Hi this is Steve Nerlich from Cheap Astronomy www.cheapastro.com and this is *The Increments*.

Spaceflight in the 1990s doesn't always get the recognition it deserves. In the seventies you still had the continuing Apollo missions followed by the development of Space Shuttle, including in the first glide tests of the Space Shuttle Enterprise. Then STS-1 launched in 1981, making the eighties a decade of space dramas that sadly included the Challenger disaster in 1986, but after that the resumed Shuttle missions did manage to launch the Magellan spacecraft to Venus and the Galileo spacecraft to Jupiter, both of which were launched in 1989. Both these spacecraft where launched in 1989.

The nineties began with the launch of the Hubble Space Telescope in 1990, which was certainly historic and the decade ended with the first modules of the International Space Station, *Zarya* and *Unity*, joined in orbit.

So, if nothing else, the 1990s did at least take us to the point of having an orbiting space station at the beginning of the 21st century, even if it looked nothing like the spoked, dual-wheel station seen in the movie 2001, which entertained us with the site of a Pan Am shuttle docking with it. In reality, the genesis of our real 21st century space station was primarily Russian and was almost entirely government-funded – not that there's anything wrong with that.

The point of this podcast is to consider whether the nineties were really just a *blink and you missed it* decade for spaceflight. Or was it a decade of vital incremental change that inched human spaceflight forward into areas that no-one had gone before. After all, most of human history is about baby steps forward, taken by people who were never quite famous enough for anyone to remember their names.

Indeed, there were a group of seven not-quite-famous NASA astronauts called the Increments, whose spaceflight experiences spanned most of the 1990s, and who took quite a number of baby steps to help us get to where we are now. All their increments were carried out aboard the Russian space station *Mir*, alongside a mostly cosmonaut crew – with the objective of giving American astronauts experience in long-duration spaceflight.

The first Increment, Norman Thagard, launched on a Soyuz TM-21 in March 1995, before returning home 115 days later on the shuttle mission STS 71. This was the longest time in space for an American astronaut, although Russian cosmonauts had already exceeded that. After Thagard, female incrementer Shannon Lucid spent 188 days in space, from March to September 1996 and spending 179 days aboard *Mir*. The next incrementer, John Blaha, spent just 128 days in space, launching in September 1996 and coming home in January 1997. During his time in orbit, Blaha was prohibited from voting in the 1996 US election, which saw Bill Clinton re-elected for a second term. As a consequence, the state of Texas later amended its election statutes to permit voting from space.

In the next increment, things got a bit more complicated. Jerry Linenger went to *Mir* in January 1997 spending 132 days in space, which still lagged behind Shannon Lucid's 188 days, but he did pack a lot into his stay. For example, on February 23 1997, not long after he had arrived on *Mir*, there was a problem with one of the oxygen candles.

Human beings have to breathe a lot of oxygen and of course there isn't a lot of it in space. You can store oxygen in tanks, but storing it as a gas takes up a lot of volume and is not a realistic solution for long-duration spaceflight. On space stations, most oxygen is manufactured by the solar-powered hydrolysis of water. But in case that isn't enough, supplementary oxygen is also produced by lighting an oxygen candle, usually a canister of potassium perchlorate. Similar chemical oxygen generators are used to deliver emergency oxygen when you are on a plane, something goes wrong and masks suddenly drop from the ceiling. They are also used in submarines, during longer-than-expected dives.

The ignition and thermal decomposition of potassium perchlorate contained in a canister half the size of SCUBA tank, can produce eight person-hours of breathable oxygen and oxygen can be stored in this way for twenty years or more. So these handy, space-saving devices were in regular use on *Mir*, which burned through thousands of them during its fifteen year flight time.

Now these oxygen candles don't actually burn with a naked flame, but the chemical decomposition of potassium perchlorate generates a lot of heat and of course the candles generate a lot of oxygen, which are two of the three things that you need to start a fire. The third thing, something flammable, which started the quickly-spreading fire on *Mir* in February 1997, was a small piece of latex glove which one of the crew must have caught on a sharp edge when swapping out a replacement candle.

The fire burned for around fourteen minutes and there's a thing about space stations – they don't have fire exits. So imagine three humans orbiting the Earth at 27,000 kilometers an hour, trapped within a small room that was quickly filling with vision-obscuring and breathing-impairing smoke. Did they bounce around the walls going *Oh my God, we're all going to die*? No, they made sure every crew member had breathing mask on, fed from an independent oxygen supply, and then they put the fire out.

Jerry Linenger's problems didn't end there. *Mir*'s reputation as a dilapidated, under-funded junk-heap (a reputation it didn't really deserve) was bolstered by a series of equipment failures during Linenger's increment – including the oxygen generator, the carbon dioxide scrubbers and the (ahem) urine processing facility. *Mir* also lost attitude control at one point, resulting in a potentially life-threatening spin and there was also a near collision with a unmanned resupply ship. But apart from all that, the crew completed all their mission objectives and Linenger completed every single science experiment he had been tasked with. Not too shabby.

The next increment was Mike Foale, who carries a lot of UK astronaut records, since there haven't been all that many UK astronauts – only seven, including 2 space tourists at last count. So he was the first UK astronaut to do a spacewalk, although he is also the only UK astronaut to do a spacewalk. But he did grab the world record and held it until 1998, for the longest *anyone* has spent time in space, 374 days – and of course he does continue to hold that record within the UK.

Anyhow, there were no near-misses for this astronaut, because on the 25th of June 1997, an unmanned Progress supply vehicle collided with *Mir*. The collision punctured the surface of *Mir*'s Spektr module causing, what is technically known in spaceflight, as a bad day. The crew managed to close the hatch on the Spektr module before asphyxiating and Foale stuck

his thumb to the window and quickly tracked the movement of the stars outside so that he could advise Russian ground control how to counteract the station's uncontrolled post-collision spin – a clear demonstration that astronomy is not only an enjoyable pastime, it also save lives.

The increment after that was David Wolf, who spent 128 days on *Mir* and finally became the first American to vote from space, even if it was just a local ballot. He described the experience – the voting, not the spaceflight – as 'strangely moving'.

And finally, the last increment was undertaken by Andy Thomas – born in Australia, although subsequently spending his entire astronaut career as a US citizen, not that there's anything wrong with that. This boy from Adelaide completed a 141 day stay in space, thereby completing 1,000 days of *Mir* space station occupancy undertaken by the U.S. increment astronauts.

That was in 1998. Andy Thomas did later visit the international space station in 2001, though in a NASA rather than a Pan Am shuttle. Pan Am actually went out of business in 1991.

Thanks for listening. This is Steve Nerlich from Cheap Astronomy www.cheapastro.com. Cheap Astronomy offers an educational website where it's now a revamped website. No ads, no profit, just good science. Bye.