SECRET

X64-80215

NASA TMX 50787

Code 5A

GROUP (4)
DOWNGRADED AT 3 YEAR INTERVALS; DECLASSIFIED AFTER 12 YEARS.

SATURN REPORT

Restriction/Classification Cancelled

Available to N
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CLASS

TO = UNCLASSIF

By authority of E.O. No. 11652

Changed by O.J.G. Werkheiser Date 3/11/74

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CONFIDENTIAL

SATURN REPORT (U)

(NASA TMX 50787)

IV. Potential Missions for Saturn

*X64-80215 Code 5A

Introduction: Both the Department of Defense and NASA have clearly defined missions for the Saturn which cannot be performed by a lesser vehicle. In addition, many missions which can be marginally performed by less capable vehicles in the early years, will benefit greatly by use of the Saturn. Lastly, there are, no doubt, missions for the Saturn which cannot be clearly foreseen at this time but which will come to light in the normal course of events.

Although the Saturn need is well established, the selection of the upper stage configurations remains to be made. Among the many factors to be considered in such a selection, the mission requirements are among the most important and caution must be exercised in compromising the potential of the Saturn to meet these requirements for such expedients as somewhat faster and less expensive vehicle development schedules.

It is thus the purpose of this chapter to review for the reader the many Saturn applications of forseeable interest to the Department of Defense and NASA. Having done this, the relative priorities of the missions will be discussed and the relatively high priority missions will be incorporated into a suggested launch schedule. Other NASA projects leading into and supporting the Saturn projects will be indicated. A funding plan based on the Saturn launch schedule will then be developed for the spacecraft and payloads involved.

The chapter will conclude with a discussion of the constraints placed upon the Saturn configuration by the missions and payloads.

NASA Missions and Payloads for Saturn:

The possible NASA missions for Saturn may be indicated by their payloads as follows:

Earth Satellite Missions

Unmanned

Scientific:

1. Orbiting telescope (24-hour orbit)

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This document consists of 68 pages
No. 10 of 26 Copies, Series A

Applications:

1. Combined communications and meteorological satellite (24-hour orbit)

Technological:

1. Engineering test satellite - general materials and component tests (recoverable)

2. Nuclear electric system test satellite (SNAP VIII plus electric propulsion)

3. Nuclear rocket test satellite

Manned

Laboratories:

1. Semi-permanent (preassembled)

2. Permanent space station (assembled in orbit)

Flight tests:

1. Lunar circumnavigation spacecraft

2. Lunar landing spacecraft

Staging:

1. Lunar landing spacecraft and supporting tankers

Lunar Missions

Unmanned

1. Lunar landing spacecraft

Manned

1. Circumnavigation and reentry spacecraft (preceded by unmanned flights of this vehicle)

2. Landing and return spacecraft (assembled in orbit)

Planetary and Other Missions

Unmanned

1. Orbiting spacecraft

2. Landing spacecraft

3. Solar probe

Priorities of NASA Missions:

Development of a NASA program necessarily implies an assignment of priorities to the above listed missions. Many factors must be considered in arriving at a priority list, such as:

1. Desirability of mission

   a. Scientific

   b. Psychopolitical

2. Suitability of mission to evolutionary development of vehicle and spacecraft.

3. Engineering feasibility

4. Cost

5. Timing and lead times

6. Need for Saturn as opposed to lesser vehicle

These factors have been evaluated only qualitatively in arriving at the following priority list. This listing should be interpreted to indicate generally the order in which NASA might undertake to develop the equipment required for the indicated Saturn missions, budget permitting.

Group I

1. Manned lunar circumnavigation

2. Unmanned lunar landing

Group II

1. Planetary orbiter

2. Planetary landing

3. Communication and meteorological satellite

4. Nuclear rocket test

5. Manned laboratory (semi-permanent)

6. Manned lunar landing

   a. Spacecraft and tankers

7. Solar probe

Group III

1. Nuclear electric test satellite

2. Engineering test satellite

3. Orbiting telescope

4. Permanent space station

The Group I missions are considered to have top priority within NASA. Manned lunar circumnavigation represents the next logical milestone of manned space flight and a natural prelude to manned lunar landing. The unmanned lunar landing is not only of great scientific interest but plays a vital role in the development of manned lunar landings. Although the Centaur should be quite useful on this mission, careful exploration of a landing area by a mobile vehicle will require the Saturn.

The scientific experiments involved in the landing mission include:

1. Local lunar topography

2. Lunar mapping and cartography

3. Seismic investigations

4. Magnetic field measurements

5. Lunar tides

6. Surface thermal conductivity

7. Surface chemical analysis

8. Atmospheric measurements

The Group II missions are all important to the nation and should all be completed if funding permits. The temptation to concentrate on the manned lunar landing at the cost of eliminating the other missions should be rejected. The landing effort is so great that the amount it would benefit by such a step would be relatively insignificant compared to the scientific and technological loss resulting from such a narrow program.

The Group III missions can, with the exception of the telescope and the permanent space station, be adequately handled with theCentaur for the time period under discussion. The telescope mission, advocated by the NSF, is currently of small interest to NASA. The permanent space station is currently of small interest in this time period.

<u>Description of Missions and Payloads:</u>

The following pages contain descriptions of nearly all of the payloads and missions listed above. The design approach does not in all cases represent the current NASA thinking, but is sufficiently representative to provide a feel for the problems involved.

1. PAYLOAD - Manned Lunar Circumnavigation

2. MISSION OBJECTIVES

   a. PURPOSE - To demonstrate manned lunar flight and obtain detailed optical survey of lunar surface.

   b. INSTRUMENTATION - High definition cameras, high defintion TV, voice communication, and celestial-inertial guidance backed by earth command guidance and pilot control.

   c. SUBSYSTEMS - Environmental control, inertial guidance system, pilot control system, and re-entry body.

   d. POTENTIAL USER - NASA

3. TRAJECTORY SEQUENCE - Standard escape velocity launch with midcourse, lunar vicinity and return maneuvers. 150 hours flight time. Steep angle re-entry using ablation heat control and very high angle of attack for high drag - high lift control of g forces. Glide maneuver selection of landing point. Parachute or skid landing.

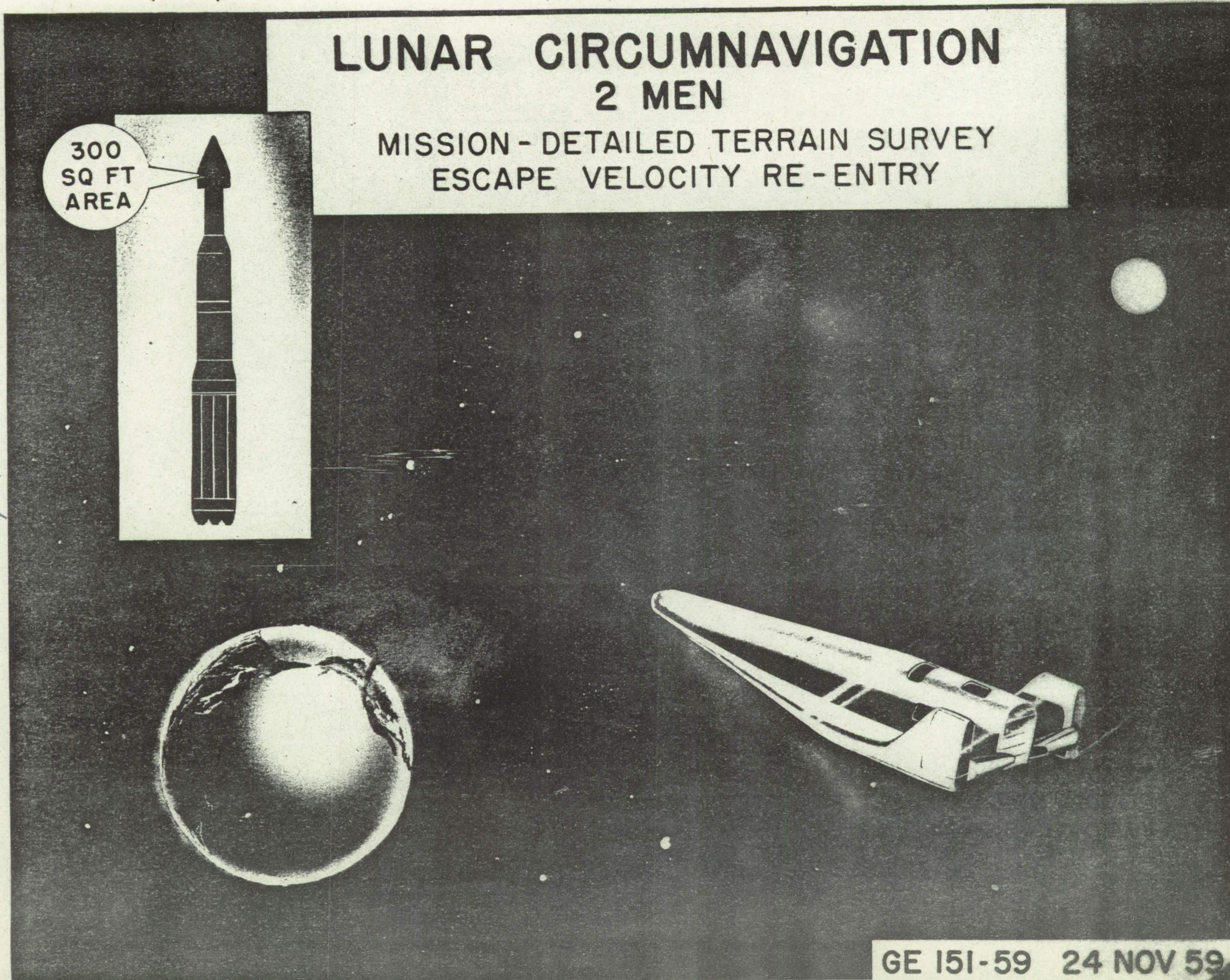
4. WEIGHT AND DIMENSIONS -

B-1 -	12,000 pounds	Adequate 2 man vehicle
B -	8,400 pounds	Marginal 1 man vehicle

5. FUNDING ESTIMATE - $200 to $300 million for development

6. LEAD TIME - 3 to 4 years starting in FY 1963

7. GROWTH POTENTIAL - Up to 34,000 pounds with SATURN C. Same re-entry capsule can be used for manned lunar soft landing.


LUNAR CIRCUMNAVIGATION
2 MEN
MISSION - DETAILED TERRAIN SURVEY
ESCAPE VELOCITY RE-ENTRY
300
SQ FT
AREA
GE 151-59 24 NOV 59

1. PAYLOAD - Instrumented Lunar Soft Landing Vehicle

2. MISSION OBJECTIVES

   a. PURPOSE - To place stationary and roving instrumented packages on the lunar surface.

   b. INSTRUMENTATION - Structure and selenolographic features, atmosphere, temperature, biomedical effects, and local features for manned flights.

   c. SUBSYSTEMS - Auxiliary power supply (solar cells plus battery), communications, braking propulsion, attitude control, terminal guidance.

   d. POTENTIAL USERS - NASA.

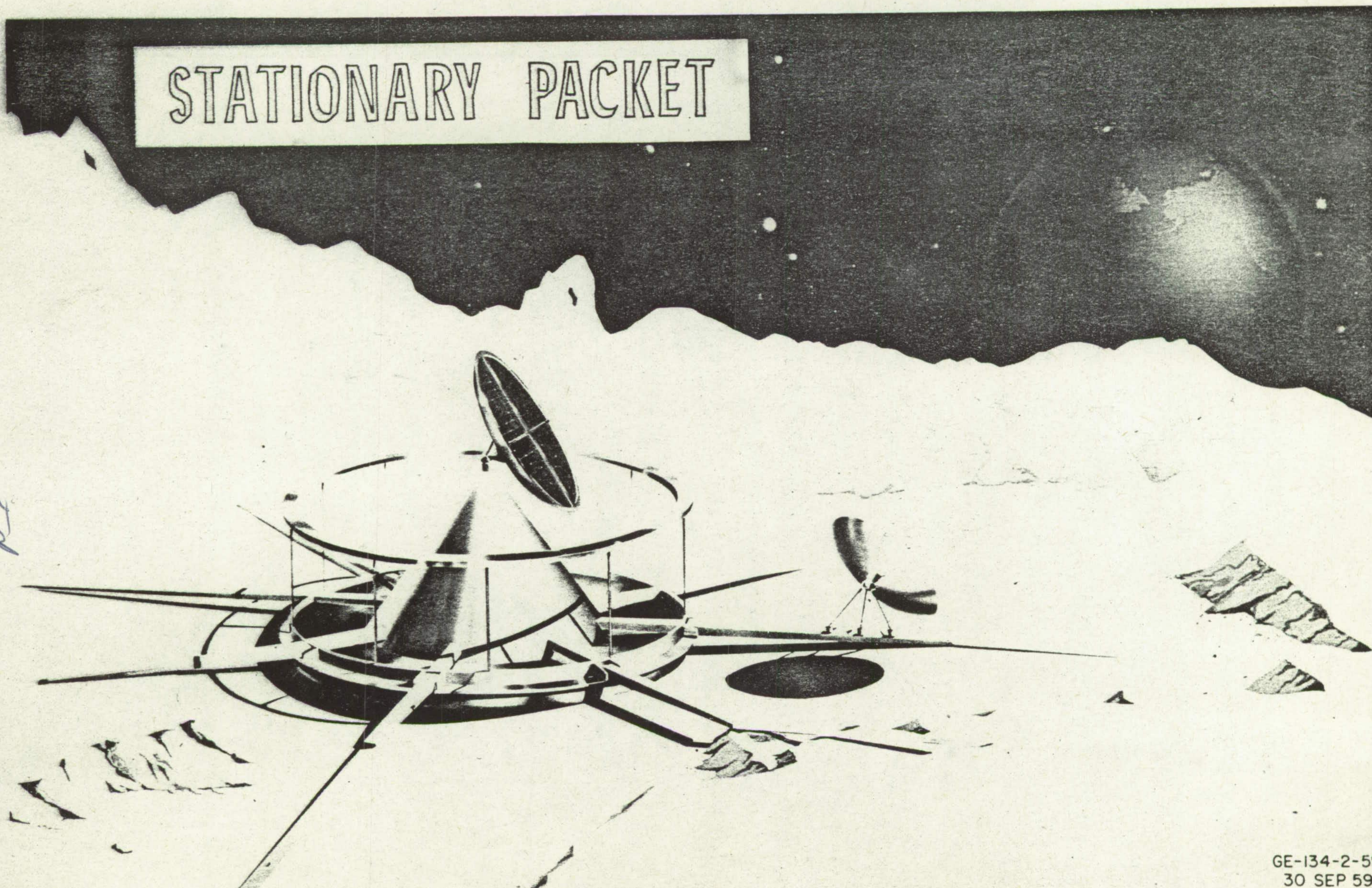
3. TRAJECTORY - 58-hour transfer, east launch from PAFB, vernier injection phase, midcourse correction by radio inertial, TV terminal phase. Lifetime of one lunar day and night for SATURN B and 2 or more lunar days and nights for SATURN B-1.

4. WEIGHT AND DIMENSIONS - SATURN B - 2600 pounds and 120 inches in diameter, cone configuration. SATURN B-1 - 3900 pounds and 120 inches in diameter by 10 feet long.

5. FUNDING ESTIMATE - $80 to $120 million for 4 packages.

6. LEAD TIME - 3½ years starting in FY 1961.

7. GROWTH POTENTIAL - Use of nuclear third stage doubles B-1 payload increasing lifetime or payload sophistication.



GE-134-2-59
30 SEP 59

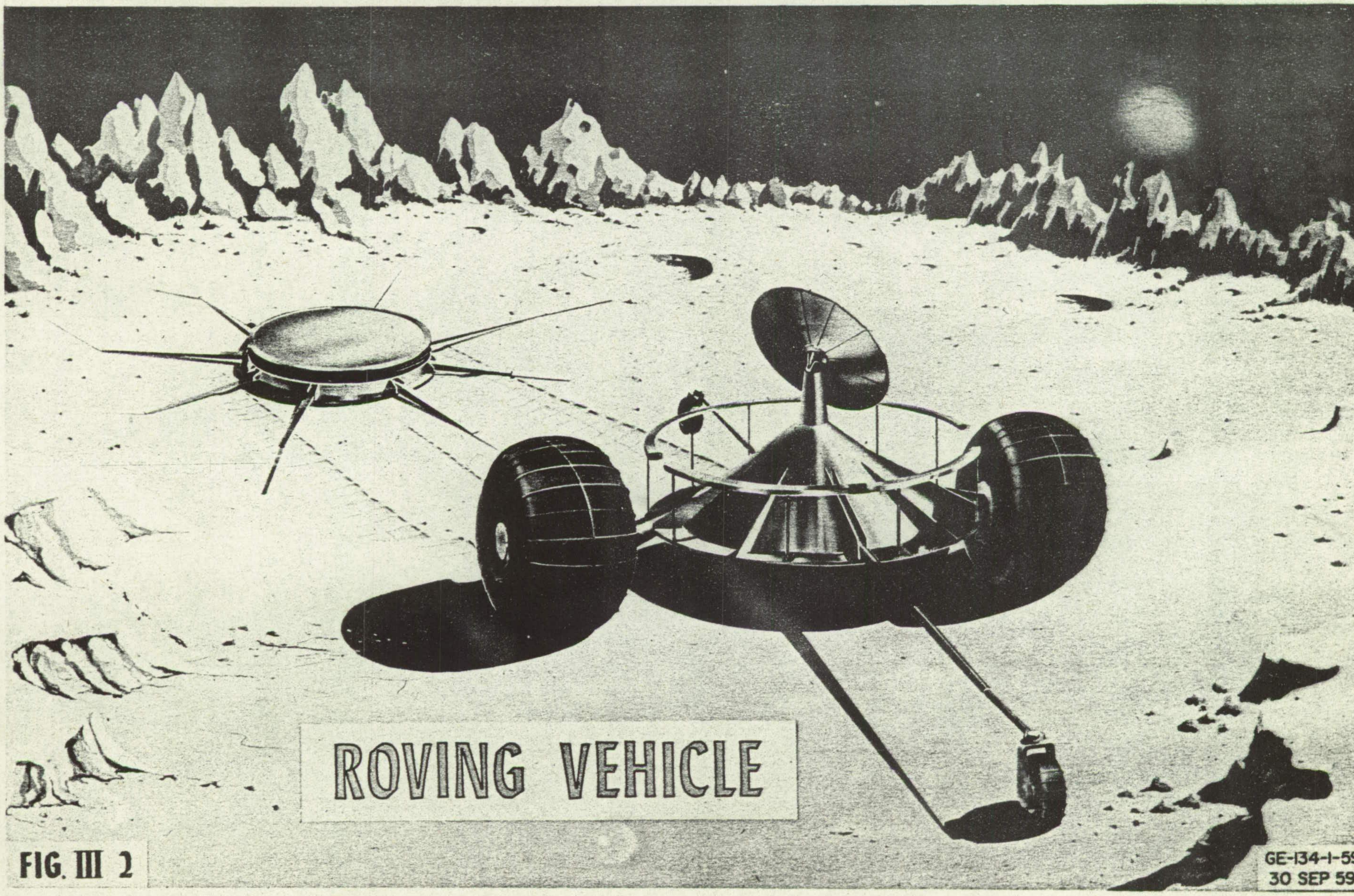


FIG. III 2

1. PAYLOAD - Martian (Venusian) Satellite

2. MISSION OBJECTIVES

   a. PURPOSE - To orbit the planets with a satellite containing several instrumented probes for atmosphere and surface study.

   b. INSTRUMENTATION - Photographic and TV coverage and typical radiation, temperature, atmospheric, etc., measuring instruments.

   c. SUBSYSTEMS - Auxiliary power (solar plus battery), attitude control, braking propulsion communications, radio link, and probes to be ejected (complete entry body with parachute deceleration).

   d. POTENTIAL USER - NASA.

3. TRAJECTORY - Near minimum energy transfer (Hohmann, elliptical) with flight time up to 260 days (146 days to Venus). Rocket braking for establishing orbit at 1000 Km. One year lifetime as satellite for SATURN B-1, 3 months for SATURN B.

4. PAYLOAD WEIGHT -

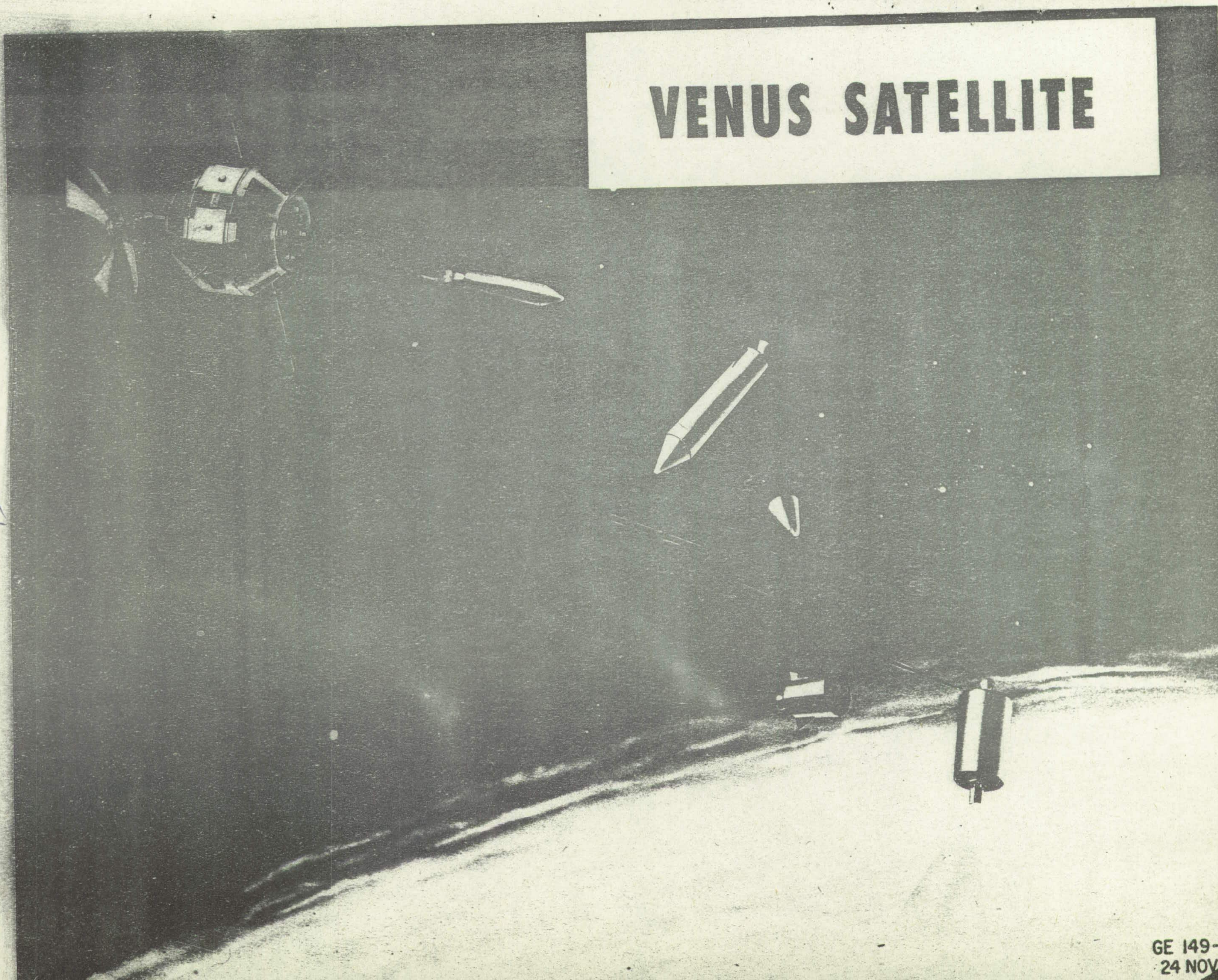
SATURN B -	Mars	933 pounds
	Venus	225 pounds
SATURN B-1	Mars	2365 pounds
	Venus	945 pounds

5. FUNDING ESTIMATE - $20 to $30 million for development and two packages

6. LEAD TIME - 2½ years starting in FY 1962

7. GROWTH POTENTIAL - Payload will approximately double with nuclear third stage on SATURN B-1.


MARS SATELLITE
GE 148-59 24 NOV 59


VENUS SATELLITE
GE 149-5
24 NOV

1. PAYLOAD - Martian (Venusian) Soft Landing

2. MISSION OBJECTIVES

   a. PURPOSE - To place instrumented package on the planet surface.

   b. INSTRUMENTATION - TV and camera coverage, sophisticated atmospheric, radiation, environmental, biological, etc., experimentation and analysis.

   c. SUBSYSTEMS - Auxillary power supply (solar plus battery) communications, radio link to satellites, and entry and soft landing system.

   d. POTENTIAL USERS - NASA.

3. TRAJECTORY - Near minimum energy transfer, flight time of 260 days (140 days for Venus), aerodynamic braking, near ballistic entry, parachute landing. Minimum lifetime of 1 year (3 to 6 months on Venus).

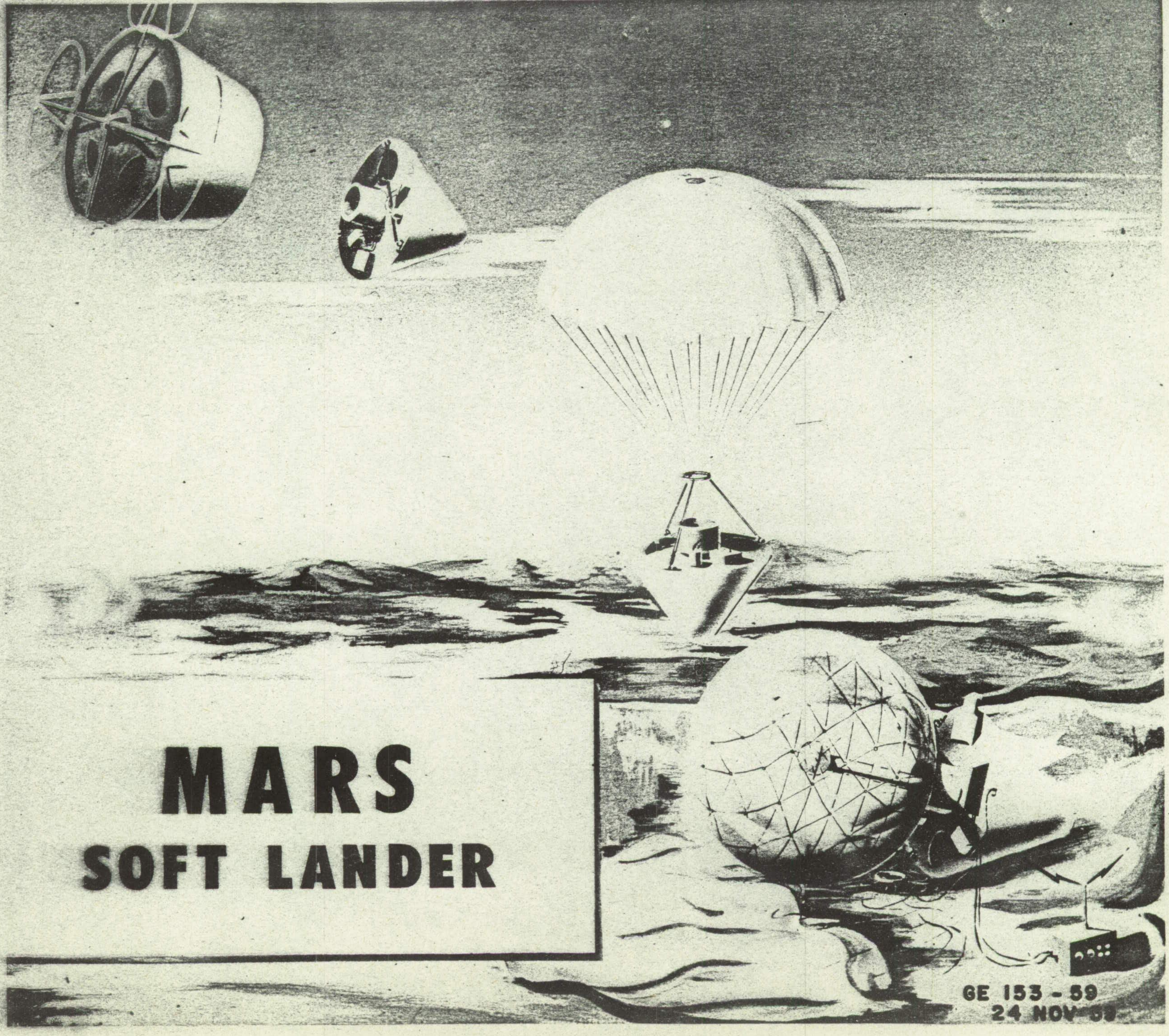
4. PAYLOAD WEIGHT -

SATURN B	Mars	1435 pounds
	Venus	1350 pounds
SATURN B-1	Mars	3400 pounds
	Venus	2830 pounds

5. FUNDING ESTIMATE - $50 to $75 million for development.

6. LEAD TIME - 3 years starting in FY 1963 (Venus) and FY 1964 (Mars).

7. GROWTH POTENTIAL - More sophisticated payload with longer lifetime and weights up to 10,000 pounds with nuclear third stage.


MARS
SOFT LANDER
GE 153 - 59
24 NOV 59

1. PAYLOAD - 24-Hour Communication Satellite

2. MISSION OBJECTIVES

   a. PURPOSE - Active real-time repeater for the long-range link of a global communications system.

   b. INSTRUMENTATION - Wideband (100 mcps) linear microwave amplifiers, four narrow-beam (1°) tracking antennas, option of high information rates or high jam-resistance, redundant equipment for added reliability, and one year minimum operational life.

   c. SUBSYSTEMS - Position and attitude control (both to +2°), telemetering, tracking and command systems, solar power supply (1 KW), and structural and thermal design for launch and orbit.

   d. POTENTIAL USERS - Military, civilian, and commercial.

3. TRAJECTORY AND SEQUENCE - Launch from AMR into any longitudinal position in an equational, circular synchronous orbit (24-hour orbit) using inertial injection guidance. Fine position control with radio tracking and command.

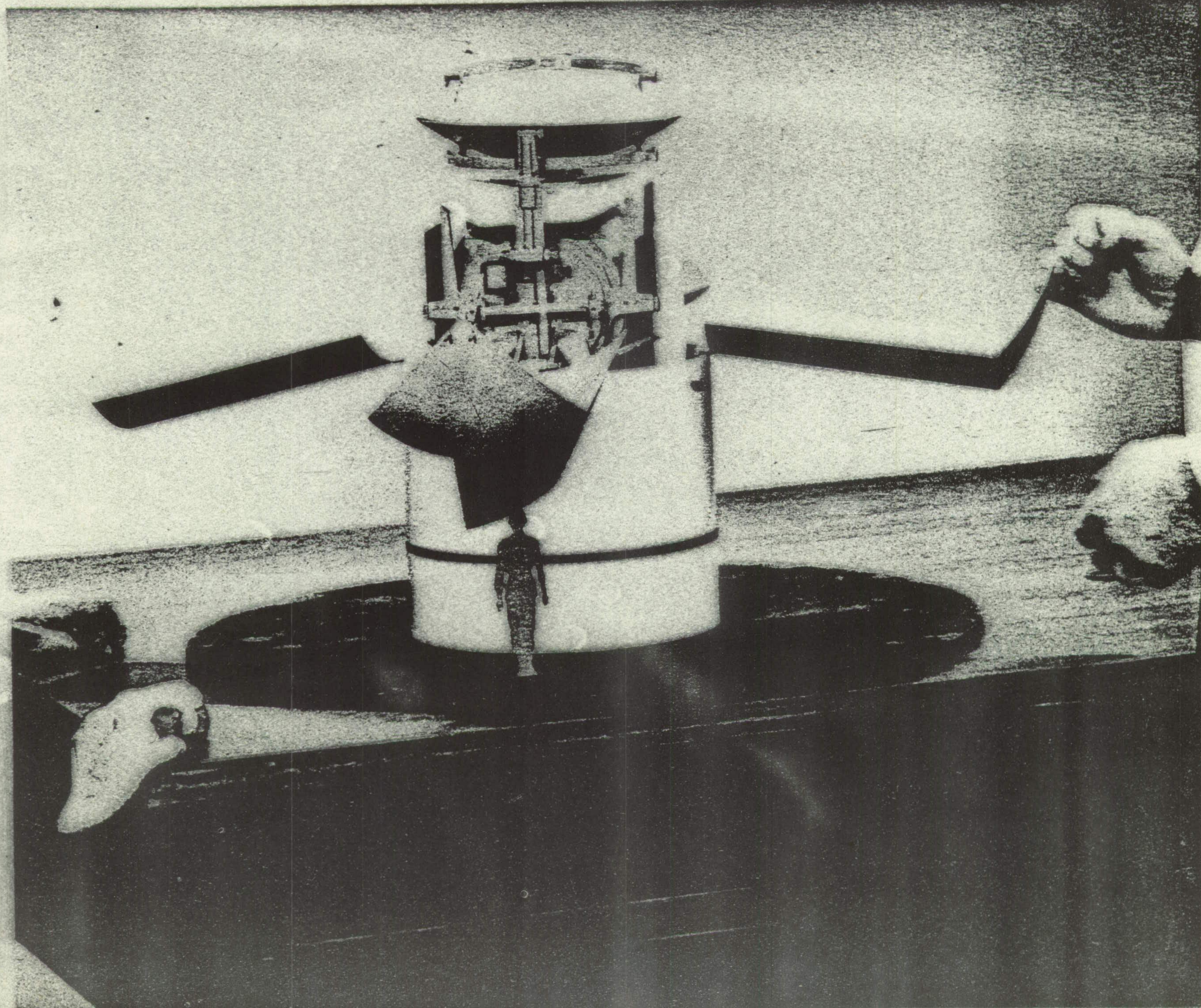
4. PAYLOAD WEIGHT (with SATURN B; payload diameter - 120 inches)

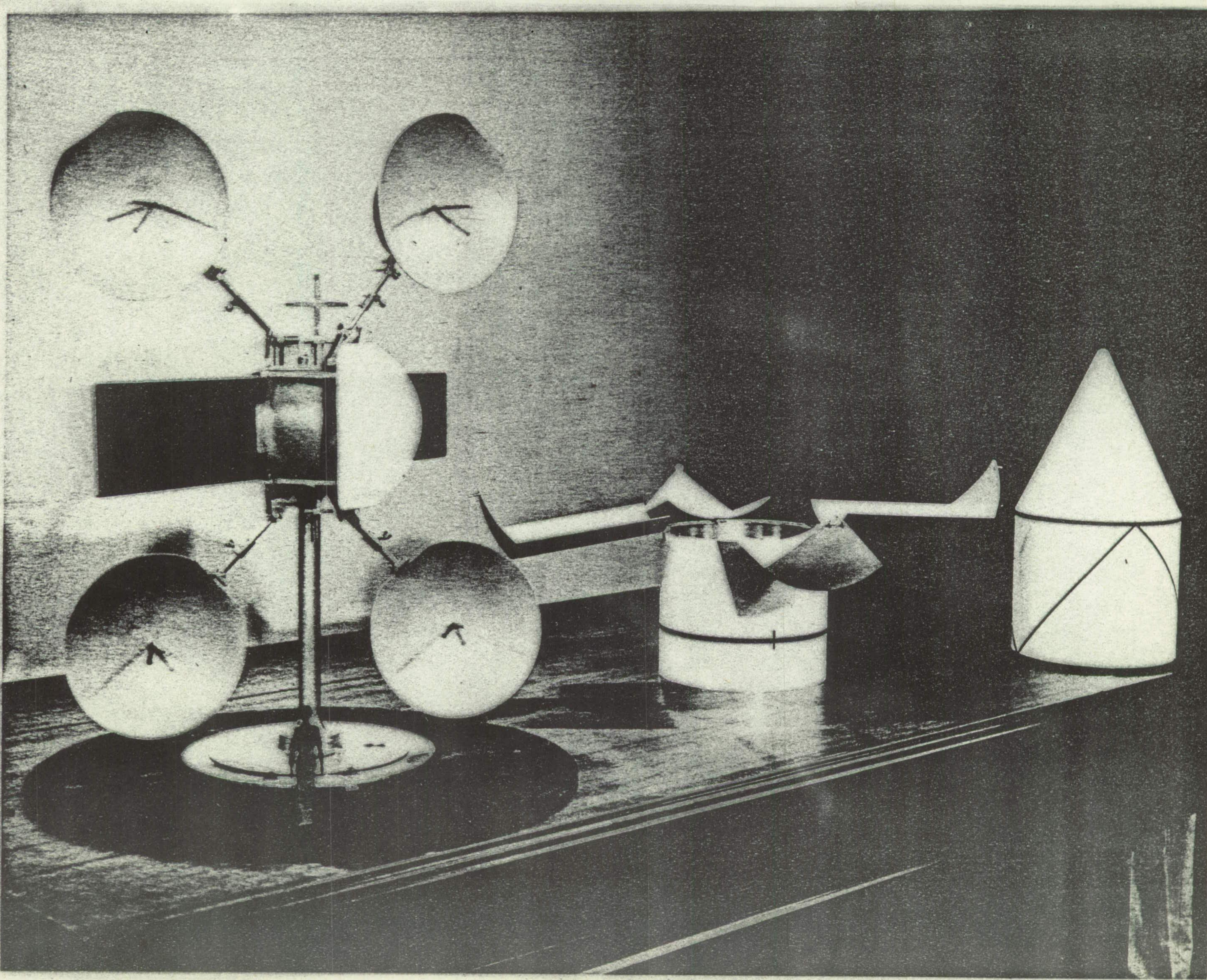
Satellite	3, 500 pounds
Interface and protection	1, 000 pounds
TOTAL	4, 500 pounds

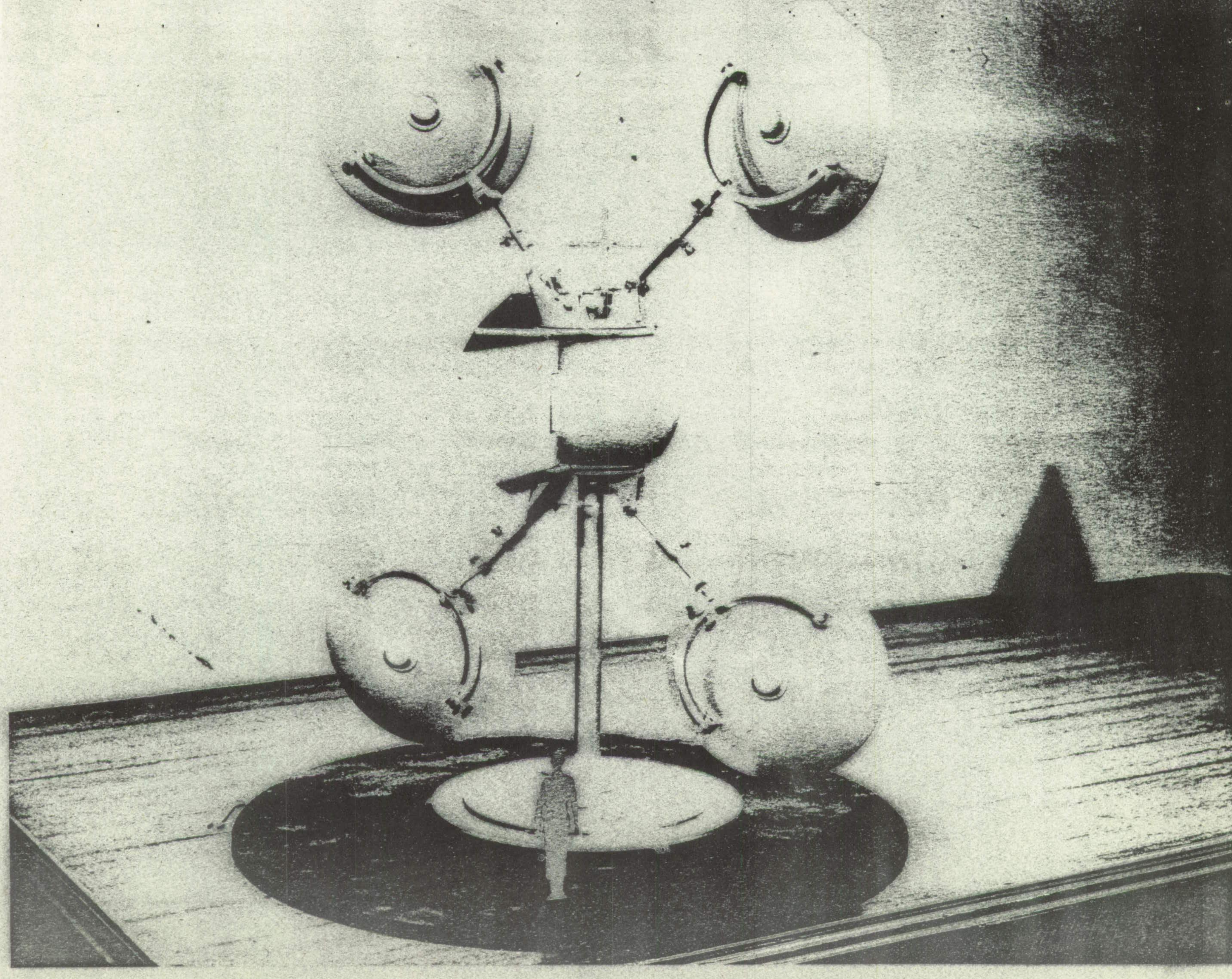
5. FUNDING ESTIMATE - R&D, 3 ground sites, hardware for 10 launchings $150 million (No vehicle cost).

6. LEAD TIME - About 4 years, earliest launch March 1964.

7. GROWTH POTENTIAL - A low cost, long-range communications system with higher information rates and longer operational life resulting from the larger payload capabilities of SATURN C and future subsystem developments.







1. PAYLOAD - Nuclear Propulsion Test Vehicle

2. MISSION OBJECTIVE

   a. PURPOSE - To conduct a feasibility flight test demonstration of a nuclear rocket propulsion (ROVER) system in a remote space environmental site.

   b. INSTRUMENTATION - General nuclear rocket test instrumentation and orbit to earth telemetry.

   c. SUBSYSTEMS - Reactor, reactor control system, hydrogen turbopump and turbine drive system, propellant flow control equipment, radiation shields.

   d. POTENTIAL USERS - NASA, AEC, and military

3. TRAJECTORY AND ORBIT - Standard ascent trajectory to any low altitude semipermanent earth orbit. Standard three-stage chemical vehicle for delivery of nuclear test stage into orbit. Permanent orbit is achieved after firing of nuclear stage.

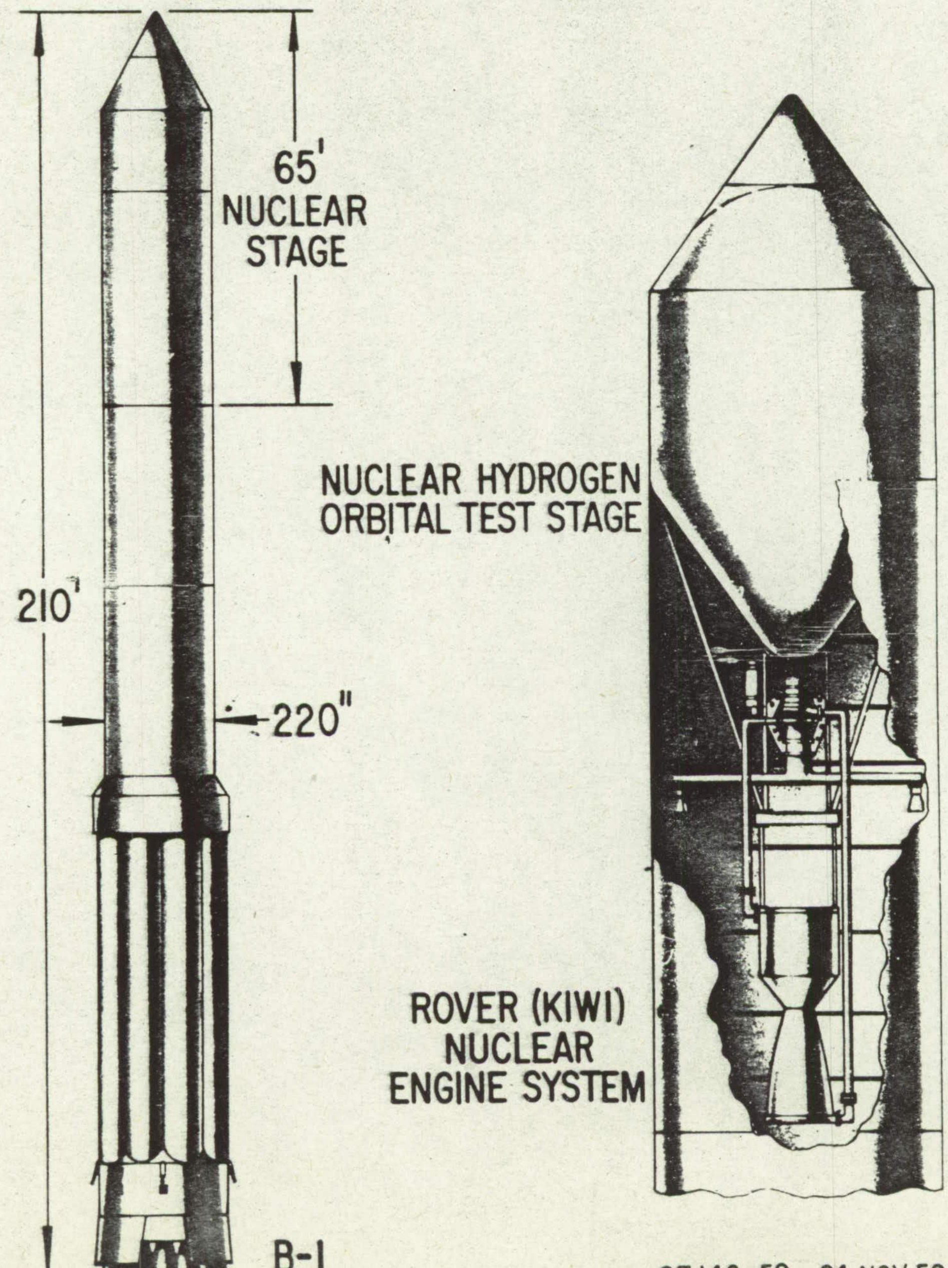
4. WEIGHT AND DIMENSIONS - 35,000 to 40,000 pounds, 220-inch cylindrical section, 60 to 70 feet in length

5. FUNDING ESTIMATE - Funded under the AEC-NASA ROVER Program

6. LEAD TIME - 5 years

7. GROWTH POTENTIAL - The nuclear stage when used as the SATURN third stage approximately doubles the SATURN chemical payload capability

SATURN NUCLEAR PROPULSION ORBITAL TEST VEHICLE



B-1

GE 146-59 24 NOV 59

1. PAYLOAD - Manned Orbital Laboratory

2. MISSION OBJECTIVE

   a. PURPOSE - Experimental laboratory for: material testing, component testing, subsystem testing (ion-propulsion, plasma-propulsion, communication, etc.), biomedical research, and other scientific and engineering research

   b. INSTRUMENTATION - General laboratory equipment and living quarters for 6 men

   c. SUBSYSTEMS - Non-propulsion power plant, rocket engine, laboratory and control room, living quarters and equipment, and return capsule

   d. POTENTIAL USER - NASA

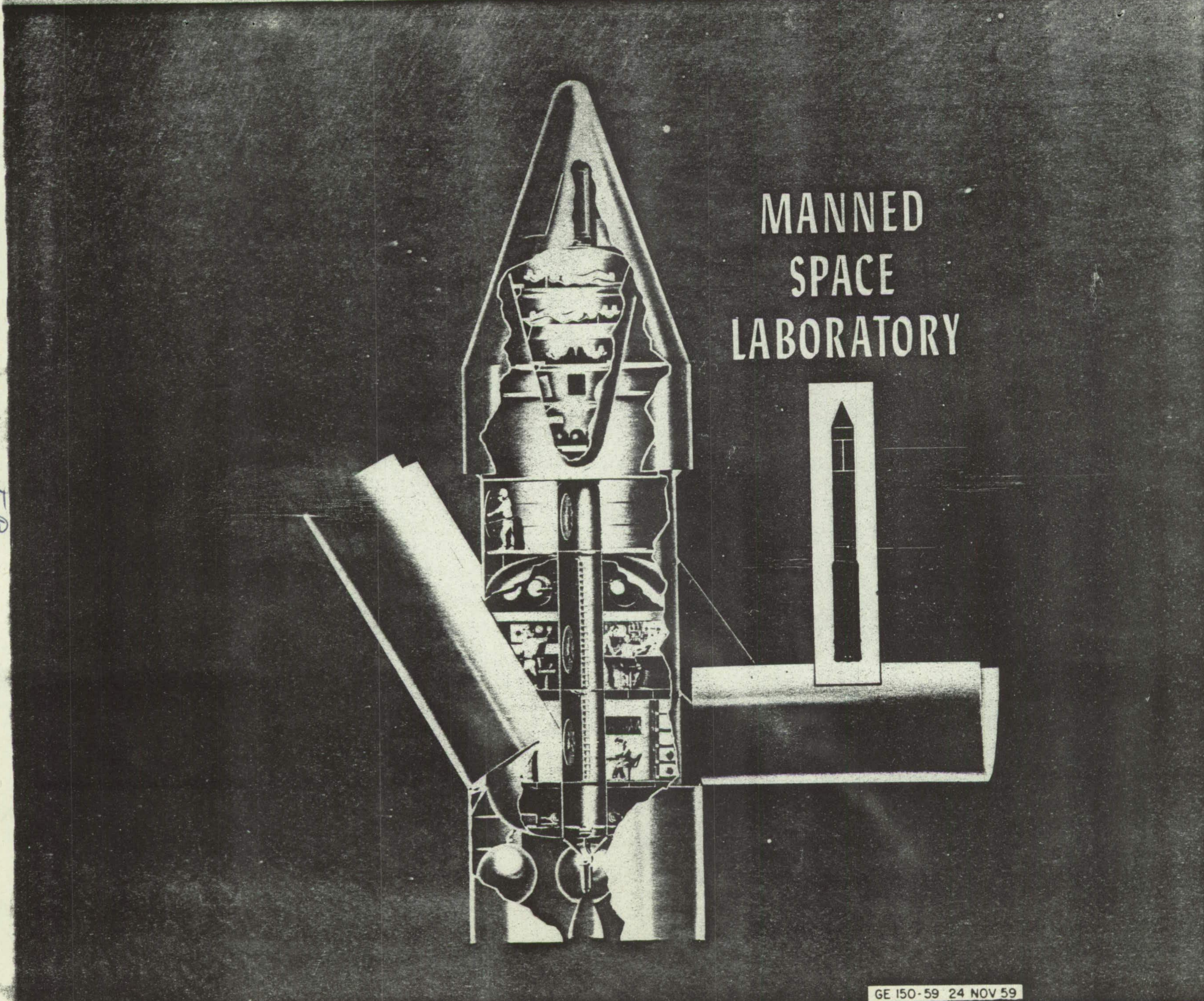
3. TRAJECTORY AND ORBIT - Standard three-stage vehicle with standard ascent trajectory. 96-minute circular orbit (307-nautical mile). 28 to 50 degree orbital inclination, or near polar orbit. Lifetime: semipermanent, part time occupied.

4. WEIGHT AND DIMENSIONS - 30,000 to 50,000 pounds, 220-inch cylindrical body, 30 to 40 feet long, non-rotating

5. FUNDING ESTIMATE - $50 to $75 million

6. LEAD TIME - 4 to 5 years starting in FY 1962

7. GROWTH POTENTIAL - Additional equipment and living quarters can be added with increased test objectives


MANNED
SPACE
LABORATORY
GE 150-59 24 NOV 59

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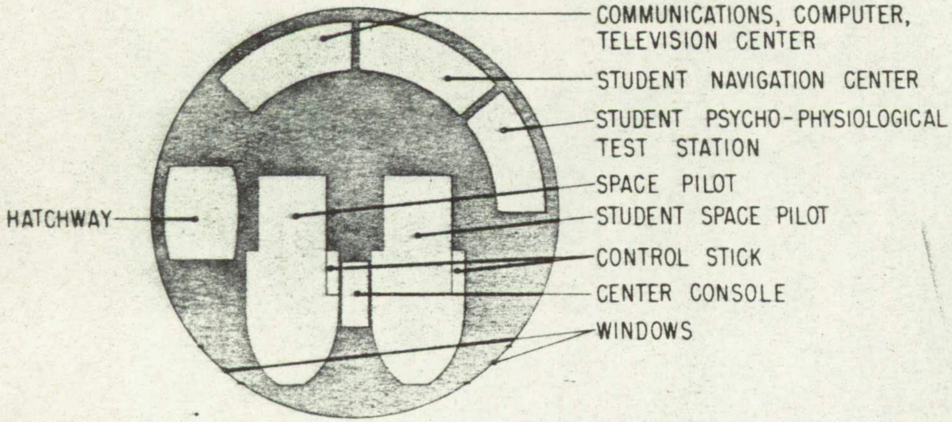
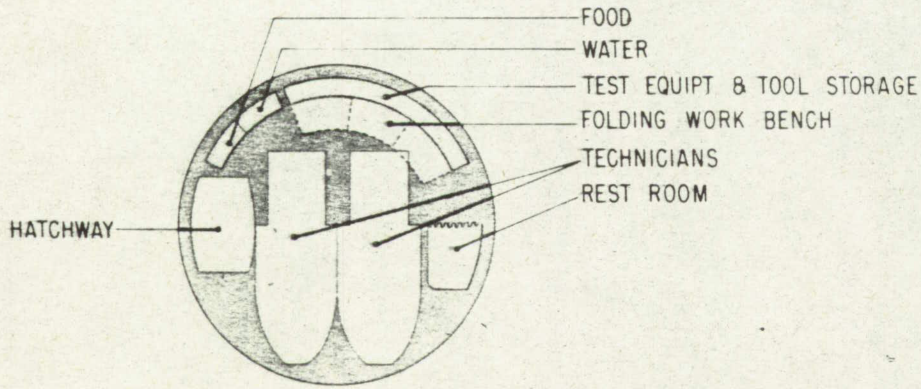
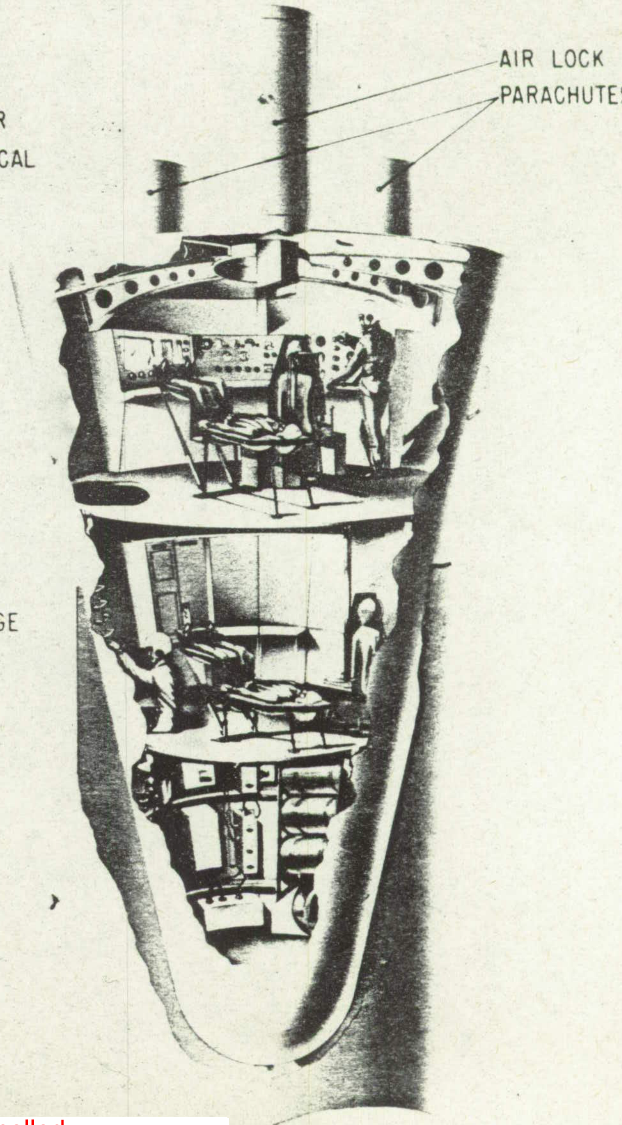
SPACECREW TRAINING VEHICLE



FIRST DECK



SECOND DECK



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3 YEARS FROM
DATE OF THIS CHART

Restriction/Classification Cancelled

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FILE NO. GE 14-59
19 FEB 59

1. PAYLOAD - Manned Soft Lunar Landing and Return Vehicle (SATURN B-1)

2. MISSION OBJECTIVES

   a. PURPOSE - Earliest possible manned lunar landing based on SATURN capabilities via orbital refueling.

   b. INSTRUMENTATION - Minimum instrumentation for flight control and navigation with limited scientific instrumentation, 2 man crew.

   c. SUBSYSTEMS - Orbital launched carrier vehicle, lunar launched return vehicle, entry vehicle, and orbital supply vehicle.

   d. POTENTIAL USER - NASA

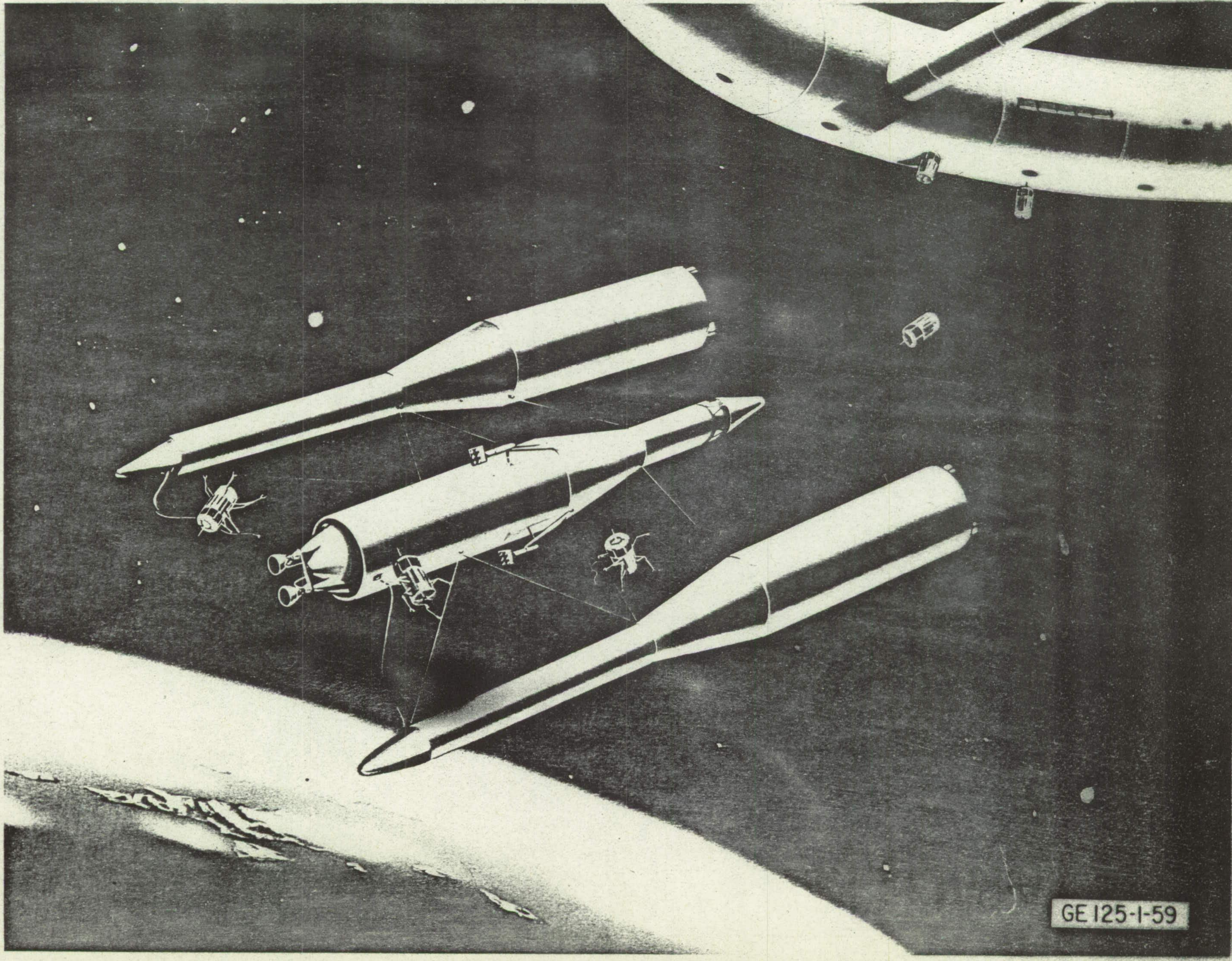
3. TRAJECTORY - Standard ascent trajectory to 307-nautical mile orbit with three-stage vehicle; lunar transfer trajectory (58 hours) from orbit; soft lunar landing; lunar escape and direct parabolic atmospheric re-entry.

4. WEIGHT AND DIMENSIONS - Orbital launched vehicle: Take-off weight: 360,000 pounds, 220-inch diameter; Lunar Launched Return Vehicle: Take-off weight: 44,000 pounds; re-entry vehicle: 10,000 pound capsule + 1,380 pound control system.

5. FUNDING ESTIMATE - For 2 flights - Vehicle development: $150 million

6. LEAD TIME - 6 Years - 4 years starting in FY 1964

7. GROWTH POTENTIAL - Basic system can provide routine supply operation for lunar observatory or other lunar explorations.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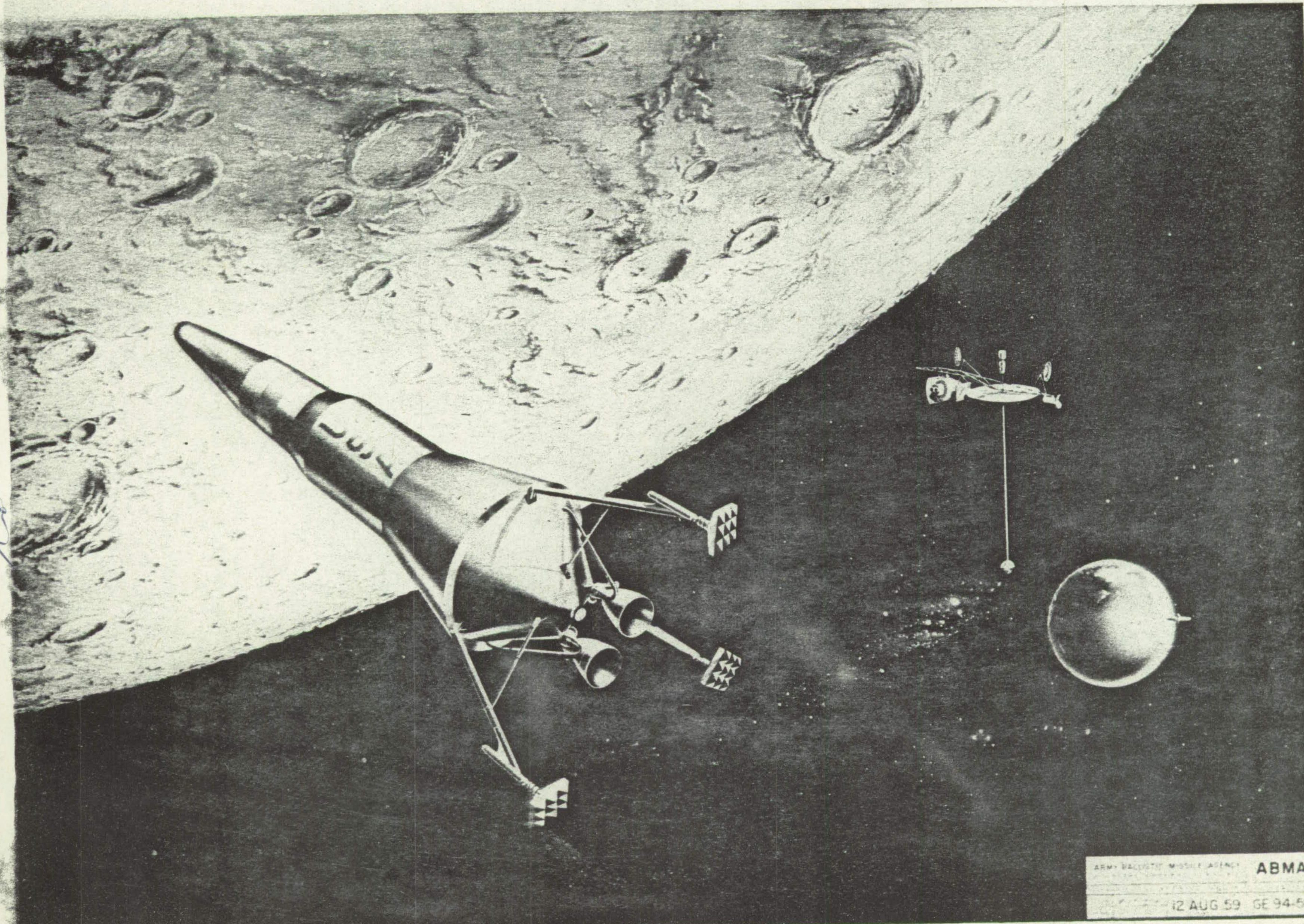
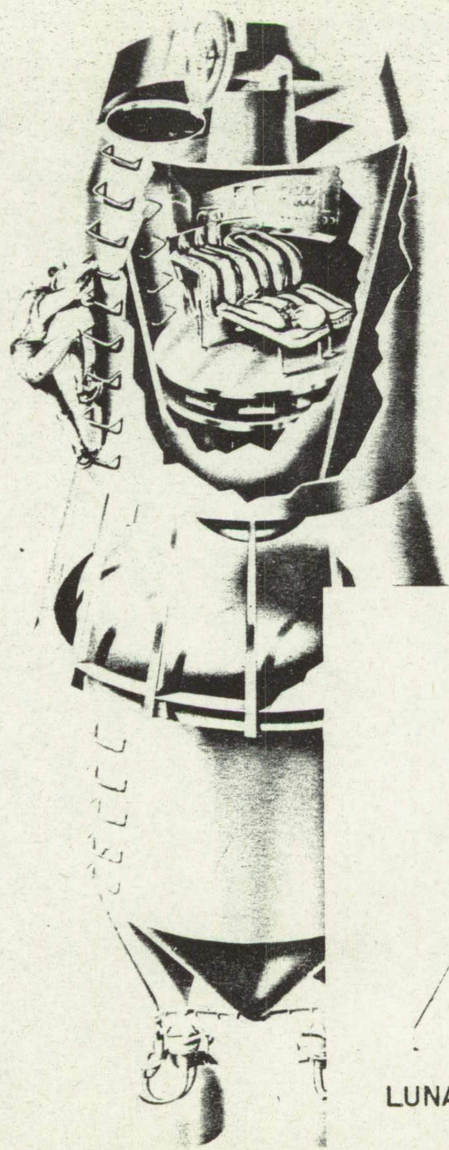
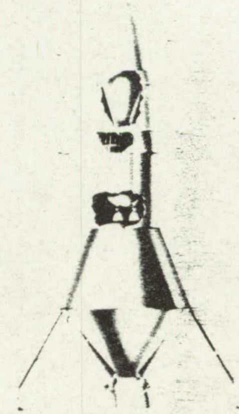

ABMA
12 AUG 59
GE 94-59





LUNAR LANDING *Vehicle*

LUNAR·EARTH *Return Vehicle*

REV A
[illegible]
3MAY59

5W

1. PAYLOAD - Solar Probe

2. MISSION OBJECTIVES

   a. PURPOSE - To place instrumented probe inside MERCURY's orbit,

   b. INSTRUMENTATION - Lyman alpha, proton, meteroid and flare studies.

   c. SUBSYSTEMS - Attitude control (solar oriented), communications, data storage and readout, auxilliary power (solar).

   d. POTENTIAL USER - NASA.

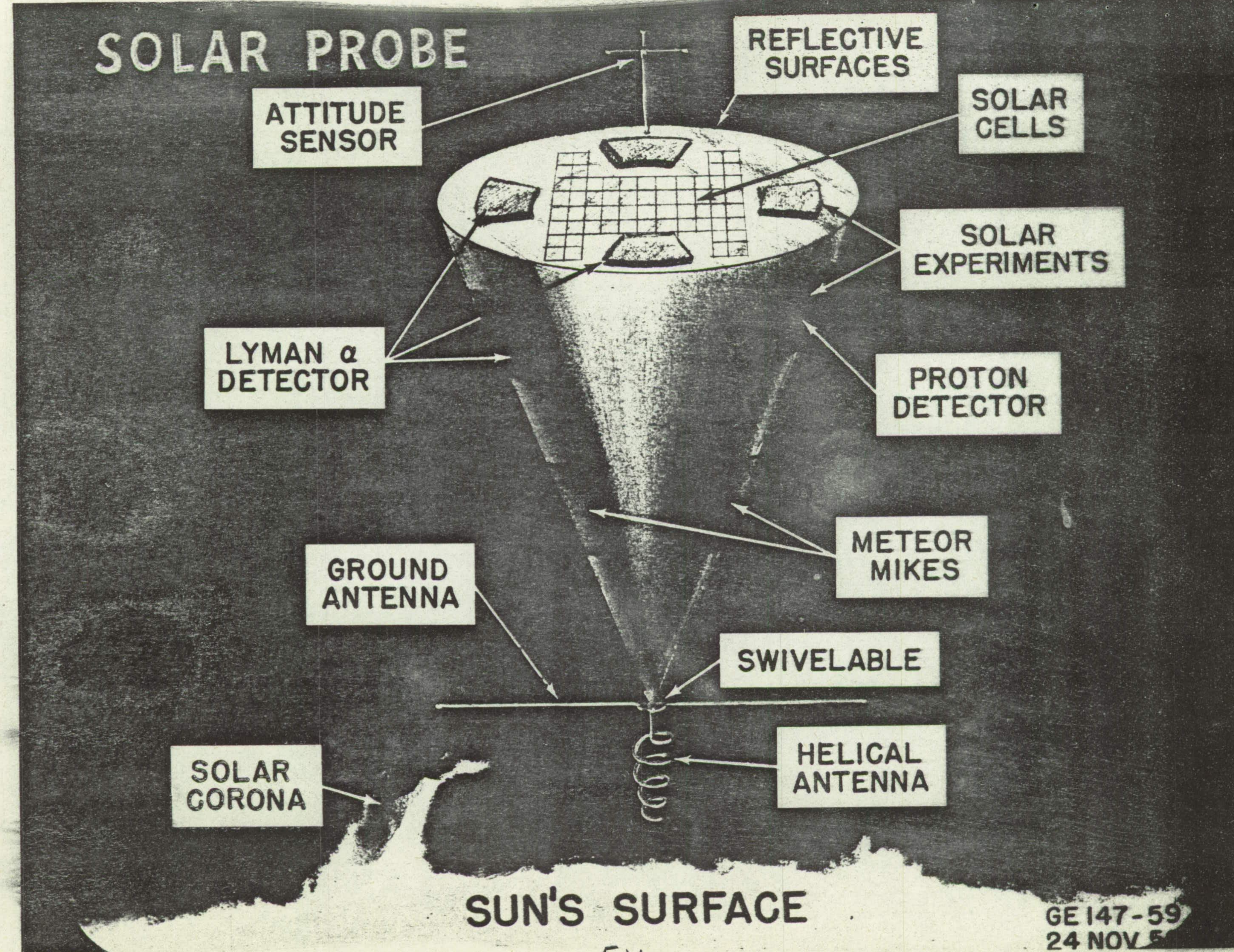
3. TRAJECTORY - Elliptical orbit similar to near minimum transfer to MERCURY (100 days or less). The closest point is dependent on payload carried. Lifetime is to be 6 months to 1 year.

4. PAYLOAD WEIGHT - SATURN B 500-2500
   SATURN B-1 500-3500

5. FUNDING ESTIMATE - $15 to $20 million

6. LEAD TIME - 3 years starting in FY 1963

7. GROWTH POTENTIAL - The use of a nuclear third stage will approximately double the B-1 payload capability.


SOLAR PROBE
REFLECTIVE SURFACES
ATTITUDE SENSOR
SOLAR CELLS
SOLAR EXPERIMENTS
LYMAN α DETECTOR
PROTON DETECTOR
METEOR MIKES
GROUND ANTENNA
SWIVELABLE
HELICAL ANTENNA
SOLAR CORONA
SUN'S SURFACE
GE 147-59
24 NOV 5

PAYLOAD - JUPITER Probe

MISSION OBJECTIVES

a. PURPOSE - To place instrumented probe near JUPITER, preferably near one of the larger Jovian moons.

b. INSTRUMENTATION - Atmospheric sensing, radiation and solar flux measuring, and other standard equipment.

c. SUBSYSTEMS - Attitude control, auxilliary power supply (nuclear), communications, temperature and radiation control, data storage and readout, etc.

d. POTENTIAL USERS - NASA.

3. TRAJECTORY - Minimum energy with approximately 3 years of flight time. Optical inertial midcourse guidance. Lifetime is to be three months in Jovian vicinity.

4. PAYLOAD WEIGHT - SATURN B 2000 pounds
   SATURN B-1 2700 pounds

5. FUNDING ESTIMATE - $15 to $20 million.

6. LEAD TIME - 3 years starting in FY 1963.

7. GROWTH POTENTIAL - Over 4000 pounds with the nuclear upper stages on the B-1.

1. **PAYLOAD** - Engineering Satellite

2. **MISSION OBJECTIVES**

   a. **PURPOSE** - To provide data on the many engineering problems connected with space flight.

   b. **INSTRUMENTATION** - General satellite instrumentation and orbit-earth telemetry.

   c. **SUBSYSTEMS** - Payload container, ablation re-entry body, attitude control system, recovery system, 60 to 75 individual experiments, and telemetry.

   d. **POTENTIAL USERS** - All governmental, industrial, and scientific organizations interested in space flight.

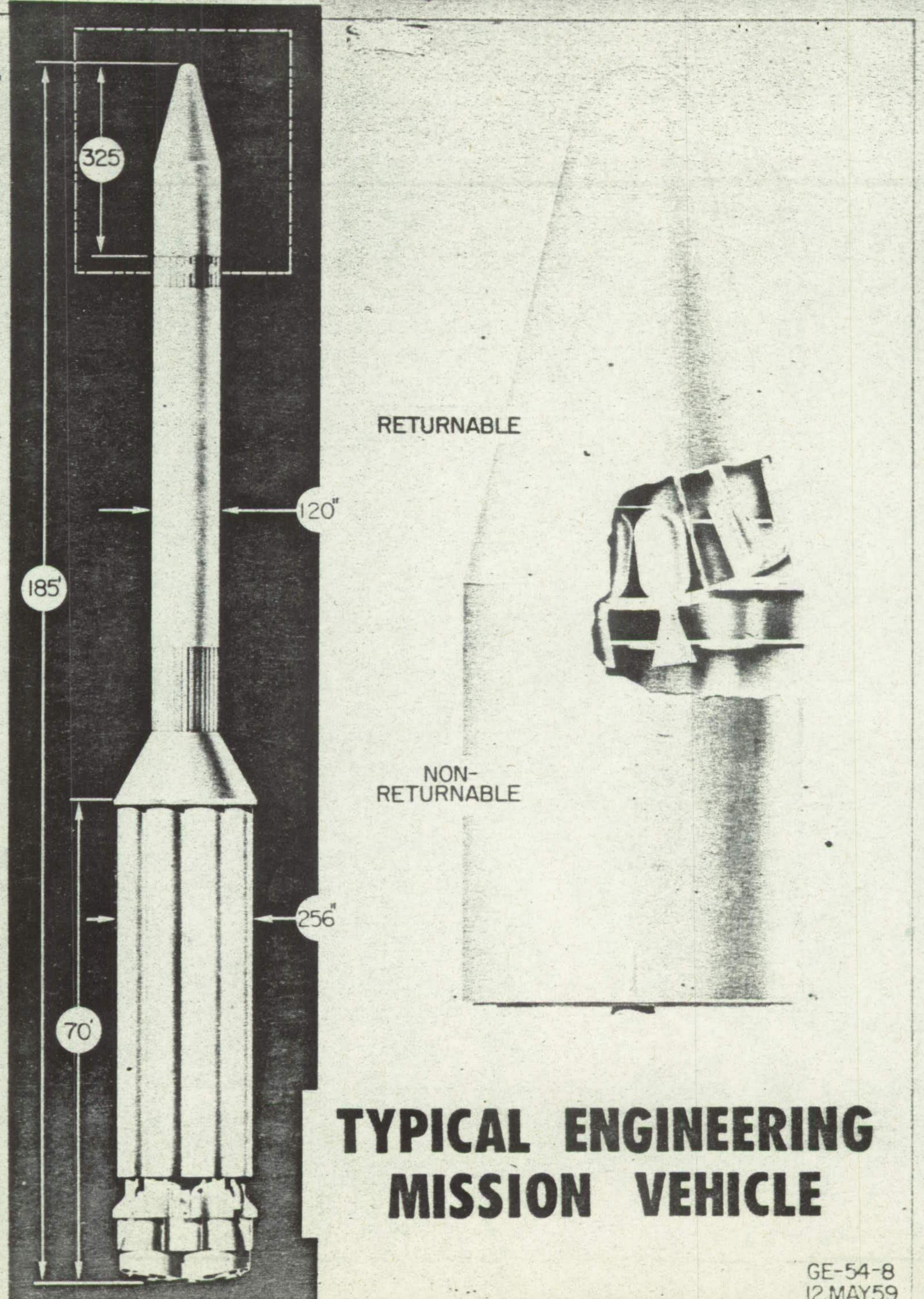
3. **TRAJECTORY AND SEQUENCE** - Standard ascent (two stage) with injection at 100 miles with excess velocity, coast to apogee at 200 miles and circularized with solid propellant motor. Attitude controlled using a horizon seeker. Inertia reference is frozen and retro rockets fired by timer to obtain proper path angle and angle of attack for re-entry.

4. **WEIGHT AND DIMENSIONS** - 10,000 to 15,000 pounds, 120- to 220-inch diameter, 10 to 15 feet in length.

5. **FUNDING ESTIMATE** - $15 to $20 million for two satellites and spare.

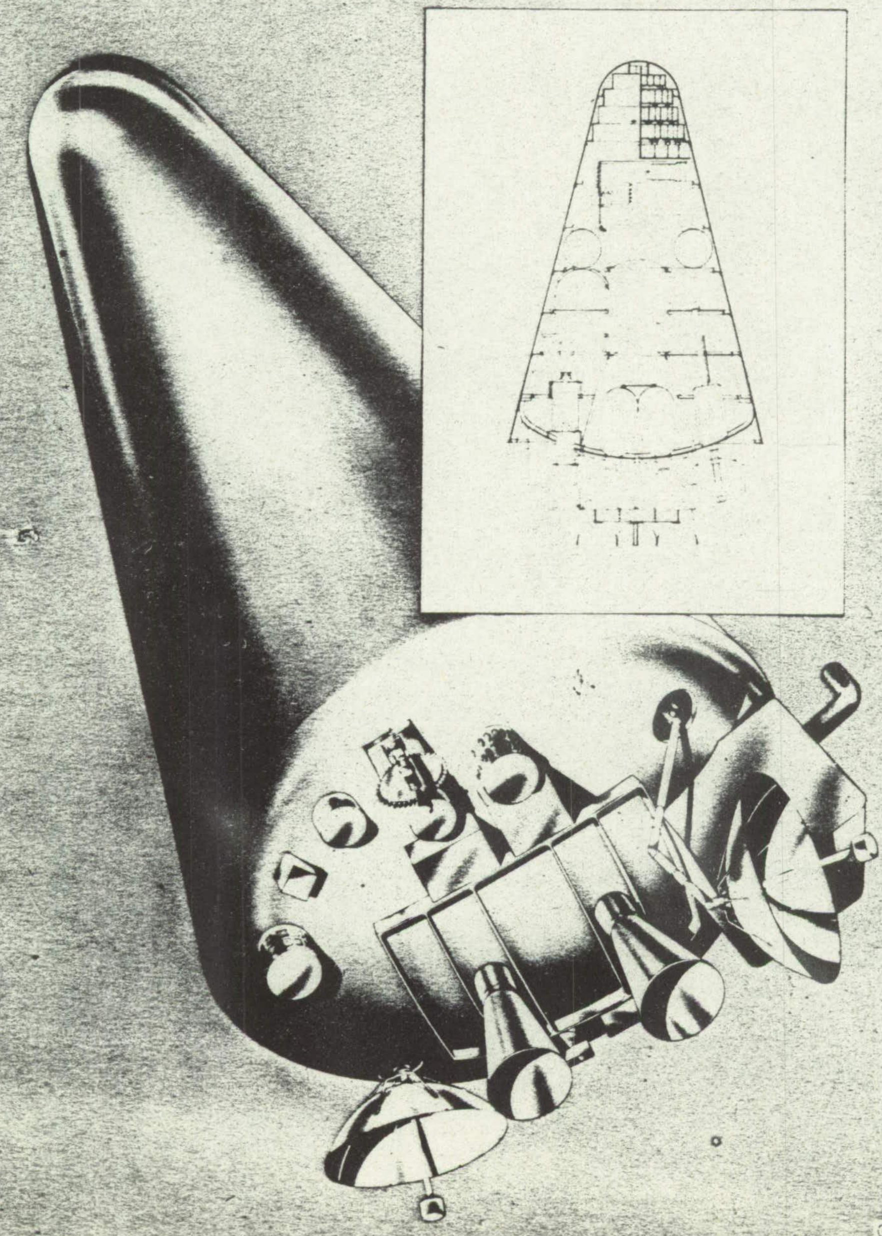
6. **LEAD TIME** - 2 to 2½ years starting in FY 1961 (Availability desired for early SATURN second-stage flights)

7. **GROWTH POTENTIAL** - Data obtained leads to large, manned orbital laboratories and other orbital and orbital-return vehicles.



TYPICAL ENGINEERING MISSION VEHICLE

RETURNABLE PAYLOAD



GE 57-59
15 MAY59

5CC

1. PAYLOAD - Large Orbiting Astronomical Telescope (50-inch)

2. MISSION OBJECTIVES

   a. PURPOSE - UV spectrophotometry, integrated photometry of selected band widths, bolometry, and direct photography with filters for stars, nebulae, planets, and interplanetary matter.

   b. INSTRUMENTATION - All-reflecting photoelectric spectrum scanner; bolometer; UV and IR photometers with photomultipliers, ion detectors, and filters; long-focus optics for direct photography (TV).

   c. SUBSYSTEMS - Coarse attitude control of whole telescope to about 1".0 of arc by wheels + jets + momentum arms; 5".0 hour around 3 axes; fine control of attitude to 0".03 of arc (mirrors rotated); slewing; data storage; data transmission; TV (for pointing and direct photography); commands: -100 +; power: 4 KW.

   d. POTENTIAL USERS - Astronomers, physicists from universities and government.

3. TRAJECTORIES AND SEQUENCING - The astronomical telescope is to be placed in the equatorial 24-hour orbit near the same meridian on which the ground observers are to be located (e.g., Kitt Peak, Arizona). Lifetime is to be 1 to 10 years.

4. PAYLOAD WEIGHT - Payload, including attitude control, will be 5,000 to 8,000 pounds. Extra weight would allow more shielding, more batteries, longer life.

5. FUNDING ESTIMATE - $15 to $20 million

6. LEAD TIME - 4 to 5 years. Depends on ABMA (NASA), AURA and individual astronomers.

7. GROWTH POTENTIAL - SATURN is capable of placing 100-inch telescope into a 24-hour equatorial orbit.

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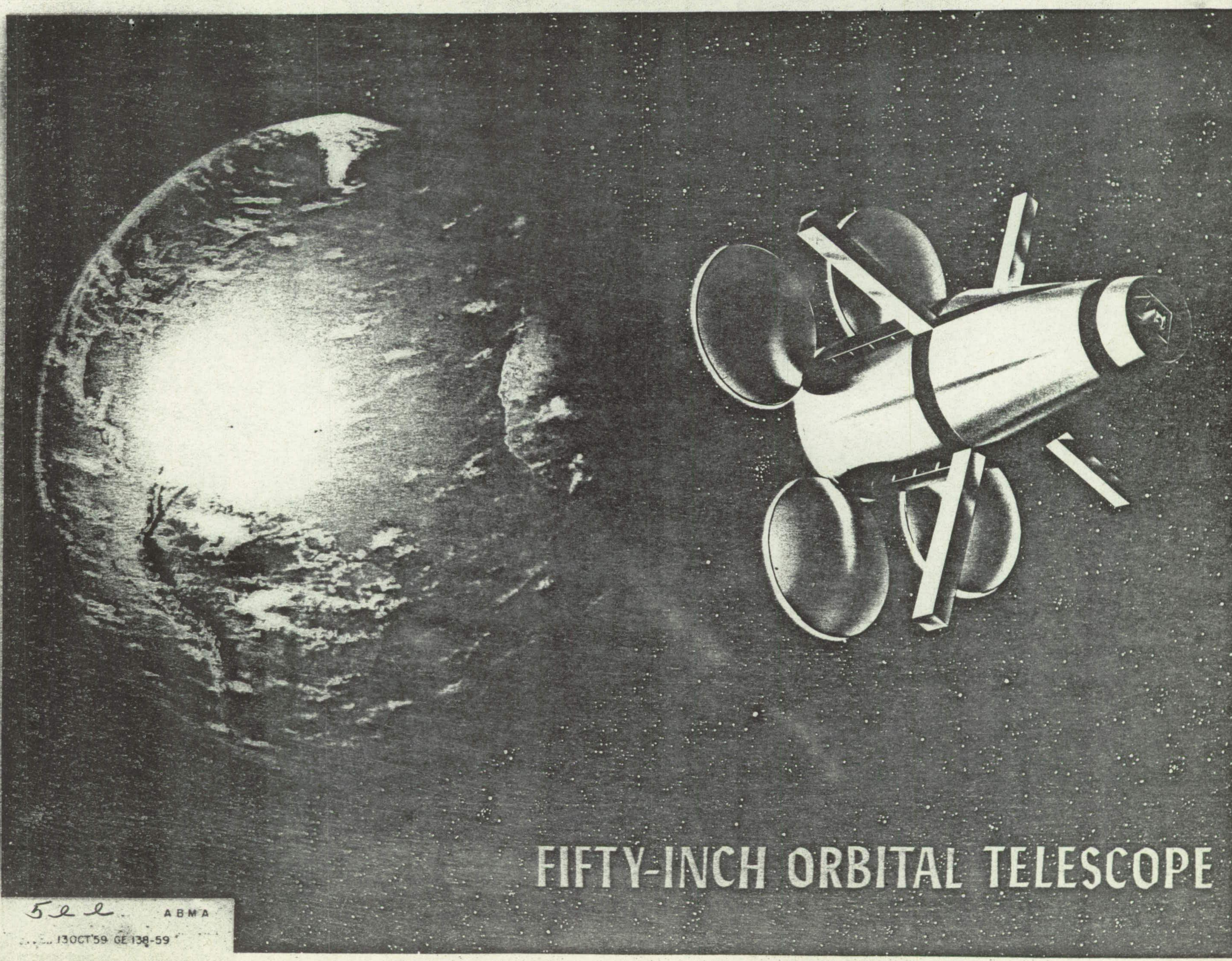


ABMA

13OCT'59 GE 138-59

1. PAYLOAD DESIGNATION - Orbital Return Capsule

2. MISSION OBJECTIVES

   a. PURPOSE - Personnel and cargo transportation earth surface - orbit and return, capacity 6 to 10 men

   b. INSTRUMENTATION - Only such as required for mission, no scientific instrumentation

   c. SUBSYSTEMS - Environmental control system, flight control system, brake rockets, communication system, and flap system for modulated drag

   d. POTENTIAL USERS - NASA, ARPA, Commercial

3. TRAJECTORY - Ballistic re-entry vehicle with modulated drag and small C_L/C_D ratio (0.3 to 0.5) for most economic orbit - earth surface transportation; no limitation of orbit parameters; optimized for 96-minute orbit

4. WEIGHT AND DIMENSIONS - Nominal 10,000 pound capsule for 6 people or 15,000 pounds for 10 people, 15 to 20 feet in length, 10 to 15 feet in diameter

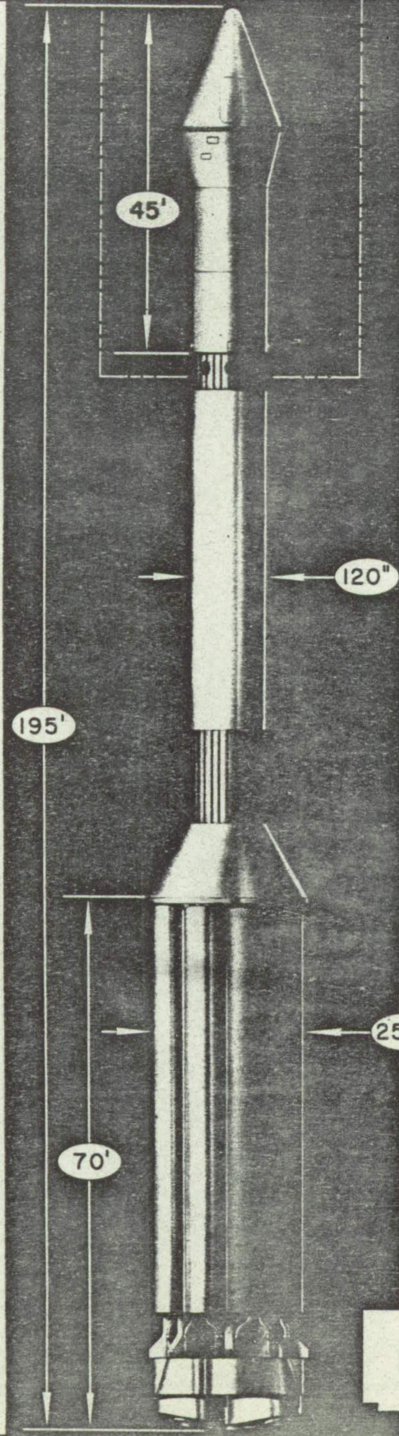
5. FUNDING ESTIMATE - $60 million

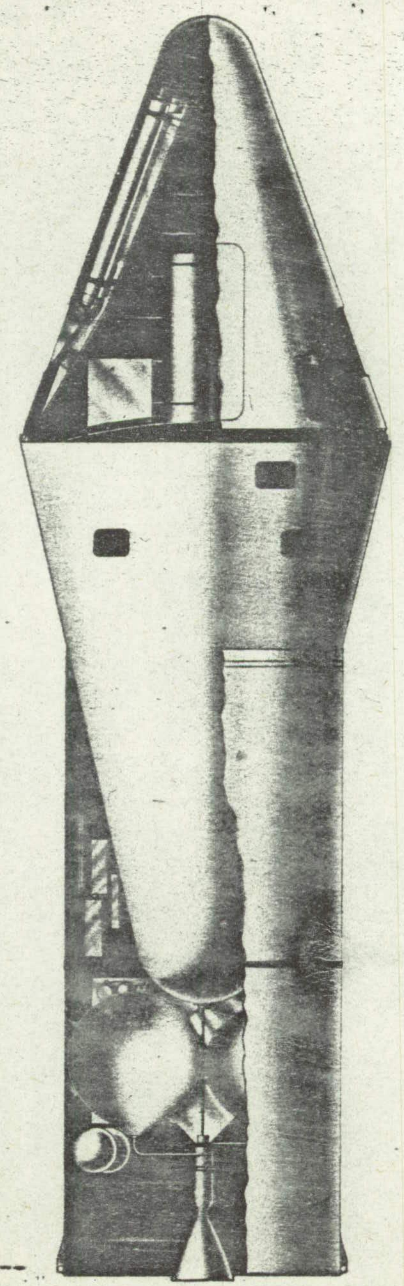
6. LEAD TIME - 3½ years if started in FY 1962

7. GROWTH POTENTIAL - Personnel and cargo capacity can be enlarged by more than 100% up to single SATURN payload capability if required at moderate cost

5 ff

REGRADED CONFIDENTIAL
3 YEARS FROM
DATE OF THIS CHART





MANNED ORBITAL TRANSPORT

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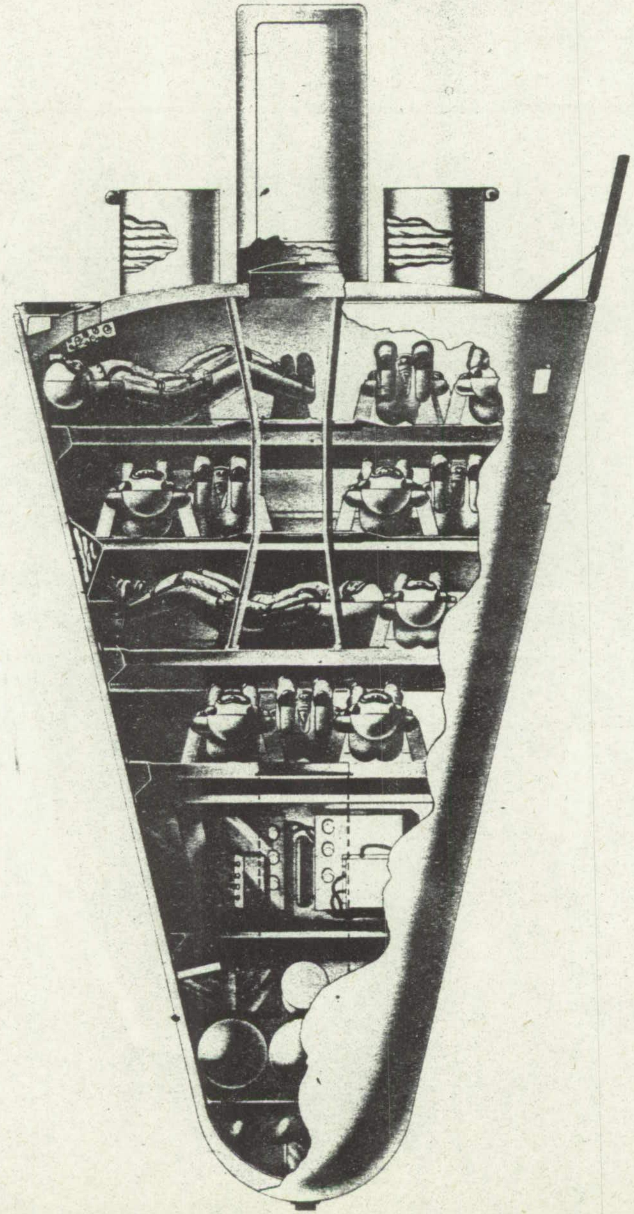
REV B FILE NO 703-1 13 MAY 59

[redacted]



MANNED ORBITAL RETURN VEHICLE

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REV B FILE NO 703-2 13 MAY 59

1. PAYLOAD - Manned Maneuverable, Recoverable Orbital Vehicle

2. MISSION OBJECTIVES

   a. PURPOSE - To provide a space maneuverable and recoverable military surveillance vehicle, or orbital control station, offensive weapons launcher and a space taxi. Also can be used for transporting maintenance crews and spare equipment for unmanned satellites.

   b. INSTRUMENTATION - Dependent on specific mission.

   c. SUBSYSTEMS - Flight control system, environmental control system, variable thrust maneuver propulsion system, communications system, and other subsystems as required by specific mission.

   d. POTENTIAL USERS - Military and NASA.

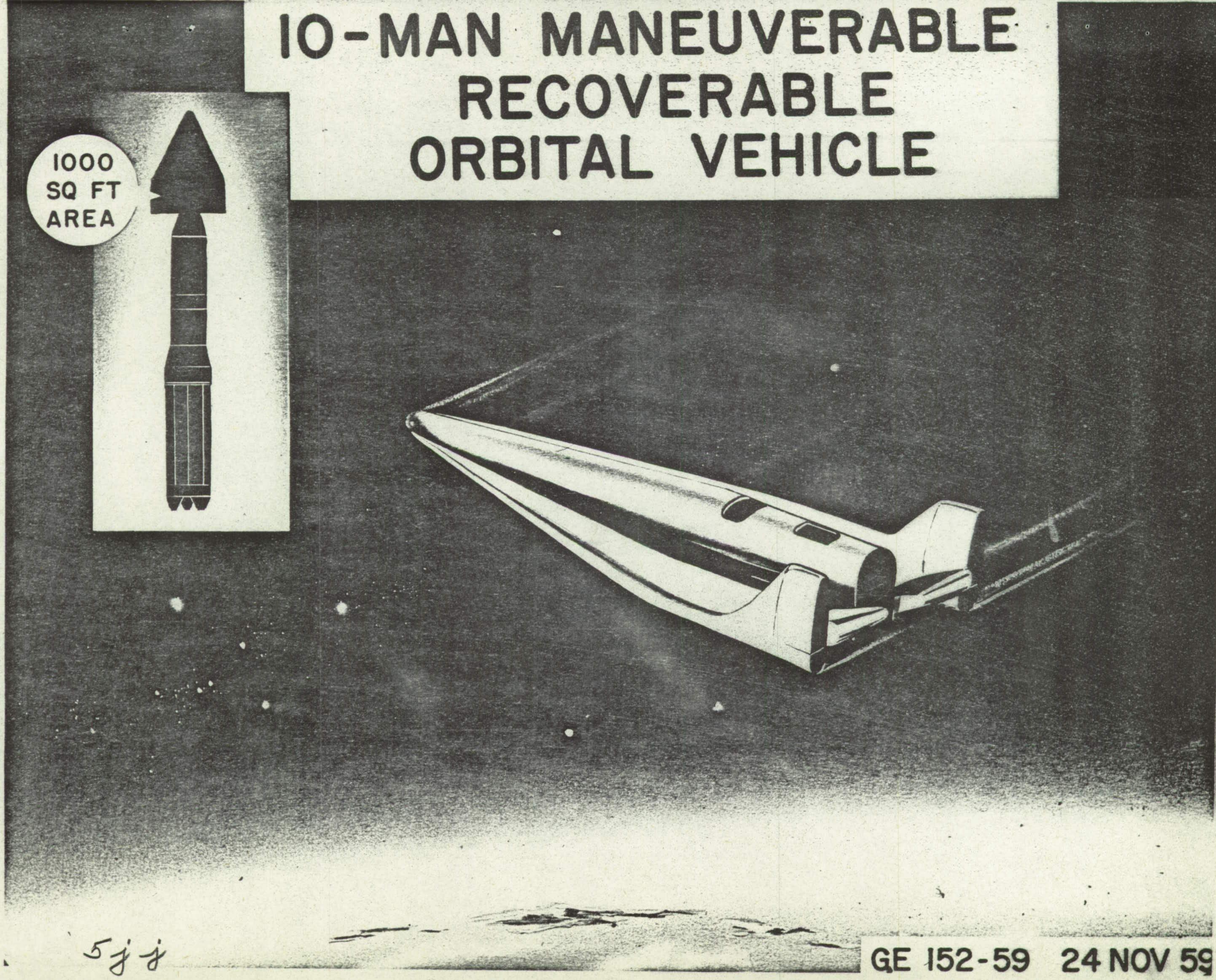
3. TRAJECTORY SEQUENCE - Standard ascent to mission orbit and perform mission. Orbital capability 10 to 30 days. Re-enter at steep angle, high drag, high lift for g control with ablative entry and final glide for landing site selection.

4. WEIGHT AND DIMENSIONS - 25,000 to 35,000 pounds (requires SATURN B-1 for winged vehicle).

5. FUNDING ESTIMATE: $300 million for development

6. LEAD TIME - 4 to 5 years starting in FY 1963.

7. GROWTH POTENTIAL - Up to 90,000 pounds with SATURN C, which would give extensive maneuvering fuel capability.


10-MAN MANEUVERABLE
RECOVERABLE
ORBITAL VEHICLE
1000
SQ FT
AREA
GE 152-59 24 NOV 59

5jj

TYPICAL NASA SATURN MISSION AND VEHICLE REQUIREMENTS

	Calendar Year 1963	1964	1965	1966	1967	1968	1969	1970	REMARKS
Launch Total	1	4	6	7	10	10	14		
MISSIONS									
I. Manned Space Flight (* manned missions)									
A. Lunar Circumnavigation									
1. Capsule qualification									
a. Low orbit	1	1							Does not specify "minimum" Saturn
b. Circumlunar type orbit		111	111	1 1					Would require Saturn B-1 by end of series
2. Manned missions									
a. Low orbit				1*					Does not specify a "minimum" Saturn
b. Circumlunar				1*1*1*	1*	1*			May require Saturn B-1 (10,000 pounds minimum)
B. Lunar Landing									
1. Rendezvous experiments with tanker & laboratory					1 1				May require Saturn B-1 (37,000+ lbs in 300-mi. orbit)
2. Assembly in orbit						111111	111111		May require Saturn C (60,000 to 80,000 pounds in 300-mi orbit)
3. Landing							X X*		Depart after assembly in orbit. Second manned if first succeeds
C. Orbiting Laboratories									
1. Semipermanent					1*	1*			Saturn B-1 preferred.
II. Satellite Applications									Does not specify a "Minimum" Saturn
A. Meteorological and Communication satellite					1	1	111		

[redacted]

Restriction/Classification Cancelled AL

Typical NASA Saturn Mission and Vehicle Requirements (continued)

MISSIONS	Calendar Year 1963	1964	1965	1966	1967	1968	1969	1970	REMARKS
III. Lunar Exploration (unmanned)									Does not specify a "minimum" Saturn
A. Soft landing			1 1	1	1	1	111		
IV. Planetary Exploration									Does not specify a "minimum" Saturn
A. Orbit			1		1				
B. Land					1		1 1		
V. Technological									May require Saturn B-1
A. Nuclear rocket test					1 1				(30,000 pounds in 300-mi. orbit)

[redacted]

AL

Typical NASA Program Feeding Into Saturn Projects

Program Area	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	Remarks
I Manned Space Flight											
A Project Mercury	A→	→	→								
B Maneuverable capsule				A→	→						B-Techniques applied to lunar and rendezvous capsules
C Lunar circumnavigation											
1. Technological development (Hyperbolic reentry and guidance)				C C C	C C C						C.1- Scale models
2. Capsule qualification											Full scale space-craft
Earth vicinity				S→	→						
Circumlunar						S→	→				
D Lunar landing											
1. Rendezvous experiments				(Item B contributes)				S→	→		Experiments with tanker and orbit-ing laboratory.
2. Landing experiments on earth							Unselected boosters →	→	→	→	"Land" above atmosphere and in desert
3. Assembly in orbit									S→	→	
E Orbiting Laboratories				(Item C-2 contributes)				S→	→	→	

[redacted]

Typical NASA Program Feeding Into Saturn Projects (Cont)

Program Area	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	Remarks
II Satellite Applications											
A Meteorology											
1. Preliminary (TIROS)	TD →										
2. Earth oriented (800 mile)		TAG →	→	→	AAG or C →	→	→	→	→	→	
3. Earth oriented (24-hour)								S →	→	→	Share with communications
B Communications											
1. Reflector	TD →	→	→	AAG →	→						Go to rigidized structures
2. Repeater	AAG →	→	→	C →	→	→	→	S →	→	→	Military program primarily
III Lunar Exploration (Unmanned)											
A Orbit	A A						C →	→	→		Select site for manned landing
B Land		V V		C C C	C C C	S and C →	→	→	→	→	Good mission for Saturn if reliability holds up manned effort

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Restriction/
Classification
Cancelled

AL

Typical NASA Program Feeding Into Saturn Projects (Cont)

Program Area	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	Remarks
IV Planetary Exploration											
A Fly by		(V V) Test	V V								
B Orbit					C C	S →	→	→	→	→	
C Land						S →	→	→	→	→	
V Technological Developments											
A Recoverable materials and components					S →	C →	→	→	→	→	Piggy-back rides on early "unloaded" Saturns
B Nuclear electric test satellite						C →	→	→	→	→	Saturn not required for test period

KEY:

- TD = Thor Delta
- A = Atlas
- TAG = Thor AGENA
- AAG = Atlas AGENA
- V = Vega
- C = Centaur
- S = Saturn

[redacted]

L

TYPICAL SATURN SPACECRAFT AND PAYLOAD DEVELOPMENT COSTS

MISSION	Calendar Year 1960	1961	1962	1963	1964	1965	1966	1967	1968	TOTAL	REMARKS
I. On Previous Saturn Schedule											
1. Manned lunar circumnavigation	20	60	80	40	20					220	2 plus 1 spare
2. Unmanned lunar landing	5	10	30	40	20	10				115	3 plus 1 spare
3. Planetary orbit				15	25	10	5			55	2 plus 1 spare
4. Planetary landing					24	40	16	8		88	2 plus 1 spare
5. Communication and Meteorological satellite				15	45	60	30	15		165	10
6. Nuclear rocket test satellite (no reactor costs)			8	16	24	24	8	4		84	1 plus 1 spare
7. Manned laboratory (semi-permanent)			10	20	30	30	10	5		105	1 plus 1 spare
8. Manned lunar landing Spacecraft Tanker					20	60	80	40	20	220	2 plus 1 spare
9. Solar probe							6	10	4	20	1 plus 1 spare
Total cost (Millions)	25	70	128	146	198	234	155 →Drop	82 doubtful	24	1072	
II. Others											
1. Engineering test satellite										20	2 plus 1 spare
2. Jupiter probe										20	1 plus 1 spare
3. Orbiting telescope										40	1 plus 1 spare
4. "Taxi" for orbiting lab. and refueling operations										60	

DEPARTMENT OF DEFENSE MISSIONS AND PAYLOADS

Current thinking of the Department of Defense on its required satellite missions and payloads is summarized in the following table:

	Altitude N. Mi.	Weight Lb.	Time
COMMUNICATIONS	5600 Polar	500	1960
	24 Hr. equ.	1200	1962
	24 hr. equ.	5000	1963
RECONNAISSANCE	300	3000-5000	1960-62
	300	7000-10,000	1962-69
	1000-6000	10,000	1965
BALLISTIC MISSILE DESTROYER (SPAD)	100-200	5000-10,000	1963
	300	15,000-25,000	1964-66
	300	35,000-70,000	1966
SATELLITE INSPECTOR	300-500	8000-15,000	1964-66
	300-1000	25,000-35,000	1966-67
	1000-24 hr.	40,000-70,000	1968
ELECTRONIC COUNTER-MEASURE SYSTEMS	150-300	1000-3000	1962-64
	300-6000	8000-12,000	1964-68
	300-24 hr.	40,000-70,000	1968

Communication capabilities are essentially paced and limited by the availability of launching vehicles. The 5600 nautical miles polar orbit with 500 lbs. payload is based on the ATLAS AGENA vehicle. The first 24 hours syncronized equatorial communication satellite can be achieved by the ATLAS CENTAUR vehicle with a payload capability of 1200 lbs. If and when higher payload in orbit capability becomes available, communication mobile video channels, satellite-to-satellite relay, and finally relay from other satellites such as reconnaissance and early warning will become feasible.

Detailed discussion of the advanced communication satellites and of Dyna Soar follows:

Advanced Communications Satellites

1. Statement of the Problem

Military communications satellites will require heavier payload capabilities than presently available. Several military satellite communications systems are under active development or study. The present system planning will culminate in a 24-hour synchronous orbit communications satellite which would be placed at an altitude of 22,300 statute miles above the surface of the earth and would be synchronized with the rotation of the earth. Three symmetrically spaced satellites would provide world-wide communications with the exception of two small areas located at the Poles. The requirements on the vehicle which will establish such a satellite system are extremely severe and rigid. The satellite must not only be lifted into the 22,300 mile equatorial orbit, and the orbit changed from 28° to equatorial, but also must be accurately positioned in its orbit. Furthermore, the payload itself is required to maintain its station with small tolerances and in perfect synchronism with the earth. Communications antennas are necessarily of a relatively narrow beamwidth to obtain best efficiency, and therefore require accurate pointing, which in turn requires accurate attitude stabilization of the satellite.

Several modes of communications from such a satellite system stand out as being highly desirable from a military point of view. These may be categorized into communication between ground stations; communications between satellite and a mobile stations, such as airplanes, ships, mobile communication vans, etc.; communications between the satellites themselves, which is necessary for true world-wide coverage; and, possibly, communications from the communications satellite to a reconnaissance satellite in a considerably lower orbit. This last mode of operation would enable the reconnaissance satellite to relay collected intelligence information back to the United States essentially instantaneously.

In the discussion to follow, the capacities for communications of the various satellite configurations are discussed in terms of the number of voice channels or the number of video or television channels that they can handle. The system design and subsequent discussions are based on the building block approach, starting with a repeater in the satellite consisting of a basic group of eight rf channels. This concept agrees closely with the presently planned system for the first 24-hour communications satellite, and appears to have considerable merit for future systems. If additional channel capability is required, more channels (and requisite power supply capability) may be added. The numbers that are provided in this report are based on information theory and the best estimates on weight of communication equipment, stabilization equipment, and electrical power conversion equipment which can be made at this time.

A certain amount of fixed equipment of a non-communication character is required for any satellite. The additional weight of communication equipment required increases as the information capacity increases at a rate which is a little less than the rate of increase of the electrical power requirement. The electrical efficiency of power supply equipment increases with size. For this reason, as can be seen from the weight distribution figures shown in paragraphs 2, 3 and 4, a large payload uses weight more efficiently than a small payload and, therefore, additional communications capability can be obtained.

In discussing the military communications capability of satellites which may be of interest to the DOD, consideration must be given to anti-jam (AJ) protection of the communications channels. It is believed that an AJ capability must be available in any military communications satellite system and, for this reason, the AJ capability is considered an integral part of any and all payloads discussed herein. The AJ protection as discussed in the charts to follow is realized by spread spectrum techniques, where the information is properly coded and transmitted at a relatively low power over a very wide rf band. For example, a 30 db AJ protection takes a normal rf carrier and spreads its frequency spectrum 1,000-fold over the available rf spectrum. At the receiving end, this process is reversed and the signal is recovered from a low level spread spectrum into a usable communications channel.

Paragraphs 2, 3 and 4 give a detailed description of the estimated communication capability of three different booster configurations. Paragraph 5 presents in summary form the results of these calculations. The figures given in this report should be considered as examples based on the eight channel building block concept. Obviously, many different combinations are possible. Furthermore, it is assumed that ground station equipment development will keep pace with the satellite and booster developments to take full advantage of the increased communications capability.

2. Present Concepts for a 24-Hour Communications Satellite Utilizing the ATLAS-CENTAUR Booster, with a Payload Weight of 1200 Pounds in Orbit

2.1 Communications Payload

The communications payload for a 24-hour satellite which is presently planned as Project DECREE will consist of a 1200-pound active repeater satellite. This satellite will have the capability of providing communications between points on the ground, using 60-foot diameter tracking antenna dishes. The satellite will operate at an rf frequency of 2 kmc and will contain eight rf repeater channels with a transmitter power of one watt each. The satellite will require 280 watts of primary power. The satellite, as presently envisioned, will be capable of providing 96 channels of voice communication from ground to ground with 30 db of AJ protection. It will not be able to provide a video channel, due to signal-to-noise limitations. The satellite will not be able to provide communications facilities to mobile stations, nor will it provide communications between communications satellites, nor from the reconnaissance satellite to the communications satellite. A summary of the communications capability of the DECREE satellite system is given in Table I.

TABLE I

Communications Capability of the DECREE Satellite System

Booster: ATLAS CENTAUR
1200 lbs. in 24-hour orbit

	Channel Capacities	
Terminals	Voice	Video
I. Ground to ground (60' dish)	96 30 db AJ	0
II. Satellite to mobile (3' dish)	0	0
III. Communications Satellite to Communications Satellite	0	0
IV. Reconnaissance Satellite to Communications Satellite	0	0

2.2 DECREE Satellite Weight Breakdown

Table II gives an estimate of the weight breakdown for the 24-hour satellite for the ATLAS-CENTAUR booster. It is to be noted that the communications weight is 38% of the total; whereas the antennas, structure, station-keeping, and attitude control functions require 62% of the weight.

TABLE II

Weight Breakdown for Decree Satellite

Equipment	Weight (Lbs.)	% of Total
Communications	170	38
Power Supply	280	
Station-keeping, attitude control, etc.	560	62
Antennas and structure	190	
	1200	100

2.3 Number of Vehicles to be Used in an R&D Test Program

At the present stage of planning, seven vehicles are proposed for the R&D testing of a 24-hour satellite concept. The various vehicles will be fired in an orderly engineering manner to test the various aspects of the communications satellite system, including placement into orbit, station-keeping, attitude control, oriented power supply capability and reliability of the communications package. It is clear, of course, that in order to provide an operational system, three satellites have to be stationed into specific locations, which requires additional vehicles beyond those quoted here for R&D testing of single satellites alone.

2.4 Launch Schedule

The launch scheduling depends primarily on the availability of the CENTAUR vehicle. Present plans call for the first flight test in September 1962, one launch every two months thereafter and completion of test in September 1963.

2.5 Cost Estimate

Total cost for the DECREE program as presently planned, including the procurement and launching of seven ATLAS-CENTAUR vehicles, is estimated as $90,000,000.

3. Saturn B1 3-stage Vehicle Communications Satellite Capabilities

It is anticipated that the Saturn B1 3-stage vehicle can place 5200 pounds into a 24-hour synchronous orbit. The communications system described below is based on this weight estimate. The satellite for this system could contain eight rf channels operating at 8 kmc with a power output of 100 watts each. It will require approximately 8000 watts of primary power for the communications system. This system can provide communications between points on the ground using 60-foot diameter fixed antenna dishes. In this mode of operation, it can provide 960 voice channels with 40 db AJ protection, or an alternate configuration can provide eight video channels from ground to ground. Otherwise, the system could provide 96 voice channels with 30 db AJ protection in a satellite to mobile station operation. The mobile station is assumed to have a 2-foot dish which must track the satellite. An alternate configuration would be eight video channels from the satellite to the mobile station. This system can provide communications between two communications satellites of 96 voice channels with 30 db AJ protection or eight video channels. It is to be noted here that the allocation of the channels between ground to communications satellite and between communications satellite and communications satellite depends upon the system user. The figures given refer solely to the capability of the active repeater in the satellite. This system will not provide a capability for communicating from a reconnaissance satellite to the communications satellite. The radio frequency of 8 kmc has been chosen as an advance over the 2 kmc which will be used in the ATLAS-CENTAUR configuration. There are important advantages in using higher frequency, and at the time scale of development, the component requirements for operating of 8 kmc can expect to be available. Table III gives a summary of the communications capabilities of this system.

TABLE III

Communications Capability of Saturn B1 Satellite System - 5200 Lbs. in 24-Hour Orbit

	Terminals	Channel Capacities: Voice	Channel Capacities: Video
I.	Ground to ground (60' dish)	960 40 db AJ	8
II.	Satellite to mobile (2' dish)	96 30 db AJ	8
III.	Communications Satellite to Communications Satellite	96 30 db AJ	8
IV.	Reconnaissance Satellite to Communications Satellite		0

3.2 Weight Breakdown of the Communications Package for the Saturn B1 3-stage Vehicle

The communications portion consisting of the electronics required for the active repeater functions are estimated to weigh 1200 pounds. The electrical power supply required to drive this system can be obtained from 1500 pounds. Station-keeping, attitude control, etc., require approximately 2000 pounds, since the attitude control is particular must be relatively accurate for optimum utilization of the narrow beamwidth of the communications antennas. The antennas and the remainder of the satellite structure is estimated to weigh 500 pounds. Table IV gives a summary of this weight break-down.

TABLE IV

Weight Breakdown for Saturn B1 Satellite

Equipment	Weight (Lbs.)	% of Total
Communications	1200	52
Power Supply	1500	
Station-keeping, attitude control, etc.	2000	48
Antennas and structure	500	
Total	5200	100

8 rf channels @ 8 kmc
100 watts each
8000 watts primary power

3.3 Required Launch Vehicles

It is estimated that not less than four satellite payloads in orbit will be required for successful completion of the R&D phase. The total number of launch vehicles will depend on the reliability of booster and upper stages.

3.4 Launch Schedule

Satellite and communications payloads can be made available by mid-1963. Launching should be scheduled at a rate of one firing every two months.

3.5 Cost Estimate

Cost for development and fabrication of eight complete satellite payloads is estimated to be $40,000,000. Cost for procurement of vehicles and launch cost are not included.

4. Saturn B2 4-stage Vehicle - 7800 Pounds in a 24-Hour Orbit

4.1 Communications Capability

The communications capability of this system is enhanced primarily by the additional weight which allows additional rf power, more redundancy and some additional capability, primarily in the reconnaissance satellite to communications satellite area. The satellite communications package consists of ten rf channels operating at 8 kmc and two rf channels operating at 12 kmc. The transmitter power of each channel is 100 watts. It will require 12,000 watts of primary power. The additional in-orbit weight capability of the 4-stage Saturn B_1 booster provides the capability to receive information from reconnaissance satellites via communications satellite to the ground for an instantaneous relay of the collected reconnaissance satellite information. The two rf channels operating at 12 kmc are assigned to the relaying of reconnaissance satellite information. The choice of this frequency allows a certain amount of AJ protection, since this frequency is attenuated by the atmosphere and therefore provides some power advantage over a ground based jamming transmitter. This communications system will provide ground to ground communication capability, using 60-foot diameter fixed dishes. It will provide 1200 voice channels with 40 db AJ protection and two video channels. Or it will provide ten video channels from ground to ground, plus two video channels from reconnaissance satellite to the communications satellite. In a different mode of operation, the system can provide 120 voice channels with 30 db AJ protection from the communications satellite to a mobile station, using a 2-foot diameter dish. Or, it may provide ten video channels from satellite to mobile station. In addition to either of these modes, it can always provide two channels of video information. The system can provide communications from communications satellite to communications satellite of 120 voice channels with 30 db AJ protection, plus the two video channels, or it can provide ten video channels plus the two special video channels, using the 12 kmc frequency. The system can provide two video channels from a reconnaissance satellite to the communications satellite and from there to the ground.

The communications capability here is primarily designed to provide the reconnaissance satellite to communications satellite link. For this reason, two special rf channels were set aside. However, other distributions are possible, but the limited scope of this report does not permit to list alternate approaches. It three satellites are spaced equidistant in an equatorial orbit around the earth, complete world-wide coverage can be obtained, and it is toward this goal that such a large number of channels becomes a true advantage. In a complete global communications system using these satellites, all of these channels are not available from ground to ground since some of them must be used to relay the information from one communications satellite to one of the others for retransmittal to a distant ground station not in view of the first satellite. However, to obtain a meaningful comparison, the number of channels quoted represent the capability of the active satellite repeater, regardless of the channel assignments made by the channel user of the system. Table V shows a summary of the communications capability.

TABLE V

Communications Capability of Saturn B_2 Satellite System
7800 Lbs. in 24-Hour Orbit

Terminals		Channel Capacities	
		Voice	Video
I.	Ground to ground (60' dish)	1200 + 2* 40 db AJ	10 + 2*
II.	Satellite to mobile (2' dish)	120 + 2* 30 db AJ	10 + 2*
III.	Communications Satellite to Communications Satellite	120 + 2* 30 db AJ	10 + 2*
IV.	Reconnaissance Satellite to Communications Satellite		2*

10 rf channels @ 8 kmc
*2 rf channels @ 12 kmc
100 watts each
12,000 watts primary power

4.2 Weight Estimate of the Communications Satellite

Table VI shown the weight estimate for the system.

TABLE VI

Weight Breakdown for Saturn B_2 Satellite

Equipment	Weight (Lbs.)	% of Total
Communications	1800	55
Power Supply	2500	
Station-keeping, attitude control, etc.	2500	45
Antennas and structure	1000	
Total	7800	100

4.3 Required Launch Vehicles

Six complete satellite payloads in orbit will be required to achieve all R&D objectives. The total number of launch vehicles will depend on the reliability of booster and upper stages.

4.4 Launch Schedule

Satellite payloads can be made available by early 1964. Launching should be scheduled to begin after completion of the earlier 5200-pound test phase, at a rate of approximately one every two months.

4.5 Cost Estimate

Cost for development and fabrication of six complete satellite payloads is estimated to be $60,000,000. Cost for procurement of vehicles and launch cost are not included.

5. Summary of Communications Capability

In order to allow a comparative evaluation of the capabilities and advantages of large boosters for communications satellite applications, the data discussed in the previous paragraphs are summarized in Table VII. Table VII follows.

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TABLE VII

Military Communications Capability Active Satellites
24-Hour Orbits

		ATLAS-CENTAUR 1200 lb.		SATURN B_1 (3-stage) 5200 lb.		SATURN B_1 (4-stage) 7800 lb.	
		Voice	Video	Voice	Video	Voice	Video
I.	Ground to ground (60' dish)	96 30 db AJ	0	960 40 db AJ	8	1200 + 2* 40 db AJ	10 + 2*
II.	Satellite to mobile (2' dish)	0	0	96 30 db AJ	8	120 + 2* 30 db AJ	10 + 2*
III.	Communications satellite to communications satellite	0	0	96 30 db AJ	8	120 + 2* 30 db AJ	10 + 2*
IV.	Reconnaissance satellite to communications satellite		0		0		2*
		8 rf channels @ 2 kmc 1 watt each 280 watts primary power		8 rf channels @ 8 kmc 100 watts each 8000 watts primary power		10 rf channels @ 8 kmc *2 rf channels @ 12 kmc 100 watts each 12,000 watts primary power	

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Table VIII represents the respective weights.

TABLE VIII

Military Communications Satellites

24-Hour Orbits

Components	ATLAS-CENTAUR Weight (Lbs.)	SATURN B_1 Weight (Lbs.)	SATURN B_2 Weight (Lbs.)
Communications	170	1200	1800
Power supply	280	1500	2500
Station-keeping, attitude control, etc.	560	2000	2500
Antennas and structures	190	500	1000
TOTALS	1200	5200	7800

It can be concluded from the discussion and the summary tables that there is a definite need for large boosters for military communications application. The data in this report should only be considered as a reasonably realistic estimate of the communications capabilities requirements and weights required for the various communications satellite systems contemplated. The building block approach to the design permits a flexible application of the capabilities of each satellite to meet the military needs as they may crystallize during the time span required for the design of the system. This approach also provides flexibility as to the weight of the payload into orbit and furthermore may allow for the possibility of combining a communications satellite with other payloads as may be desired in the future. Also, in an operational system, the larger number of similar channels provide redundancy which in turn enhances the inherent reliability of such a satellite system. Some of the additional weight which can be provided by the larger boosters will be used to build inherently more reliable systems of longer useful life so that the economics of firing the booster will not be overshadowed by the reliability aspects of keeping a communications satellite in operation in orbit.

The above discussion indicates that even such a large orbital payload as 7800 pounds in orbit will not satisfy all of the military needs which are reasonably expected for the period under consideration. Whereas the number of voice channels and teletype channels appears to be adequate for some time to come, additional requirements will develop on world-wide video channels and particularly on relay links for information and command of military satellites and space vehicles of differant kinds, particularly in the area of relay of information from reconnaissance and early warning satellites. Employment of large military space stations, and later on, deep space probes, will require communication and data links which would advantageously operate in frequency ranges above 10 kmc. These very high microwave frequencies will not penetrate the ionosphere, but will allow high gain antennas of reasonable size and very long ranges and limited rf power.

Communications satellites of such capabilities are beyond the payload capability of even the Saturn B_1 vehicle.

Dyna Soar

A. Integrated listing of possible missions

1. Global Dyna Soar Military Test System

2. Interim Weapon System utilizing a maximum of DS Test System Hardware. Possible missions are

   a. Reconnaissance
   b. Satellite Inspector
   c. Earth-to-orbit transport

B. Description of Missions, Payload, and Development Plan

1. Dyna Soar Program. The objective of the DS program is to exploit military weapon systems operating in the hypersonic and orbital flight regimes. The DS Program is comprised of three steps, which are scheduled so that significant data from the previous step is available prior to comitting large amounts of money on a subsequent step. The following describes those steps.

a. Step I. - The objective of Step I is to explore the flight regime, demonstrate maneuverability, demonstrate controlled landing, and perform testing with an approximately 330 ft^2 single place hypersonic glider. That glider is sized by the 1000# test payload; the maximum gross weight will be approximately 10,000#. The booster will be a modified Titan ICBM and impart velocities of 19,500 to 22,000 ft/sec to the glider, dependent upon glider loading. The aforementioned velocities are less than orbital and as a result, Step I will fly on the Atlantic Missile Range only; the glider, however, will be designed for reentry from orbit. Figure 1 shows the schedule for Step I and subsequent steps.

b. Step II. - Step II is subdivided into Step IIA and Step IIB. Possible application of the Saturn vehicle to Dyna Soar are to be found in Step II.

Step IIA. - Step IIA is a military test system which representa a logical extension of Step I, previously described. Step IIA will utilize the same basic glider (330 ft^2 - 10,000#) as employed in Step I but with a bigger booster to provide global and/or orbital capability. The objectives of Step IIA will be to explore the remainder of the flight regime from 22,000 ft/sec to orbital velocities and gather data on reentry of the glider from various orbits. In addition, military sub-system testing will include the testing of multiple reconnaissance sensors, rendezvous equipment, etc.; the feasibility of various military missions can be confirmed during Step IIA.

As stated earlier, the basic Step I, 10,000# glider will be employed in Step IIA. In order to accomplish some of the military testing required and to provide some maneuver capability in orbit, additional payload is desired. That payload will be carried in a "trailer" attached to the glider and jettisoned prior to reentry. The glider-trailer concept has great flexibility and will allow a variety of payloads to be carried for different test missions. It is currently estimated that the total booster payload for Step IIA will be in the range of 10,000 to 15,000 lbs. (glider included); the wing area will remain at about 330 ft^2. The booster will be fired eastward from Cape Canaveral during the R&D program. Figure 1 shows the schedule for Step IIA; it is to be noted that the decision to allocate funds for large scale hardware development is not required until after the first manned flight of Step I, and that one year is allowed between the last flight of Step I, and the first global flight in Step II. Step IIA is currently in the planning stage; present estimates are that a B launch program, over 21 months, provides a logical follow-on to Step I.

The schedule shown in Figure 1 assumes that the Dyna Soar will utilize a booster from the National Booster Program which is already in development and capable of flying the DS glider. The decision lead times shown allow for only reorder time on hardware parts.

Step IIB. - Step IIB is an interim weapons systems application of Dyna Soar and is in the study stage. It is to utilize most of the same hardware as Step IIA and to provide a limited weapons system capability. Step IIB is shown in Figure 1 as lagging Step IIA, from which it must draw data. At the present time, no specific applications of Dyna Soar have been chosen but the three most promising are for reconnaissance, satellite inspection, and earth-to-orbit transport.

The same "glider-trailer" concept of carrying additional booster payload (as described above for Step IIA) will be utilized in Step IIB. Though the same basic glider (330 ft^2 and 10,000#) will be employed, it is natural to expect a more serious rearrangement of equipment between the glider and trailer than for the test system IIA. In most cases, the glider will be capable of approximately a 12-hour mission, if desired.

The payload requirement for Dyna Soar Step II vehicles is estimated at 15,000 to 20,000 lbs. (330 ft^2) in a polar orbit at approximately 70-150 n. mi. The additional payload required for the weapons system over the test system is largely required for increased maneuverability in orbit in the case of the satellite inspector, and partially so in the case of the reconnaissance and earth-to-orbit transport. The best method of providing that maneuverability is still under study; however, from the booster stanpoint, the use of the last stage tankage and/or engines, or portions thereof, is attractive.

The desired launch requirements for Step IIB are the following:

i. Polar orbit.
ii. As close to 360° launch freedom as possible (Inspector).
iii. Operate from a soft site on a peactime basis.
iv. Launch approximately 1 flight/wk.
v. Provide the most economical boost capability consistent with previous requirements.

c. Step III. - The objective of Step III is to provide a fully qualified weapon systems based on Dyna Soar technology. Step III is in the study stage at this time.

The tentative launch requirements for a Step III weapon system are 360° azimuth launch, 90° inclination orbits, no booster fallout on the continental USA, soft launch site, and sustained launch rate. The aforementioned general requirements for a booster for Step III weapons system (together with the current estimation of the availability date for the weapons system (see Figure 1) favor a more sophisticated Recoverable Booster Support System (RBSS)). Although continuing studies will consider all applicable boosters in the National Booster Program, it is currently felt that Dyna Soar Step III weapons systems may not be adaptable to Saturn-type boosters.

C. The Effect on Saturn Boosters

1. General Comment

As stated previously, the possible applications to Dyna Soar are to be found in Step IIA and Step IIB. It should be specifically understood that the USAF has made no decisions relative to the use of Saturn, or parts thereof, relative to other boosters for Step IIA and IIB. As a part of the USAF Step IIA study, a booster study and detailed evaluation will be undertaken and will consider performance, economy, availability, program interference, etc.; the study and evaluation will be completed in approximately July 1960.

2. Effect of Dyna Soar Step II Characteristics on Saturn.

a. <u>Payload Capability.</u> - The 330 ft^2 wing on the glider requires a stronger structure to offset the increased bending moment about the booster/glider center of gravity; available data indicate that the 3-stage 120" Saturn is capable of flying a 250 ft^2 glider; this capability is not adequate for DS. If the Centaur stage is removed, then the reduced moment allows a 2-stage Saturn to fly gliders at substantially greater than 250 ft^2 wing area. Presuming this to be adequate for Dyna Soar, the 2-stage Saturns could be employed for Step IIA only.

Even though adequate for Step IIA, the desirability of utilizing the same booster for Steps IIA and IIB and the desirability of using a portion of a high energy third stage to provide maneuverability in orbit tend to preclude the choice of 120@ upper stages.

The Saturn configuration with 160"/120" upper stages have adequate payload capability, and 200" upper stages have more than adequate payload capability.

b. <u>Use of Upper Stages Alone.</u> - Since the upper stages of Saturn are capable of boosting certain Dyna Soar configurations as first and second stages alone, without the 1.5×10^6# booster, serious consideration must be accorded this possibility.

The 120" stages are adequate for DS Step I.

The 160" stages are adequate for Step IIA and for limited application in Step IIB. It is mandatory, however, to develop a 160" hydrogen-oxygen stage as a second stage (third stage on Saturn); that stage should have approximately 80,000 thrust and about 70,000# of propellant. With the development of a 150,000 Lox-H_2 engine and a new 160" stage, (substituted for the 80,000 stage), it is estimated that the 160" 2-stage booster with four engines would be fully adequate for Step IIB. It is fully recognized that the usual Saturn upper stages, ground launched, would require a major development program. To balance that cost, however, is the high cost of flying hardware if a program of one launch/week (Step IIB) is prosecuted. It is not known where the break-even point lies; current studies will provide the answer by July 1960. Many of the same arguments used relative to the 160" dia. stages are applicable to the 220" stages. However, less modifications are required on the 220" version. In general, the 200" stages will be adequate for both Steps IIA and IIB. Because of the larger diameter and the combined ability to hold hydrogen better and resist bending moments, the 220" 2-stage booster should show even greater advantage over the 160" 2-stage booster if 150,000 were installed in Stage II. Answers to break-even points on cost must await completion of the study mentioned above. The use of 220" stages would, however, occasion additional costs due to logistics and facilities problems not so serious in the 160" version.

3. Reliability and Safety.

The Saturn configurations would have to have the rocket engines man-rated prior to use in Dyna Soar. Man-rating is still somewhat vague, but involves malfunction analysis, testing at engine limits, malfunction detection equipment test, etc. The number of flights required prior to manned flight cannot be estimated now.

The winged glider "up front" induces a much higher destabilizing moment than normally occurs with conventional payloads. These destabilizing moments can be offset by the control authority of the rocket engines through artificial stability loops. Should an engine failure or control system failure occur, however, little time is available to escape. It is a requirement of a Dyna Soar booster to be equipped with static fins such that the booster glider is statically stable, affording a much higher safety margin in the event of failure.

Regardless of the presence of fins, during the staging operation (first and second stage) there will be a short period of time between first stage separation and effective thrust control of the Stage II engine. It is desired that the time of no control be minimized to reduce the divergence between the glider and the upper stages to a minimum. Specific consideration should be given to the staging problem with a winged glider on various Saturn configurations.

4. Growth Potential.

The 120" version has no great potential for Dyna Soar.

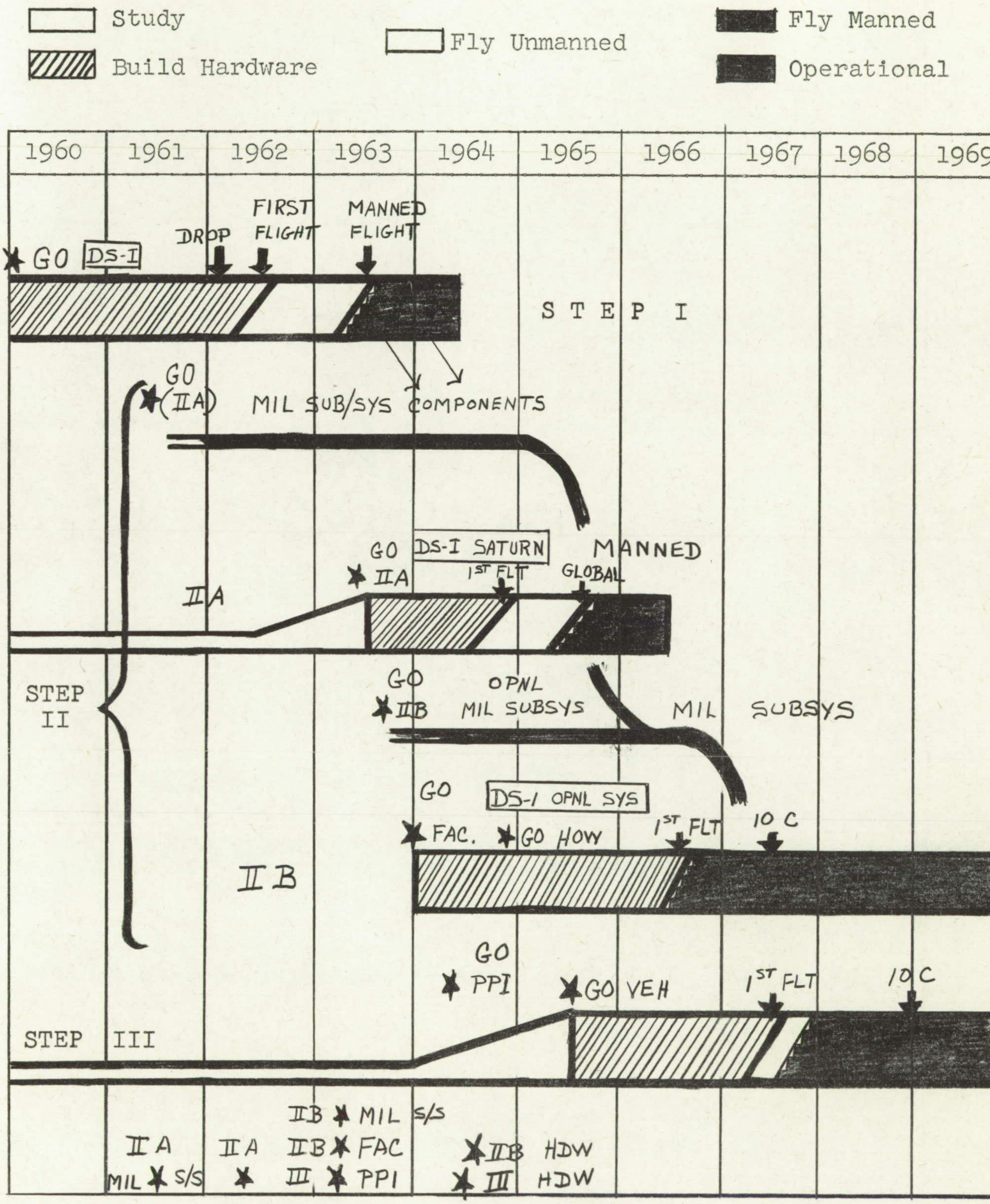
The 160" upper stages could grow by developing a 160" hydrogen-oxygen stage and replacing the 120" lengthened Centaur with it. The added diameter provides for higher stiffness, shorter moment arm to c.g., and larger hydrogen capacity.

The growth potential of the 220" version of Saturn is large; however, the necessity for that growth potential in Dyna Soar is questionable.

5. Schedules

Figure 1 presents the schedules of Dyna Soar Step I, II, and III. The Step IIA schedule calls for first flight in third quarter of 1964, just when the Saturn is finishing its 10-flight R&D program. Additional testing beyond the 10-flight R&D program would probably slip the Dyna Soar Global flight date to some degree. In general, there is a compatability between the Saturn and Dyna Soar schedules.

DYNA SOAR SCHEDULES



DECISION TO ALLOCATE FUNDS