Spin doctor: Rhea Seddon (right) tests the biological effects of the space shuttle's rotating chair.

Testing times

Preparing astronauts for a journey to the red planet has become NASA's research priority for the International Space Station. But such experiments will need more than the skeleton crew now running the station. **Tony Reichhardt** reports.

At a meeting in Annapolis, Maryland, last February to draw up a 'roadmap' for NASA's use of the International Space Station, Terri Lomax, a research manager for the agency's exploration directorate, recounted the list of medical issues that worry doctors about sending astronauts on a 30-month round trip to Mars.

She put up a chart showing that 588 of 607 space-shuttle crew had reported 'medical events' or symptoms during their flight. The implication was that nearly everyone got sick. Astronaut Ed Lu, sitting towards the back of the room, raised his hand. "But aren't most of those stuffy noses?" he asked.

Lomax conceded as much, then presented statistics on the deterioration of bone in orbit — astronauts don't want brittle bones when they land on Mars. Lu raised his hand again. He spent six months on the space station in 2003, and gained, not lost, bone mass. So had

other recent space-station astronauts. The difference? They had a treadmill, so they could exercise to counter the debilitating effects of weightlessness.

Lomax then moved on to radiation, maybe the biggest threat of all. She said more dosimeters were needed on the station to characterize the risk. Up shot Lu's hand. We already know about the radiation environment in space, he said. What we don't know is how it would affect interplanetary travellers — and studies on the station would not help, because it is shielded from the most dangerous radiation.

The space station should be a unique place to do science, including the sort of biomedical testing needed before NASA sends astronauts to Mars. But some people question whether the right experiments are being planned, and

if so, whether the station will be equipped to answer them.

It's a key concern not just for astronauts, but for the \$30-billion space station, which is still only half finished 21 years after design work began. Europe and Japan plan a mixed portfolio of physics, biology and materials science for their station modules, which they hope to see launched by 2010 (see 'Stalled countdown', opposite) despite the space shuttle's current woes. But NASA, the project's main underwriter, has recently settled on human research as the top priority for the orbiting laboratory.

Ever since 2004, when the White House announced plans to send people to the Moon and on to Mars, NASA has been reshaping its space-station research to support the new goal. Details of the Moon-Mars programme are expected at the end of this month. Some

in Congress want the agency to keep a percentage of station research for fundamental experiments in biology, physics and materials science. But biomedical studies are clearly the new focus.

Speaking to a congressional committee in June, NASA's new administrator, Michael Griffin, listed the agency's priorities for space-station science: all involved either medical research on humans or work on life-support systems to keep people healthy in space.

"Machines that work fine on Earth commonly break down in space"

NASA also has a new 'bioastronautics roadmap', released in February, that outlines 45 risks to space travellers that need further study. John Charles, deputy chief scientist for bioastronautics at the Johnson Space Center near Houston, Texas, calls it "our best collective guess" on the hazards of going to Mars, from kidney stones to contaminated water.

Some risks, such as the space sickness that afflicts two-thirds of shuttle astronauts, don't worry Rhea Seddon, assistant chief medical officer at the Vanderbilt Medical Group in Nashville, Tennessee, and a veteran of three shuttle missions. "Do you research it to death?" she asks, or simply administer the anti-nausea drug Phenergan, which works — although no one knows how.

Other risks are more serious. Four might scupper a Mars expedition: radiation, bone deterioration, psychosocial problems, and how to provide medical care in a weightless spacecraft millions of miles from home.

At least three can be researched partly or wholly on Earth. Psychosocial questions can be studied in analogous settings such as underwater habitats. NASA's radiobiology research has shifted to studies of ionizing radiation on animals at the Brookhaven National

spaceflight (T. Lang *et al.* *J. Bone Miner. Res.* **19**, 1006–1012; 2004). And even if some astronauts gain overall bone mass, loss of some kinds of bone tissue might weaken their limbs. Anecdotes aside, says Pawelczyk, bone loss remains a serious concern.

Seddon agrees, and says this is one area where more research really is needed. "Ed Lu is probably willing to go to Mars tomorrow," she says. "I wouldn't be."

The station is a good place for such research, but there is one major problem: not enough test subjects. Today the station can accommodate just three long-term residents — the number that fit in the Russian Soyuz craft that doubles as a lifeboat. When the shuttle was grounded following the Columbia disaster, NASA cut the crew to two to save on resources.

According to NASA's bioastronautics roadmap, addressing all 45 risks would require flying 200 test subjects on the station. Charles calls that "an embarrassing number, because it's way beyond the realm of possibility". So far there have been 26 long-term residents in five years.

Attaching two Soyuzes to the station would raise the crew to six, but there is currently no timetable, nor funding, for doing so. And NASA's own replacement vehicle for the shuttle wouldn't be ready to operate as a six-person lifeboat until at least 2010.

One solution is to supplement human data with animal studies. Earlier plans called for a large centrifuge, built by Japan, as part of a programme of gravitational biology research. But NASA is reportedly preparing to cut animal research from the station. Funding for the centrifuge and animal habitats will therefore be one of the most closely scrutinized items in the space-station research plan unveiled later this month.

Seddon understands NASA's reluctance to send animals into space. They are expensive and difficult to house in weightlessness, and they complicate astronaut training. But they may be the only way to address one of NASA's top concerns about going to Mars.

Lu, meanwhile, highlights a different worry. He wants to make absolutely sure the equipment works — particularly the life-support system that cleans the astronauts' air and filters their water. He knows from personal experience how commonly machines that work fine on Earth break down in space. If the air filtration on a Mars ship stops working, he says, "you're dead about two months out".

That's the real problem for long-term human spaceflight, thinks Lu, more than stuffy noses or weak bones. Testing technology may end up as the station's final purpose. "The actual ship itself is the experiment," he says. "I think that's really what the station has to offer."

Tony Reichhardt writes for *Nature* from Washington DC.

Additional reporting by Jenny Hogan and David Cyranoski.

Stalled countdown

ESA/ALenia

Hitching a ride: Europe's Columbus lab needs a lift to the space station on the shuttle.

While NASA decides what research to do on the space station, the European and Japanese space agencies are still waiting for their laboratories to launch.

Europe's Columbus module, currently stored in Bremen, Germany, is ready to go. The Japanese are putting the finishing touches to their Kibo laboratory. Both need to hitch a ride on the beleaguered shuttle.

Columbus and Kibo are equipped for basic science — including studying plants and animals in microgravity, and for investigating material growth and fluid physics. Neither agency has been swayed by NASA's overhaul of the science goals to focus on exploration.

"If anything, we might try to accommodate some of the US scientists on our programme," says Marc Heppener, who coordinates station research for the European Space Agency (ESA). "We see, with regret, that some of their good science proposals are not making it to the space station."

Europe's research plans are in good health, says Heppener, despite frustrating delays to the shuttle schedule. Some European experiments have been rescheduled to fly on Russian Soyuz rockets, and the agency has funded a vigorous ground-based research programme.

So any further hold-ups generated by Discovery's recent troubled flight won't derail the European effort. "We've waited so long, we can wait another few months," says Alan Thirkettle, of ESA's Directorate of Human Spaceflight.

But Europe is considering how best to modify its research if the partially constructed space station is stuck with two or three astronauts, rather than the hoped-for crew of six. "Plan B is not to start panicking," says Thirkettle. Instead, experiments that require a lot of time will be scrapped and others automated.

Japan is also sticking to plan A. "If the United States won't launch Kibo, which is a possibility, we don't have any alternative to go to," says Yasunori Matogawa, an associate executive director at the Japanese agency.

NASA is expected to present options to its partners by the end of the month. **J.H. & D.C.**

NASA

Short-staffed: the International Space Station is currently home to just two astronauts.

Laboratory in New York. And in-space medical care could be practised on the ground, with notable exceptions such as weightless surgery.

Attempts to curb bone loss could benefit from research on the station — but how big a risk is it really? Based on recent astronauts' experience, Lu thinks diligent exercise will hold the problem at bay. Combining workouts with bisphosphonates, a class of drugs developed to treat osteoporosis, could be the answer.

Not so fast, says James Pawelczyk, a Pennsylvania State University neurophysiologist who flew on a shuttle Spacelab mission in 1998. Research published by Thomas Lang of the University of California, San Francisco, based on data from 14 space-station astronauts, shows substantial loss of bone in the hip and a smaller loss in the spine as a result of long-term