ASTROPI

Ben Everard is definitely not bitter that he didn't get the chance to program space computers when he was in school.

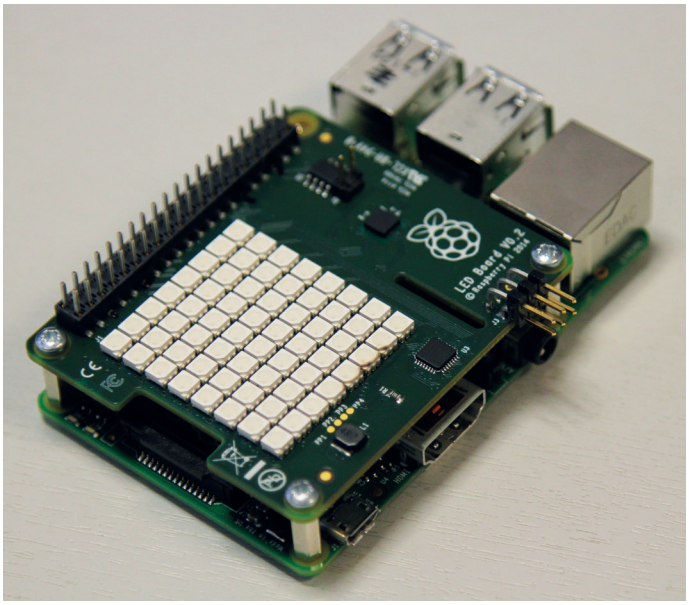
The most expensive structure ever built hurtles around the earth at almost 8km per second. It's 400km above sea level and needs to be occasionally pushed back up to stop it falling back down to earth. It's been mankind's home in the skies for over 14 years, and has provided innumerable scientific advances in that time. However, up until now, the International Space Station (ISS) has been missing one thing: a Raspberry Pi.

Fortunately, all this is about to change. Tim Peake, a British astronaut, will be taking two Raspberry Pis with him when he goes up to the ISS towards the end of 2015, and the Raspberry Pi Foundation is running a competition to see what runs on these boards.

The competition is open to school children in the UK (with separate categories for primary and each key stage of secondary school). Entrants don't have to be expert programmers, as the Pi Foundation is on hand to help implement the plans; the main challenge of the competition is to come up with ideas for what experiments to run on the computers.

Just running software on a Raspberry Pi wouldn't be any different in space to on earth, so in order to take advantage of the extraterrestrial location, the space Pis will be fitted with Astro Pi HATs, which include a whole range of sensors:

- **Gyroscope** In space, there's no up or down. Without gravity, the concepts don't really make sense, so what does this mean for the ISS? Is it spinning, and if so, how fast?
- **Accelerometer** The ISS is moving very fast, but is it's decelerating slowly. This means it's constantly falling towards the earth and occasionally has to be pushed back up into orbit. An accelerometer could be used to measure this falling as well as any irregularities in the station's orbit.
- **Magnetometer** Compasses always point north when you're on earth, but in space it's not quite so simple. With magnetic field fluctuations and solar wind, there's more variation. This sensor could show what's going on.
- **Temperature** Space is cold. Very cold, but above the atmosphere, the sun's rays are very powerful. What does this mean for life on the ISS, which crosses from summer to winter every 45 minutes?
- **Barometric pressure** The ISS is a tiny bubble of air floating through the vast vacuum of space. Only the thin walls stop the whole thing popping and dooming everyone on board to death. How well is the pressure maintained, and should the astronauts fear the bends?
- **Humidity** Humans are constantly breathing out wet air, and perspiring moisture through their skin. In a small enclosed space like the ISS, can this cause a problem?
- **Camera** A bird's-eye view of earth or an image of the stars uninhibited by any atmospheric haze. Which



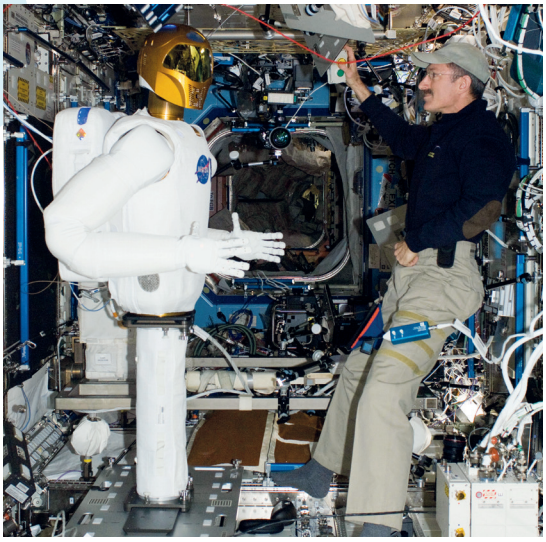
The Astro Pi HAT is the best sensor board on the market, and opens up a whole new world of possible Pi projects

Linux in space Penguins in orbit and beyond

These Raspberry Pis join a long and illustrious line of computers running Linux in space. In fact, the International Space Station is already a Linux-only affair. After a Windows virus outbreak in space (caused by an infected USB stick), all the laptops on board now run Debian.

As well as laptops, there are a large number of embedded Linux systems in space. R2, the humanoid robot on the ISS, is powered by Linux, as are all 71 of Planet Labs' Dove satellites that are swarming in the upper atmosphere and photographing the earth every day (we covered the Planet Labs project on page 32 of LV008).

Linux hasn't just been limited to Earth and its orbit. Linux also powered NASA's Spirit rover that went to Mars (the more recent Curiosity rover used VxWorks RTOS).



Left R2: The humanoid robot in space. The future is here and it's running Linux.
Right We don't know who the judges will be, but Major Peake has a degree in flight dynamics, so working that into a proposal may grab his interest.

would you choose?

- **IR Camera** Infra-red radiation shows different things to visible light, but what does this mean for the view from space?
- **Real Time Clock** As well as keeping tabs on the date and time, this could be used to determine the location of the ISS at any point, since its orbit is highly predictable.

In addition to these sensors, the Astro Pi HATs will have an 8 x 8 matrix of LEDs and some push buttons so the astronauts can interact with them.

We're not part of the team the decides what gets chosen and what doesn't, but if we were, we'd be most interested in projects that combine data from more than one sensor, for example, combining the gyroscope with temperature, humidity and barometric pressure to see how the atmosphere inside the ISS changes as the station spins and moved around the world.

The Astro Pi HAT has a great set of sensors, and obviously could be put to good use down here on Earth. Those of us not lucky enough to be able to design projects that run in space can still get hold of this hardware for terrestrial use. By the time you read this, they may be for sale commercially, as they are promised 'early in 2015'. Keep an eye on **raspberrypi.org** for details.

Although Britain has a strong space industry, traditionally this country has focussed more on hardware than people and few Britons have ever been to space (the first was Dr Helen Sharman, the first Yorkshirewoman in space). Major Peake will be the first to do so with government funding. This project is part of a government drive to get more British people – and school children in particular – interested in STEM subjects. In addition to funding this mission, the UK Space Agency has another £2 million of public money to help fund projects to get people interested in this mission. Hopefully, we'll see more funding like this from the UK government to invest in the future of one of our leading high-tech industries.

"Although Britain has a strong space industry, traditionally we've focussed more on hardware than people."

Not a UK student? More ways to get a computer into space

The Astro Pi competition is only open to school-age children in the UK, but that doesn't mean that other people can't access computing resources in space. California Polytechnic State University has developed the Cubesat system to make it easier to get into orbit. Cubesat is a standard specification for small satellites to make it easy for them to piggyback on launches for a tiny fraction of the normal launch cost. Developing Cubesats is far more involved than the Astro Pi competition, but you also have far more control over your computing.

Even though this is far cheaper than most space launches it can still be expensive, but there are a few programs that can help people get started. Keep an eye on **www.cubesat.org** for details of projects in your area. Alternatively, if you want to go it alone (and have the budget to), companies such as Innovative Solutions in Space (**www.isispace.nl/cms**) can help with everything including getting a launch.

The easiest option for most people is to cheat a little bit and only go as far as the upper atmosphere. Helium weather balloons (or high altitude balloons) can take loads up to about 40km above earth for far less even than the cost of a Cubesat. Dave Ackerman has sent several Raspberry Pis up already, and blogged about the experience on **www.daveakerman.com**. It might not technically be space, but you'd never know that from the photos that come back.