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

Well folks I booked the 10th of June so I could give you a few days advance notice that Hyabusa, Japanese for peregrine falcon, is due to drop its sample return canister at 2pm Greenwich mean time, or coordinated universal time for all you astronomers out there, on Sunday the 13th of June 2010. Unofficially titled, the little spacecraft that could, Hyabusa has had its fair share of trials and tribulations over its seven year mission so perhaps it's best to say I really, really hope it's going to land its sample return canister on Sunday.

Hyabusa is an ion drive spacecraft mission led by the Japanese Aerospace Exploration Agency - or JAXA - launched in May 2003 to the asteroid Itokawa which it sort of almost landed on in November 2005.

Now Itokawa, fully titled 25143 Itokawa because it was named by an astronomer, is variously a near Earth object or NEO, an Apollo asteroid meaning its one of a group of asteroids whose orbits cross Earths and have an orbit bigger than Earth's - and they're called Apollo asteroids, because the first one ever found was named Apollo - or sorry 1862 Apollo, because… you know.

In fact, Itokawa's solar orbit is so big that it also crosses Mars' orbit - so additionally it's also called a Mars crosser – as well as an Earth crosser. Furthermore, it's also an S-type asteroid, meaning it's thought to be siliceous, meaning it's primarily comprised of silicates. So, it's just a big rock really - while the more common C-type asteroids are carbonaceous, meaning they are more like a dried clay with organic compounds mixed in.

Itokawa is estimated to have a surface gravity of only about one ten thousandth that of Earth with an escape velocity of about 20cm/sec - which isn't all that much. A good sneeze would probably put you in orbit - although sneezing into your space helmet won't really work - and opening your space helmet just to see if you can sneeze yourself into orbit means you may not be the sort of person the astronaut office is really looking for.

Anyhow, back to Hyabusa. A long list of misfortunes began soon after its 2003 launch when one of its four ion thrusters failed. Then still not long after leaving Earth a large solar flare burnt out some of Hyabusa's solar panels meaning its remaining ion drive thrusters' electromagnets could not be run at full power. This added three months to its travel time to Itokawa and left much less time available for interaction with the asteroid, so the planned landings were reduced from three to two.

Just a few months out from Itokawa, Hyabusa's reaction wheels failed. These are electrically powered flywheels – and enable the spacecraft to change its orientation in space using gyroscopic forces. With the reaction wheels gone the spacecraft could only rely on its thrusters to turn the spacecraft which was less effective and burnt more fuel. But OK, the mission was still feasible – and every mission has a few glitches, right?

On its arrival to Itokawa in September 2005 one of the two planned landing sites was found to be too rocky to consider landing leaving only one site remaining. But before the landing was attempted, the MINERVA space hopper was deployed – a small probe with a

gyroscopic flywheel of it's own which made it kind of hop along the surface of a low gravity object like Itokawa, so that it could make detailed observations of the asteroid's surface.

But… because of the radio delay between Earth and Itokawa, Hyabusa had been built with all these automated mission rescue protocols, including an *Oh my God, I'm on collision course* protocol which unexpectedly kicked in when the spacecraft was about 40 meters from the asteroid's surface. As a consequence, the spacecraft was already autonomously moving itself away from the asteroid before the command came from Earth to release the MINERVA hopper. The hopper deployed and just drifted off into space, too far away to be captured by Itokawa's weak gravity field.

Undaunted, on November the 19th 2005, an attempt was made to touch down Hyabusa on the surface - and it was successful (*woo hoo*) – although communications blacked out when it was about 10 meters from the surface and were only re-established when the spacecraft was found to be nearly 100 meters from the surface, spinning aimlessly in its pre-programmed 'safe' mode. It took four days for JAXA to determine from telemetry data that the craft had in fact landed, before its automated *Oh my God, I'm on collision course* protocol had kicked in - again.

A second attempt to land, this time to collect a sample, was conducted on the 25th of November 2005. A similar level of chaos ensuedand the planned firing of small metallic projectiles intended to throw up dust that would then be taken up by Hyabusa's so-called collection horn was not recorded in the telemetry data – and it's most likely that the projectile firing just didn't happen. However, the sample collection door was certainly opened and then closed again, so the hope is that at least a few grains of asteroid dust may have drifted into the collection horn while it was that close to the Itokawa's surface.

In any case, with two semi-successful touchdowns on Itokawa, it was time for Hyabusa to return to Earth - and it's about then that its problems really started. Towards the end of 2005, it became apparent that something was amiss with Hyabusa's propulsion system and it appeared to have a steady fuel leak, making it difficult to keep it on course. In December, the spacecraft had a sudden attitude change, probably due to out-gassing from a new fuel leak and the spacecraft was turned to an orientation where it could no longer communicate with Earth.

A long period of radio silence followed until March 2006, as the spacecraft passively stabilized back into line so that JAXA could regain control. It took until June 2006 for JAXA to confirm that two of Hyabusa's four thrusters were still working – just enough to commence the return to Earth on the 25th of April 2006. In August 2006, another of Hyabusa's thrusters was successfully reignited so that it had three working thrusters, although in November 2009, one of the earlier working ones failed. So, that just as it was about to line itself up for a return to Earth, once again it was back to just having two of four working thrusters and no other attitude control systems available to modify its trajectory.

But with a bit of jiggery pokery - sorry for the technical jargon there - JAXA were able to generate just enough delta V for a proper Trajectory Correction Maneuver - TCM 0 in April 2010.

From there things really started coming together as TCM 1 was successful in May 2010 to get Hyabusa on an Earth re-entry trajectory, followed by TCM 2 on the 22nd of May to tighten that line up a bit further.

TCM 3 on the 6th of June, which will happen just after I record this, will put the spacecraft on line with the Woomera South Australia landing site - and TCM 4 on the 10th of June - that's today for you folks - will be the very last course correction before the sample return canister separates from Hyabusa on June the 13th and lands at Woomera, South Australia - 3 hours later at 2pm UTC.

As for Hyabusa, the 510 kg mother ship - having successfully brought its sample return canister through a such a fraught filled journey back to Earth - will become a briefly bright artificial meteor on the 13th of June 2010 - the last noble gasp of this plucky little Japanese spacecraft that could, at the very end of its amazing seven year mission.

Thanks for listening. This is Steve Nerlich from Cheap Astronomy, www.cheapastro.com. Cheap Astronomy offers an educational website where we're happy to sit back and let smart people in space agencies do all the hard work. No ads, no profit, just good science. Bye.