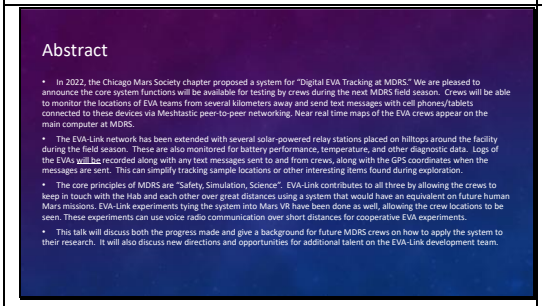
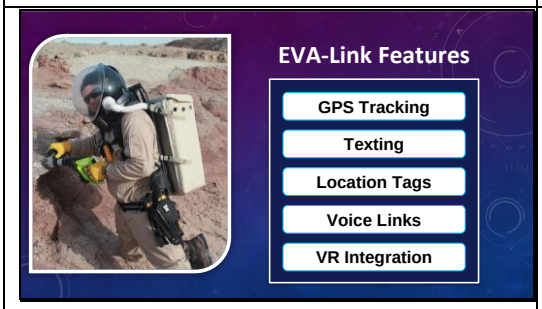
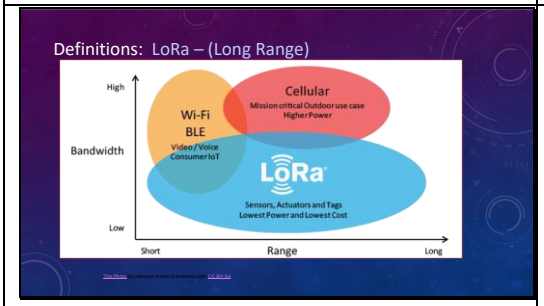
Hi everyone.
Eric and Jason have done this talk in past years, and this year it's my turn.



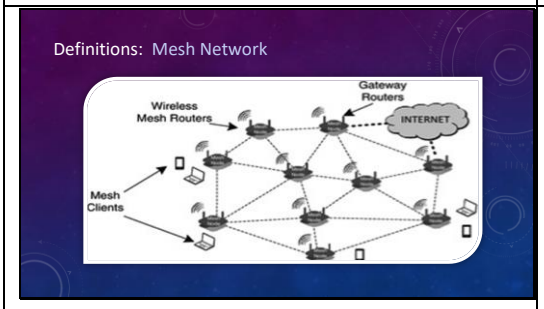
First, I'll introduce EVA-Link and the connected systems.
This past year, we tested it at MDRS with prototypes and made improvements.
This coming field season, we are installing EVA-Link at MDRS as standard equipment.
Lastly, I'll get into planned improvements and how you can join our efforts.

	A key problem with MDRS has always been that once you get outside the range of the handheld radios, you are basically cut off from rescue or communications. On the map, if you go as far as the orange circle and your radio only goes as far as the green one, you may have a problem if you break something and can't call for help. All geotagging of samples had to be done with a hand-held GPS. You can use smart phones to geo-tag pictures and therefore sample sites, but that restricts the data to personal devices.
	Outdoor Analogs need a system that gives basic text and GPS tracking information over very long ranges. You want crews to report locations for both help and science reporting.
	The core principles of MDRS are Safety, Simulation, and Science, in that order. We wanted a system that could add to all three elements at once. A live tracking system can make EVAs safer by showing where people are if they are overdue and allowing them to send an SOS. Live tracking also makes the experience more immersive for both field crews and those at the Hab keeping track of them. Finally, science is simplified by allowing crews to log and retrace their steps in the field.

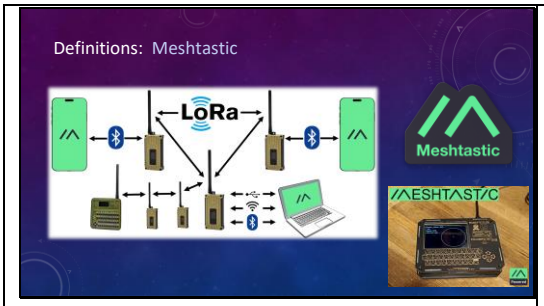
The overall system extends beyond the hab and desert to include mission support around the world. We can also use a custom version of Mars VR to see the beacons and EVA crew locations. This is an invite-only network so we maintain the security and privacy of crews on and off site. It also means we can link simulations so that an EVA participant in Hawaii could text another in Utah, or either crew can get help from anywhere.



Before we get started, I need to define a few words. Our hardware uses a digital radio system called LORA, which stands for Long Range. It can send very slow data signals over many kilometers with very little power, so it's commonly used with things like weather balloons, CubeSats, and weather stations.



A mesh network is like wi-fi, but every device in the system sends signals that any other networked device can hear. Those devices then resend that information and so on for a limited number of bounces, called "Hops". You can send from device to device without a central hub.
You may have seen a similar system proposed for exploring caves on the moon and mars with robots. Each would leave a bread crumb trail of mesh network relays as they went. This is the same principle.



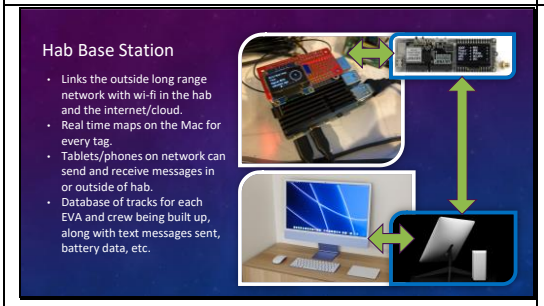
The most popular open-source LORA mesh network protocol is called Meshtastic.
This software package can run on smart phones, browsers or dedicated pocket devices to exchange data. Connect a small Meshtastic device with a Lora radio and Bluetooth to the phones you want to use, and then let the devices send the messages or other data to the mesh network. This also works with PCs connected to these devices. Meshtastic can be linked to the internet backbone so that messages can be sent globally. It also allows encryption and private channels.

Let's go over the hardware and then dig into what the system does.

First, we put a small, affordable Meshtastic device inside each suit, or on it with a clip. By itself, this system can send GPS data back to the network for each crew member every minute. When used with a tablet or smart phone, it can also send text messages and display maps with every beacon on it in near-real time. Since the text messages and tracking data are together, you can geo-code what you say to identify sample locations or send an SOS with your coordinates.

We installed relays on various hills halfway through the last field season.

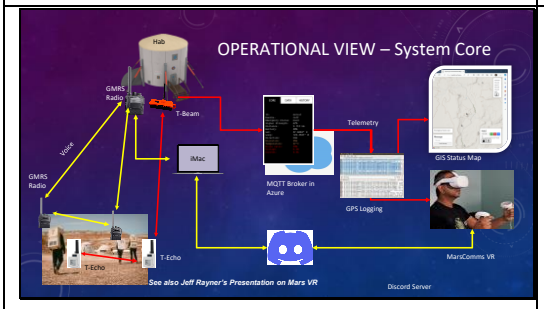
These are solar powered and check in with their battery and temperature data periodically, along with their position. This set were made by Peter Dekluyver, and so got nicknamed the Peter Repeaters.



At the Hab, we have a special T-Beam that can route all the data to a server in the cloud via Starlink.

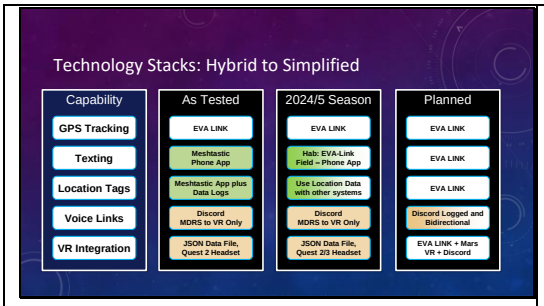
Our cloud system also hosts a map for tracking the astronauts in their suits outside and any other data sources. This can be viewed on the iMac, but also by anyone with a valid account.

We also have a Raspberry-Pi based system that communicates with the T-Echo devices back in the hab to keep the software updated.



We still use the hand-held radios for voice communication when close to the hab. We use Discord to share voice between the computer network, VR, and the radios.

We can send the GPS log data and tracking data to the VR model of terrain. So for short range experiments within a kilometer of the hab, it will be possible to see and talk with crews in VR while they work outside.

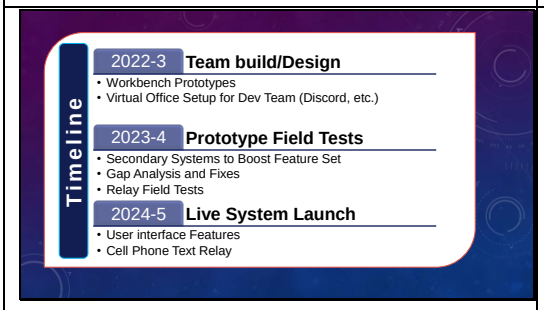


As of now, the whole MDRS ecosystem can do texting, GPS tracking, location tags, voice, and show crew locations in VR.

However, we're using other systems in parallel like Meshtastic and Discord for most of that functionality. Keeping them separate for now lets us ensure each is working in the MDRS environment before certifying them.

As we merge them into a single, simplified system, I want to be able to explain the whole system in five minutes and have a new crew know 90 percent of the functionality.

So… from PowerPoint to MDRS in three short years…

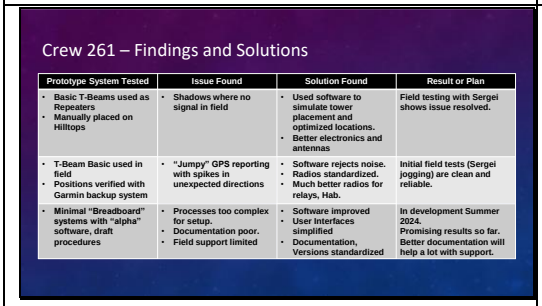


During the last season, we got prototypes in the field with James Burk's Crew.

We have just assembled the package for permanent use at MDRS for the new field season.

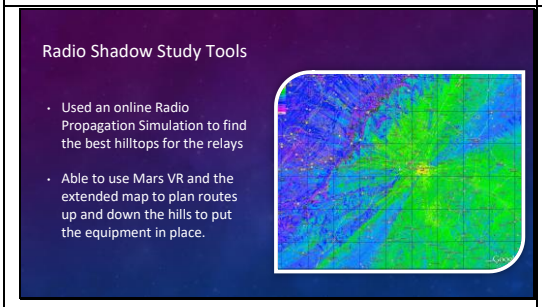
Any crew at MDRS going forward will have basic tracking capability.

Thanks to James Burk's Crew 261, we got some live data from our homebuilt prototypes, shown here. We found lots of signal blocking and other problems on site that didn't appear in our neighborhood experiments.



We found jumpy signals where bad data made crew members spontaneously teleport for a minute or two. Filtering the noise out of the data cleaned up these stray readings. Improving the beacons also helped de-Heisenberg our teleporting crew members with more data points.

We also found documentation gaps to fill for crew members going forward.



We found some online tools for modeling radio shadows. This allowed us to overlap our relay stations to knock out the shadow zones.

We also built much better repeaters for live use this next year. We field tested them for a few months before putting them away until the next season. For testing, Sergei wore a beacon out jogging a few times and we track his position from home over our network. No teleportation detected.

The repeaters are solar powered and check in with their battery and temperature data periodically, along with their position. This set were built by Peter Dekluyver, and so got nicknamed the Peter Repeaters.

On our map view at the Hab, we've made a lot of improvements. In the short term, we want to label crew members by name rather than suit number using a list of crew suit assignments. We eventually want to add the text message feature here as well. This is a work in progress.

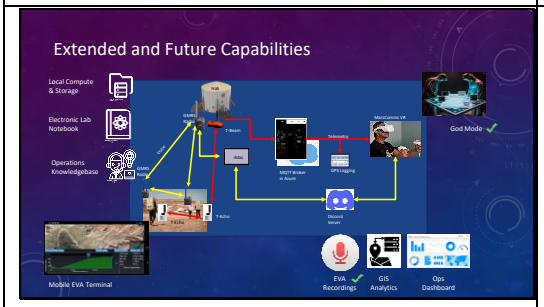
Clicking the download button will send all the logged position and message data to a local drive. This is also the data log we are integrating with Mars VR to show crew positions.

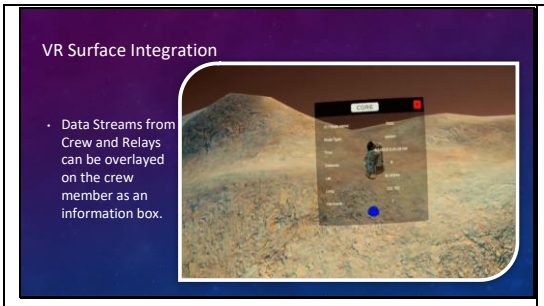
Speaking of Maps, the Mars VR custom version for EVA-Link has been expanded with satellite data so you can see all the landmarks to the horizon, not just the few square kilometers where we have drone maps. Some of our beacons are in places like Phobos Peak which were off the original map. Putting on the headset can show crew in real time as tiny icons on a room-sized map, and teleporting down into VR shows them as suits.

So with EVA Link and Mars VR – you can view the map on the screen, and in VR from either from the surface or from the air.

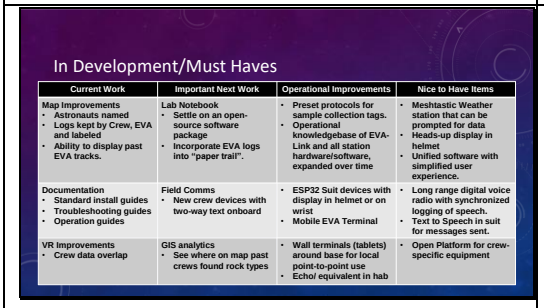
And as I've mentioned, we are finally live with a production system this season! These are the suit terminals being shipped out after having improvements to the hardware and software configured. We can also remotely update them to a degree.

So, what next?



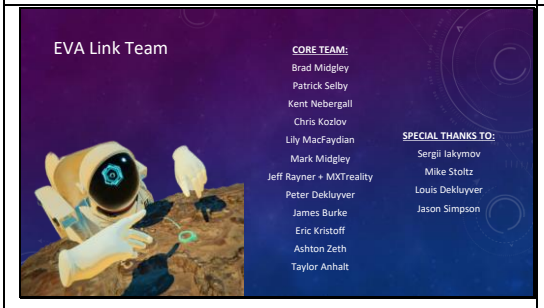


We are also working to add the live suit data to the icons in VR. For now, this is just the battery and temperature of the sensor in the backpack. Doing live health data is difficult because of medical privacy and experimentation laws. That said, there's nothing preventing a crew member from monitoring themselves privately with a Smart Watch and lining up the data later by time stamps. I would like a temperature sensor in the helmet, though.



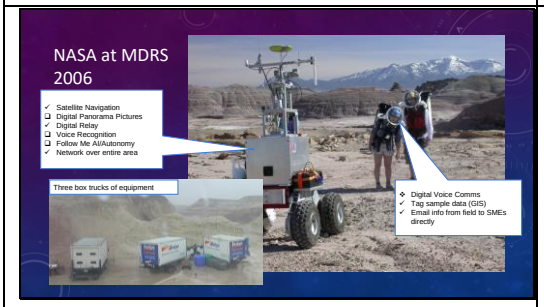
So as noted, we are wrapping up our baseline system in the coming months before the field season. We want a lab notebook system for the Science Dome that works with the EVA logs. Ultimately, this would give scientist a paper trail from the field to the lab and publication. We want to make the suit systems smarter for two-way texting, so you can log samples or ask what's for lunch.

In the long run, we found a compatible and affordable weather station and a heads-up display. Our gadget junkies are salivating.



I want to acknowledge our team. This started out as me with a PowerPoint presentation three years ago. And now it's going live thanks to all these awesome people who actually know how to build stuff.

Do you build stuff and code stuff? Or document stuff? Please talk to me or scan this QR code at the end of the talk.

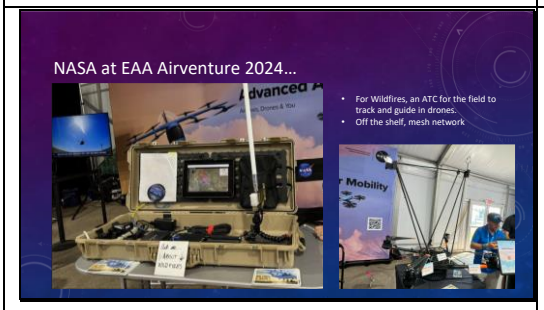


In 2006, NASA sent several crews out to Mars Desert Research station to experiment with long range digital communications and rovers that interacted with crews via voice commands.

They brought out three moving trucks of equipment and could cover the entire zone with wi-fi bandwidth linked to a satellite ground station. They could track astronauts in the field and send geotagged messages on samples.

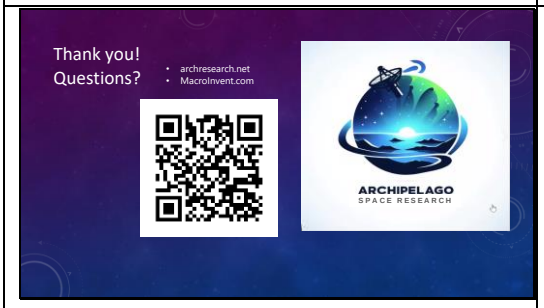
So, in the nearly two decades since then, we no longer need three moving trucks to track astronauts in the field…

Thanks to 20 years of technology advancements, we get roughly fifty percent of the benefits of the NASA system for less than they spent for gas money for one of those trucks. You could basically pack all the gear for EVA-Link in a carry-on suitcase.



A couple weeks ago, I saw this at EAA Airventure in Oshkosh. This is a NASA Advanced Air Mobility project to make an Air Traffic Control system for drones using off the shelf parts and a mesh network. It's for use in wildfires when they fly drones at night to monitor hot spots and weather conditions. On the right is a drone with weather instrumentation on top for checking conditions around a fire zone.

So at least one NASA project is much more like EVA-Link than the NASA project that inspired it in the first place.



Thanks everyone. Any questions?

The QR code is for a volunteer form. If you are on an MDRS crew in the coming field season, please also contact us to learn more about how to use the system before you arrive.