# The sky's the limit

What inspires someone to be a spacecraft designer? And how can you become one? **Russ Hodge** from the European Molecular Biology Laboratory in Heidelberg, Germany, interviews Adam Baker and reveals all.

Imagine a fleet of satellites the size of footballs drifting over the surface of the International Space Station and making repairs, or peering deep into moon craters in search of water. Although most satellites today are large and weigh several tons, space engineering companies across the world are hoping to take advantage of microelectronics and other technologies to make them much smaller. That could dramatically reduce the costs of boosting a cargo into space, which often amounts to more than € 20 000 per kilogram.

This is one of the arguments that people raise against manned spaceflights, says Adam Baker, an engineer and project manager for Surrey Satellite Technology Limited (SSTL) in the UK. "Sending up a normal adult would cost about €1.5 million, just from the weight alone. The real costs are of course much higher, because you also have to send up everything necessary to sustain and protect that person. Imagine everything you'd have to take along on a mission to Mars."


Adam Baker, spacecraft designer

He'd love to see the European Space Agency send a manned mission to the red planet, but it's much more likely that the next generation of spacecraft to go there will be nanorobots carrying miniaturised laboratories. That could yield a wealth of information about the problems humans would face on Mars, especially if the probes returned samples to earth. It's something Adam has thought about a lot; in his last job, he and his colleagues tried to design an engine that could derive its fuel from the Martian atmosphere.

He has had his hand in several other fascinating projects, such as figuring out how to fly a balloon through the clouds of Venus and to keep it aloft for a month. "The surface of the planet is incredibly hot, but 70 or 80 kilometres up, there's a benign atmosphere," Adam says. "We'd like to know what it's like because Venus has been through the worst-case scenario of a runaway greenhouse effect. How did it get that way? We might learn a lot about our own atmosphere."

Flying such a balloon for a month would be tricky, he says, especially since normal power systems – based on solar energy – probably wouldn't work. You couldn't count on enough sunlight getting through the dense atmosphere. So the team looked at other options: a small nuclear reactor, or fuel cells, or even a simple combustion engine. Although the probe has not yet been built, the lessons learned about how to do this at a reasonable cost will be applied to future missions.

The exciting thing about SSTL, Adam says, is that the company can carry out all the stages of a project, from designing something to building and testing it. The main facility in Farnborough, near London, has cleanrooms, thermal vacuum chambers, solar simulators, and everything else you need to reproduce the harsh conditions of space.

Many an engineer has spent a sleepless night worrying that a satellite he or she been building for two years won't succeed. But some important projects have made it from the drawing board into space. While we were talking, for example, an SSTL satellite was tracking a huge fire that had broken out near London. A jet-fuel storage facility in Hemel Hempstead had burst into flames early on a Sunday morning, in an explosion that could be heard 150 kilometres away. Monitoring the fire is just the sort of job for which the Disaster Monitoring Constellation (DMC) – a network of five satellites all built by SSTL – was designed. As a member of the propulsion engineering group, Adam played an important role in developing, building and testing the satellites' engines.

A DMC satellite passes overhead every three or four hours, giving the quick, frequent feedback that is necessary in an emergency – with a single craft, you might only be able to monitor a situation every few days. The cameras on board offer an ideal combination of high resolution and broad coverage: each image encompasses an area 600 by 600 kilometres in size. "The resolution isn't high enough to make out single people," Adam says, "but the cameras are able to operate in the red, green and infrared ranges. That's perfect for studying fires, or vegetation, or the weather. We watched Hurricane Katrina and the 2004 tsunami. You can also watch humans' impact on the environment. We've tracked ships cleaning out their tanks, creating oil slicks."

Here, too, low weight and efficient design significantly reduce a satellite's price tag, putting space within reach of customers who normally couldn't afford to put something into orbit. SSTL has constructed satellites for Nigeria, Turkey and China, and built Algeria's first-ever spacecraft. "This gives countries a foot on the rung of space and space-related applications," Adam says.

So how does a person become a spacecraft designer? Adam remembers some key events from his childhood. When he was young, he lived for a few years in the Far East, experiencing first-hand an incredible boom in technology. That sparked a lifelong interest in engineering.

When Adam was ten years old, NASA's Voyager space probe flew by Saturn on its way out of the solar system. "There was a *National Geographic* lying around with absolutely stunning pictures of the rings. It was amazing to me that we could have a craft up there taking images like that – as if the planet were right next door."

The school that he attended when he returned to the UK didn't offer courses in space science or engineering, but Adam stocked up on physics, chemistry and mathematics. Those subjects come together in materials science – the study of metals and other substances and their applications in areas ranging from electronics to aircraft design. This field was given a huge boost in the 1960s by the American space programme; special alloys of metals, polymers and other materials had to be designed to withstand conditions in outer space. Adam decided that this was what he would study at Oxford University.

Just before leaving school, however, he took part in the UK's first-ever space school, a week-long camp sponsored by Sevenoaks School in Kent – a camp that is still run every year. It gave Adam and a group of other like-minded 17-year-olds the chance to visit a space science lab and attend lectures and workshops by people working in the field. "It was great to hear that there really was a way to get a job in the space industry," he says.

Oxford University had plenty of materials science, but no space programme. Adam spent most of his PhD peering down an electron microscope, almost a bad joke for someone whose dreams lay in the stars. What he was doing was, though, connected to aeronautics: in his dissertation he tried to find a way to make the insides of jet engines out of titanium – which is much lighter than the nickel alloys used in today's engines. The project wasn't entirely successful because the method he used produced forms with erratic shapes. "That's not something you want to have in a jet engine that has to run at extremely high temperatures for billions of hours," he says.

In the meantime, Adam found a new way to keep in touch with outer space. Oxford University encourages its students to join clubs, and if there is none to fit your tastes, you can found your own. So Adam created the university's first space society, and he and his friends started working on rocket engines. "Some of them were really large. We got sponsorship and went to conferences, where we gave talks about what we'd been doing." After such a presentation in 2001, he was approached by representatives from a company that built satellites.

"They said they might have a job," he said. "They warned me that I wouldn't be building things quite as exciting as our work with the club. I said, 'Where do I sign?' Again, they said the work wouldn't be quite as exciting, but the things I would be building would get into space. Again, I said, 'Where do I sign?' The very first day of work they had me assembling a propulsion system for a satellite that is now in orbit for Algeria."