Hi, this is Duranee for Cheap Astronomy, www.cheapastro.com. This is SISS, Science on the ISS – and today's episode is *Ham radio.*

This episode of Science on the ISS isn't *exactly* about scientific *research*, but it is about science education. It's also about the longest-running *science-related* activity that's ever been conducted aboard the ISS and it's a science-related activity that ISS crew members are not likely to want to give up any time soon.

The word ham implies being clumsily amateurish, like a ham actor, and was initially attributed to 19th century telegraph operators who had not yet fully-mastered the skill of delivering Morse code messages quickly and efficiently. They were hence described as ham-fisted – which was itself a term already used to describe amateur boxers. Nonetheless, after long-distance communication went wireless with the advent of radio, amateur radio operators happily referred to themselves as *ham* radio operators whenever they undertook any non-commercial on-air activity.

An installation simply called the *International Space Station Ham Radio* was the first-ever *payload* to be brought aboard the ISS, where payload means anything that isn't directly involved in keeping the station operational or in orbit. The ISS ham radio was turned on less than two weeks after the crew of Expedition 1 boarded the newly-united Zvezda, Zarya and Unity modules in November 2000. Since then, various other ham radio setups have been used on board the ISS, allowing the astronauts to make contact with over 1,000 schools, and with backyard radio ham enthusiasts all around the world.

The rules are that any space to ground ham radio contact must be managed by licensed ham radio operators at both ends. So, any astronauts who want to get involved have to become licensed first. From a recent count of both active personnel and retirees, over 200 astronauts are licensed radio hams. The very first ham radio communication from space was made by astronaut Owen Garriott aboard Spacelab – which was a reusable module built by the European Space Agency. Spacelab was intended to demonstrate what could and *would* later be achieved aboard the ISS. It was an astronaut-crewed module that orbited the Earth, even though it never left the cargo bay of a Space Shuttle, and everyone aboard it just did science experiments… and lots of them. And within the very first Spacelab, aboard shuttle mission STS 9 in November 1983, Owen Garriott contacted ground-based ham radio operators via a hand-held VHF/UHF transmitter. This began SAREX, the *Space Amateur Radio Experiment*, which continued to operate over multiple Shuttle missions up until mission STS 93 in 1999. After that, ARISS, the *Amateur Radio on the International Space Station* program, took over and is still running today.

But sticking with the Space Shuttle era just a bit longer, mission STS-37, which launched in 1991, was the first mission in which every member of the crew was a licensed ham operator and the mission flew with an upgrade to previous shuttle ham radio installations, which was called SAREX 2. STS-37 was a notable space shuttle mission in other ways too. It included the first US space walks undertaken in six years, following the Challenger disaster in January 1986. One of those STS-37 spacewalks tested procedures that were expected to be used aboard *Space Station Freedom* once it became operational. These were procedures designed to test the feasibility of moving heavy equipment around (and also moving astronauts around) using manual, mechanically-assisted and electrically-powered procedures – and many of these procedures are now in routine use on the ISS.

But, you may be wondering, what the heck was *Space Station Freedom*? Plans to build *Space Station Freedom* were first announced by US President Reagan in 1984. It was planned to be a solely US initiative, perhaps as a response to Russia's success with the Salyut space station program – a success that was soon to be upstaged by the space station *Mir* in 1986. The US continued talking about *Space Station Freedom* for many years, as it went through several design changes and a lot of downscaling (both in ambition and in cost) until, in 1993, US President Clinton finally announced that what might have been *Space Station Freedom* would be merged with what might have been *Mir 2* – along with a European and a Japanese space module and with a helping hand or two from Canada. And so the ISS was born.

One of the many good things about this decision is that the ISS now maintains a precessing orbit, inclined 52 degrees to the equator, much like Mir's orbit was. Such an orbit is necessary to enable fuel-efficient docking with space vehicles that are launched from the Baikonur Cosmodrome, in southern Kazakhstan. *Space Station Freedom* had been planned to orbit at a 29 degree inclination to the Equator since it only needed to line up with launches from Cape Canaveral. The 52 degree orbit adopted by the ISS means that it flies over most of the populated regions of Earth – only missing the northern and southern polar regions. The 29 degree inclination orbit of *Space Station Freedom* would have put it out of both visual and ham radio range to much of northern Europe, North America, as well as southern parts of Australia, South America, South Africa and all of New Zealand. And of course, the ISS's 52 degree orbit means its multinational crew can undertake multilingual ham radio communications with people from multiple nations in English, Russian, various European and Scandinavian languages – and also Japanese.

Ham radios aboard the ISS can be found in the European Columbus module, along with some hand held units in the Russian Zvezda module. Operations-related radio contact with the ISS's multinational mission controls is managed with other hardware, but the ham radio installations are still considered to be useful emergency backups should something go wrong with the main radios.

The work schedules of the ISS astronauts dictate how much time they can spend being radio hams. The crew's usual working day is twelve hours long from 0730 - 1930 UTC, while their scheduled sleep period is from 2130 to 0600. So the crew's personal time on work days is between 0600 to 0730 in the mornings and between 1930 to 2130 in the evenings – although with eating, chatting, emailing friends and family, sightseeing and teeth cleaning, there's not that much time left for ham radio. ISS astronauts generally get weekends off as well, although it's understandable if the astronauts decide to devote their weekends to some genuine down-time, which means there's not much time for ham radio on weekends either.

So, if you are a ground-based ham wanting to speak to an astronaut ham in orbit, luck is definitely a factor. Since the ISS is whizzing overhead at 7.7 kilometres a second, even in the narrow time windows when an astronaut might be on air, you only have five to eight minutes while the ISS is in range. The exact time you have depends on where the ISS is in the sky. If it orbits straight overhead, it should be in radio range for a whole eight minutes, but if it's down towards the horizon you'll only get five minutes or less. Beyond that, what time you get to chat might also depend on just how interesting your conversation is – because there may be other radio hams downrange who are just as keen as you are to get their full five to eight minutes of chat.

So, here's a quick SISS tip – if you are over twelve years old don't ask the astronauts how they go to the toilet in space. It's not every day you get to talk to astronaut in orbit – and at such moments, it's important to remember that you are over twelve years old.

Of course, if a *school* has scheduled a call as the ISS passes overhead, those students will get their whole five to eight minutes and they will get to ask the crew 10 to 20 questions about anything they like. Most of the time though, the students have rehearsed their questions beforehand and during those rehearsals most students come to realise that when you have a once in a lifetime opportunity to speak to an astronaut, it's probably best to skip past all the toilet stuff – and that's even they aren't twelve years old yet.

Indeed, avoiding toilet-based discussion may become even more important in the future, because ham *radio* is not the end of the story. In August 2013, a ham *TV* installation was installed aboard the European Space Agency's Columbus module. After working through various tests and trials and after waiting until a ham on the ground got the right hardware, in 2016, UK astronaut Tim Peake transmitted the first ham TV broadcast from the ISS to a TV ham in England.

For now, ham TV is unidirectional. So you can see the astronauts, but they can't see you – even though there is 2-way sound. But, in the future, it could be two-way – and maybe you don't want to be that first person recorded on You-Tube who asked the dumb toilet questions in the one time that they got to speak to an astronaut in orbit.

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