

COMET & CLOSE APPROACH ASTEROID MISSION

CONTRACT JPL 950870

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3875 FABIAN WAY • PALO ALTO, CALIFORNIA

**COMET & CLOSE APPROACH
ASTEROID**

MISSION STUDY

FINAL REPORT

CONTRACT JPL 950870

A G E N D A

Presentation of Study Material

"Comet and Close Approach Asteroid Mission"

Contract JPL 950870

Philco Corporation
Western Development Laboratories
Palo Alto, California

Participants:

Frank Elsbree	-	Space Vehicle Systems Sales
G. O. Moore	-	Manager Space Vehicle Programs
Reece Jensen	-	Space Vehicle Guidance Studies
John Savides	-	Manager Scientific & Inter-Planetary System Studies

WHY A COMET MISSION?

ASTROPHYSICS

ORIGIN & FORMATION OF SOLAR SYSTEM
DATA TO TEST THEORIES OF EVOLUTION

EXO BIOLOGY

"LIFE" IN SOLAR SYSTEM
CARBON MOLECULES

FUNCTIONS OF COMET PROBE

COMPLEMENTARY

DIRECT SAMPLING OF PARTICLES AND FIELDS
CLOSE RANGE OBSERVATIONS
DETECT PREDICTED EMISSIONS

SUPPLEMENTARY

CONFIRM EARTH—RECORDED
SPECTRAL EMISSIONS
AMBIGUOUSLY IDENTIFIED

CORRELATIVE

SIMULTANEOUS SPECTRO-PHOTOMETRIC OBSERVATIONS DURING INTERCEPTS

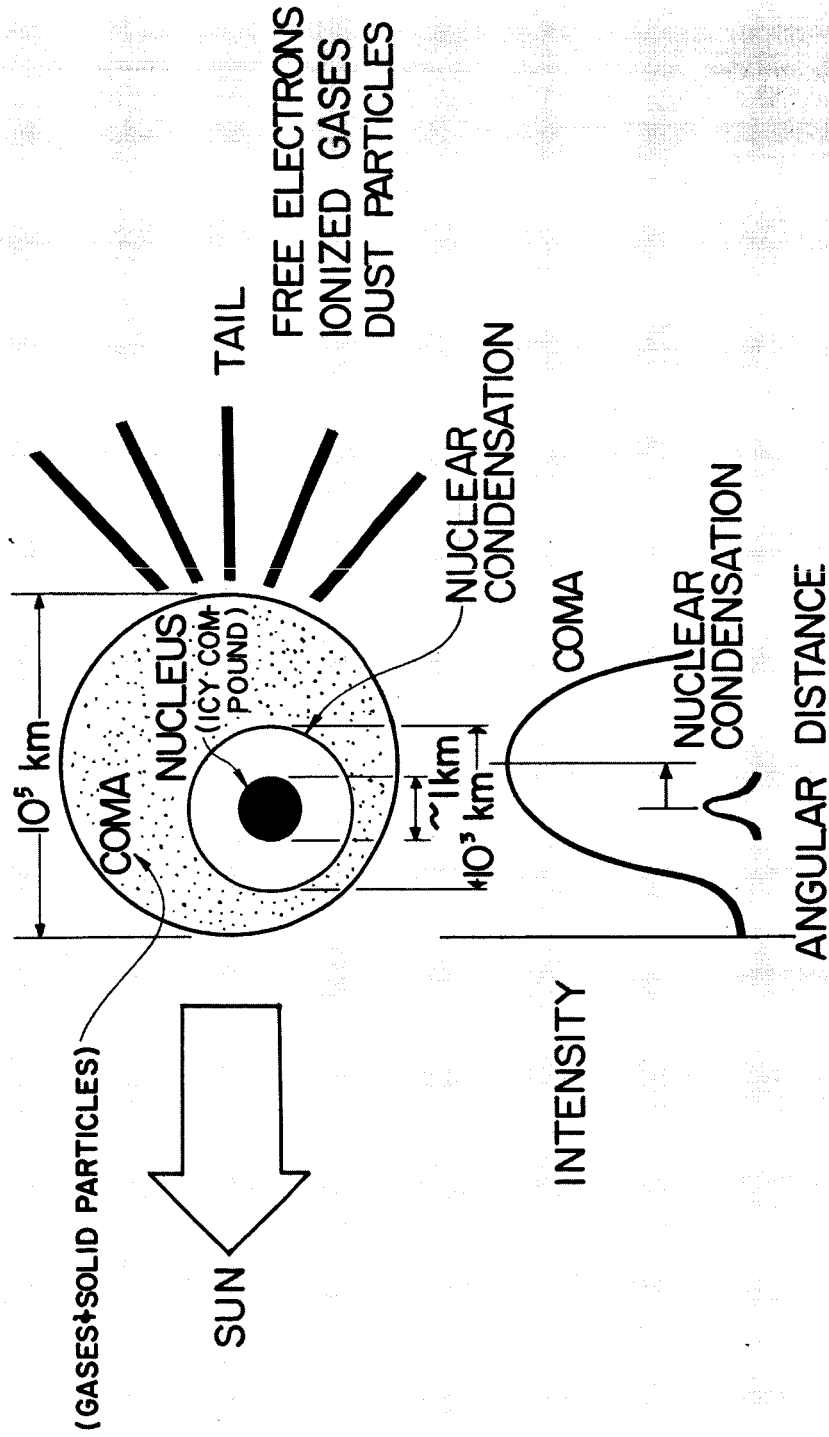
MISSION OBJECTIVES

- MEASURE DISTRIBUTION OF MATTER AND OF MAGNETIC FIELD THROUGH COMA OF COMETS
- OBSERVE NUCLEUS
- DETERMINE CHEMICAL COMPOSITION OF COMETARY MATERIAL
- MEASURE PHYSICAL AND CHEMICAL PROPERTIES OF CLOSE-APPROACH ASTEROIDS

COMET & CLOSE APPROACH ASTEROID STUDY

- DETERMINE TRADE-OFFS AMONG MISSION PARAMETERS, INSTRUMENT REQUIREMENTS, AND SUBSYSTEM PERFORMANCE FOR MISSIONS TO SELECTED COMETS AND CLOSE APPROACH ASTEROIDS DURING PERIOD 1967-1975
- FORECAST STATE-OF-THE-ART AND APPLY NEW TECHNOLOGY TO CONCEPTUAL DESIGN OF COMET/ASTEROID PROBES
- DEVELOP CONCEPTUAL SPACECRAFT DESIGNS
- SPECIFY FEASIBILITY OF ADAPTABLE SPACECRAFT DESIGNS
- COMPARE COMET/ASTEROID SPACECRAFT CONCEPTS WITH MARINER 1964 DESIGN
- ESTIMATE MISSION COSTS, SCHEDULES, AND PROBABILITY OF SUCCESS

COMET MODEL



STUDY OUTLINE

PRELIMINARY TARGET SURVEY - C3



TRAJECTORY ANALYSIS - VEHICLE
DEPARTURE • TRANSFER • RECOVERY



TRAJECTORY ANALYSIS - COMET
ORBITAL DATA • ACCURACIES • RECOVERY



GUIDANCE REQUIREMENTS

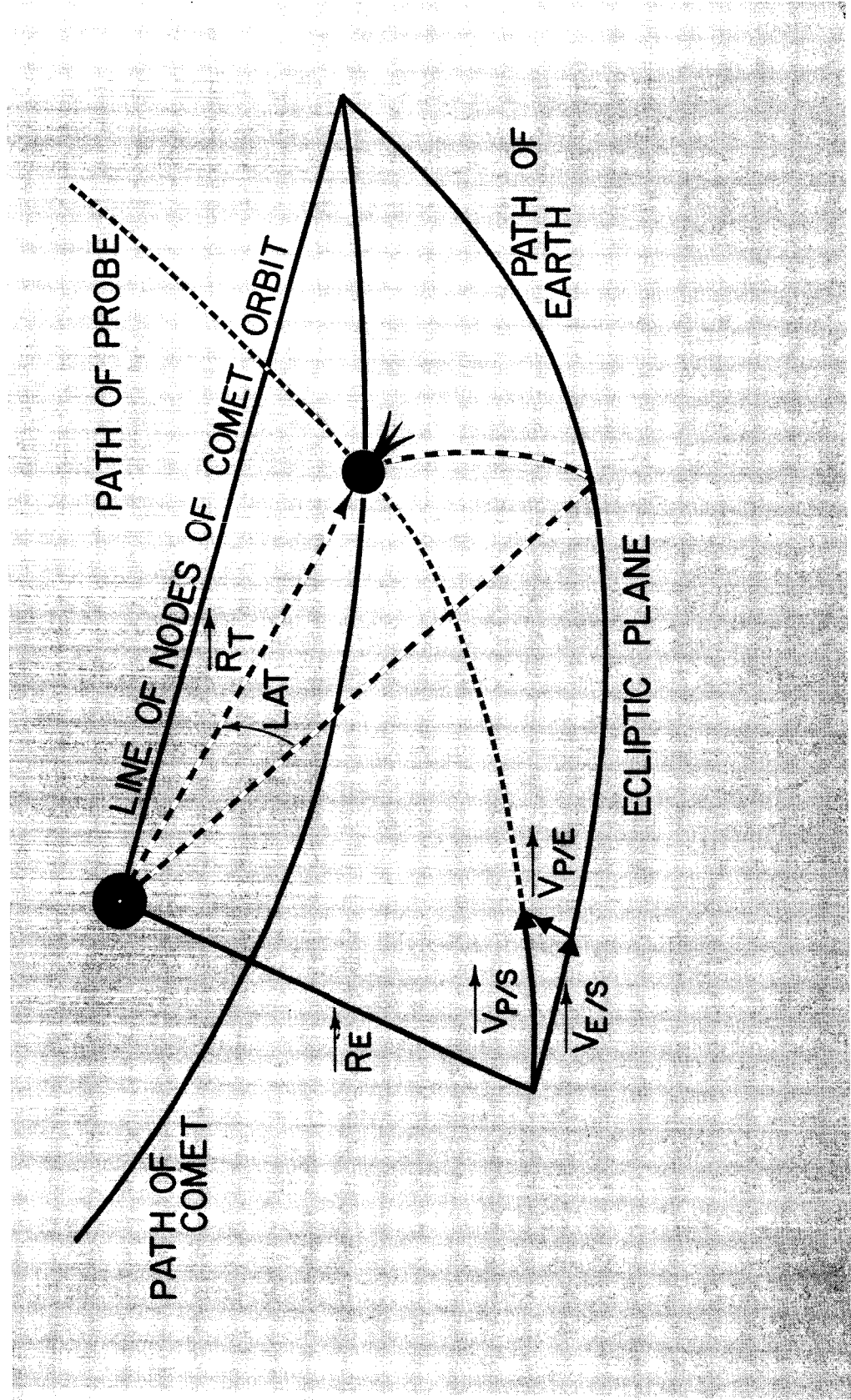


SELECTION OF PRACTICAL TARGETS

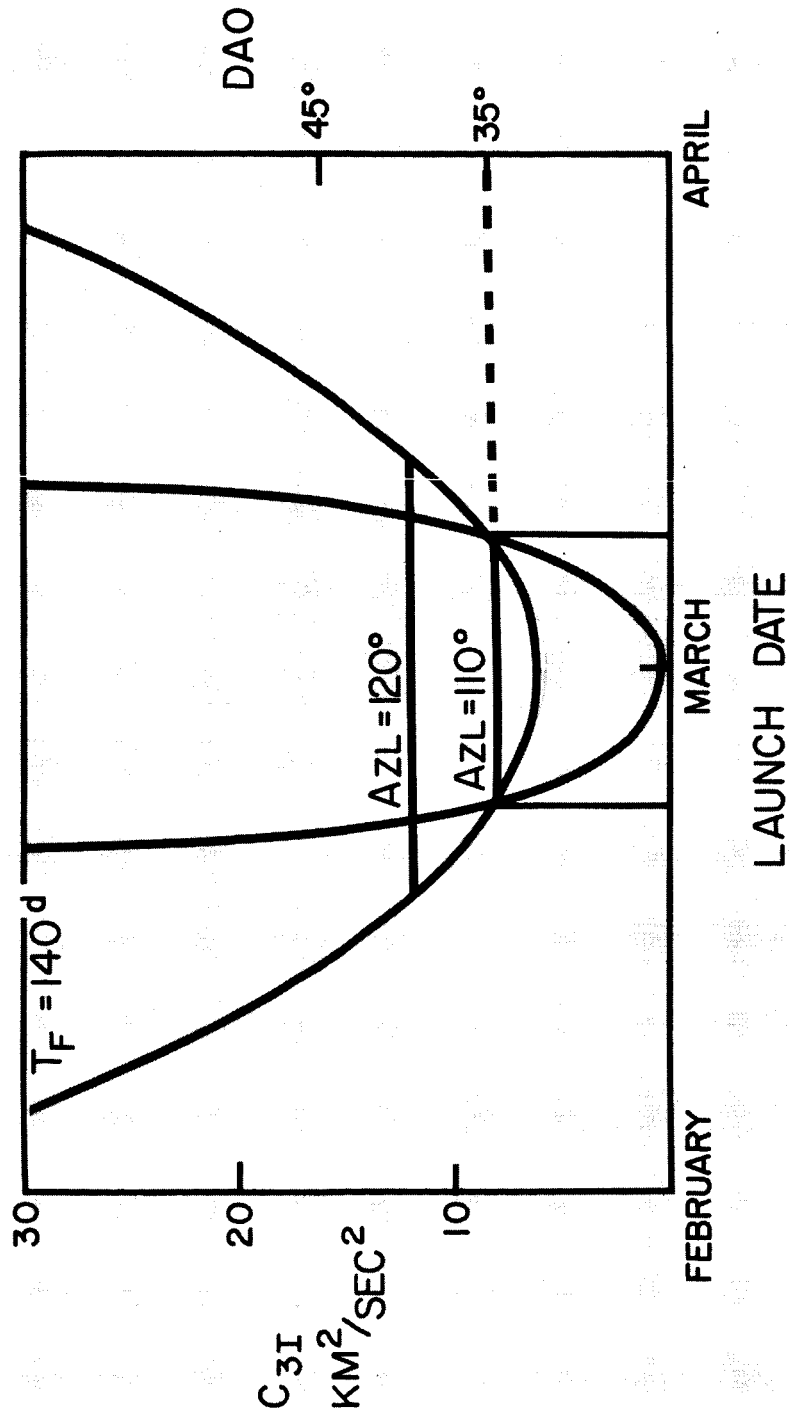
PRELIMINARY COMET SURVEY

LAUNCH	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
FEASIBLE MISSIONS	ATLAS AGENA							TUTTLE- GIACOBINI KRESAC		
	ATLAS CENTAUR	TEMPEL (2)			KOPFF				BROOKS (2)	
MARGINAL MISSIONS		1	1	2	1		1		3	
EXCEED ENERGY REQUIREMENTS	2	12	2	2	2	5	3	1	6	2

HELIOCENTRIC TRANSFER GEOMETRY

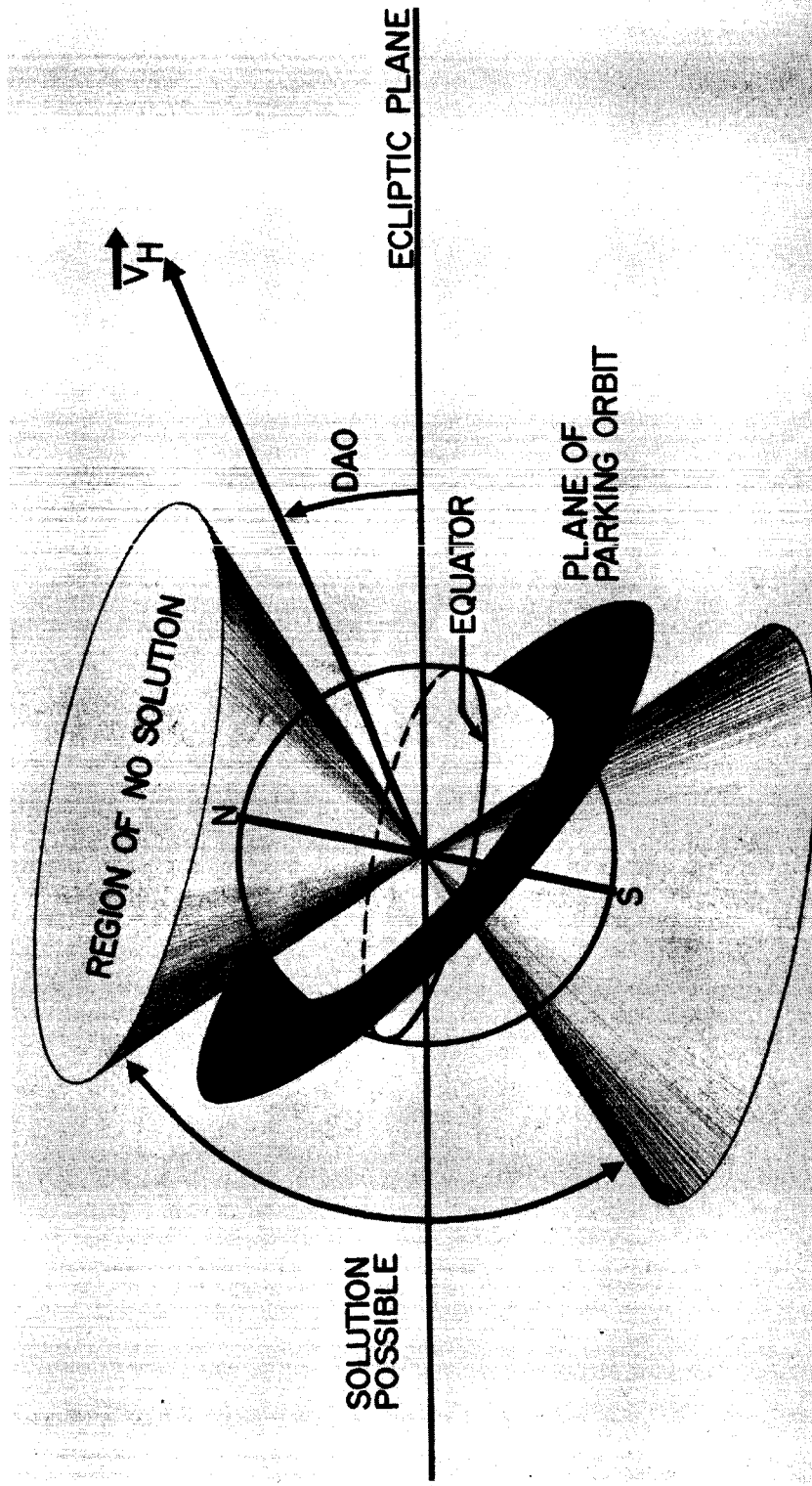


COMET PONS-WINNECKE



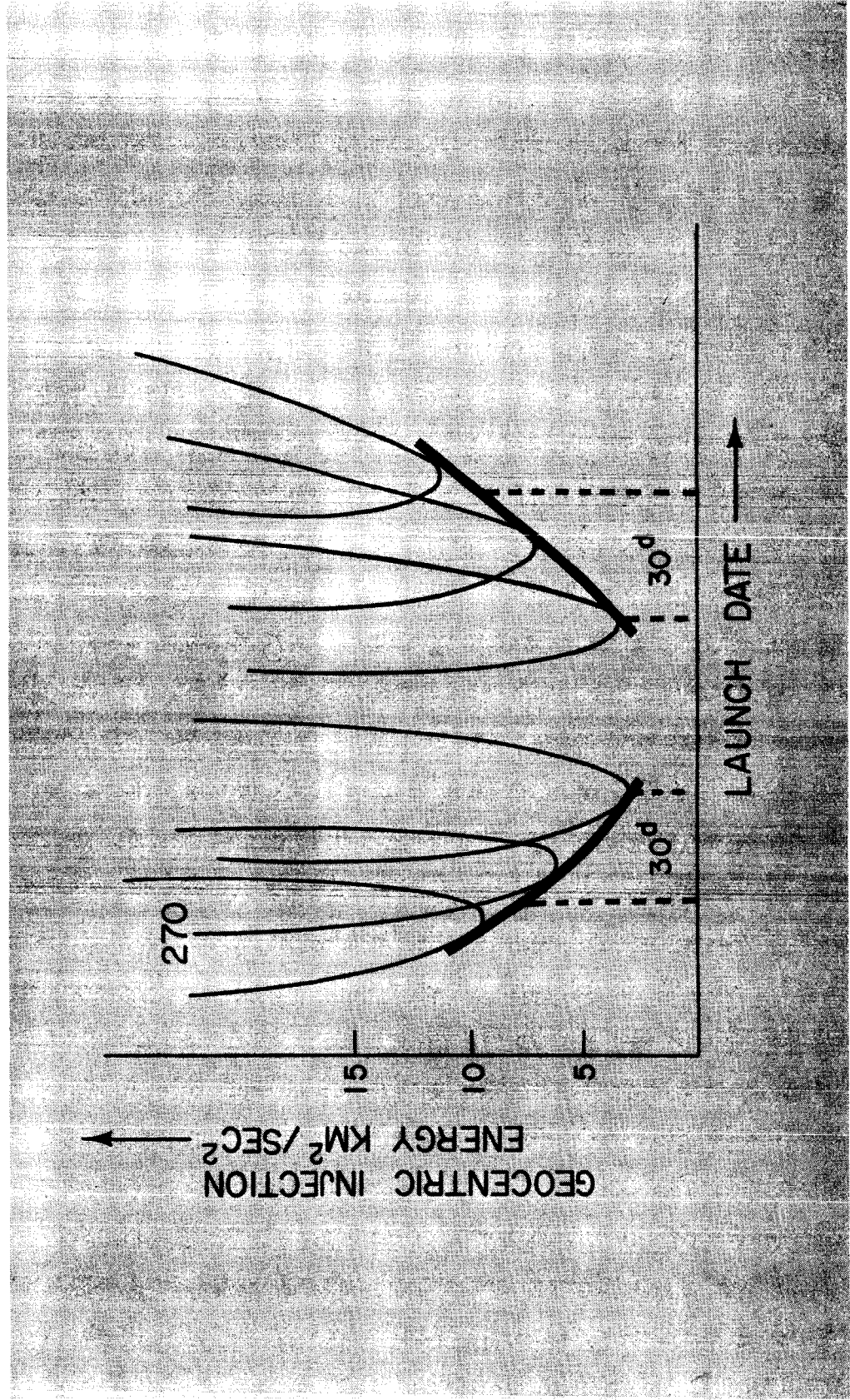
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PARKING ORBIT LAUNCH GEOMETRY



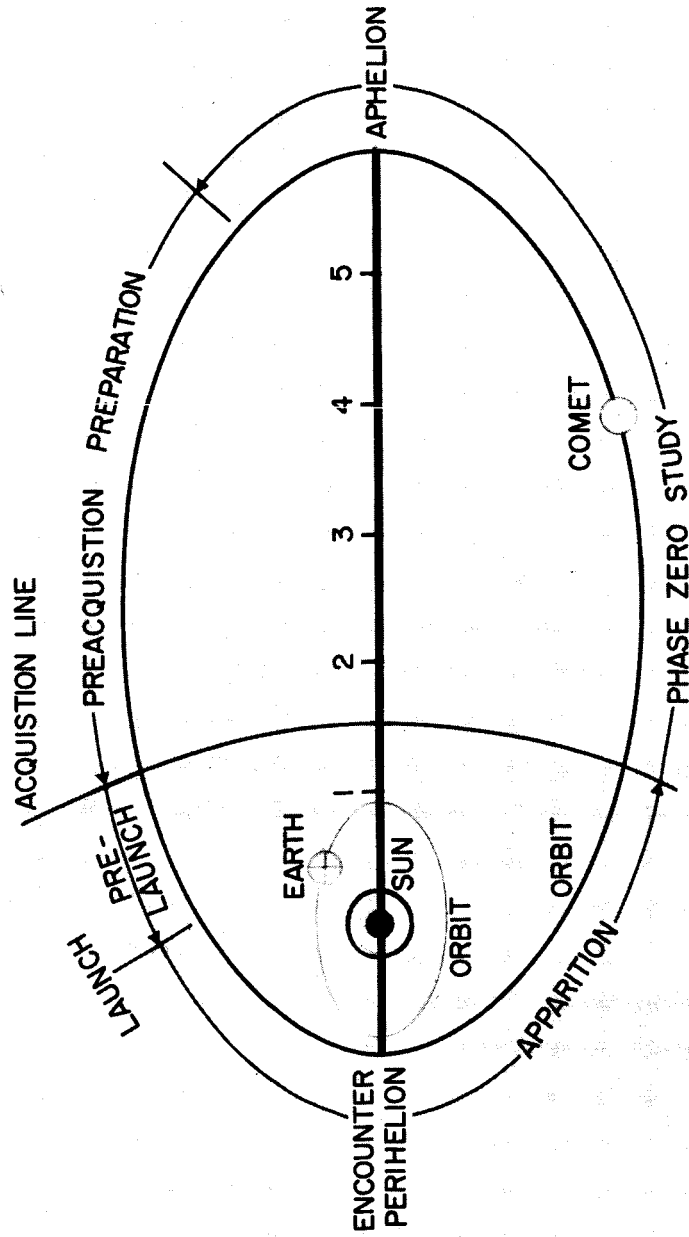
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PONS-WINNECKE 1969-1970



PHILCO: SCHEMATIC OF COMET MISSION EVENTS

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COMET COMET POSITIONAL UNCERTAINTIES AT PERIHELION

COMET	INITIAL ACQ UNCERTAINTY W/O ORBIT RE- FINEMENT	INITIAL ACQ UNCERTAINTY WITH ORBIT RE- FINEMENT	COMET UNCER- TAINTY AT TIME OF LAUNCH	COMET UNCERTAINTY AT TIME OF 1ST CORRECTION		COMET UNCERTAINTY AT TIME OF 2ND CORRECTION *		UNCER- TAINTY AT THE TIME OF ARRIVAL IN KM (4")*
				30 d AFTER INJECTION	60 d AFTER INJECTION	40d BEFORE ARRIVAL	20d BEFORE ARRIVAL	
TEMPEL(2)	1.5 ^d	1 ^h	10 ^m	4 ^m	3 ^m	4-8"	2-4"	1200
PONS- WINNECKE	4 ^d	3 ^h	30 ^m	10 ^m	7 ^m	4-8"	2-4"	1800
KOPFF	1 ^d	2 ^h	30 ^m	10 ^m	7 ^m	4-8"	2-4"	5300
BROOKS(2)	0.5 ^d	1 ^h	10 ^m	4 ^m	3 ^m	4-8"	2-4"	5800

* AS VIEWED FROM THE EARTH

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COMET RECOVERY TABLE

COMET	PREDICTED DATE OF RECOVERY	PREDICTED DATE OF LAUNCH	LEAD TIME (MONTHS)
TEMPEL (2)	JAN 10, 1967	APR 10, 1967	3
PONS-WINNECKE	DEC 1, 1969	JAN 31, 1970	2
KOPFF	DEC 15, 1969	FEB 1, 1970	1.5
TUTTLE-GIA.- KRESAK	JAN 6, 1973	OCT 5, 1972	-3
BROOKS (2)	MAY 4, 1973	MAY 4, 1973	0

MARINER-C COMPARISON

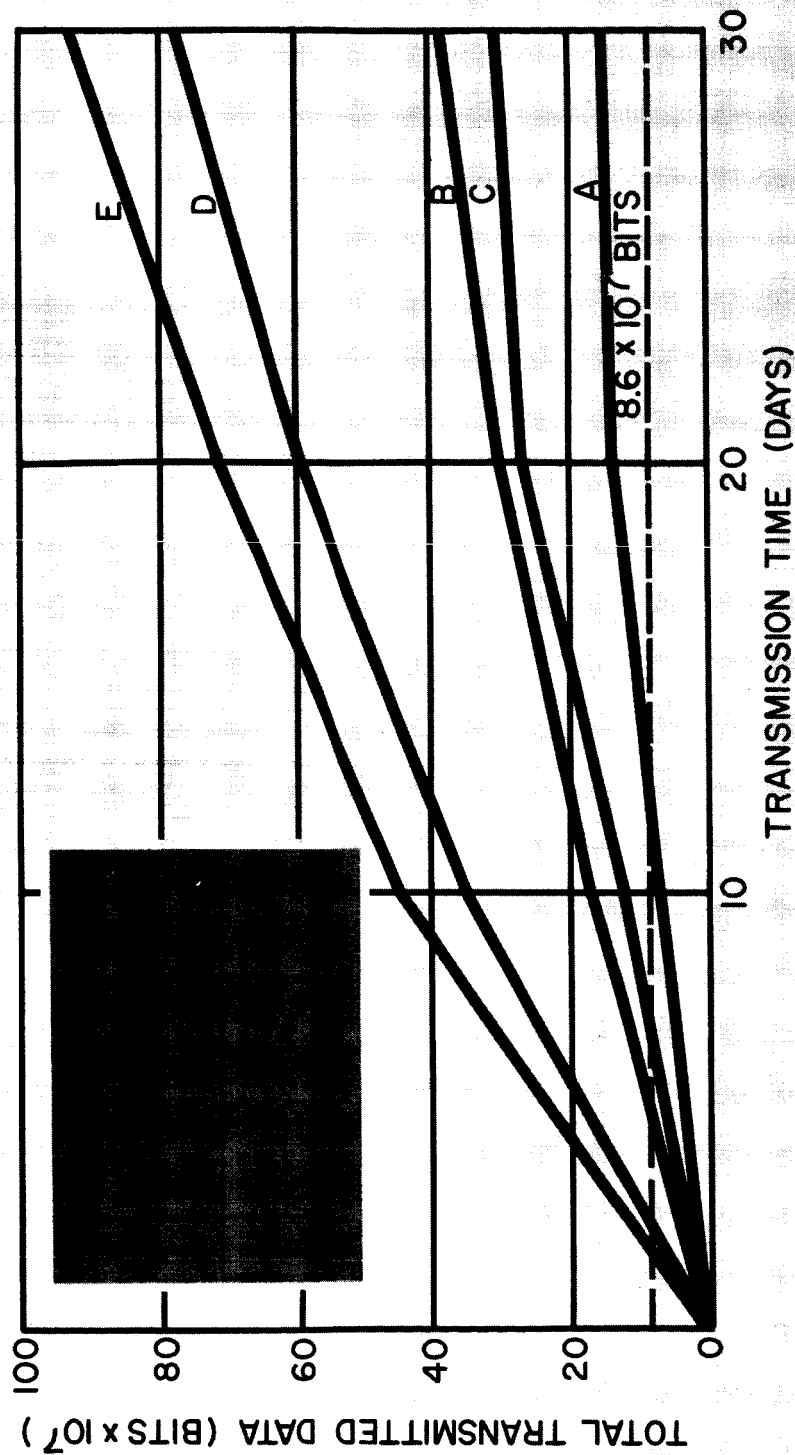
COMPARISON PARAMETER	MARS		PONS-W (I)	PONS-W (II)
INJECTION ENERGY $C3 \text{ KM}^2/\text{SEC}^2$ (30 DAY LAUNCH WINDOW)				
INJECTED PAYLOAD (LBS)				
TIME OF FLIGHT (DAYS)				
COMMUNICATION DISTANCE (MILLIONS OF KM)				
COMMUNICATION DATA RATE (BITS/SECOND)				
RELATIVE APPROACH VELOCITY (KM/SEC)				
MIDCOURSE VELOCITY REQUIREMENTS (M/S) (W/ PRERECOVERY STUDY)				
MINIMUM APPROACH DISTANCE (KM)				

TELECOMMUNICATION HARDWARE

COMPONENT	SOURCE
TRANSPONDER	MARINER-C
10 WATT POWER AMPLIFIER	MARINER-C
OPTIONAL 25 WATT POWER AMPLIFIER	NEW - AMPLITRON - RAYTHEON TWT - WATKINS-JOHNSON
4-FOOT ANTENNA	MARINER-C
RANGING MODULE	NEW
COMMAND DETECTOR	MARINER-C
COMMAND DECODER	MODIFIED MARINER-C
DATA ENCODING & STORAGE	MODIFIED MARINER-C
TAPE RECORDER	MODIFIED MARINER-C
PRE AMPLIFIER	NEW
OMNI ANTENNA	MODIFIED MARINER-C
COMPUTER SEQUENCER PROGRAMMER	MODIFIED MARINER-C

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TOTAL ENCOUNTER DATA RECOVERABLE FOR PONS-WINNECKE



COMET EXPERIMENTS

INSTRUMENT	WEIGHT
MAGNETOMETER	6.1
DUST DETECTORS (2)	2.3
PLASMA PROBE	7.0
ION COLLECTION TRAP (CENTRAL LAUNCH)	8.0
IONIZATION CHAMBER	2.6
G-M TUBE	2.1
ION-MASS SPECTROMETER	8.0
ULTRAVIOLET PHOTOMETERS (2)	3.0
UV PHOTOMETERS (2)	3.0
UV SPECTROMETER (CENTRAL LAUNCH)	22.0
TELEVISION (GALILEO TRAJECTORY)	35.0
TOTAL INSTRUMENTS:	99.1
BOOM TRACKING ASSY:	53
GLASS-CONTAINER TOTAL:	152

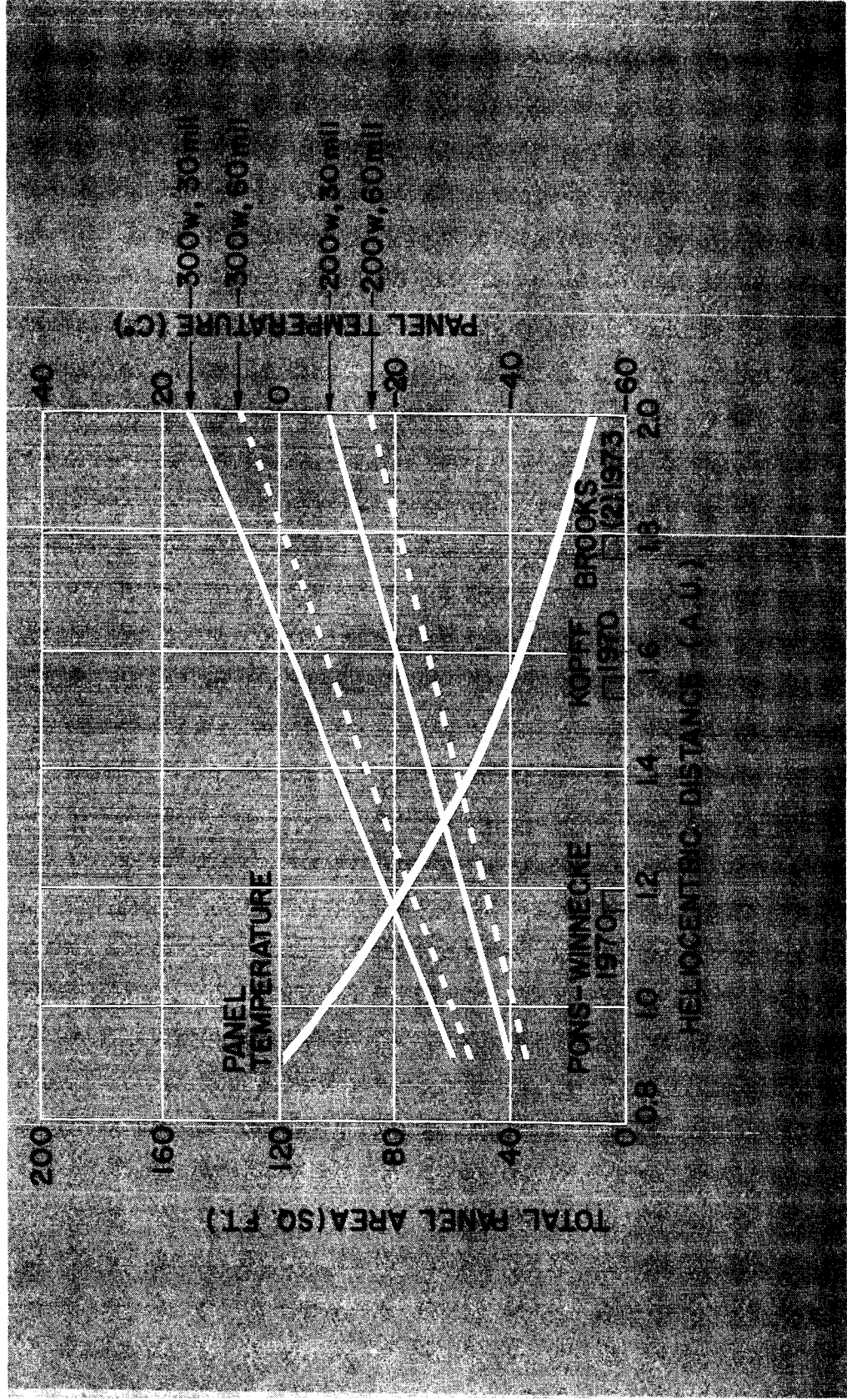
INSTRUMENT	WEIGHT
MAGN. FLD. $B \sim 0.2-0.02$ GAUSS	6.1
DUST DETECTORS $B \sim 0.02$ GAUSS	2.3
SOLAR PLASMA-COMET PLASMA INTERACTION	7.0
CHARGED-PARTICLE DISTRIBUTION	8.0
COSMIC-RAY SPECTRUM	2.6
TRAPPED - RADIATION	2.1
ION DENSITIES	8.0
HYDROGEN INDICATOR	3.0
EARTH-DETECTED SPECTRA (CN, C ₂ , CH)	3.0
AMBIGUOUS & PREDICTED SPECTRA (O ₂ , NH ₃)	22.0
SURFACE FEATURES	35.0
TOTAL INSTRUMENTS:	99.1
BOOM TRACKING ASSY:	53
GLASS-CONTAINER TOTAL:	152

ASTEROID EXPERIMENTS

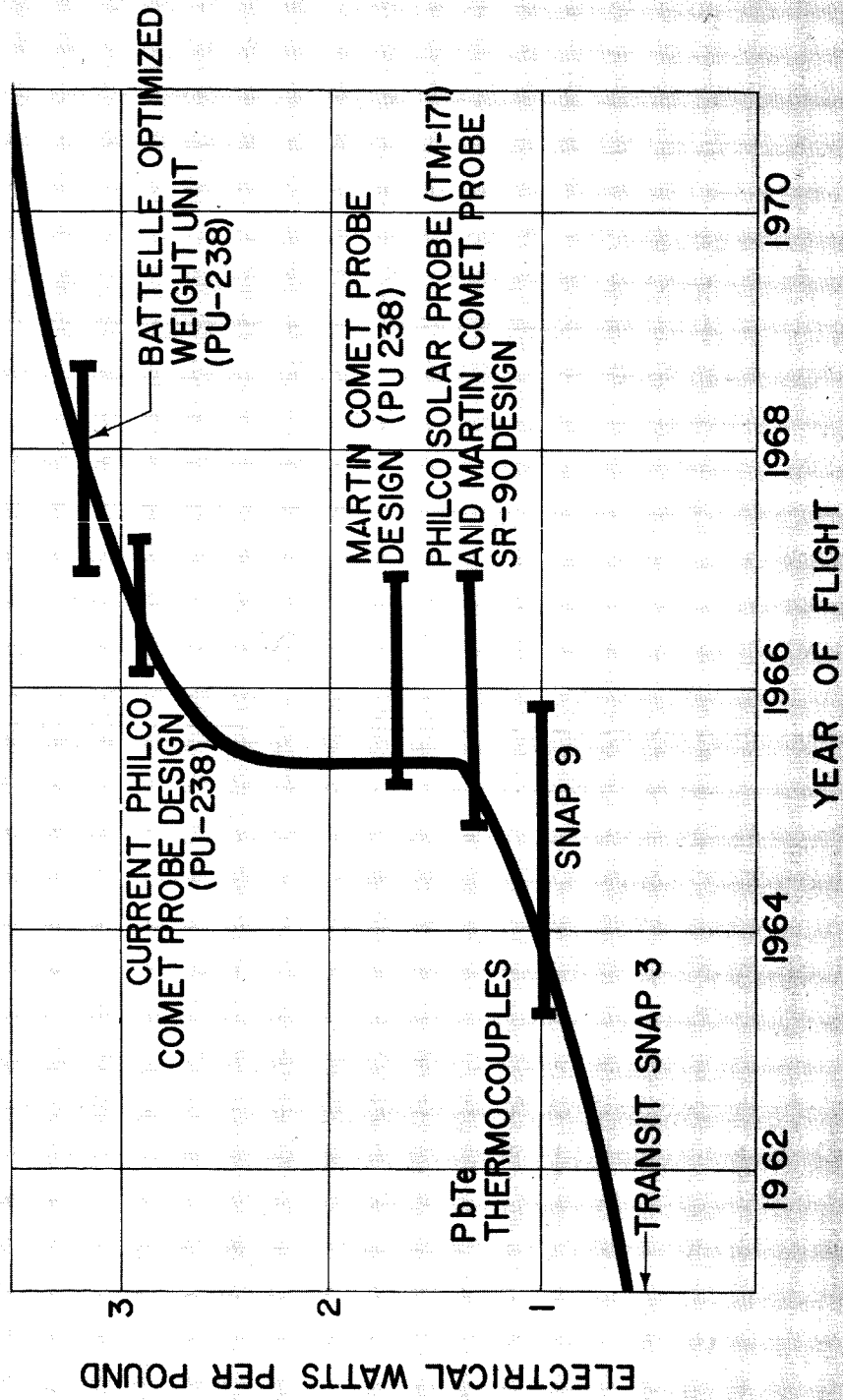
EXPERIMENT	OBJECTIVE	TECHNIQUE
VISUAL OBSERVATION	ASCERTAIN SHAPE, SIZE AND ROTATION	TV WITH COLOR FILTER
INFRARED RADIOMETRY	DETERMINE SURFACE TEMPERATURE	IR RADIOMETER
ULTRAVIOLET PHOTOMETRY	DETERMINE SURFACE EMISSIONS	UV PHOTOMETER (e.g. MARINER C)
MAGNETIC FIELD	MEASURE DIRECTION & INTENSITY	MAGNETOMETER (e.g. MARINER - C)
SHOT GUN	ANALYSE SURFACE COMPOSITION	SPECTROPHOTOMETER OBSERVATION ARTIFICIALLY CREATED DUST STORM

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TOTAL PANEL AREA VS. HELIOCENTRIC DISTANCE



RADIOISOTOPE THERMOELECTRIC POWER GENERATORS FOR SPACE VEHICLES



**MARINER-C COMET PROBE
ATLAS-AGENA LAUNCH**

SUBSYSTEM	
SCIENCE	
GUIDANCE & CONTROL	
PROPULSION	
TELECOMMUNICATION	
POWER	
THERMAL CONTROL	
STRUCTURE	
TOTAL WEIGHT	
RELATIVE MISSION VALUE	

COMET & CLOSE APPROACH ASTEROID STUDY ADAPTION OF MARINER C

USE ATLAS-AGENA TO PONS WINNECKE -1969

MARINER C MODIFICATIONS

REMOVE:

PLANET SCAN ASSEMBLY
TV ELECTRONICS
SCAN ELECTRONICS

-27 lbs.

ADD:

PIPS CAPABILITY TO 120 M/SEC
ION MASS SPECTROMETER
GIMBALLED COMET TRACKER
UV PHOTO METER

+50lbs

REVISE:

SOLAR PANELS TO REMOVE 15 FT²
DAS & CC&S LOGIC CIRCUITRY
NET CHANGE

-15 lbs.

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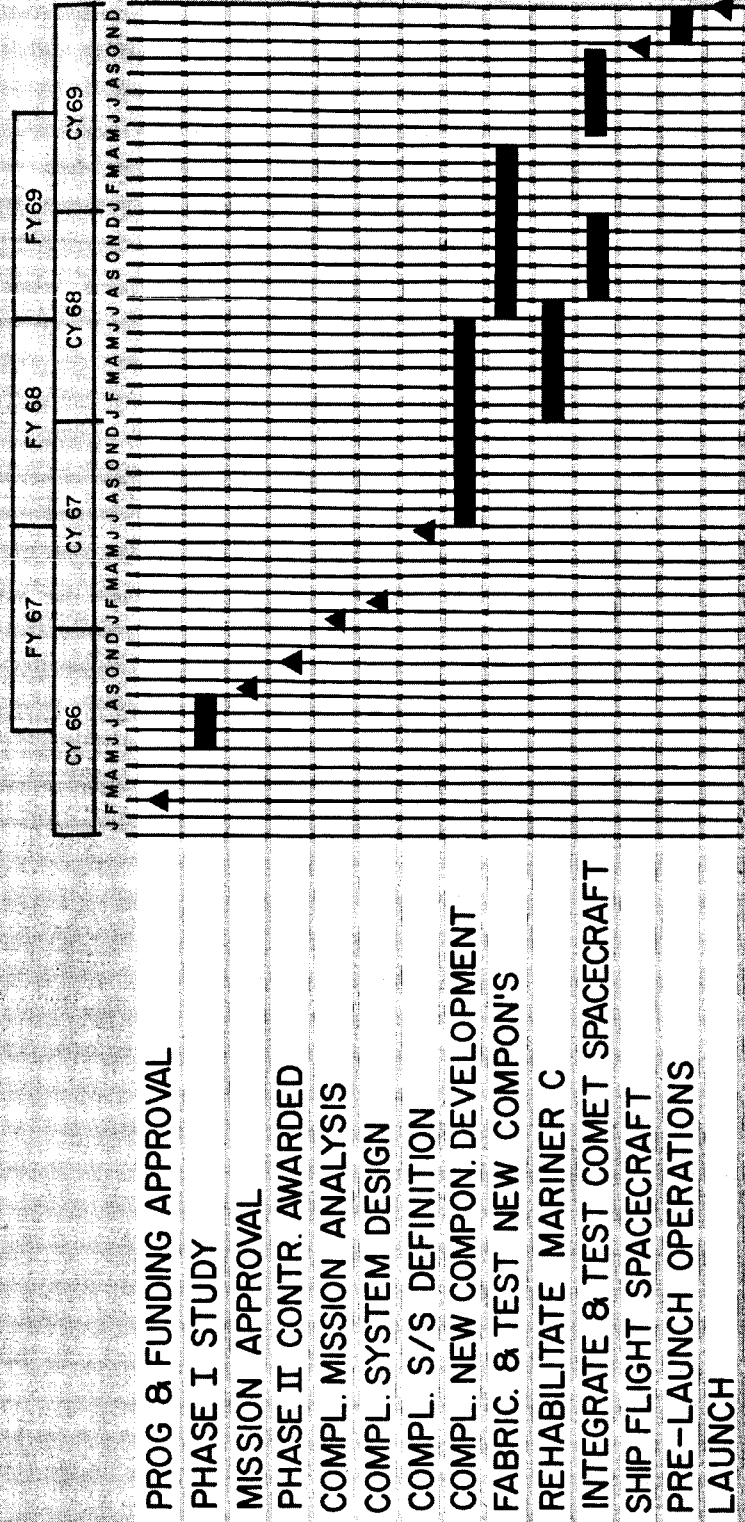
+8lbs.

ATLAS/CENTAUR COMET PROBE WEIGHT BREAKDOWN

SUBSYSTEM	PHOTOVOLTAIC CONFIGURATION	ISOTOPIIC CONFIGURATION
SCIENCE	152	152
GUIDANCE & CONTROL	80	80
PROPULSION	100	100
TELECOMMUNICATION	110	110
POWER	119	110
THERMAL CONTROL	30	30
STRUCTURE	110	110
TOTAL (200 w)	<u>701</u>	<u>692</u>

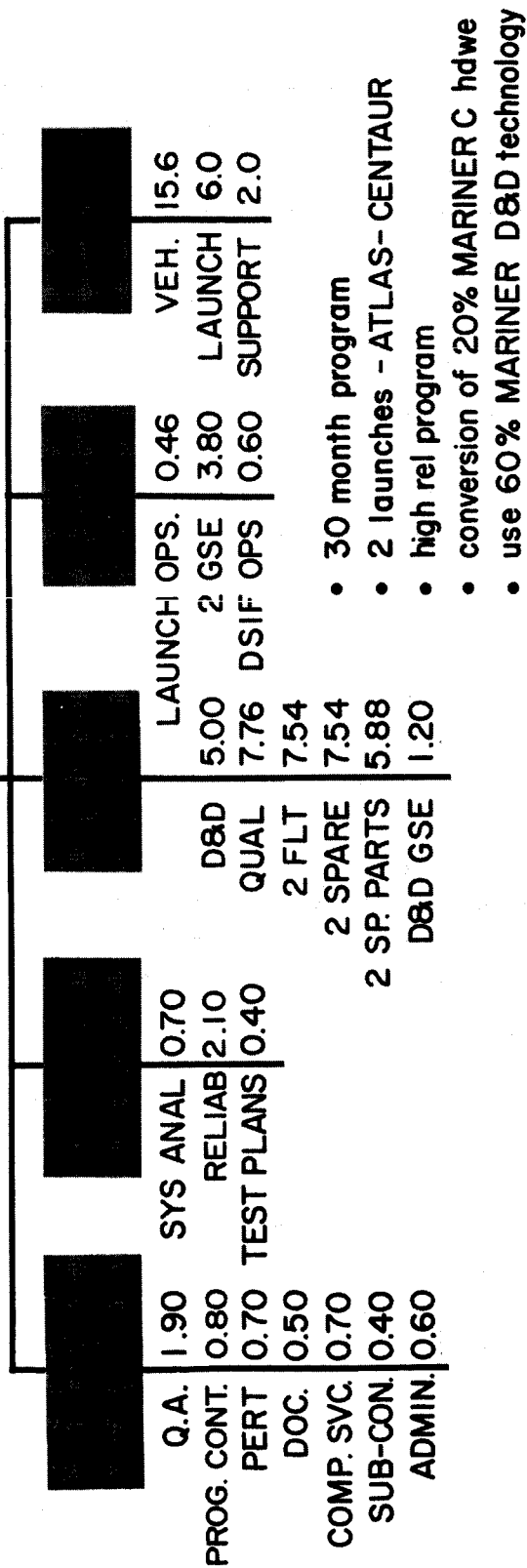


COMET & CLOSE APPROACH ASTEROID MISSION-MAJOR MILESTONES



COMET & CLOSE APPROACH ASTEROID PROBE
PROGRAM COSTS

\$ in Millions



COMET & CLOSE APPROACH ASTEROID STUDY ADAPTATION OF MARINER C-COSTS

GROUND RULES:	
REHABILITATE SPARE MARINER	
MINIMUM MODIFICATION - ONE SPACECRAFT	
ATLAS-AGENA LAUNCH	
PROGRAM START - 1ST QUARTER 1967	
SYSTEM ANALYSIS	\$50 K
RELIABILITY ANALYSIS	\$35 K
DESIGN & DEVELOP	
COMET TRACKER	\$100 K
SOLAR PANELS	\$25 K
REVISE SCIENCE INSTRUMENTS	\$50 K
REHABILITATE MARINER C	\$300 K
FABRICATE OR PURCHASE REVISED COMPONENTS	\$400 K
INTEGRATE REVISED COMPONENTS	\$60 K
CONDUCT ACCEPTANCE TEST	\$60 K
LAUNCH VEHICLE	\$7.8 M
LAUNCH SERVICES	\$1.3 M
PROGRAM MANAGEMENT	\$250 K
TOTAL PROGRAM COSTS	\$10.5 MILLION
ONE ADDITIONAL SPACECRAFT	\$1.8 M

COMET PROBE CONFIGURATION

