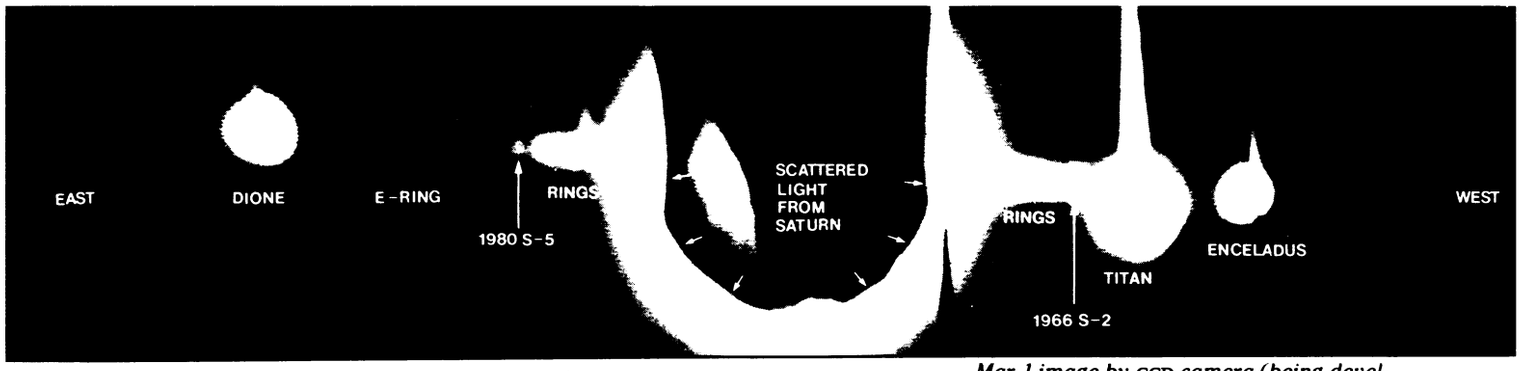

Mar. 1 image by CCD camera (being developed for Space Telescope wide-field/planetary camera team) shows additional satellites of Saturn and wide, faint "E-ring." 1.54 m Catalina telescope/U. of Ariz.

Saturn: More moon madness

How many satellites does Saturn have? It is a seemingly straightforward question, but the answer is far less clear. Following astronomer W.H. Pickering's 1898 discovery of Phoebe, the planet's ninth moon, the matter seemed settled, though Pickering thought he had found a tenth in 1904. In 1966, however, the issue abruptly became muddier. French astronomer Audoin Dollfus reported that *he* had found a tenth satellite, which he named Janus, but subsequent attempts to confirm its location were less than fruitful, and it has been a matter of controversy ever since. Also in images from that year, University of Arizona astronomers John Fountain and Stephen Larson later concluded that they had found an eleventh moon, an identification that was dubbed 1966 S-2. Other researchers, however, concluded that so many different orbits could be calculated from the 21 or so images cited that it was impossible to be sure that they really represented a single, identifiable satellite. One or more previously unknown objects did appear to be circling Saturn, but the number of confirmed satellites with clearly established positions stayed fixed, at least in conservative astronomical tabulations, at nine.

Early last September, the Pioneer 11 spacecraft became the first probe to pay the planet a close visit — and the number again started jumping around. Not only did Pioneer 11's camera indicate one or more possible new satellites, but its charged-particle detectors revealed still others, identified by the "wakes" that formed as the moons swept through the magnetically trapped particles. In recent months, earth-based observers have returned to the fray, thanks to the fact that, about every 13 to 15 years, there occur periods when Saturn's thin rings appear edge-on to earth, making small satellites easier to spot. Numerous astronomers have taken advantage of this rare alignment (the last chance in the current series is this July), and the results have been piling up. All told, Pioneer 11's scientists have reported six satellite indications that did not match the established nine, and earth-based observers have provided at least seven more.

This does not mean that Saturn is now believed to have 22 satellites. Some of these identifications would almost certainly be of the same objects. The problem lies in figuring out which are which. But according to Brian Marsden of the Harvard-Smithsonian Center for Astrophysics in Cambridge, part of whose job is to look for links among such diverse observations, order appears to be emerging.

Saturn, he says, now appears to have no fewer than 13 satellites, with a small possibility that there are as many as 18. One of them may be one that appears in a Pioneer 11 photo, as two or three of five charged-particle identifications, in earth-based photos including a charged-coupled-device image by B. A. Smith, H. J. Reitsema and Larson from the University of Arizona, and in perhaps 13 of the 21 plates cited by Larson from 1966. All, says Marsden, may be 1966 S-2, orbiting Saturn once every 16 hours 38 or 39 minutes, some 150,000 km from the planet's center.

At least two identifications in the charged-particle data (1979 S-3 and S-5) appear to be distinctly different objects, with orbital radii of about 169,000 and 141,000 km, and much farther out lies yet another candidate, 1980 S-6, faintly visible in a plate from France's Pic du Midi observatory. Another CCD image from Arizona reveals 1980 S-5, which may or may not coincide, Marsden says, with 1979 S-3 or S-5. Similar matches and non-matches among these and other data will determine how high the final total rises. But the hoary old nine has bitten the dust. □

The coming of Halley: The world readies

The National Aeronautics and Space Administration's plans for studying comet Halley have been in trouble for years. A 1976 idea to send a spacecraft cruising side by side with the comet on a sunlight-pushed "solar sail" never got past the preliminary paperwork, nor did a proposal for a similar mission using an electric ion-propulsion system. A subsequent scheme, using the "ion drive" simply to fly past Halley on the way to a year-long rendezvous with a smaller comet, was stalled a few months ago when budget cuts eliminated the funds for the ion drive's development. (Attempts to get the money restored, a slim prospect at best, have since run up against President Jimmy Carter's government-wide dollar-slashing plans.)

But Halley has a unique allure. Besides being the only comet most people can name, it has been described as "the most scientifically valuable single comet in the sky." NASA still hopes to fly a spacecraft past it, and the vehicle may have company. There may be as many as four — or even more — individual probes sent to study the famous object, whose subsequent apparition will not take place until well past the middle of the 21st century.

- The United States: NASA's envisioned flyby (which would initially appear in the fiscal 1982 budget) could include a probe that would be launched from the passing craft to approach the comet's nucleus. With the demise of the Halley-plus-rendezvous mission, the European Space Agency recently pulled out of a plan to provide the probe (feeling, says an ESA source, that too much of the Halley-only mission's overall success or failure would then be riding on ESA's shoulders), but the West German government has expressed interest in taking on the job. There are also trajectories (combined in some cases with augmented propulsion or a gravity-assisted "slingshot" around the earth) that would enable flybys of more than one comet from a single launching. But the latest budget tightening makes any specific prediction risky at best.
- Europe: Following cancellation of its plans to build a probe for a NASA spacecraft, ESA is now considering building a full Halley spacecraft of its own. Last week, the agency's science program committee selected an astrometry satellite (to be called Hipparcos) as ESA's next major project, but at the same time it instructed ESA to pursue the study of a Halley mission, saying that, if necessary, Hipparcos could be delayed to make room for it. ESA and NASA hope to coordinate their respective Halley flights, such as with complementary experiments or with one craft flying through the comet's tail while the other goes past its head.
- Japan: Now awaiting (and expected to receive) funding from the Diet is a spacecraft to be called Planet A, to be sent on a sun-circling path that will take it inside the orbit of Venus when the comet is close to the sun. Japanese space officials have also begun coordination talks with NASA regarding the mission, which is expected to

include ultraviolet imaging.

• The Soviet Union: In December 1984 or January 1985, the Soviets plan to launch a spacecraft that will go into orbit around Venus and deploy large, instrumented balloons to bob around in the planet's atmosphere. As it works out, the orbiter will be on station when the comet passes closest to the sun (about 90 million kilometers) in early February of 1986. This will be the comet's most active phase, and at that time, the orbiter will be only about 40 million kilometers from it, barely a sixth as far as the earth. To the orbiter's instruments, the comet could appear as much as 30 times brighter than it will ever be to terrestrial observers, and French scientists have indicated that Soviet planners may expand the Venus mission to include the study of Halley. There have even been hints that the orbiter might be equipped to send probes toward the comet.

Besides the deep-space, "in situ" observations, there will be considerable activity from earth orbit. The shuttle-launched, 2.4-meter Space Telescope is likely to be a major tool, although protecting its optics and instruments requires that it not look at Halley when the angle between the comet and the sun is less than 45 degrees. The Spacelab research modules being built in Europe for the shuttle may include one — which could be flown two or three times — instrumented especially for Halley. Such a package would probably include mostly existing instrumentation, says Lewis Friedman of Jet Propulsion Laboratory, but there could be some modifications to enable aiming more closely to the sun. The present International Ultraviolet Explorer satellite will probably be inoperative by that time, but NASA's planned Infrared Astronomy Satellite, if its scheduled 1984 launching is at all delayed (such as by budget cuts) could still be active. Closer to the ground, high-flying aircraft may be used to collect dust left in the atmosphere when the earth passes through the region where the comet's tail crosses the planet's orbit.

In addition, a huge International Halley Watch is already being organized to coordinate the activities of ground-based observatories (as well as of interested amateurs). Spectroscopy, photometry and a host of other techniques will be brought to bear, and even for the imaging studies alone, says Robert Chapman of NASA's Goddard Space Flight Center in Maryland, preliminary inquiries have produced "very interested responses" from about 30 observatories, together representing every continent on the planet. By comparison, he says, Operation Kohoutek, organized to study another comet several years ago, included only 18. But the Kohoutek watchers had only a year to prepare. The Halley observers have half a decade. "I really believe," says Chapman, "that we have a network that will enable us to see the comet at any hour of the day or night." □