

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

So, what exactly is a space station? A definition has never been rigidly defined, but we all know what a train station is. So, how about we say that a space station is a bit like a train station? That is, it's a place that spacecraft can go to, to exchange passengers and cargo, before departing again. Unlike a train station, a space station is not really a fixed point, but its current location is always known and its future location is always predictable.

The first mention of space stations in *fiction* date back to the late nineteenth century. The first *non-fiction* mention of space stations was by Konstantin Tsiolkovsky, the man behind the Tsiolkovsky rocket equation. Tsiolkovsky discussed the idea of a rotating orbital space station, an idea that was later portrayed in the 1968 release of *2001 A Space Odyssey*, with its wheel and spokes space station. Tsiolkovsky was of course Russian and as it turned out Russia was the first country to really make space stations a thing.

The world's first real space station, Salyut 1, was launched in April 1971 and boarded by the crew of Soyuz 11 in June 1971, who remained aboard for 383 Earth orbits, over a period of 23 days.

The reason you don't often hear about the tremendous achievement of Salyut 1 is that the mission's success was overshadowed by disaster – when, after departing the station, a depressurisation valve on Soyuz 11 accidentally activated and depressurised the cabin. At that time, wearing a space suit during launch and landing was not considered mandatory. The cosmonauts Dobrovolski, Vokov, and Patsayev were all found dead after the capsule had re-entered the atmosphere and landed via automated procedures.

Salyut 1, the space station, continued to orbit until October 1971, before it was deliberately de-orbited over the Pacific Ocean. Salyut missions 2 to 5 followed over subsequent decades up to 2007, including the achievement of a Soviet space duration record of 63 days by the crew of Soyuz 18. However, it was only a Soviet record as, over this period, the US launched Skylab, which was visited by three crews, the third crew setting a world record of 84 days in space from November 1973 to February 1974.

But, apart from Skylab, the Americans didn't seem all that sold on the whole space station concept. So, it was the Russians who continued to take the major steps forward. After Salyut 5, the Russians shifted to a new generation of Salyut stations, which had more than one docking port. Having more than one docking port meant that a station could remain permanently manned, because a second crew could dock and come aboard to get a handover from the first crew before the first crew's departed via their own spacecraft, already attached to the other docking port. The first crew aboard the multi-docking ported Salyut 6 stayed aboard for 96 days in 1977 and 78, breaking the earlier Skylab record. Successive crews then proceeded to successively break more world records, with the third crew aboard Salyut 7 staying aboard for 237 days in 1984.

The next major development was modular space stations, where each modular unit could have several docking ports, not only to allow for the docking of multiple spacecraft, but also to allow two or more modules to be joined together.

The first such modular space station was the Mir which was in orbit from 1986 to 2000. Mir was composed of seven pressurised modules, which had docking ports for both Soyuz spacecraft, as well as US Space Shuttles. Mir's lifespan extended beyond the Soviet era to the dissolution of the USSR in 1991, after which its upkeep was maintained by the Russian Federation. In this new era of international cooperation, Russia invited the first American aboard Mir in 1995. That was Norman Thagard, the first of the *Increments* astronauts – and listen to Cheap Astronomy episode 167, if you want to know more about the *Increments*.

With the Mir having so well demonstrated the benefits of international collaboration, what was once intended to be the core module of Mir 2 instead became the Zvezda module, which was added to the already co-joined Zarya (Russian) and Unity (US) modules in order to give the forming ISS full life support capability. The first crew of the ISS, appropriately called Expedition One arrived in November 2000, giving the world a space station and a space odyssey to pursue in 2001 and beyond.

The Mir was in orbit for almost 10 years. The ISS has already well surpassed that, since it was first manned in 2000 and is still going strong here in 2015. The ISS is primarily composed of the Russian Orbital Segment and the US Orbital segment. The ISS multinational crews tend to concentrate a lot of their work around their respective nationalities' infrastructure, but there is still plenty of collaborative teamwork around the whole station – and all crew members often meet together for meals and a chat in the appropriately-named Unity module.

So, that is most of space station and ISS history to date. But, it's worth noting that the ISS isn't the only game in town. The Chinese Tiangong 1 remains in orbit as we speak, although its mission life is over. It was visited and occupied by a taikonaut crew, including China's first female taikonaut, in 2012 and was again visited in 2013 by another taikonaut crew that included China's second female taikonaut. Tiangong 2 is scheduled for launch in 2016 and is expected to be followed by Tiangong 3, which may become a component of China's first modular space station, to be progressively assembled over the 2020s.

Also still in orbit and also mission-completed are Genesis 1 and Genesis 2, two prototype inflatable station modules built by Bigelow Aerospace. Neither have been visited by crew or cargo, so we can only call them test modules, not space stations. But, such inflatable modules may be the next big thing in space station design. Inflatable technology allows you to launch a low volume, aerodynamically-streamlined payload and then expand it out into something much bigger once it's in orbit.

Bigelow's vision is that the first privately-owned space station will be built from inflatable modules. Indeed, Bigelow is hoping to build the first space hotel, which they propose to call the Skywalker. But, to date, Bigelow claims that all its plans have had to be put back because there aren't enough launch rockets. Bigelow has to compete with NASA and Roscosmos to get on a rocket and *everyone* who wants to get on a rocket has to live with the intermittent delays caused by rocket launch failures. But, we live in an age where space is starting to look like a good investment opportunity. There's going to be a whole lot more rockets launching in the coming decades.

And while we're talking about the future, what is the future of the ISS? The USA has now extended its commitment to the ISS through to 2024. And Russia, which is already planning to send more modules up to the ISS in the next few years, has even more ambitious plans for the longer-term.

At the end of the ISS's life, Russia plans to remove some still-viable modules to establish a new station called OPSEK, the Orbital Piloted Assembly and Experiment Complex. At this stage, OPSEK could potentially be an entirely-Russian space station, since the American government is struggling to make any long-term commitments.

And of course, the private sector has plans. The Boeing company has suggested that bits of the US orbiting segment could be recycled and repurposed to form the Exploration Gateway Platform. This Platform would be a modular space station parked out at an Earth-Moon Lagrange point. This would position the Platform well outside of Earth's van Allen belts and make it a half-way station for lunar missions, as well as being a launch platform for deep space missions.

Having been in orbit for just fifteen years, the ISS is only just now settling into its role as an orbiting science laboratory. And an important part of its role as a science laboratory is to monitor its own performance as a space station, building a body of data about what works and what doesn't. The best way to do something well, is to try and do it a little better day after day – and take notes while you go. It's a learning process which first started with Salyut 1 and might still be going by the time that Deep Space 9 is commissioned.

(ends)