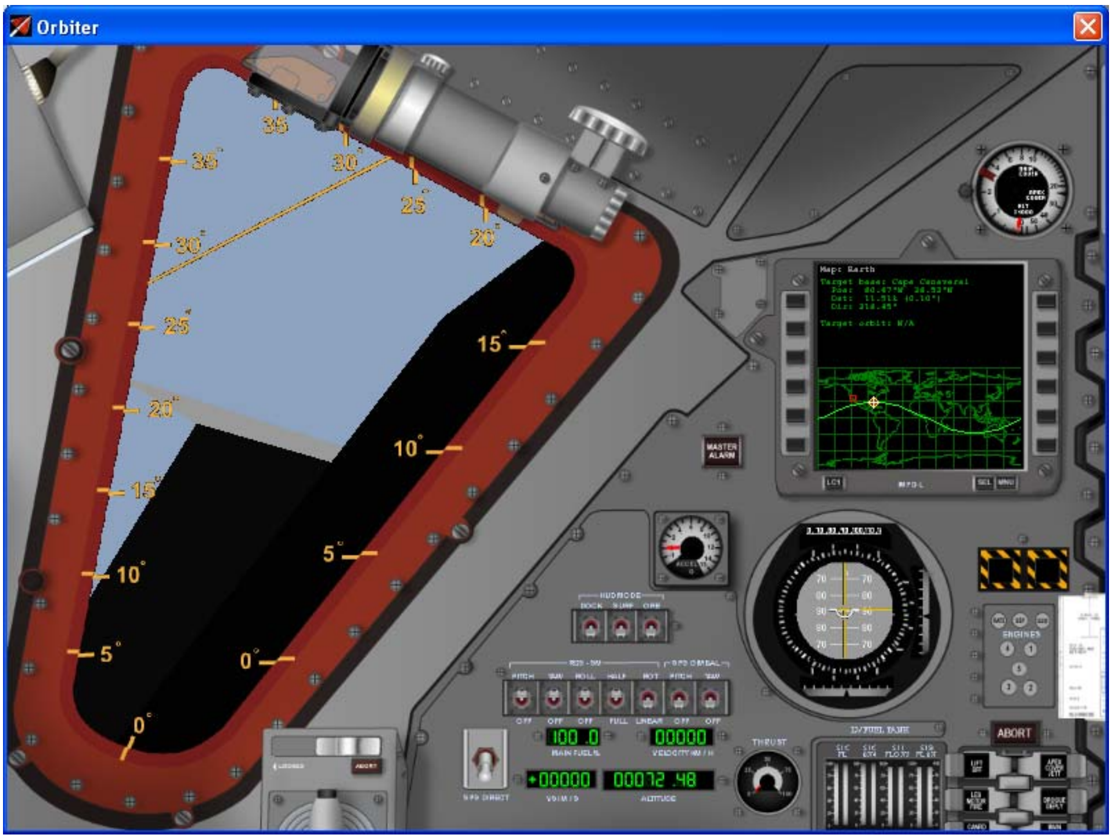
News over version 3 is that almost all is new. Apollo has now have a panel that control internal systems. So function keys has been disabled. You now more press K to open the Hatch and E for EVA, but you have to operate the proper switch sequence to perform the EVA.

So all system has been reviewed. The panel now introduces engine attitude control over the 3 axis and enable to finely tune vessel behavior.

Both rockets Saturn 1B and Saturn V now uses Engine Gimbaling during all powered phase. LEM is also brand new, it does have Hover Engine gimbal control, and a brand new custom panel.

Information provided by panel has been adapted with my vision to orbiterís need. So it is probably not exact but it may looks like if you have imagination.

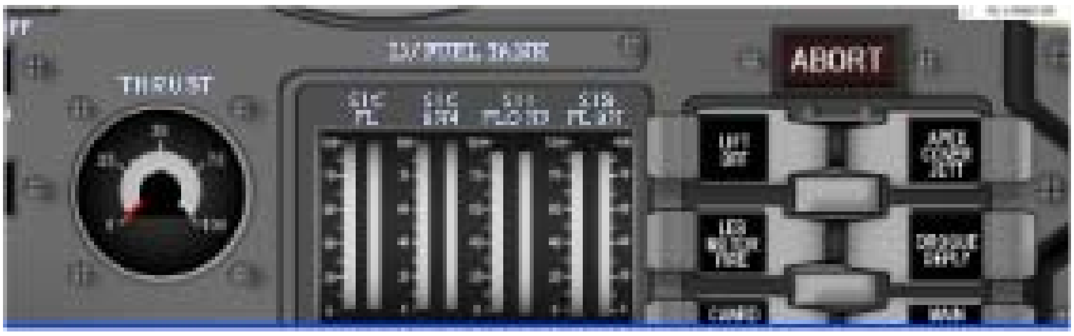
6) Command and Service Module PANEL



The main panel is designed to fit at 1024X768 and 32 bit colour. It scrolls from left to right.

Letís examine the main Systems :

7) Gauges and Lift Off indicators



On The Left the Main Thruster indicator, shows you how much percent your main engine (whatever stage) are running.

On The Right the main gauges that indicates differently wether rocket you fly.

Four left needles indicates the First stage Level Fuel and oxidizer tank.

Next two needles indicates the SII fuel and OX level if you run on the Saturn V launcher
Next two needles indicates the SIV-B fuel and OX level if you run on the Saturn 1B launcher

The last two needles indicates the SIV-B fuel and OX level.

On the Right the Launch status indicator.

LIFTOFF Green indicates that you have started your flight. Will Turn white after SIV-B Separation like others launch indicators, they are not active at the CSM level.

LES Motor Fire. Turn green when tower is jetisonned.

Canard DPLY, indicates the canard wing at the top of Escape Tower, only available in Abort mode.

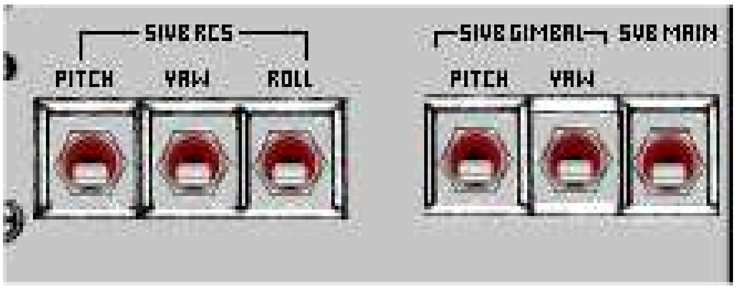
APEX Cover Jett, turns green when in landing mode the APEX Cover frees the Earth Landing System (Parachute in facts). Scheduled at 25000 Ft Alt.

Drogue Deploy, indicateg Drogue chute status

MAIN Deploy Main Chutes status.

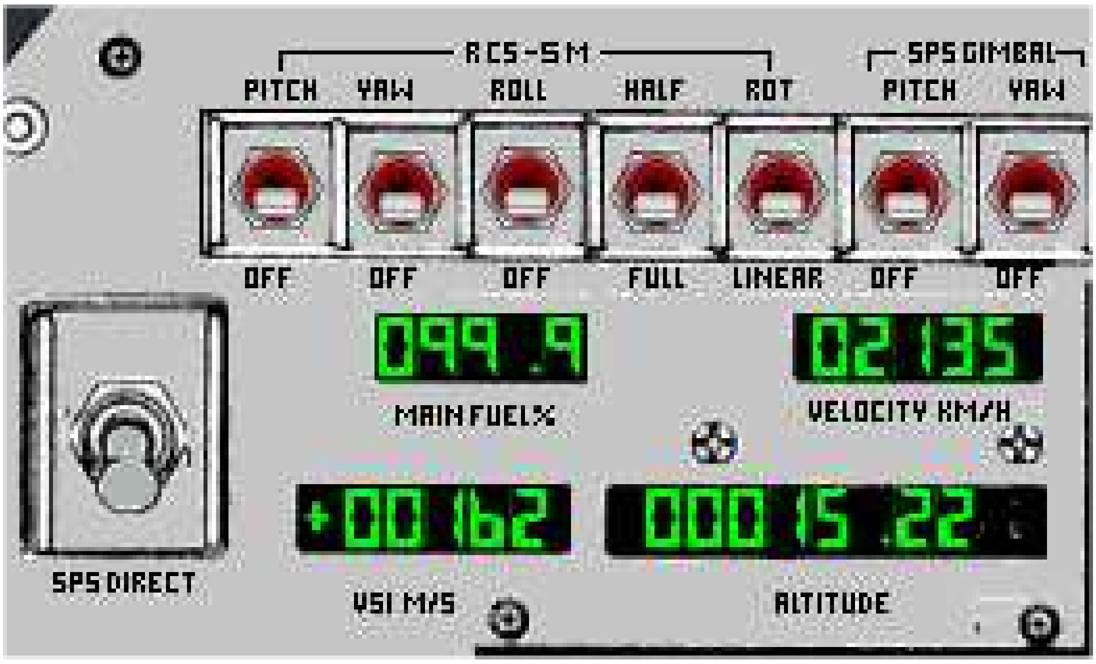
ABORT indicator ligths RED when abort in progress.

8) SVI-B Engine controls



The SIV-B Stage is controlled either by APS Rcs Jet and by Main Engine Gimbaling.
You engage either One or both system.
The SIVB Main switch does reignite the Main Engine only on Saturn V as the SIV-B used on Saturn 1B packages is not restartable.

9) Main Flight Display and SM RCS System



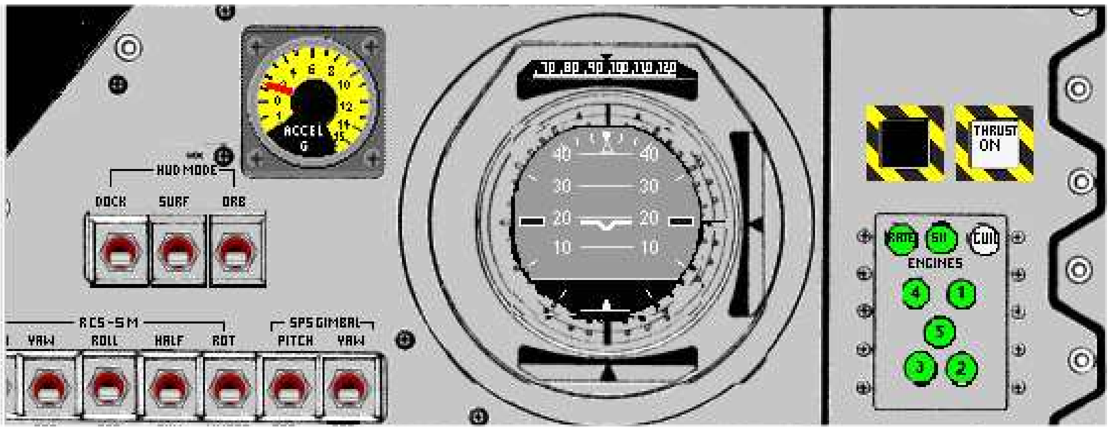
The RCS selection for SM Engine does include a switch for selecting Half-Power (normal mode for CSM) and FULL Power (for LEM assembly).

SPS Direct Switch connect the SPS Engine to his propellant unit. It does not ignite the SPS Engine.
Linear mode only available for the SM stage.

The fuel display indicates the current default propellant resources for the current stage.

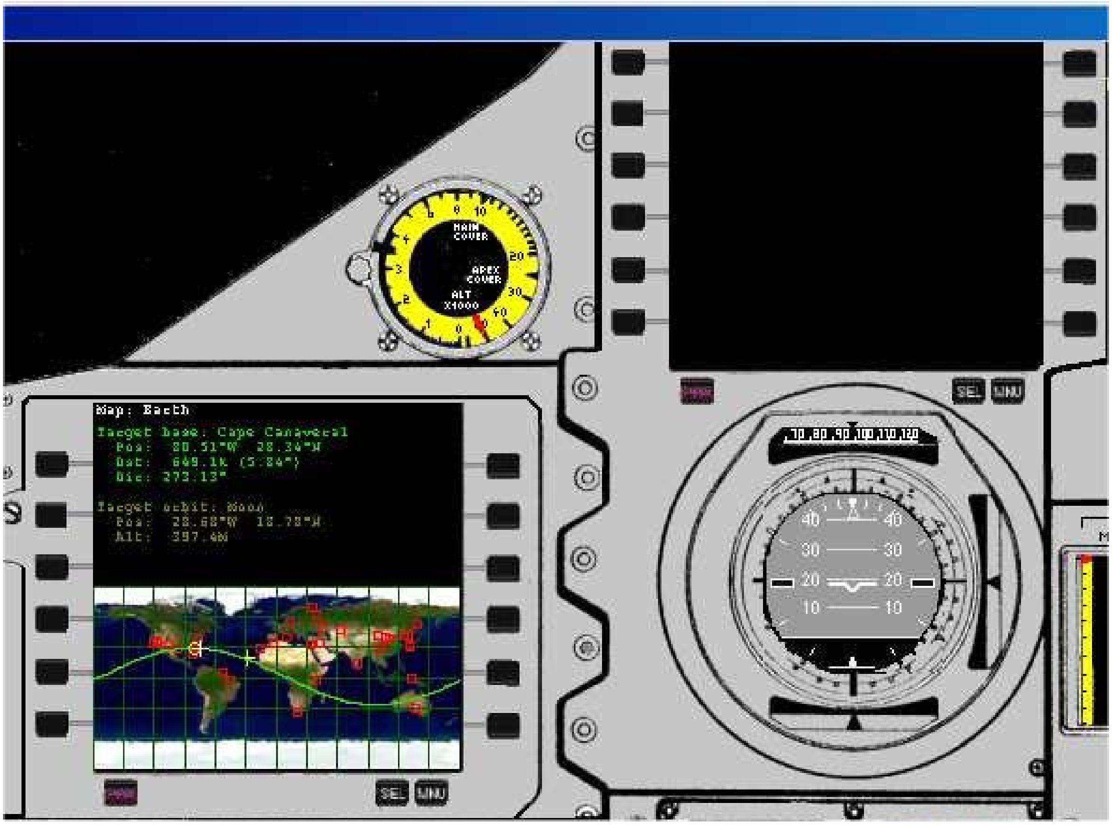
- Velocity indicates total velocity in KM/H unit.
- Altitude indicates Alitude in M, KM MM
- VSI is indicated in M/S

10)Analog Display and Engine indicator



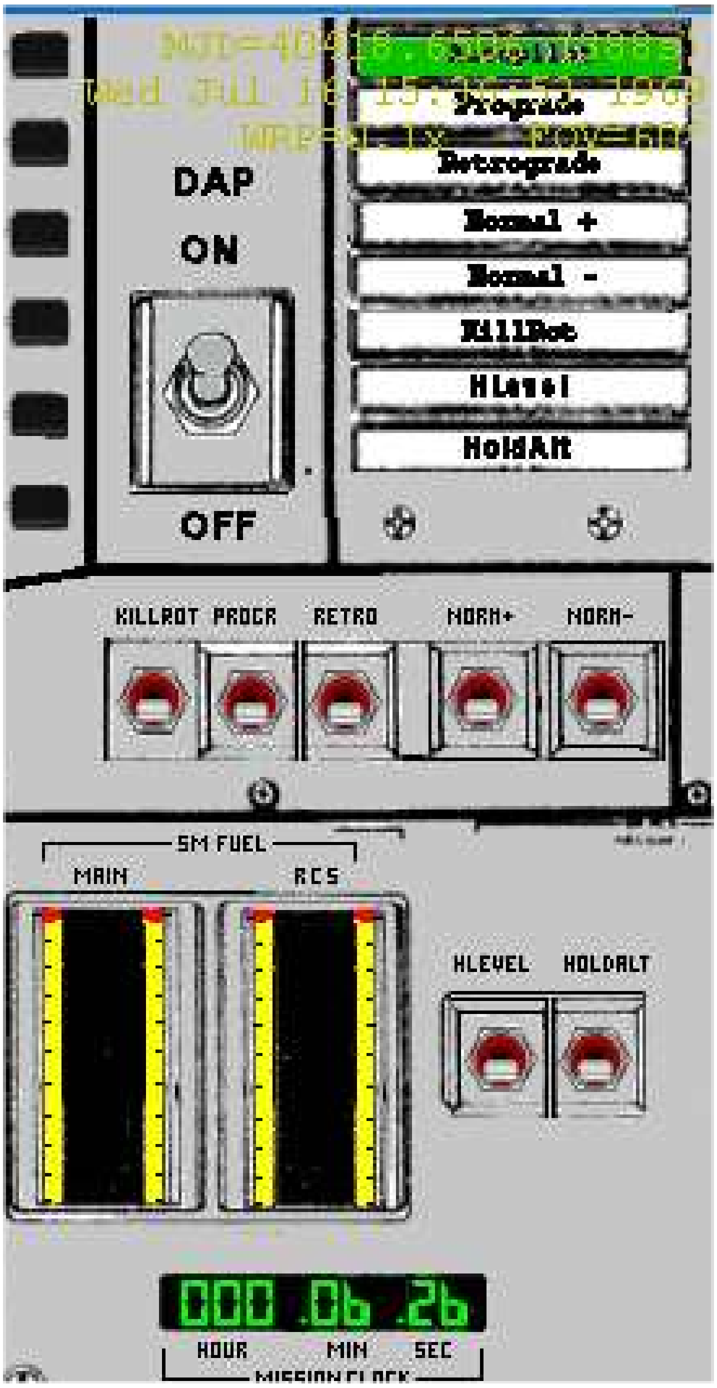
- The G-Meter does indicates Total Acceleration in G unit.
- HUD Mode engage the selected mode. If none selected, HUD is turned off.
- The Artificial Horizon indicates the Heading in Degrees in the upper slider.
- Ullage abd Thruster indicator
- Rate Means fuel flows
- SII indicates you wich stage is running
- GUID indicates wteher autopilot Guidance nav is engaged or not.
- The 1 2 3 4 & 5 is Engine Status.

11)MFD and Altimeter



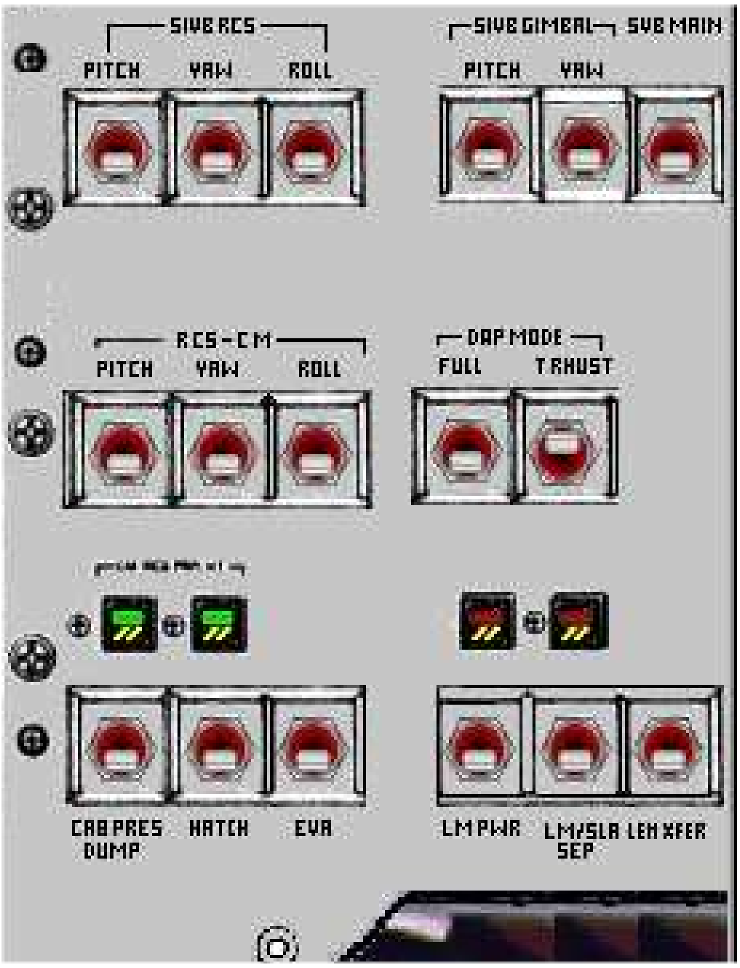
-The two main MFD can display any Orbiter MFD
-The control buttons are active (From Deltaglider code)
- The Altimeter indicates reentry event it is graduated with Feet.
- Pilot HSI is same as the commanderís one.

12)Navmode Indicators and Gauges



- DAP Switch controls the Digital Auto Pilot.
- DAP Indicator is green when engaged ñ RED when disengaged ñ and white when unavailable.
- The Navmode siwtch are labeled
- Mission clock display
- Main SM Fuel are fuel and oxydizer tank for SPS engine
- RCS Left is SM Rcs, Rcs Right is CM RCS

13)Cabine Autopilot and LEM control



- RCS control are labeled
- Cab Pressure dump If on indicator is RED cabin is no more pressurized
- Once cab pressure is dumped, you can operate Apollo Hatch to perform EVA
- LM PWR turn Green when LEM is powered (required for SLA/SEP)
- LEM XFER (no more used buggy !!)
- DAP Mode FULL, if engaged, Autopilot does control over guidance. If off, then Autopilot only displays information on DSKY but engine gimbal are controlled by Joystick
- THRUST mode, does activate the autopilot Orbital monitoring. If engaged, Autopilot will cut off main engine when the smallest value of Excentricity is achieved. Even if Guidance is in manual control. This can be helpful since you cannot restart SIVB engine the way you want.

14) Jetison Control & EDS

- EDS can be disabled through this switch now

To operate cover protected switch right-clivk with mouse on the switch.

- LEM SEP2 used to undock the LEM (Keeps Docking Probe on Apollo)
- LEM FINAL used to undock LEM Ascent Stage (Jetison Dokcing probe)
- SM SEP 1 & 2 needed to jetison SM.
- SVIB to separate from SIVB

15)DSKY Computer

DSKY module programme are from Movieman so refer to the ìflyingsaturnv.htmlî doc file in the package to be aware of DSKY operations.

The Display is used by Autopilot to communicate datas on its mode. See Autopilot sections.

The Displayable data varies upon use.

- PROG indicate the current program number
- VERB indicate the VERB data
- NOUN indicates the NOUN data
- The three line displayed under are R1 R2 and R3 Data register. They carry differents values (Look at the Autopilot section)

16)Flight Operation

Apollo may be flown via either Saturn1B or Saturn V launcher. Mainly operations that differs will mention the Rocket concerned either S1 or S5.

17)Engine Control

. Joystick and keyboard controls Engine gimbaling. The zero attitude is ensured by Gyroscopical control of position. (Code from Rob Conley Mercury project). Result is a very intuitive flight and a enhanced control over the rocket.

1st Stage has got 5 Engines on S5 and 8 on S1. Engine is Gimbaled in the 3 axis.

SII for S5 only. Engine is Gimbaled in the 3 axis.

SIV-B CSM and LEM. Engine are gimbaled only in pitch and yaw axis. Except for LEM that gimbals for pitch and roll.

The missing Axis is obtained by engaging RCS control in the required direction (Yaw for LEM and ROLL for S4B/CSM).
The Rocket controller enables you to uses killrot function only for the required direction axis.

So in concrete the gyro will stabilize for pitch and yaw but not for roll, but the killrot will when using SVIB Thrusters.

18)Staging operation

Staging during the early part of flight is no more available through the J key.

First stage cannot be manually jetisonned, only on fuel depletion :

When Empty the 1st stage will cutoff. 2 second later, it will be separated from the main rocket.

- On S5, 8 Ullage motor are fired on the aft interstage to provide positive acceleration for propergol stabilization and engine startup.
- On S1, aft interstage will be jetison and the 3 verniers Engine of SIVB will provide few seconds ullage to enable S4B ignition.

S5 Second Stage SII cannot be manually jetisonned, only on fuel depletion :

- AFT Interstage jetisonned about 20 seconds after seps.
- Escape tower jetisonned 30 seconds after Seps

S1 Second Stage SIV-B:

- Escape tower jetisonned 22 seconds after seps
- Insert in orbit but not restartable.
- APS to provide RCS attitude.
- Manual separation through panel switch.
- Dockable with ASTP Docking module if Flight is AS-211

S5 Third Stage SIV-B:

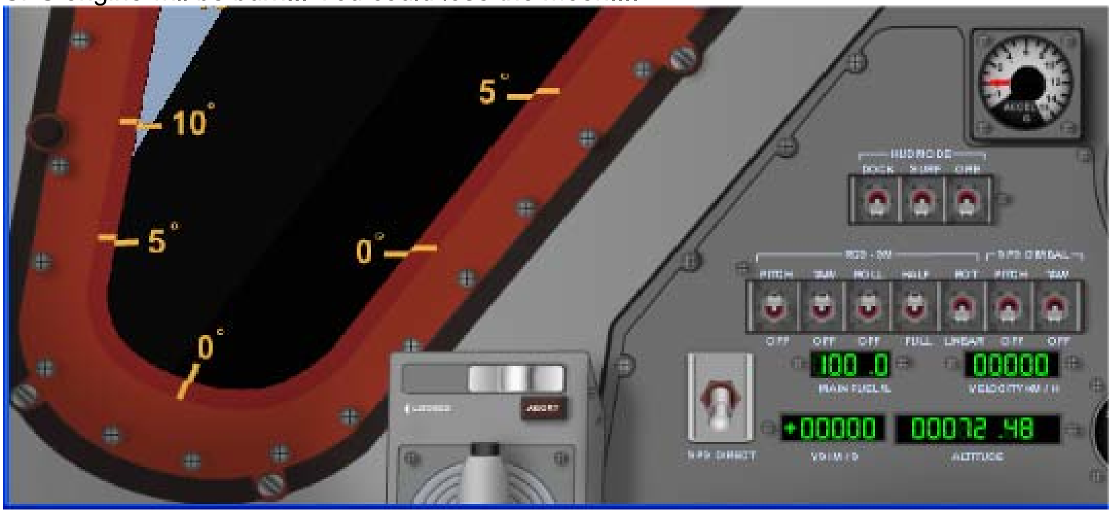
- Insert in orbit restartable but not at will, process involve APS 5 seconds ullage. Triggered by corresponding switch
- APS to provide RCS attitude.
- Manual separation through panel switch.
- Dockable with a Full LEM inside SLA.

19)EDS and ABORT

The EDS system Emergency Detection System provides automatic abort if an engine failure occurs before 100 sec flight is achieved.
It can be disabled through EDS switch.

Manual Abort is trigerred by pressing the ABORT command on the commander thruster control (click on the lever). The Abort lock switch has to be in right position to command abort. In left position abort is disabled.

CAUTION : Abort function remains active until SVI-B has been jetisonned, so while in parking Low Earth Orbit, if you press accidentally the abort command, then the CSM will separate and SPS engine will be burn... You could lose the moon....



Abort mode 1B is applied while the Escape Tower is in place.
Escape motor is fired and Capsule is separated from SM and rest of rocket.
After 5 seconds burns Escape motor runs out of fuel. Canard Wings are deployed and the capsule is stabilized. 20 seconds later, the escape tower is jetisonned by remaining jetison motor. Capsule has RCS control to place in reentry Attitude.

Atfer tower is jetisonned, Abort mode will use the SPS Engine burn and separate both second and third stage, regarding configuration. Commander has then manual control over SPS burn. And proceed either to parking orbit insertion wether to reentry burn.

20) Earth Landing System

You can monitor the reentry through the accelerometer in G unit and VSI and finally the ELS controls final landing.
At 24000 ft, the Apex Cover is jetisonn
At 22000 ft env, the drogue chute is deployed.
At 8000 ft Main chute is deployed, your speed should drop around 10 m/s
At 0 ft chutes are dropped and landing balloons are deployed.

You can use Cab press Hatch and EVA switch to perform recovery operation for the crew in their rescue dinghy. ☺

21) Autopilot

The Autopilot now takes full advantage of Engine gimbaling during all ascent phase.
It also has a completely different algorythm for orbit insertion.
Result is pretty accurate and supports easily to run at 10x time warp so it is now possible during all launch phases. Be aware that at time warp vocal countdown are falsed.

It does display many indication through DSKY display.

Operation are set as following.

Pre-Launch phase :
Landed on the PAD the DSKY will indicate DPROG 01 R1 00250 R2 00054 R3 0000

Means Prog 1 (Pre-Launch) ; R1 = Preset Altitude = 250 Km ; R2 = Preset Heading = 54∞

This avlue are set through scenarios file entry actually. Later release are planned with access to those value through DSKY program interface but itís for later.

At launch DAP first perform program 10 which is an initial pitch manoeuver. It has two main goal, help clear the tower quickly due to wind danger. Heads towards the sea in case of abort in early part of flight.
Prog 11 (intial pitch) ; R1 = Preset pitch =86∞; R2 = Actual pitch= 90∞

At 1200 m Alt, the DAP switch to program 12,

Basically the DAP will roll rocket in direction of selected liftoff heading.
the DAP has been successfully tested from heading = 5∞to 175∞itís more than the real rocket the S5 was able to launch only from 72∞to 108∞.

The Heading selection had been fixed and is now pretty accurate.

Prog 12 (intial roll) ; R1 = Preset roll =54∞; R2 = Actual roll= 0∞

Program 13 ñ Heading track.
The DAP track the target heading combining pitch and yaw gimbal. Usual attained with pitch from 80 to 70 ∞
Prog 13 (heading) ; R1 = Preset heading =54∞; R2 = Actual heading= 90∞
Program 14 ñ Pitch program

The DAP follow a presetted ascent curve by pitching progressively till 35∞
Prog 14 (Pitch program) ; R1 = target pitch =54∞; R2 = Actual pitch= 56∞; R3 = Time in second.

Program 15 ñ Ascent phase

The ascent phases maintain pitch of 35∞till 80% of the insertion altitude is attained.
Prog 15 (Pitch program) ; R1 = target pitch =35∞; R2 = Actual pitch= 35∞; R3 = Time in second.

Program 16 Altitude tracking

The autopilot now uses a new algorythm to determine pitch variation during that phase. Formula takes care of precedent pitch (to avoid yoyo), and is a direct function of altitude and vertical acceleration.

It has performed very accurate result of Parking orbit at 90∞185 Km Altitude for S5 with 72.6 % Fuel left in SIVB with only 0.5 of RINC with Moon.

The S1B has performed flight form 220 to 360 Km of orbital insertion altitude with Exc of 0.0009.

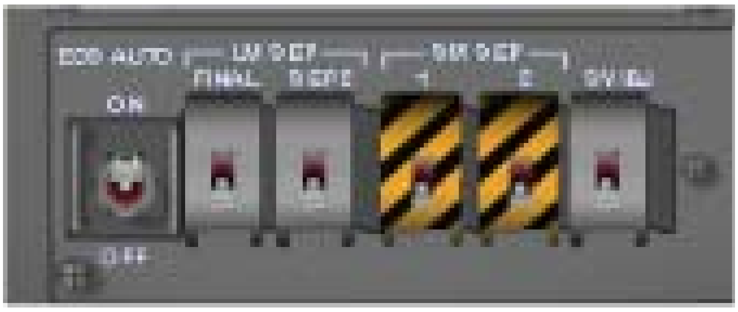
Independantly of guidance control. If full mode is selected autopilot will completely runs the rocket like in real flight. If you disengage guidance but keep autopilot running, then it will monitor for you the best engine cutoff moment as far as you are above 120 Km alt.

If you disengage guidance, the DSKY will still make calculation and will display target calculated and actual pitch yaw roll infos. So you can reengage the DAP Guidance any moment you like.

22)SIV-B Separation and Docking

After you have achieve Earth Orbit with Saturn 1B, you cannot restart S4B engines, so once stopped, it is stopped !

Jetison the S4B with the cover protected switch of the panel.



So right click on the SVIB-J button will open the cover. A left click will separate.

The SLA panel are dropped, and the CSM antenna deploys.
Engage RCS for SM (should be done automatically).

Turn on using RCS and dock back to the ASTP Docking module.

You may use the Docking MFD in vusual mode.

To Jetison the S4B and have the docking module powered.
Turn on LEM PWR switch on main console to power the ASTPDM and the switch SLA/SEP to jetison the S4B. The two light should turn Green as the ASTP DM is in place and ready for dock to soyuz.

To jetison the ASTP Docking module, use again the LEM PWR and SLA/SEP switchs. It will drop the ASTPDM. You can redock using docking MFD and reassemble the ASTP and CSM with same switch.

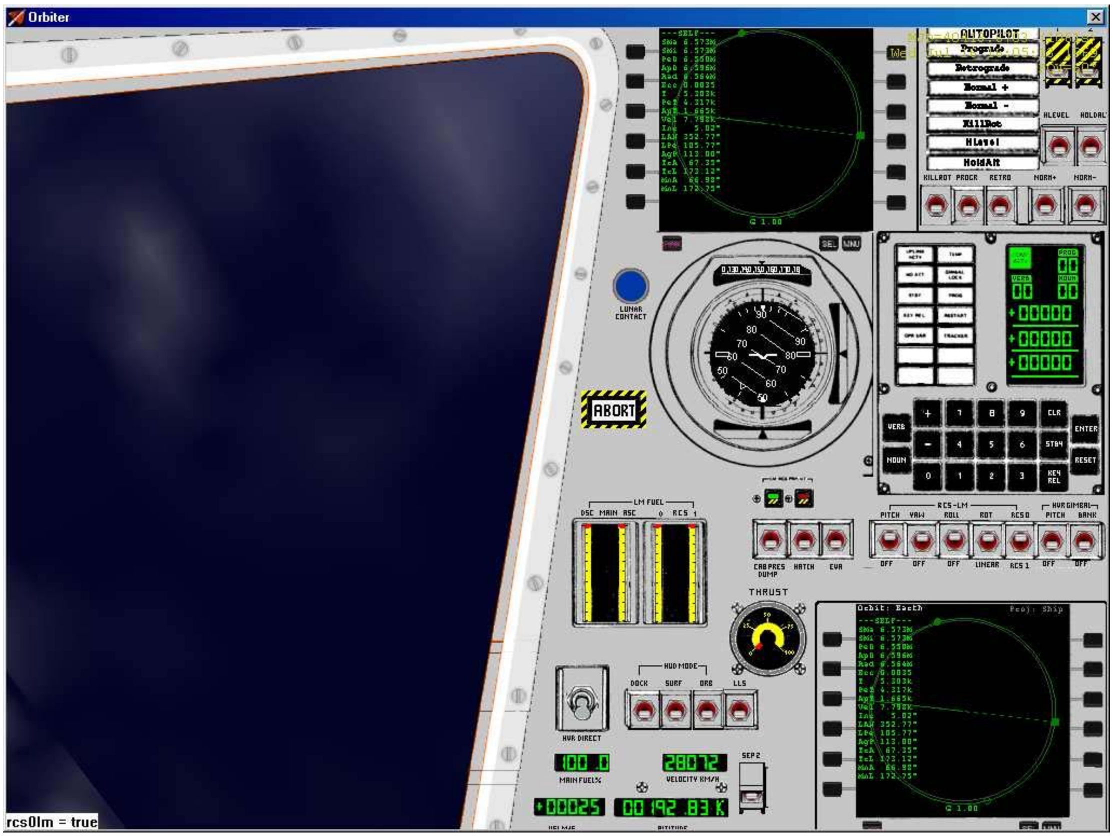
For the Saturn 5 when you have achieve your TLI burn or in low earth orbit for Apollo 9 flight, you separate S4B the same WAY and you dock back to the LEM using the docking MFD in visual mode.

Once docked, two things happens.

- You can Jetison the LEM/S4B with the LEM SEP2 switch.
- You can Jetison the S4B and activate LEM using the LEM PWR SLA/SEP switchs.

Then you now will be able to use F3 key to select the LEM as a vessel. This will only be possible when docked to the LEM.

23)LEM PANEL and SYSTEM



LEM panel works the same way has CSM panel. Except that the two yellow/black switch upper right corner does separate the ascent and descent stage.

The RCS selector is also new. It does choose beetween RCS0 (Descent stage) and RCS1 (Ascent stage).

Main gauges indicates descent fuel / left Ascent fuel /right Descent RCS left ñ Ascent RCS right.

SEP2 does perform undock. Rest is self explanatory.

1) Flight Plan to the moon and back

Introduction

Basically the Moon is an Earth satellite like any other space station except on the gravity point. When to satellite get close to each other, their respective mass does attract themselves.
When you approach the ISS from the Shuttle or another ship, as both ISS and shuttle mass is ridiculous regarding Eath Mass perturbation are not significant. When approaching the Moon due to his mass it is not the same. So flying to the Moon is like having a space rendez vous with a space station (of course, itís a little bit more complicated but for our purpose thatís enough.
The first point is to calculate the correct launch window (the exact time where the moonís position is optimal for minimum fuel travel from the launching point.
This may be a little complicated but Add-on and history books does provide a correct scenario for that. So all we have to do is launch the Apollo 11 Launch file and thatís correct. Weíll see later thatís not same for the return. (Scenario starts 1H prior to launch)

4 Lift OFF

Capcom : Youíre go for the launch ! The scenario starts 1H00 sec prior to launch time :13H32:00

5 4 3 2 1 Ignition - Here we
are !! Just Thrust to 100 %
and watch the lift off...
Has soon as the Saturn has left the tower jump back in the cockpit...
When you reach 1000m alt
(that's coming quick) just
lower your nose about 5∞
you should be at 85∞pitch
and then you begin to
accelerate in the horizontal
plane.
Letís take a look at the
instrumentation :
On the surface MFD (Left).
You notice Vspeed (that
your climb speed) and
Vacc.
Use your Vacc to adjust
your pitch.
As your rocket burns fuel, it gets lighter and lighter producing the same Vacc needs less and less
pitch.
On the other hand, reducing pitch does produce more horzontal acceleration (Acc).
Achieving an orbital injection means attaining a defined speed (about 7.5 km/s in orbiter) at a
defined
altitude (of course with Vspeed ~ 0).
So, ascent profile is a two time operation :
ï Climbing up out of the atmosphere
ï Accelerating to attain the desired horizontal speed
At 30000m (100.000 ft approx) atmosphere is enough thin for leaving us consider that it is no more
a
matter for acceleration so at that point horizontal acceleration begins to be our first preoccupation.
Be carefull cause last release of AMSO project is very short petrol.
After reaching 30000m,
chase the 0 Vacc and
maximum horizontal
acceleration.
At the end of the 1st Stage
Burn, you should be about
2000ms Hspeed and 60 Km
Alt with around +1750m/s
Vspeed
At the 1st Stage Separation,
your horizontal speed
should be around 1850 m/s
(my best result with the
central thruster early cuttoff
!!)
TAKE CARE ñ First stage
combustion is absolutely
critical ! It does directly
define how many fuel youíll
have left in the SVIB
achieving your orbital
injection. Apollo 11 Real
Flight ended 1st stage burn
at 52Km alt.
After separation, maintain
around +30∞pitch angle it
till Vacc reach 0m/s. It
occurs about 40% fuel left.
Target speed is about
6500m/s
At the end of the second

stage burn.
Watch Carefully, You
ApoApsis should be at
6550Km
The second Stage burn
begin to 30∞pitch.
When Vacc reach 0m/s≤
(about 50% fuel), switch the
hud to orbit mode.
Proceed next ascent phase
by controlling your apoapsis
value. Tips is to reach a
100 Mn radius orbit. So
6371 + 185 Km = 6556Km
So if your apoapsis value is
higher, fly under your orbit
path, if it is lower, fly above
the orbit target path on the
Hud
If you cannot reach the
exact apoapsis, donít waste
fuel trying to adjust here.
6550Km is a target value.
Anything above 6500 is ok.

5 Ascent Profile vs Autopilot

Autopilot:
Autopilot guidance has been smoothed.
From now Autopilot is user adjustable (by scenario file, dynamic mode available trhough DSKY module).
TOALT value in config file is the Target Orbital Altitude in KM. Valid range 150 to 250
TOHDG Target Orbital Heading valid range from 90 to 25 is the initial heading after launch.
The auto pilot has 5 modes that are called among different situation :
Based on the Altitude level :
- First mode gives initial pitch down to start burning in the good direction. ALT > 100m pitch down to +86∞
- Second mode start Bank the Rocket in the requested heading direction 450 m to 1500m
- Third mode set the correct heading by combining both banking and pitch to adjust to selected heading.

(TOHDG value) 1500m to 4500m
- Fourth mode Level the rocket by settings the bank angle to 0∞(around 75~80∞pitch) 4500m to 9500m
- Fifth mode level the rocket goes up to orbit based on a final active guidance. This last mode first check
minimum ALT (related to value stored default is 200Km) climbing at 35∞when approaching the specified
ALT, Autopilot switch to Track corresponding APOApsis by Adjusting and monitoring vertical speed.
The Elapsed Time is stored in the config file so is the autopilot is able to resume the good mode from any
interruption.
Last but not the least is MECO. It is triggered by monitoring minimum excentricity, so the Engine cutoff
occurs when the best orbit is achieved With a minimum excentricity of 0.03 at 120Km min Alt. Of course
Commander will only advise Houston of booster shudown if you have installed both orbiter sound 2.1a
(dpolli.free.fr) and the Saturn1B Sound package (common for both NASSP part)
Best result for Moon mission is 185 Km ALT and 90∞Heading. Result has a final guidance that is a little
hard, maybe algorythm has to be afined but the result has got a diabolic precision. Final autopilot
sequence may cause impredictable orbit if time acceleration is used. it is safe to use time accel at 10X
during the ascent phase except for the final adjustement. Finally decided to disable time warp if

autopilot
engaged as it is not safe.
Be carefull, cause SVIB-200 series differs from the SVIB-500 that has been used with Saturn V rocket.
The SVIB-500 had J2 Engine (main motor) re-ignition capability that was broughted by an additionnal tank
in the APS system (the two little jets pack located at the bottom of stage).
the SVIB-200 series used for Saturn1B was fitted with lighter APS that did not allow the J2 engine to
restart.
On the SIVB-500 series used for SaturnV APS has a tank for ullage operation. SO engine works ! you
may want to start it manually it's up to you ! but the rocket has got a sequence for S4B restart involving a
countdown and ullage sequence press G to start engine this way. (Only on NASSP).
See Following Table for Ascent Profile :
ALT Pitch Vspeed Vacc Hspeed Acc Fuel ApoApsis
300m 90∞31 m/s 3 m/s≤32 m/s 3 m/s≤90% ----
1000m 85∞75 m/s 4 m/s≤75 m/s 4 m/s≤82% ----
3000 75∞150
m/s
6 m/s≤155 m/s 5 m/s≤72% ----
9000 65∞280m/s 6 m/s≤330 m/s 8 m/s≤51% ----
15000 55∞415m/s 7 m/s≤525 m/s 12,3 m/s≤39.5% ----
30000 35∞585
m/s
6 m/s≤964 m/s 21 m/s≤22% ----
40000 20∞670
m/s
1m/s≤1408 m/s 21 m/s≤10% ----
52000 20∞701
m/s
3 m/s≤1907 m/s 26.3 m/s≤0% ----
S1C Cuttoff 20∞750
m/s
-1 m/s≤1950 m/s -2 m/s≤0% ----
S2-Ignition ----
60500 20∞683
m/s
-4 m/s≤1850 m/s -3 m/s≤100% ----
65000 20∞Tower Jetison (Switch Hud to Orbital mode)
75000 35∞495 -4 2056 5.4 94% 6460
100 Km 35∞284 -2.5 2474 7.2 76% 6478
120 Km 35∞153 -0.5 3320 10 58.8% 6495
132 Km 35∞160 +4.6 4437 12.8 25% 6505
150 Km 8∞480 -2.5 5298 20 10% 6550
167 Km 0∞368 -1.6 6080 21 0% 6562
S2 ñ Engine Cutoff
181 Km 0∞210 -2.25 6345 6.5 90% 6555
195 Km -5∞0 0 7200 0 65% 6555/6553
Main Engine Cut Off (MECO) at 12:34 min