GENESIS OPERATIONS MANUAL

Contents

1. Genesis spacecraft specifications and functions

Specifications

The Genesis spacecraft has two main parts - the "Bus" containing the propulsion system, solar panels, navigation and science payload - and the "SRC" (Sample Return Capsule) containing the sample collection mechanism and re-entry parachutes.

Mass of "Bus"	289 kg
Mass of "SRC"	205 kg
Mass of fuel (Bus)	142 kg (Fuel ISP 3000 Ns/kg)
Total Mass at launch	636 kg

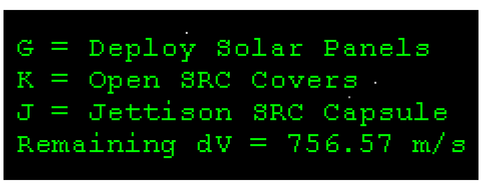
Propulsion System
The propulsion system has four 22N main thrusters, giving a total max.thrust of 88N in the +Z direction (forwards).

There are eight 1N RCS thrusters for attitude control. The RCS is only "balanced" for rotation around the Z axis - rotation around the X or Y axis will give a very small dV in the +Z direction (so take it slowly when "yawing" of "pitching").

There is no "Translation" RCS except in the +Z direction (can be useful for making small adjustments to maintain halo orbit at L1).

Since the RCS are quite weak compared to the mass of the spacecraft, using Orbiter's automatic "Prograde" or "Retrograde" functions can be inefficient and may take some time to settle down - it's better to do it manually.

Genesis Bus Controls
Available commands are displayed in the top-left corner of the HUD, together with the total remaining dV capability of the spacecraft.



Note: The SRC can *only* be jettisoned if the solar panels are deployed and the SRC cover closed. The SRC is jettisoned with a speed of 0.3 m/s .

Genesis SRC Functions
The SRC has no propulsion system and travels on a ballistic trajectory. All parachute operations are automatic.

The drogue parachute is deployed at 33km alt.

At 20km alt., the SRC will automatically create the "AS350" recovery helicopter on a helipad approximately 45km N.E. of the Genesis SRC position. See " **as350_en.pdf** " for more info about the AS350 recovery helicopter.

The Genesis SRC Parafoil is deployed at 6.7km alt. This is your target for mid-air recovery by helicopter. It will slowly spiral down, flying at about 15m/s and losing altitude by 4m/s.

Note: There is a 1/100 probability that the parachute system will fail at re-entry ;-)
An on-screen warning message will be displayed if this occurs.

2. GenesisMFD functions

To use the GenesisMFD you must activate it in the Orbiter launch pad "Modules" tab.

The graphic displays shows a *record* of your trajectory around the Sun->Earth/Moon L1 point (it's *not* an orbit propagator like IMFD"Map"), it takes a *new data point every two days* and will record continuously for up to 4 years. It is reset if you exit the simulation or change the focus vessel.

The trajectory is shown in a *rotating frame of reference* - the Sun-L1 line is constant (along the X-axis in the first two views, and perpendicular to the display in the 3rd view).

It also shows numerical information of the position and velocity of the L1 point *relative to the spacecraft,* the C3 energy of the spacecraft relative to Earth, and the separation angle of the Sun and spacecraft as seen from Earth.

Controls

Press [**Shift-V**] or Click on [**VW**] tab = Cycle through views (1-3 graphic, 4 numerical)
Press [**Shift-B**] or Click on [**ZM+**] tab = Increase Zoom level of graphic
Press [**Shift-N**] or Click on [**ZM-**] tab = Decrease Zoom level of graphic

Displays (views 1-3 graphic, view 4 numerical)

View 1 (default view) "Ecliptic Projection" - viewpoint is looking "down" on the plane of the Ecliptic from above ("North").

View 2 "Ecliptic Plane" - viewpoint is looking along the plane of the Ecliptic in the direction of Earth's orbital velocity.

View 3 "L1-Sun Line" - viewpoint is looking along the L1-Sun line, towards the Sun.

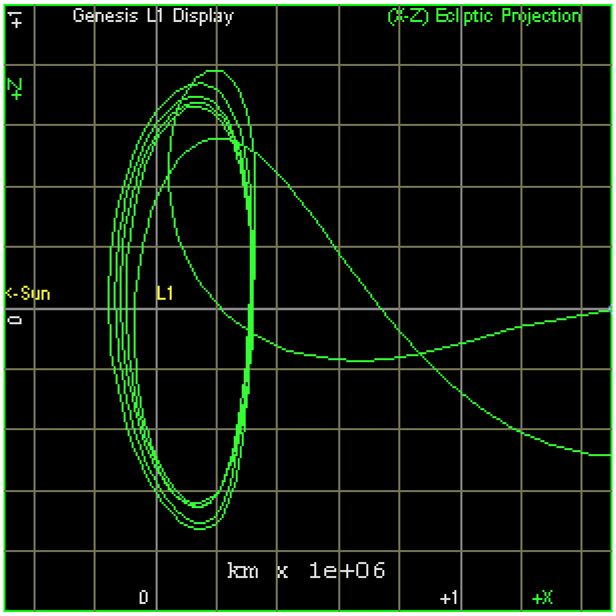
L1 point is always at the origin (0,0) of the graph. The position of the spacecraft is shown by a white "+", the position of Earth is shown in View 1 & 2 by a blue "o".

View 4 "Numerical Display" - shows the *position*, *velocity* and *distance* of the L1 point relative to the spacecraft *in the spacecraft's frame of reference* (+Z is "forwards", +Y is "up", +X is "right").

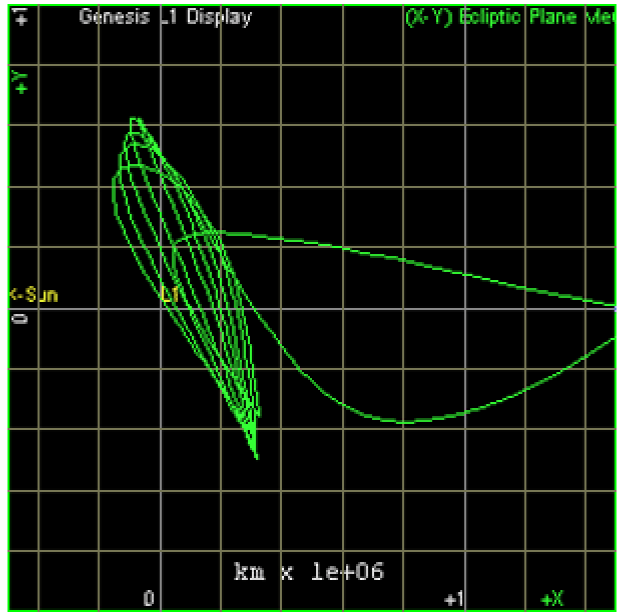
It also shows spacecraft C3 energy relative to Earth, and the Sun-Earth-Spacecraft separation angle.

Calculation of L1 position is correct to within 65km of the position given by JPL Horizons data.

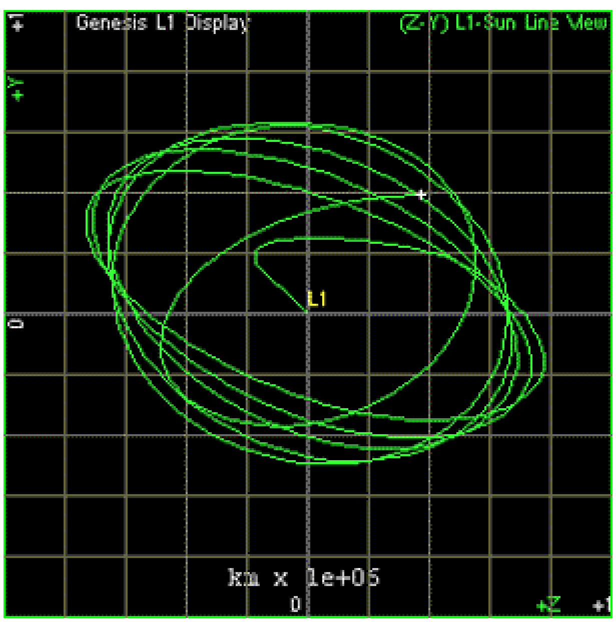
<u>GenesisMFD display</u>



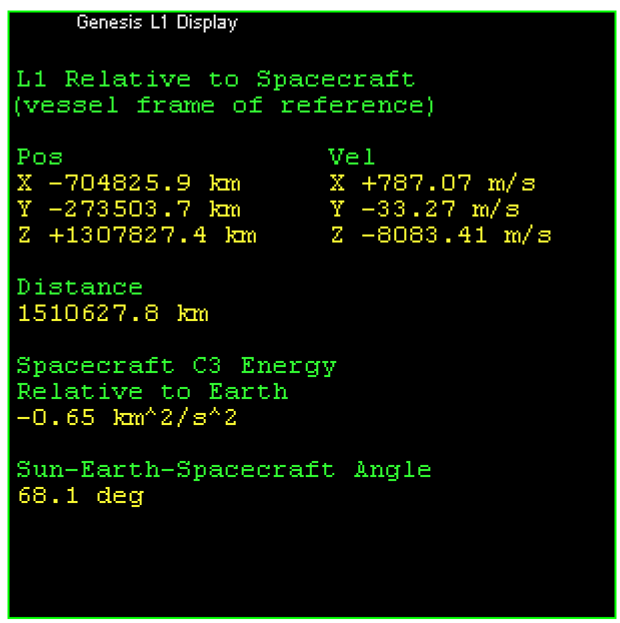
View 1 “Ecliptic Projection”



View 2 “Ecliptic Plane”



View 3 “L1-Sun Line”



View 4 “Numerical”

3. Scenarios

The scenarios are located in the "GenesisMissions" folder, which you will see in the Orbiter launchpad "Scenarios" window.

1 Genesis Launch - scenario begins at T-40 seconds, launch the DeltaII, flight designation 287, at 16:13:40 UTC. *This scenario requires the "Delta II Missions v.2" add-on (www.avsim.com) to be installed.*

2 Genesis post Launch - scenario begins shortly after final 3rd stage burn-out. Genesis is on course for halo orbit around L1.

3 Genesis Halo Orbit Nov 2002 - Genesis is halfway through its mission, in a halo orbit around L1.

4 Genesis Re-entry - about 30 mins before SRC separation. Perform final course corrections to target base "Genesis Site", re-orient spacecraft to re-entry attitude and spin up to 15 RPM. Jettison SRC capsule 4hrs before re-entry. Make avoidance burn by Genesis_bus.

5 AS350 practice SRC recovery - Genesis SRC recovery drop-test. Practice your helicopter pilot skills by recovering the Genesis_SRC_Parafoil, now 5km above the helicopter pad.

4. Launch notes

Launch at 16:13:40 UTC , 8th August 2001
Launch azimuth 92 degrees
Parking Orbit 185km, 28.5 degrees inclination (equatorial)

An autopilot is available to take you to parking orbit. Press [P] to use the autopilot at T-10 seconds. You can cancel the autopilot at any time by pressing [P] again, but it cannot be restarted. The autopilot ends about 10 seconds after 2nd stage engine cut-off, and is not always perfectly accurate - you may need to perform a small burn to ensure you are in a safe parking orbit.

Once parking orbit is achieved, place the launch vehicle stack in Prograde attitude (press [ ).

Open up SurfaceMFD and OrbitMFD and watch your longitude and apogee altitude.

At Longitude 123.98 East, engage the 2nd stage engine at full thrust until your apogee altitude is 2700km, then cut the engine.

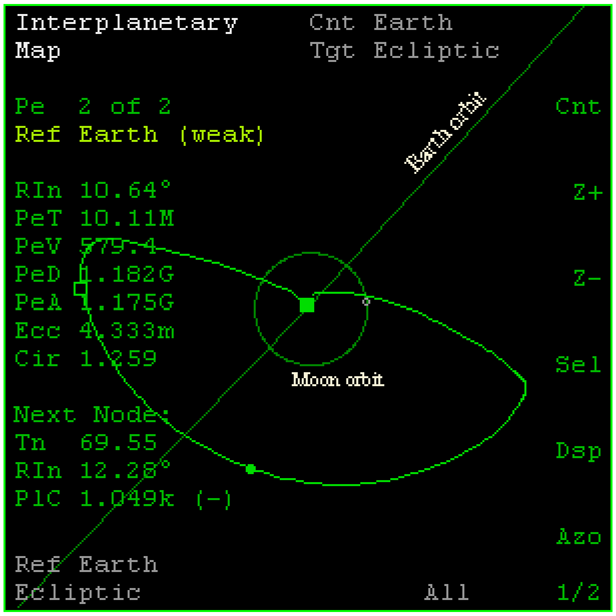
At Longitude 132.00 East, cancel Prograde attitude (press [ ) and jettison 3rd stage [J]

At Longitude 134.91 East, engage the 3rd stage engine at full thrust until fuel is finished.

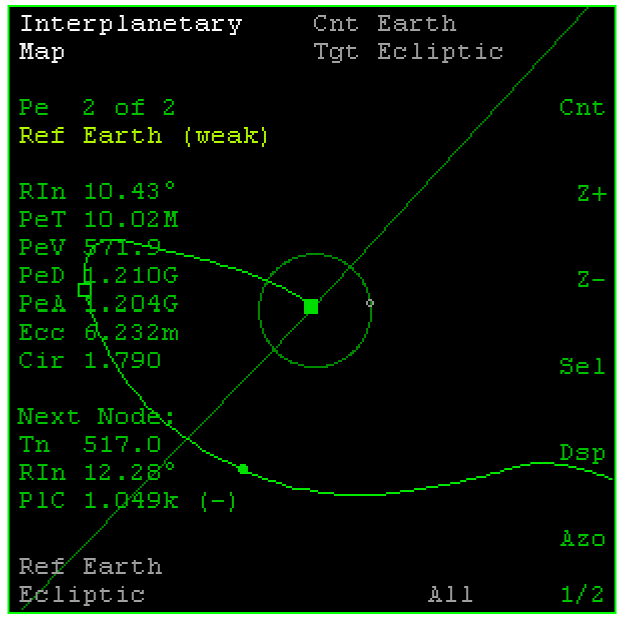
Jettison the Genesis spacecraft [J] and deploy the solar panels [G]

Now open up IMFD “Map” display and ensure that
[Cnt] = Earth
[Ref] = Earth
[Prj] = Ecliptic

The trajectory is very sensitive to initial velocity and it’s unlikely you made a perfect launch. You will probably see your trajectory looking like one of these two cases:

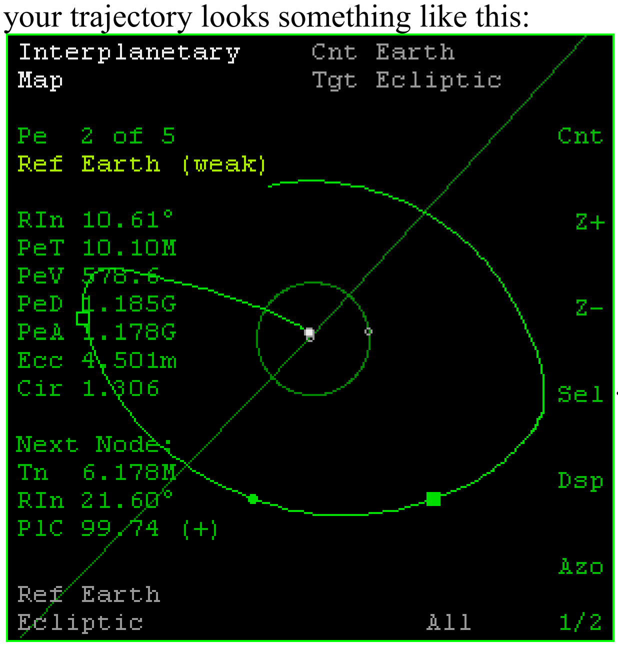


Not enough velocity



Too much velocity

Burn Prograde (relative to Earth) to increase velocity, or Retrograde to decrease velocity until your trajectory looks something like this:



If you look at your OrbitMFD, your apogee altitude should read approximately 0.008AU (ref.Earth)

You may like to open up the GenesisMFD at and check that your C3 energy is about - 0.64

Once you have achieved a reasonable launch trajectory, you do not need to make any further course corrections until you have passed the distance of the L1 point from Earth.

5. Maintaining halo orbit around L1

You may have noticed from the previous IMFD "Map" images that the halo orbit around L1 looks like a "*rugby ball*" shape - the aim is to maintain that orbit until it's time to begin your return to Earth.

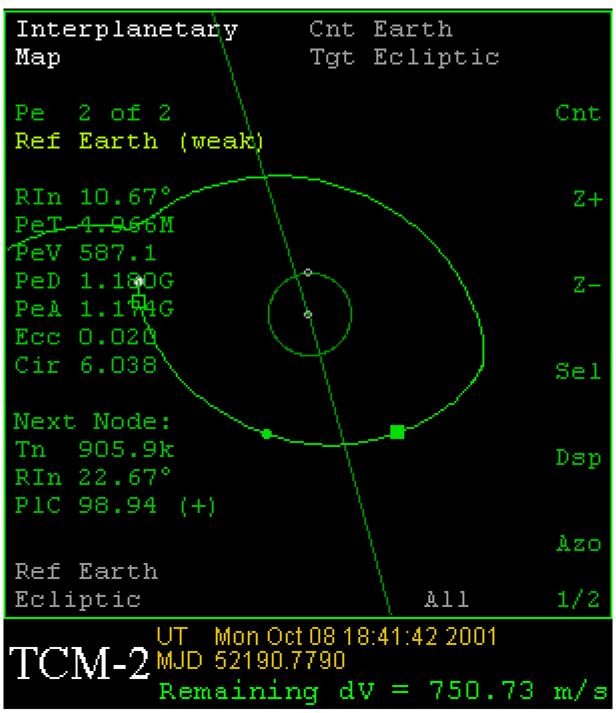
The trajectory is *very* sensitive to any changes in velocity, you should not need to use more than 80 m/s dV during the whole time you are in the halo orbit.

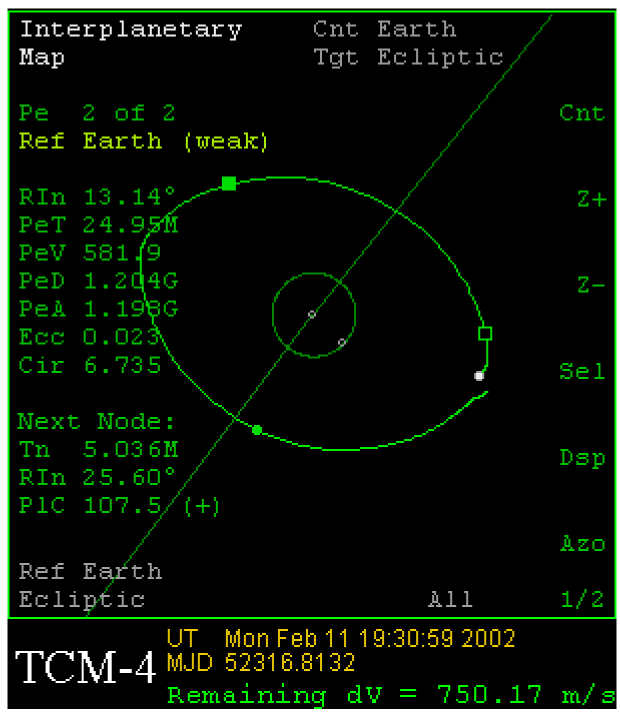
You will probably need to make a course correction every 2 or 3 months. I have found the most efficient way of making corrections is to *thrust directly towards* or *away* from the Sun.

Thrusting *towards* the Sun will pull your trajectory *away from Earth*.
Thrusting *away* from the Sun will pull your trajectory *towards the Earth.*

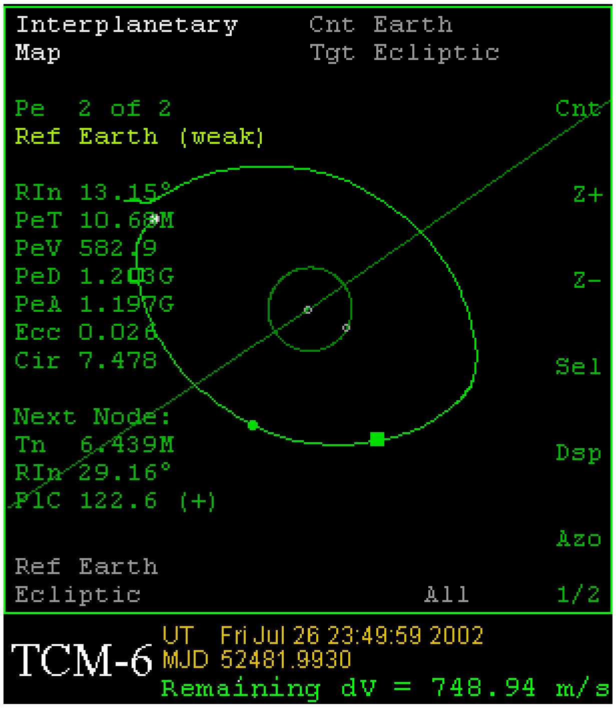
Begin to make course corrections once you have passed the distance of the L1 point for the first time. It is not necessary (or even possible) to make the orbit *perfect* - just try to keep the next ½ or ¾ of the orbit on course.

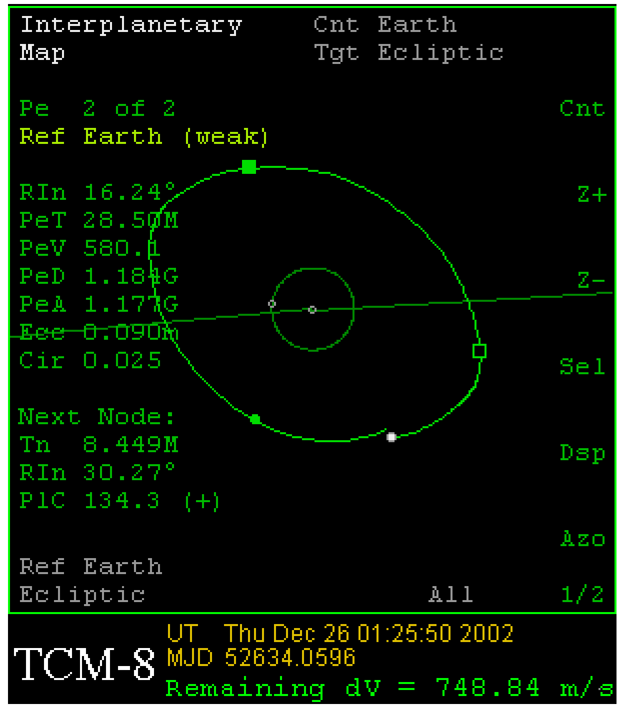
The following series of IMFD "Map" images were taken after various course corrections during the mission:

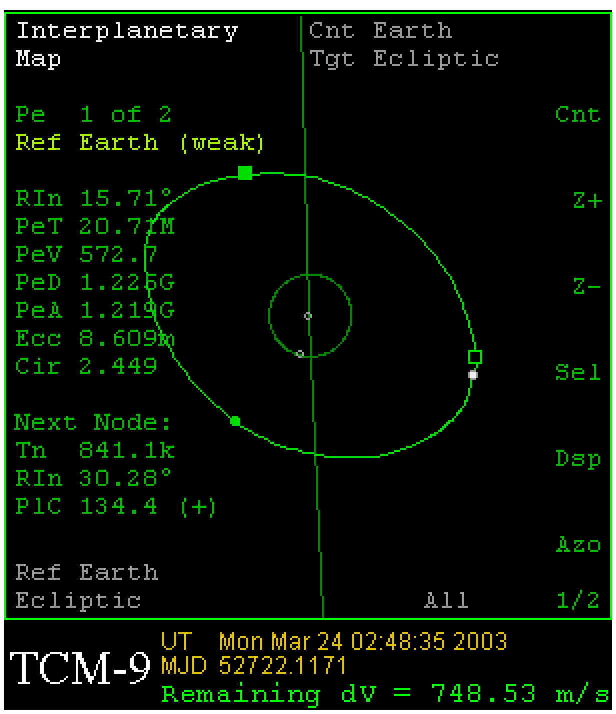


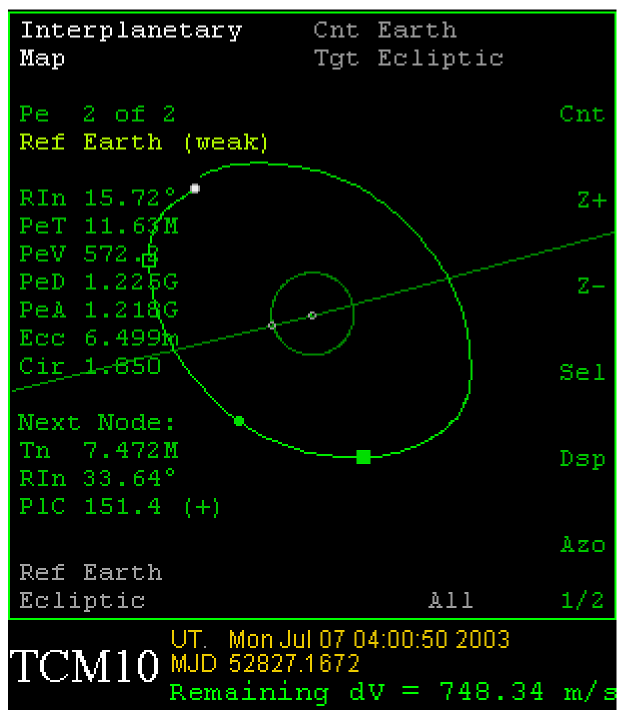


Maintaining L1 Halo Orbit - IMFD "Map" Images





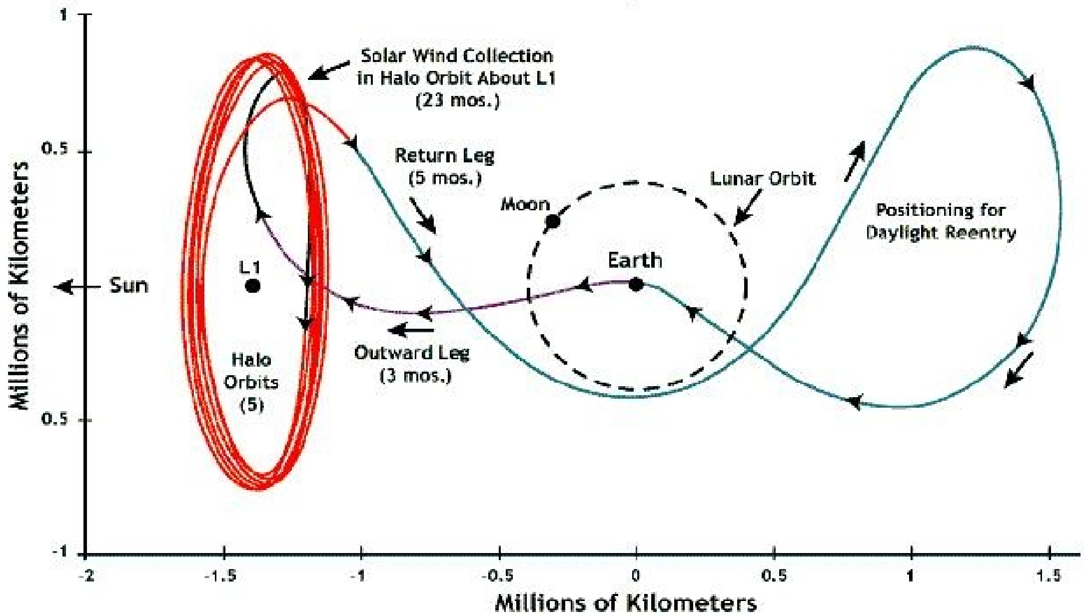




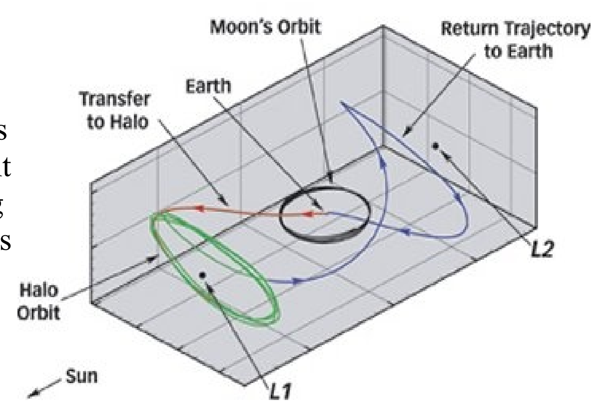
6. Return to Earth and SRC re-entry

Set-up Return to Earth

You must begin to set up your return to Earth in October 2003, about 11 months before re-entry. As you can see in the following graphics from NASA, the spacecraft makes a flyby of Earth at about the distance of the Moon's orbit, then loops around the L2 point before returning to Earth for a daylight re-entry and recovery over Utah.



Hopefully you should still have in excess of 650m/s dV remaining, which should be more than sufficient for accurately targeting the re-entry and performing the Earth-avoidance manoeuvre by the Genesis_Bus once the SRC has been jettisoned.

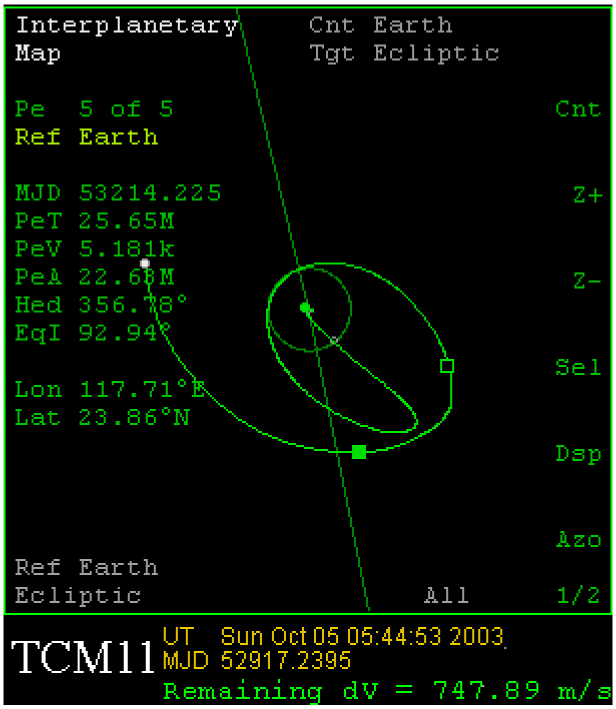


Note: IMFD "Map-config" settings

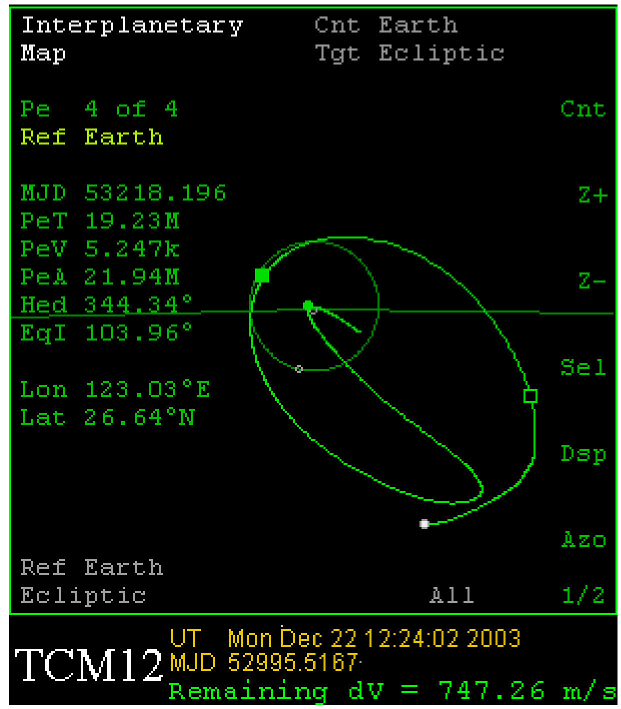
If you have not already done so, you must set up the parameters for IMFD "Map" display correctly. Go to the IMFD "Map-config" page (click on [Mod] tab 3 times) and set the following parameters:

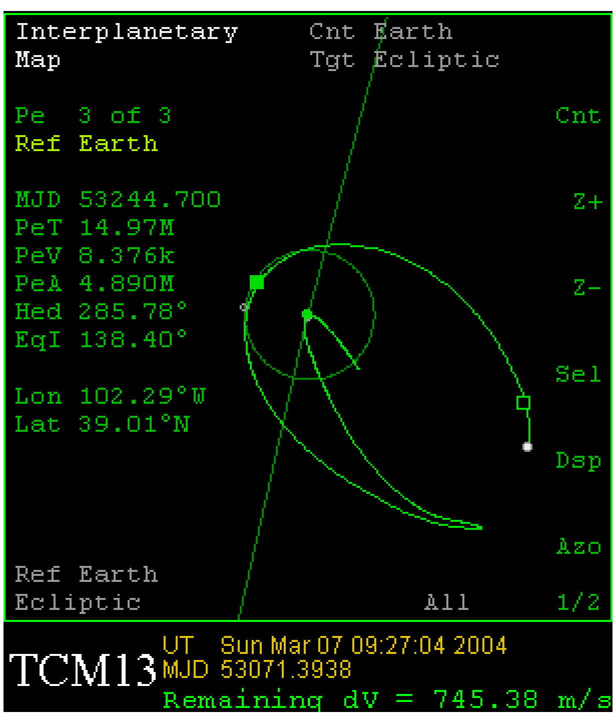
Period Limit : No
Hyper. Limit : No
Tgt Weak Pe : No
One Pe/Ref : No

At the beginning of October 2003, make a burn towards the Sun to pull your orbit closer to the Earth, flying by Earth at about the distance of the Moon's orbit before returning for re-entry approach. Once your trajectory looks something like the following image, click on the [Sel] tab until IMFD displays the numerical information about your final re-entry Periapsis. Then you can make some small adjustment burns to get the Periapsis Alt (PeA) to a minimum.



After the 5th October 2003 re-entry set up burn.





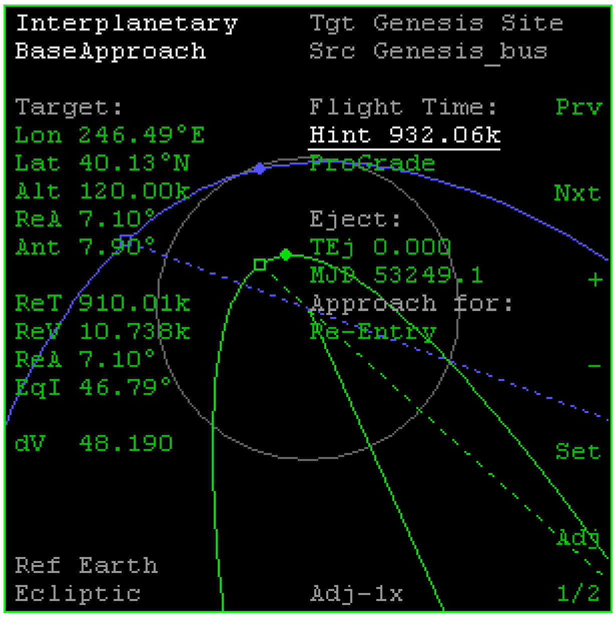
As you can see in the images, the PeA is down to 4890 km and the re-entry date of MJD53244.7 is closer to the actual re-entry date of MJD53256.67 (8th September 2004).

At about 10 or 11 days before re-entry you can start to use the IMFD "Base Approach" function to make a really accurate re-entry.

Using IMFD “Base Approach”

Included in this add-on is the surface base “Genesis Site” which is the historical landing site in Utah. You can use this as a target for IMFD “Base Approach”, set the parameters as follows:

Ref = Earth
Tgt = Genesis Site ReA = 7.10 Hint = (enter the PeT value from the
Alt = 120.00k Ant = 7.90 IMFD “Map” display)



IMFD “Base Approach” set up, 11 days before re-entry

SRC Release and Bus Earth-avoidance manoeuvre

4.5 hours before re-entry, make your final course correction using IMFD “Base Approach”.

Next, assume Prograde attitude relative to Earth and yaw left 70 degrees (to azimuth 290 on the HUD “Orbit” display).

Make a burn in that direction of 0.30m/s (to cancel out the SRC jettison speed). Go back to Prograde attitude and yaw right 110 degrees (to azimuth 110 on the HUD “Orbit” display).

This should be approximately the correct position for the SRC at re-entry into the Earth’s atmosphere.

Rotate the spacecraft about it’s Z-axis (roll) until it is spinning at approximately 15rpm.

Jettison the SRC [J] 4 hours before re-entry and kill the Genesis_Bus rotation.

For the Genesis_Bus Earth-avoidance manoeuvre, yaw right 90 degrees from Prograde (azimuth 90 on HUD “Orbit” display) and burn the main engine until your Periapsis is well above the Earth’s atmosphere.

SRC Re-entry

All functions of the Genesis_SRC are automatic and it has no propulsion or aerodynamic controls, so all you can do now is watch it re-enter the Earth's atmosphere until the AS350 recovery helicopter becomes available for use (when the SRC reaches 20km alt).

SRC re-entry sequence:
At 33km alt. The drogue-parachute is deployed.
At 20km alt. The AS350 recovery helicopter is created and focus is switched to the helicopter.
At 6.7km alt. The Genesis_SRC_Parafoil is deployed
Nominal alt. for recovery of Genesis SRC Parafoil by AS350 helicopter ~ 3km.

7. Essential Info / Quick Reference

Launch at 16:13:40 UTC , 8th August 2001. Press [P] for autopilot to parking orbit at T-10.
Launch azimuth 92 degrees, Parking Orbit 185km, 28.5 degrees inclination (equatorial)

2nd Stage final burn Prograde at longitude 123.98E, until Apogee alt.2700km
Cancel Prograde attitude and jettison 3rd stage at longitude 132.00E
3rd Stage burn at longitude 134.91E, use all fuel.
Check C3 energy (aprox. -0.64). Check IMFD "Map", burn Prograde or Retrograde rel.Earth for "Rugby Ball" shaped orbit.

Next course correction at first Apogee - burn toward Sun or away from Sun.
Maintain "Rugby Ball" shaped orbit shown on IMFD "Map" (Cnt=Earth, Ref=Earth)

Set up re-entry trajectory October 2003 (11 months before re-entry)
Nominal re-entry date 8th September 2004 16:00 UTC (MJD53256.67)

IMFD "Base Approach":
Tgt = Genesis Site Alt = 120km ReA = 7.1 Ant = 7.9

AS350 controls quick-reference:
[K] = Start Engines(30 sec) [Shift-H] = Heading Hold / Normal [Shift-X] = AutoAlt
[Shift-P] = Deploy Grapple Hook [Shift-S] = Stationary [Shift-D] = Descend and Land
[Shift-G] = Return to Helipad

Known Bug: Sun texture may become invisible when using the AS350 helicopter.

Thanks!.....
to Dr.Schweiger and all Orbinauts, especially Jarmonik, Mustard, Jekka & Momo, Veronique....
...and a big "Merci!" to Ludovic "Brainstorm" Leroy for donating his (considerable) talents as modeler and programmer for the AS350 helicopter, Cheers Ludo! :-)
BJ 08