



**EXCERPT OF THE Q&A (Names are not indicated, for uniformity. For the complete Q&A part, you may view the video here: <http://tinyurl.com/NASAEngrtoUPD>)**

**Q1: *I just wanted to hear someone from NASA telling us why is it worth what we're trading it for? (Referring to the opportunity cost of allocating a budget in NASA versus spending in "feeding children in Africa or giving medicine, or education for prisoners)."***

**Villar:** I'm going to use the U.S. budget... 'cause I'm not really aware of the Philippines' budget.. but actually, everything NASA does is less than 1% of the overall American budget. So I think we're getting a lot in return. Let's say, if you have a hundred dollars, we're using just one cent of it not just to build not just Curiosity, but everything NASA does.

It's beyond me to understand where that money is going to help, like poverty or education, — the only thing I can say is that NASA is operating on a very, very, very small amount of money, relative to our national budget.

I do agree that it's within the politicians' responsibilities to report where the money goes, but as far as the US is concerned, NASA has very, very, very small budget. It's going to other places. I don't know the education budget is but I'm sure, I would imagine it's more than like NASA.

When we build spacecraft like Curiosity or satellites, we're also developing technology which helps the poor, whether it's communications, or technologies for third world countries, like plumbing systems (He gave an example.).

When we build stuff, it's not just for space exploration, which is, we should be doing that, right, for our curiosity of our cousins in whole wide universe. But we're actually, every time we do something, we are actually building technologies that can help us on Earth too... on very little money relative on our national budget.

**Q2: Recently SpaceX launched another resupply mission for NASA, Do you as a JPL engineer, feel threatened by the rise of SpaceX?**

**Villar:** That's a common question. Actually, no. SpaceX and JPL have very different objectives. SpaceX right now is into launch vehicle for their resupply missions. JPL is focused on solar system exploration. Completely different things. Like the NASA centers, they are all have their own specialties. Although SpaceX is planning to go to Mars, I think in 2018, they are trying to send their first spacecraft. It's really exciting. Actually, no one in JPL that I know of see them as competition. We see them as, 'we are all in the space industry together,' like 'we're one human, not SpaceX or JPL or whatever.' We're doing this for the sake of space. Actually SpaceX consults with JPL or areas that they are starting at like EDL- entry, descent, and landing, that's one of our specialties so they ask us. They consult with us. But they are doing amazing things and I have friends who work there. Sometimes people move between JPL and SpaceX or some other company and come back. I feel it's one human [inaudible] trying to explore the universe. They are doing awesome stuff. We always watch what they're doing. It's great

**Q3: What academic path do you recommend for me or for us who also aspire to have a job as yours?**

**Villar:** NASA usually recommends, 'you shouldn't go to the field because you wanted to be an astronaut but you should do something that you love.' Because it's really hard to be an astronaut so you need to make sure you're actually in a field that you're able to do even if you don't do that (become an astronaut). The reason I said that because in NASA JPL, we have people, 5000 employees. There are people with Math degrees, Mechanical Engineering, Electrical Engineering, Business, Economics [...].

You should try to go to a field that you really enjoy-- 'learning the concepts' versus 'I want to be these jobs.'

**Q4: What are you excited for in the near future in space technology, or maybe in the Philippines' space technology?**

**Q4a: Do you play Kerbal Space Program?**

**Villar:** Is that a game? (Student: It's like a space simulator. I heard lot of guys from NASA play this game.) I don't know. Well a lot of people play PokemonGo.

I think the biggest thing I'm excited about is getting a human to Mars and that's what NASA is working on. We're trying to get a human to Mars in 2030s. It is not just NASA, there are other organizations there that are trying. There are companies that are trying to send people to fly by Mars and come back, or send people to Mars one way and never come back. We're still a whole way but The Martian [movie], it is ... we're in the beginning stages of that but hopefully one day we can send a human to Mars. Outside of that, we always talk about Mars, right, 'cause it's the closest planet. But there are a lot of interesting bodies in the solar system like Europa, which is the moon of Jupiter and some others which has underwater oceans. So if you think that, there could a life there too. So hopefully NASA or any space agency can explore other bodies to see what else is out there aside from Mars. But Mars is cool so that's what I'm excited about.

**Q5: (with reference to the comparison of Mars' landing site as that of the Grand Canyon) I would like to know if you know the specific geological aspects [in Mars], say, rock composition or surrounding elevation or the landing site that made it safe for the rover?**

**Villar:** I don't know the specifics, but I can tell you that whenever we choose a landing site, that process also takes years. For example, for 2020, we started that two years ago. So every year we come together with the science community. To simplify this, there are two camps-- the science where they want to see the interesting part about the landing site, and the engineering or how safe it is. Usually they don't agree because the safest place is the flattest place, and it's kind of boring. So we have to find a balance between interesting science and places safe to land. So Gale crater was good from a scientific point of view because of the layers but also good for landing because it was lower on Mars. The lower it is on Mars, the more time we have to react to EDL (Entry, Descent, and Landing), the more time we could use the atmosphere to slow down. Usually landing sites that are much lower are more beneficial for engineering purposes. It just so happen that that was a good balance of the layers for geologist and the heights and the ground for EDL.

**Q6: How do you see the rovers developing in the future? Anything really cool, like flying stuff, like drones or something, or manned rovers?**

**Q6a: What would it take to build a colony on Mars?**

**Villar:** I think you're saying drones. I think I'm allowed to say this... but it was being proposed that we would have a helicopter on the next rover. But it's not final yet. But hopefully, in the future, whether the next one, it would be cool to have drones paired with the rover. That'd be really cool.

The next question. The colony. The last class I took was Human Space Flight and the thing that I realized after taking this class was, we have a long way to go. Technology wise, right, and also psychologically, as well. Things in the Mars were, we can't breathe the air on Mars so we need things that will generate oxygen for us, things that will help us sustain food. Like, we can't plant potatoes on Mars yet. We have the International Space Station, right? I should not have planted lettuce on the International Space Station and have eaten that. There's a lot involved [like] generating water. We also need rovers because when we're exploring Mars as humans, we're limited by our oxygen and water resources. So if we have rovers, they could carry those with us, or habitats. We also have to think about the return trip. On the Martian [movie], there should have been a Mars Ascent Vehicle, the MAV. Usually, the smart strategy is to send the MAV before we send the humans so if something goes wrong we can go back. There's a lot involved.

I think one of the biggest things that people probably didn't realize is the psychology. Just imagine being in a really small room for 8 months. I don't know. But little things you take for granted, like a small plant. There are studies that show, 'cause there are remote bases on Earth like in Antarctica, or just in Houston where they are simulating environments for astronauts to see how well they would do. Just putting one little plant really helps, right? It's psychologically 'you don't know it's there but it helps.' And one more thing, Astronaut Scott Kelly recently came back. I think he was in space for almost a whole year, in the International Space Station. So that was a huge accomplishment. We're slowly getting there. I think there are still technological developments that we're missing and technological aspects we still need to understand and do better with.

**Q7: I saw a picture of Curiosity lately, that it had holes in its wheels. So my question is, what would the team do if the situation arises that there will be major damage to Curiosity?**

**Villar:** Good research. We started noticing the wheels getting damaged maybe less than a year ago and that was because we were driving through terrain that we do not expect. So immediately, when anything happens on the rover, whether it's hardware or software, there are what we call Tiger teams (Mars Architecture Tiger Team). So a group of experts in that area would like, go off and go like, "what happened?", or "what do we do?" Since then, they understand why this has happened, and they'd go hours and hours of testing (JPL) on the MarsYard (simulated Martian landscape) and another institution in the States. So there's two things happening-- one, for Curiosity, we have put restrictions on where we could drive, so we can see where it's going, like 'you can drive there,' 'no, you can't drive there.' So the team has been maneuvering through terrain that we know we could drive through. So the wheels, it's more precautionary. So we know the wheels would last for much long ... actually much longer than the pictures you see with holes. During the lifetime testing, it was getting stripped off, only like half or so is left on the wheel and it's still functioning. So together, with the precautionary trails, we'll be fine. For 2020, now we know that, we'll be beating up the wheels. We're changing the design, making it stronger, changing the way it's shaped a little bit.

**Q8: Is it really true, like you see in the movies or in the websites, that the government is covering some data from NASA like, if the data you recovered is like, there are aliens on the outer space?**

**Villar:** I can't speak for other agencies. But NASA is a public government. NASA is funded by the US government, and the US government is funded by the people. So for NASA-specific projects, everything is public. As soon as we know, soon thereafter, the public knows. We don't hide anything. Now, things in the military are private, right?

But everything I know, you can ask me, and I will tell you. Same thing with the people in NASA. Although NASA does ... the military or special agencies contract with NASA personnel for specific projects and there could be secrets there too. But people have clearances so .. I'm not on those projects but I have co-workers in JPL who work on those projects and they can't tell me anything. But for the most part, you can send NASA project. It's public information. NASA doesn't hide anything.

**Q9: How long is the expected life span of the rover?**

**Q9a: During the flight from Earth to Mars, are there any modifications done with the Mars Curiosity rover? [Ex. Changing tire pressure, or calibrating certain mechanical components, or cameras inside?]**

**Villar:** Usually, we know how long we're supposed to ... we're contracted at first to operate a mission. We do testing a lot more than just that. Curiosity's prime mission was one Mars year which is about a little under two Earth years. So we did testing to make sure it'd last two or three times that. Also, in 2003 or 2004, the Spirit and Opportunity rovers, they were supposed to operate in three months. And until today, ten years later, one of them is still going. All I'm going to say is I don't know what its expected lifespan is, but it'll not be limited based on the power source. We have nuclear power source which will last for a very long time. It'll be limited to the pieces of hardware. Say for example, the wheels. If we didn't take care of the wheels, that's the

first thing to go, or just mechanisms in general. So I don't know the exact time. Who knows? But I think it'll be for a very long time for Curiosity.

(for 2nd question) That's a good question. Well, we can't really move anything during the travel to space. But we did modifications, like software-wise-- so if we wanted to update some software on the rover or kind of fine-tune how we're going to do entry, descent, and landing. Also, throughout the journey, we want to make sure that instruments there work. So we can turn them on but they are not moving just to know if we turn the switch and it's on. So we do those types of things. We also have software errors that sometimes happens so we'll have to send a new set of software to fix it. Those types of things. But we're not hardware-related. Like the wheels, there's no error. It's just a solid piece of aluminum. But the point is that we do testing of software-related things.

**Q10: Why do you use the skycrane thing rather than another parachute, like the one they used in Opportunity (rover)?**

**Villar:** The Opportunity also had parachutes. But what you're probably thinking about is that they also had air bags. I don't know if you guys have seen this but after the parachute, there are a lot of air bags that deploy and kind of bounces on the surface. So for Curiosity, it's way bigger, way more massive and the air bags were not going to work. So they had to innovate. There were several concepts before skycrane but eventually that's what we came down to.

**Q11: Nabanggit ng Scientific America na ang US ang masyadong tutok sa Mars. May dalawa na silang robot do'n at balak pa atang ipadala ang Mars InSight, sa seismic ata 'yon. Ta's itong Mars 2020 rover. Bakit nalang hindi po sa Europa nakatutok 'yong NASA kasi ang Mars madami na'ng nakatutok d'yan, kahit China, saka EU. Bakit hindi gumawa ng ground-breaking na mission ang NASA sa Europa na hindi pa nae-explore kasi so far, pare-pareho naman ang lumalabas na resulta sa Mars. What's new?**

**Villar:** I think I answered that a little bit earlier. I definitely want to go to Europa, but something to keep in mind is that we are working on that. It's not just Mars. JPL does explorations for all the [heavenly] bodies. And so, the Europa mission is actually currently being built... There are different phases of the project. There's a whole team of engineers. One floor above where I work are working in Europa. They are working on the Europa spacecraft and there are other teams working on concepts to get to other places, not just Mars. There's a focus on Mars. It's because we eventually want to send humans there. And it's the natural place to go 'cause it's the closest.

**Q11a: 'Di ba may batas ang Kongreso ng US na ang NASA ay ipinagbabawal na makipag-cooperate sa gobyerno ng China. Yung NASA ba, bukod sa technological experts, wala na ba silang magagawang paraan para makipag-cooperate sa China, which we all know, is a rising space [technology] power.**

**Villar:** In The Martian [movie], that was really cool, right? How, in the movie, the Chinese helped the Americans. I don't know exactly what the policies are between the US and China, but it's unfortunate that we are kind of prohibitive to work with them. But other countries, we work with them. A lot of the instruments in Curiosity come from other countries. So I don't know what the politics are like but hopefully one day, we could all come to an agreement that space exploration is a human thing, not a country thing.

***Q12: What were the considerations taken (re. Use of nuclear power in Curiosity)? How does nuclear power work for Curiosity?***

**Villar:** I'm not a nuclear engineering expert but I can kind of answer your question but they actually guide us to not answer these kinds of questions. But I will say, if nuclear power actively decays, it creates heat, and we could use that heat to generate energy to power our battery. There's a whole organization that is responsible for making sure that precautions are made to make sure it doesn't harm Earth or the rover, especially Mars. There are planetary protection measures to make sure that we will not contaminate Mars. But also some people were worried when we launched nuclear spacecraft from Earth. During the launch, something could happen. But there's a whole organization that kind of deals to make sure that we will be fine if something does happen. I don't know that process. I know there's a lot involved, a whole lot of signatures, all the way up the chain. So rest assure, we should be fine.

***Q13: What do you do to other equipment/instruments you sent to Mars? Do you leave it there? I'm just worried it could contaminate the planet.***

**Villar:** Okay. Good question. We never brought anything back from Mars so whenever we sent a satellite or a rover, it just stays there. But part of the landing sites selection is making sure that, if something happen that would blew away our hardware, it would not cause any contamination problem. They all stay there and we have to keep track of where everything goes. For example, in the entry, descent, and landing, we know the rover's here, and we also know where the parachute's going to end up. There's (coordinates) x, y, and z. So we know where things are in the surface of Mars and we make sure we take care of it and understand that it's okay for those items to be there.