# Science AMA Series: We're NASA space communications experts, and we're talking about how NASA connects astronauts to Earth. AMA!

NASASpaceComm [1] and r/Science AMAs[1]

[1]Affiliation not available

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**Abstract**

Thank you for all the questions! We are signing off now. Hi, we're NASA technologists working on space communications systems that allow NASA to connect astronauts to Earth. This can include communications with Mission Control in Houston, with schools for STEM activities and even with social media accounts. Our Space Network provides 24/7/365 communications capabilities with the International Space Station, and with launch vehicles that service the space station. This year, we're launching a new Tracking and Data Relay Satellite that will expand the capabilities of that network. We're also working on laser communications for future human spaceflight missions. We are: · Don Cornwell, NASA Advanced Communications and Navigation Projects Lead ·Bob Menrad, NASA Exploration and Space Communications Associate Director ·Todd King, NASA Project Manager for Orion Laser Communications System (LEMNOS) ·Greg Heckler, NASA Deputy Telecommunications Lead for Tracking and Data Relay Satellites Amber Jacobson, NASA Exploration and Space Communications Education and Public Outreach Lead Don't forget to follow us on Twitter at @NASA_TDRS, @NASALasercomm and @NASASCaN!

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NASASPACECOMM R/SCIENCE

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Hi, we're NASA technologists working on space communications systems that allow NASA to connect astronauts to Earth. This can include communications with Mission Control in Houston, with schools for STEM activities and even with social media accounts. Our Space Network provides 24/7/365 communications capabilities with the International Space Station, and with launch vehicles that service the space station. This year, we're launching a new Tracking and Data Relay Satellite that will expand the capabilities of that network. We're also working on laser communications for future human spaceflight missions. We are:
· Don Cornwell, NASA Advanced Communications and Navigation Projects Lead
·Bob Menrad, NASA Exploration and Space Communications Associate Director
·Todd King, NASA Project Manager for Orion Laser Communications System (LEMNOS)
·Greg Heckler, NASA Deputy Telecommunications Lead for Tracking and Data Relay Satellites
Amber Jacobson, NASA Exploration and Space Communications Education and Public Outreach Lead
Don't forget to follow us on Twitter at @NASA_TDRS, @NASALasercomm and @NASASCaN!



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- Do astronauts have unfettered access to the internet?
- What's the ping like between computers on the ISS and earths internet?
- Are you on-call support techs for the astronauts? (Have you ever had to ask the astronauts if their routers lights are blinking?)

sleepyzealott

The Space Network supports customers 24/7 and operators, technicians, and engineers are always on shift to immediately work any problems. If ISS does have a problem, Mission Control, not the astronaut, certainly has us investigate the status of the ISS link as part of their troubleshooting. We maintain voice comms with Mission Control at all times to facilitate this process. -Greg Heckler

I remember learning about how relatively simple it was to pick up signals from Sputnik to the point where most schools -- even elementary schools -- had the equipment to pick up the beeps.

Are the signal strengths here high enough that similar analog equipment could pick up anything? Are the messages encoded using documented standards, or using proprietary encoding? Are they encrypted?

I guess what I'm really asking is what would it take to listen in at home, even if it the messages were

undecipherable?

fishybell

There is a large community of amateur radio enthusiasts who actively track satellites, I would suggest you do some googling to give you some pointers. With modern software defined radio technology distinguishing between "analog" and "digital" signals is no longer relevant. Here is a great link for an amateur who set up a system to receive data from the GOES weather satellites. Most NASA and international space missions use CCSDS standards for modulation and coding. In short, it is a lot easier (and cheaper) to receive these types of signals than it was even a decade ago. The ISEE-3 effort was a great example. We use software defined radio equipment in our labs everyday, and it is quickly becoming the preferred architecture for our flight communications equipment, as well. -Greg Heckler

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fishybell

Hi fishybell. Great question...I remember reading the "Amateur Scientist" in Scientific American magazine years ago giving plans for to do similar things with the early weather satellites. When it comes to science missions, some are engineered specifically to support the mode of operations your asking about. As an example, EOS/Terra is specifically designed with a direct-broadcast capability to permit this very thing all around the globe. The challenge is getting the data when the signal is weak...by design. Why? Because engineers attempt to use the lowest possible spacecraft power to save mass yet close the link to the ground. This requires larger terminals on the ground; and, as a result, becomes impractical very quickly for the home user or hobbyist to try and do this. - Bob M.

What are the up/down data rates you usually achieve??

Datesy__

Today the Space Network can deliver up to a 25 Mbps uplink (we call it a forward link) and a 300 Mbps downlink (which we call a return link). Right now we are upgrading the Space Network receivers to support a 525 Mbps return link from the ISS. The ISS upgrade will be completed in 2018. The larger Space Network ground upgrade SGSS will support data rates up to 1.2 Gbps! Since the TDRS satellites are a bent-pipe relay, we can perform these improvements by modifying the ground system equipment which is much cheaper than launching new satellites. If you really want to learn about Space Network services, I can point you to the Space Network User's Guide SNUG. -Greg Heckler

What are the up/down data rates you usually achieve??

Datesy__

Hi Datesy,

NASA, working with the MIT Lincoln Labs, has demonstrated laser optical communication with the Lunar Laser Comm Demonstration (LLCD) from the moon on the Lunar Atmosphere and Dust Environment Explorer (LADEE) mission. In that mission, LLCD was able to downlink and uplink mission data at 622 Mbps and 20 Mbps, respectively, from the moon. An upcoming mission, Laser Comm Relay Demonstration (LCRD), will send data, bi-directionally at 1.2 Gbps from one ground station in California, to the LCRD spacecraft in GEO, back down to another ground station in Hawaii. Future developments are in progress and may be capable of even higher data rates!

Todd

Reddit demands top quality OC and I will deliver:

This is an UNOFFICIAL patch for LCRD. I hope I don't disinvite myself from being a federal employee. -Greg Heckler

NASASpaceComm

I risk my career for a meme, and no upvotes :(. -Greg Heckler

How did you get into your line of work? As an astrophysics student this is interesting to hear about!

efie

I was fortunate enough to attend Purdue University in the Aerospace Engineering department. One of my professors was a former NASA employee and he directed me towards an internship at NASA GSFC in 2002. I've been here ever since and started full time in 2006. The first part of my career I worked as an embedded programmer/signal processing geek for a spaceflight GPS receiver project GPS Navigator, and then I moved to the space communications and navigation group in 2009/2010. I started supporting the TDRS-KLM project in 2012 and have had an amazing time helping build, launch, and commission two TDRS spacecraft (soon to be a third!).

The 450 division at GSFC has a huge summer intern program, we expect to have over 50 interns this year. Space navigation and communications is an expansive field. Getting a bit of data or computing the range from a satellite to the Earth is a very complicated task and it takes all kinds of expertise. I work every day with aerospace engineers, electrical engineers, computer science majors, technicians, physicists, computer engineers, and satellite operators. Although I am a small cog in a huge machine, it's amazing to come into work everyday. -Greg Heckler

How did you get into your line of work? As an astrophysics student this is interesting to hear about!

efie

Hi efie. Thanks for asking. I grew up in the 60's and fell in love with the space program. As a result, I knew that this was the career path I wanted to pursue. In my specific case I started my career as a contractor before becoming a civil servant. That position was very exciting: I was a science operations controller for Hubble Space Telescope before it was launched. This position gave me many skills that I still rely upon today. From there I would apply for positions that both increased the challenges while still was exciting to me as a person. Keep up your studies...you are in a very exciting field. - Bob M.

How did you get into your line of work? As an astrophysics student this is interesting to hear about!

efie

Hi efie,

I believe that there are many paths to NASA. As a Project Manager for several spaceflight projects, the coolest thing I've come to appreciate is the diverse set of skills that are needed to make a project successful. I've been so fortunate to work with teams of super talented people that cover all sorts of important disciplines. Many are ones you might expect (e.g. astronomy, science, systems, mechanical, electrical, thermal, and software engineering) but there are many other disciplines that are just as critical: parts engineering, human resources, mission assurance, financial manager, education and public outreach, orbital mechanics and navigation, comm, administrative support, task scheduling, procurement and contracts management. I could go on and on. But any academic discipline can get you into NASA, just work hard and reach for the stars!

Todd

Thanks for offering your time here! :) I have a few questions...

1. Does the "space network" operate on a conventional TCP/IP stack? Or is it an in-house solution?
2. Are all the routers and hardware using a custom (Linux kernel?) Operating system?
3. Is much data lost between say, earth and a Voyager probe?
4. Do you pronounce it "router" or "rooter" ?

Cheers!

EDIT before I sleep: What addressing scheme do you guys use?? I'd love to know the logical address of the ISS haha!

aptgetcoffee

Right now we encapsulate or strip TCP/IP frames so it is invisible to the actual Space Network network. There is certainly raw TCP/IP (and UDP) traffic between the Space Network ground stations and mission operations centers (MOCs). Most of this traffic is carried by our own private network, which leases bandwidth from backbone providers. We are looking forward to explicitly extending IP networks into space, and we are working on Disruption Tolerant Networking (DTN) right now to achieve this. In the future we want space comm access to be analogous to using a cell phone here on Earth, always available and on-demand.

We use COTS products for TCP/IP routing, as we encapsulate or strip the TCP/IP traffic we have frame processing units, which are usually provided by smaller companies under contract. Given the mix of equipment in the ground station, we have ancient VAX systems, Windows, and now some of the products are built on top of Linux.

Yes, sometimes we have data outages with our customers which are treated seriously. The Space Network requirement is to achieve 99.5% of scheduled services, and historically has exceeded this requirement.

"router".

-Greg Heckler

If we left for Mars today would we have a reliable communications system in place already? How well

developed are our current techniques for communicating at distances like that?

MindFuckYourPsAndQs

We talk to spacecraft and rovers at Mars everyday, so I would say our systems are reliable. The underlying techniques are all established and are exercised by the Deep Space Network, the issue is capacity. As more "things" are at Mars the more data will need to be relayed back to the Earth. Humans generally have high data volume requirements, and the current methodology of using direct Mars-to-Earth links or using the Mars orbiters to relay data would not be sufficient to service the needs of humans at Mars. Optical communications will be part of the solution to providing more bandwidth between the Earth and Mars. Also, humans are less risk tolerant and generally like to have backup options and failsafes.

All of these large architectural trades are being studied by right now by NASA. When we go to Mars establishing a Mars communication and navigation network will likely be a first step. -Greg Heckler

If we left for Mars today would we have a reliable communications system in place already? How well developed are our current techniques for communicating at distances like that?

MindFuckYourPsAndQs

Hi. Thanks for your question. Putting aside for the moment your definition for "reliable" the answer would be yes. We already have it. There have been numerous missions to Mars already...some landers and some orbiters...and the pictures and science data is fantastic! Will the current systems, as 'reliable' as they currently are, meet the requirements for human missions? It depends upon the mission concept being used at the time. What we know today is that the reliable comm channels are smaller (in data rate) than what is desired by the science community for future investigations and by mission designers who want to make the experience to Mars as Earth-like as possible. This is why we are now working on advanced communications systems such as laser-based optical communications. Here too things are getting very exciting. As an example, the LLCD system that flew on LADEE successfully exceeded 600 Mbps (moon to Earth) on a cloud free day! Now that is hauling the mail!! As a result, that team was able to transmit the first all-optical comm HDTV video of NASA Administrator Bolden to the moon and back. Today we are building the optical system that will be mounted on the second flight of Orion and capable of transmitting 4K UHD video back to Earth. So, the answer is yes...and growing. Go to <esc.gsfc.nasa.gov> to stay abreast of the advances taking place. - Bob M.

How good are laser comms expected to get? What's their hypothetical upper limit for passing data? I've seen a system that had an early version of a laser comm link and it was very impressive. Do you think lasers will replace UHF as the standard primary space TTC comm link, or will it just be used to pass massive amounts of data in downlinks? Are there any drawbacks to laser comms aside from the obvious atmospheric/footprint issues?

Ferret8720

NASA's laser comms heavily leverage the components and technologies developed for the ground-based optical fiber telecom that powers the Internet. in turn, these systems can now deliver data at rates of petabits per second, where a petabit is 1 followed by 15 zeros of data bits! There is nothing to preclude similar rates in space laser comms in the near future. https://phys.org/news/2012-09-petabit-fiber-transmission-km.html - DrDon

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Ferret8720

I'll answer this from the navigation perspective. We use our current microwave communication systems to gather range and Doppler measurements at the same time we transport data. We are working on optimetrics technology to enhance optical communications systems to gather similar observations. Our goal is to achieve 10's of nanometers ranging accuracy, whereas our current microwave based methods are only accurate to meters or centimeters. -Greg Heckler

How much manual intervention is required to get personal messages between astronauts and family members? What are the basic steps to deliver a message from an astronaut's keyboard on the ISS to the public Internet here on earth (and vice-versa), and how automated is it?

DrSheldonC00per

Hey there, we answered that question here -Amber

Is life there anything like the movie "The Dish"?

And, more seriously, do we still have a significant capability for communication above Low Earth Orbit? I know several of the big Apollo dishes have been decommissioned. Have you replaced that capability?

x31b

There are hijinks in any workplace. I was fortunate enough to travel to Antarctica three seasons to work on the McMurdo TDRSS Relay System to help get it ready to relay data downlinked by SMAP back to the US through TDRSS. McMurdo is an interesting place with very interesting people. Regarding the big Apollo-era dishes, they are still in service and have recently been overhauled. JPL, which manages the Deep Space Network, is working on combining multiple 30 meter antennas to replace the larger 70m dishes over the long term. You can always check on the status of the Deep Space Network at any time! -Greg Heckler

Thanks for doing an AMA on these things, I'll keep it in item form to make it easier to answer.

- What kind of modulation are you using?
- Are you still using turbo codes for FEC?
- What bitrates can you reliably achieve?
- Why do I not work for you guys yet?

cmol

Most NASA and international space missions use CCSDS standards for modulation and coding. Right now a lot of the modulation and coding is traceable to Apollo and the (Unified S-band] (https://en.wikipedia.org/wiki/Unified_S-band) standard developed at that time. The TDRS program deviated from the Unified S-band and started using CMDA technology in the 70s, way before cell phones used it for 2G and 3G in the 90's. Right now, as we try to get as much data through the current satellites as possible, we are working on implementing higher order modulation and modern coding schemes, such as LDPC. The ISS upgrade will use a combination of 8PSK and LDPC 7/8s. And yes, NASA still supports turbo coding. It's hard to "retire" old modulation/coding schemes until the actual

satellites that use them are decommissioned. -Greg Heckler

Who builds your receivers? I'd assume them to be among the most sensitive on the planet, how many dBm is Voyager coming in at? At what gain on the parabolics? What kind of exotic preamps and filtering?

Thanks!

RF-Guye

Our receivers are pretty specialized because we have our own modulation and error correcting code standards, although we contract out to build them. NASA has three networks, the Near Earth Network (NEN), Space Network (SN), and Deep Space Network (DSN). DSN services the planetary spacecraft and are link/power limited. SN and NEN are more bandwidth constrained. When you are asking about getting another 0.1 dB out of a link, DSN are the experts. They have cryo-cooled LNAs and do a lot of work to operate in these regions. -Greg Heckler

Nothing technical here, just wondering how ISS or Mars or Moon bound astronauts communicate with family on Earth? Are they allowed regular contacts. Especially those with children. Are they private actual talking directly conversations. Private from the public or only for publicity purposes. Can they only happen if family in NASA comma centre type place. I realise must be some controls, can't have family ringing up to ask where they put the car keys, in the middle of a space walk or something.

Roselace

The Space Network supports regular voice contact between the ISS crew and their families through the ISS<->TDRS link. As a policy we treat astronaut privacy very seriously and we have procedures in place strictly for these situations. In general these voice contacts are scheduled ahead of time and they do not occur spontaneously, except in the case of emergencies. -Greg Heckler

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Roselace

Astronauts about the Station communicate with their families through our Space Network, and they have regular contacts as their schedule permits. They can have private conversations with them as well. -Amber

First: thanks a lot for your great work!

What is the delay time (ms) if "ping" the station?

MilesTeg81

ISS uses TDRS, which are in a geosynchronous orbit. A ping would have to go from the Earth, up to a TDRS, down to the ISS, and then all the way back. Two way light time to GEO is ~240 ms, but you have to traverse that path twice to get a ping, so about 500 ms. The ground station delay is not that

significant. tl;dr Great for checking out /highqualitygifs from space but not so good for playing Overwatch or TF2. -Greg Heckler

How lost would you be without Einstein's theory of relativity?

gtrpunk

Very! In space communications and navigation we have to deal with relativity every day. NASA uses GPS on spacecraft, and GPS has to account for both both special and general relativity to work. Given the high velocity of satellites we also have to deal with the Doppler effect created by relativity in our receiver designs, which makes them more complicated than radios for terrestrial wireless systems. -Greg Heckler

If in the future we manage to reach other solar systems, normal communication methods will be too slow. In your opinion, what technology could solve this issue? Maybe it could be quantum entanglement?

Guguskis

It's hard to beat the speed of light, see the No Communications Theorem. We are working on quantum communications technology to increase the capacity of classical channels and also distribute quantum keys. A little bit out of my wheelhouse but I pay attention whenever I attend NASA technology forums. -Greg Heckler

Thanks for coming to answer questions!

I'm curious: Do astronauts ever get any privacy? Can they request private communications with family? Or is someone from NASA always listening in?

asbruckman

Hey, we answered that here. -Amber

How often are satellites launched for the purpose of aiding communication capabilities? And how many are already up there that you use for this purpose?

hummusfalafel

The TDRS project launched TDRS-A (TDRS-1) in 1983 and TDRS-M (TDRS-13) will be launched on August 3rd. The Space Network maintains 5 active satellites at any time, some have been retired and some are in storage. LCRD will launch in 2019, we are excited to transition to the era of optical communications and to jump onto the next technology curve.

1.) Is there a constant pressure working for NASA with more and more countries having there own space program ? 2.) Did you feel the governement budget cuts towards NASA ?

Poca-

Hi Poca. No pressure...just opportunity. I have had the very good fortune to work with ESA, CNES,

EUMETSAT and the Japanese Space Agency. These experiences have been very rewarding and I include my international experience amongst my most important. Your question on the budget is very timely. In short, as civil servants AND taxpayers we feel the urgency to provide value to the nation in everything we do regardless of the specific budget entrusted to us. - Bob M.

Where did you guys go to school and what were your majors

Alushi99

Hi Alushi99. I attended Rider University (New Jersey) where I majored in physics, and minored in math and biology. I earned my Masters in computer science from the Johns Hopkins University (Maryland). - Bob M.

Where did you guys go to school and what were your majors

Alushi99

Hey there, I went to the University of Maryland and majored in communications (the public relations kind, not the space communications kind :) ) -Amber

Where did you guys go to school and what were your majors

Alushi99

Hi Alushi99. Undergrad at U. Penn in Materials Science and Engineering. PhD at U. Wisconsin (Go Badgers!) in Materials Science and Engineering. Todd

Where did you guys go to school and what were your majors

Alushi99

Purdue University, Aerospace Engineering. -Greg Heckler

Hi from the office right next door to yours, Todd!

What sort of bandwidth is LEMNOS hoping to achieve, and how does that differ from our currently in-place methods of communicating with spacecraft at that distance?

zeu5

Hey Neighbor,

LLCD on LADEE demonstrated 622 Mbps downlink and 20 Mbps uplink from around the moon. LCRD will be relay data at 1.2 Gbps bi-directionally from one ground station to another. For the Orion EM-2 Optical Comm (O2O) project for LEMNOS, we are starting "small" and only providing up to 80 Mbps downlink and 20 Mbps uplink from around the moon as a first step towards making Laser Comm an operational reality for future NASA missions. I fully expect to operationalize higher data rates in the future. Exciting times!

Todd

Hey, whats the process like for getting a job in something like this, or any job at NASA in particular like? Almost graduated with my masters in astrophysics and I'd obviously be interested in going down this route but don't have much idea what it requires or what NASA are looking for. From the UK btw.

Groggolog

All civil servant jobs at NASA are posted through usajobs.gov. We suggest you check that site out and apply through there. We also have a number of federal contractors that help us as well. - Amber

Do you still have opportunities for HAM radio users to talk to the station in the moments it is in range? I remember doing that with my granddad, talking to Atlantis in the 90's.

dwilliam16

We definitely do! Check out the ARISS website for more information. - Amber

Would you share a Speedtest.net test result from the ISS?

newpaths

Hi newpaths. Great question...I just used the application the other day to check out my new modem. We use other means to measure the symbol rate of our links...but come up with information that answers the same types of questions. - Bob M.

How does Voyager still communicate with us

zrleonard187

Hi. This spacecraft uses the original radio and transmits with the Deep Space Network. - Bob M.

Hi folks, thanks for doing this AMA!

A couple years back, I wrote a brief for a contest that talked about the need to establish a communication satellite network prior to Mars colonisation.

Is it too early to be putting such a system into place, or is there just no need for that level of redundancy and re-usability for communications within the inner planets?

Thanks again for taking the time, in my eyes you folks are the rock stars of exploration. :)

rrauwl

I certainly expect NASA to increase the communications capability between Earth and Mars before humans get there. A local Mars network is a real option and is under study. SCaN is there to fulfill the need as it is defined by the Human Exploration Office (HEO) -Greg Heckler

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Thanks again for taking the time, in my eyes you folks are the rock stars of exploration. :)

rrauwl

Hi rrauwl. I have not read your brief but think it would be very interesting to do so. You ask an excellent question: do we build the infrastructure first and then send humans to Mars? Or, do we send them and let the infrastructure follow? The answer is balance. There is a need for reliable communications wherever we send our robotic and human spaceflight missions. We are working as an Agency to be balanced in doing that so we use the fewest dollars to the accomplish the most objectives. Thanks for the kudos. It is an honor that is highly valued and we promise to never take it for granted. - Bob M.

First of all, thank you for all you do in supporting our missions for knowledge and understanding.

- How do you feel about ARISS and other Amateur Radio in space programs? / Do you have contingencies in place to use these systems in case of ground net failures?
- Percentage wise, how much of your tech is COTS?

xterraadam

Hey there,

We love ARISS! Actually, ARISS is part of the Space Communication and Navigation Program here at NASA. We do have contingencies in place. The Space Network provides communications services to the International Space Station, but we do have compatibility with VHF in the event that we need it. - Amber

Between the earth and mars I assume the SNR of the signal is very poor in that channel. What modulation do you typically use and is there a great deal of error recovery in the form of FECs in the message to self correct due to symbol errors which I assume are fairly severe?

Additionally for Doppler correction, what would be a normal shift in frequency you observe and how do you correct it?

PMmeBoobsImRich

For the Space Network and user near the Earth we experience hundreds of kilohertz of Doppler shift, which we have to accomodate in our signal and receiver design. We design our links bounded by the Shannon limit, the performance of our error correcting codes, and add margin to make sure they work! Right now the most powerful codes we use are LDPC codes, which NASA developed for space and are standardized by CCSDS. -Greg Heckler

What's the phone number for the ISS?

J50GT

867-5309

-Greg Heckler

Is there a book you'd recommend for someone interested in satellite communication?

Double-Down

For the whole history, Read You Loud and Clear! -Greg Heckler

How many redundant coms systems are there usually and what would be the worst case scenario should the primary means fail? I mean, what is the most primitive means of communicating when everything else goes wrong?

Olandsexport

For robotic missions we bin things into two categories. The first, TT&C is for commanding and controlling the satellite itself. TT&C links are usually lower frequency, lower data rate, low latency, and the systems are highly redundant. TT&C links usually are designed to work without the spacecraft able to point itself for resiliency. For science data the links are usually higher data rate, higher latency, and hence implemented using higher frequencies and bandwidths. We assume the spacecraft can point itself and the comm system to enable the higher rate link. Most missions therefore carry effectively two independent communication systems to meet the two needs. Often once a satellite is operational and everything is normal the TT&C traffic will be interleaved into the higher rate science link, but not always. -Greg Heckler

Since the objects you're communicating with in space are always moving, do you have to send data to where they're going to be or where they currently are? I can only imagine the calculations required to send data to a moving object in deep space.

mtfletch11

Yes, we certainly "lead the target" for deep space missions with long light times. For some deep space missions the uplink from the groundstation will have be terminated before the downlink from the satellite arrives. For near Earth missions this effect is not as relevant as the error is usually well within the beam width of the antennas being used for communication. As we work to implement laser communications, with much tighter beams, the pointing problem becomes more difficult, even near the Earth. -Greg Heckler

Thanks for the AMA. What's the most common misperception about your role within NASA and/or communications with our astronauts?

Bonus points for favorite space book/movie that most accurately depicts space communications.

LastLTR

They don't even know we exist! As the universe's wireless internet service provider we are often forgotten about completely within NASA, and certainly outside of NASA. Because communications is so fundamental to operating a satellite or flying humans in space we make sure things "just work" at all times. -Greg Heckler

How do you guys feel about STEM and Technology fields becoming more mainstream and cool rather

than having the preception of being "nerdy"?

Eugeneeeeee

We love that STEM and technology is becoming more mainstream, and love even more that STEM became STEAM (Now with art!). One of the big things that we do here is inspire future generations to want to explore space, and we need people who specialize in STEAM fields to do that. -Amber

Could it be possible to communicate with spacecraft with light? If so, how would that work?

TheRagingScientist

Yes! LCRD will launch in 2019 and is doing exactly that. Believe me, it takes a bit of rocket science to make it work ;). -Greg Heckler

What technologies are used for this type of communication? (directional antennas?)

Lasers on satellites sounds like a fantastic idea for high speed communication. Just get the signal to the satellite, and the laser sends it the rest of the way.

ittimjones

You can get a good overview for what we're doing in laser communications here: http://spie.org/newsroom/pw15_plenary_landing/pw15-plenary_cornwell DrDon

How do you do handoff when the location of the space station changes?

RE: Orion Laser Communications System -- What do you think about SpaceX's proposal to put lots of optical links between a huge number of satellites?

sdhillon

TDRS provides global coverage to ISS and there are some transition times when handing between relays but it is minimal. The ISS provides the Space Network its state vectors/TLE's daily and updates them promptly after maneuvers so we always know where to point the TDRS antennas. -Greg Heckler

I know we have the Deep Space Network parabolic dish antennas & receivers that cover the globe. Has any consideration been given to putting repeaters in orbit around the Earth and other planets? The objective being to retransmit distant satellite signals (e.g., Voyager I & II) back to Earth with a greater signal strength.

DotComCTO

Hi DotComCTO. Interesting question. Engineering wise I guess you could...and when it comes to Mars...we see that beginning to happen. However, cost to implement is the biggest constraint. Do we build a repeater for the one mission that is past the Heliopause? Or build the next optical communications space-based relay? Unfortunately, the ideas exceed the funding to implement them. That said like you I am always interested in hearing about whether or not we've made contact with the Voyager and how far away it is at that moment. - Bob M.

Hello! I am excited that this AMA is going on. What would you say are the downsides of pursuing a career in astronomy? I am a current student with an unfathomable fascination for the subject who is currently studying Earth and Planetary Science. Along with the first question, what path would you recommend in regards to major choice for someone pursuing a career in astronomy, what might be some major differences?

Mitto

Hi Mitto. My first position in the space program was working on the pre-launch preparations for the Hubble Space Telescope. This gave me a great chance to talk with astronomers from around the world. One was Dr. A. Sandage...who was a research assistant to Dr. Edwin Hubble. There were some neat stories shared in those conversations! If you are compelled to ask fundamental questions about our universe then what could possibly be the downside? Yes, a job is a job...but a job that excites you, challenges your mind and gives you a chance to advance humankind's knowledge...well, what could possibly be the downside? Your Earth and Planetary studies now make great sense, but you will need to consider choosing at some point. This can been seen in the science community today where there are different communities. Note, though, that Astronomy is hugely broad; and, as a result, it is much more than planetary. I do not observe the Earth science community considering themselves "astronomers" so be mindful that there is a distinction. As you suggest there are differences: astronomers look out into the heavens and seek to answer their questions without the ability to touch what is being studied. By contrast Earth scientist often use field campaigns to insert themselves into the systems they study...and sometimes get wet as a result. ;-)Good luck with your studies and with coming to the answers of your excellent questions. - Bob M.