

EXOMARS MISSION

By Papyref
October 2016



1 - Installation

Unzip the Exomars Mission pack in your Orbiter folder.

This addon requires:

- **InterplanetaryMFD 5.5 by JarmoNikanen** that you can find on the site <http://users.kymp.net/p501474a/Orbiter/Orbiter.html> and it is necessary to activate in the Launchpad -- >module
- **Pad24_UR500_V1 by Papyref** that you can find on Orbit Hangar

2 - Goal of the mission

It consists in launching around March a probe called TGO (Trace Gas Orbiter) which must be placed in orbit around the planet Mars to study the presence and the origin of gases present in Martian atmosphere and trace of methane to try to determine if it is of biological origin.

The space probe was launched on March 14th, 2016 by a Russian rocket Proton. After being itself inserted around March in orbit in October 2016

The mission must use the technique of aerobraking during 12 months before starting the scientific phase of the mission which must be completed in 2022

The space probe of a total mass of more than 4 tons transports a payload of 712 kg including 4 groups of instruments (spectrometers, cameras, detectors of neutrons) and the experimental European Lander ED M (Schiaparelli) which it must release near Mars.

This one must be posed over Mars and thus make it possible to validate the techniques of atmospheric entry and landing on this planet.

It carries a heat shield, a parachute speed reducer, Lander (small undercarriage motorized, in front of being posed carefully to deposit Rover).

Although this mission does not comprise a Rover, I imagined and added this one for the fun.

The site of landing selected Oxia Planum is in the plain Meridiani Planum by 6,1° W 1,9° S at an altitude -1424 meters. It is not far from the site of landing of the rover Opportunity.

3 - Launching and transit towards Mars (in March in October, 2016)

The launch window towards the planet Mars opened on March 14th and closed again on March 25th, 2016. TGO is thrown with the EDM Lander by a Russian rocket Proton KM / Briz M since the cosmodrome of Baikonur on March 14th 2016 at 18h33 GMT

For the rocket Proton it is about the first launching of an interplanetary space probe for more than two decades but the profile of this flight is close to launch in orbit a communication satellite

Launching spreads out over 11 hours because the increase of the floor Briz M is relatively weak and its use, three successive blast-off is needed:

- T0: take-off
- 1'59": ignition of second stage
- 5 '24": ignition of the third stage
- 9'31": dropping of the third stage. The space probe is on an orbit of standard parking with altitude 175 km and an equatorial incline of 51,5 °
- 1 h 34': ignition of the floor Briz M for 18 mn

The orbit is from now on 175 x 5800 km. The ignition of the engine takes place in contrast to the azimuth of position which Mars will occupy at the arrival envisaged on October 16th

- 11 '01": Ignition of stage Briz

The ignition of engine takes place in opposite azimuth of position which Mars will occupy at the arrival envisaged on October 16th

A correction of trajectory will be if necessary accomplished in mi - course
Three or five days before its manoeuvres of insertion on orbite around Mars the probe liberates Schiaparelli who will perform a direct return in Mars atmosphere whith hyperbolic trajectory

The following daytime TGO perform a maneuver of Mars approach to have a simple atmospheric braking which will transform its orbit into a very elliptical orbit

I have included some scenarios for some stages

4 - Launching and put in orbit 175x175 km

Open scenario 1 –Launching TGO and maunch immediatly by pressing P key for automatic launch to reach an orbit 175x175 km incline 51,5 °

Once orbit is reached the third stage must be dropped by pressing the J key
must be dropped by pressing on the key J and keep only the top floor Briz

If you activate Multistage2015MFD in the Launchpad module you will be aable to open the MFG and follow the lauch parameters (read the Multistage 2015 doc)

5 – Elliptical orbit 175x5800 km

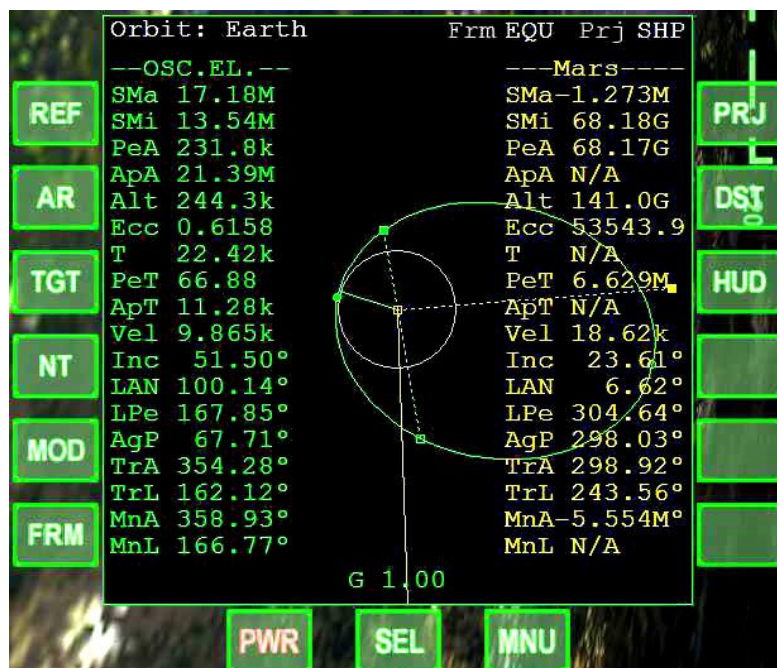
It is necessary to make ignition in opposite of the position which will occupy Mars at arrival by October 15 th.

As the period of revolution of march is about 59000000 s and your estimatel time for travel is about 19000000 s(215 days from March 15 th till October 15 th) Mars as will have moved $360 \times (19/59) = 116^\circ$

As it is difficult to us to calculate the instant of ignition, we are going to trust in ESA and ignite in prograde in MET = 1h34'

6 - Elliptical orbit 250x21400 km

Always following the timing of ESA we ignite in MET=4 h which is a point a little before the periapsis to not disturb the orbit



PeA is not exactly in 250km but we correct in apoapsis with little ignition in prograde

7 - TGO on orbit transfer

ESA performs a last ignition in MET =10 h19 'who carries peak to the position which will occupy march in 7 months.

We do not have its capacities of predictive calculation and we are going to use IMFD (read the documentation if you don't know what is)

In the apoapsis of the new orbit, make a small ignition in prograde to carry PEA to 250 Km. We will so comply with the planning of ESA

Open Interplanetary (IMFD) on both MFD:

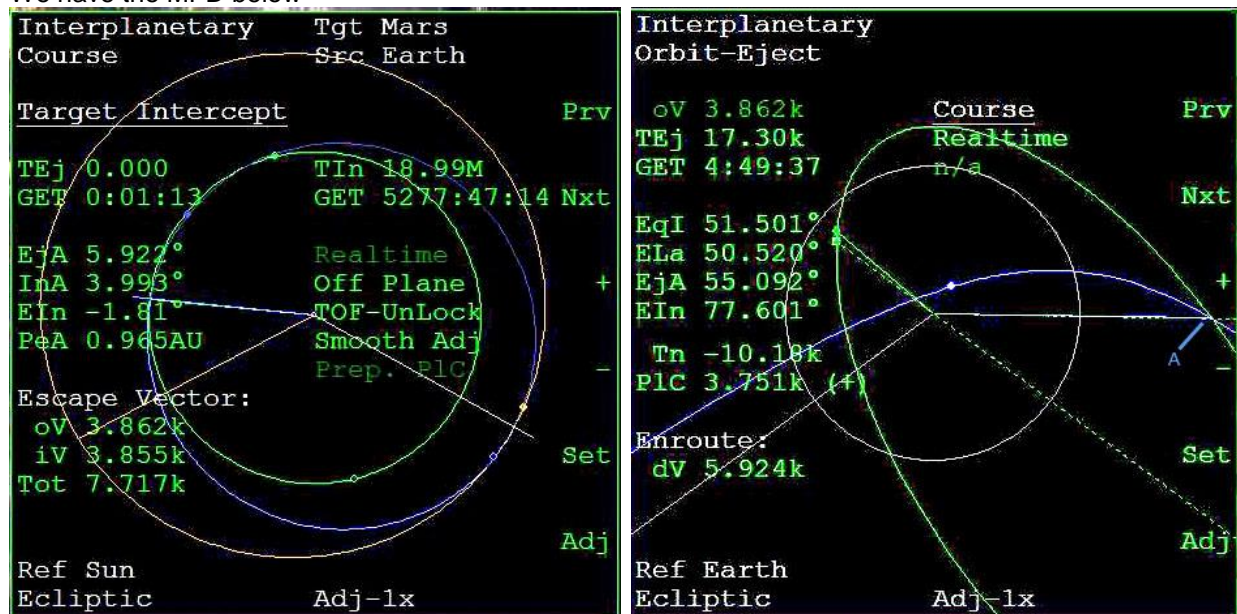
On MFD to the left

- Open Interplanetary (IMFD)
- Make Course → Target Intercept → Set
- You are asked what is objective. Make TGT → Mars → Enter
- By using Prv or Nxt to move to go on Tin to make Set and enter 19M(19000000) which is in seconds the approached time for travel

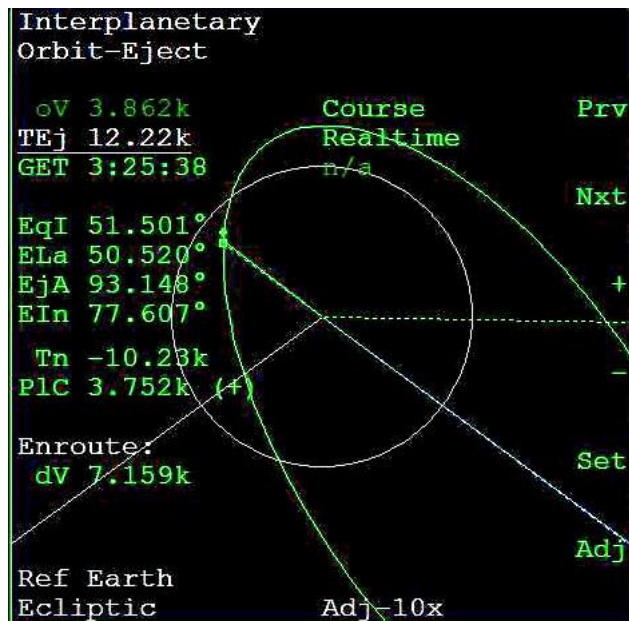
On MFD to the right

- Open Interplanetary (IMFD)
- Make MNU > OpMode > 0 and Enter what is going to couple the two MFD for the transmission of datas
- Make OrbitEject what is going to allow us to search a solution for ignition allowing to minimize the consumption of fuel
- By using + go in Course mode

We have the MFD below



It is not still good solution because the orbit of ejection in blue cuts the Earth in grey and it is necessary to correct by changing TEj on Orbit-Eject



By using Prv or Nxt choose TEj and make him vary to lead the point A to coincide with the ray in dotted line
the orbit in blue is not any more in the MFD but not be worried it cuts no more Earth

In Course, Earth is taken as a source Src because the trajectory is calculated between two bodies Earth and Mars turning around the same point which is the sun
As the Earth does not have engine, it is necessary to use Orbit-Eject to use the engine of the rocket

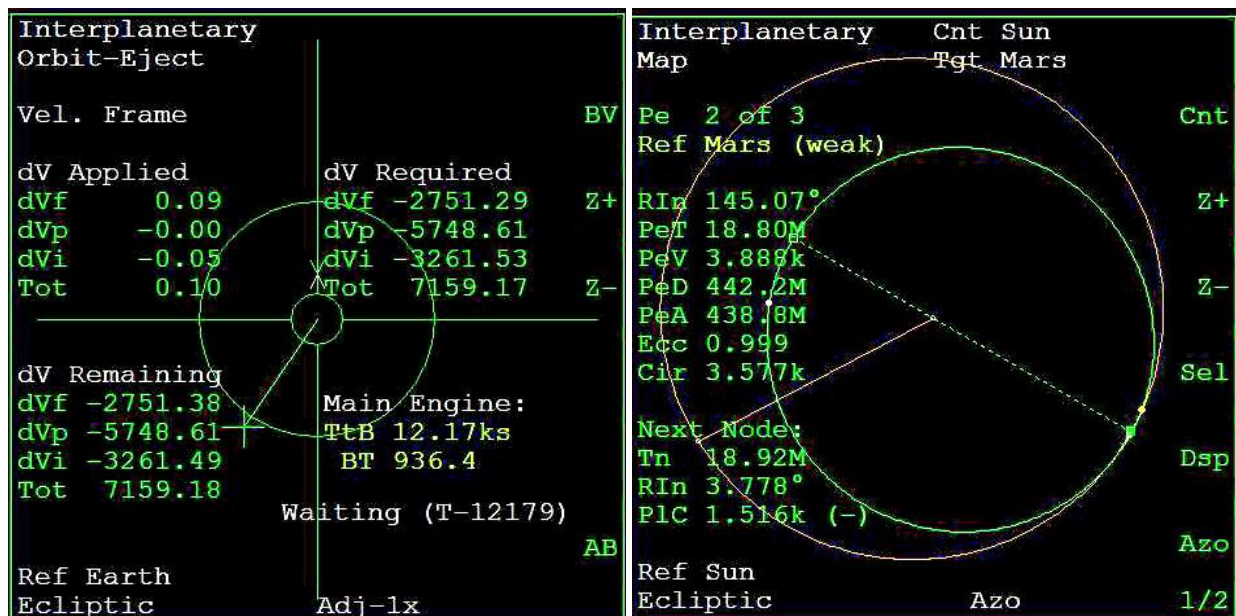
On Orbit-Eject make PG → BV → AB to prepare ignition
Ignition is going to last 936.4 s and will occur in 12179 s (See figure below)

You can speed the time he will be automatically brought back in x10 to T-180
After the end of ignition on MFD of right to make MNU → Map → TGT → Mars → Enter and the choose Pe2 of 3 to see which is the periapsis predict in Mars arrival

You see on the figure below that PEA = 438,8M what is very well because it is only a little more than distance Earth-Moon

We are under way towards Mars and we will make a correction with mi-course by July first

Remark – The values which you will get for your mission can differ a bit but this is normal and it is only important to be near



8 - Trip towards march and correction on middle travel

Two minutes after the end of ignition, separate TGO of the 4th stage Briz by pressing on the J key

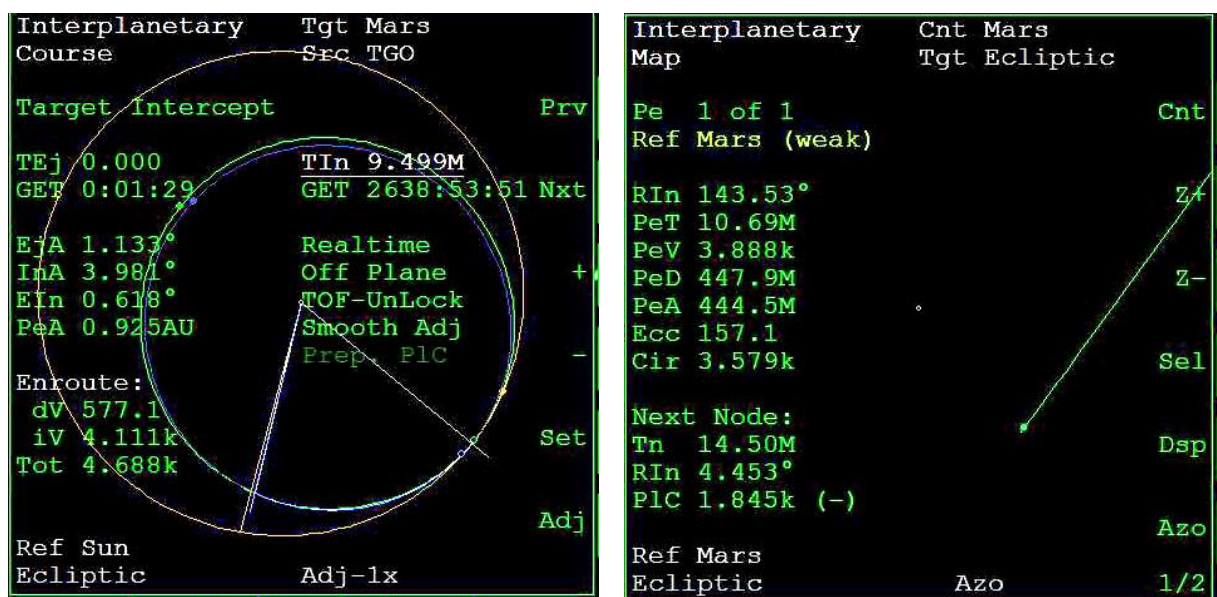
Then deploy solar panels by pressing on the K key and the antenna by pressing on the G key

Take care by pressing K key to not press anyway key J because you would separate EDM of TGO what must be made only near Mars

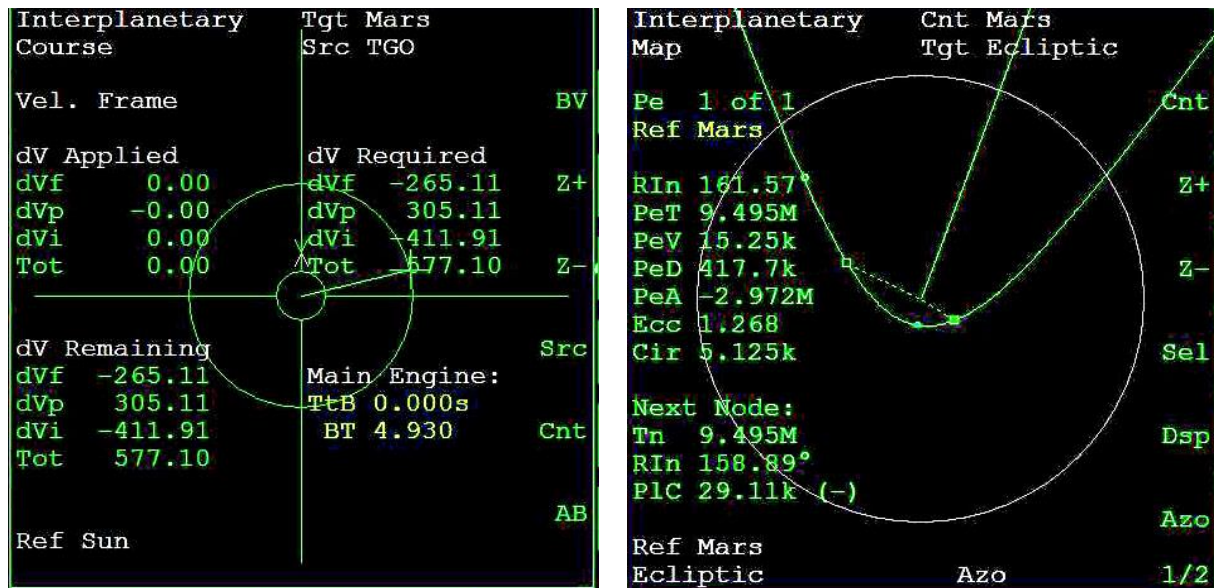
You can use **scenario 7- Correction à mi-parcours** for time saving

It is necessary to open again Course- Target Intercept and Map on both MFD and coupled both as we made before

As we are in mi travel it is necessary to change Tin to have a value of 9.5M (we had 19M at launch)



- On Course make PG → Src --> Set and enter X to choose TGO then validate with Enter
 - On Course make PG → BV to see the value of the time for ignition. It is less in 5s and this is a very economic correction !
 - Make AB to launch ignition
- It is possible to see on Map that PEA onmarch is -2.972M that means than without approach correction we will hit !



9 - In approach of march

When we enter in SOI (sphere with Mars influence is preponderant) we make a correction with TGO a correction with TGO and later EDM will be released in ballistic trajectory

If Orbit standard MFD is opened with Mars in reference, $G < 0.5$ and Alt is about 100M

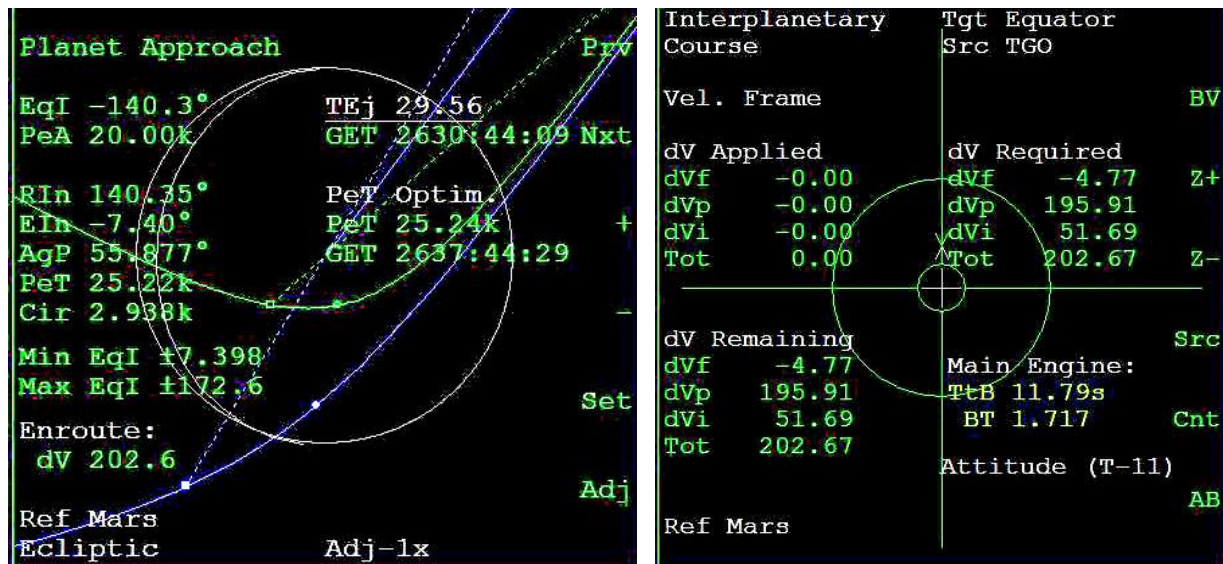
You can open scenario 8 –Mars à 100M for time saving

9.1 - Correction of trajectory for EDM

Later, TGO will correct its trajectory for an aero-braking in the atmosphere to take an elliptical trajectory

- On MFD of left, with Prv or Nxt, go to Target Intercept if you are not on him and make + to return on Course menu
- Go on Planet Approach and make Enter. Then make REF→Mars→Enter (**important otherwise you risk to have Sun for reference**)
- Use Prv or Nxt to go on PeA and to make Set→20K→Enter (this give us a trajectory with no risk to rebounding on the atmosphere which begin about 65k)
- Use Prv or Nxt to go on Tej to make Set and to enter 50 to postpone ignition of 50s and to allow TGO become stable then to make Enter (**very important for accuracy**)
- Make PG -->BV-->AB at once for ignition which will take less than 2 seconds

By opening standard Orbit on right MFD you see that PeA after ignition is a bit less in 20K. That is normal seen the accuracy of correction at this distance of Mars



This correction will not allow to putdown EDM to the point fixed for missionbut we will not be able to make better !

After correction drop EDM with the J key

He is going to move away in ballistic trajectory

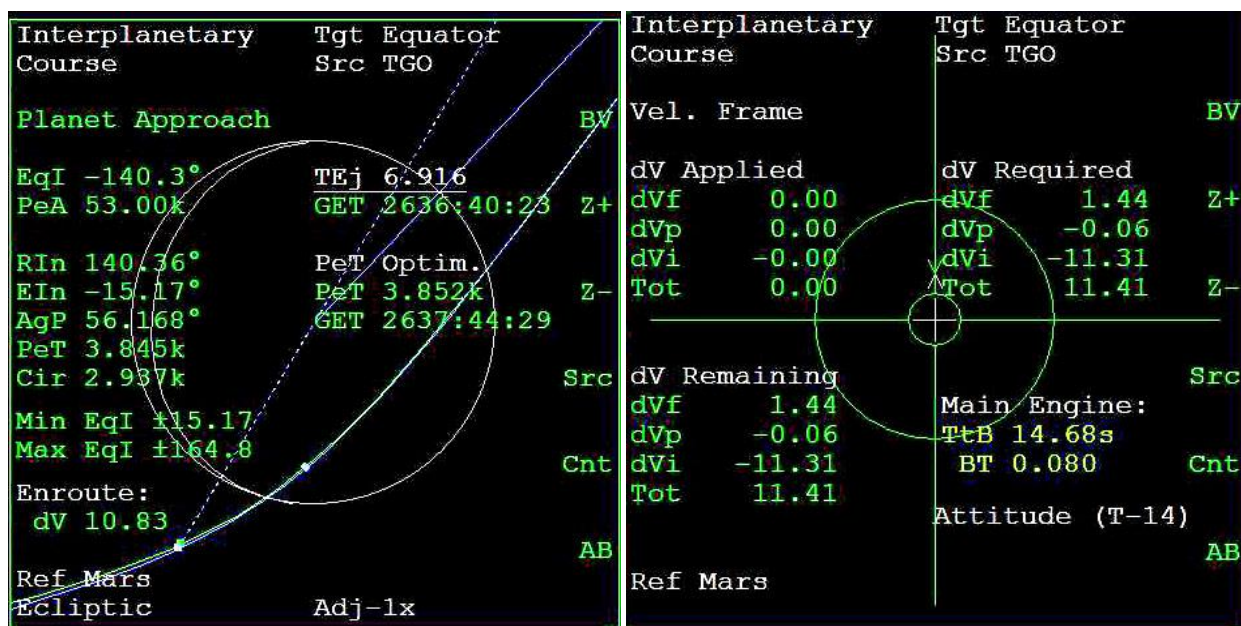
You remain focalized on TGO to be able to correct its trajectory slightly later

9.2 - Correction of trajectory for TGO

The atmosphere of Mars begins towards 65 km of altitude and you would not too much penetrate with TGO since we only want to decelerate him so that it as an elliptical trajectory (Ecc close of 1) With coefficient drag of TGO a correct value for PEA is 53K.

To have a good precision, we will make correction when TGO will be in 10M of Mars

We will operate as before but by taking PEA = 53 k

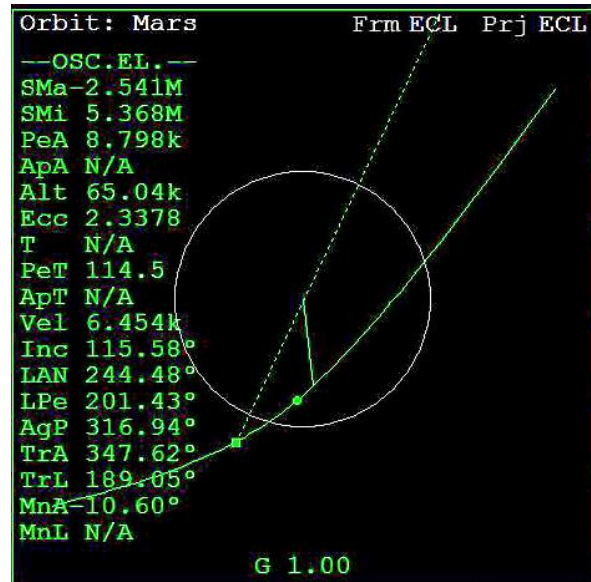


They see that the time of combustion is very weak and it is very important to take TEJ = 30 before activate ignition so that TGO stabilises

9.3 - Landing of the Lander

It is the most delicate stage of mission!

- By making F3 let us focalize on EDM inapproach of Mars towards 10M
- Pass in Prograde and stabilise with Killrot then delay Prograde
- Without increase the time up too much (100x max) continue approach to altitude =100k and then decrease time to 1x
- Open standard Surface and Orbit MFD



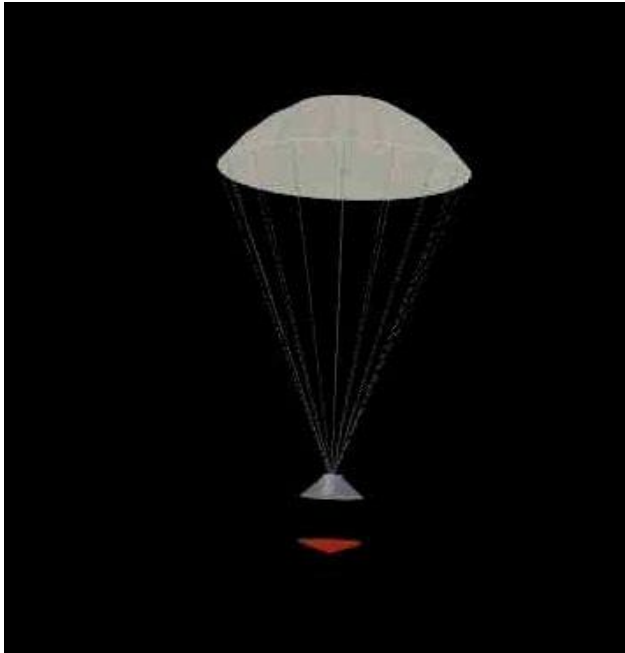
You see that that atmosphere influence begins felt towards Altitude=65K when the GS value begin to decrease with penetration



On HUD continue supporting EDM in prograde and follow decrease of speed GS and altitude

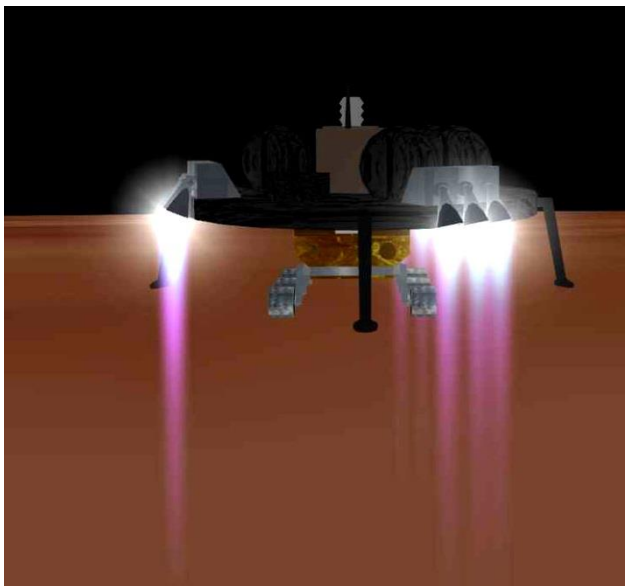
At altitude=10km, open the parachute by pressing on the G key

The slowing down of speed is violent because the parachute adds a big drag coefficient



Abolish maintaining in Prograde and you see that group is going towards a vertical positioning
As a pendular movement under the parachute is going to occur, use Killrot to stabilize vertically

At Alt = 7 km drop the thermal shield by using J key



Continue descent until 1,2Km and drop the Lander by pressing on the J key

Display its train by pressing on the G key

Now following Vs on Surface MFD try to keep $VS < 20$ m/s by a little ignition of the engines
After landing, cut engines

Note –

Gear of Lander and Rover don't exists in this mission and y have imagnated for more fun

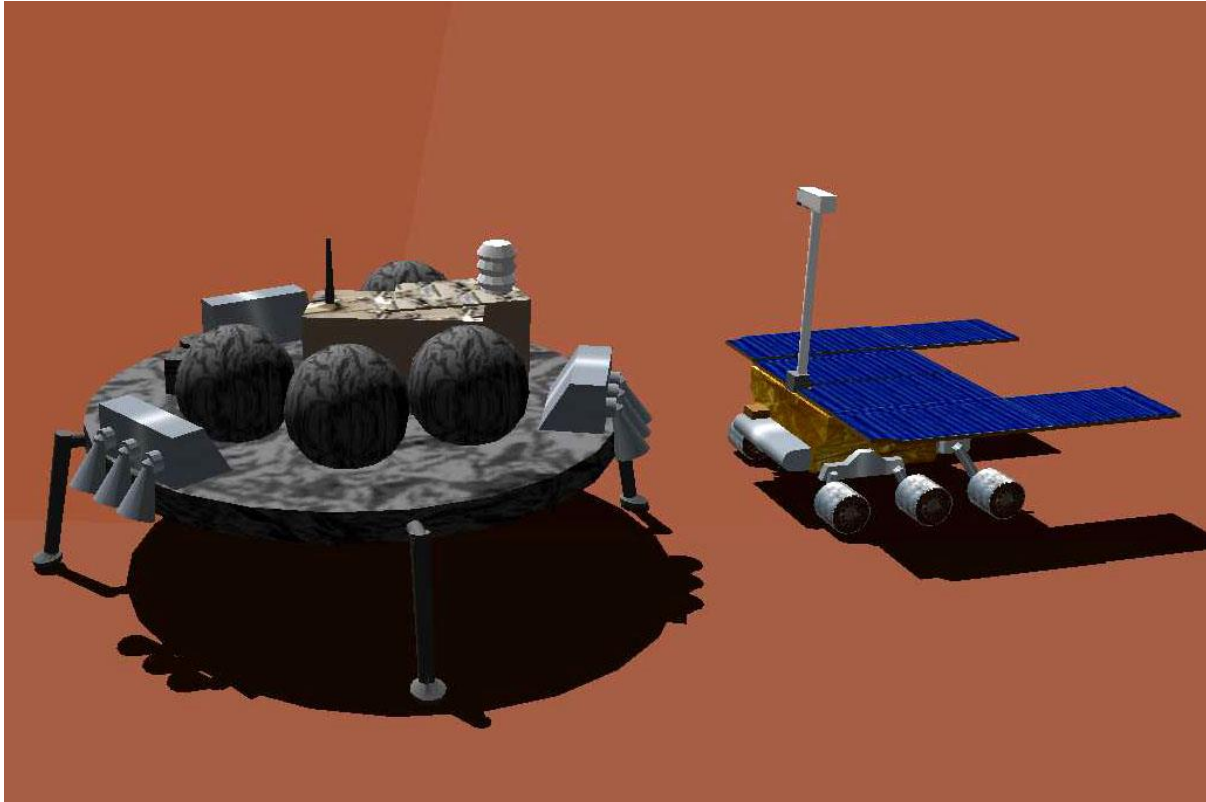
It is possible to pilot the Lander with numerical pad keys or with a joystick but this is very difficult

Once Lander put down liberate Rover by pressing on the J key

There are two possibilities then:

- Make take Lander off and put it down farther to clear Rover
- Make turn Rover by using keys 4 and 6 of the numerical keypad to run him between the Lander gear and move it toward or backward with Ins or Sup keys of the numerical keypad

For Rover G key allows to display the periscope and the solar panels and the K key move
G allows to displaythe periscope and the solar panels andthe key K to display the borer to take a sample (not true of course)



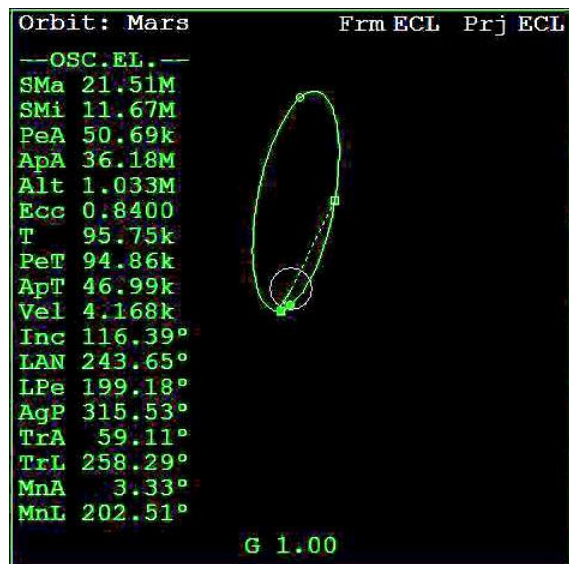
We are put down on October 4th at about 21 h GMT but it's dark. If you want to see shadows it will be necessary speed the time up to pass in day. We are early little on real mission but it is not wrong.

8. 4 - Orbit of TGO

After landing of Lander, let us refocalize by F3 on TGO

We see that if everything is well that orbit is now rather elliptical and we have not used a drop of fuel.

You can try to make another passage using Planet Approach with $PeA = 65\text{km}$ in Apapsis. After this you can circularize at 400 km using no much fuel.



We will stay there and I wish you good entertainment !

Papyref
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