Around the world in 90 minutes

You name it, it's up there, says **Hazel Muir**

WHEN Sputnik 1 beeped its way around the Earth in 1957, space was a very tranquil place. How things have changed. Today some 5000 tonnes of stuff is whirling around above our heads – equivalent to more than 660 of London's classic double-decker buses.

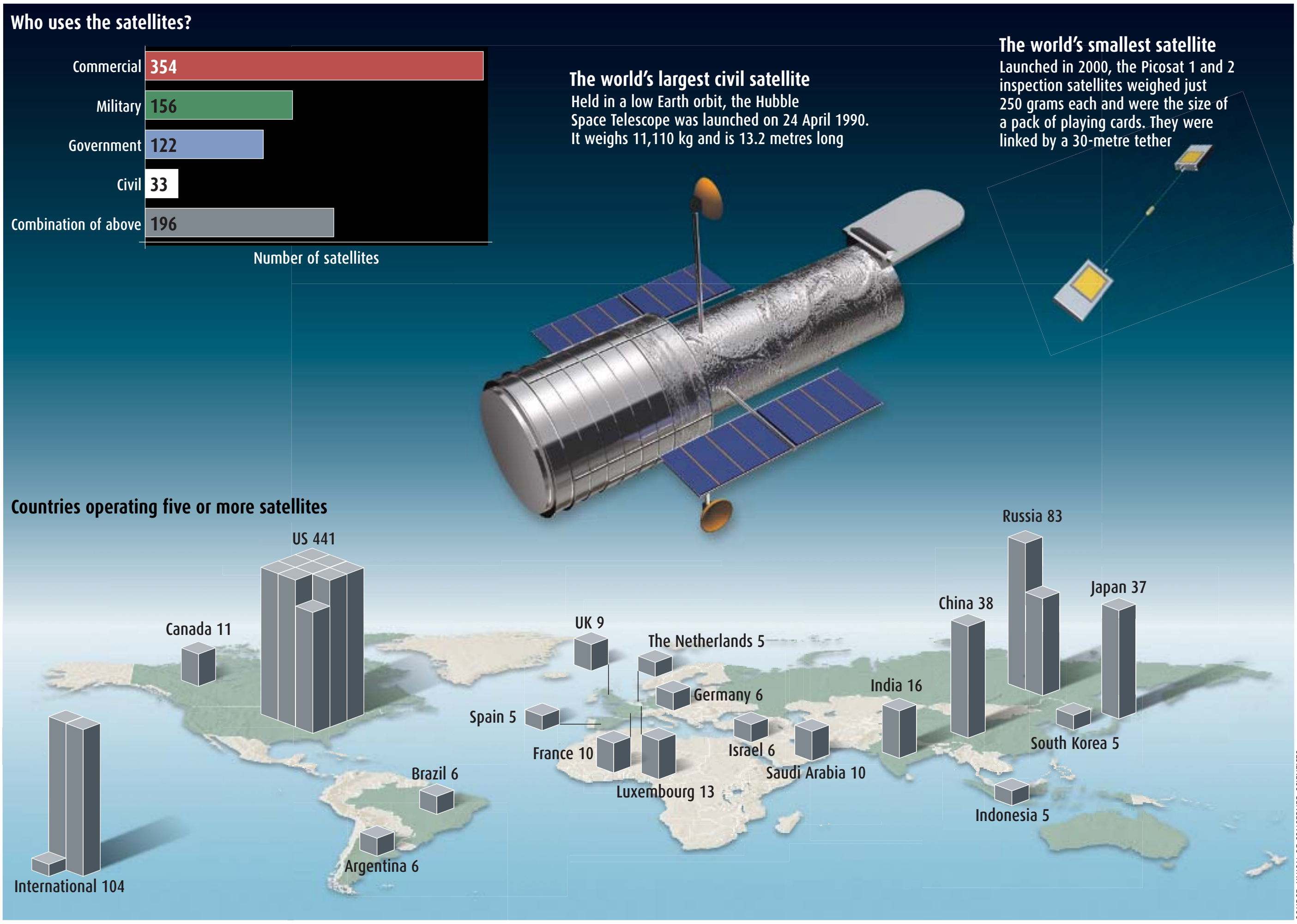
Some of these objects are satellites in the everyday sense – precision instruments doing a sterling job of relaying communications or monitoring our environment and alleviating the impact of natural disasters. The rest, however, include anything from clapped-out rockets to shrapnel and other useless rubbish, and experts fear that the volume of orbiting space debris is reaching critical levels.

"It's a runaway problem," says Mark Matney, a space debris scientist at NASA's Johnson Space Center in Houston, Texas. "Even if we stopped launching anything today, the environment will continue to get worse for a century."

So what exactly is flying about up there? There are currently around 860 operational satellites owned by more than 40 countries. ▶

SATELLITE CENSUS

There are around 860 satellites in operation by more than 40 countries. The amount of material in orbit weighs 5000 tonnes, the vast majority of which is junk



SOURCE: UNION OF CONCERNED SCIENTISTS

The US alone runs more than half of them. Nearly a fifth are military satellites, while the largest single use is for commercial communications, mainly television.

Their uses have changes too. Until the 1990s, long-distance phone calls were usually transmitted by geosynchronous satellites, which hover around 35,800 kilometres above the Earth. The trouble was, the signal travel time introduced an annoying 0.3-second delay. Today most international phone calls are sent via terrestrial fibre-optic cables, although satellite phone use is again growing in remote areas and disaster zones where there may be no terrestrial network.

What lies above

The sensitivity of today's satellites is stunning. For example, they can sense the millimetre-scale changes in the shape of volcanoes that often presage a dangerous eruption. "Using overlays of radar images taken at different times you can measure tiny nuances in the shape prior to an eruption and alert the population," says Heiner Klinkrad from the operations centre of the European Space Agency (ESA) in Darmstadt, Germany.

Experts suspect that military surveillance satellites can probably see objects just 20 centimetres wide from a height of 400 or 500 kilometres, though the exact figures are classified. "You could certainly pick out individual people at that resolution, even though you couldn't identify them," says Philip Davies, a spokesman for Surrey Satellite Technology (SSTL) in Guildford, UK.

Compared with the first commercial communication satellites, today's satellites have a far wider range of sizes, from a tissue box up to a double-decker bus. Billion-dollar behemoths have become possible thanks to heavy-lift rockets like Europe's Ariane 5, which can send payloads weighing as much as 9.6 tonnes up to geostationary altitude, and as much as 21 tonnes into low Earth orbit.

To lower the cost of launching Earth-observation satellites, SSTL has pioneered the development of much smaller craft that can nonetheless do cutting-edge work. These typically weigh from 150 to 250 kilograms and occupy about 1 cubic metre. Meanwhile, an international project called CubeSats involving over 60 universities, schools and private firms has taken downsizing to new extremes, by launching cubes just 10 centimetres across into orbit, mostly for educational purposes and to test small sensors. Since 2003, 18 CubeSats have been successfully launched, and last year a NASA mission called GeneSat-1 used a block of three CubeSats to measure space radiation damage to the DNA of *Escherichia coli* bacteria.

However, the vast majority of orbiting material is doing nothing at all. According to Klinkrad, who is head of ESA's space debris office, around 93 per cent of known orbiting objects are useless debris. They range from retired satellites to abandoned rocket stages and lost accessories like lens caps. There are also countless smaller fragments, mostly the wreckage of more than 200 recorded spacecraft explosions and a few collisions.

The US operates a worldwide network of optical and radar sensors that tracks and catalogues roughly 12,500 operational satellites and pieces of debris. It can spot anything larger than about 10 centimetres in low Earth orbit and objects larger than 1 metre in geosynchronous orbit. Unfortunately though, most debris is too small to track. Klinkrad estimates that the total number of objects larger than 10 centimetres is about 18,000, rising to 580,000 if you count fragments down to 1 centimetre.

Even such small fragments are a threat to other spacecraft because they are moving at enormous speeds. "If a 10-centimetre fragment collided with a satellite, it would catastrophically destroy it," says Klinkrad. Even the impact of a 1-centimetre object can terminate a satellite's mission.

On 11 January this year, the catalogue of trackable debris increased by more than 25 per cent overnight when China destroyed one of its defunct weather satellites with a missile, shattering it into more than 2400 pieces the size of an orange or larger. Estimates suggest it created a further 35,000 fragments below this size.

The satellite shattered at an altitude of 863 kilometres, already the most crowded region of space. "That's about the worst altitude to do such a test," says Klinkrad. "Any more anti-satellite tests there would be devastating." At such a high altitude there is little atmospheric drag on the fragments, so many will take decades or centuries to fall back to Earth.

Other debris includes clumps of copper needles, launched in the 1960s as part of a wacky experiment in radio communications. High-altitude nuclear tests by the US had disrupted part of the ionosphere, interrupting radio communications that normally bounce off the lower ionosphere. The US was worried that vital communications might fail in the event of a real nuclear attack, so it decided to build an artificial ionosphere by launching some 480 million fragments of radio-reflecting copper wire. They were supposed to completely disperse into a thin ring around the Earth, but many fused together into mats. "There are dozens of clumps still floating around up there, and they can be seen by radars," says Matney.

There are also more than 30 defunct nuclear reactors circling the Earth, most from Soviet reconnaissance satellites launched between 1967 and 1988. In total, about a tonne of radioactive fuel is orbiting the Earth, although it doesn't pose a health hazard here on Earth, since the Soviet Union retired most of its nuclear satellites into orbits between 700 and 1500 kilometres above the Earth, where they will remain for hundreds of years to allow their radioactivity to decay. What's more, the cores of 16 of the reactors were ejected from their sturdy beryllium casings so that the radioactive material burns up when it does eventually re-enter the atmosphere, rather than potentially landing in one piece.

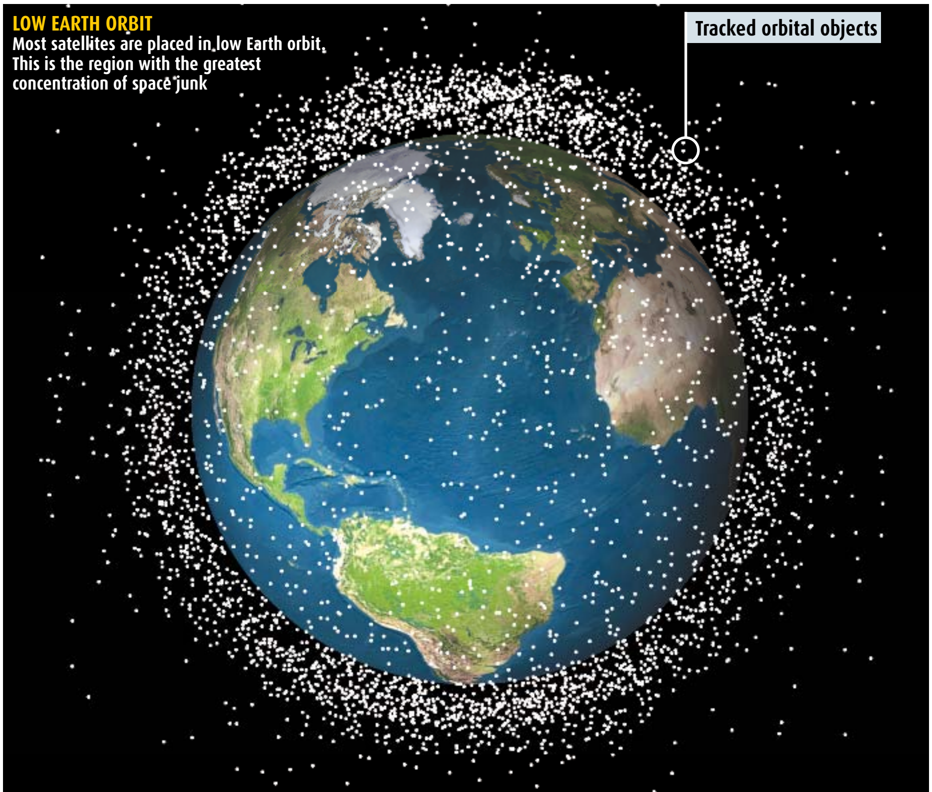
However, these separations released globs of coolant fluid, an alloy of sodium and potassium, creating yet more troublesome debris. "There are many thousands of sodium-potassium spheres at an altitude of about 850 to 1000 kilometres," says Matney.

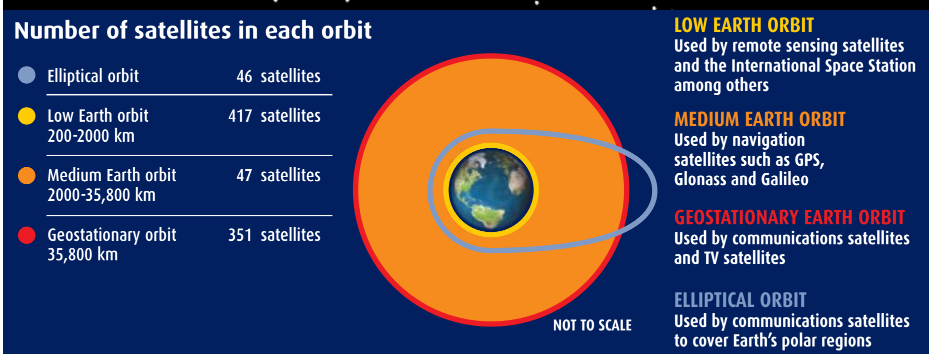
The problem can only get worse over the coming decades as collisions between satellites and fragments create yet more debris. The United Nations issues guidelines on good practice to minimise explosions and collisions in orbit, but satellite operators often flout the rules (*New Scientist*, 23 April 2005, p 8). Unless the industry cleans up its act, Sputnik 1's legacy will be a shambolic junkyard where high-tech satellites fear to tread. ●

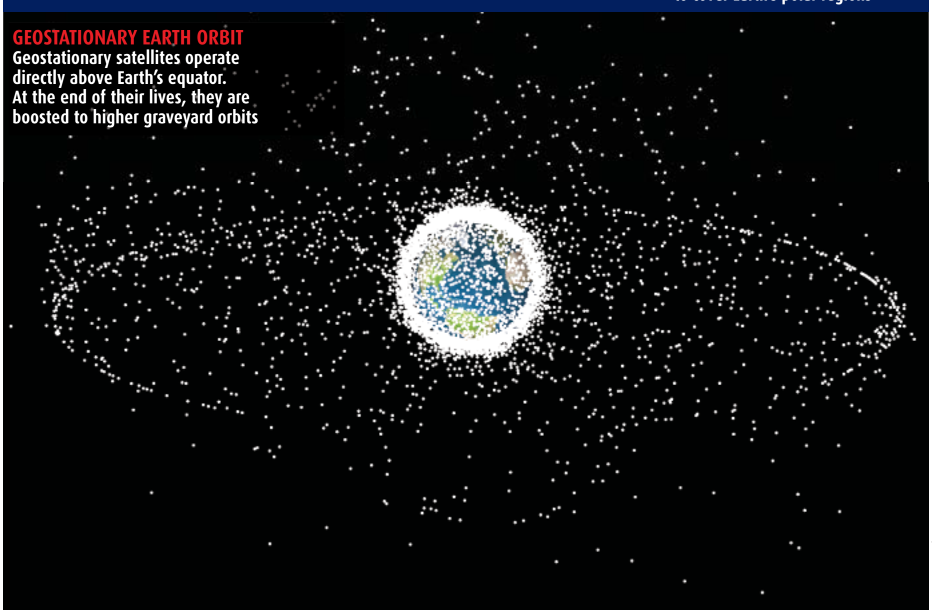
Space oddities

- **Some military reconnaissance satellites are believed to weigh more than 14 tonnes**
- **Canada's MOST satellite (Microvariability and Oscillations of Stars) is often called the world's smallest space telescope. It could fit in a small suitcase and is affectionately known as the Humble Space Telescope**
- **The oddest satellite might well be SuitSat, an old Russian spacesuit launched from the International Space Station loaded with batteries and transmitters in 2006. It re-entered the atmosphere several months later, but plans are afoot for SuitSat-2**

HALO OF JUNK







SOURCE: NASA/JSC

WHAT IS IT ABOUT SPACE THAT INSPIRES YOU?

BRIAN SCHMIDT

Space is the final frontier for humankind: it is now and always will be. It is the place that we will always know the least about because of its almost limitless extent. But it also offers the potential of almost unlimited opportunity.

Brian Schmidt, astrophysicist at the Australian National University's Mount Stromlo Observatory near Canberra and discoverer of the accelerating expansion of the universe

SLAVA TURYSHEV

I grew up in a small, remote region of the Altai mountains almost exactly under the spot where most of the Soviet spacecraft launched from Baikonur cosmodrome would jettison their first stages. From the balcony of our apartment, my father and I would watch a rocket appear from behind the horizon and climb higher and higher. Suddenly we'd see a cloud of gas indicating that the first stage had separated from the rest of the rocket. It was an emotional picture that got me thinking about space.

When I was 9 years old, I started to design, build and launch rockets. My largest rocket was over 2 metres long and had two stages, a parachute, a science compartment and a little mouse as a passenger. I was 12 at that time. My cousin and I built all the essential parts from local materials, including the solid propellant. That established my interest in space exploration.

Today physics stands at the threshold of major discoveries, and this progress has, in part, inspired me to continue with my space efforts. I can now design and build systems that can fully utilise the space environment and new technologies to study gravitation, cosmology and astrophysics.

Slava Turyshev, astrophysicist at the Jet Propulsion Laboratory in Pasadena, California

CATHERINE CESARSKY

The lack of boundaries, the perception of infinity.

Catherine Cesarsky, director general of the European Southern Observatory in Garching, Germany

JOSÉ FUNES

I was 6 years old on 20 July 1969, when Neil Armstrong made his "giant leap for mankind". This is my first memory of my interest in exploring space. I would say that the cosmos raises in me a great desire to know more about it. In this desire there is a deeper one: to find God, the creator.

José Funes, director of the Vatican Observatory in Tucson, Arizona