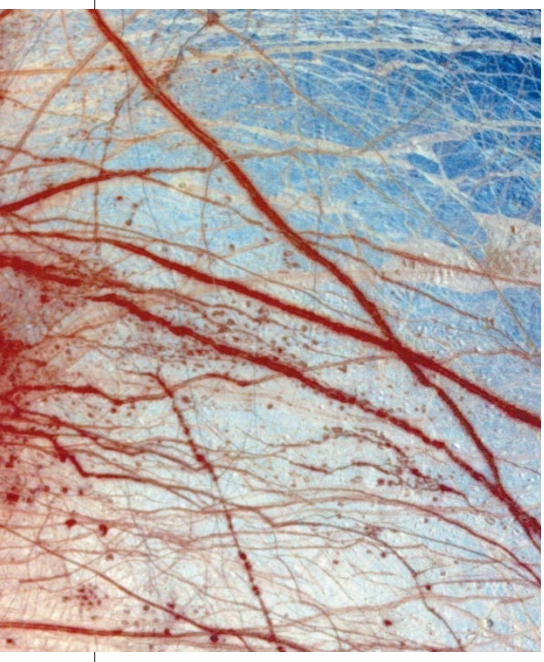
Breaking the nuclear taboo

Despite public fears, nuclear-powered spacecraft are back on the agenda. Tony Reichhardt looks into the latest plans for planetary exploration.

Studying the fringes of our Solar System can be a frustrating business. Jupiter's moon Europa, with its ice-covered ocean, and Saturn's cloud-shrouded Titan are exciting places. The problem is getting there. Not only are the outer planets far away, but extra fuel is needed to brake a spacecraft into orbit around a tiny moon circling a massive planet. The exorbitant costs of launching spacecraft weighed down with sufficient fuel rule out most missions.

Delegates at a NASA meeting on new approaches to exploring the outer Solar System, held in February at the Lunar and Planetary Institute in Houston, kept coming back to an old but controversial solution: nuclear-powered rockets. Giovanni Bignami, scientific director of the Italian space agency ASI, puts it bluntly: "You can't seriously go to the planets unless you use nuclear propulsion. All the rest is junk." But funding agencies, sensitive to public opinion, will need convincing. Protests against the small amounts of onboard plutonium at the launch of NASA's Galileo mission to Jupiter in 1989 and the Cassini Saturn mission in 1997 have turned 'nuclear' into a forbidden word.

Rockets produce thrust by forcing a high-pressure gas to escape through a nozzle, which accelerates the craft in the opposite direction. The space shuttle's main engines, for example, produce high-pressure gas by combining liquid oxygen and hydrogen. A nuclear thermal rocket would use the heat generated by a small nuclear reactor to turn liquid hydrogen into high-pressure hydrogen gas. Nuclear rockets have the edge because, in weight terms, they use less fuel to produce comparable thrust.



Out of reach? The weight of fuel needed makes it expensive to put a craft in Europa's orbit.

Billions of dollars have been spent on nuclear propulsion research since the 1960s, but an engine has yet to be tested in space. Interest flared up in the early 1990s, when NASA was asked to consider sending astronauts to Mars. But NASA's proposals were too expensive, and when the programme stalled, so did interest in nuclear rockets.

Now, for the first time in years, propulsion experts find themselves with modest funding to study engines powered by nuclear fission. Researchers at NASA's Glenn Research Center in Cleveland, Ohio, believe a 500-kilogram nuclear-powered spacecraft could be flying past Pluto in as little as six and a half years after its launch — around four years faster than conventional rockets could manage. Glenn's veteran nuclear rocket designer Stan Borowski puts costs for the ten-year development of a nuclear thermal engine at $1.5 billion.

In Italy, Bignami's agency is funding preliminary work on a concept developed by Nobel prizewinning physicist Carlo Rubbia, now at the University of Pavia. Rubbia's proposal would use americium-242 rather than uranium for fuel. Conventional nuclear thermal engines generate heat from fission, and then transfer the heat to a separate container of hydrogen. Rubbia proposes placing the americium in direct contact with the hydrogen, making the heat transfer more efficient (*Nature* **397,** 374; 1999). Work on 'Project 242' is currently focused on bonding americium to a substrate.

Another possibility is nuclear electric propulsion (NEP), in which electricity generated by a reactor is used to expel a stream of ions from the back of the rocket. The thrust is small, but even a small thrust will eventually accelerate a spacecraft to high speeds in the near vacuum of space. Ground tests of the Safe Affordable Fission Engine (SAFE, in case anyone misses the point), a NEP engine developed at NASA's Marshall Space Flight Center in Alabama, are already under way.

GENESIS SPACE PHOTO LIBRARY

NASA

Blasted: the small amounts of plutonium used in Cassini's Saturn mission provoked protests.

Ground tests are one thing, but building an engine and flying it in space is another. So will NASA make a serious go of nuclear propulsion this time? US missions to the outer planets are currently in a confused state. NASA wants to launch a Pluto mission in the next few years — proposals for the project are due in this week and one group is known to be submitting a nuclear propulsion option. But the new US administration is keen for NASA to prioritize work on propulsion technologies. NASA science chief Ed Weiler has said the propulsion research will "look at what's really needed" to make the Pluto mission successful, including nuclear thermal rockets and NEP.

Looming over discussions at last month's meeting was the question of how the public will react. Borowski's group at Glenn is already preparing a public information campaign. Others hope that President George W. Bush will provide the backing that his predecessor, Bill Clinton, declined to give.

All of which creates a cautious sense that perhaps, finally, nuclear propulsion's time has come. For some, it clearly feels like now or never. As William Jeffrey of the US Defense Advanced Research Projects Agency said at the NASA meeting: "If we can't make this a compelling argument now, we probably can't in our lifetime." ■

Tony Reichhardt is a contributing correspondent for *Nature*.

Project 242

http://ars.rm.asi.it/~webars/Project242/P242_main.html

Safe Affordable Fission Engine

http://stday.msfc.nasa.gov/presentations/IST3.pdf