Uranus and Neptune: Voyager 2's prognosis for the long haul

Last August, the Voyager 2 spacecraft flashed past Saturn, providing a treasure trove of new data and capping the 20 years of what some scientists have called "the Golden Age of Planetary Exploration." Then "the Great Hiatus" began. No U.S. spacecraft will visit another world until January of 1986, when that same Voyager 2 takes the first close look ever at distant Uranus, so far beyond Saturn that its discovery in the late 18th century more than doubled the size of the known solar system.

It will have been a monumental trek. The probe will have been in space for nearly eight and a half years and covered more than 5 billion kilometers since its Aug. 20, 1977 launching. And if all goes well, it will spend three and a half years more heading for an August 1989 encounter with Neptune.

The National Aeronautics and Space Administration is understandably keeping close watch over its charge, whose continued welfare represents what may be the only U.S. planetary visits of the 1980s. (The proposed Galileo orbiter and probe of Jupiter may not reach its goal until early 1990, and it will take budgetary battling if even a reduced version of the oft-delayed Venus-Orbiting Imaging Radar mission is to be developed for 1988. Comet Halley, it appears, will be left as a target for the probes of other nations.) The Voyager 2 encounters thus promise not only new additions to the list of close-studied worlds, but grist for scientists who will by then have endured nearly half a decade of data-starvation.

A recent analysis of the spacecraft's condition, carried out by engineers at Jet Propulsion Laboratory in Pasadena, the Voyager control center, therefore becomes a vital indicator of the potential for a U.S. role in solar-system exploration for many years to come. The prognosis? Good —with luck, work and TLC.

Voyager 2's photopolarimeter, which tracked a star through Saturn's ring-plane for a detailed picture of the ring structure and which is scheduled for the same feat at Uranus, suffers from an occasionally sticky filter wheel, but it did not affect the Saturn results and seems to be holding up well. An infrared sensor, valuable for compositional and thermal measurements, has lost a bit of its sensitivity, but it too seems up to its tasks. The principal areas of concern are five:

- The scan platform, a movable mounting that is steered by computer commands to aim the craft's cameras, infrared and ultraviolet sensors, and photopolarimeter, has caused probably the most visible concern. Just after passing through Saturn's ring-plane last Aug. 25, data showed that the platform had started to drag when moving in azimuth, one of its two axes of motion. Some observers initially felt the culprit to be a stray particle — perhaps even from, or knocked loose by, the rings themselves—lodged in the gears (Voyager 1's platform had temporarily suffered a similar ill, though nowhere near Saturn, in 1978). But the azimuth movements did not ease as they should if such a particle were being ground away by continued motion. The azimuth drive system was supposed to be capable of the equivalent of 4,000 full, 360° rotations, says Charles Kohlhase of JPL, yet it had been through only about 350. A laboratory test was then conducted with an identical device — which "froze solid," Kohlhase says (although it was more rigorously tested), at 348. At fault: a leaking lubricant, which caused a drive gear to bind on its spindle. Voyager 2's system is still balky, and engineers are now studying another test unit to see whether slower movements can prolong its lifetime. About 50 to 100 more rotations, Kohlhase estimates, should handle both the Uranus and Neptune encounters.

But Voyager 2 is a versatile device, often enabling alternative ways of accomplishing its goals. If the scan platform ends up capable of moving only in its elevation axis (which is so far okay), the azimuth movements could be provided by rolling the entire spacecraft. There is plenty of steering gas for the task, and the principal losses to the scientific instruments *not* mounted on the platform, says assistant project scientist Ellis Miner, would be largely confined to charged-particle sensors that work best when always facing into the oncoming flow of a planet's corotating magnetic field.

- The craft's narrow-angle camera (the one that takes the highest-resolution photos), says Kohlhase, "may not have the lifetime we originally thought it had." After counting on about 6,500 hours of use between Saturn and Neptune, engineers have noted a decline in the camera's "erase current," suggesting that there may be only about 3,000. The remedy will be simply to turn the camera off between distant observations of the planets rather than running it continuously. The close-in picture sequences should be unaffected, Kohlhase says, and there should be little consequence even for the more remote imaging.
- One of the two computer memories in which Voyager 2 stores and manipulates scientific data (other memories handle the control of the spacecraft itself) has suffered a partial mental block. Each memory holds 8,192 "words," but a failed integrated-circuit chip has cost the use of 256 of them in one of the units. For the Jupiter and Saturn flybys, this would have made little difference — either memory could handle the job—but to husband its power at distant Uranus and Neptune, the spacecraft must send its data back to earth more slowly, leaving room for fewer photos and other observations to be collected. To up the total, Voyager 2's handlers plan to employ a technique called "data-compression," in which, for example, the 8-bit binary "word" needed to numerically describe the brightness of a given picture element can be shortened to a smaller number that merely carries the difference between one element and the next. This would allow room for far more such measurements, potentially tripling the number of photos that can be taken and transmitted in a day, but it requires the use of both memories — one to arrange or "format" the data and the other to apply the compression technique.

All is well so far. The only problem would arise, says Kohlhase, if a few more 256-word blocks in the faulty memory also become unusable. The failed chip, he notes, could have succumbed merely to the deterioration of old age, and Voyager 2's flight past Neptune is targeted for four days after its 12th birthday.

There is one possible malfunction, however, that could conceivably cost the entire Neptune encounter:

- One of the spacecraft's two receivers ceased functioning in April 1978, and the probe has been depending ever since on its spare. In case that should fail, the probe's memory has been sent a set of instructions that say, essentially, "If you never hear from earth again, follow the enclosed plan." In it is a batch of computer commands sufficient to conduct an entire encounter with Uranus, scientific observations and all. The uncertainties in correctly aiming for Neptune while still so far short of even Uranus make the inclusion of a Neptune plan hardly worthwhile, although a Neptune "aim-point" at Uranus is already in the computer. A Neptune list will have to wait until Uranus is passed.

As far as the JPL engineers can tell, the receiver is showing no ominous signs of deterioration. There would even be a way to circumvent *it,* by sending commands through the craft's radio-astronomy instrument, but that would probably require the construction of a large transmitting antenna on earth, costing several million dollars, and the plan is deemed unlikely.

- A pair of components called "travelling-wave tubes" in the craft's X-band transmitters had been made with too high a "cathode-conversion temperature," engineers discovered a few months ago. They are fine so far, but a consequence could be that they can withstand far fewer than their specified 2,000 on-off cycles. Rather than changing back and forth from X-band (which can handle higher data rates) to S-band, engineers have decided to leave the transmitters in X-band all the time. This raises a question of the tubes' operating lifetimes, but one has plenty of hours left. The overall view of Voyager 2's chances, says Kohlhase: "Optimistic."

—J. Eberhart