Ages: 14 to 17 years old

SCIENCE CASE

Mission to Mars II[1]

Team members

Writer: _____

Equipment manager: _____

Reader: _____

Spokeperson: _____

Computer technician: _____

Context

Nowadays, Mars is a cold and dry planet, but in the past, it was covered in rivers, lakes and, likely, an ocean. For this reason, scientists ask themselves: could there have been life on Mars?

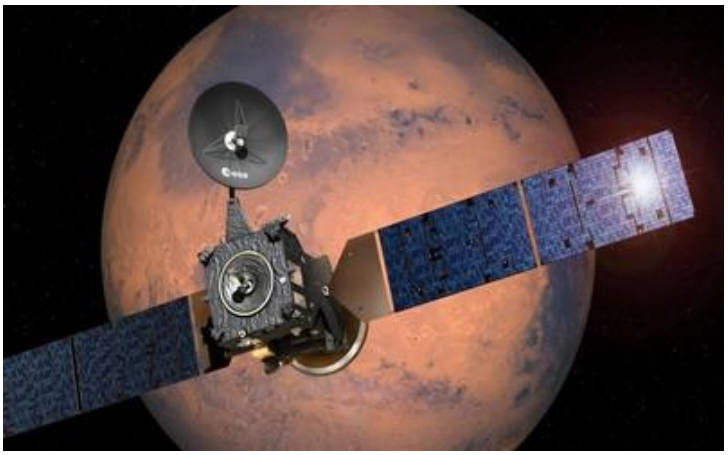


Figure 1: Artistic impression of Mars and the ESA spacecraft ExoMars (Credit: ESA/AP)

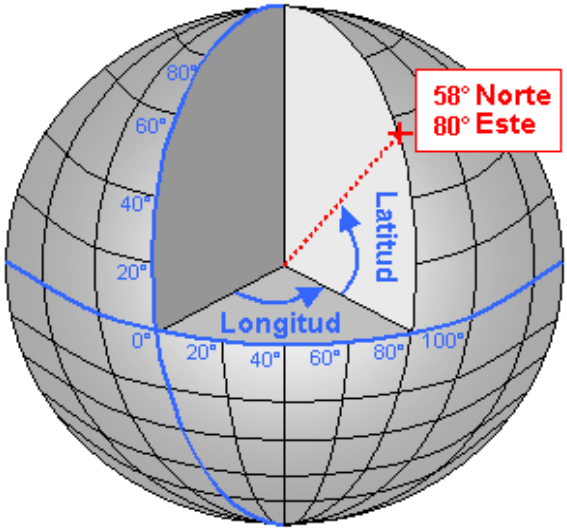
[1]*Educational material manufacturated by "Asociación Planeta Ciencias" under the initiative and coordination of the European Space Agency inside the CESAR program framework.*

This is one of the main motivations to send missions to the Red Planet. An example is the ESA mission, ***Mars Rover*** 2020, which will excavate 2 meters under the surface of Mars to look for evidence of life in the past. Before the ***rover*** (remote-controlled exploration device) stars to take data on Mars, it has to survive a long trip to the Red Planet and land successfully on its surface. Each mission to Mars needs many years of work and preparation, because it is very hard to **land on Mars**.

One of the key elements for the success of these missions is choosing the perfect place for landing a spacecraft on Mars. With your help we are going to identify it during this science case. But before that, let's review the concepts of **latitude and longitude,** which is what we use to locate ourselves on the surface of a planet (like Earth, for instance)

- The **latitude** measures the vertical position. It is the angle between the equator line and the spot we are in. In the Northern hemisphere, the angle is between 0 and 90º, whereas in the Southern hemisphere, the angle is between 0 and -90º (always negative value).
- The **longitude** measures the horizontal position. It is the angle between any given circumference that goes through the poles and the spot we are in (on Earth, that circumference is the **Greenwich meridian**). That angle is between 0 and 360º.

The latitude and the longitude are measured in degrees (º), minutes (') and seconds (").



Font: http://tarifamates.blogspot.com.es/2013/11/latitud-y-longitud-coordenadas.html

Science case: Landing on Mars

We are going to perform a mission to land a robot on Mars. We start by dividing into research groups:

Get to know the Google Earth software on Mars (for every team)

Access the Google Earth software and explore the selection of planets, learn how to turn them and choose several images (different colours of terrain).

Search with Google Mars for areas on Mars that look the most interesting to you.

Examples: Valles Marineris, Eos Chasma, Aeolis Mons

Research 1: From the point of view of the spacecraft, where (latitude, longitude, elevation) would you land on Mars? Why?

Taking into account the area on the planet that spins faster, where the spacecraft would go through more atmosphere (use Google Mars for that), identify a range of coordinates (latitude, longitude and height) where the spacecraft would land more safely / easily.

Justify your answers.

Research 2: From the point of view of the rover (explorer robot), which terrain would you land on? Why?

Taking into account the orography and the kind of terrain on Mars (use Google Mars for that), identify the type of place with the range of coordinates (latitude, longitude and height) where you would land on Mars.

Justify your answers.

Research 3: From the scientific point of view, where would it be more interesting to land on Mars? Why?

Taking into account that there may be past life on Mars, we could find areas where there had been liquid water back then, and therefore it could contain life as we know it on Earth.

Conclusions (a speaker by team)

Put the obtained results of the research by each group in common and try to find an optimal point of landing on Mars.

More educative resources (for teachers):

Google Earth Pro:
https://www.google.com/earth/

Cuadernillo de CESAR: *El Sistema Solar*
http://cesar.esa.int/index.php?Section=Booklets

Exploración en Marte (ESA):
http://exploration.esa.int/mars/

http://exploration.esa.int/mars/44997-the-red-planet/

http://exploration.esa.int/mars/43608-life-on-mars/

http://exploration.esa.int/mars/53845-landing-site/
http://exploration.esa.int/mars/58307-the-hazards-of-landing-on-mars/

Geological maps of Mars:

https://pubs.usgs.gov/sim/3292/

ESA Education:
http://www.esa.int/Education

Project CESAR:
http://cesar.esa.int/

ESA Kids:
http://www.esa.int/esaKIDSes

Planetary Latitude and Longitude:
http://tarifamates.blogspot.com.es/2013/11/latitud-y-longitud-coordenadas.html

DEVELOPMENT OF THE MISSION

Get to know the Google Earth software on Mars

Material for the preparation

- Computer or device with touch screen
- Installed ***Google Earth Pro*** software

Let's get to know how to use *Google Earth* software, in particular in Mars.

- Open the program Google Earth.
- At the top of the screen, there is a symbol of a ring planet, use that button to select the planet to explore.

Figure 2: Software Google Earth showing Earth (Credits: Google Earth)

You can use the symbol of the hand to rotate the planet. Like this, you can easily see every perspective of Mars and compare them among themselves. You can also select different layers, which correspond to images of the terrain in several colours (see an example in Figure 3).

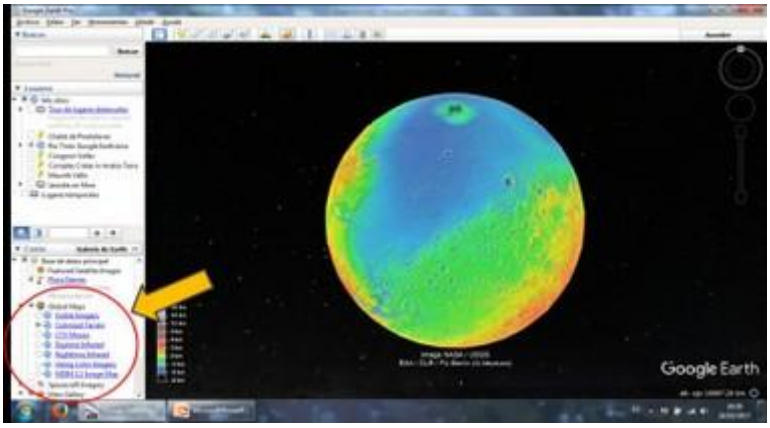


Figure 3: Areas of Mars as seen in different colours depending on the terrain (Credit: Google Earth)

Search with Google Mars the areas that look more promising on Mars. For instance, Valles Marineris, Eos Chasma, Aeolis Mons...

RESEARCH 1: LANDING A SPACECRAFT ON MARS

Material for the research

- Computer or device with touch screen
- Installed ***Google Earth Pro*** software
- Globe of the Earth

Step 1. Latitude and Elevation

Use the globe and point somewhere on the surface of the planet. As the planet rotates, the point moves in a circle. This point would describe a maximum circle on the Equator and a minimum circle on the poles.

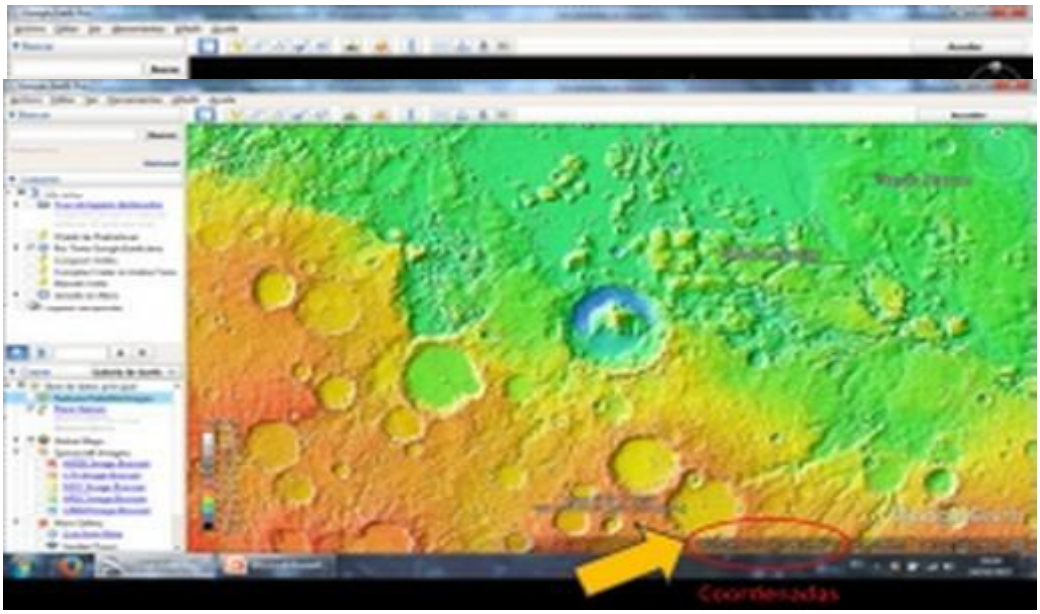
Knowing this, Where do you think the planet rotates faster: close to the equator or to the poles? Why?

Open the **Google Earth** program and change the planet to Mars. From now on, we will call this option **Google Mars.**

Imagine your spacecraft traveling from Earth to Mars at top speed. In which part of the planet will the spacecraft have to slow down less to catch up to the rotation of the planet: close to the Equator or close to the Poles? Explain why you think that.

Step 2: In Google Mars, choose the option "***Colorized Terrain"*** in the section "Global Maps" and a colored image of Mars will appear. Here, the highest areas appear as orange

or brown, and the lowest ones appear as blue. These images will help you compare both hemispheres.



What differences can you see between the two hemispheres of Mars? In general, where can you find the highest areas? And the lowest ones?

This difference between the two hemispheres of the planet is called "**global dicotomy**" of Mars.

Using Google Mars, identify:

The coordinates of the **highest areas** in Mars.

Name	Altitude	Coordinates

The coordinates of the **lowest areas** in Mars.

Name	Altitude	Coordinates

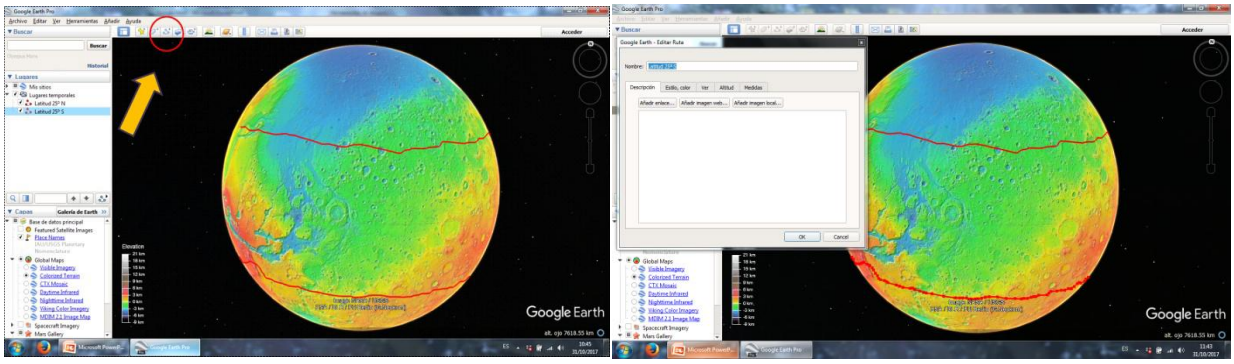
Since the Martian atmosphere is very thin, most of the landing equipement use some sort of parachute to help slowing down the spacecraft.

Where do you think the **parachute** could be more effective: the highest area or the lowest area of Mars? Why?

Taking into account every discovery in steps 1 and 2, and specially the general shape of the Martian surface, arrive at your own **conclusions**:

Where do you think it is safest to land on: Northen hemisphere or Southern hemisphere? Why? Draw it in Google Mars.

NOTE: To draw in Google Mars, you have to go to the option: adding a route (as shown below):



RESEARCH 2: From the point of view of the rover, which terrain would you land on?

Material for the research

- Computer or device with touch screen
- Installed ***Google Earth Pro*** software

Now that we have decided which latitudes are safer for landing, we need to find a more specific región where the satellite can land safely.

If the satellite does not survive landing, the misión would be a failure. Finding a landing spot where the satellite suffers the least is of major importance.

Step 1: What surface would you avoid for landing?

Step 2: Inside the area of the chosen latitudes, mark:

- with green circles the safest places you found to land, and
- with red circles the avoidable or dangerous ones.

Why did you chose those?

Step 3: Would a choice be any of the following: Valles Marineris, Eos Chasma, Aeolis Mons? Inspect them with detail and provide an answer.

Valles Marineris

Eos Chasma

Aeolis Mons

RESEARCH 3: Geological history of Mars

When choosing the landing site, considering an area with the greatest scientific interest possible is very important. Therefore, geological characteristics and the age of the terrain are two key aspects for landing.

The geological history of Mars can be divided into the periods Noachian, Hesperian and Amazonian. These geolical periods can be distinguished by specific minerals, which reflect climatic changes on the planet.

- **Noachian**, or Mars ancient period, goes from 4.1 to 3.7 billions of years ago. During that period the planet was more humid and warmer than nowadays. There was a large amount of liquid water running through the Martian surface, excavating huge tunnels. There was also a magnetic field that protected the surface from the solar wind, which is what still happens on Earth.

- **Hesperian** took place between 3.7 and 3.0 billion years ago. This was the time of great volcanic activity and great floods in Mars. There were extensive lava plains, and the liquid water was less extended and more acidic.

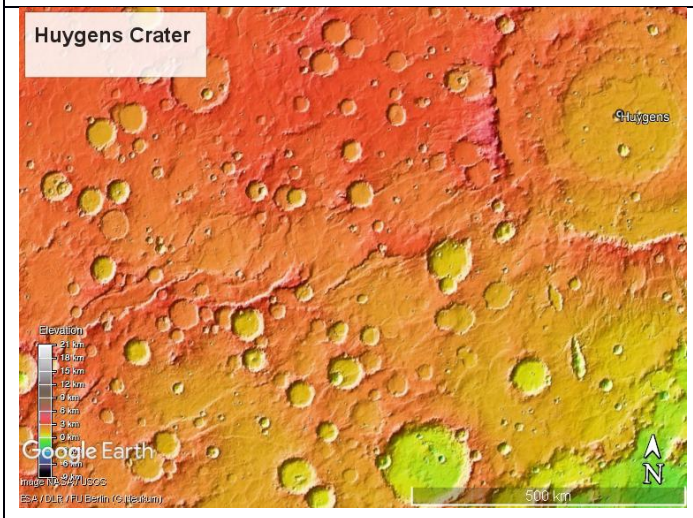
- **Amazonian** lasts since 3.0 billion years up until now. During this period, the magnetic field disappeared, which allows the solar wind to reach both the Martian atmosphere and surface. This event caused the water to be divided into hydrogen and oxygen, its molecular components. The Martian atmosphere could not retain the hydrogen and it was dragged by the solar wind into space. On the other hand, the oxygen oxidized (rusted) the whole planet: the reddish color of the surface is due to the iron oxide.

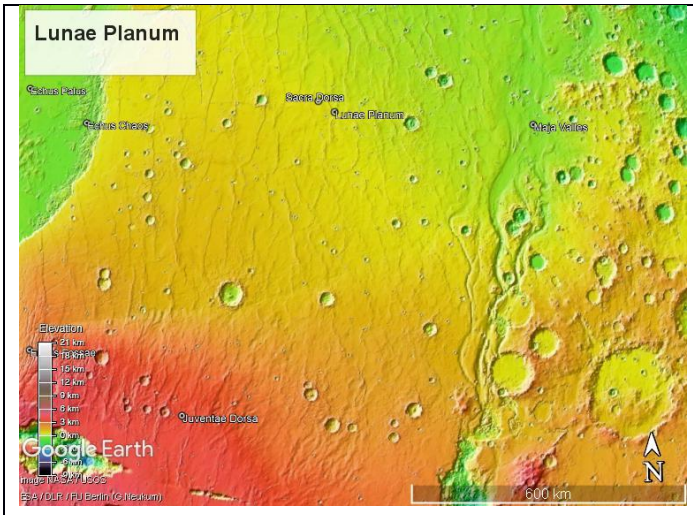
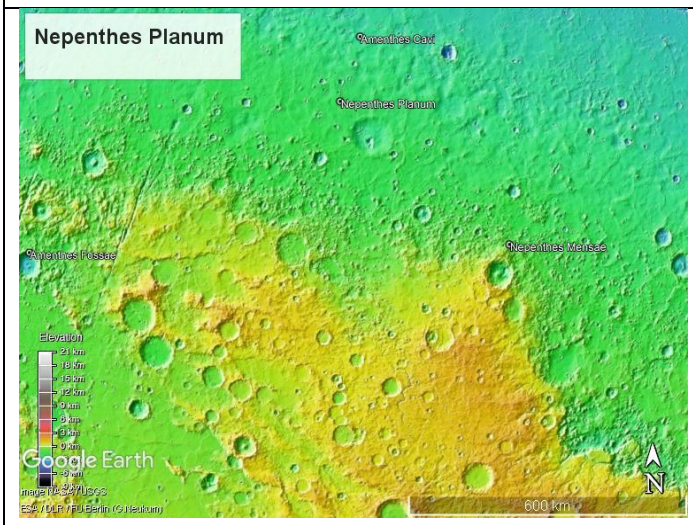
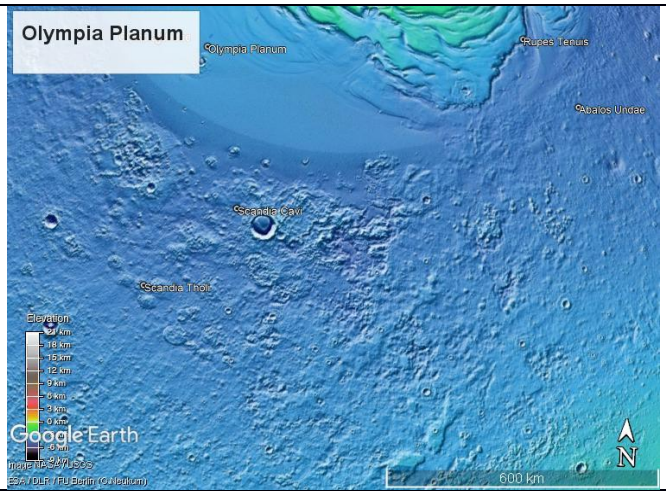
Step 1: After reading the previous information, answer the following questions:
Which one is the period with higher probability of having harbored life on Mars: Noachian, Hesperian or Amazonian? Why?

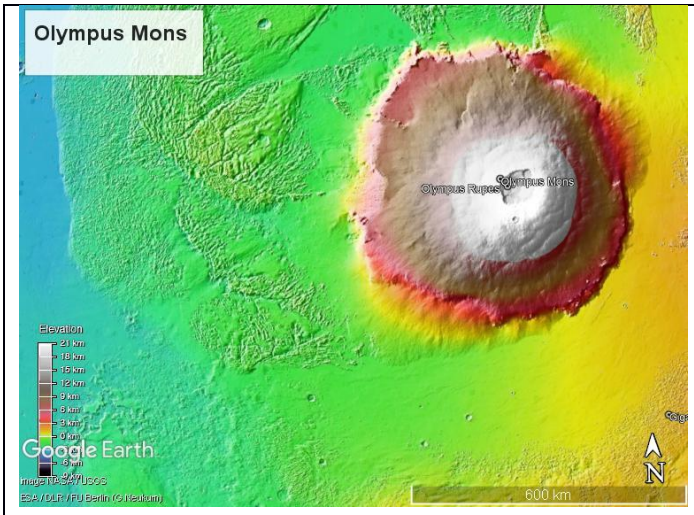
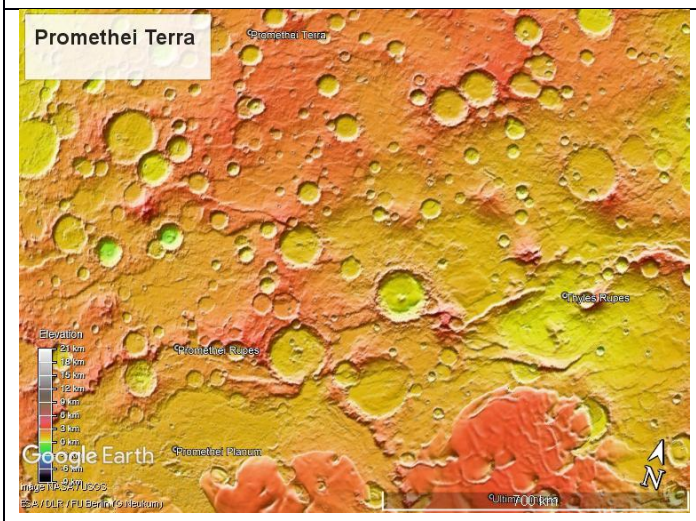
In **planetary geology**, we can know – approximately – the age of a Surface by counting the number of craters (impacts) that it has. An ancient surface has a great amount of craters, since it has been exposed longer to impacts, and those craters are bigger; whereas a younger surface has been formed more recently and therefore it is younger, geolically speaking.

Step 2: You are going to see different Martian surfaces. Try to determine its approximate age.

Which geological period do these Martian pictures belong to?

Picture	**Martian period**
	

 Lunae Planum Tithonium Chasma Lunae Planum Elevation Google Earth 600 km N		
 Nepenthes Planum Nepenthes Planum Nepenthes Mensae Elevation Google Earth 600 km N		
 Olympia Planum Olympia Planum Rupes Tenuis Abalos Undae Scandia Cavi Scandia Tholi Elevation Google Earth 600 km N		

Step 3: Finally, we want to determine which specific characteristics could be more interesting to study, from a geological point of view, and this could be use to determine the landing site in Mars.

When scientists look for signs of life, they often start by looking for signs of water. **ILD** (*Interior Layered Deposits)* are an interesting geological formation you can look for, because they indicate the presence of water in that area in the past.

These deposits in layers or sheets have been analysed and they have shown hydrated minerals (they need to be in contact with vast amounts of liquid water to be formed). Since there are many layers, one on top of the other, there is a very good chance **some traces of past life can be found**, if there was any at some point.

The following picture shows the deposits in layers from Juvenae Chasma, as taken by the instrument CASSIS on board of the ESA misión, TGO (Trace of Gas Orbiter).

Interior Layered Deposits (ILD) from Juventae Chasma, in a picture taken by ESA misión, TGO. The picture covers an area of 25 x 7 km wide. Copyright: ESA/Roscosmos/CaSSIS, CC BY-SA 3.0 IGO.

Choose in Google Mars the visualization option “CTX Mosaic” mode. This mode allows to see pictures of the Martian surface with greater resolution. Follow these instructions:

1. Find “Ganges Mensa” in Google Mars (type it on the search box)
2. Zoom out from the picture until you find objects of 80 km of height. That information can be seen in the right corner called “eye alt”.

Can you find the Interior Layered Deposits (IDL) in Ganges Mensa?

Do you think there is a place where you can safely land your spaceship in this región? If not, why do you think the robots have never explored this región?

CONCLUSIONS

Taking into account what we have learned and discussed today, the time for **choosing the landing site on Mars** has come!

Finding a balance between every aspect of the mission, according to the different research that each team has been carrying, is going to be difficult. Remember that team work requires to listen to everybody and to reach an agreement in the perfect spot for landing on Mars. Answer every yes or no question below.

Team members

Expert in Google Mars handling: _____

Expert in efficiency/safety of the spaceship: _____

Expert in efficiency/safety of the rover: _____

Expert in scientific data of Mars: _____

Coordinator of the team: _____

Does the **place for landing on Mars** fulfill the following **conditions**? Answer **yes** or **no**:

Does it have a correct latitude?	
Does it have and adecuate terrain?	
Does it have information from an interesting period of Mars history?	
Are there traces of past water nearby?	

Spot for the Mars landing: look for the following data using *Google Mars*:

Name of the area	**Latitude**	**Longitude**	**Observations**

What difficulties have you encountered when looking for a perfect spot for landing, given that the place had to be both safe and scientifically interesting?