David Sang

Materials for space travel

Imagine that you are in a spacecraft, orbiting the Earth. You're travelling at 27 000 km/h through the vacuum of space. You're above the Earth's atmosphere; the beautiful Blue Planet lies below your feet.

Density

To get into space, a rocket packed with fuel is needed to lift your spacecraft into orbit. Typically, it takes 100 kg of rocket and fuel to launch 1 kg of spacecraft. To make the most of the lifting force available, spacecraft are usually made of low density materials such as aluminium alloys, similar to the materials used for aircraft.

However, it is better to use an even lighter material especially if it remains stiff and strong when very thin. Carbon fibre composites are good for this, and future spacecraft may have very thin outer shells made of carbon nanotube materials.

Getting tough

We talk of the 'vacuum of space', but space isn't empty. There are lots of hazards. For example, there is the problem of space debris – pieces of old spacecraft whose orbit crosses yours. You can avoid collisions with the biggest pieces simply by shifting up or down slightly. But the smallest pieces are difficult to avoid because no-one knows where they are.

Each dot represents an item of space junk in orbit around the Earth. Most is close to the Earth while there is a second concentration in geostationary orbit further out into space.

If you collide with a piece of debris the size of a pebble while travelling at high speed, your spacecraft could be wrecked. So any craft must be made of tough stuff. Space engineers are working on self-repairing materials which can automatically 'heal' any damage done by collisions with particles in space. (See the article about self-repairing polymers on page 6 of this issue of CATALYST.)

Testing times

There's no better way to test materials for use in space than by taking samples up into orbit and exposing them to the space 'weather'. The photograph on pages 10-11 shows NASA's MISSE experiment on board the International Space Station. A suitcase sized panel juts out from the ISS. Its surface is covered in samples of materials, coatings and electronic devices. Eventually these will be returned to Earth where materials scientists will assess their suitability for use in future spacecraft.

Materials engineers examine samples ready for testing in NASA's MISSE experiment

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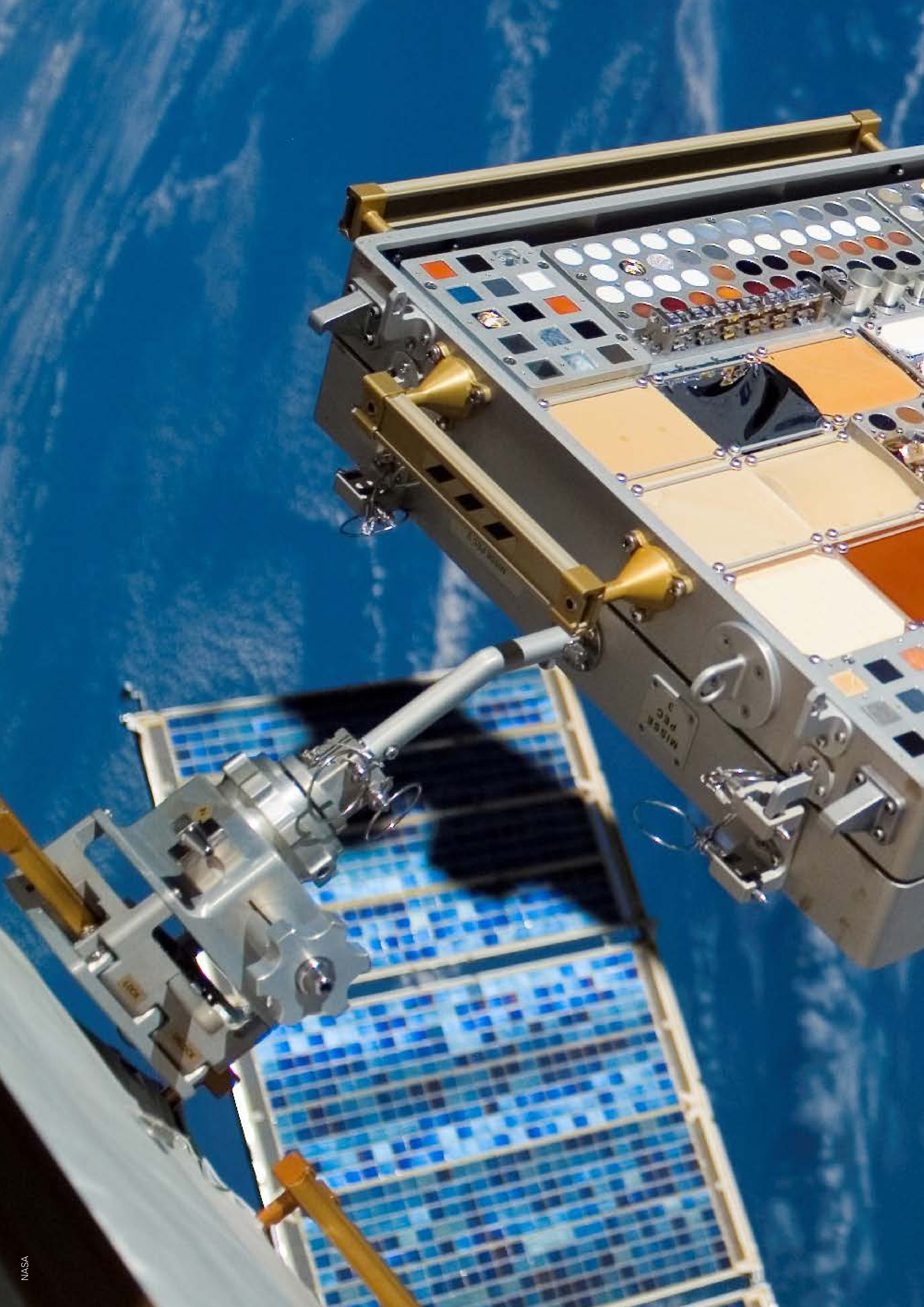

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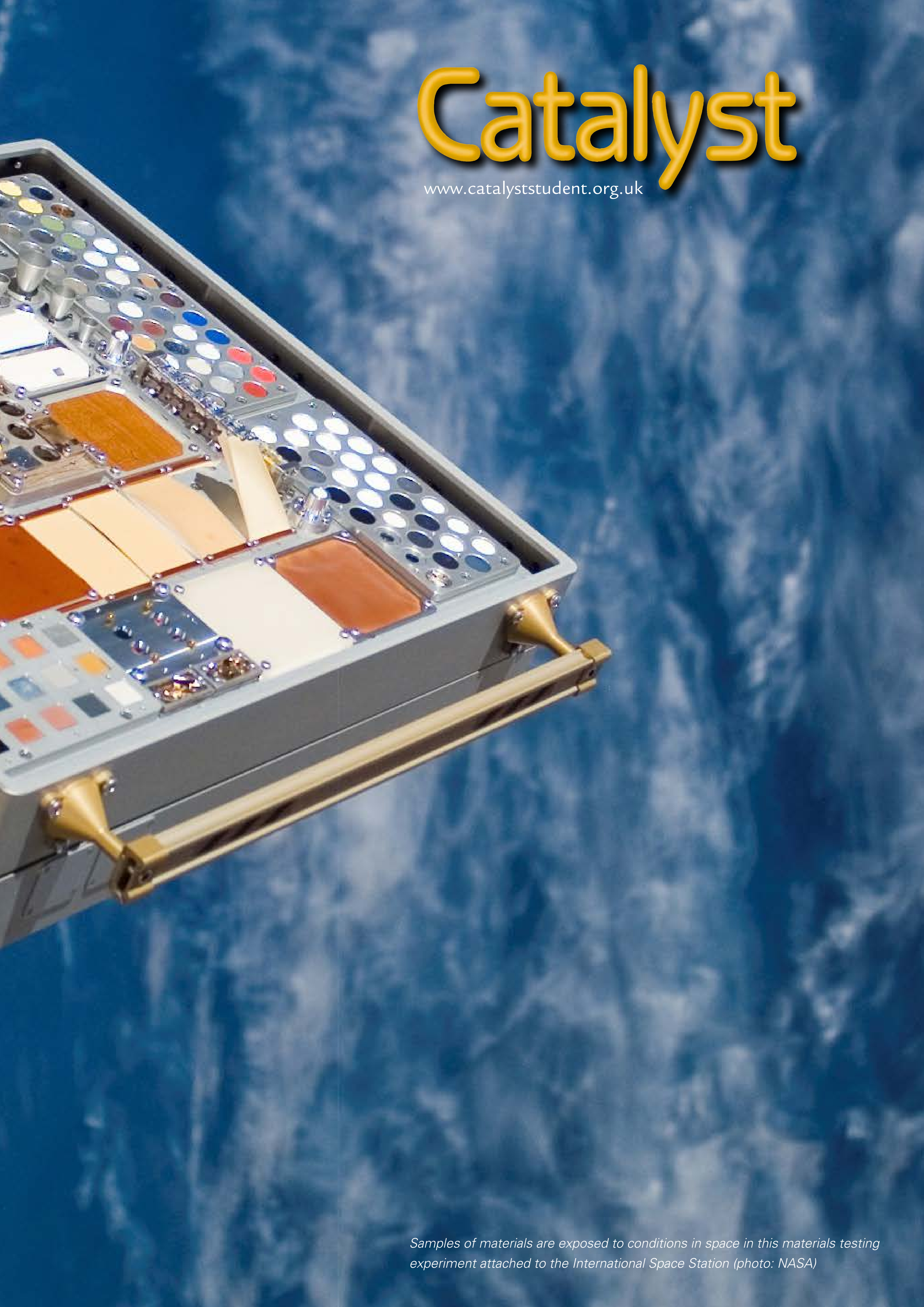


Samples of materials are exposed to conditions in space in this materials testing experiment attached to the International Space Station (photo: NASA)

Radiation dangers

Another hazard to human space travellers is radiation. In low-earth orbit the Earth's magnetosphere deflects charged particles (see the article on page 19 of this issue of CATALYST). However, if astronauts travel to Mars they will not have this protection as Mars does not have a magnetosphere or an atmosphere to absorb radiation.

High energy cosmic rays coming from deep in space can penetrate the skin of a spacecraft and harm the crew inside. If a gamma ray strikes the nucleus of, say, a metal atom, the nucleus may split into a shower of charged particles in a process similar to nuclear fission. So materials must be found which are made of lighter atoms – for example, carbon nanotubes – which do not split in this way.

NASA's space weather forecasters predict when intense bursts of radiation from the Sun are heading our way.

How much radiation?

Astronauts must accept that they will receive an increased radiation dose whilst in space, although much is done to reduce their exposure. The table shows some typical exposures. The unit used is the millisievert (mSv).

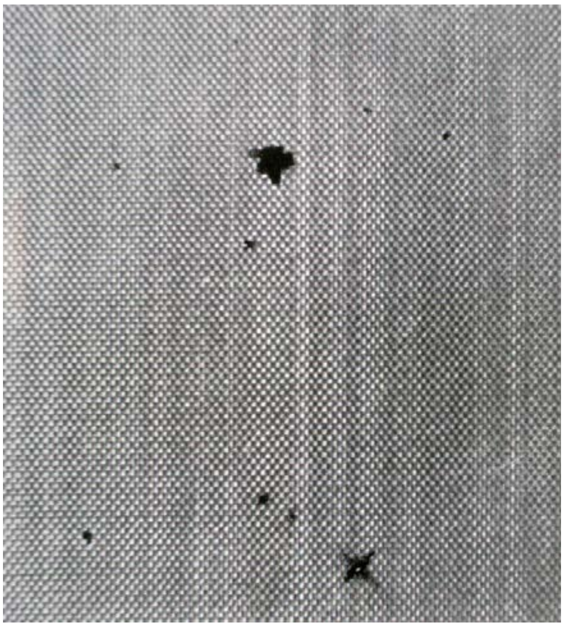
source of exposure	radiation dose
human exposure to background radiation, global average	2.4 mSv per year
full-body CT scan (X-rays)	10 – 30 mSv
6 month stay on International Space Station	80 mSv
6 month trip to Mars	250 mSv
1 year on Mars surface	250 mSv

Space suits

In designing a spacesuit, the challenge is to provide protection for the astronaut while allowing free movement. Traditional suits have sufficient pressure for oxygen to dissolve in the wearer's bloodstream. For working outside the spacecraft, the suit has a tough outer layer which protects the wearer against the impact of fast-moving particles of dust or debris. This opaque layer also provides protection against the Sun's ultraviolet rays.

An alternative design is the skintight suit. This is made of an elastic mesh, designed to prevent the swelling-up of flesh when exposed to a vacuum. Tests have been carried out in the zero-gravity environment of a parabolic flight aircraft but it is proving difficult to ensure that all parts of the body are correctly compressed. Would-be astronauts complain that it is very difficult to put such a garment on.

Skintight spacesuits designed at the Massachusetts Institute of Technology – this type of spacesuit is intended to be worn inside a spacecraft but is more often seen in comic books.



A test sample of fabric used in spacesuits, showing holes made by micrometeoroids (high-speed dust particles)

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