Europa vs. Titan

Planetary scientists are in the final stretch of a first-time competition designed to get the most science for the buck from the next big planetary mission while avoiding the fiscal debacles of the past.

TEMPE, ARIZONA—Frances Bagenal wants to get back to the outer solar system, but that will take some doing. It will be at least 20 years before an instrument-laden robot can slip into orbit around Saturn’s Titan, a deceptively Earth-like moon lashed by liquefied natural gas storms, or around Jupiter’s Europa with its potentially inhabited, ice-covered ocean. And the trip will likely cost a good $3 billion, money that is only getting scarcer at NASA.

So Bagenal and her colleagues in the community of outer planets scientists are submitting themselves to a unique, two-stage selection process for the next major mission to the outer planets: a winner-takes-all competition to deliver the best science at the best price.

“Usually, a committee of graybeards meets and decides” which multibillion-dollar mission NASA will fly next, says Bagenal, a space physicist at the University of Colorado, Boulder, and the outgoing chair of NASA’s Outer Planets Assessment Group. In the past, the broader planetary community was pretty much left out of the final decision-making, and there was nothing competitive about it. Now, for the first time, independent study teams of scientists and engineers have taken their best shots at designing missions to the Jupiter or Saturn system and pitted them head-to-head.

“I think that’s healthy,” says Bagenal. “Each team has had to hone its arguments [even though] it means not everyone gets their favorite instrument on board.” In the process, scientists are having “to stand up and be responsible for the costs so we don’t get a shock down the road,” she says. The novel approach will culminate late next month in the selection of a single mission.

Obsolescence

NASA’s foray into community-based competition of the biggest missions came after discoveries in the outer solar system made the latest formal prioritization of future missions outdated. The so-called decadal survey from a committee of the National Research Council in 2002 (Science, 19 July 2002, p. 317) had just two missions to the outer planets among its 13 priorities for the decade 2003 to 2013: the relatively modest Juno mission to Jupiter itself to be flown in 2011 and a so-called flagship mission to Jupiter’s Europa. Flagship missions are NASA’s most expensive, running well above $1 billion apiece. The Europa mission gained that status after the Jupiter-orbiting Galileo found signs in 1997 of an ocean beneath kilometers of ice on Europa, raising the prospect of life. And the prospect of life, the decadal survey made plain, was the mission’s prime driver.

But astrobiology soon beckoned from other quarters around Jupiter and Saturn. In 2005, NASA’s Cassini spacecraft, the outer planets flagship following Galileo, discovered a huge plume of ice-laden water vapor spewing from an overheated south pole region of Saturn’s little moon Enceladus. Again, liquid water might lurk beneath the icy surface. And in 2005, beneath the haze of Titan, Cassini and its European Space Agency (ESA) Huygens lander found a profoundly frigid but eerily Earth-like world. Earth-like, that is, if you substitute liquefied natural gas for liquid water, water ice for rock, and dark organic gunk for soil. The astrobiology angle came with the gunk. Given its complex origins in Titan’s upper atmosphere, it should bear a strong resemblance to the primordial organic matter that came together to begin life on Earth.

Enticing new targets were cropping up, but the next decadal survey was not due out for years, and the prospect of getting to Europa was fading fast. Engineers had long struggled with designing a practical mission. “Each and every one of [the missions studied] was unimplementable,” says James Green, director of the planetary science division at NASA Headquarters in Washington, D.C. Jupiter’s intense radiation belts threatened to fry the electronics of any spacecraft that lingered in Europa’s vicinity for more than a few weeks.

So NASA decided to go to the outer planets community for more possibilities. In 2007, in a process reminiscent of open competitions for missions a fifth the size (Science, 23 July 2004, p. 467), four groups of about a dozen scientists and engineers each were given half a year to work up missions to orbit one of four outer planet satellites: Titan, Europa, Enceladus, and Jupiter’s moon Ganymede.

Ambitious. One proposed joint NASA-ESA mission would send an orbiter, a splashdown lander, and this nuclear-fired hot-air balloon to Titan, land of natural-gas lakes and icy ground dirtied with organic goo.
A frigid mystery. Titan (false color) somehow mimics Earth’s complexity despite extreme cold.

Two missions eventually survived this head-to-head competition, with NASA Headquarters judging. The latest radiation-hardened electronics made Europa look more practical. And Titan came through, in part, because it “offers a deeper and broader science yield than Enceladus would,” suggests outer planets astronomer Heidi Hammel of the Space Science Institute in Boulder, Colorado. What Titan lacks as a potential abode for life, she says, it makes up for with both prelife organic chemistry and fascinating atmospheric and geologic processes.

Enceladus lost out. It “was at a disadvantage,” explains engineer Amy Simon-Miller of NASA’s Goddard Space Flight Center in Greenbelt, Maryland. “We had to start from scratch,” as no one had ever studied going into orbit around Enceladus. Enceladus has so little gravity and orbits so deep in Saturn’s powerful “gravity well” that getting into Enceladus’s orbit with any affordable propulsion system seemed impractical. Ganymede, on the other hand, was accessible but lacked both astrobiological interest and Titan’s bevy of active geological, geophysical, and hydrologic processes, notes outer planets astronomer Heidi Hammel of the Space Science Institute in Boulder, Colorado. In addition, “things have shifted from a total astrobiology focus to more of the wonders of exploration,” he says, making Titan’s geocomplexity all the more attractive.

Neck and neck

The four were eventually down to two, and those were about to come up against some fiscal rigor. First, S. Alan Stern—NASA associate administrator for space science at the time—imposed a skimpy $2.1 billion limit on the next outer planets flagship mission. Stern’s dollar ceiling “was very healthy,” says Bagenal. “It made people prioritize, be really ruthless.”

Meanwhile, money problems began to loom with NASA’s Mars Science Laboratory (MSL), the behemoth rover scheduled to launch in October 2009. MSL’s increasingly public problems finally forced a 2-year launch delay earlier this month (Science, 12 December, p. 1618). The cost overrun totaled as much as $800 million over the $1.6 billion set in 2006 when NASA committed to the mission. “We have to be careful we don’t go down that path,” Bagenal said at a meeting of her assessment group here last month.

As it happened, the path for the next outer planets flagship mission took a sharp turn when Stern left NASA this past March and was replaced by Edward Weiler (Science, 4 April, p. 31). Parallel studies of missions to Titan and to Europa had been under way since February. NASA study teams had merged with ESA teams to design joint, multicraft missions, but the NASA teams had stuck to Stern’s price cap. Weiler wanted alternatives. He did ask for a core option costing $2.1 billion or less, but he added a “full decadal science” option delivering all the science in the decadal survey at whatever cost and an option hitting the “sweet spot” in between, where the science return on the dollar would be maximized. He gave the teams several more months to come up with their proposals.

The flagship—on-the-cheap NASA core missions did not fare well. At the Tempe meeting, after final reports were submitted, NASA outer planets program manager Curt Niebur confirmed that the core option “just wasn’t compelling enough to invest $2 billion.”

Sweet spots, on the other hand, were more palatable. The Europa orbiter team started with the half-dozen instruments onboard in their $2.1 billion core option and added instruments one by one. The total cost rose slowly until they reached the 13th instrument, the mass of which required a bigger, much more expensive rocket. The sweet spot of $3.0 billion had just been passed. The Titan orbiter team took a somewhat different approach to calculating their sweet spot, but it came out to $2.5 billion. The Cadillac missions fell well out of the running.

Ready, set, …

At the Tempe meeting, Ronald Greeley of Arizona State University, Tempe, NASA co-chair of the joint science definition team, declared that “the Europa Jupiter System Mission is essentially ready to go. Of course, the key driver is exobiology.” And the theme of the proposed joint mission to the Jupiter system is the emergence of possibly habitable worlds. Both the NASA and the ESA spacecraft—to be launched in 2020 on separate rockets carrying a dozen instruments each—would first orbit Jupiter, probing its magnetosphere and flying by all four moons. NASA’s would then enter Europa orbit to probe the ice shell with radar, size up the interior by gauging the ice’s tidal flexing, and survey the geology and chemistry of the surface for signs that ocean water ever makes it to the exterior. Meanwhile, the ESA spacecraft would orbit Ganymede.

The Titan team’s pitch is broader. “There’s something on Titan for virtually all aspects of planetary science,” was how Jonathan Lunine of the University of Arizona, Tucson, NASA co-chair of the Titan Saturn System Mission (TSSM) science team, described it. The mission would investigate how Titan functions as a system, determine how far prebiotic chemistry has developed, and continue exploring Enceladus with a dozen instruments each—would first orbit Jupiter, probing its magnetosphere and flying by all four moons. NASA’s would then enter Europa orbit to probe the ice shell with radar, size up the interior by gauging the ice’s tidal flexing, and survey the geology and chemistry of the surface for signs that ocean water ever makes it to the exterior. Meanwhile, the ESA spacecraft would orbit Ganymede.

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