ISSE-3/ICE Telecommunications Summary

International Sun-Earth Explorer-3, ISEE-3, ISEE-C or Explorer-59, renamed ICE International Cometary Explorer in 1983
Launched 1512 GMT 12 August 1978 on a Delta 2914 from ETR Launch Complex 17B
COSPAS Identification 1978-079A, USAF Space Catalog number 11004

Structure:

Mass: 390 kg dry, 479 kg at launch
16 sided cylindrical body, 1.73m (5'8'') across by 1.61m (5'4") high
A tower elevates the telemetry antenna above the spacecraft body and provides a clear field of view for several cosmic-ray detectors. The spacecraft body supports a total of ten appendages. Two equatorial experiment booms (3 m long) support the magnetometer and plasma-wave sensors. Four wire antennas (each 49 m long) are deployed in the spin plane as part of the radio-wave and plasma-wave investigations. Two axial antennas (7 m each) extend above and below the spacecraft parallel to the spin axis to render the radio-wave measurements three dimensional. Finally, two short inertial booms provide stability.
Spin stabilized with a nominal spin rate of 19.75 ±0.20 rpm (1%).
A hydrazine propulsion system is used for attitude and ΔV maneuvers. 12 TRW MRE-4 thrusters , four radial, four spin-change, two upper-axial, and two lower-axial with 8 conospherical fuel tanks held ~90 kg (200 lbs) of hydrazine, providing a total ΔV capacity of about 430 m/sec. Pulse mode thruster operations were monitored in real time by a single unidirectional pendulous servo force balance accelerometer mounted near the spacecraft centre of gravity with its sensitive axis 60° from the spin axis. As a result of a nominal launch, gas usage has been much lower than anticipated, resulting in a substantial amount of excess gas still being available.
A Ball Bros. Panoramic Attitude Sensor (PAS) and a pair of Adcole Fine Sun Sensors (FSSA and FSSB), accuracy about 0.1° with 0.004° FOV, determined spacecraft attitude which maintained the spin axis pointing within 1 degree of the North Celestial Pole or normal to the Ecliptic plane
Upper and lower ring of 16 solar cell panels each, 175W beginning of life and 160W end of life (3 years)
14 cell Silver-Cadmium 19.7 V 10AH battery
Spacecraft main bus voltage 28±2% VDC
Designed and managed by GSFC, manufactured and integrated by Fairchild Space and Electronic Co with components and experiments supplied by GSFC and universities.

Telecommunications:

Redundant telemetry data multiplexer units
Redundant digital command decoders and relays
Redundant S-band transponders, each 5 Watt RF output

Transponder A:	2090.66 MHz RHCP uplink, command or ranging
	2270.40 MHz RHCP downlink, telemetry or ranging
Transponder B:	2041.95 MHz LHCP uplink, command
	2217.50 MHz LHCP downlink, telemetry

Transmit antenna: medium gain with dual inputs for simultaneous right and left hand circular polarization downlink, 8 rows of 4 elements, 7 dBi, ±6° beamwidth, multibeam, electronically steerable, four lobe, omni directional coverage in azimuth

Receive antenna: 2042 MHz, intermediate gain, 1 row of 4 elements, 0 dBi, ±45° beamwidth

Ranging: Phase coherent ranging using $f_{downlink} = 240/221 \times f_{uplink}$

Command: PCM/FSK-AM/PM, 256 bps, f_1 7500 Hz, f_0 9000 Hz. AEM/IUE type decoders with a total capacity which is not all installed or used, of: 128 discrete low voltage impulse commands, 70 latched relays for power or pyrotechnics and 64 37-bit serial digital commands with NRZ data, 4266 Hz clock and individual enable lines. The command word length is 60 bits consisting of an 8 bit spacecraft/ decoder address, a 44 bit command data field, a 7 bit Error Check code and 1 bit fill. The 44 bit command can be either one Serial/Discrete bit (0) and 8 of 43 bits for discrete command code or one Serial/Discrete bit (1), 6 bit serial command address and 37 bit serial data. A preamble for uplink carrier acquisition and bit synchronization is at least 15 zeros followed by a 1 bit Sync (1).

Telemetry: The PCM telemetry bit stream can be convolutionally encoded with constraint length K = 24, Rate R =1/2, non-systematic and non-transparent. G1=73353367 octal and G2=53353367 octal with G2 parity output inverted. This is a Massey-Costello Quick Look In code where D = P1 xor P2. Linkabit LS4815 sequential decoders were used by GSTDN and DSN

Two fixed formats and two programmable formats available from spacecraft dataplexers?
Emergency format - 64 bps, ?? words/minor frame, 3 word sync code $FAF320_{hex}$
High/Low/Engineering format - 2048/1024/512 bps, 128 words/minor frame, 4 word sync code $EC819FBE_{hex}$

2048 bps, 1024, 512 and 256 bps	PCM (BiØ-L)/PM	PM ±60°
128 and 64 bps	PCM (NRZ-L)/BPSK/PM	1024 Hz sub-carrier, PM ±40°

A High/Low/Engineering format minor frame is 128 8 bit words with 116 words for science data from 12 instruments, 6 word sub commutation of spacecraft housekeeping data, 1 word for minor frame identification and 4 words for minor frame synchronization. A major frame is 32 minor frames

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ISEE-3/ICE Telemetry format for High Data Rate (2048 bps) and Low Data Rate (1024 bps)

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79
80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111
112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127

116 words for science data
Words 30, 31, 62, 63, 92, 95 – 192 Spacecraft housekeeping words sub commutation over 32 minor frames
Words 60, 61 – Minor Frame identification (0-31 is 5 bits), format ID, data rate, coding, status, command verification?
Words 124, 125, 126, 127 – minor frame synchronization words, $EC819FBE_{hex}$

Tracking: GSFC Ground STDN 26m (85') network from launch to 1983, data rate 2048 bps at L1 then by JPL DSN, data rate 1024 bps during ICE phase, 512 bps on 12/9/1985, 256 bps on 1/5/1987, 128 bps on 24/1/1989, 64 bps on 27/12/91; terminated 5/5/1997

ISEE-3/ICE Timeline:

12 August 1978	ISEE-3 launched
20 November 1978	injected into L1 halo orbit
10 June 1982	Leave L1 halo orbit
November 1983	start 2 months Parallel STDN and DSN operations
22 Dec 1983	After 5th Perilune at 119.4 kms, commence heliocentric orbit and renamed International Cometary Explorer, ICE
6 Jan 1984	512 bps at handover to DSN
8 September 1985	1024 bps
11 September 1985	Giacobini-Zinner GZ encounter
12 September 1985	512 bps
31 October 1985	First Halley encounter
28 March 1986	Second Halley encounter
5 January 1987	256 bps
24 January 1989	128 bps
20 Oct 1990	JPL Advance Receiver test with 256 symbols per second on 1024 Hz sub carrier.
Nov-Dec 1991	Extended ICE mission with Ulysses on same Sun radial
27 December 1991	64 bps
19 December 1995	Telemetry modulation turned off, carrier used by JPL Radio Science
5 May 1997	ICE mission support terminated
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18 Sept 2008	ICE carrier recovered and tracked by DSN [7,8]
August 2014	**ICE <u>returns</u>** to Earth-Moon vicinity[11, 12]

Internet references: Accessed July 2012

1. http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=1978-079A
2. http://nssdc.gsfc.nasa.gov/nmc/spacecraftTelemetry.do?id=1978-079A
3. http://tmo.jpl.nasa.gov/ipn_progress_report/issues.cfm?force_external=0
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10. http://nssdcftp.gsfc.nasa.gov/spacecraft_data/isee/isee3/
11. http://cohoweb.gsfc.nasa.gov/helios/heli.html
12. http://mdkenny.customer.netspace.net.au/2012-ISEE-3-SWE-543.pdf

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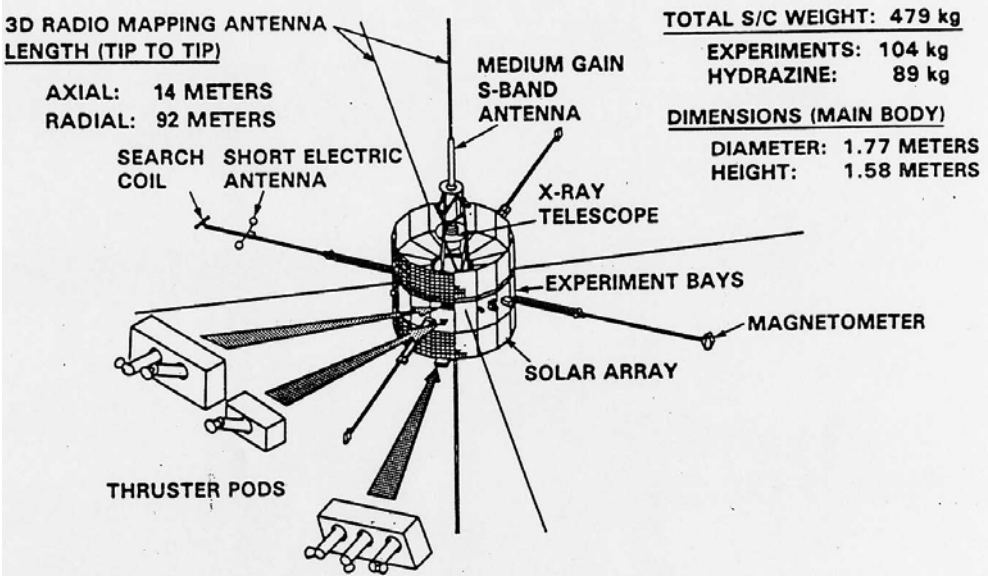
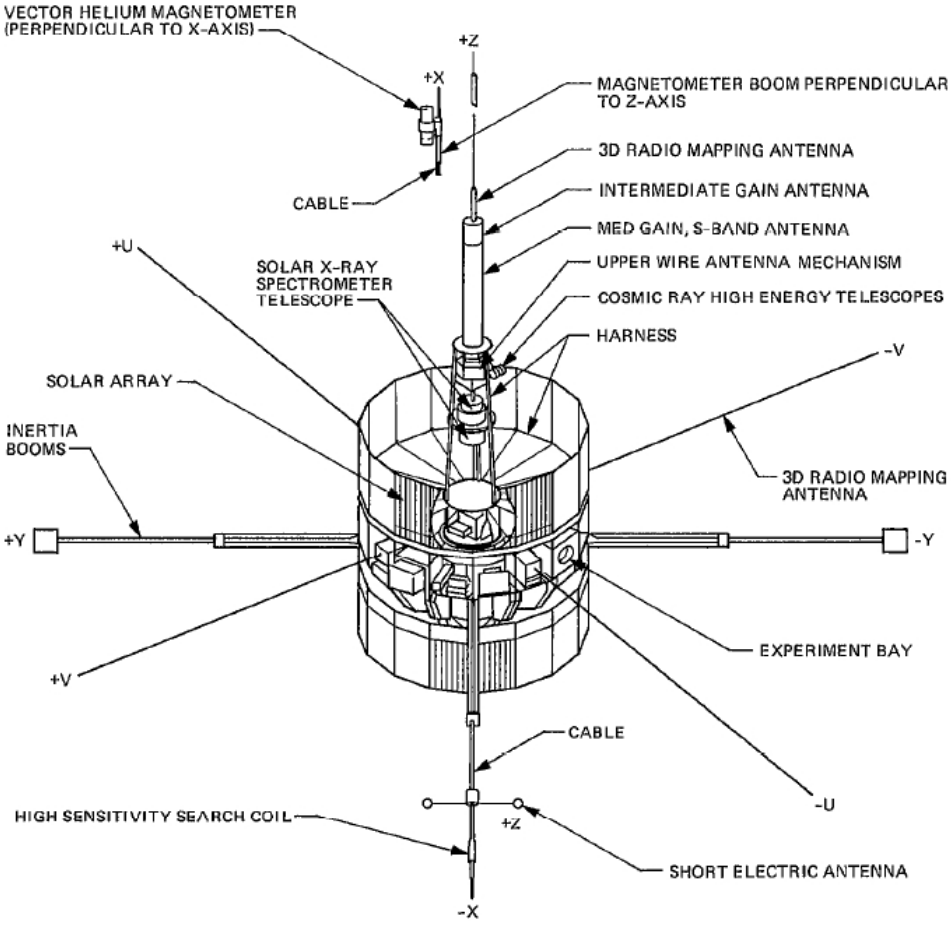
ISSE-3/ICE Telecommunications Summary





ICE spacecraft

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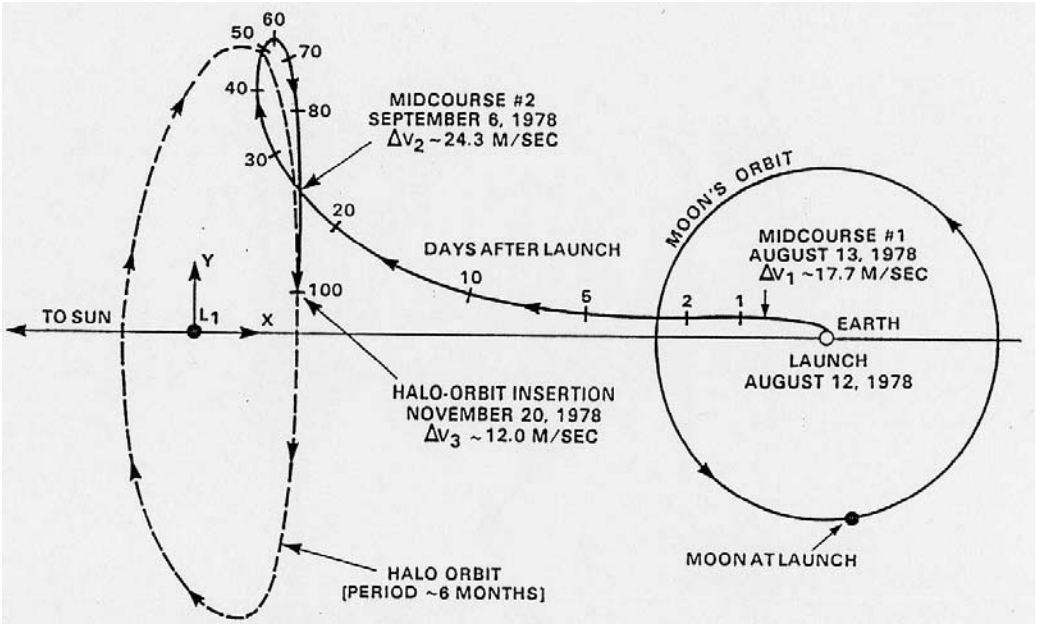

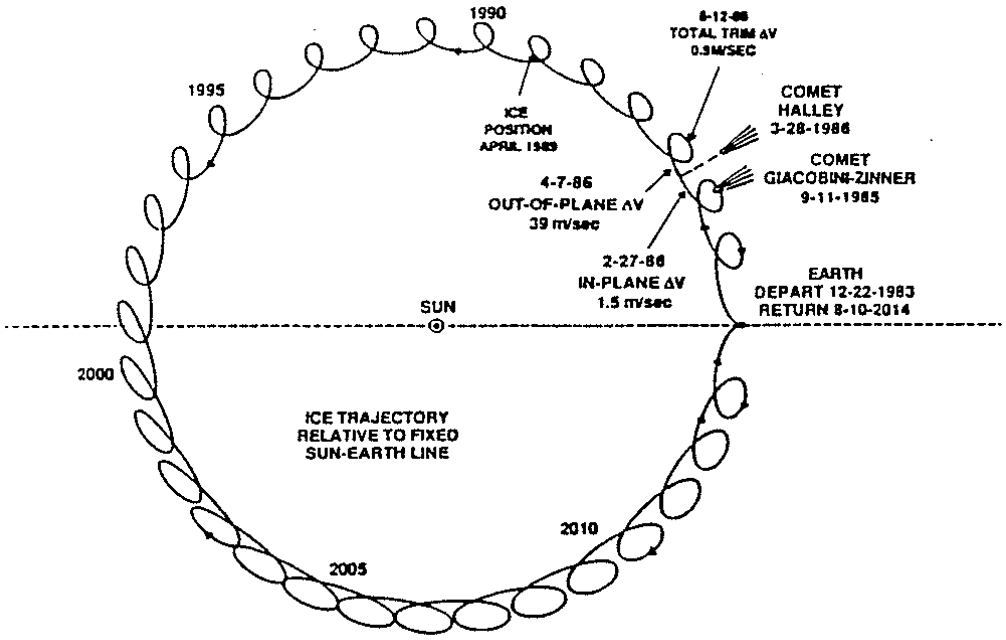

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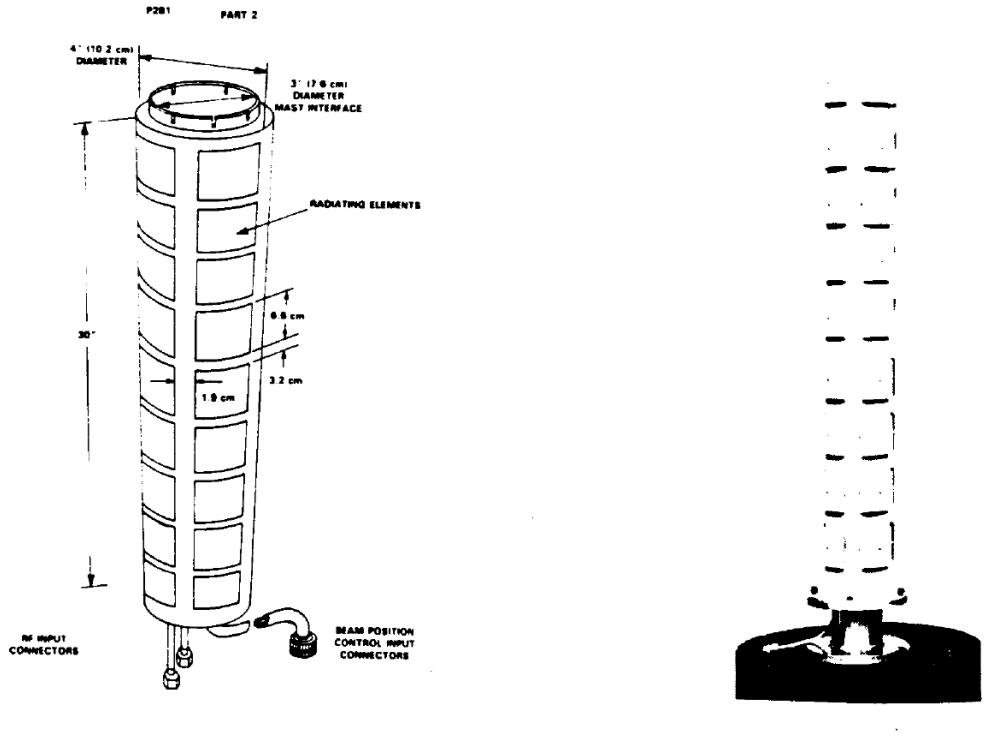
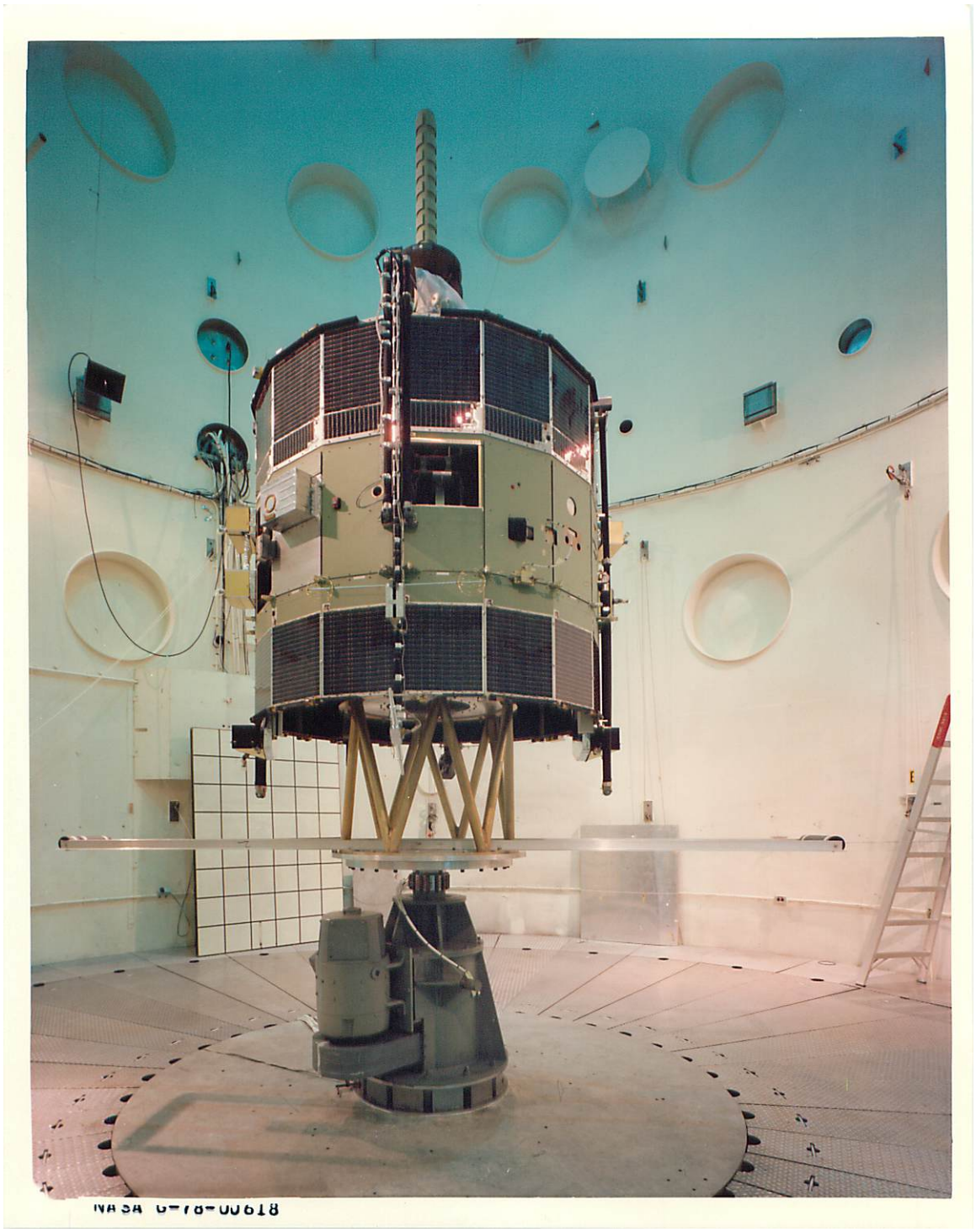


ISEE-C Antenna Radiator External Configuration

ISSE-3/ICE Telecommunications Summary



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