

## TO MARS AND BEYOND

Interview with Dr. Firouz Naderi, the director of solar system exploration at NASA JPL



***NASA's Jet Propulsion Laboratory (JPL) is the leader of the planetary missions. Located in Pasadena, California, this laboratory is responsible for the operation of NASA's planetary spacecraft and its deep space network. The Leonardo Times was able to have an interview with Dr. Firouz Naderi, who is the director of the solar system exploration program at JPL, to talk about the new exciting missions NASA has planned for future.***

TEXT Aryadad Fattahyani, BSc student Aerospace Engineering, Editor Leonardo Times

***Could you tell our readers about yourself and what you have been doing at JPL?***

Well, seeing as I have been at JPL for 33 years, there is a lot of ground to cover. Let me begin by telling you about what I am currently doing at JPL. Right now, I am the director for solar system exploration and discovery missions to all target bodies in the solar system except for Mars, which is a different program. We are currently doing a number of things right now: we have a spacecraft that has visited and orbited asteroid Vesta, the second largest asteroid, and it is now headed to the largest asteroid, Ceres. This is the first time that we can actually go into orbit around one body and come out and go into orbit of another body, and this is because we are using solar electric propulsion, which enables us to do this. We have also have

a mission around Saturn, called Cassini. It has been there since 2004, so almost ten years, and it is studying Saturn, its rings, and its moons Titan and Enceladus. We also have a mission that is on its way to Jupiter, which called JUNO; it is the first solar powered mission to deep space. Usually, nuclear power is used for such deep space missions. In addition, we are working on a mission that we are going to land on Mars in 2016, which will put a seismometer on the surface of Mars, so that we are be able to use the seismic waves to understand the interior of Mars. Another two mission are very exciting and are currently in the planning stage: first, we will be sending a spacecraft to study Jupiter's moon Europa, to better understand the nature of the ocean on Europa. Perhaps the most exciting mis-

sion, which was announced by NASA only a short time ago, is that we are going to try a deep space rendezvous with an asteroid and correct its orbit so that when it comes back to Earth, it can be captured by the Moon, and then astronauts can fly to it and study it.

***You started working at JPL in 1979; in your opinion, what is the most challenging aspect of working at JPL?***

Well, the space exploration is a challenging activity; basically all the activities we do at JPL are challenging projects. They are usually novel and first-time missions and nobody has attempted them before, so I would say the very nature of space exploration is perhaps the most challenging aspect.



Figure 1. Dr. Firouz Naderi

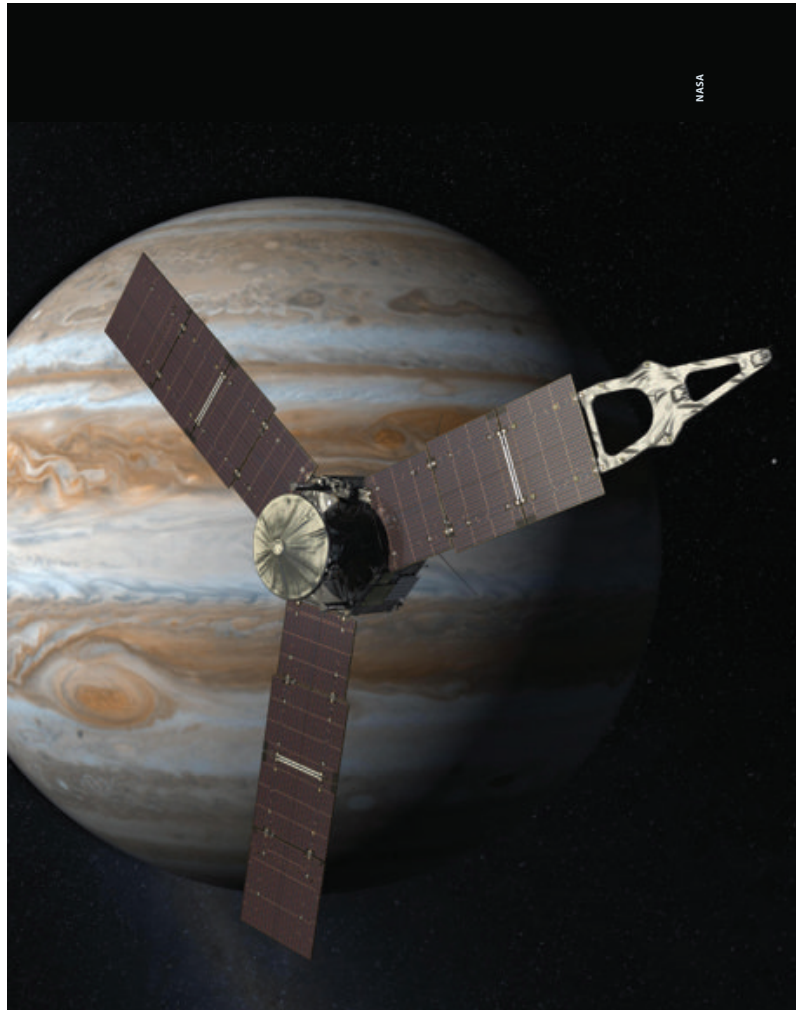


Figure 2. NASA's JUNO orbiter is to enter its orbit around Jupiter in 2016

***TU Delft is renowned for its aerospace programs. Have ever worked with people from TU Delft or have you ever heard about the programs?***

No, unfortunately I have not had an opportunity to work with your university.

***A Dutch private company is planning to establish a permanent colony on Mars by 2023. This is the Mars One program and entails people volunteering for a one-way trip to Mars. Do you think this is a feasible project? Do you think that people can live on Mars with the current developing technology? If not, what would be the major problems?***

The answer to the first questions is no, it will not happen. Humans on Mars are at least two or more decades away. The single biggest problem would be the entry, descent, and landing on Mars. The largest thing we have landed on Mars was Curiosity. Curiosity weighed a ton and the delivery system near the surface of Mars weighed in at another ton, so we have delivered two tons to the surface of Mars. In order to land humans on

Mars, we would need to land something in order of 40 tons. The problem is that basically, the technology of how to land something of that size is not available. An additional problem is that we also do not have the technology right now to sufficiently protect the humans biologically during the time it takes to travel to Mars. All in all, I think the whole notion of land-

**“ All the activities we do at JPL are challenging projects. ”**

ing humans on Mars by 2023 is, with all due respect, preposterous.

***Time to talk about some technical aspects of your job. With the current Mars missions and the InSight mission, there is a lot of emphasis on the exploration of Mars. We know that our solar system might have more to offer. For example Europa has an ocean under its surface, so life could potentially exist over there. What would you say is the most promising candidate for future non-Mars missions?***

Well, it has to be Europa, which offers the most promise for existence of life. It certainly has the water required. In fact, the ocean in Europa is estimated to contain two times as much water as all of the oceans on Earth combined. There might be chemical energy, which is required for metabolism and biological activity. We believe that the molecules, the organics, will also be available. So, that would be the location or the target in the solar system with the most promise for biology today. Furthermore, finding life on Europa is more exciting than finding life on Mars, because there is always a probability that the life that has evolved on Earth might have been seeded by Mars, or vice versa, through some kind of meteorite. This means that the source for life on Mars and Earth could conceivably have been the same. If we were to find life under the crusty ice of Europa, that would be a definite second genesis of life in the solar system, which would be very exciting in the sense that life, independently, arose in two different and separate locations in the solar system.

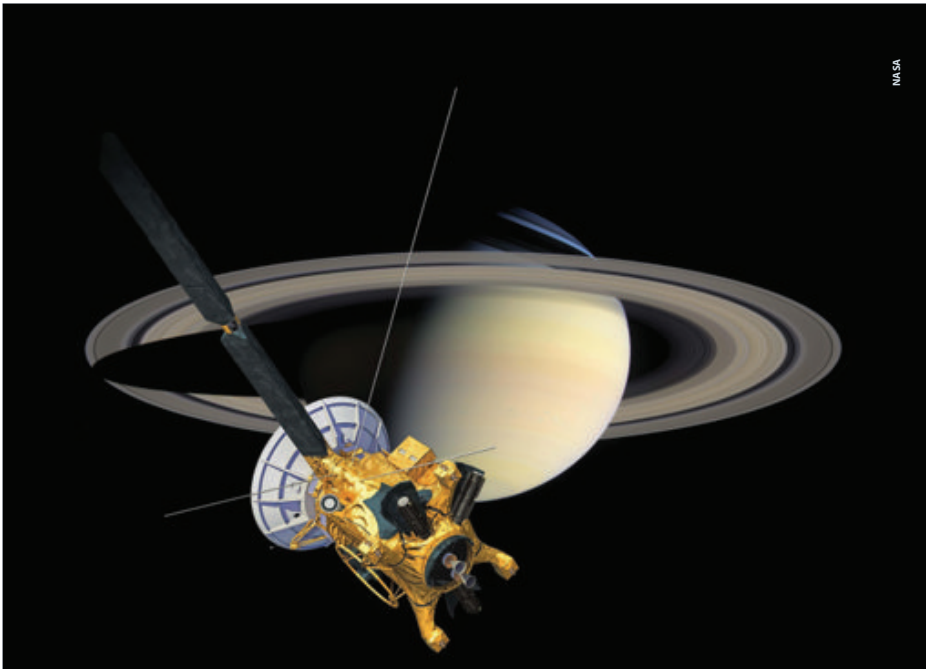


Figure 3. NASA's Cassini orbiter was accompanied by ESA's Huygens probe



Figure 4. NASA's Mars Odyssey has been on-mission since 2001

*Other than the JUNO mission that was discussed earlier, do you have any plans regarding the exploration of Europa?*

**“Humans on Mars are at least two or more decades away.”**

Yes, we do. In fact, we are trying get a mission funded to go to Europa in 2021, although we will not be putting the spacecraft into orbit around Europa itself. Because of the radiation, such a mission could probably not last for more than a

month. Instead, we are going to put the spacecraft into an orbit around Jupiter with 32 flybys of Europa. Every time we fly by, we are going to use the gravity from Ganymede and Callisto to change the orbit of the

spacecraft to obtain full coverage of Europa. The name of this mission is Europa Clipper and it would likely cost about 2.5 billion dollars. We are currently in negotiation with NASA and Congress to get it funded.

*With the current budgetary difficulties, how does JPL try to maintain the absolute leading role in the field of planetary exploration it has been playing over the past decades?*

As you may know, JPL has had more planetary missions than the rest of the world combined. So, as you mentioned, it is the global leader in planetary exploration, and NASA is committed to maintaining the expertise that has been developed and evolved over five decades at JPL.

*The USA, and California in particular, sees a rise in commercial space companies such as SpaceX and Xcor. Does JPL, apart from NASA COTS/CCAP grants, plan any collaboration with these entities and do you think that it would be beneficial to collaborate with these companies?*

Well, SpaceX builds rockets and we make spacecraft, so the chances are quite high that in the future, we will use SpaceX to launch some of our spacecraft. For example, the Falcon 9 Heavy would be a promising launch vehicle to go to deep space. So yes, we will be using their rockets.

*Looking at the JUNO satellite, we see that it is the first beyond-Mars mission without RTGs, i.e., Radioisotope Thermoelectric Generators, do you think that this will be a trend for future deep space missions?*

Well, it is not truly the first one beyond a Mars orbit to do this. There is also the Dawn spacecraft, which uses solar electric propulsion and solar arrays, which is currently operating in the asteroid belt, which is also beyond Mars. JUNO would indeed be the first mission without such generators that we have sent to any of the outer planets. It is a law in the USA that every time we want to use a nuclear powered spacecraft, we have to show that there was absolutely no alternative. This means that every time we even contemplate using technologies as ASRGs, i.e., Advanced Stirling Radioisotope Generators, or MMRTGs, Multi-Mission Radioisotope Thermoelectric Generators, we need to show that solar powered spacecraft would not have been a possibility. For now we believe that we will probably be using nuclear power again for the Europa Clipper mission.

*Over the past years, there has been a trend towards miniaturization and use of Commercial Off-The-Shelf (COTS) components in spacecraft. Do you foresee a similar trend in planetary exploration spacecraft? For example, the use of multiple micro rovers instead of one single larger rover.*

At JPL, in order to make sure that our engineers develop a broad range of skills, from mega spacecraft to small spacecraft, we are also now looking at cubesats that

could be delivered to the target by the mothership. While at target, the cubesats will separate and do some complementary science. For example, for the Europa orbiter, even though we are in an orbit around Jupiter, we are thinking about including potentially five or six cubesats that would separate. They would go towards Europa and eventually crash into it, and along the way, they would be using magnetometers, spectrometers, and imagers to get close-up data from Europa. We are also using cubesats in other ways. So far, all the cubesats that have been launched have been in Low Earth Orbit; JPL is working on the world's first interplanetary cubesat that we can hopefully launch sometime in 2014. I mentioned the asteroid retrieval mission earlier, of which I do not know whether it has publicized it in Europe yet, in which we are planning to bag an asteroid. We think we will take a cubesat and release it, so that it could image or video the actual capture of the asteroid.

*Since you have been involved in the projects such as Spirit and Opportunity, our readers might wonder how long it usually takes to go from the preliminary design of such rovers to the final design. How long does this whole process take?*

Well, Spirit and Opportunity were actually exceptions. Typical cycles from the very beginning to actual launch for planetary missions take five years. We did Spirit and Opportunity in two years, which was very remarkable and will probably be very hard to duplicate again. But, as I said, the process takes approximately five years for typical mission.

*Time to move on to the well-known Curiosity mission. How satisfactory has the mission been so far? How long are you expecting the rover to be operational?*

The mission has basically achieved its scientific objective. The scientific objective of Curiosity was to find out whether Mars could have the potential to be a habitat; not that it has been, but could that it could have been a habitat. We now know that the answer is yes because we have found rivers where water which we could drink has flowed, maybe up to knee-deep. We have also shown that all the biogenic elements like oxygen, carbon, hydrogen, sulfur, phosphorus, and nitrogen are all present on Mars, and furthermore, we have found molecules in different states of oxidization, which means that they would have had the chemical energy to metabolize a biological entity. All in all, we have shown that Mars could indeed have been a habitat. We have not shown that there currently is or has been biol-

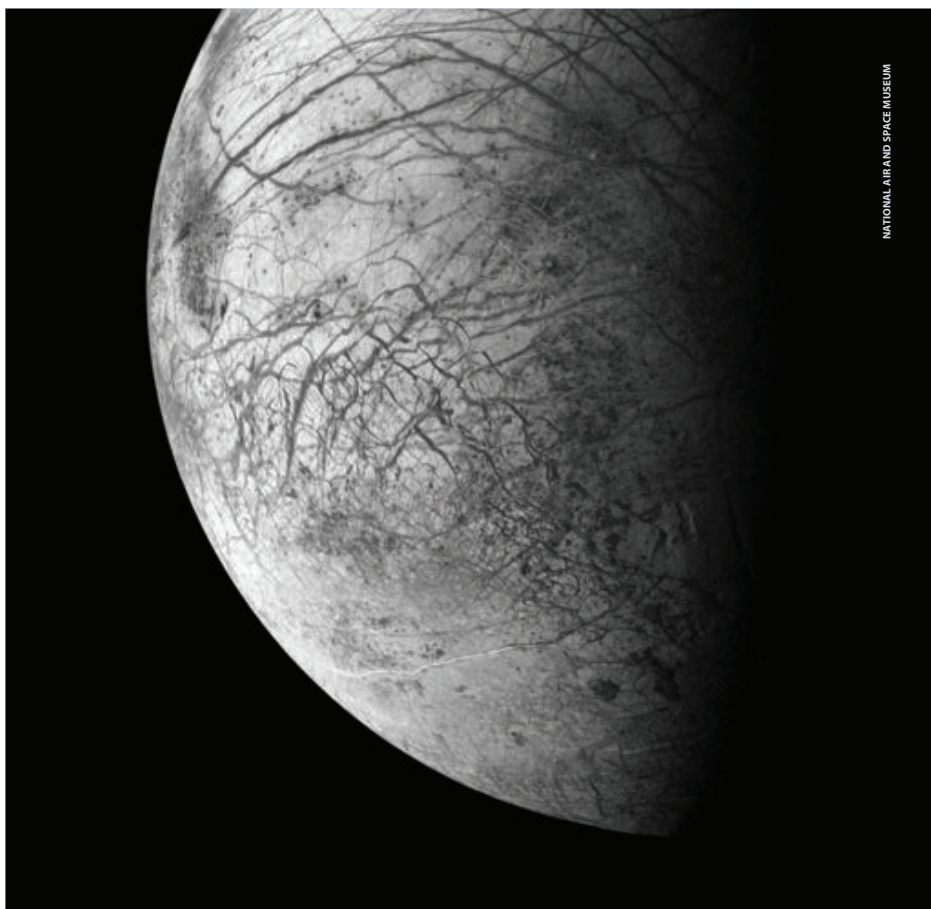


Figure 5. Europa, one of Jupiter's moons

ogy on Mars; this was not the objective of Curiosity. The objective was to find out whether it could have been a habitat and the answer is yes. As far as the lifetime, consider that we designed Spirit and Opportunity with a period of ninety days in mind and Opportunity has now been operational for nine years. Curiosity has been designed for two Earth years, i.e.,

so it has to basically stand down for a month.

*As the director for solar system exploration, what do you see for the future of space exploration for the next decade or two? How much progress are you expecting NASA to make regarding this issue by that time?*

I have mentioned to you some of the most challenging missions a decade ahead: the Europa mission, the asteroid retrieval mission, and potentially with Mars 2020, the first leg of a Mars sample return from that planet.

*A hypothetical question: if you could set a mission goal for exploration without any concern for budgetary requirements or political support, what would that goal be?*

Maybe a Hydrosat to the ocean of Europa where you would in fact land on the surface of Europa. You could then have a nuclear jet that could melt its way through the thickness of ice. This could then go underneath the ice, leaving behind a tether so it can communicate back to the surface and eventually to Earth. From there, we could go to the ocean below and maybe a submarine of sorts would detach and explore the ocean and send information back via sonar (SOUND)

## “ Finding life on Europa is more exciting than finding life on Mars. ”

one Martian year, so who knows how long it would last! I would certainly not be surprised if goes for a decade.

*While on this topic, let us focus on the solar conjunction between Earth and Mars that is currently happening. How did you manage to control Curiosity during this period?*

We have just been able to restore communication with Curiosity. And as for communication, you really do not communicate. You have minimal communication: you simply do not do anything and you do not command it to do anything,

Navigation And Ranging) to the ship. This could in turn be transmitted to Earth, together with the images taken and data collected. This mission could potentially find that there is some form of evolved life in the oceans of Europa.

*It would be interesting for our readers if you could share with us one of the best memories of your career?*

I was named the Mars program manager after NASA had experienced two failures in 1998 and 1999. This meant that the very first activity or launch to Mars under my direction was the launch of Mars Odyssey in 2001. Seven months after the launch, at the control room, we were all waiting to get a Doppler signal indicating that the orbiter had successfully wrapped itself around Mars. Especially given that the previous two NASA attempts has resulted in failure, everyone was looking to have a success. For those two or three minutes when we were waiting for the Doppler

signal to come back and say that indeed we are in orbit around Mars, those were some of the hardest times. But of course, we did it successfully and we went on to build Spirit and Opportunity, and afterwards Phoenix and finally Curiosity. So, all in all, we have had the good fortune

**“ The objective of Curiosity was to find out whether Mars could have been a habitat. The answer is yes! ”**

of having six successful missions to Mars whereas previously, the record of Mars exploration has not been very good.

*As my last question, I would like to ask you, as a person working for NASA, what your advice would be to enthusiastic students who would want to work in the same field as you do?*

The success in a career does not happen overnight, so you need to be passion-

ate about the job that you do and you need to remain curious. Every five years, I have changed focus at JPL. I started my job at JPL working on communication satellites, did that for five years and then changed focus to Earth remote sensing, which I then also did for five years. After that, I did astrophysics and managed Mars programs, each for five years. Then I did strategic planning and finally moved into my current job, which I started two or three years ago. Some people would like to stay in a single field and

spend twenty or thirty years on it. That is very good because then they can become world experts in one field; I prefer to be familiar with many more aspects of space exploration and that is what has kept me interested for more than thirty years. ✓



Figure 6. An aerial view of NASA's Jet Propulsion Laboratory