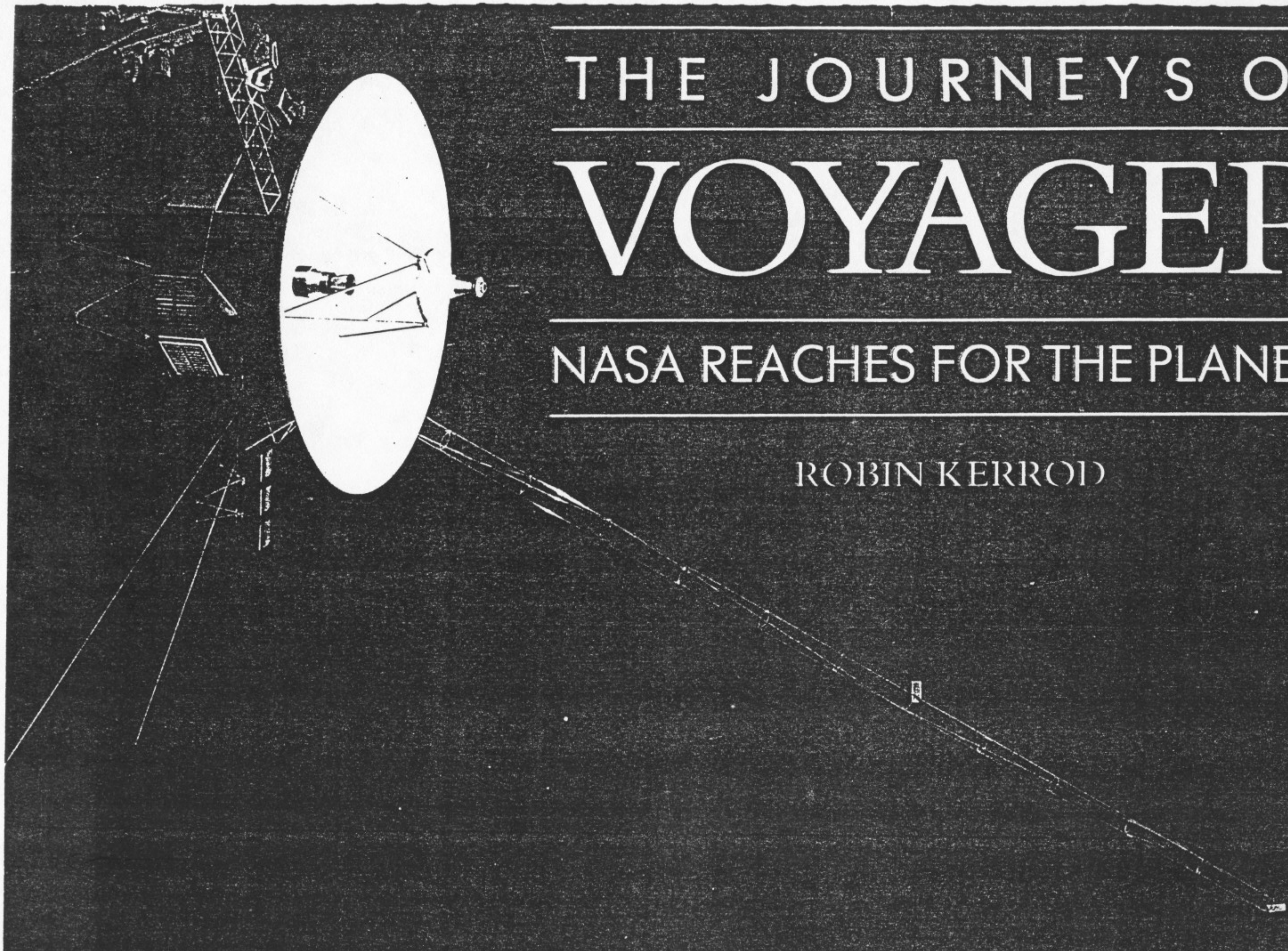
THE JOURNEYS OF

VOYAGER

NASA REACHES FOR THE PLANETS

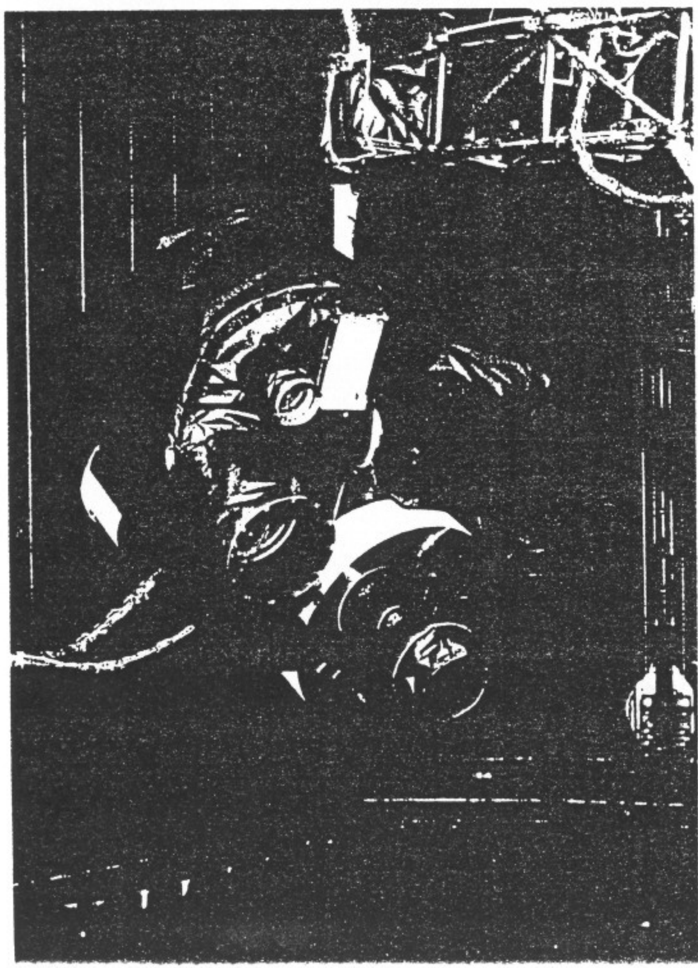


ROBIN KERROD

CE-IN-A-LIFETIME ENCOUNTERS WITH JUPITER, SATURN, URANUS AND NEPTUNE

VOYAGER

1 The Voyager Project



◀ Instruments on Voyager's science boom scan platform. They pick up infrared and ultraviolet radiation, as well as light in the visible region of the spectrum.

▶ (Opposite) The path of Mariner Jupiter Saturn through the solar system. Before the probe was launched, in summer 1977, it was renamed Voyager. The picture shows the probe in its final configuration.

In the early 1960s, when space scientists began to meet with some success in sending space probes to the near planets Venus and Mars, their thoughts inevitably turned to the giant outer planets. How could they explore these giants in a reasonable time frame, given that they lie hundreds of millions, even billions, of kilometers away?

Mars sometimes comes within 60 million km (37 million miles) of Earth. But Jupiter lies nearly three times as far away as Mars; Saturn, nearly twice as far as Jupiter; and Uranus, twice as far away again. Translate this into measurements and the magnitude of the problem becomes evident. Uranus, for example, is nearly 3 billion km (2 billion miles) away! Even using the most powerful rockets of the day, a flight to Uranus would have taken decades.

In 1965, however, a graduate student at Caltech (California Institute of Technology) named Gary Flandro came up with a brilliant notion: Why not use the gravity of one planet to accelerate a space probe and "sling" it toward another planet? The concept of the gravitational "slingshot", or gravity-assist method, was born.

"My gravity-boost idea wasn't new," recalled Flandro in 1989. "Astronomers had known for a long time that a comet speeds up when it passes close to a planet. I was the first to apply the same idea to a spaceship."

Gravity-assist meant that space scientists could give a space probe a much greater speed than was possible by means of a direct launch from Earth. It promised a much shorter journey time to the outer planets, provided they were favorably placed in the heavens.

tracking
Following the path of a spacecraft through space.

trajectory
The path of a spacecraft through space.

trajectory correction maneuver (TCM)
Firing thruster rockets on a spacecraft so as to change its speed and therefore its trajectory through space.

Voyager chronology

1962 In December NASA's Mariner 2 spacecraft becomes the first successful interplanetary probe, when it reports on the hellish conditions on Venus.

1965 Caltech graduate student Gary Flandro puts forward the idea of gravity-assist to reduce journey times to distant planets.

1969 The United States Congress approves the Pioneer project to send two reconnaissance craft through the asteroid

1971 NASA selects teams of scientists to support a number of Grand Tour missions to all the outer planets, but by the year's end, the original plans have to be drastically curtailed for budgetary reasons.

1972 Congress approves the revised plans, for two launches to Jupiter and Saturn, project name Mariner Jupiter Saturn. The MJS project begins officially on 1 July. Meanwhile, the pathfinding Pioneer 10, launched on 2 March, is heading towards the asteroid belt.

1973 On 5 April Pioneer 11 lifts off to follow its sister craft to Jupiter, but in an orbit that could allow it to continue to Saturn. On 3 December Pioneer 10 makes its closest approach to Jupiter.

1974 Pioneer 11 makes its closest approach to Jupiter on 2 December, then successfully enters an orbit that will take it to Saturn.

1977 On 20 August Voyager 2 begins its journey into deep space. Voyager follows on 5 September, in a faster trajectory.

1978 On 23 February Voyager 1's scan platform jams, putting the mission in jeopardy, but by May the problem has been rectified. On 5 April Voyager 2's primary radio receiver fails, as does circuitry in the backup. But by modifying signal transmission techniques, full communications are restored on 13 April.

1979 On 5 March Voyager 1 flies within 278,000 km (173,000 miles) of Jupiter. One-way radio time-lag: 47 minutes. Voyager 2 makes its closest approach to Jupiter on 9 July, passing 650,000 km (404,000 miles) over the cloud tops. Pioneer 11, farther out, keeps its rendezvous with Saturn on 1 September. It swoops within 21,000 km (13,000 miles) of the atmosphere.

1980 Voyager 1 makes its close encounter with Saturn on 12 November, at a distance of 124,000 km (78,000 miles). One-way radio time-lag at Saturn: 1 hour 26 minutes.

1981 On 25 August Voyager 2 flies within 101,000 km (63,000 miles) of Saturn .

1983 Pioneer 10 crosses the orbit of Neptune, at present the outermost planet, and in theory becomes the first spacecraft to leave the solar system.

1986 On 24 January Voyager 2 encounters Uranus, flying some 80,000 km (50,000 miles) above the cloud tops. One-way radio time-lag: 2 hours 45 minutes.

1989 Voyager 2 makes its last planetary encounter, with

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