How to send a space probe to Mars !

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Materials : a computer (windows PC) with the serious game 'Earth to Mars' (E2M)

1. *What is the Earth's escape velocity determined with the software ?*
2. *Did the mass of the probe have an impact on this speed ?*
3. *Did the mass of the probe have an impact on the energy (and the rocket) needed to reach this speed ?*
4. *Write here the caracteristics of the better launch to Mars :*

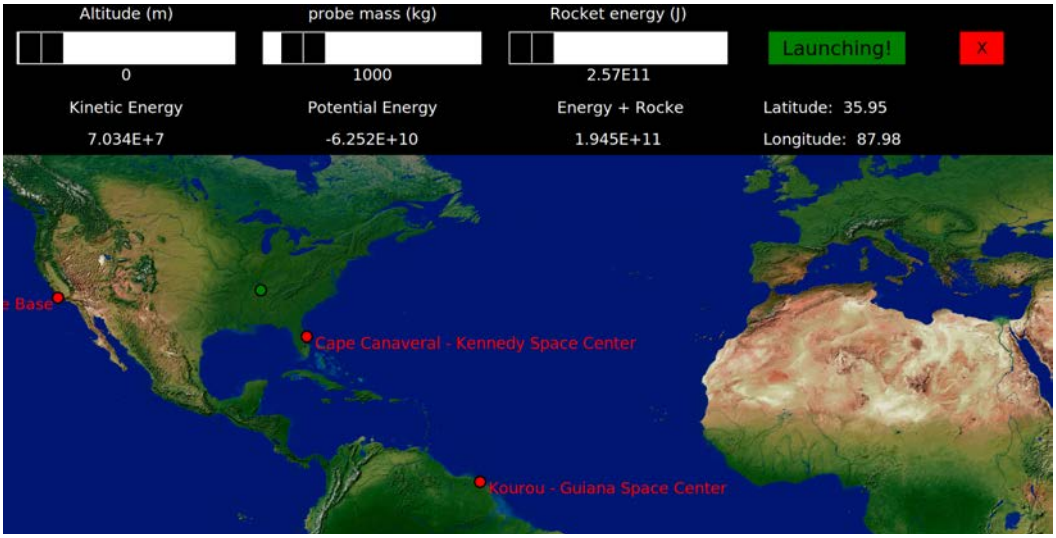
Rocket Energy	Latitude	Longitude	Initial mass	Departure day	Duration of the travel	Mass landed on Mars

The serious game 'E2M' run through 4 steps.
Each step allows to understand different things about space missions. You can stop the simulation by using the red button with the black cross. You can also go back to a previous step to modify some parameters if needed.

First step – Launching site
You can choose a launching site by a left clic on the map. You can move the map by drag and drop.

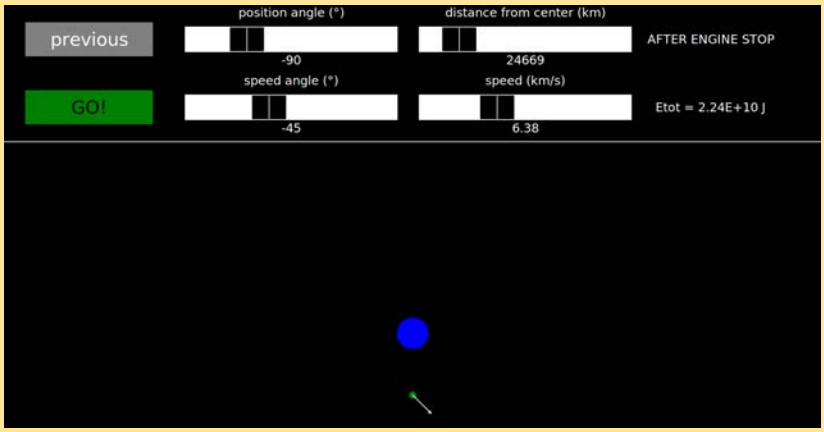
When the launching site is selected, the software calculate the potential energy (linked to the distance from the centre of the Earth) and the kinetic energy (linked to the rotation of the Earth and the latitude of the site). All the locations are not equivalent!
You have now to choose the energy of the rocket (in the range of what is possible for the Atlas V rocket used for the InSight mission). You can choose the initial mass of the space probe too.

These parameters will have an influence since the end of the simulation. You will probably have to go back to this step later.
Once all the parameters are chosen, click on the « launching » green button to go to the next step.



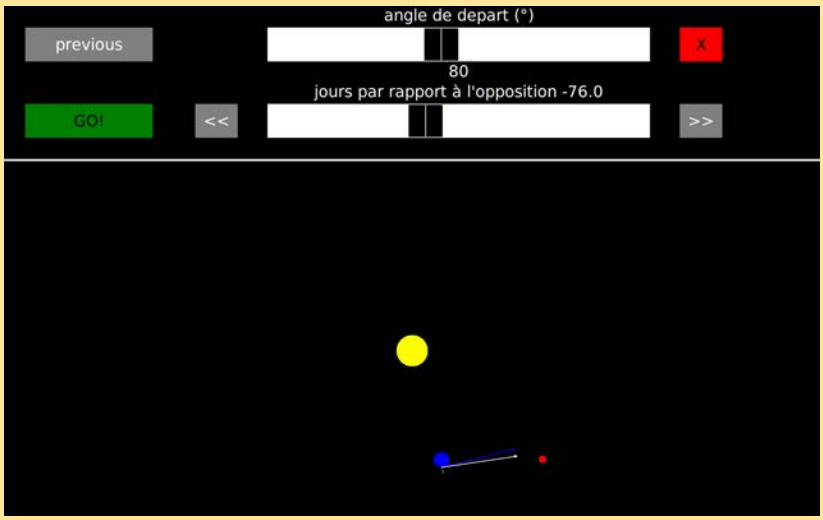
Second step – After the separation with the rocket
After the launch, the rocket gives his energy to the probe.

You can now view the different possible trajectories with this energy (you have to go back to the first step if you want to modify it).
The total energy is written on the control panel. You can easily verify that with a negative energy, you can only turn around the Earth with an elliptic trajectory and with a positive one, you can go out of the area of influence of the Earth (necessary to go to Mars). The residual velocity is as big as the energy is high. When the energy is zero, the reference is a residual velocity of zero at an infinite distance of the Earth.
You can also investigate the escape speed of the Earth (speed needed on the ground level to escape from the influence area of the Earth) by modifying the parameters of the step one.
If the energy is high enough, the probe goes away and the message « travel! » appears. The simulation goes alone to the third step.



Third step – Earth-Mars travel
In this step you can view the Sun, the Earth and Mars.

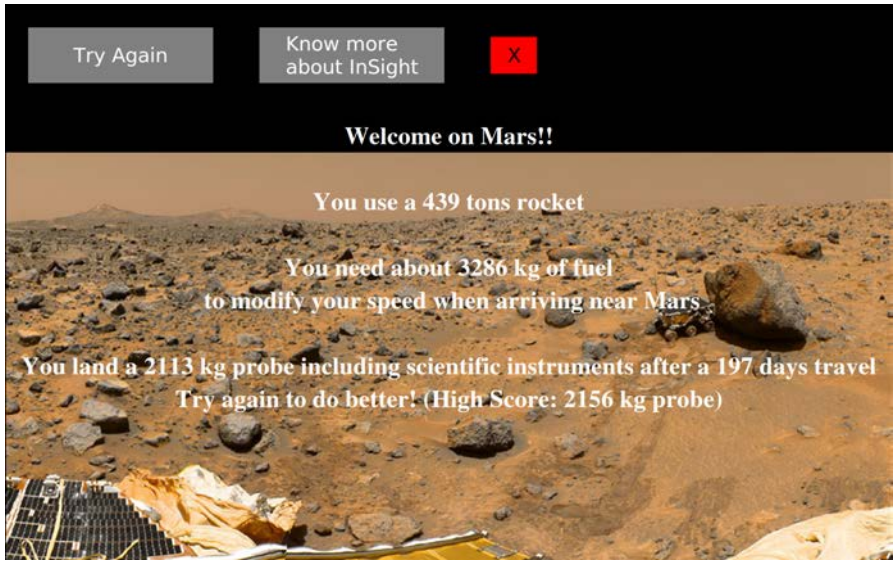
The probe escapes from the Earth with a residual velocity and you have to intercept Mars. Many trajectories are possible but the Hohmann transfer orbit is the most economic (it's the same case for a transfer to a geostationary orbit).



You have to choose the relative position of the Earth and Mars by choosing on the control panel the day against the opposition (day 0). You have to choose the direction of the residual velocity (green vector). The blue one is the velocity given by the rotation of the Earth around the sun and the white one is the sum of these vectors.
Once it's done, you have to press the green « GO! » button to launch the animation. If the probe burns into the Sun or if you miss Mars you can press the red « STOP » button to modify the parameters before to try again. When you reach Mars, the message « Landing » appears and the simulation pass to the fourth step (after two videos that you can skip).

Fourth step : The results

The probe has finally landed on Mars. But to do so, the probe have to modify his speed when arriving close to Mars and then slow down to touch the ground without problems. The simulation calculates the mass of fuel necessary to do so starting from the mass selected on the first step.
If the travel time is short, that means you have used a powerful rocket (expansive) and you will need a lot of fuel to modify your speed when arriving near Mars (that's why the travel is so long).



You can now optimize the parameters to land a more important mass on Mars with a less expansive rocket.

Have fun !