

## Halley Comet Missions

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*DSN operations in support of the recent Halley Comet closest approach are described in introduction of the subsequent articles.*

In man's continual quest to explore and understand the nature and origin of the solar system, 1985 through 1986 may well be noted as the "Year of the Comet." The first in-situ measurements of a comet occurred on September 11, 1985, with passage of the International Cometary Explorer (ICE) through the tail of Comet Giacobini-Zinner 7800 km downstream of the nucleus. ICE threaded the needle as it scored a bullseye by intersecting the neutral sheet bisecting the tail. Encounter operations support provided by the DSN was described previously in six articles in *TDA Progress Report 42-84*, February 1986. DSN Multimission Navigation Team support of ICE was reported on in *TDA Progress Report 42-86*, August 15, 1986.

This unprecedented encounter was followed six months later by the spectacular rendezvous of a fleet of five spacecraft in the vicinity of Halley's Comet during the four-day long period of March 9 through 13, 1986. The Halley armada included Japan's Sakigake (MS-T5) and Suisei (Planet-A), the Soviet Union's Vega-1 and Vega-2, and ESA's Giotto. Twelve days later, ICE also passed within Halley's sphere of influence.

In addition to the aforementioned six spacecraft, two other interplanetary explorers turned their instruments in the direction of Halley's Comet at various times during the year. The long-lived Pioneer 7 and the Venus orbiting Pioneer 12 contributed to the library of space-based measurements made during the Halley exploration period. Table 1 provides a compilation of the time and distance of closest approach to Halley's Comet for all eight spacecraft. For Pioneer 12, which is in orbit about Venus, this table entry represents the closest approach of Halley and Venus.

It has also been an unprecedented period in the arena of international cooperation between national space agencies and the worldwide scientific community. The International Halley Watch (IHW) and the Inter-Agency Consultative Group (IACG) provided mechanisms and forums which contributed to the successful encounters with both Halley and G-Z. The IACG initiated the Pathfinder concept using on-board instrument pointing angle data and DSN VLBI data obtained during the earlier arrival of the two Vega spacecraft. This improved the

Halley's Comet ephemeris and hence aided in the final Giotto targeting; of all the spacecraft, Giotto had the closest approach to the nucleus. Articles covering the ICE G-Z encounter science results appeared in *Science*, Vol. 232, April 18, 1986. Halley mission encounter science is reported in brief in the aforementioned issue of *Science* and in greater detail within *Nature*, Vol. 321, No. 6067, May 1986, and *Geophysical Research Letters*, Vol. 13, No. 8, August 1986.

Earth-based observations gathered by the Astrometric Network of the IHW were collected at JPL and distributed to both ESA and Intercosmos. Ephemeris development at JPL for both Comet Giacobini-Zinner and Halley's Comet supported ICE and the two Japanese missions. The DSN participated in the support of all eight missions as briefly summarized in Table 2. The following six articles provide further description of these efforts.

**Table 1. Summary of spacecraft close approaches to Halley's Comet**

Mission	Halley closest approach			
	Distance, km	Date (1986)		
		Day	Month	Hour:min (UTC)
Vega-1	$8.9 \times 10^2$	6	Mar	07:20
Suisei (Planet-A)	$151 \times 10^3$	8	Mar	12:08
Vega-2	$8.0 \times 10^3$	9	Mar	07:20
Sakigake (MS-T5)	$7 \times 10^6$	11	Mar	03:18
Giotto	$5 \times 10^2$	13	Mar	23:03
ICE	$28 \times 10^6$	25	Mar	09:30
Pioneer 7	$12 \times 10^6$	20	Mar	23:36
Pioneer 12 (Venus Orbiter)	$40 \times 10^6$	3	Feb	18:20

**Table 2. Summary of DSN support for Halley's Comet mission set**

Mission	DSN role
Giotto	Telemetry, command, and navigation support for near-Earth departure phase and Halley encounter.
Sakigake (MS-T5) Suisei (Planet-A)	Telemetry, command, and navigation support for first ten days after launch and as requested during cruise. Telemetry support during Halley encounter.
Vega 1 Vega 2	Encounter orbit determination using DSN VLBI techniques.
ICE	Telemetry, command, and navigation support from Dec. 1983 lunar swingby through comet-postencounter interplanetary cruise.
Pioneer 7 Pioneer 12 (Venus Orbiter)	Telemetry, command, and navigation support since launch.