TECHNOCULTURE

Scientific balloon missions

Episode 39

Full transcript

Guest: José V. Siles [José]
Host: Federica Bressan [Federica]

[Federica]: Welcome to a new episode of Technoculture. I am Federica Bressan, and today my guest is José Siles, radio frequency engineer at NASA's Jet Propulsion Laboratory in Pasadena, California. Welcome to Technoculture, José.

[José]: Thank you Federica. Thank you for having me today.

[Federica]: So, this podcast is a lot about learning about technology and also how it impacts society. And when one thinks of state-of-the art technology, one thinks of NASA because state of the technology and oftentimes large scale infrastructures are involved in the research that you do. Can you talk a little bit about what research is being done today here? What is the main, or what are the research questions?

[José]: Well, JPL, I'm sure that everyone knows what it is, but for those that are not familiar with JPL, it was actually the first NASA centre. It was created before NASA existed, in 1936, by four students of Caltech, they were doing research on rockets. And one day they almost blew up a building there at campus. So, they were sent out to here, close to the mountains here in Pasadena! They were really, really interested in their research. but they were not that interested in breaking buildings. So, they were encouraged to come here and continue their research on actually Halloween 1936, they have the first, let's say, successful launch where they had this rocket that they lifted up a few centimeters and then it fell down and exploded. But it was the first time that a rocket lifted up. So, that was actually the first day of JPL. And then many years after, in 1958, when NASA was created, JPL became part of NASA. And since then, JPL had run out the missions for NASA like Cassini, Galileo... More recently, the

Voyagers which are now the only man made spacecraft that are out of the solar system. So, nowadays, JPL just leaves the robotic exploration for NASA to explore the solar system and even beyond, you know, we go to astrophysics missions and all that.

[Federica]: And you are a radio frequency engineer. So what is your expertise at what type of research you participate in?

[José]: So, my research is mostly developing science instruments for studying, for example - we talk about planetary science to try to detect water and its composition in ocean walls, basically it's like most of the other planets where there's liquid water and we could think that maybe that water can have some kind of life. And so, with these instruments, we can detect that water from far away. The composition of that water. We can even use the technology to, for example, understanding climate. So, for example, to improve weather predictions, it would look into the clouds and try to detect, for example, humidity in clouds. And we can apply the same kind of technology for astrophysics to mostly study star formation. So where do the stars form...

[Federica]: So, it's not all about outer space, it's also about monitoring climate on Earth. So, there are applications for Earth...

[José]: Of course. There are three main areas of research: astrophysics, planetary sciences and Earth, and of course taking care of our own planet is one of the key goals of Nasa and JPL.

[Federica]: And what kind of technology is involved in the research that you do?

[José]: The technology, or the part of the science where I work on is far infrared. And the technology that we develop is to study the universe and the far infrared. So, the far infrared is the range of the electromagnetic spectrum which is between optical emissions and microwaves. Microwaves is the frequency at which your cellphone, for example, works. So, 98% of the photons emitted since the Big Bang, and 50% of the total luminosity falls in that frequency rate, so it's very important to understand the universe and study all the planets, and atmosphere of planets and so on. But it's very difficult to create technology on that region just because it happens to be there in the middle of nowhere in terms of technology. So, we have to use technology everyone has nowadays, like anything you can find in your own home like microwave technology and try to multiply that up to go to these higher frequencies, which is 10,000 or 20,000 higher than, for example, your cell phone, and use it to detect signals from the sky. So, these circuits, for example, that we design will fit in a piece of your hair, so it's really, really small. Now, the Antarctica connection is not because we are in this technology studying things that are there. We go to Antarctica, because we want to launch a radio telescope from there to go to the stratosphere and look to the stars from the stratosphere. And the reason for this is the Earth's atmosphere blocks all the signals, mostly because of the water vapour, so we really need to go very high to look at these signals. And of course, using a balloon to launch this radio telescope to the stratosphere is cheaper than a space mission. So, it allows us to use this technology before it can actually be infused in a space mission.

[Federica]: And can you talk a little bit about the balloon technology? It sounds so simple! And it sounds so non-futuristic technology, it reminds me of hot air balloons!

[José]: Well, that is the idea right, it's like doing astronomy like in the old days. Actually, one of the first, if not the first scientific balloon was in 1912 by Victor Hess, he didn't go all the way to the stratosphere, but he used a balloon, and he was actually riding himself in the balloon. And he just was going up in altitude, I think up to five kilometers, something like that, and he was trying to measure with a detector the radiation as a function of altitude. He discovered the cosmic rays and then he got a Nobel Prize in 1936 because of that. So, since then, there have been more than 10,000 scientific balloon missions.

[Federica]: When did people stop going up with the balloon? Because clearly you don't, today, for the altitude and for other reasons...

[José]: Well, for scientific reasons, I think probably the early nineties. But I think there's some mission in the late [?] or something like that. I mean, I don't recall right now the numbers, but yeah, you're correct. Nowadays, when we go to the stratosphere, you don't take people with you. The instrument, the telescope goes up and you just control it from the ground. But we use helium balloons. So, very large balloons, like in diameter 400 ft. That's like a football field, is 130m in diameter, and it has 40 million cubic feet off helium inside. So, it's massive and the radio telescope can weigh up to even a 5000 lbs.

[Federica]: So, the balloon is needed to lift the machinery. And how precisely can you control it? Can you, don't go there, come back?

[José]: We control the pointing of the telescope. The balloon goes up to 130,000 ft. at least. In our mission you can go slightly higher, slightly lower, depends on the weight of your specific technology, and on your science requirements. You go up there, and when we fly from Antarctica, we use something called the Antarctic vortex, which is some winds that circulate around the continent. So, what happens is the balloon goes up and then gets circulated around the continent, so it doesn't drift off continent, and after the mission that allows you to land and recover the instrument and update the technology and fly again. You cannot control where the balloon is during the flight, because it just goes with the wind. But you can very precisely control the pointing. So, what you do is the telescope is actually correcting the position and you are constantly pointing at your target. So, you're looking at the star forming region, the telescope is constantly looking to that. So, we can control the elevation of the telescope and the azimuth of the telescope, but not the overall position of the gondola.

[Federica]: Every time you go on a mission like this, I believe that you have more than one question. You collect different types of data. It's not one mission, one project. Or is it?

[José]: Well, there are a lot of things to do. So, every mission starts with a scientific question, right? And it could be a broad question like, where we're coming from? Or, how life originated on Earth? Or, could there be life in any other place in the solar system, or elsewhere? For example, if we just take the example of this balloon mission, which are very popular now, what we're trying to understand is how a star forms. And you would think why? Why is it important to know how the stars form? Well, let's take a step back. So, you think that the Milky Way, just the Milky Way, our galaxy, has between 100 and 400 billion stars. I'm asking you a question now, can you imagine how many galaxies are in the universe?

[Federica]: Too many for my little brain!

[José]: Okay, so now you multiply that for the number of the stars, average stars in a galaxy...

[Federica]: Mind blowing. Yeah.

[José]: So, what is clear is that there are a lot of stars in the universe. So, with so many stars, they have to play a key role in the galactic evolution, how galaxies evolve, how the universe evolved. And, beyond that, all the molecules, all the atoms that form our bodies, originated in the stars. For example, the carbon comes from the stars. So, you study how a star forms, how those molecules form, their life cycle... because a star forms, and then eventually dies, and all that material is ejected again and goes through several cycles. So, if you want to understand where we're coming from, somehow you need to understand how the stars form, and if you want to understand if there could be life elsewhere, star formation is also a good place to start to understand how that material is combined into planet formation and all that. So, in the end, we're trying to contribute to answering this NASA question, which is, where we're coming from.

[Federica]: Could you give some example, in simple terms, of the impact of the applications of this research - if any in the short term or/and in the long term?

[José]: Yes, sure, at the end all the knowledge that we do for these missions are used in the ground, for a near time, for humankind or for humans. So, for example, the same technology we use for these missions in astrophysics or even planetary science could be used to develop imaging systems for bio-medicine or medicine. So in the near/mid term, it could be used to improve how we are able to predict diseases or to detect diseases in the early stages like cancer, Alzheimer, diabetes, diseases like that. So, actually we're working in a small project with NIH, to try to infuse this technology on some of their system for early detection of diseases - as I said. We can use the same technology to study climate, or weather. So, we recently flew - January this year, and December last year - similar technology on an airplane, on a NASA airplane, we were looking at the humidity profiles inside the clouds. And that helped the climatologists to understand better how the weather works, and to improve weather predictions. And that is something that is the first time it has been done using the technology that was actually developed initially for astrophysics. So, there are a lot of uses and, as an engineer also is the excitement of that, not only creating technology for studying the universe or other planets, but also to give back to humans and help to improve our life on Earth, or create a technology that can help us in the future, especially if we can cure diseases or help to cure diseases.

[Federica]: And that is something that many people, I'm sure, don't know, that NASA is associated with space explorations, but it actually goes from medicine to predicting the weather, monitoring the climate. And this type of research is clearly multidisciplinary, requires the contribution of many different experts. What disciplines are involved in this?

[José]: Pick any mission you want and you probably have plenty of them! In an astrophysics mission, of course you have astrophysicists, you have engineers, you have physicists...

[Federica]: Chemists?

[José]: Well, yeah, of course, I mean, astrophysicists are chemists in the end. I mean, it is a part of that. But then if you go to planetary science, you have geologists, you could have astro-biologists, pretty much everything you can think of.

[Federica]: And the human factor is very important in this type of research. You have mentioned it in some of your previous talks. You say, "this is teamwork." Can you talk a little bit about the human factor in executing such complex plans, large scale plans that require lots of preparation...

[José]: Well, teamwork is the key. I always say that you cannot land something on Mars with thousands of people, if people don't get along. Working at JPL, and NASA in general is like, or if you go to a specific projects, it's like working in a family. You know, I come to work and I just come to play with my friends. It's a little bit like how it feels! So, it's a very nice environment where you really are so excited to make a mission work, to go to another planet, land a rover in another planet, fly a radio telescope to the stratosphere, that basically everyone wants to make it happen. Everyone wants to help each other to accomplish the task. Everyone wants to learn from each other. We have the best on each part, you know, in specific balloon mission again, you have people that take care of the gondola, people that take care of antenna, people that take care of the receivers, people that take care of the mechanical drawings. So, they're the best in their field and just have the opportunity to work with all these people and learn and and all together become better. So, yeah, it's key. And then if we factor in the Antarctica factor, which is basically the fact that now you're going there for a couple of months, building this or re-assembling this radio telescope there, so you spend with your team 25 hours a day during two months in a row... you know, that's the typical question, you say that you hate each other or you love each other! And normally the answer is the latter. I mean, you get so close to each other, you get to know each other so well. And that actually helps the mission. Because you can just look at your colleague to the eye and you know what he's thinking. You know, it is just amazing. And of course, you trust each other a lot.

[Federica]: To conclude. Would you like to say what you're working on right now?

[José]: Well, we were selected for a new Antarctic flight. It's a larger telescope than we have flown before, we went actually in Anctartica in 2015 and 2016. This new mission is going to fly in 2023.

[Federica]: This is the normal life cycle? Like, one of these missions... preparation, go there, collected the data, come home, analyze the data... takes five years or so?

[José]: Well, balloon missions are lower budget and they are missions that are somehow accelerated. You try to do it faster with a lower budget, but you want to take some risks and try to infuse or test new technologies that, as I said before, can be used afterwards used in space missions. So, a long mission is for five years, more or less. You can talk about a space mission, it could be from 10 years to sometimes even 20 years. If you go to Jupiter, that takes 5-7 years to get there. You know, that mission cycle is much, much longer. And of course, you have many more instruments. They're a much larger missions. So, depends on the kind of mission. But for balloons, yes, it's 4-5.

[Federica]: And I interrupted you. You were saying you were selected to participate in the next?

[José]: Yeah, so we're building, in this case, another radio telescope for the far infrared. We're gonna study again star formation. But we're gonna use this time a 2.5 meter telescope, which is large, the largest or one of the largest that has ever been flown from a balloon platform. And the reason to use a large telescope, or at least one of the reasons to use that large telescope is because we want to look not only inside our galaxy, but also in other galaxies. We want to compare how stars form in different galaxies, in different states, to complete - or to try to understand better this whole star forming cycle.

[Federica]: Thank you very much for taking the time and for being on Technoculture.

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