# Small scale, big challenges

Small satellites give more access to space, but the design challenges remain large.

By **Graham Pitcher**.

When we first placed satellites into Earth orbit, they were relatively small. Sputnik, launched in 1957 by the USSR, weighed 80kg. Explorer 1, the US' first satellite, weighed 14kg.

By the 1990s, satellites had become big: some communications satellites weigh close to 6tonnes. Such devices are not only big, they're expensive. And with good reason; they have a planned operating life of many decades.

But space is also of interest to those with less financial clout and attention is returning to designing satellites of a similar size to those launched in the early days.

The words 'micro', 'nano' and 'pico' are appearing in the satellite world. Joost Elstak is a systems engineer with Surrey Satellite Technology (SSTL), the University of Surrey spin off recently acquired by EADS Astrium. He said microsatellites weigh around 100kg. "There's no global definition, but nanosatellites generally weigh around 10kg and picosatellites can be less than 1kg."

SSTL claims to have changed the economics of space when, in the late 1970s, it pioneered COTS satellite technology – taking readily available devices and adapting them to the environment of space. Elstak said: "We are one of the few companies that does this. We have experience and we can prove that the approach works."

One of SSTL's latest projects is to place the RapidEye constellation of five satellites into orbit around the Earth. Each satellite is identical and weighs around 150kg. The commercial system images many areas of the world to an accuracy of 6.5m. Because the five satellites are spaced equally around the Earth, it is possible for the majority of the Earth's surface to be imaged every day.

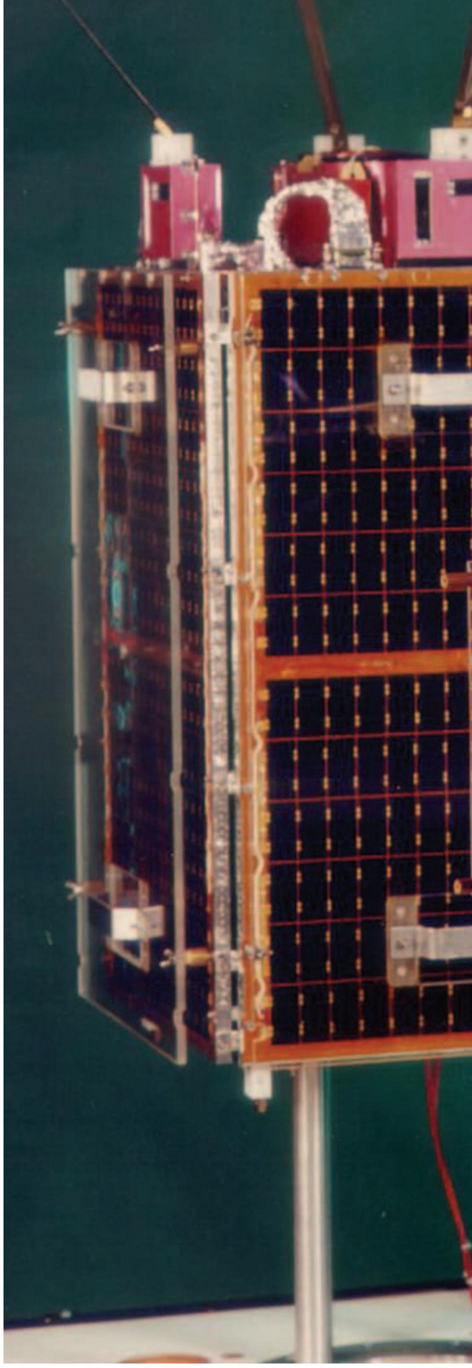
Elstak said the main constraint with small satellites is the use of resources. "All five RapidEye satellites were placed into orbit using one launcher, which places mass and volume constraints on the design. But we also need a certain amount of power and have to optimise our designs in order to get the most out of every part. But power is critical; you have to make sure that you can do everything that you want to."

RapidEye satellites have been designed around the imaging system. "The spacecraft is there to service the imager," Elstak said, "providing the necessary resources, such as an on board computer and an attitude control system. While it is important to have the imager pointing in the correct direction, accuracy and stability are equally important."

The satellites feature a bidirectional S band communication link, with a further X band link for download. As imagers become more capable, data rates climb. "The RapidEye downlink has to support data rates of 80Mbit/s," Elstak pointed out, "and newer missions are looking to download data at rates in excess of 200Mbit/s. Once you have the ability to detect features of 1m and smaller, the amount of data captured increases dramatically."

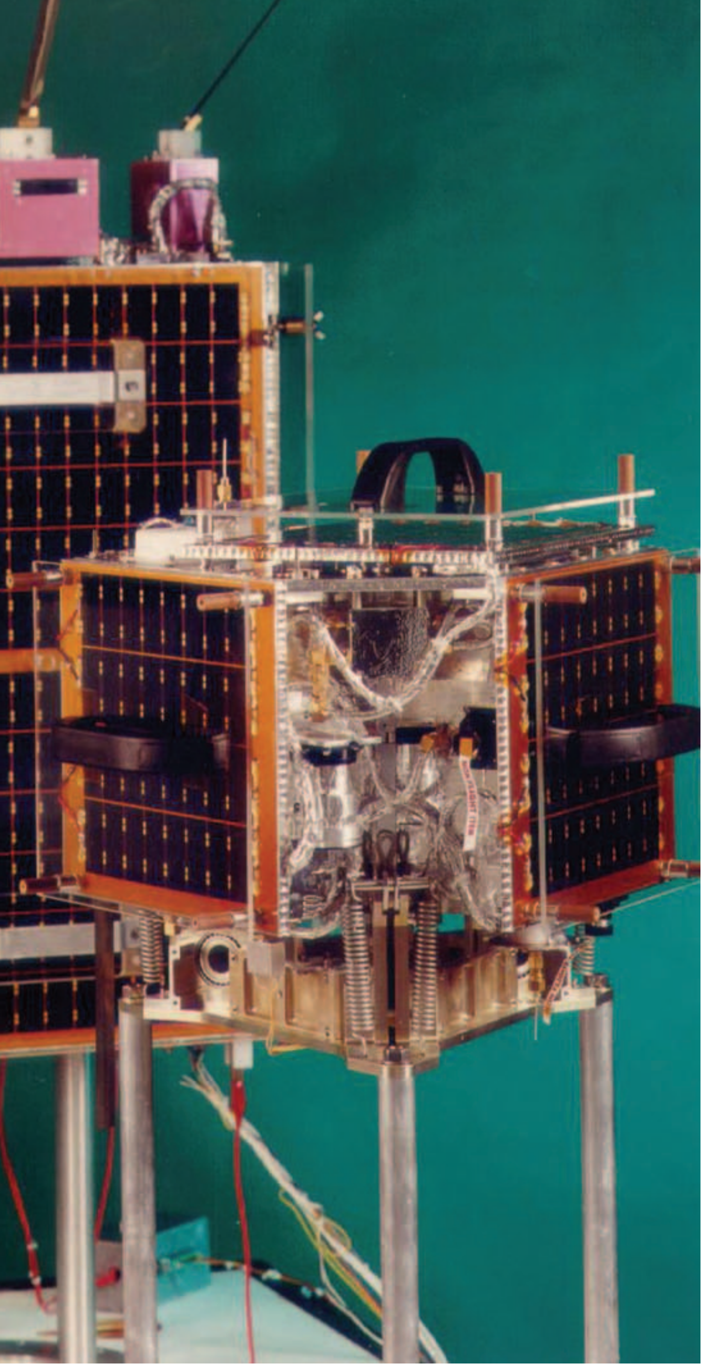
But space is a hostile environment and further measures need to be taken. "We need to design satellites in such a way that they are thermally stable. That can be done by providing battery heating; the RapidEye imagers, for example, need to be kept at a constant temperature in order to guarantee their accuracy."

Radiation is another factor that works against the electronics systems in satellites. "We have to make sure that critical components are shielded," Elstak



*Right: The 6.5kg SNAP-1 nanosatellite, front, was launched in 2000 by SSTL as a technology demonstrator. Tsinghua-1, rear, a 49kg microsatellite, was launched in 2000 as an Earth observation satellite for Tsinghua University.*

*Above: A technician works on SNAP-1*



ELSTAK: “NEWER MISSIONS ARE LOOKING TO DOWNLOAD DATA AT RATES IN EXCESS OF 200MBIT/S.”

affirmed. “Core electronics are housed in aluminium trays in the centre of the satellite and this approach has been used for about the last 10 years. But we also use materials which can limit the effects of radiation.”

Nevertheless, redundancy is designed in. “Usually, it’s dual redundancy,” Elstak noted, “but it does depend on the component. For attitude control, we typically fly four systems in a configuration that allows for one to fail.”

Data storage is another area where full redundancy is catered for. “We have a complete back up system,” he continued, “as well as a reserve on board computer.”

Other systems are designed to degrade. “We may not get full functionality,” he added, “but the system as a whole will work. We have to look at the system as a whole and ask whether we can make that work, rather than doubling up on all components.”

Two particular components used in SSTL projects are Atmel’s TSC695F, a radiation tolerant 32bit risc processor implementing the SPARC V7 architecture, and CASA-2 – CAN asic for space applications – from Italian microelectronics company Aurelia. This part comes packaged in Atmel’s radiation hardened MG2RTP asic. Both parts are manufactured on a $0.5\mu$m cmos process.

Does SSTL use asics or are radiation hardened fpgas the way to go?

According to James Nicholas, leader of SSTL’s onboard data handling group, the TSC695F family and CASA-2 are asics, so technically they are used. “However, SSTL doesn’t design asics. SSTL’s niche is to use COTS components and we’ve built significant expertise and heritage in selecting and flying suitable COTS components in space. This means we have access to more current technology and so do not need to look at designing an asic when we have demanding requirements.”

According to Nicholas, programmable logic is currently meeting SSTL’s requirements. “We use antifuse, flash based and, more recently, sram based fpgas. Each has its pros and cons, so we select the right parts for the design. We’re always looking at what devices are coming to the market and there are some technologies we have our eyes on.”

Once reason for not using asics is design time. “The time from SSTL signing a contract to the satellite launching is typically 18 to 24 months,” Nicholas noted. “FPGA development cycles and reconfigurable/fast programming times help allow us to meet these timescales, particularly when payloads and interfaces vary. Flash and sram based fpgas can, of course, be reconfigured in orbit and this is a key advantage over asics, since it offers interesting and exciting opportunities for our satellites. We could, for example, change encryption or compression algorithms or reboot a data recorder as a high performance data processor.”

Power for the RapidEye satellites is provided by bolted on solar panels. “It’s the best way to go,” Elstak said, “because this allows for more agility. While big deployable solar panels give much more power, it takes more time for the satellite to settle. That, in turn, means there are fewer imaging opportunities for satellites such as RapidEye.”

Power is stored in lithium ion batteries. “These have replaced nickel cadmium batteries over the last few years,” Elstak observed. “They have better power density, less degradation and better reliability.”

In fact, the move to lithium ion has allowed satellites to be more productive. “Earlier missions were limited by what NiCd batteries could provide,” Elstak concluded. “Lithium ion allows operators to get more out of the satellite later into a mission.”