SPECIAL REPORT

Which moon to shoot for?

Planetary scientists have a rare chance to pick the destination for their next big mission. But will it be Titan or Europa? **Eric Hand** reports.

In 2005, Jonathan Lunine, a planetary scientist at the University of Arizona in Tucson, was one of the first dozen people to glimpse the surface of Saturn's moon Titan. As the Huygens probe fell, a bizarre landscape emerged: an icy world of hills and channels carved by liquid methane. "And I had two emotions, one right after the other," he says. "The first was elation, astonished elation! And the second one, almost immediately, was sadness. Because I knew that I wouldn't get to see this again in my scientific lifetime."

But Lunine might just be that lucky — if NASA and the European Space Agency (ESA) choose to return to Titan two decades hence. By the end of this month, agency officials plan to pick a destination for a massive mission, costing nearly US$4 billion, to be launched around 2020 for the distant reaches of the Solar System. The battle pits Titan, which recent discoveries have made the cool new kid on the block, against Jupiter's moon Europa, which has long sat atop community wish lists.

> "Are you going to pick the brightly coloured horse, or are you going to ask, 'Is that horse ready to run?'"

The impending decision — a big deal for a science community that typically sees its projects come to fruition just once a generation — has planetary researchers taking sides. "I think it's going to come down to a matter of the science," says Lunine, co-chair of a study pushing for a visit to Titan. His mission, described in glossy brochures and snazzy computer simulations, includes a hot-air balloon straight out of a Jules Verne novel, which would drift in Titan's cold breeze.

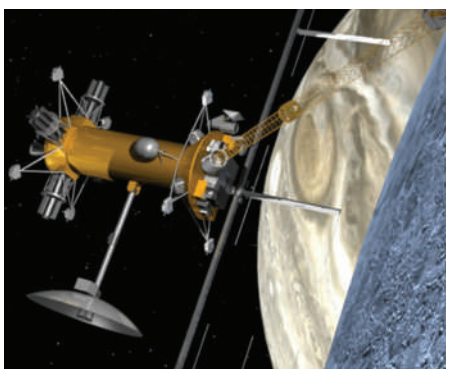
On the other side are the Europa supporters, who argue that a decade of mission-design work should carry the day. They envisage a NASA mission to Europa combined with an ESA mission to Ganymede, another Jovian moon with an intriguing magnetic field. Bob Pappalardo, a planetary scientist at the Jet Propulsion Laboratory (JPL) in Pasadena, California, has worked on five Europa mission studies over a decade; the Titan mission concepts, he says, just recently got going. "Are you going to pick the cool, brightly coloured horse, or are you going to ask, 'Is that horse ready to run?'" he says. "These reviews should be looking at the teeth and gums and seeing which one is ready to go."

Ten years ago, a mission to Europa would have been the brightly coloured horse. In 1995, the Galileo probe began an 8-year tour of Jupiter's system, during which it snapped the first close-ups of Europa's scarred surface. Analysis of a magnetic anomaly soon revealed the moon's most astonishing feature: that eggshell of ice is thought to enclose a warm, salty ocean. Scientists immediately clamoured to return. The JPL began a Europa Orbiter mission study in 1999; Europa was ranked a top priority in an important 2002 community list; even Congress told NASA, in 2005, to begin a Europa mission.

The need to go back is still great, says Pappalardo. Galileo made only 11 passes of Europa and was hampered by an antenna that failed to fully deploy, limiting its data transmissions. An orbiter equipped with new instruments — in particular, an ice-penetrating radar — would end debate over the thickness of the ice shell, and reveal the depth of its fissures and cracks. Astrobiologists want to know how isolated any ocean might be from the surface, where withering radiation would make life tough but could also lead to chemical exchanges that nourish life.

Safe from harm

Radiation would damage not only life but spacecraft electronics and, over the past decade, engineers have developed technology to combat it. The earlier Europa studies funded research in radiation-hardened, or rad-hard, electronics that are now used on military satellites and NASA spacecraft, making the components cheaper. Where rad-hard components still don't exist or are too costly, engineers will nestle the orbiter's 11 proposed instruments behind metallic shields of tantalum and tungsten.



NASA

A trip to Europa would mean building an orbiter...

Still, 20% to 30% of the mission's cost is for radiation protection, according to Europa study leader Karla Clark of the JPL. The Europa orbiter must fit within a NASA cost envelope of $2.9 billion, while the ESA contribution, the Ganymede orbiter, must cost less than €650 million ($860 million). At those prices, a landing element, or even an ice-drilling cryobot, is impossible. But Pappalardo argues that sending a Europa orbiter now could pave the way for a future lander — by scouting for the smooth pavement. "We're ready to go to Europa now," he says, "and we'll be ready to do Titan next."

Jupiter, then Saturn, then Europa, then Titan — this notion of ordered 'turns' doesn't fly for Ralph Lorenz, a planetary scientist at the Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland. By that logic, he says, it's Neptune's turn; it's Venus's turn. "You've got to choose the mission that's giving you the best science value for the money," he says. "And Titan is the low-hanging fruit." With its atmosphere, its hydrological cycle and even its potential for cryovolcanism, Titan would mobilize a much wider scientific community, he says.

NASA would send a spacecraft into polar orbit for four years, where it would spend more time at Titan in its first three days than the Cassini mission to Saturn will in its entire mission. To keep costs down, the orbiter would carry six instruments — about half as many as Cassini. But they would be fine-tuned for Titan, says Lunine. A mass spectrometer, for instance, would be sensitive to molecular chains with hundreds of carbons — orders of magnitude more sensitive than Cassini's spectrometer, which is limited to molecules with seven or eight carbons.

After arrival, ESA would showcase its contributions. The first — a dropped lander akin to Cassini's Huygens probe — would splash down into one of two giant methane-ethane lakes near Titan's north pole. It would float for a few hours in the complete darkness of winter and suck up samples through straws, sifting for the molecular evidence of organized organic chemistry that, even if pre-biotic, so excites astrobiologists. "You go to the lake," says Lunine, "because the lake is nature's great

M. HEGNER

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...but a mission to Titan could feature a hot-air balloon.

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But the *pièce de résistance* is the 11-metre-wide hot-air balloon, which, drifting along 10 kilometres high in gentle winds near the equator, would image the surface through the methane mist. Heated by lumps of radioactive elements, the balloon would circle the moon at least once in a lifetime of a minimum of six months, says Athena Coustenis of the Paris Observatory, the lead European study scientist for the Titan mission. The heat shield used during the balloon's initial descent would not be wasted: there is a proposal to have it stick gently in the soil as a 'geosaucer', with a seismometer and magnetometer to measure tidal flexure and cryovolcanic rumblings. The balloon is likely to be built in France where, says Coustenis, "balloons are a big deal".

In the end, the decision between Titan and Europa could come down not just to scientific promise versus technological readiness, but also to agency politics. The decision-makers, Edward Weiler and David Southwood, science chiefs for NASA and ESA respectively, haven't been shy in expressing personal opinions. "I've seen the data coming out of Cassini and it knocks your socks off," says Weiler. "I just have a preference for Titan." And Southwood says, "I have an emotional preference for Saturn and Titan. But I probably have a scientific longing for Jupiter."

Early decision

After reviewing the mission studies and reports from the competing teams, Weiler and Southwood will hold a teleconference by the end of the month in the hope of making a decision before an ESA advisory committee meeting on 3 February. Weiler says technological readiness will probably be a deciding factor. If both missions are deemed technologically sound, Weiler says he may ask a panel convened by the US National Academies for advice on the most scientifically worthy moon.

"Balloons are a big deal in France."

At ESA, the chosen mission will still have to compete against two other missions vying for one €650-million slot within the agency's Cosmic Vision programme, a competition not due for final selection until 2011. But Southwood says that ESA needs to decide now whether it wants to pursue Titan, or Ganymede during a NASA mission to Europa. That's because the technologies and approaches needed for either moon are so disparate. Titan would mean developing a lander and balloon linked tightly to the US orbiter. Ganymede would mean developing an orbiter to be launched separately from the US Europa probe. And should Europe decide, come 2011, that some entirely different mission should get the Cosmic Vision slot, then NASA would be left to either pick up some of the European ideas for its own Titan or Europa mission, or to scale back its own ambitions.

Although proposal scientists are nervously anticipating the decision, they will have a lot longer to wait for the mission itself. A probe launched for Jupiter in 2020 wouldn't arrive in Europa orbit until 2028, and a balloon bound for Titan wouldn't deploy until 2030. Lunine would be 71 years old — not necessarily beyond the workplace and, he hopes, spry enough for a little ballooning. ■

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