**Mission Planning for Robotic and Human Exploration**
Dr. Jessica Marquez
NASA Ames Research Center
**Moderator: Jeff Nee**
**October 11, 2016**
**2:00 pm CT**

Coordinator: This conference is now being recorded. If anyone has any objections, you may disconnect at this time. Thank you, you may begin.

Jeff Nee: All right, thank you very much. Hello everyone and welcome. I'm Jeff Nee from the Museum Alliance, the moderator for today's talk. Thank you to all of you for joining us and to anyone listening to the recording in the future. Today we'll be talking about Mission Planning, Robotic and Human Exploration.

As a final reminder do not put us on hold even if you have to step away because some phones play holding music, which totally happened last telecon so it does happen so don't do that. Just make sure your phone is on mute so that no noises from your end disrupt the talk.

The slides for today's presentation can be found on the Museum Alliance and Solar System Ambassador sites. If you have any problems at all, please email me at J-N-E-E@jpl.nasa.gov.

Our main speaker today is Dr. Jessica Marquez. She is a Human Systems Engineer at NASA's Ames Research Center. She has a PhD from MIT in the Department of Aeronautics and Astronautics, as well as a master's from the same place.

Her undergraduate is in mechanical engineering from Princeton and her expertise is in space human factors, engineering and human computer interaction. I'm not exactly sure what that means but I'm sure I'll find out.

She currently is the Lead Discipline Scientist for Human Automation Robotic Integration within NASA's Human Research program. She has worked on a myriad of projects, recently developing and deploying planning and scheduling software tools for flight controllers in space operations.

Also on the line we have Andrea Jones, the Director of International Observe the Moon Night -- which I hope you all did something cool last Saturday -- and the Lunar Reconnaissance Orbiter Education and Public Outreach Lead.

Now our speakers have indicated they're happy to take questions at the end. So just remember to re-mute yourself afterwards. And if you want to do one final check that you are in fact muted go ahead and just say your name into your phone right now and we can tell you if we hear you. Great, didn't hear a thing.

(Greg): (Greg).

Jeff Nee: So Jessica. Oh (Greg), I hear you.

(Greg): Okay.

Jeff Nee: Yes, I love checking. That's why I check. Thanks (Greg). Okay Jessica I'm going to let you take the way. Thank you so much.

Dr. Jessica Marquez: Great. Hopefully you can hear me.

Jeff Nee: Yes, absolutely.

Dr. Jessica Marquez: I didn't do the mute test.

Jeff Nee: Okay good.

Dr. Jessica Marquez: Thank you for having me at your virtual series. And I'd like to just tell you a little bit about mission planning and what that is about with respect to human and robotic exploration.

So I realize that my slides don't have slide numbers so hopefully you guys can follow along. I'm going to repeat the title of the slide.

So next slide called "Outline." [Slide 2 of 23]

My goal for this talk is to really introduce you guys to the idea of mission planning; why is mission planning hard for space; and then also highlight some of the software that we have developed here at NASA Ames through our Human-Computer Interaction Group that enable mission planning; and then touch upon what are some of the future mission planning challenges and what we're doing about that.

So next slide. Next slide's titled "Space Flight Mission Operations." [Slide 3]

So here is a very classic picture for mission operations integration from NASA. This is just an illustration of the complexity of what it takes to do space flight mission operations.

So each one of these circles really identify a different component of mission operations and their roles in mission operations in order to enable space flight to happen. So I'm just going to briefly go through these circles. And then the talk is mostly focused on the circles that are highlighted in green.

So in order to talk about this let's ground this with an example for the International Space Station. So for the - for the Space Station to actually fly above us it requires all these components so you need a mission design.

So that's very basic; we have a Space Station, it has a certain number of solar arrays, certain number of modules or rooms, and you have six people that are living in the Space Station.

The program requirements are things more like "Thou shall have 300 hours of science per year." Those are the kind of program requirements that happen.

Then you have things like mission facilities or training facilities.

Mission facilities are things like our Mission Control in Houston or the other Mission Control in Europe, Japan, Marshall, which is in Alabama.

Training facilities are the places where flight controllers and astronauts can train in order to actually do the mission, which is the next circle "Mission Execution." Mission execution is making sure that the Space Station is running and that the astronauts are doing all the science that the program requires them to do.

As part of that task astronauts and flight controllers need to train, which is the Mission Training bubble.

And finally all of this is enabled by having mission planning and mission products. So that means how we plan to have all the astronauts and all the ground making sure that they are running the Space Station and doing the things that the program expects them to do.

Next slide titled "Types of Mission Planning." [Slide 4]

In order to discuss a little bit about mission planning I wanted to give you a broad overview of what that means. So in general mission planning is laying out a set of activities in time that have the right amount of resources or capabilities to accomplish your objective.

Now this is a very general statement of what mission planning is but mission planning comes in a variety of flavors.

So, the most broad one is your strategic, which is identifying goals and coordinating with major events.

The next one is tactical; how do you actually achieve the specifics of this goal given the resources that you have?

And finally you have the operational which is the exact implementation of the plan; how are you exactly going to do this in space?

The interesting thing -- having worked both in robotic missions and human space flight missions -- that both of these types of programs and space flight missions follow this process. The biggest difference is really the implementation component. One - on one end you have robots executing your goals and then on the other side you have people trying to execute these goals.

So in order to give you a more concrete example of the strategic, tactical and operational types of mission planning I'm going to go to the next slide which is called "Mission Planning 101." [Slide 5]

So this is a - my attempt to simplify the mission planning problem in a way that illustrates all the different questions that flight controllers need to tackle when trying to do mission planning.

So this is - here we have sort of a picture of a little Mars Rover on a Mars field with a rock that I have drawn. And you have the satellite that is communicating between the rover and Earth.

So in this example we have that the goal of the - of - not of the rover, but the goal that we have here on Earth is to analyze the composition of that rock for the scientists back on Earth. So that would be just the overall requirements or objectives that would be set forth; do science.

So what does that take? So in the next slide it - we start breaking down that objective into strategic plans. [Slide 6]

The strategic plan would be that I have three days to look at this rock, drive through the rock, sample it, analyze it, and send back the results to Earth. From a strategic point of view this is relatively straight forward, "These are my goals, this is how I'm going to implement it." And the challenge is then making sure that each one of these things are actually accomplished and in a very literal kind of way.

So the next slide which is labeled "Tactical," shows how I - how you break down each one of these strategic plans into a more tactical plan.
[Slide 7]

So for instance "Drive to the rock," that seems fairly straight forward. If you were a person perhaps it would be straight forward but for a rover you need to understand all sorts of things about the rover; where it is, how far are you from the rock -- you need to know that before you can make a plan.

You need to understand does it have enough power to get there? Can we send the commands for it to drive?

This satellite that I have here in this picture is orbiting Mars. It's only occasionally able to send data back to the rover. And then also, understanding as the rover moves along, "Have I arrived to the right rock?"

[Slide 8] Next slide. Again, this is another slide that says, "Mission Planning," but with more tactical examples.

Similarly, you would break down statements like "Sample the rock" and "Analyze the rock" to further understand all the requirements and constraints that go into the strategic plan.

Can I - can the rover sample this rock? Is the rover driving? That seems like a very counter-intuitive question to ask but it's very simple; you can't sample a rock while the rover is moving so you have to make sure that the rover has stopped moving before you can even move the arm.

"How do you move the arm," is another question. How do you place it in the right location? How do I send the commands that say "Stretch, move to the right, move over and turn the sample hand?" So all of those things need to be specified.

And again, you look at information about power and commands and making sure that you're doing the right thing. You have to get all this data back from the rover to make sure that you're actually sampling the right area.

Finally, analyzing the rock. Once you have - once you're there, once you're confident that your robotic arm is right on the right place, you want to analyze the data that you - the sample that you have collected. And often these are the activities that are - consume the most power and the most memory.

So you don't want to get into a situation where you took a rock and you pulverized it and you analyzed it and then realize you don't have enough computer space to save your data. Because that was the whole goal of your - of this example which was to collect scientific data and send it back to Earth.

So again, you have to look at issues of memory, issues that commands have been able to be sent from the satellite to the rover. And then you also want to make sure that once you have the data on the rover that the data is able to be sent back to Earth, and again, through the satellite which is orbiting around Mars.

So hopefully these basic examples illustrate the next slide which his really talking about why planning is so complicated. Planning is complicated because you have so many mission constraints.

[Slide 9] This is my attempt to illustrate all the different types of mission constraints. So the kinds of things that we talked about in the Mars example are environmental constraints; was it day time, did you get power through solar rays, or did you have - were you on sandy or rocky terrain which allowed you to reach the rock at a faster or slower speed? So the environmental constraints are the biggest constraints that we have.

And then we have our objective, in this case our goal of collecting samples, and then your mission resources which are the things that limit you. There is so much power that the rover can have, there is so much computer space or data reception, or there's a certain number of communication passes from the satellite -- and all of these are what are called the mission resources.

So only the intersection of your objectives and your mission resources allows you to make an actual feasible plan.

And then you have other constraints that you impose on those plans which could be things like safety margin or you want to optimize a plan so that it's the most efficient plan possible. But in general mission planning is really challenging because you have to integrate all of these constraints in order to come up with a plan.

So the next slide [Slide 10] is called "Tactical and Ops Planning Flow."

So at the end of the day what you want to do is you want to have a set of activities that you have scheduled in time and that you have given the command sequence to do.

So in the case of the rover you have told the robot exactly what you wanted to do, the robot does it in the execution phase, and then the robot reports back to you as to whether it has done the task or not, and then you assess if it's done the task, and then you plan the next day.

So in this process the constraints sort of flow right into the activity planning and the scheduling because you'd want to have a timeline that actually allows you to reach the goals that you want to do but within the constraints that you were given for the mission.

So keeping all those examples in mind -- if you turn to the next slide [Slide 11] -- can you imagine all the constraints in resource and activities that are required for the International Space Station?

So in this picture you have the Space Station. And I'd like to point out a few things that hopefully will make you think about all the different challenges in terms of constraints in resources and activities that the Space Station has to deal with.

So when I see this picture I see our beautiful Space Station but I also know that it is orbiting around the Earth. So it goes around the Earth every 90 minutes. And I know that every 45 minutes it's going to be behind the Sun - or rather behind the Earth and not see the Sun.

And then I think about how we have these solar arrays -- these very large solar arrays, there's eight of them -- that depend on the Sun. And then I see these white squares which are actually radiators which are keeping the thermal balance of the Space Station.

I see all the different modules of the Space Station; I see an Orb Room, I see the Japanese Space Station - sorry, the Japanese module, the European module, the U.S. module, as well as the Russian modules all connected together.

I see at least three visiting vehicles; I see two Soyuz -- which are the Russian vehicles that are connected to the Space Station -- and I see the Space Shuttle on the top.

I also see at least three robotic arms; one on the Space Shuttle, one on the Space Station and one on the Japanese module.

So all these components have to work together seamlessly within - for the Space Station. And the Space Station is a 24-hour, 7-day mission. It means that every single minute of the day something is happening in the Space Station and someone is making sure that that gets executed on the right time every day.

So if you go to the next slide [Slide 12] it's titled " SPIFe, Scheduling and Planning Interfaces."

So for the - for over ten years our group here in NASA Ames called a Human-Computer Interaction Group has been working on a variety of planning and scheduling interfaces for different types of missions. This image shows you a timeline of all the different missions we have supported to-date.

Back in 2003 we started supporting the Mars Exploration Rover or the MER. So those were the first set of twin rovers, Spirit and Opportunity. We started working developing some planning tools for them.

After that we also supported the Phoenix Science Lander. That is a Polar Martian lander and that's the first time we developed our planning and scheduling tool called Spiffy.

Dr. Jessica Marquez: The different versions of spiffy have been deployed in all sorts of different missions.

We have MSLICE which is our - the planning and scheduling tool for the Mars Science Laboratory or Curiosity.

Soon after we started working on Curiosity's planning and scheduling tool we started working with the International Space Station. In the International Space Station, we have deployed three different types of planning and scheduling tools which I will talk a little bit about in the next few slides.

We also started working with satellites that orbit the Moon. And that's LADEE, and that was run from here, from NASA Ames.

Finally, as we start our 10-Year work on mission planning we have moved to trying to develop more mobile, user-friendly tools called Playbook. And we have deployed these in a variety of different Earth Analog missions -- which again, I will talk a little more later.

So next slide [Slide 13]. So I thought I'd talk to you a little bit about the ISS planning tools so that you get a better sense of the types of planning that happen for different components of the Space Station.

So the first tool I wanted to highlight is called APEX. And APEX is just the planning and scheduling tool for the attitude determination and control. And that's just a big word for making sure we know exactly where the Space Station is and what orientation it is at.

As I mentioned the Space Station rotates around the Earth every 90 minutes. Since it's only a little over 100 miles above the Earth you still have some friction from the atmosphere. So it still sort of - it is rotating around the Earth but then it slowly starts degrading its orbit and slowly starts coming back down to Earth.

So in order to prevent a crash you have to in regular intervals give it a boost, basically push it up a little bit. And so those are called Thruster Maneuvers or Re-boosts.

There's also other thruster maneuvers to orient the Space Station in different ways. And sometimes we have to do that for docking events with the shuttles.

Attitude control is also very important when you're trying to dock all sorts of visiting vehicles. It's very critical that when two vehicles meet that there are precisely aligned.

So APEX, our planning and scheduling tool, integrates all this information, schedules the specific re-booster maneuvers and then communicates all that information out to the rest of the flight controller team. As you might be able to imagine, knowing where the Space Station is, exactly is very important for all the flight controllers so that all their plans are based off the actual position of the Space Station.

Another interesting thing about this tool is that it also helps facilitate communications about position and orientation with our Russian counterparts. Because the Space Station is composed of both a U.S./European and Japanese and Russian component and both the Russian and the U.S. segments have capabilities to create the re-boost or basically move the Space Station.

So in the next slide [Slide 14], "ISS Power Planning," this is another tool. But the basic function of this tool is to look at how much power is actually being generated by the Space Station and comparing it against how much power is actually being used by the Space Station.

And that seems very simple when I say it like that but it's actually very complicated because at any one point you need to really model and be able to understand how much Sun is being reflected on the solar arrays.

So as I mentioned, the Space Station orbits around the Earth. And so for 45 minutes it's getting - its solar arrays are pointing right at the Sun. And then each solar array actually moves so that it is pointing as best as possible to the Sun.

Once it goes behind the Earth and it becomes in shadow the Space Station draws all its power from its batteries. So it's a very intricate connection of Sun, solar arrays, rotation of the solar arrays, how those energies are converted to power for the batteries, and then how the power is then distributed through the batteries through the entire Space Station.

So it is like imaging you and your neighborhood have mapped out every single outlet in your house and have connected it in some way to a diagram that allows you to understand where all the power for each outlet is going to and from.

Finally, you also have to understand how much power is being consumed. So often you have very large experiments that draw power.

There are some instances where you have to turn off certain experiments to allow for power to be redistributed to other areas. There are certain periods of time where the solar arrays do not get enough power -- enough sunlight -- because there is some event happening like a docking or a spacewalk.

When you have a spacewalk the solar arrays don't move. So you actually end up having less power. So when you're doing a spacewalk you have to be very careful to make sure that all your power's diverted to supporting this critical task without putting the Space Station in danger of losing power.

And again, power is used for everything from basic breathing air to powering other items and running all the life support systems in space missions.

So next slide [Slide 15] is called "ISS Crew Planning and Scheduling." This is another tool that we also developed. And this is where the ground can schedule all the activities that both the astronauts and ground personnel are supposed to do every single day.

So one of the things about Space Station is that the crew's schedule is planned out by the minute so there's an expected time where they're sleeping, an expected time where they're eating or exercising.

But then all the science activities, all the maintenance activities are all scheduled in these timelines, all the activities that the ground have to do like for instance diverting power like we mentioned before or doing a re-boost of the Space Station. Again, all of these activities get scheduled in our tool.

And we do planning from a range of six months out all the way down to the day of planning. And we integrate all sorts of communication availability, power availability.

And if you go to the next slide [Slide 16] called "Score, Crew and Ground Planning," I've taken a screen capture of what our tool looks like.

So on the top we have a Time, so those are just days.

Next you have these things called Conditions. So here is where you integrate all information about the communication that's available. So the green and orange bands happen to be when you have telemetry information available and when you can have voice and video available. It gives you information about what orbit you're in, the orientation of the Space Station, if it's day or night.

The next band is what the activities that the astronauts are doing. So the bands that are say FE3, FE5 and FE6 are activities that the astronauts might be doing at any one point.

So, you see things like doing outreach activities with the ground with the PAO which is the Public Affairs Office. They might be doing inventory, they might be exercising, they might be running experiments or they might be doing maintenance tasks.

The other capability of our tool is being able to see how these resources are expected to be consumed over time. And so I wanted to give you guys sort of a small capture of all the things that happen. And there's a lot more that I couldn't capture in this screen shot.

So just to pull it all together the next slide [Slide 17] is labeled "Integrational Planning Software Tools." This is a picture of the ISS Mission Control and NASA Johnson Space Center.

In NASA Johnson Space Center, we have three different software tools -- APEX, PLATO and Score which I discussed earlier -- and they're used by three different flight controller disciplines in order to do planning.

And in the next slide [Slide 18] one of the most rewarding events of my career has been to see how the first time that these tools were used in synchrony in order to do some re-planning for a visiting vehicle.

In this example, which I believe happened around 2012 or 2013, we had a HTV. The HTV is just, imagine a closet. It's a supply ship and it contains a lot of supplies. And it's launched by the Japanese SpaceX - space program, JAXA. And they - for whatever reason the launch was delayed slightly by a few days. So there's a picture of the HTV on the top and the launch on the left side.

Now a slip of a few days might not - might seem inconsequential but the amount of coordination required to allow for the supply ship to arrive to the Space Station is rather complicated.

So we have a picture in the middle of the astronauts. The astronauts need to have time separated in their schedule to make sure that they are able to capture the visiting vehicle, that they are able to then maneuver the arm and handoff the coordination to the ground.

And the ground also moves the robotic arm to make sure that it's at the right place. And then it passes the ball back to the astronauts to make sure they do the last motion where - it's called birthing which is basically connecting the visiting vehicle to the Space Station.

All of this requires not just coordinating the ground time and the crew time but making sure that there's enough power to control all these systems; control the robotic arm, there's enough data, there's enough video to be able to communicate between the ground and the Earth, that there is - that the Space

Station is positioned in exactly the right place and there's a clear understanding of how to capture the vehicle with the arm.

And all of this was seamlessly integrated into our tools and we were able to help in the re-planning and improve their efficiency of - to do this task.

So in the next slide, [Slide 19] I wanted to touch a little bit about Journey to Mars which is "What do we do next?"

So I spent a lot of time telling you about Mars exploration and ISS exploration but we are -- as NASA -- heading towards becoming Earth-independent. And what that means is that when we have people and robots on Mars that they are able to do a lot of these tasks on their own. They're able to manage their schedules on their own because they want to be Earth-independent.

So in the next slide, [Slide 20] it's called "Preparing for our Future Needs," and I just wanted to give you a sense, a little bit of the kind of things that make this problem unique.

So while we saw managing one rover had all these constraints imagine having to do science, having rovers that are driven by people, having multiple people on Mars, having multiple rovers that are deployed or I like this picture of Mars because it has a little science or weather station in the background.

We're going to have stationary things, mobile things that are being directed from Earth or from Mars. We're going to have rovers that are driving people around. We're going to have space suits that need to be - and spacewalks that need to be coordinated and planned.

And hopefully now that I've talked to you about the Space Station and our rovers you get a better sense of how much more complex planning and scheduling is going to be in the future. And at the same time we're going to have to make better tools that will enable astronauts to manage some of the schedule.

So in order for us to prepare for the future what we do is we practice on Earth analogs. So on the next slide, [Slide 21] it's called "Earth Analogs, the (Sock)."

So one of the things that we do here at NASA is that we practice. And if you go back to the very first slide, you know mission operations is, "Plan as you train, train as you fly." And so basically you plan, train, fly -- you always practice, practice, practice.

So what we do on Earth is that we find places that are similar to some of the environments we might find in Mars and we call those Earth Analogs.

So I am part of an Earth Analog team called BASALT. And the goal of BASALT is to do science exploration but also simulate some of the constraints that we'll have when operating on Mars.

Specifically, we have low bandwidth, so that means little data, and communication latency which means any time you send data it's going to take in the order of minutes for that data to arrive to our ground control. So while we're simulating these we have the sciences doing exploration.

So on the left side there is two astronauts who are simulating exploring Mars. And then back on the Earth side we have people trying to understand all the data that is coming from Earth - sorry, from our simulated Mars and looking at how we can develop new capabilities and technologies that will enable us to effectively work on - in space.

So right now we use our tools in these Earth Analogs to better understand the challenges that we need to face and fix before we actually go to Mars.

And in general, on my last - second to last slide, [Slide 22] "Future Mission Planning Challenges," these are the three things that I think are most important for planning and scheduling in the future.

One of them is better integrated human-robotic planning. So a lot of the vision of exploring Mars is exploring Mars with people and robots at the same time. We have yet to do this type of planning in an integrated fashion. And I think this is sort of the forefront the - of what planning and scheduling tools will be aiming towards in the future.

I also think that we need better ways of enabling astronauts and crew to execute and re-plan. Again, this is something that we have always made Mission Control do but as we go farther and farther away from Earth we need to enable crew to do some of this as well.

And finally, having a more-tighter, more integrating planning process. That example of the visiting vehicle - the Japanese visiting vehicle demonstrated that you can have a tighter more integrated planning process. And imagine how much more powerful it'd be if all these tools were able to talk to each other and facilitate re-planning more easily.

And with that I will take any questions [Slide 23]. And I know there's also a video that we'd like to see.

Jeff Nee: Thanks Jessica that - I'm going to be honest, that was even more interesting than I thought it would be. But I'm a huge nerd and I like this sort of thing. But I'm going to assume everyone else does too.

What do you mean exactly about tighter and more integrated? So just that the spacecraft need to talk to each other better? Is that what you mean?

Dr. Jessica Marquez: So one of the things that we learned when we were working with the Space Station program is that each one of - so remember that picture of Mission Control? Each one of those positions has their own set of tools. And so it's very challenging for the information to flow between these tools because they were all created independently.

So in my example of how we had APEX, PLATO and Score, because we were a single team developing all these tools we made the hooks so that they could talk to each other pretty easily and exchange data.

As we make more complicated missions that capability or that feature really needs to be an integral part of development. That data can be easily shared. There's a common standard because as we develop more and more tools there's much - there's more potential to become little silos of data. And without being able to easily exchange data it makes it - it makes the planning process a lot harder.

It's a very practical sort of challenge.

Jeff Nee: Great, thanks. I'm going to give other people a chance. I have a whole list of questions though it's - but if anyone wants to jump in just feel free to interrupt me. I…

Jim Schier: Jessica this Jim Schier. I'm at headquarters. I'm the Chief Architect for Space Communications.

One of the things that I'm working on designing into the next generation communications architecture is the ability to do unscheduled communications rather than scheduled communications.

So that will involve an upgrade on the software. It will also require an upgrade on the communications software. So when you picture that little satellite overhead…

Dr. Jessica Marquez: Yes.

Jim Schier: Picture an upgrade on that. And then an upgrade on the operating system so that it can take advantage of the communications whenever it's there. So that's going in through a capability called DTN, Delay and Disruption Tolerant Networking.

We have that running on ISS now but not taking advantage of unscheduled communications capabilities yet. That's planned for future development with the humans in space including Mars exploration.

So one of the things I'm hoping to do is relieve you of one of your constraints -- or at least greatly reduce it.

Dr. Jessica Marquez: Yes, that's a really big challenge, particularly in deep space. There is - in some ways there's a bottleneck. There is only one way right now that we can communicate with deep space and Earth and that's the Deep Space Network.

And because of that the demand on the Deep Space Network is pretty large relative to its size.

So imagine every single mission that's in outer space, Voyager, Cassini, all the Mars satellites and Mars rovers. And as we start deploying more missions out to the edges of our universe - of our solar system, sorry, that bottleneck becomes tighter and tighter because there is one source. So it is a very big challenge.

Jim Schier: So one thing we might do is collaborate on models of how DTN enabled communications operates for you to incorporate into your planning tools.

Dr. Jessica Marquez: That'd be great.

Steve Bullock: Hi, good afternoon. Hi Jessica?

Dr. Jessica Marquez: Yes.

Steve Bullock: Yes, this is Steve Bullock calling all the way from St. Croix in the U.S. Virgin Islands. And I hope the weather that you are having is as sunny as we are here in the islands.

I have a question for you in respect to the Earth Analog, the strategic planning. Do you - what goes into your strategic planning to, I guess compensate for the constraints of the length of the mission from Earth to Mars in terms of whether the astronauts would be able to contend with the grilling mission to get there?

So you mentioned - you spoke about the analog - Earth Analog on, you know, on simulation and so on. But in terms of the specific mission and how long it's going to be, what are some of the - how are you dealing with the constraints of the extra pressure that the astronauts will be under?

Dr. Jessica Marquez: Yes, so we in BASALT specifically, in this Earth Analog, we are specifically only simulating one particular event and that is spacewalks or EVAs. And so we're focusing right now on that aspect. So we aren't - so in this particular Earth Analog we're not exploring all the different types of constraints that might happen since it's relatively focused.

There are other Earth Analogs that look into those kinds of issues; there's an Earth Analog at NASA Johnson where it's studying confinement and the effect of different communication latencies; we also have simulations called NEEMO, the mission - sorry, Earth Analog Mission NEEMO that is under water.

So I can't answer that completely except to focus on sort of the problem that we see with regards to executing a spacewalk with a science team and a Mission Control involved.

So we're learning a lot about what is the kind of information you need to share; how do you share that information in a timely manner; how much time do we give the science team to provide feedback to the astronauts that are collecting the science data?

And the interesting thing, having participated in several of these Earth Analogs, even though these are simulations the people that are playing the astronauts feel very responsible and do feel the pressure and the stress of being in this extreme environment, to do a good job, to be able to collect science that other people are depending on them to collect.

So it's interesting that there's still - there is an effect that exists but it is not an effect that has been imposed on them. So that's the best I can answer that question.

Jeff Nee: Jessica, how long was your Earth Analog mission?

Dr. Jessica Marquez: So the BASALT simulations, what we are trying to do is systematically evaluate all these different effects on mission operations. So we simulate a spacewalk and basically we have two astronauts that go to a particular site, collect samples for the science team, and then they come back.

And so we've done those multiple times. The last mission we did ten of them. this upcoming mission now in November, we're going to do another ten simulations. But even for each simulation we vary the factors.

So for instance, one simulation might have a five-minute communication latency and you have all the data you possibly can have. The next one will be a five-minute delay but then we take away the video. The other one was we have a fifteen-minute delay and we take away the video.

And so by systematically understanding how all these different factors may affect your mission we're trying to learn what are the most important pieces of data and how you present that data so that we can then make recommendations for future exploration of Mars.

Adrienne Provenzano: Hi Jessica. This is Adrienne Provenzano, I'm a Solar System Ambassador. And my question is, saw the next three crew[members] finally got the go ahead to go to the ISS next week and I'm wondering how the tools you work with were used to deal with the recent delay.

Dr. Jessica Marquez: Yes, so that basically - any time there's any launch of delay of people that also has a huge repercussion for planning. And again, you have to change all the constraints -- the power, the position -- and push it off to the next day.

So the - one of the challenging things about this last reschedule was that they basically said, "Yes we're rescheduling this but we don't have a date." So that meant that for what was it, like, three or four weeks, there was no way of actually getting ahead, like doing your homework and doing the re-planning…

Adrienne Provenzano:I see.

Dr. Jessica Marquez: …so that it's ready for the next thing. And so basically I think that they had to do all this re-planning pretty much pretty quickly because I think they only recently updated the launch schedule.

The other thing that's happening that - since you brought up the launch. One of the cool things that is happening in our group in the next year is that our tool Playbook which is our - sort of research next generation planning and scheduling tool, is deployed on Space Station and we're hoping that an astronaut on Space Station is going to be using it in the next six months to manage their schedule, to determine what activities they want to do in space and then execute from that tool.

So we're really excited…

Adrienne Provenzano:Thanks.

Dr. Jessica Marquez: …to see that happening on Space Station. Because that's sort of the first time that we are able to both provide tools that enable re-planning and being able to do it in the most realistic environment that we have which is Space Station.

Adrienne Provenzano: So ideally the crew members would be empowered to do more of their planning on their own or at least have more input into that?

Dr. Jessica Marquez: Yes, exactly. And so that's sort of the very first test that we're going to do, which is give them that capability and then see did - was this - did this disrupt operations; was it done effectively; did you feel like it was empowering or satisfying to be able to do this?

Adrienne Provenzano: Great, thank you.

Dr. Jessica Marquez: Thank you.

Jeff Nee: So Jessica just from your own experience with the BASALT and your own experience with all the planning, I mean how far do you think we are from actually planning a real mission to Mars? Like, does the 2030s actually sound real? In your personal opinion I mean, just from what you've seen.

Dr. Jessica Marquez: I think we can go towards our landing people on planning Mars mission to Mars by the 2030s. I think the challenge is going to be that it is not going to be as complex as our visions are. It will be a relatively - in comparison to what we hope to do on Mars it's going to be a much simpler plan just because there are limited resources for which we can send structures to Mars.

So it will - I think if we do - if we are able to make it to Mars by the 2030s it'll be a far simpler mission than the ones that have been written about in terms of becoming completely Earth-independent, multiple robots, multiple rovers, large habitats. It will probably be a little more straight-forward.

Jeff Nee: And I guess the same question for things like space tourism just around the Earth. I mean, do you think we're at the point where it doesn't take as much planning to send somebody just into low-Earth orbit anymore or do you think it still takes all the tools that you're thinking about?

Dr. Jessica Marquez: So one of the things - one of the differences between mission operations and space tourism is that the goal in space tourism is to enjoy and have - enjoy space, right, microgravity.

It's sort of like the equivalent of saying "Do I plan my vacation out or do I - or like I plan my day-to-day schedule at my job?" So I think that that's the big difference, right, that there are all this planning that has to happen in terms of launching and maintaining the capability.

But you're not going to plan people's time if they're taking a touristic trip as opposed to something like the Space Station or missions to the Moon or asteroids, you have other objectives that you're trying to meet. And so you're trying to make science, you're trying to test some technology, you're trying to evaluate something. So all that also requires a lot of other constraints and objectives and more planning.

Hopefully we will have launch capabilities that enable every-day people to go into low-Earth orbit. I certainly hope I get to do that. So I think that that planning will be much more focused on some of the things that we have a lot more experience on which is planning the launch, maintaining the vehicle state well and returning people.

Jeff Nee: Great, thank you. And I know we started a little late and I want to be respectful of everybody's time. Maybe I'll give a few seconds if anybody has any last second questions and then I want Andrea to have a minute or two.

Steve Bullock: Hi Jessica, I have a quick question again from Steve from the VI. Are you concerned that there are some other independent entities that are, you know, I guess advertising missions to Mars?

And you know, I'm looking at the planning that you have explained and that you have laid out here that would go into that mission, it's very complicated and complex. Are you concerned that this might not happen with some of these private missions being touted about, one-way missions and so forth?

Dr. Jessica Marquez: No I'm not worried. I think right now the private missions are sort of like the very first. It's even - be like higher level than strategic, right? It's almost goal-defining, "Let's define the goal of what we want to do."

So I think once people start going down all these levels of mission planning they'll start to realize what they have to do. So I think we're still pretty early on in the - in planning so I think we're okay, not worried.

Thank you everybody…

Jeff Nee: Great.

Dr. Jessica Marquez: …for your wonderful questions.

Jeff Nee: Yes it's - it was a great presentation too, thank you Jessica. Andrea did you want to say your piece before we wrap up?

Andrea Jones: Sure, yes. Thanks again Jessica. It was wonderful to hear more about the mission planning work behind the scenes, so that was great. And I wanted to let you all know about a new resource that's out that is a new NASA music video, which is something that we don't normally send out.

But in collaboration with the Lunar Reconnaissance Orbiter and the Season 1 winner of NBC's The Voice, as well as another singer/songwriter Matt Cusson, we have a music video called The Moon and More. And it's all about - well it's intended as an inspirational piece that was filmed in several different museums and at a number of places with really great backdrops around the country.

And it's a song that's really all about getting kids to think about, you know, "Dream big and get out there and you can do anything that you put your mind to whether it's, you know, getting into science or getting into anything that you're interested in, you can do it." And so it has lots of Moon images and pieces from the Lunar Reconnaissance Orbiter in it and was sponsored by that, but it's really a larger piece that can be used anywhere.

And I just would like to encourage you all to check it out. It's included in the links associated with this presentation. And read a little bit more about it. I sent you to the press release. And then share it with, you know, your family, your friends, and your visitors if you are at a museum and would like to show it and think it would be of interest to them.

So just something kind of new and different and something kind of fun. And I hope you'll check it out and share it. Thank you.

Jeff Nee: Thank you Andrea and…

(Diane Sartori): This...

Jeff Nee: No, go ahead.

(Diane Sartori): This is (Diane Sartori). I just wanted to say that Video is wonderful. I'm going to share it widely.

Andrea Jones: Wonderful. Thank you Diane. My 3 year-old…

Andrea Jones: …daughter has it on repeat. She loves it.

Jeff Nee: Yes.

Andrea Jones: So I'm glad you enjoyed it as well.

Jeff Nee: Exactly what I was going to say. And you know, I'm doing a music festival some - at some point next year and I'm totally going to feature that as well, so.

Andrea Jones: Great.

Jeff Nee: And if you didn't know that NASA does music, we do. You know, like Andrea said, "It's not something we normally do," but NASA does support the arts. NASA does really do a lot of cool artsy stuff like this every now and then. So if you need more resources like that let the Museum Alliance or let Kay know for the Ambassadors.

Any last second questions for Jessica or for Andrea while we have everyone on the line?

Woman 1: Yes. Andrea, would you mind repeating the information about the video? I had to leave for a minute and I didn't catch all that. I want to make sure I view it.

Andrea Jones: Sure, yes it's - oh, go ahead.

Jeff Nee: Yes I was just going to say it's all on the Web sites. So if you're on - if you're an Ambassador, Kay has it on her Web site. It includes a downloadable link as well, for those people who need it offline. So Andrea was nice enough to get us that. And it also has the regular Web site.

It's all on the Web sites. If you have any issues, again, you can email either Kay or myself.

Woman 1: Thank you.

Jeff Nee: Jessica I did have some quick things. I could probably Google this myself but since I have you here it will be really easy. About what bandwidth did you work with on your BASALT mission? You said it was really low bandwidth. I'm totally curious what bandwidth you had on your Earth Analog Mission to Mars.

Dr. Jessica Marquez: Yes, so I don't have the number in front of me but we - the idea was to start exploring different levels of bandwidth. So for BASALT we had constant video, constant voice, constant data imagery, position chat. And so all of that…

Jeff Nee: So better than dialup?

Dr. Jessica Marquez: Excuse me?

Jeff Nee: So better than dialup connection…

Dr. Jessica Marquez: Yes.

Jeff Nee: …I guess. Okay.

Dr. Jessica Marquez: Yes. So we - it was sort of like, "Let's start with all the bandwidth we could possibly imagine and then work from there backwards."

Jeff Nee: Okay.

Dr. Jessica Marquez: So we're starting to take away elements, not necessarily limit the bandwidth yet but taking away some of these bandwidth elements. And then subsequently, in future deployments we will control the bandwidth more specific.

Jeff Nee: Okay thanks. I'll have to ask the Mars people on our next telecon about how much bandwidth they actually get to Mars. Okay.

Any last second questions? I always like giving people this one last second. Okay, well then I will be the very, very first to thank you, Jessica, so much. This was really interesting. Again, I think we're all…

Woman: We're all (unintelligible)…

Jeff Nee: Yes, we're all nerds here and we love this sort of stuff. And you know, people don't think about it. I certainly didn't before the talk. So thank you for sharing this with us.

Woman 1: Thank you Jessica.

Woman: Thank you.

Dr. Jessica Marquez: Take care guys.

Jeff Nee: Take care everybody. And you know, remember our next talk is on Thursday for the STEREO Tenth Anniversary Mission - or STEREO's Mission's Tenth Anniversary rather. Information is always on the sites. If you have any questions now or in the future my email again is J-N-E-E@jpl.nasa.gov. The recording and transcripts will be on as soon as we can. Okay thanks everybody and have a wonderful day.

Woman: Thank you.

Woman: Thanks.

Woman: Thanks.

END