NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

COMMUNICATIONS SATELLITE HANDBOOK

A BRIEF REFERENCE TO CURRENT PROGRAMS

Get D.R.A. after checking

JULY 1970

REVISION 3

PREPARED BY FLIGHT SUPPORT DIVISION

MANNED SPACECRAFT CENTER

HOUSTON, TEXAS

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FOREWORD

This Document has been prepared in order to inform interested personnel of the various communications satellite programs currently in existence and of those being planned for the future.

It has been the intent here to present only the major programs or studies in existence and it should be understood that numerous other studies are being made and other systems are being proposed. The outlines listed here include NASA Programs, DOD Programs and commercial programs in order to inform the reader of the type of work being accomplished and/or contemplated.

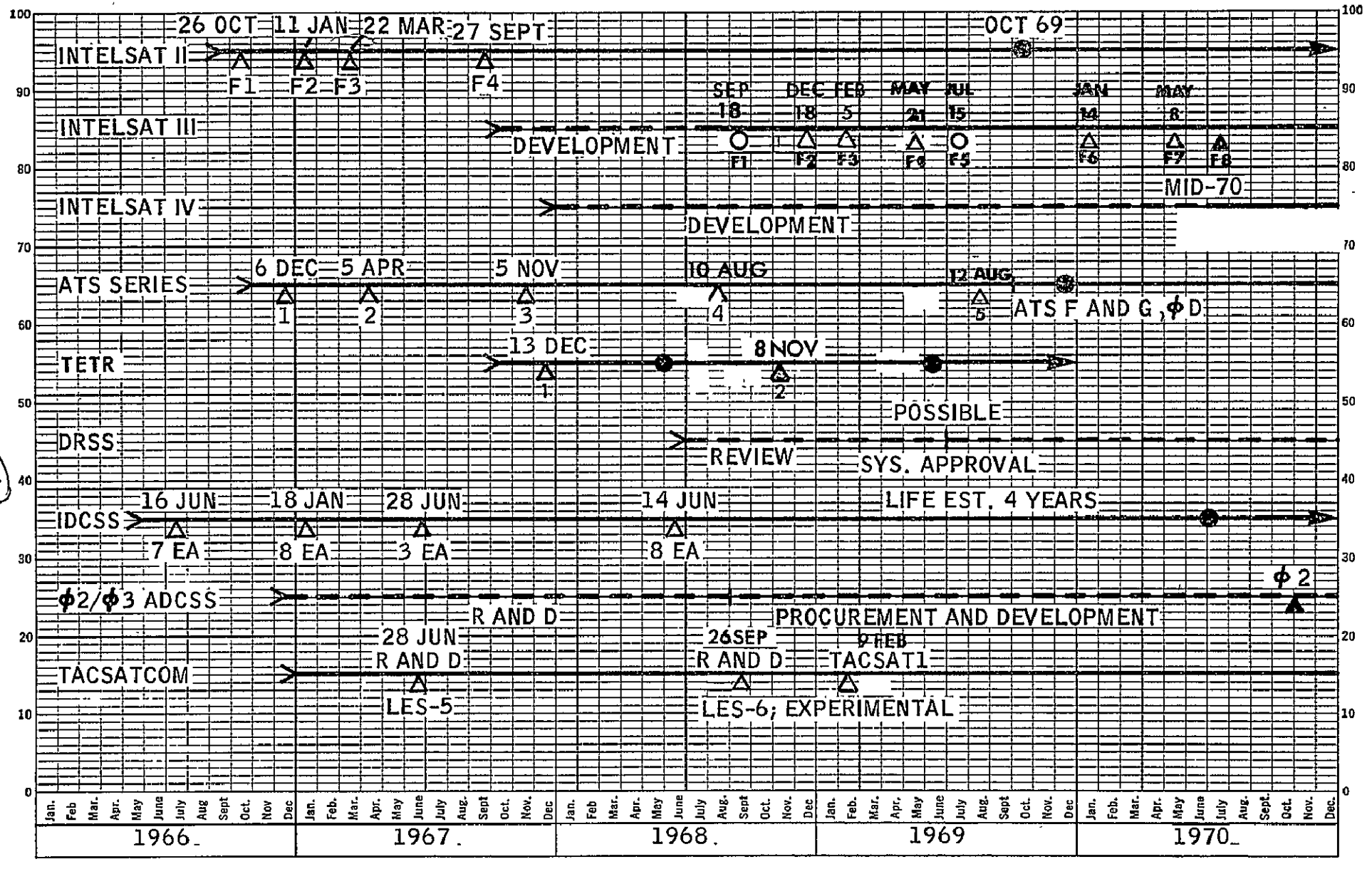
The information furnished is quite general and any questions which arise of a more technical nature should be directed to Mr. Kenneth W. Wildman, Flight Support Division, Systems Engineering Branch, Communications Systems Section, extension 6128. Additional information will be supplied if available.

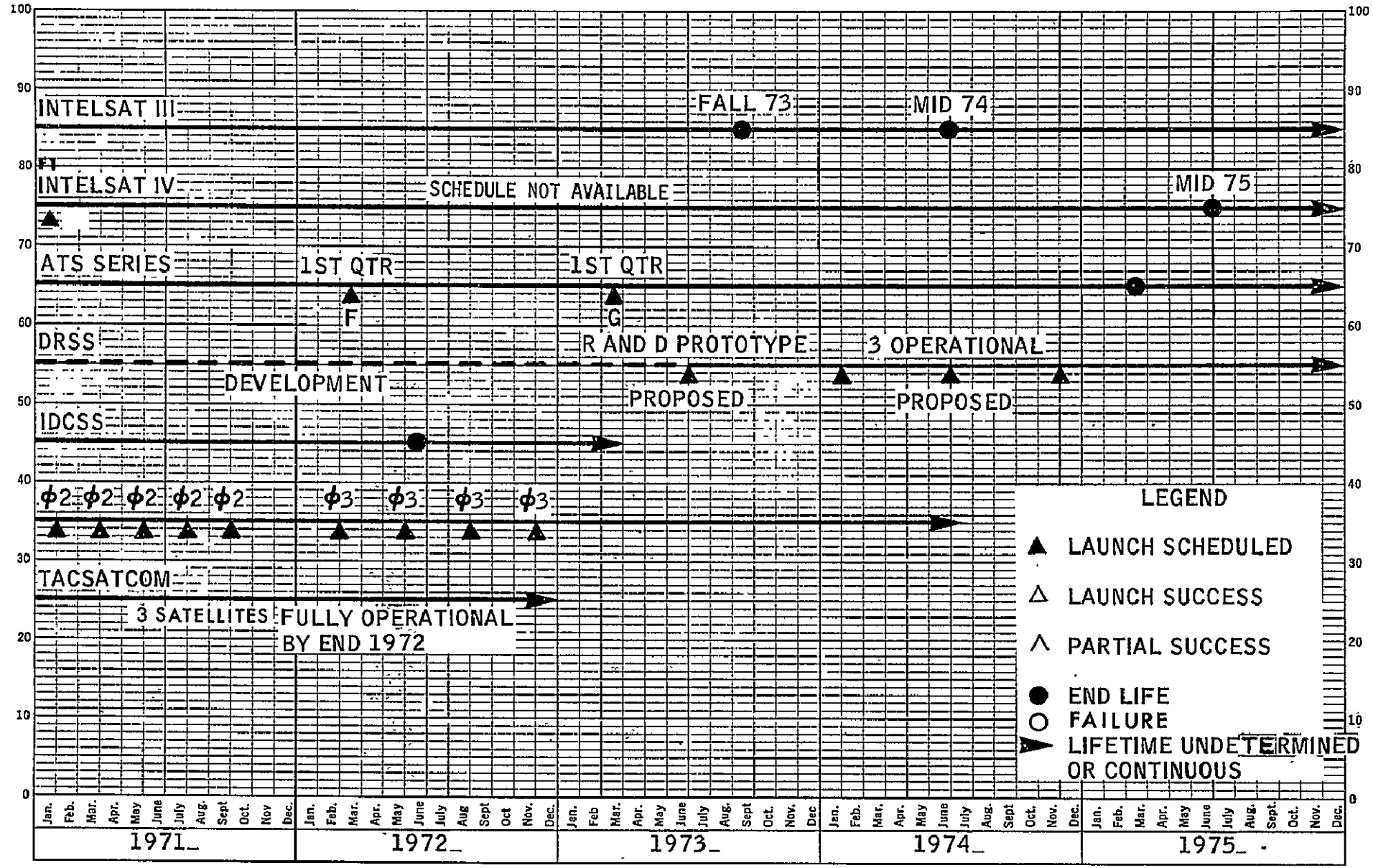
This document will be periodically updated as the various existing programs progress or as new significant programs are announced.

ACKNOWLEDGEMENT

Acknowledgement is made to Mr. Joseph G. Sobala, mail code 843, Goddard Space Flight Center, for his assistance in the revision of this document.

LAUNCH SCHEDULES




INTELSAT III
FALL 73
MID 74
F1
INTELSAT IV
SCHEDULE NOT AVAILABLE
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OR CONTINUOUS
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W O R L D L I S T I N G

LISTING OF EXISTING AND PROPOSED EARTH STATIONS THROUGH 1972

	COUNTRY	STANDARD STATION	REGION	DATE OF OPERATION	S O U R C E
1.	ALGERIA (Algiers)	x	ATLANTIC	1972	World Plan Meeting 11/67
2.	ARGENTINA* (Balcarce)	x	ATLANTIC	15 Sept. 1969	
3.	AUSTRALIA				
	Carnarvon 1*	+Non-standard	PACIFIC	4 Feb. 1967	
	A. =Carnarvon 2*	x	PACIFIC	1 Oct. 1969	
	B. Moree*	x	PACIFIC	23 May 1968	
	C. Ceduna*	x	INDIAN OCEAN	1969 (Dec.)	Application to I.C.S.C.
4.	BAHRAIN* (Ras Abu Jarjur)	x	INDIAN OCEAN	14 July 1969	
5.	BRAZIL* (Tangua)	x	ATLANTIC	22 Feb. 1969	
6.	CAMEROON (Yaoúnde)	x	ATLANTIC	1971 (July)	Letter from Director, POSTEL, Cameroon, 3/10/69
7.	CANADA				
	Mill Village 1*	x	ATLANTIC	24 Oct. 1966	
	Mill Village 2*	x	ATLANTIC	29 Jan. 1969	
8.	CHILE* (Longovilo)	x	ATLANTIC	22 July 1968	
9.	CHINA (Rep. of)* (Taipei)	x	PACIFIC	1969 (Dec.)	Telex from DirGen Telecomm Taipei, dated 5/11/69
10.	COLOMBIA* (Choconta)	x	ATLANTIC	1970 (Aug.)	Application to I.C.S.C.
11.	EAST AFRICA* (Mt. Margaret) (Kenya)	x	INDIAN OCEAN	1970 (May)	Kuwait Meeting 5/69
12.	ECUADOR (Quito)	x	ATLANTIC	1971	Letter from Minister of Public Works, 29/3/68

	COUNTRY	STANDARD STATION	REGION	DATE OF OPERATION	S O U R C E
13.	ETHIOPIA (Sululta)	x	ATLANTIC	1971	Telex sent by Aemro Araya, 13/5/68
14.	FRANCE				
	A. Pleumeur Bodou 1*	x	ATLANTIC	28 June 1965	
	=Pleumeur Bodou 2*	x	ATLANTIC	3 Nov. 1969	
	B. Martinique	x	ATLANTIC	mid-1971	French Representative to Atlantic Traffic Sub-Group Meeting 5/69
15.	GERMANY				
	Raisting 1*	x	ATLANTIC	28 June 1965	
	=Raisting 2*	x	INDIAN OCEAN	10 Oct. 1969	
16.	GREECE* (Thermopylae)	x	ATLANTIC	1970 (April)	Application to I.C.S.C.
17.	INDIA* (Arvi)	x	INDIAN OCEAN	1970 (March)	Kuwait Meeting 5/69
18.	INDONESIA				
	=Djatiluhur 1*	x	INDIAN OCEAN	19 Sept. 1969	
19.	=IRAN* (Asadabad)	x	ATLANTIC	4 Oct. 1969	
20.	ISRAEL (Emek Haela)	x	ATLANTIC	1972	Letter from Mr. N. Raz, Engineering Services, Israel 25/4/69
21.	ITALY				
	Fucino 1*	+Non-standard	ATLANTIC/ INDIAN OCEAN	28 June 1965	
	Fucino 2*	x	ATLANTIC	17 August 1967	
	Fucino 3*	x	INDIAN OCEAN	1970 (2nd Q)	Telex from Telespazio dated 1/9/69

	COUNTRY	STANDARD STATION	REGION	DATE OF OPERATION	S O U R C E
22.	IVORY COAST (Abidjan)	x	ATLANTIC	1971	Letter from Secretary of PTT, 8/5/68
23.	=JAMAICA (Morant)	x	ATLANTIC	1971 (Feb.)	Letter from Asst. Traffic Manager, Cable & Wireless Ltd., dated 6/10/69
24.	JAPAN				
	A. Ibaraki 2*	x	PACIFIC	26 March 1968	
	B. Yamaguchi*	x	INDIAN OCEAN	1 July 1969	
25.	=JORDAN* (Baga)	x	ATLANTIC	1970 (Oct.)	Application to I.C.S.C.
26.	KOREA (Rep. of)* (KumSan)	x	PACIFIC	1970 (Feb.)	Application to I.C.S.C.
27.	=KUWAIT* (Umm-Al-Aish)	x	INDIAN OCEAN	20 Oct. 1969	
28.	LEBANON* (Arbaniyeh)	x	ATLANTIC	7 Sept. 1969	
			INDIAN OCEAN	1970 (3rd Q) (Lebanon Earth Station will initially work Atlantic satellite, then Indian Ocean Region satellite at a later date.)	
29.	MALAYSIA* (Kuantan)	x	INDIAN OCEAN	1970 (March)	Application to I.C.S.C.
30.	MEXICO* (Tulancingo)	x	ATLANTIC	13 Jan. 1969	
31.	MOROCCO* (Sehouls)	x	ATLANTIC	1969 (Dec.)	Application to I.C.S.C.
32.	NETHERLANDS (Amsterdam)	x	ATLANTIC	1972 (4th Q)	Netherlands' Representative to the I.C.S.C. - 6/69
33.	NEW ZEALAND (Warkworth)	x	PACIFIC	1970 (4th Q)	Letter from Director General, GPO - 2/7/68

	COUNTRY	STANDARD STATION	REGION	DATE OF OPERATION	S O U R C E
34.	NIGERIA Lanlate 1	x	ATLANTIC	1970 (4th Q)	Letter dated 4/2/69 from General Manager, N.E.T., Ltd.
	NIGERIA Lanlate 2	x	INDIAN OCEAN	1971	Operations Representatives' Conference - Indian 5/68
35.	PAKISTAN				
	A. East (Rangamati)	x	INDIAN OCEAN	1971 (3rd Q)	(Kuwait Meeting 5/69
	B. West (Karachi)	x	INDIAN OCEAN	1971 (2nd Q)	(
36.	PANAMA* (Utibe)	x	ATLANTIC	7 Sept. 1968	
37.	PERU* (Lurin)	x	ATLANTIC	3 July 1969	
38.	PHILIPPINES				
	Tanay 1*	x	PACIFIC	28 April 1968	
	Tanay 2	x	INDIAN OCEAN	1970	Telex from POTELCO - 7/1/69
39.	SAUDI ARABIA* (Dahban-Jeddah)	x	ATLANTIC	1971	Application to I.C.S.C.
40.	SCANDINAVIA				
	Tanum, Sweden	x	ATLANTIC	1971 (4th Q)	Scandinavian Representative to the I.C.S.C. - 3/68
41.	SENEGAL (Dakar)	x	ATLANTIC	1971	Letter from Mr. N'Diaye - 6/5/68
42.	SINGAPORE	x	INDIAN OCEAN	1970 (Dec.)	Kuwait Meeting 5/69
43.	SPAIN				
	A. Canary Is. 1*	Non-standard	ATLANTIC	7 April 1967	
	=Canary Is. 2	x	ATLANTIC	1971	Telex from Operations Representative, CTNE 2/10/69

	COUNTRY	STANDARD STATION	REGION	DATE OF OPERATION	S O U R C E
43.	SPAIN (Cont.)				
	B. Buitrago 1*	x	ATLANTIC	11 Jan. 1968	
	Buitrago 2*	x	INDIAN OCEAN	1970 (April)	Application to I.C.S.C.
44.	SUDAN (Khartoum)	x	ATLANTIC	1972	Telex from Director, Dept. of PTT - 9/9/68
45.	SWITZERLAND (Bern)	x	ATLANTIC	1972	Swiss Representative to the I.C.S.C. - 3/68
46.	THAILAND				
	Si Racha 1*	x	PACIFIC	8 April 1968	
	Si Racha 2*	x	INDIAN OCEAN	1969 (Dec.)	Application to I.C.S.C.
47.	=TRINIDAD	x	ATLANTIC	1971 (April)	Letter from Asst. Traffic Manager, Cable & Wireless Ltd. - 6/10/69
48.	TURKEY (Ankara)	x	ATLANTIC	1972	World Plan Meeting - 11/67
49.	UNITED ARAB REPUBLIC(Cairo)	x	ATLANTIC	1972	Telex - 9/9/68
50.	UNITED KINGDOM				
	A. Ascension Is.*	Non-standard	ATLANTIC	7 April 1967	
	B. Goonhilly 1*	x	INDIAN OCEAN	1 July 1969	
	Goonhilly 2*	x	ATLANTIC	26 Nov. 1968 ø	
	C. Hong Kong 1*	x	PACIFIC	6 Sept. 1969	
	=Hong Kong 2	x	INDIAN OCEAN	1971 (Feb.)	Letter from Asst. Traffic Manager, Cable & Wireless, Ltd., - 6/10/69
51.	UNITED STATES				
	Andover*, Maine	+Non-standard	ATLANTIC	7 April 1967	
	A. Andover*, Maine	x	ATLANTIC	28 June 1965	
	B. Etam, W.Va.*	x	ATLANTIC	6 Jan. 1969	

	COUNTRY	STANDARD STATION	REGION	DATE OF OPERATION	S O U R C E
51.	UNITED STATES (Cont.)				
	C. Cayey, P.R.*	x	ATLANTIC	25 Jan. 1969	
	D. Alaska (Talkeetna)	x	PACIFIC	1970 (July)	Letter from Comsat to Manager - 25/10/69
	E. Brewster*, Wash.	x	PACIFIC	8 Dec. 1966	
	F. =Guam (Pulantat)*	x	PACIFIC	2 Nov. 1969	
	G. Jamesburg, Calif.*	x	PACIFIC	1 Dec. 1968	
	Paumalu*	+Non-standard	PACIFIC	3 Dec. 1966	
	H. Paumalu 1*Hawaii	x	PACIFIC	8 Dec. 1966	
	Paumalu 2*Hawaii	x	PACIFIC	1 Dec. 1968	
52.	VENEZUELA (Caracas)	x	ATLANTIC	1970 (4th Q)	Atlantic Traffic Sub-Group Meeting - 5/69
53.	VIET NAM (Rep. of)(Vung Tau)	x	PACIFIC	1971	Letter from Ministry of Communications and Transportation - 6/5/68
54.	ZAMBIA (Lusaka)	x	INDIAN OCEAN	1971	Operations Representatives' Conference - Indian - 3/69

* Approved by the I.C.S.C. for access to the space segment.
= Change from previous report.
\+ To be utilized primarily for TT&C.
Ø Goonhilly 1 originated service on 28 June 1965.

STANDARD STATION: 85 foot antenna or larger.

INTELSAT I
(EARLY BIRD)

PURPOSE: To provide the world's first communications satellite and to gain needed experience in operating a commercial COMSAT before, and as a stepping stone to a full scale system that is INTELSAT II. Experience gained was in the following:

1. Procurement of launch vehicles and services from NASA
2. The arrangements for international participation in COMSAT service.
3. Integration of COMSAT service with other communication services, distribution centrals, mechanical interfaces, etc.
4. FCC's approach to rate-setting for COMSAT services.

ORBIT: Geostationary

STABILIZATION: Spin

LOCATION: Atlantic Ocean - maintained between 25° W and 40° W Longitude

DESIGN LIFE: 18 months - system celebrated its third year of successful commercial service on April 6, 1968.

OPERATING FREQUENCY RANGE: S/C receives on 6301 ± 13 MHz, 6390 ± 13 MHz
S/C transmits on 4081 ± 13 MHz, 4161 ± 13 MHz

MODULATION: FM

DEVELOPER: Hughes Aircraft Company

SYSTEM: Two independent frequency translation repeaters, each with 25 MHz bandwidth; two 6 watt TWT's, one operating and one spare.

S/C TM XMTRS are either two microwave beacons or two 1.8 watt 136 MHz VHF XMTRS.

CIRCUIT CAPABILITY: System can relay commercial quality TV or provide up to 240 two-way, telephone grade, channels. One channel will simultaneously transmit 22 or more telegraph messages.

ONBOARD POWER: 45 watts from 6000 N-on-P body mounted solar cell array. Two nickel-cadmium batteries with total of 1.5 amp/hour capacity; no eclipse operation capability.

LAUNCH DATE: April 6, 1965 (Atlantic I) by a thrust augmented Delta Rocket. Commercial operation was initiated on June 28, 1965.

USER: United States and European commercial carriers. Of the 240 circuits available, initially 66 were used for telephone and record. This total has grown to 148 presently. TV use has grown from 31 programs taking up 35 hours leased time in 1965, to 90 programs and 80 hours in 1966, to approximately 160 programs and 125 hours in 1967.

ANTENNA: S/C utilizes an omni directional receive antenna with a gain of 4db and a co-linear slot array transmit antenna with 9db gain and an 11° squinted beam with 6 watts ERP.

REMARKS: S/C Control System utilizes two independent H_2 O_2 fueled systems with a predicted station-keeping lifetime of three years. Maneuvers are required at 8 to 9 month intervals.

Total system outage time has been approximately one percent with all of this being attributable to the five participating Earth Stations and the U. S./European Interconnects. The satellite contribution to out-of-service time has been zero.

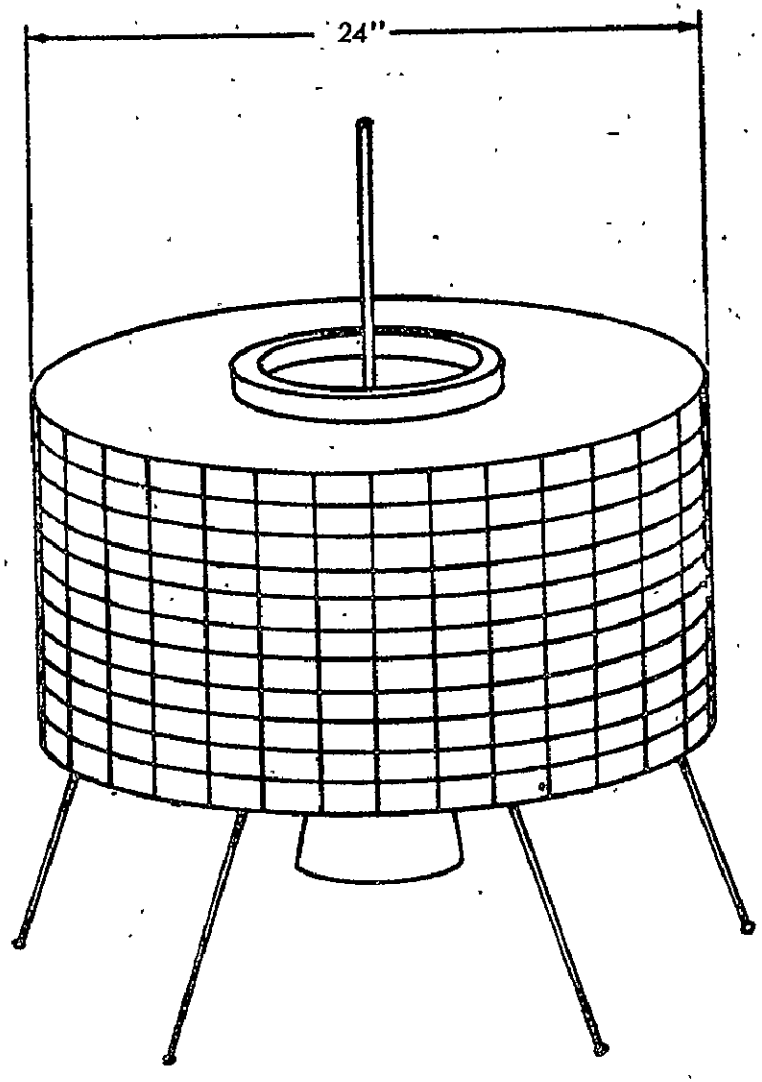
S/C provided the first computer-to-computer data exchange.

Longitude drift per day - $.014^{\circ}$W.

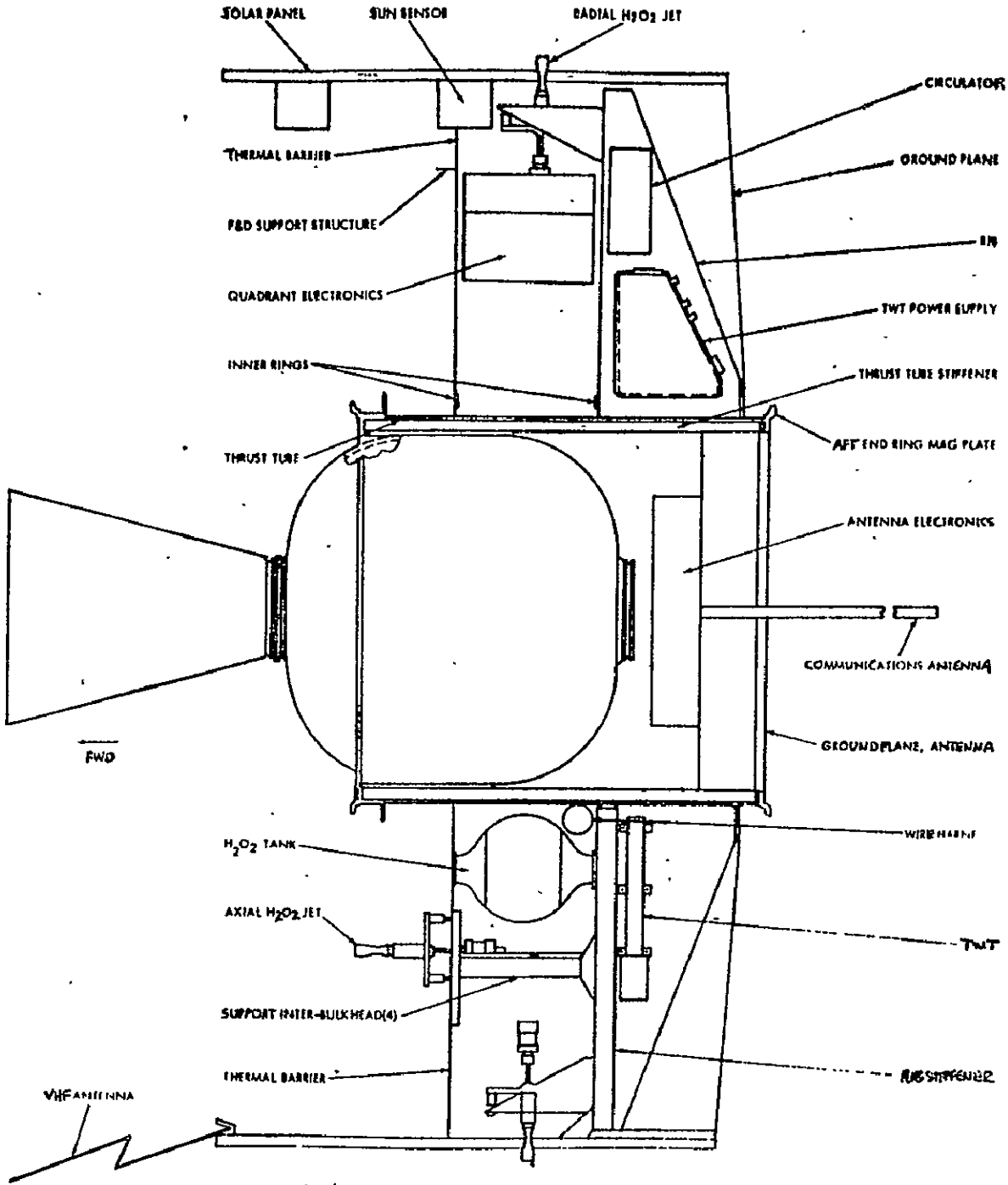
Inclination of orbit plane - 1.86°.

Declination - -89.8°.

S/C weighs 85# in orbit and is 24 inches in diameter.



SPACECRAFT



INTERNAL ARRANGEMENT OF SPACECRAFT

INTELSAT II

PURPOSE: First commercial communications satellite system to provide commercial telephone, television, and teletype (TTY) service on a 24 hour/day basis.

ORBIT: Geostationary

STABILIZATION: Spin. System uses a hydrogen peroxide sub-system for station keeping and attitude control.

LOCATION: F1 - Elliptical orbit
F2 - 176° East Longitude (maintained between 174° E and 176° E)
F3 - 6° West Longitude (maintained between 1.5° W and 11.5° W)
F4 - 174° East Longitude approximately; maintained within 1-2° of F2.

DESIGN LIFE: Three years

OPERATING FREQUENCY RANGE: S/C receives from 6.283 to 6.409 GHz (X-band)
S/C transmits from 4.058 to 4.186 GHz (X-band)

BASE BAND MODULATION: FM

DEVELOPER: Hughes Aircraft Company

SYSTEM: Active Repeater - Two Redundant Linear Repeaters, each with 126 MHz bandwidth. Four 6-watt "TWT's", one, two, three, or four operating at a time. System includes two microwave telemetry beacons and two 1.8 watt 136 MHz VHF telemetry transmitters.

CIRCUIT CAPABILITY: 240/Satellite (Voice) or
1 Satellite (TV)

ONBOARD POWER: 100 watts from 12,756, N-on-P Solar Cell Array. Two rechargeable nickel-cadmium batteries with 9 ampere-hour capacity to power 3 TWT's and repeaters through eclipse.

Atlantic Satellite:
- Power available with one carrier - 35.5 watts
- Power available with multiple carriers - 25 watts
- Power needed to provide:
  - 14 channels to ships and islands - 11.7 watts
  - 14 channels to Andover - 2.8 watts
  - Power remaining for other services - 10.5 watts

Pacific Satellite:
- Power available - Same as Atlantic
- Power needed to provide:
  - 7 channels to ship - 5.8 watts
  - 7 channels to CRO - 1.4 watts
  - 14 channels to Brewster - 2.8 watts
  - Power remaining for other services - 15 watts

LAUNCH DATES: 1 - October 1966 - Partial success
1 - January 11, 1967 - Success (Pacific I)
1 - March 22, 1967 - Success (Atlantic II)
1 - September 27, 1967 - Successful (Pacific II); completed the INTELSAT II system

USERS: DOD leased 40 circuits (Pacific)
DOD leased 4 circuits (Atlantic)
NASA leased 12 V/D and 8 TTY circuits (Pacific)
NASA leased 12 V/D and 8 TTY circuits (Atlantic)
INTELSAT Countries
Commercial Carriers

ANTENNA: Microwave antenna is an 18" electronically despun multiple element biconical horn which is linear polarized for transmitting and orthogonal polarized for receiving. It has an ERP of 15 watts and a gain of 8 db. The transmit portion has a 12° beam centered at the equator.

REMARKS: NASA has leased for the use of a specific amount of power through a satellite as well as a particular number of circuits.

F-4 was launched for commercial service only, with some circuits leased by DOD. NASA will not utilize this satellite unless it is strictly on a commercial basis.

S/C weighs 195# in orbit and 357# at launch, is cylindrical, 56" in diameter and 26.5" high.

S/C launched by a Thrust Augmented Delta Rocket.

Pacific satellites provide communications primarily to Japan, Thailand and the Philippines.

A BETTER QUALITY OF THESE

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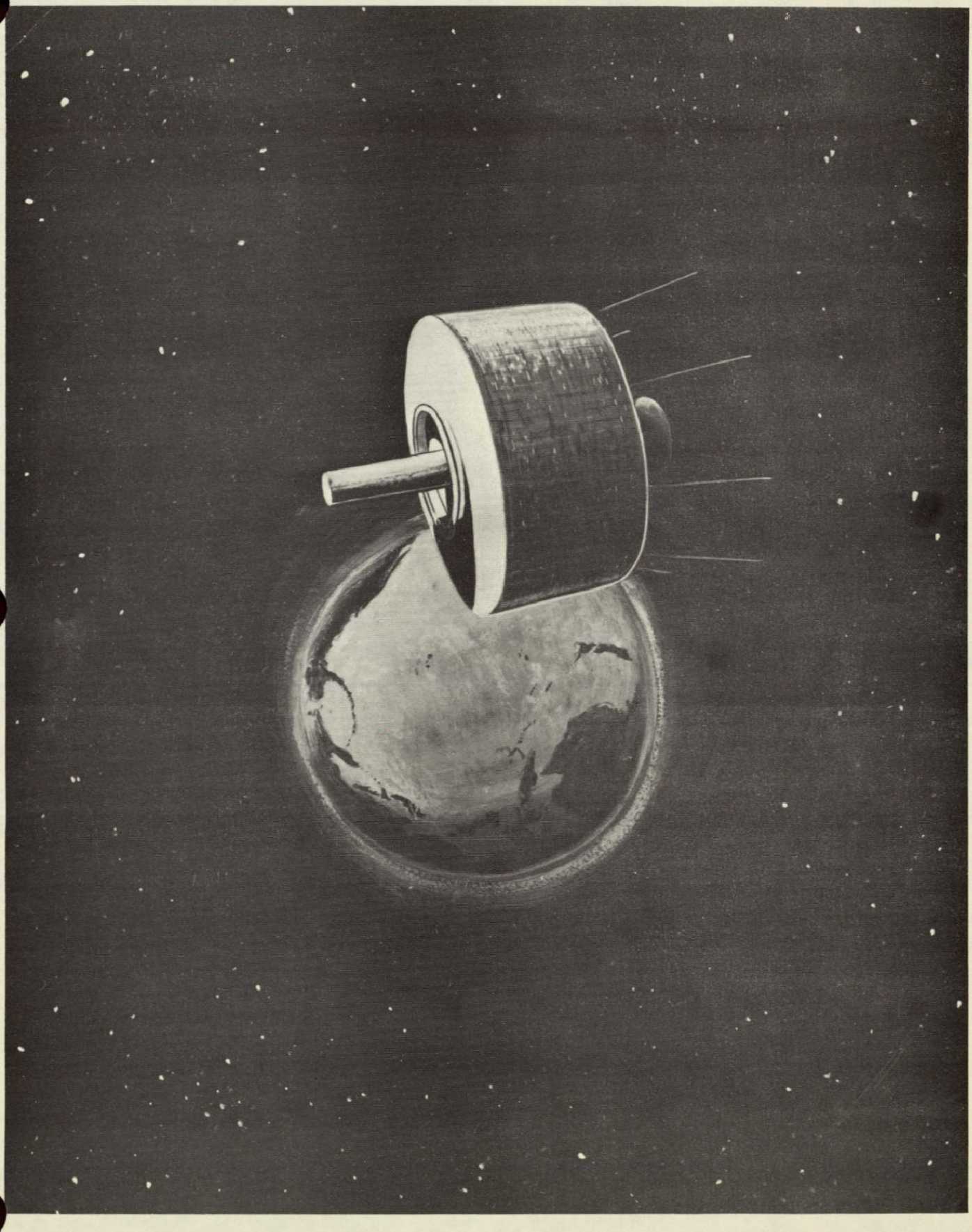
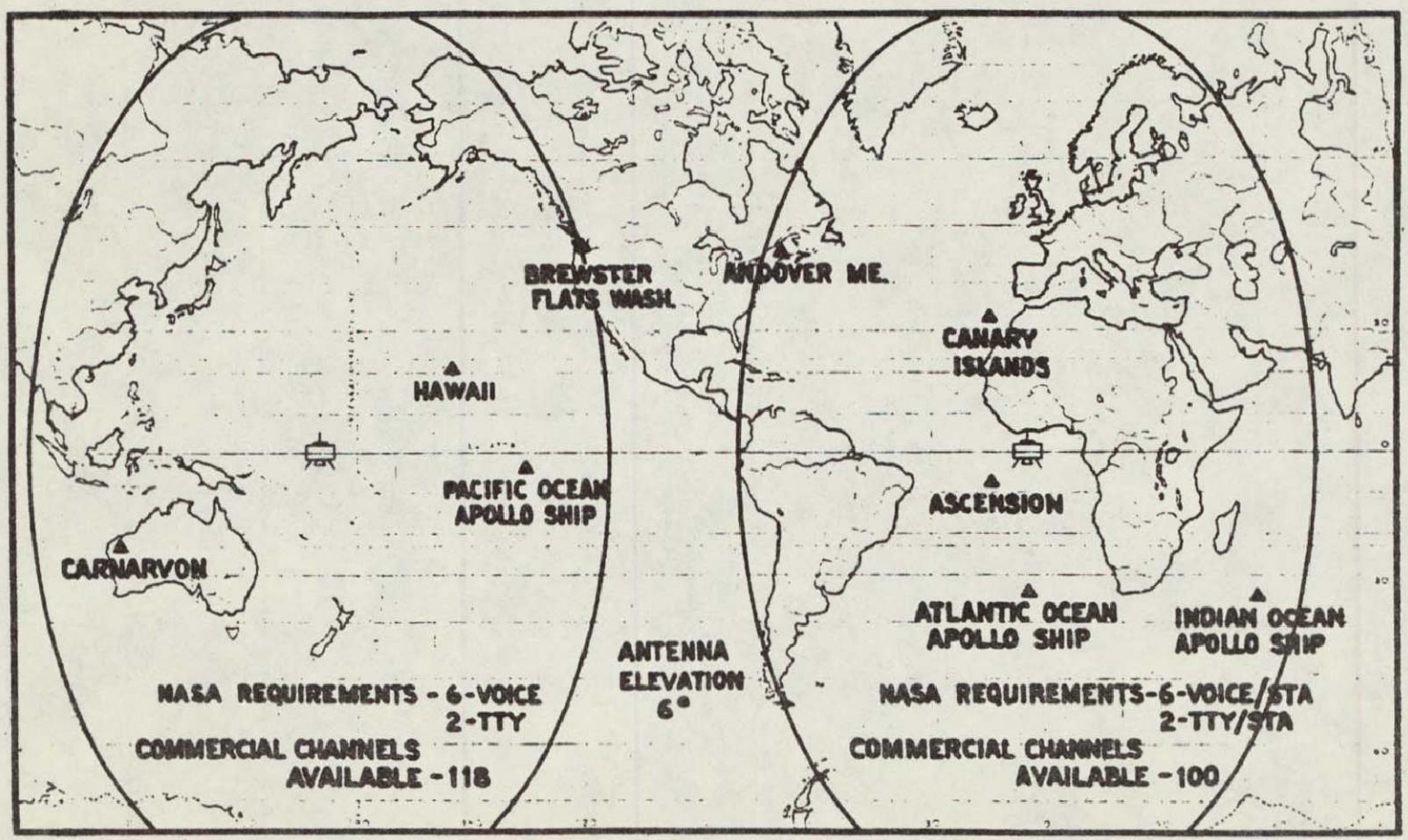


APOLLO COMMUNICATIONS SUPPORT

INTELSAT
II



INTELSAT III

PURPOSE: Basically the same as Intelsat II except that this is an interim "Global System" and has been designed from the start as a commercial system.

ORBIT: Geostationary - Insertion will be at a maximum of 30° inclination.

STABILIZATION: Spin from 65 to 117 rpm

LOCATION:
- F-1 Resulted in failure
- F-2 Over Atlantic at 30° West longitude
- F-3 Over Indian Ocean at 62.5° East longitude
- F-4 Over Pacific at 174° East longitude
- F-5 Resulted in Failure
- F-6 Over Atlantic at 24° West longitude
- F-7 Over Atlantic at 19° West longitude
- F-8 May be airborne spare

DESIGN LIFE: Five Years Minimum

OPERATING FREQUENCY RANGE: S/C transponder A transmits from 3.705 to 3.930 GHz and receives from 5.930 to 6.155 GHz.
S/C transponder B transmits from 3.970 to 4.195 GHz and receives from 6.195 to 6.420 GHz.
Command signals occur in the 6.155 to 6.195 GHz band.

MODULATION: FDM/FM
AM Commands
TDM Arrangements
IRIG Standard (PAM/FM/PM)

DEVELOPER: TRW Systems/ITT/Sylvania

SYSTEM: Active wide band linear repeaters providing two independent microwave channels each having greater than 225 MHZ bandwidth. They are identical except for operating frequency range.

Total ERP (effective radiated power) per transponder is 22.0 dbw.

Frequency response - ERP variation across each 225 MHz band is 2db peak to peak.

Receiver sensitivity - single carrier output C/N at an input density of -74.1 dbw/m^2 is 77.3 db at any point in the beam or any frequency.

SYSTEM (con't.): Gain - single carrier flux density required to saturate the final TWT of -74.1 dbw/m^2 at the center frequency.

System has 2 TWTS at 11 watts each.

CIRCUIT CAPABILITY: Primary modes of operation:

1. Single and multiple carrier analog transmission such as FDM/FM voice, FM monochrome or color TV.
2. Single or multiple carrier digital transmissions including TDM arrangements.
3. Combination of any of the above transmission types.

Specifics:

63 total telemetry channels available plus 7 spares.
30 separate command functions.
1000-1200 voice circuits with a capacity trade-off as follows:

900 standard telephone and one B&W TV channel.

600 standard telephone and two B&W TV channels. i.e., 300 duplex telephone circuits for one TV simplex channel.

ONBOARD POWER: N-on-P silicon solar cells providing the following:

Initially - from 181 watts at 90° sun angle to 162 watts at 66.5° sun angle.
After six years - from 148 watts at 90° sun angle to 132 watts at 66.5° sun angle.
Twenty cell Nickel-Cadimum, 9 amp hour battery. The steady state unregulared loads of the solar array and battery require 106 watts nominal in the primary bus.

LAUNCH DATES:
F1 - September 18, 1968 -failure
F2 - December 18, 1968 - sucessful
F3 - February 5, 1969 - sucessful
F4 - May 21, 1969 - sucessful
F5 - July 25, 1969 - failure
F6 - January,1970 - sucessful
F7 - May 8,1970 - sucessful
F8 -

USERS: Intelsat countries

ANTENNA: System utilizes a mechanically despun conical beam antenna for transmitting and receiving data and on omni directional command antenna.

The receive antenna is left hand circular polarized with a bandwidth of 5.925 - 6.425 GHz.

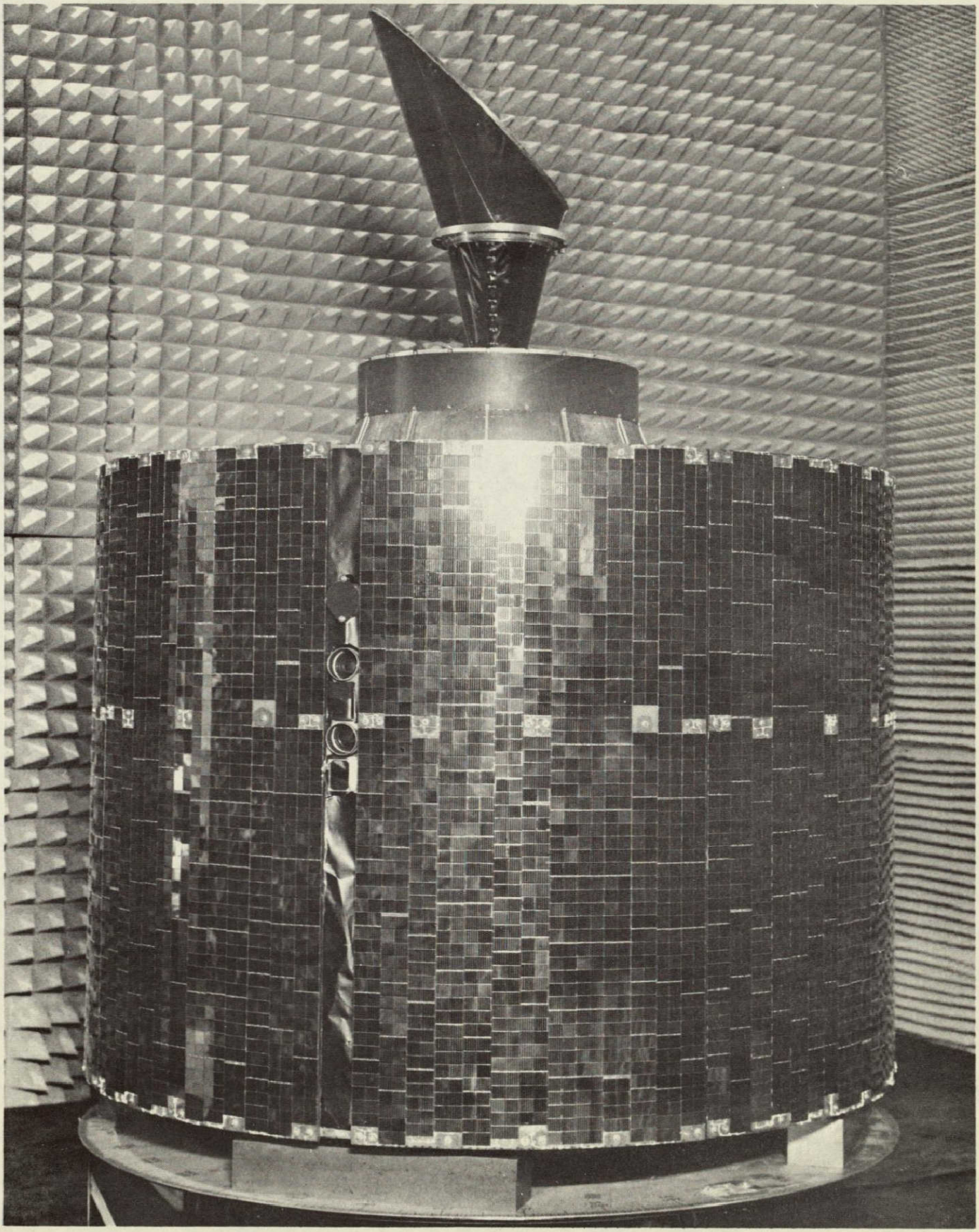
The transmit antenna is right hand circular polarized with a bandwidth of 3.700 - 4.200 GHz.

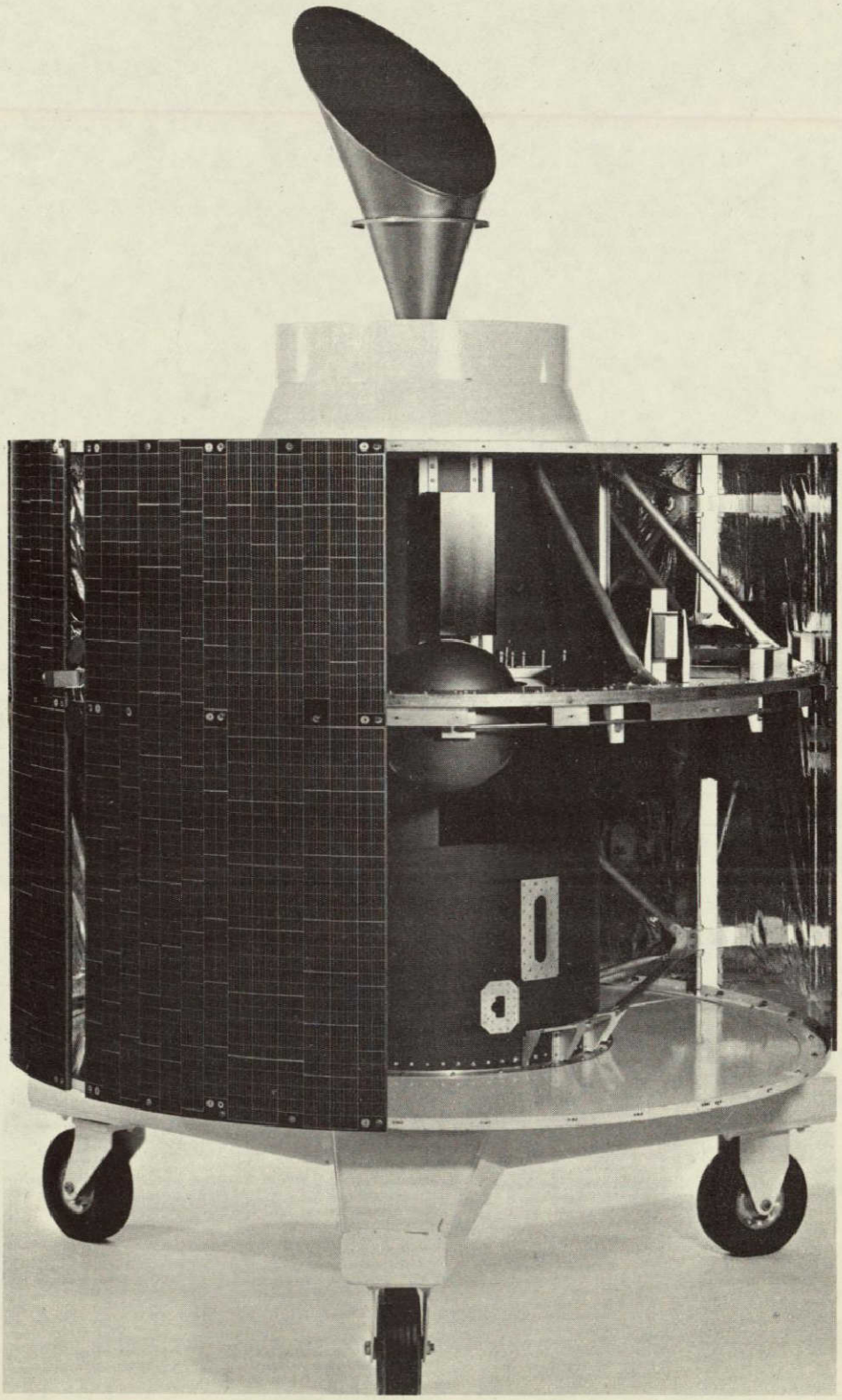
The command antenna is left hand circular polarized.

Receive and transmit antenna beamwidth is 19° (17° $\pm$ 1°).
Antenna gain is approximately 17 - 18 db.

REMARKS: S/C is 42.53" in hight (62.85" including antenna)
S/C is 56" in diameter
S/C weighs 608# at launch (268# satellite proper and 340# of Apogee motor)

Launch vehicle is improved Douglas Thor-Delta DV-3L





INTELSAT IV

PURPOSE: First multipurpose satellite system designed to replace INTELSAT III as a fully "Global System". The system will provide nearly simultaneous access by all users on a frequency/time sharing basis and will also be used for several special purpose communications roles.

ORBIT: Geostationary

STABILIZATION: Spin

LOCATION: Present plans for the five satellites are:

F-1 Over Atlantic January 1971

F-2 Over Pacific

F-3 In-orbit spare

F-4 In-orbit spare

F-5 Ground spare

DESIGN LIFE: Seven years

OPERATING FREQUENCY RANGE: Receive frequencies range from 5932 to 6418 MHz. Transmit frequencies range from 3707 to 4193 MHz. A single command frequency within the 6168 to 6182 MHZ band will be used.

MODULATION: FDM-FM Voice
FM TV
TDMA arrangements

DEVELOPER: Hughes Aircraft Co.

SYSTEM: The system will provide 12 transmission channels that maybe operated simultaneously. Each satellite will have two receive antennas and four transmit antennas. Two transmit antennas will provide global coverage and the other two will provide spot beam coverage.

CIRCUIT CAPABILITY: The spacecraft will have a capacity of 3,000 circuits with transponders in earth mode and 9,000 circuits with transponders in the spot beam coverage mode. 12 transponders provide 12 TV channels or 3,000 to 9,000 telephone circuits depending on mode or certin combinations thereof.

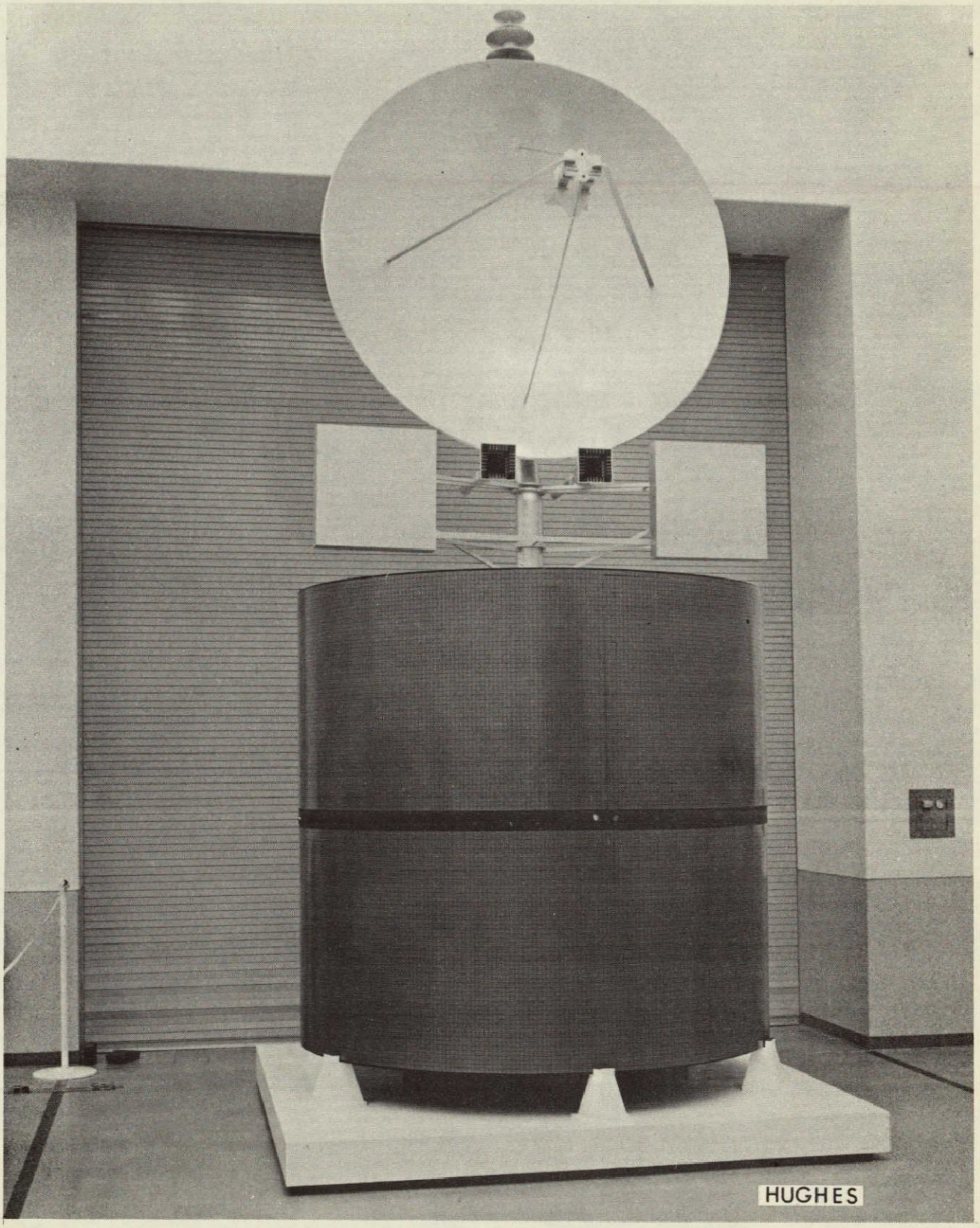
ONBOARD POWER: Silicon solar cells and nickel-cadmium battery cells.

LAUNCH DATES:
F-1 1st qtr 1971
F-2 2nd qtr 1971
F-3 4th qtr 1971
F-4 1st qtr 1972
F-5 as required

USERS: INTELSAT countries.

ANTENNAS:
2 Receive
2 Transmit, global coverage
2 Transmit, spot beam coverage

REMARKS: Launch vehicle will be an Atlas-Centaur.
Spacecraft will weigh approximately 3080 pounds at launch and 1584 pounds in orbit.
Spacecraft overall height 17.6 feet; Solar height 111 inches.
Spacecraft diameter 93.5 inches.


HUGHES

ATS SERIES

Application Technology Satellite

PURPOSE: Evaluation and development of advanced technology techniques and components for several space applications including future communication, meteorological, and navigation satellites. All flight models will investigate the transmission of TV, voice, telegraph, digital data, and facsimile.

GROUND STATIONS: Mojave, California - Prime, 40' Parabolic Dish

Kashima, Japan - for orbit determination data

Rosman, North Carolina - Prime, 85' Parabolic Dish

Cooby Creek, Australia - Prime, 40' Parabolic Dish

Standard "STADAN" network will support normal tracking and telemetry requirements

Certain missions will require additional station support

Commercial aircraft

ATS-1 (B)

PURPOSE: To operate and obtain useful data from a number of the application, technology, and scientific experiments to include meteorological TV, two-way voice between aircraft and ground, range and range rate calculations, antennas, and other technological and scientific experiments.

ORBIT: Near Geostationary (22,277 to 22,920 statue miles at an inclination of 2.1°).

STABILIZATION: Spin at approximately 100 RPM. System uses redundant hydrogen peroxide systems for station keeping and attitude control.

LOCATION: 149° West Longitude

DESIGN LIFE: Three years. Anticipated life is ten years.

OPERATING FREQUENCY RANGE: Microwave - a. 6 GHz Band Uplink
b. 4 GHz Band Downlink
VHF - a. 149.22 MHz Band Uplink
b. 135.60 MHz Band Downlink

MODULATION: Microwave – Frequency Translation Mode - FM
SSB - Multiple Access Mode - PM

DEVELOPER: Hughes Aircraft Company, JPL

SYSTEM: Two active microwave repeaters for SHF subsystem
VHF repeater for voice
4.2 watt transmitters for telemetry

CIRCUIT CAPABILITY: S/C - Multiple Access Mode
600 FDX Voice Channels
S/C - Frequency Translation Mode
1 Monochrome or Color TV Channel with an audio subchannel, telegraph, digital and facsimile data relay, wide band data
85' Ground Antenna (Rosman II)
SSB/PM 600 FDX Voice
FM/FM 600 FDX Voice and
1 Color TV Channel
45' Ground Antenna (Mojave II, Toowoomba)
SSB/PM 120 FDX Voice
FM/FM 1 Color TV Channel

ONBOARD POWER: 23,870 N-on-P solar cells array to provide 185 watts initial power and two 22 cell nickel - cadmium batteries.

LAUNCH DATE: December 6, 1966 - Successful

USERS: NASA - prime
Commercial airlines for testing purposes
ESSA
FAA
University of Wisconsin
Aerospace Corporation
Bell Telephone Labs
Rice University
Stanford University
UCLA
University of Minnesota

ANTENNA: Microwave system utilizes electronically despun antennas as follows:

a. Co-linear array for receiving
b. Phased array for transmitting

Antennas provide 14 db gain with a 24° beam.

VHF system utilizes an 8 element phased array antenna with a 10 db gain and a 10° beam for transmitting and receiving

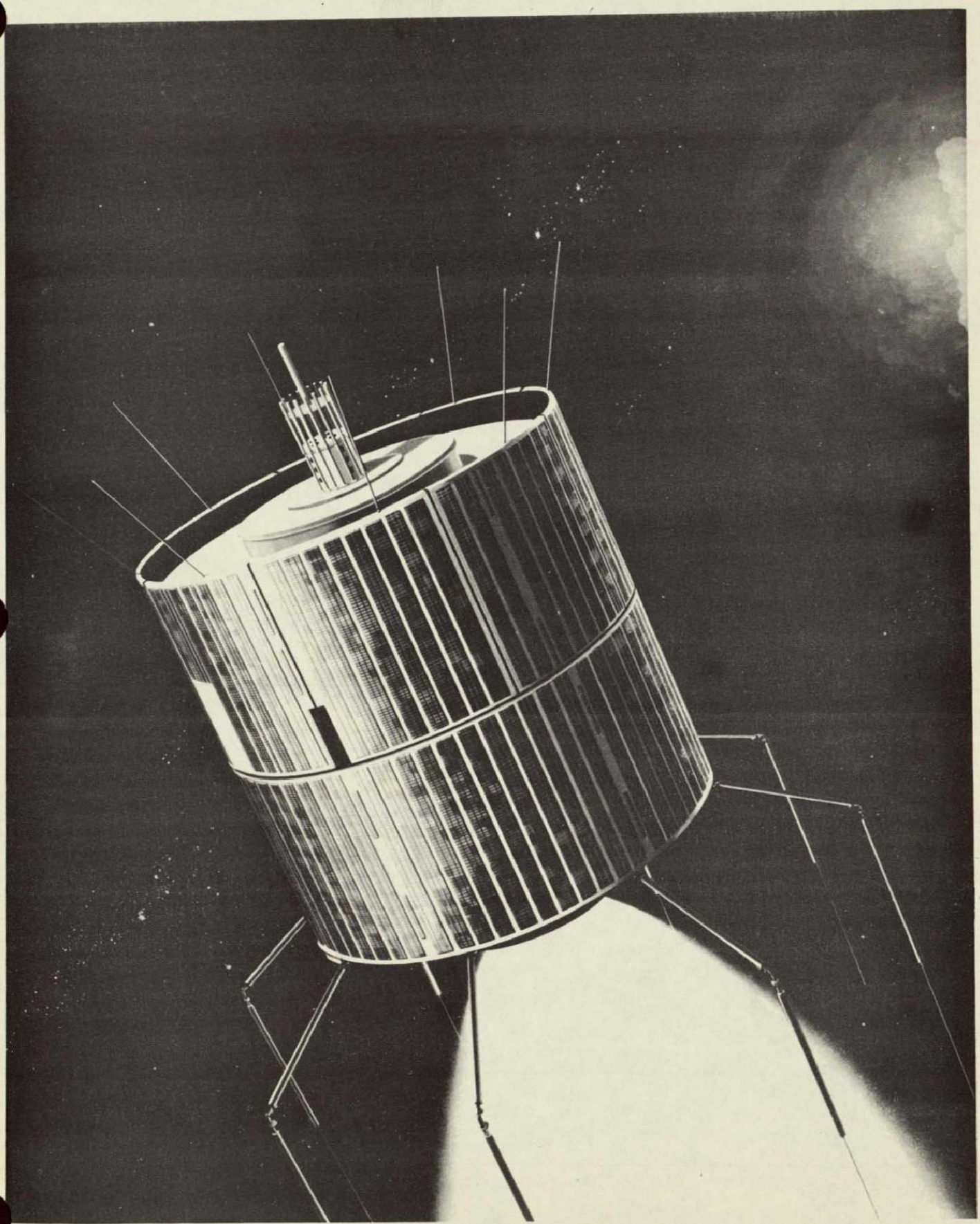
REMARKS: Aircraft to ground VHF experiment was successful

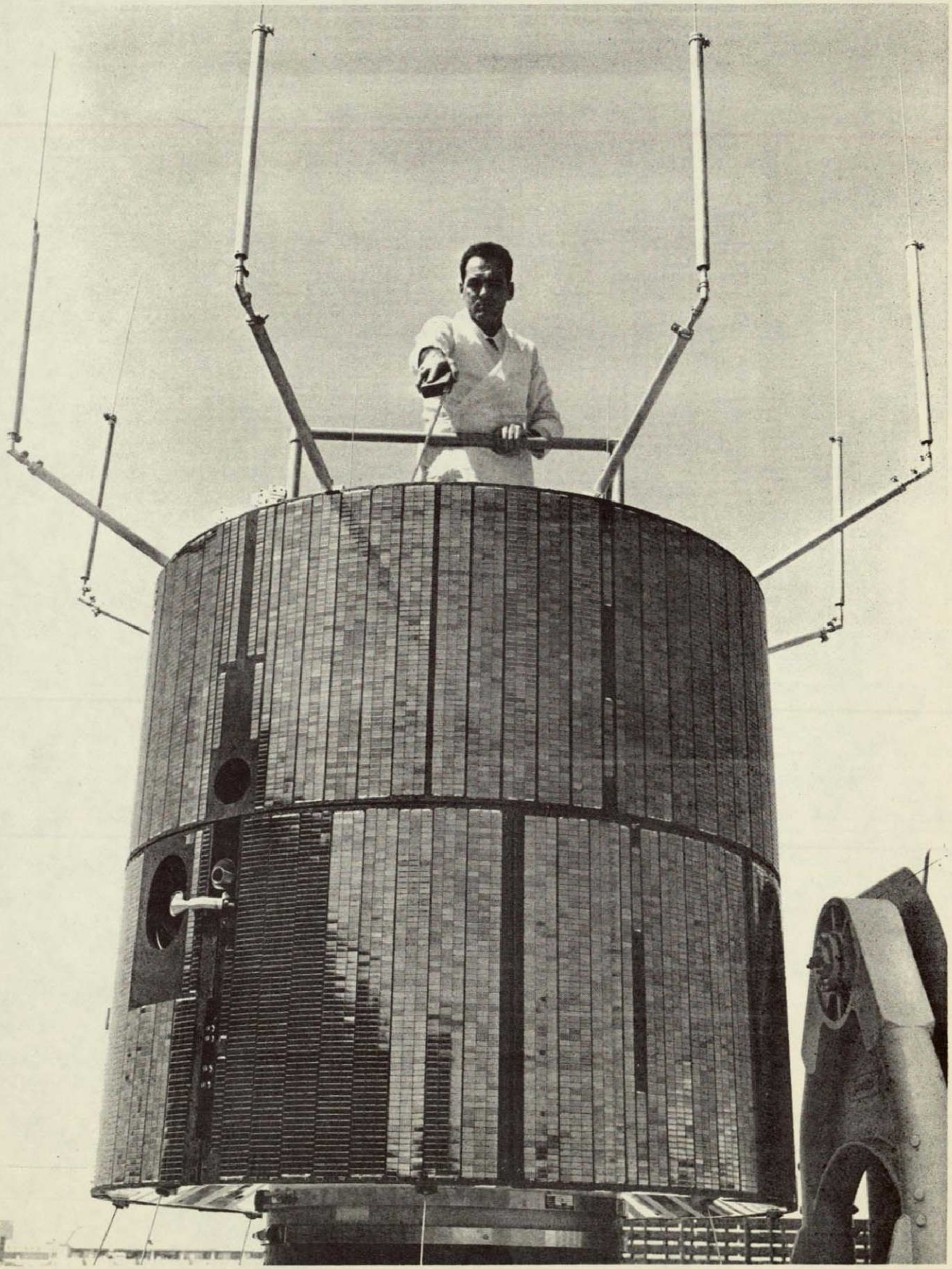
System has experienced some spin modulation of the VHF system.

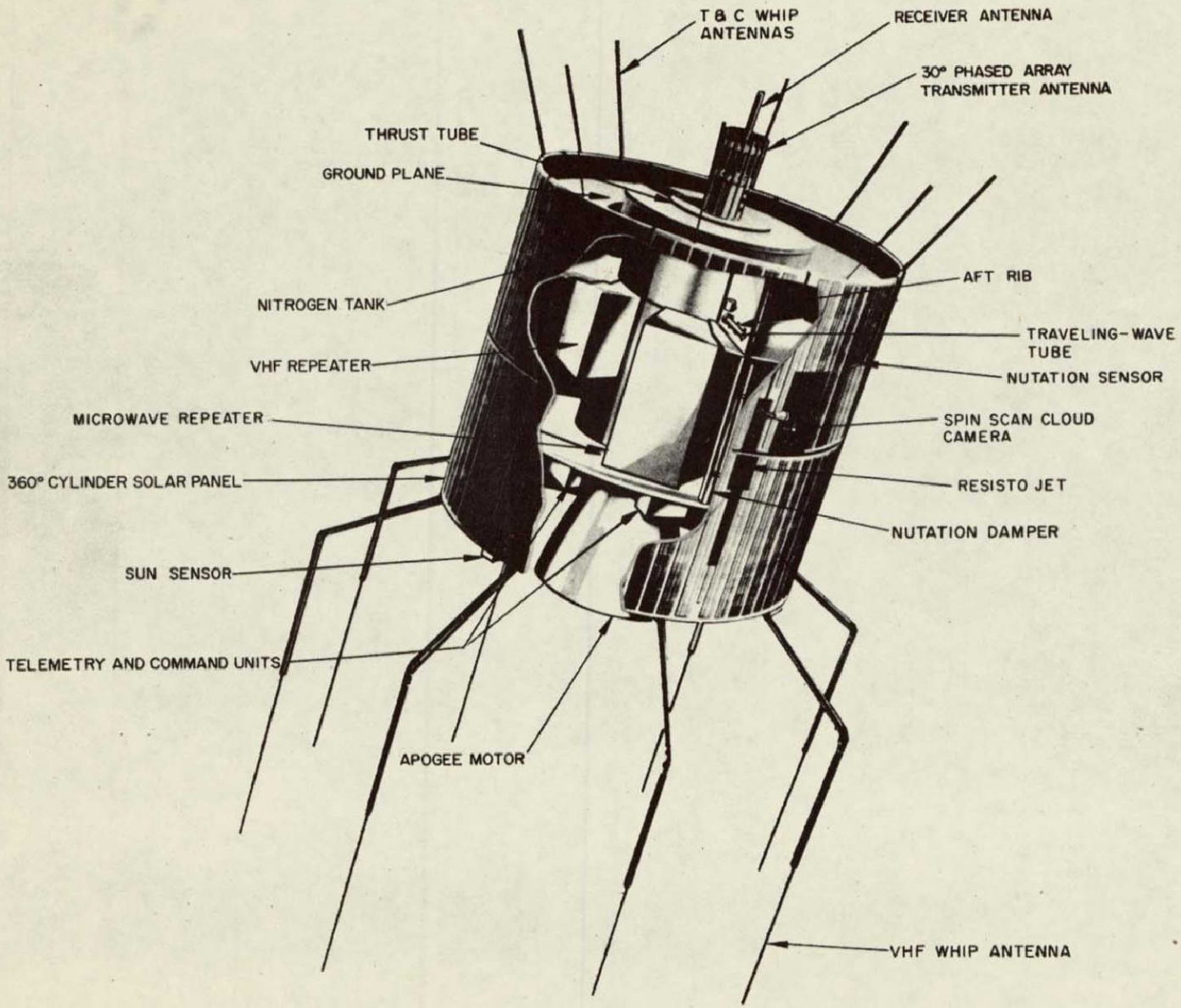
VHF system experiences RF loss on the order of 3-5 db.

S/C weighs 775# in orbit and 1550# at launch.

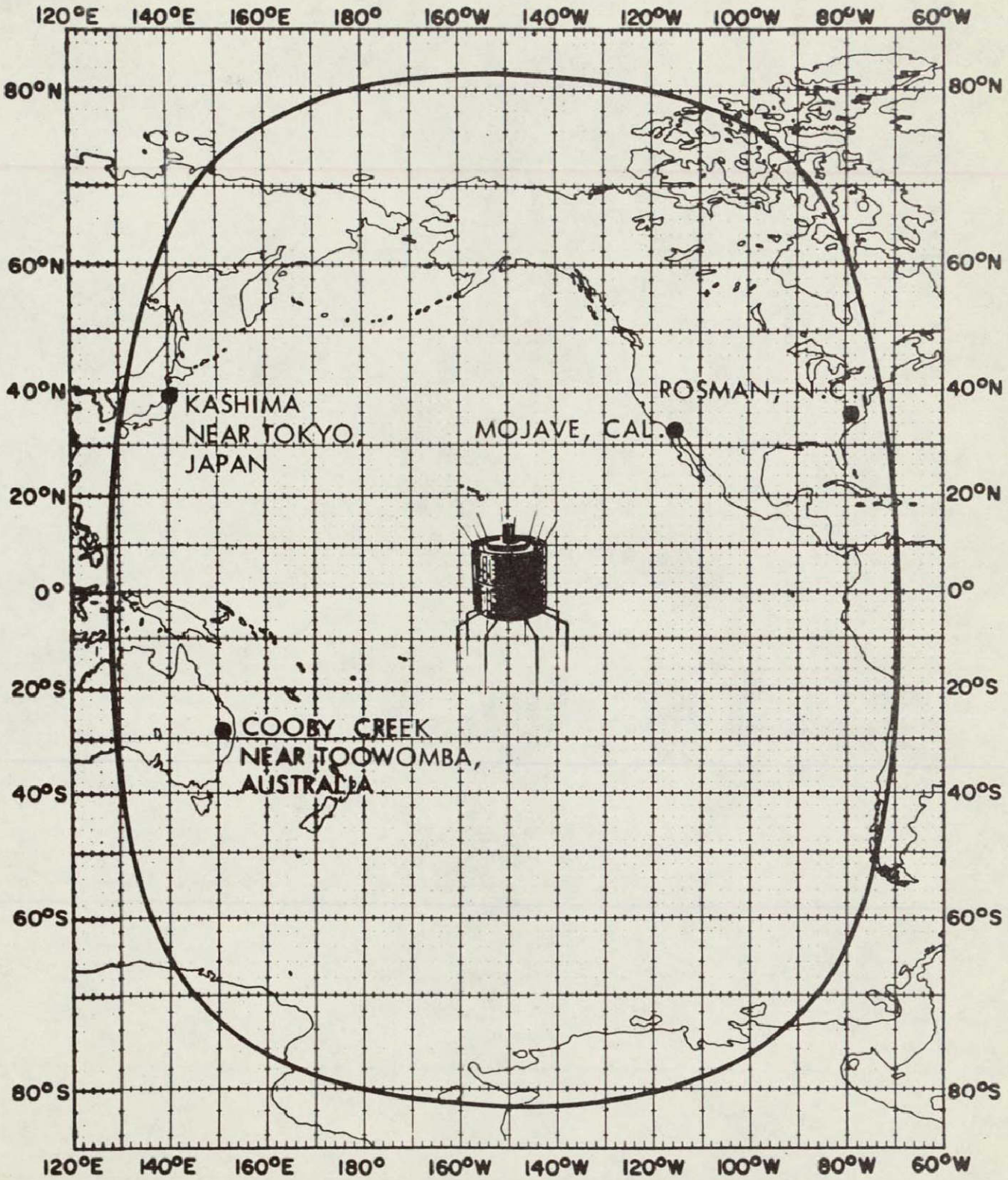
S/C launched by Atlas-Agena D is cylindrical, 56" in diameter and 57" high.







APPLICATIONS TECHNOLOGY SATELLITE (ATS-B)



ATS-B GLOBAL RECEPTION AREA

THE DARK LINE ENCLOSES THE WORLD AREAS FROM WHICH THE ATS-B WILL BE IN VIEW FOR COMMUNICATIONS PURPOSES. THE ATS GROUND STATIONS AND PARTICIPATING STATION ARE INDICATED.

ATS-2 (A)

PURPOSE: To provide a stable platform for the experiments on board; to verify, in a 6000 nautical mile orbit, the previously developed mathematical model describing a gravity stabilized vehicle; to establish design parameters; and further to demonstrate at 6000 nautical miles the compatability of gravity stabilization with missions requiring long life.

ORBIT: Planned - 6905 statute mile circular at 28.5° inclination
Actual - 115 to 6947 statute mile elliptical due to failure of Agena Rocket to fire the second time for 27 seconds.

STABILIZATION: Gravity Gradient, 3 Axis Stabilized

LOCATION: N/A

RE-ENTERED Sept. 2, 1969

DESIGN LIFE: Three years, p[r]- elliptical o[rbit] not be achieved due to

OPERATING FREQUENCY RANGE: Microwave - a. 6 GHZ Band Uplink
b. 4 GHz Band Downlink

MODULATION: Frequency Translation Mode - FM
Multiple Access Mode - SSB to PM Conversion

DEVELOPER: Hughes Aircraft Company, G.E., de Havilland, TRW, RCA

SYSTEM: Two active microwave repeaters.
Two 800 line advanced vidicon cameras.
Four 2 watt UHF telemetry transmitters.

CIRCUIT CAPABILITY:

ONBOARD POWER: Two 22 cell Nickel - Cadmium Batteries and 22,000 N-on-P solar cell array to provide 185 watts initial power.

LAUNCH DATE: April 5, 1967 - Partial success

USERS: NASA - prime, Bell Telephone Labs, University of California, University of Minnesota

ANTENNA: S/C utilizes eight whip antennas extending from the top of the vehicle for command and telemetry and four antennas extending from the bottom of the vehicle for communications.

REMARKS: Contains 4 stabilization booms, each extendable to 150 feet

Contains 2 libration damping booms, each is self extendable to 45 feet.

Satellite contains two vidicon cameras which will photograph meteorological data and record for later dump.

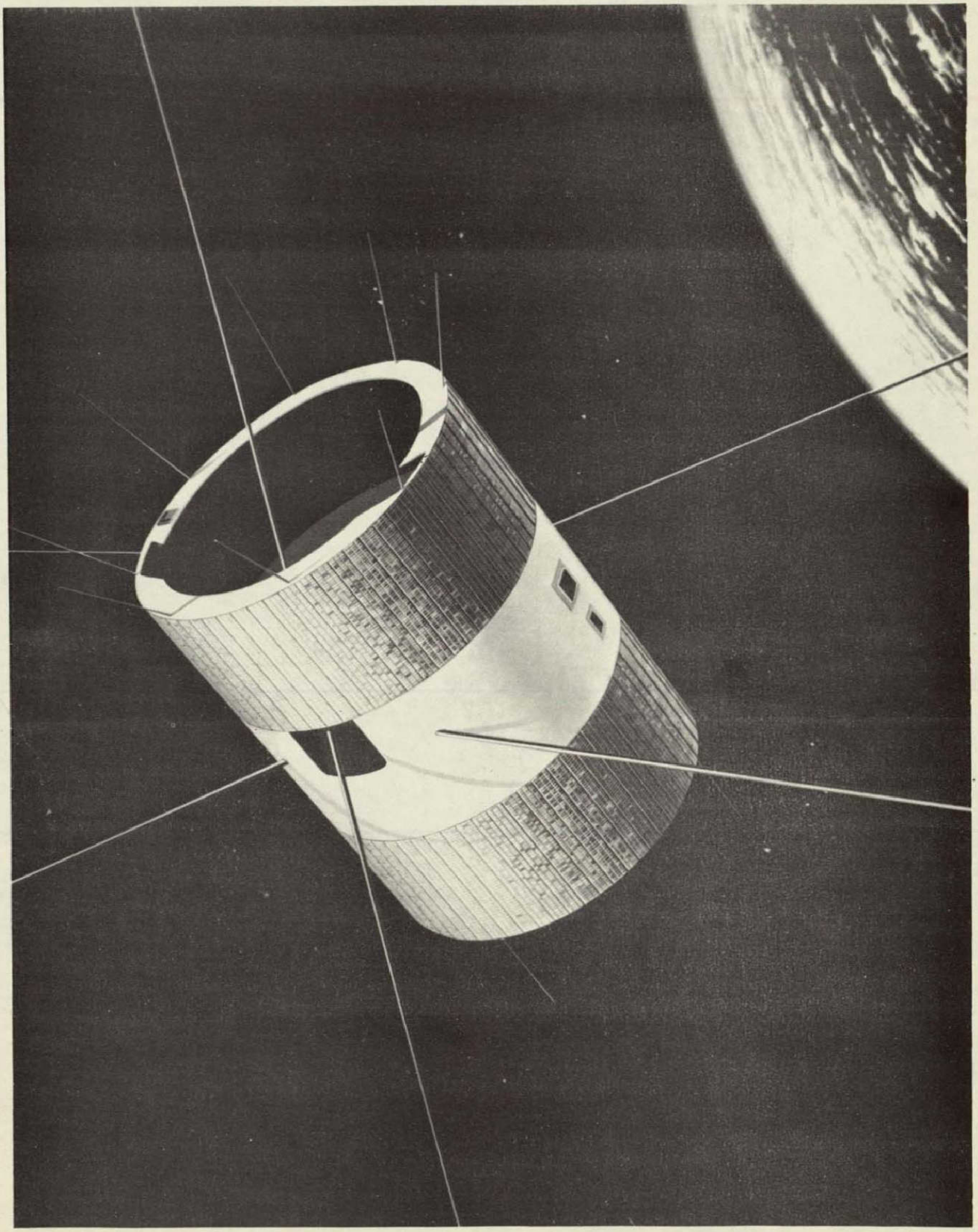
Satellite contains eight scientific experiments, a SHF (microwave) communications experiment, and a DOD albedo experiment.

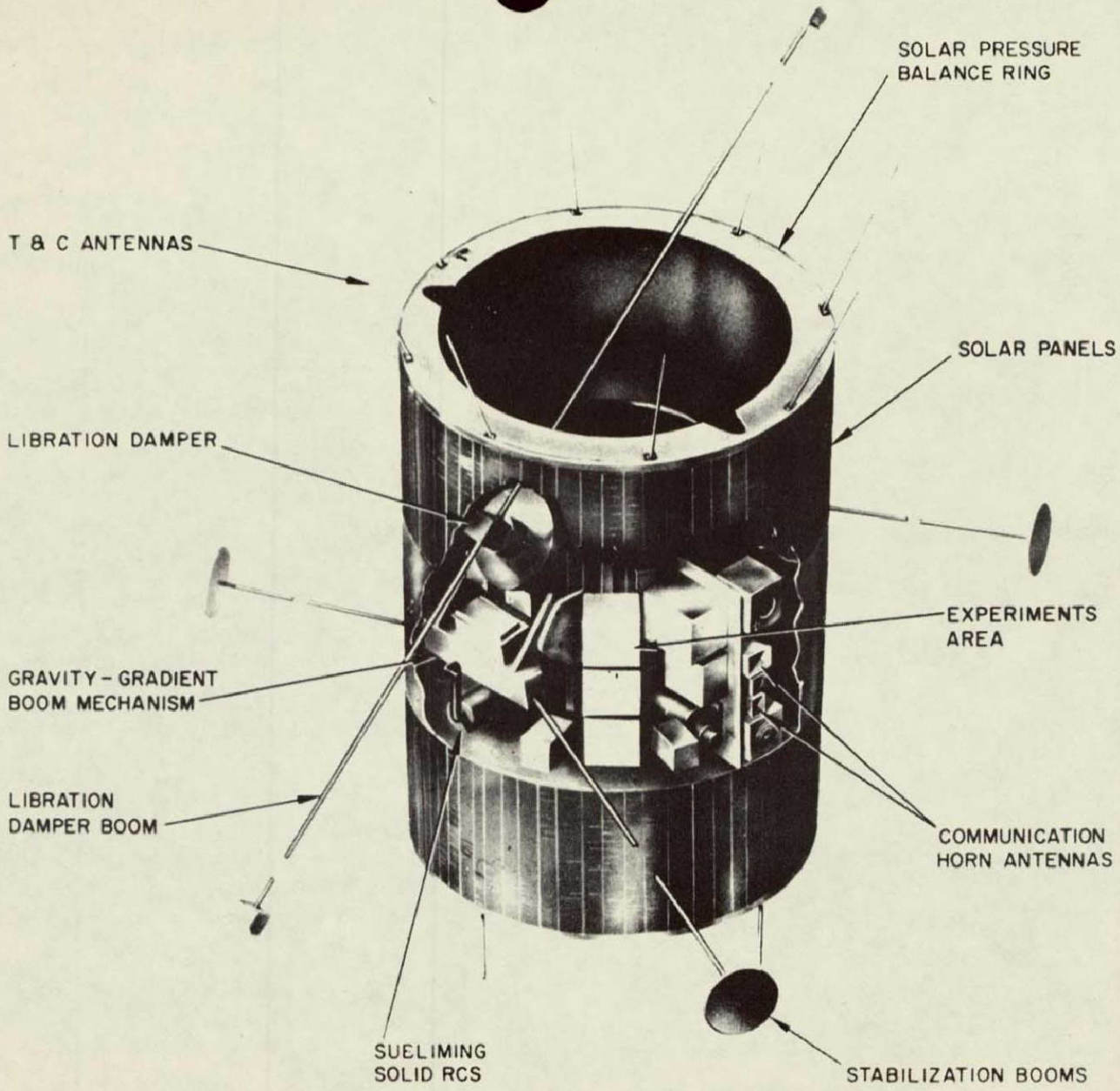
Satellite underwent severe pertubations due to highly elliptical orbit.

S/C launched by Atlas - Agena D is cylindrical, 56" in diameter and 72" high.

S/C weight is 815#.

Stabilization booms were successfully deployed and limited data were obtained from most other experiments.





MEDIUM ALTITUDE GRAVITY - GRADIENT SPACECRAFT

ATS-3 (C)

PURPOSE: Further development of experiments and concepts in the useful applications of space technology which include performing experiments with a 3 color meteorological TV camera, self contained navigation system, communications and earth resources management. No scientific experiments are planned for this flight.

ORBIT: Near Geostationary (22,228 by 22,254 statute miles)

STABILIZATION: Spin at approximately 100 RPM. System uses hydrogen peroxide and Hydrazine reaction control systems for station keeping and attitude control.

LOCATION: The spacecraft is located at approximately 47° west longitude from July thru December and at 70° west longitude from January thru June.

DESIGN LIFE: Three years. Anticipated life is now approximately 10 years.

OPERATING FREQUENCY RANGE:

Microwave	-	a.	6 GHz Band Uplink
		b.	4 GHz Band Downlink
VHF	-	a.	149.22 MHz A/C to Sat.
		b.	135.6 MHz Sat. to A/C
		c.	148.26 MHz Cmd Reception
		d.	136.47 MHz Tm downlinks
		e.	137.35 MHz Tm downlinks

MODULATION: Microwave - Frequency Translation Mode - FM
Multiple Access Mode SSB to PM Conversion
VHF - FM/PM

DEVELOPER: Hughes Aircraft Company

SYSTEM: Active repeater, utilizing two microwave repeaters for SHF communications, 2 command receivers, 2 telemetry transmitters

CIRCUIT CAPABILITY: 85' Ground Antenna (Rosman II)

SSB/PM 600 FDX Voice

FM/FM 600 FDX Voice and one Color TV Channel
45' Ground Antenna (Mojave II, Toowoomba)

SSB/PM 120 FDX Voice

FM/FM one Color TV Channel

Telegraph, Digital Data, Facsimile

ONBOARD POWER: Two 22 Cell Nickel - Cadmium Batteries and Solar Cell Array - S/C utilizes 12 watt TWT's providing ERP of 1 kilowatt.

LAUNCH DATE: November 5, 1967 - Successful

USERS: NASA - prime

ANTENNA: Microwave system utilizes

a. Mechanically despun linear parabolic antenna for transmitting and receiving, providing 18 db gain with a 19.7° beam.
b. Auxiliary collinear - array antenna for receiving
c. Auxiliary phased - array antenna for transmitting

VHF system utilizes a phased array antenna system comprised of eight 5 feet long whips which are used for transmitting and receiving. This VHF system provides 10 db gain with a 20° beam.

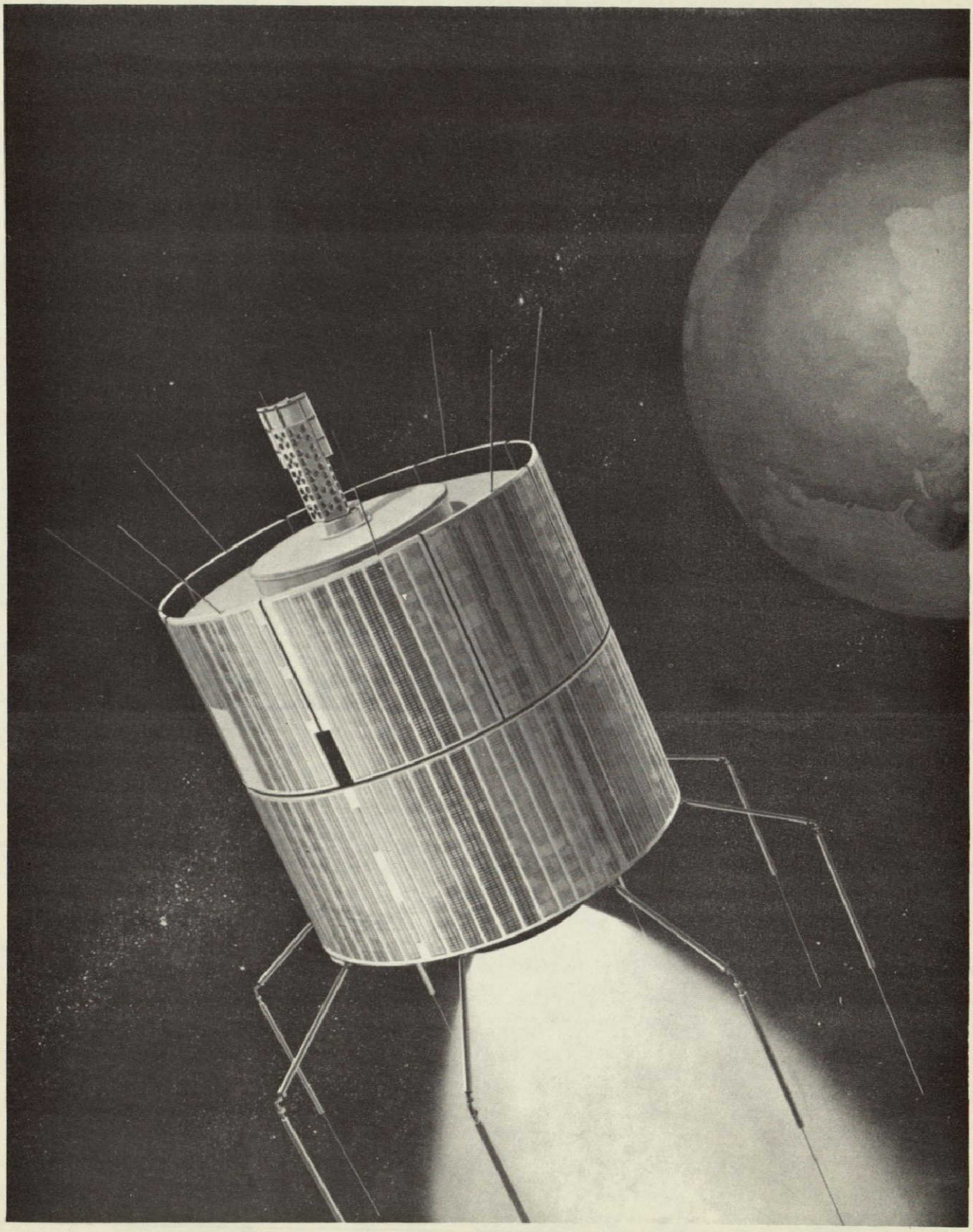
The mechanically despun antenna is working well, providing higher quality voice, TV, and facsimile relay than has been possible with other spacecraft antennas. It requires a "relatively modest" spacecraft primary power system but has raised the communications capability of satellites without increasing the demands for primary power from the S/C.

REMARKS: System will provide daylight cloud cover information on a real-time basis and utilizes a color camera which has a ground resolution of 2 nautical miles.

S/C is cylindrical, six feet long and five feet in diameter, weighs 850#, and was launched by an Atlas - Agena D.

The mechanically despun antenna has developed a thermal problem which causes it to bind during the months of April thru September. They do not plan to use it during this period.

The red channel of the color camera has failed. Pictures are limited to green and blue. The blue channel is used for black and white pictures.



ATS-4 (D)

PURPOSE: To evaluate the effects of gravity gradient stabilization at synchronous altitudes to include damper evaluation and libration determination. No science experiments were planned for this mission.

ORBIT: Geostationary planned, approximately 135 x 489 miles achieved.

STABILIZATION: Gravity Gradient, three axis stabilized. System used two ammonia-fueled resisto-jet engines for station keeping; a liquid hydrazine and an ION engine for attitude control.

LOCATION: Originally planned for approximately 107° West over the Pacific.

DESIGN LIFE: Three years. Satellite re-entered October 17, 1968.

OPERATING FREQUENCY RANGE: Microwave - a. 6 GHz Band Uplink
b. 4 GHz Band Downlink

MODULATION: Frequency Translation Mode - FM

Multiple Access Mode - SSB to PM Conversion

DEVELOPER: Hughes Aircraft Company

SYSTEM: Active Repeater, the four TWT's worked normally.

CIRCUIT CAPABILITY: System was capable of providing TV, voice, teletype, high speed data, and facsimile to include daylight cloud coverage of the full Earth-disc on a real time basis.

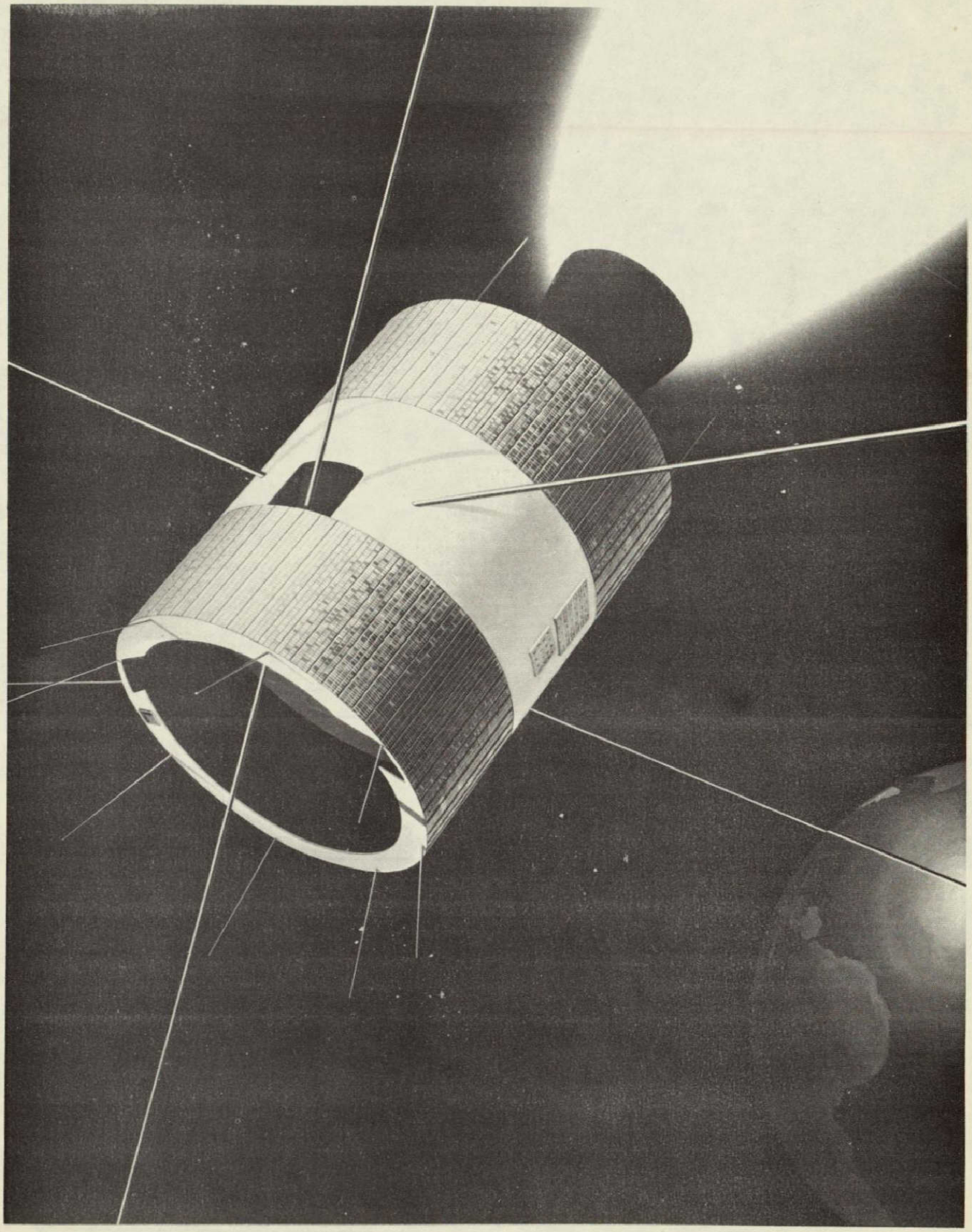
ONBOARD POWER: Two 22 Cell Nickel - Cadmium Batteries and Solar Cell Array

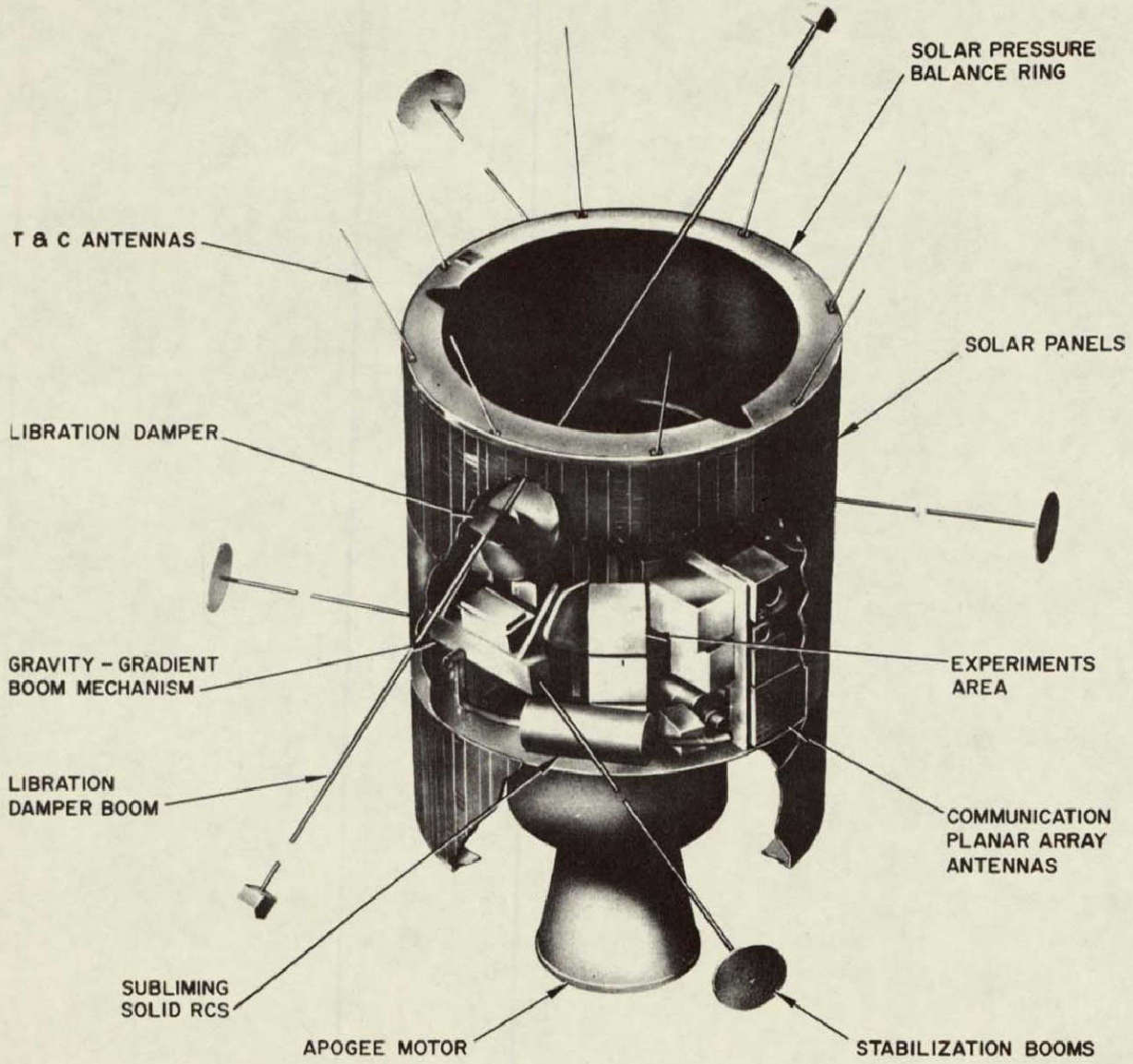
LAUNCH DATE: August 10, 1968, Partial success

USERS: NASA - prime

ANTENNA: Spacecraft utilized linearly polarized horn antennas for transmitting and receiving.

REMARKS: S/C weighed 801# in orbit and was launched by an ATLAS/Centaur rocket. The Centaur rocket failed to restart for the orbit circularizing maneuver thereby leaving the satellite in an elliptical orbit. Many of the experiments were not successful.





SYNCHRONOUS ALTITUDE GRAVITY - GRADIENT SPACECRAFT

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ATS-5 (E)

PURPOSE: To better define the environment of the stationary orbit and to evaluate the light weight system as well as to provide a stable platform for other technological and scientific experiments.

ORBIT: Geostationary

STABILIZATION: Gravity Gradient, Three Axis Stabilized. System will also use two amonia fueled resisto-jet engines for station keeping; a liquid hydrazine and an Ion engine for attitude control.

LOCATION: 105° West longitude

DESIGN LIFE: Three years

OPERATING FREQUENCY RANGE: Microwave - a. 6 GHz Band Uplink
b. 4 GHz Band Downlink
Millimeter Wave Experiment -
a. S/C receives in 31.65 GHz band
b. S/C transmits at 15.3 GHz
L-band Experiment -
a. 1650 MHz Uplink
b. 1550 MHz Downlink

MODULATION: Frequency Translation Mode - FM
Multiple Access Mode - SSB to PM conversion
Millimeter Wave Mode - AM

DEVELOPER: Hughes Aircraft Company

SYSTEM: Active Repeater

CIRCUIT CAPABILITY: Specifics unknown; however, system will be capable of TV, voice, teletype, high speed data, and facsimile transmissions

ONBOARD POWER: Two 22 Cell Nickel - Cadmium Batteries and Solar Cell Array.

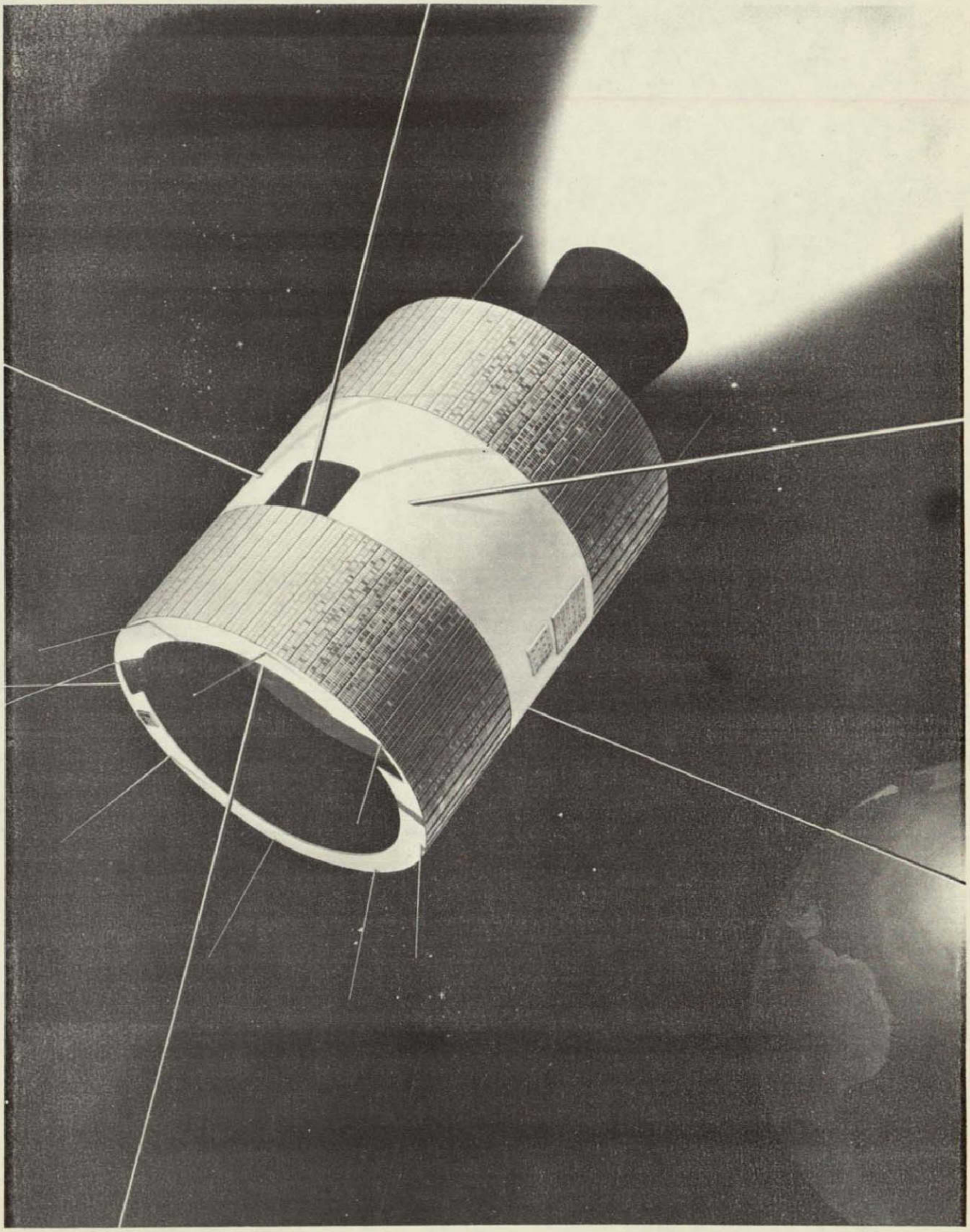
LAUNCH DATE: August 12, 1969

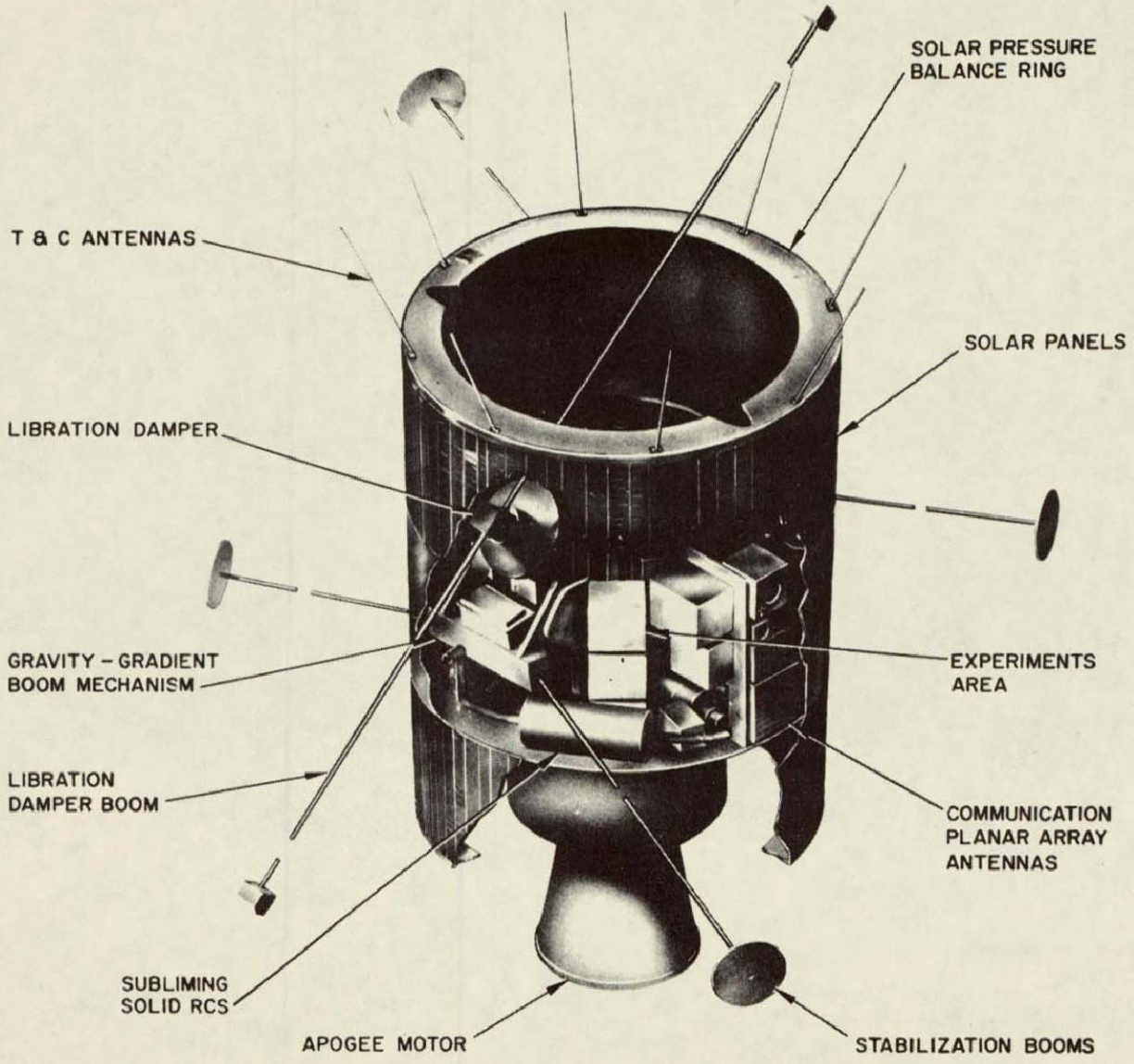
USERS: NASA - prime

a. Goddard Space Flight Center
b. University of Texas
c. Ohio State University
d. Air Force Cambridge Research Laboratory
e. Navy Electronics Laboratory
f. Defense Research Tele-Communications Establishment

ANTENNA: Two antennas will be used for the millimeter wave experiment. They will have 20 db gain with a 20° beam. Spacecraft Utilizes linearly polarized horn antennas for transmitting and receiving.

REMARKS: S/C will include a millimeter wave propagation experiment. S/C weighs 895#.





SYNCHRONOUS ALTITUDE GRAVITY - GRADIENT SPACECRAFT

ATS-F

PURPOSE: To develop and demonstrate long-lived spacecraft stabilization techniques for pointing large aperature, space-erectable antennas (30 feet or larger) with an accuracy of ± 0.1°.

ORBIT: Geostationary

STABILIZATION: Three axis stabilization with inerita wheels and jets

LOCATION: 150° West Longitude initially then move to 15° East Longitude

DESIGN LIFE: Two years

OPERATING FREQUENCY RANGE: C-band frequencies in the 4-6 GHz range
136 MHz and 137 MHz telemetry signals
L-band frequencies in the 1540-1660 MHz aeronautical range for A/C to satellite relay
S-Band frequencies for satellite to orbiting S/C experiments
850 MHz direct broadcast TV

DEVELOPER: Phase A Mission Studies completed by:
Lockheed Aircraft
Fairchild Hiller
General Electric
Fairchild Hiller and General Electric picked for 13 month Phase B&C contracts
Westinghouse is studying the ground terminal requirements.

SYSTEM: Active Repeater

CIRCUIT CAPABILITY: Specifics unknown - capability will exist for direct TV communications

ONBOARD POWER: N-on-P Solar Cell Arrays and Nickel-Cadmium Batteries

LAUNCH DATE: Last Quarter 1972

USERS: NASA - prime

REMARKS: S/C will accommodate a tracking system
S/C weight will be under 2000 pounds
S/C will employ a phase comparison system for antenna orientation.
S/C diameter will be approximately six feet with a deployable 30-foot reflector

REMARKS (con't.): Launch vehicle will be Titan III C
Optimum ground station locations are:
Rosman, N.C.
Mojave, Calif.
Europe (transportable Ground Station)
System will be used to provide data relay experiments from lower orbit spacecraft.

The Phase B&C contracts call for design and development of of the configuration for both ATSF and G and to provide specifications, drawings, and test procedures. After studies are complete, one contractor will be selected to build the S/C.

ATS-G

PURPOSE: To study and demonstrate high-accuracy stabilization and ultra-precise pointing capabilities required for laser-beam optics and submillimeter waves. This spacecraft is basically the same as ATS-F.

ORBIT: Geostationary

STABILIZATION: Three-axis stabilized with inertia wheels and jets to 0.1°.

LOCATION: Approximately 25° West Longitude

DESIGN LIFE: Two years

OPERATING FREQUENCY RANGE: S-band, C-band in the 4-6 GHZ range and UHF, and L-band.

MODULATION:

DEVELOPER: Phase A mission studies completed by:
Lockheed Aircraft
Fairchild Hiller
General Electric
Fairchild Hiller and General Electric picked for 13 month Phase B&C contracts

SYSTEM: Active Repeater

CIRCUIT CAPABILITY: Specifics unknown; however, experiments will be performed with direct TV and voice communications

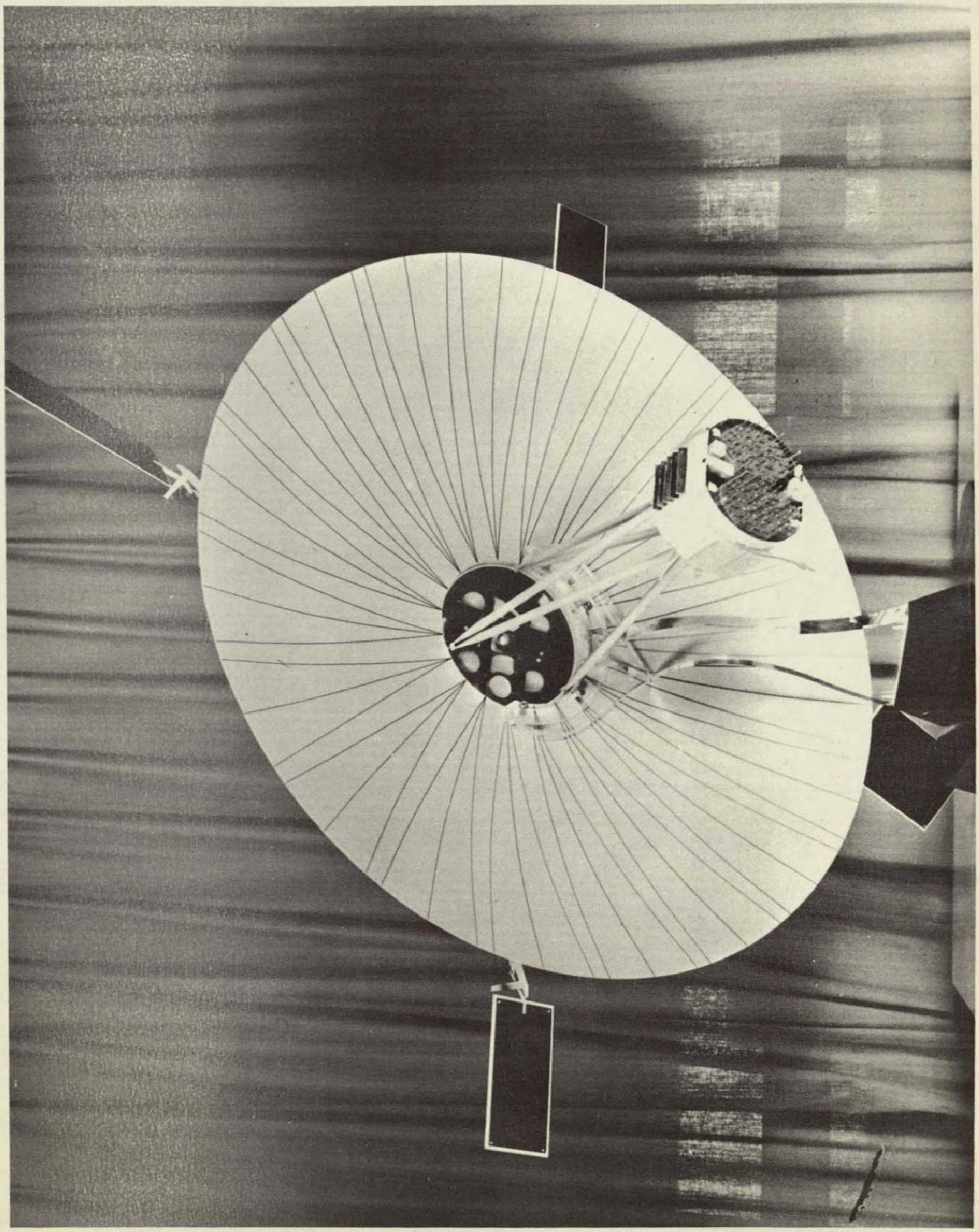
ONBOARD POWER: N-on-P Solar Cell Arrays and Nickel-Cadmium Batteries

LAUNCH DATE:

USERS: NASA - prime

REMARKS: Weight will be approximately 2000 pounds
Antenna gain at C-band will be approximately 50db.
Antenna gain at S-band will be approximately 40db.
System will be capable of performing tracking functions.
S/C will employ a phase comparison system for antenna orientation.
Launch vehicle will be a Titan III C.
Optimum ground station locations are:
Rosman, N.C.
Mojave, Calif.

REMARKS (con't.): The Phase B contracts call for design and development of the basic configuration for both ATSF and G and to provide specifications, drawings, and test procedures. After studies are complete, one contractor will be selected to build the S/C.



TDRS

Tracking and Data Relay Satellite

PURPOSE: TO provide a system of tracking and data relay satellites through which communications can be relayed between space vehicles at low to medium altitudes and to provide a capability of accommodating a tracking system to determine target vehicle orbital and/or trajectory parameters. System would use a small number of earth stations preferably located in the United States.

ORBIT: Geostationary

CONFIGURATION: GSFC plans to develop two satellites. The basic satellite will be known as the MK 1A and be followed by a later model to be known as the MK 1C.

The MK 1A will be spin-stabilized with the prime antennas mounted on a despun platform. Nutation damping is passive, using existing dual-spin technology. State-of-the-art sensors will be used for attitude determination and despin phasing, and a monopropellant hydrazine subsystem will provide for orientation maneuvers, station seeking and east-west station keeping, injection errors and spin control. A phase-lock control operation of the despun platform provides east-west pointing, slewing, and tracking functions. The despun section contains a rigid 8-foot diameter S-band parabolic antenna, an arry of four cross-polarized foldable yagi VHF elements, a set of three X-horns for the ground link, and their associated electronics. The spinning section contains the entire solar array, the power and attitude-control subsystems, and the apogee motor. A redundant telemetry and command subsystem provides for housekeeping operation during transfer orbit, using a VHF turnstile antenna on the spinning section.

The MK 1C has a substantially increased capability over that of the MK 1A. It can simultaneously track four users: two in the S-band with the large (8-foot) reflector, and and two in X-band with the small (5-foot) reflectors. As an alternate mode, the large reflector can be used for high-gain X-band tracking. VHF capabilities are the same as those of MK 1A. The MK 1A contains a single parabolic reflector mechanically steered in the east-west direction and electronically steered in the north-south direction; MK 1C uses three reflectors mechanically steered in both directions. The 8-foot reflector can simultaneously track two satellites by appropriate reflector motion and the use of a rotating linear feed array. This simultaneous

CONFIGURATION: tracking is also possible with a stationary array whose configuration, combined with reflector motion, permits constant communications with two spacecraft. The ATS-F will demonstrate an analogous technique of simultaneous tracking of two satellites, using a single reflector with multiple feeds. Both the large and small reflectors are mounted on the despun platform which moves in the east-west plane to point and track as the large reflector requires. The small reflectors must therefore offset the bias caused by the rotation of the despun platform and add their own tracking requirements to the offset. The required included tracking angle of the large reflector is ±13 degrees, which contains earth orbits up to 3000 km. The required included tracking angle of the small reflector therefore must include the 26° necessary for earth-orbit coverage, plus the 13° maximum bias caused by platform rotation, a total of 39°. The small reflectors may also be used to relay data to and from other data-relay satellites (DRS's); to allow for this, a tracking angle much larger than 39° is provided.

LOCATION: The evolutionary concept dictates growth from a two Satellite R&D network to a three and possibly four-satellite operational network.

FREQUENCIES:

MK 1A	VHF	148 to 150 MHz; 136 to 138 MHz
	S-band	1750 to 1850 MHz; 2200 to 2300 MHz
	X-band	7.3 to 8.0 GHz; 7.25 to 7.75 GHz
MK 1C	VHF	148 to 156 MHz; 136 to 138 MHz
	S-band	1750 to 1850 MHz; 2200 to 2300 MHz
	X-band	7250 to 7750 MHz; 8025 to 8400 MHz
		7900 to 8000 MHz; 8400 to 8500 MHz

MODULATION: PCM/PM and PFM/PM-FM/PM telemetery

CIRCUIT CAPABILITY: MK 1A S-band 40 MHz maximum instaneous bandwidth

MK 1C S-band 100 MHz maximum instaneous bandwidth
X-band 100 MHz maximum instaneous bandwidth

ONBOARD POWER: Solar cell array and nickel-cadmium batteries

DEVELOPER: To be developed under GSFC management

LAUNCH DATE: R&D prototype in MID-1970's

USERS: NASA, JPL, DOD, etcetera

SPACECRAFT:

Weight	MK 1A	805 lb.
	MK 1C	1161 lb.
Power	MK 1A	256.4 watts average power
	MK 1C	433 watts average power

TETR

MSFN Test and Training Satellite

PURPOSE: An Octahedral Environmental Research Satellite to provide an active target for pre-mission checkout of MSFN stations, training of MSFN ground system personnel, routine mission simulations, and development and verification of acquisition and handover techniques.

ORBIT: TETR-1, 182 by 304 nautical miles at 32.9° inclination.
TETR-2, 502 by 203 nautical miles at 33° inclination.
TETR-3, Destroyed (rocket veered off course)

STABILIZATION: Magnetic

LOCATION: N/A

DESIGN LIVE: Seven months, TETR-1 reentered 28 April 1968 after five months. Tentative lifetime of TETR-2 is 3 to 4 years.

OPERATING FREQUENCY RANGE: S-Band: 2101.9 MHz receive
2282.5 MHz transmit

VHF: 136 MHz TM
149 MHz CMD

MODULATION: USB-PM
VHF-PAM, IRIG-5TM

DEVELOPER: TRW Systems

SYSTEM: Active S-Band transponder; VHF transmitter and receiver for TLM.

CIRCUIT CAPABILITY: The satellite will be capable of performing the following S-Band operations:

1. Acquisition
2. Range rate
3. Ranging
4. Downlink telemetry simulation
5. Voice relay

ONBOARD POWER: Each triangular side contains 111 solar cells and rechargeable battery. Maximum power output is 5 watts.

LAUNCH DATE: TETR-1 - December 13, 1967 - Successful
TETR-2 - November 8, 1968 - Successful
TETR-3 - Failure
TETR-D - To be launched piggyback on OSO-H

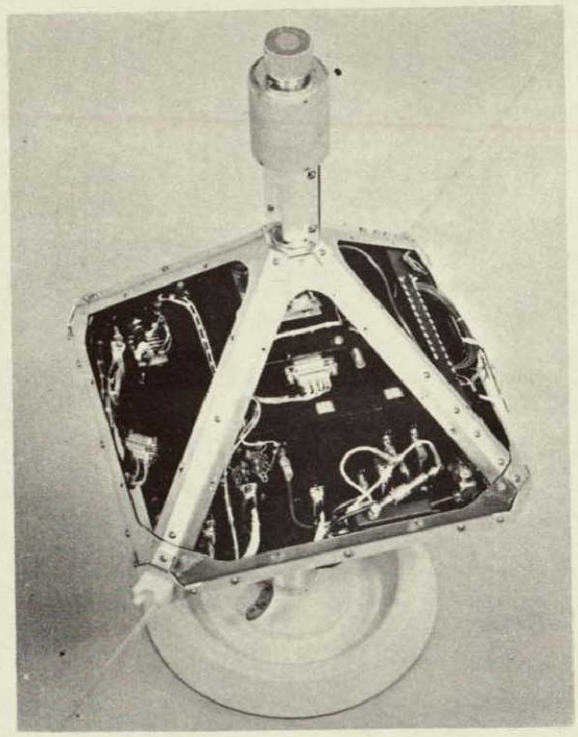
USER: NASA's Manned Spaceflight tracking stations

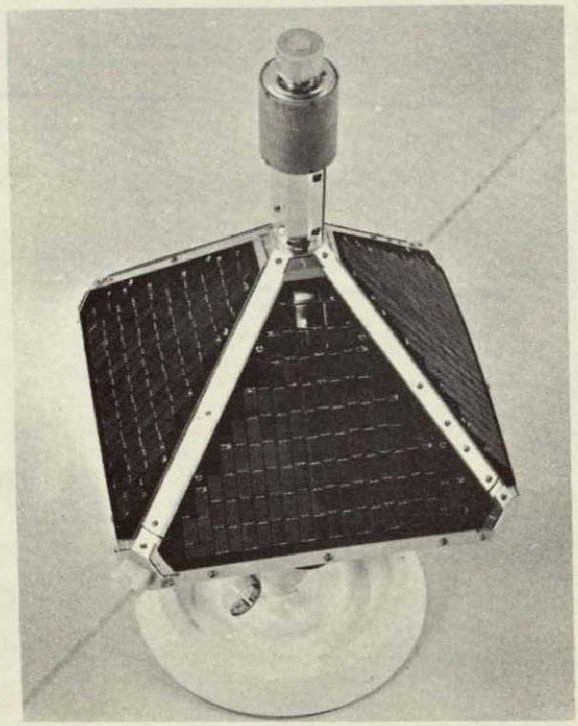
ANTENNA: Three VHF antennas stored as coils during launch - the receive antenna is a monopole and the transmit antennas are dipoles.

One S-Band antenna located 180° from VHF receive antenna.

REMARKS: Satellites are launched as secondary payloads on thrust augmented delta vehicles for Pioneer C and D missions.

The spacecraft weighs 44#.





DSCS

DEFENSE SATELLITE COMMUNICATIONS SYSTEM

PURPOSE: In 1962 the Secretary of Defense created the Defense Satellite Communications System (DSCS) and made it the responsibility of the Defense Communications Agency (DCA). The purpose of the DSCS is to enhance the capability of the Defense Communication System (DCS) long haul military communications systems with inherent improvements in survivability and flexibility unattainable by extensions of previous existing operating media. The unique requirements of the DSCS are: survivability, reliability, security, flexibility, global coverage, and growth potential. The following three entires (IDCSS, DSCS Ø2, ADCSP) are phases in the development and implementation of a DSCS to meet these requirements.

GROUND STATIONS: Camp Roberts, California (Army) 60' "Gateway Station"

Fort Dix at Fort Mammouth, New Jersey (Army) 60' "Gateway Station" and two 40' stations.

Helemano, Hawaii (Navy) two 40' stations and one 18' station.

Landstuhl, West Germany (Army) - two 40' stations.

Azmara, Ethiopia (Army) - one 40' station.

Clark AFB, Phillipines (Air Force) - one 40' station.

Nha Trang, Vietnam (Army) - 40' station.

Ba Queo, Vietnam (Army) 40' station.

Saigon, Vietnam (Army) - 40' station.

Shemya, Alaska - 40' and 18' station.

U-Tapao, Thailand - 18' station.

N. W. Cape, Australia - 18' station.

Brandywine, Maryland (Air Force) - one 40' station

Seoul, South Korea - 18' station

Okinawa (Army) 40' and 18' station

Guam (Navy) - 40' and 18' station

Turkey - 40' station

Navy ships - 6' station - 7 operational

U. K. Test Station at Christ Church, England - 40' station

Eventually more than 20 terminal locations are expected.

REMARKS: Philco-Ford has received a 20 month, $200,000 contract for investigation and development of techniques to optimize user and ground station interfaces with the DSCS.

IDCSS (PHASE 1)

(INITIAL DEFENSE COMMUNICATIONS SATELLITE SYSTEM)

PURPOSE: To conduct research, development, test, and evaluation for the purpose of demonstrating system operational feasibility; to obtain an early emergency capability and; to establish a research and development system that can be converted to a global system which will relay voice and digital communications between fixed and mobile users.

ORBIT: Near Synchronous Equatorial at approximately 20,900 to 21,000 statute miles.

STABILIZATION: Spin stabilized at 150 RPM

LOCATION: Random

DESIGN LIFE: At least four years.

DEVELOPER: Philco-Ford Corporation

CIRCUIT CAPABILITY: Capacity is dependent primarily on the size of the receiving antenna and modulation techniques. The S/C system provides approximately 20 MHz bandwidth.

60' Stations - 11 duplex voice channels or 107 narrow band vocoder channels or 1550 teletype channels or combinations of each.

40' Stations - 2 high quality or 5 reduced quality voice channels or 16 duplex secure vocoder voice channels, 50 teletype channels.

18' Stations - 1 tactical quality voice channel or 4 vocoder voice channels or 64 duplex teletype channels.

6' Stations - 4 teletype channels.

OPERATING FREQUENCY RANGE: S/C receives from 7.985 to 8.005 GHz
S/C transmits from 7.266 to 7.286 GHz
Beacon 7.299 GHz

SYSTEM: Frequency translation active repeater.

ONBOARD POWER: No stored power used but utilizes only 8000 N on P solar cells which generate 2.5 to 3 watts output power.

LAUNCH DATES: 8 - June 16, 1966 - Successful
8 - January 18, 1967 - Successful
*3 - June 28, 1967 - Successful
8 - June 14, 1968 - Successful, system was completed with this launch.

USERS: U. S. Military - prime

ANTENNA: S/C utilizes a circularly polarized, bi-conical array antenna which provides a toroidal beam with a 28° beam-width. The antenna gain is as follows:

Gain - 4.5 db minimum to 6.5 db maximum in the plane normal to the spin axis; 3db minimum in all directions within $\pm 14^{\circ}$ of this plane.

REMARKS: S/C weighs about 100# in orbit

Individual satellites deploy from the transtage truss structure at velocities of from 0 - 35 fps.

Satellites drift approximately 27.7°/day

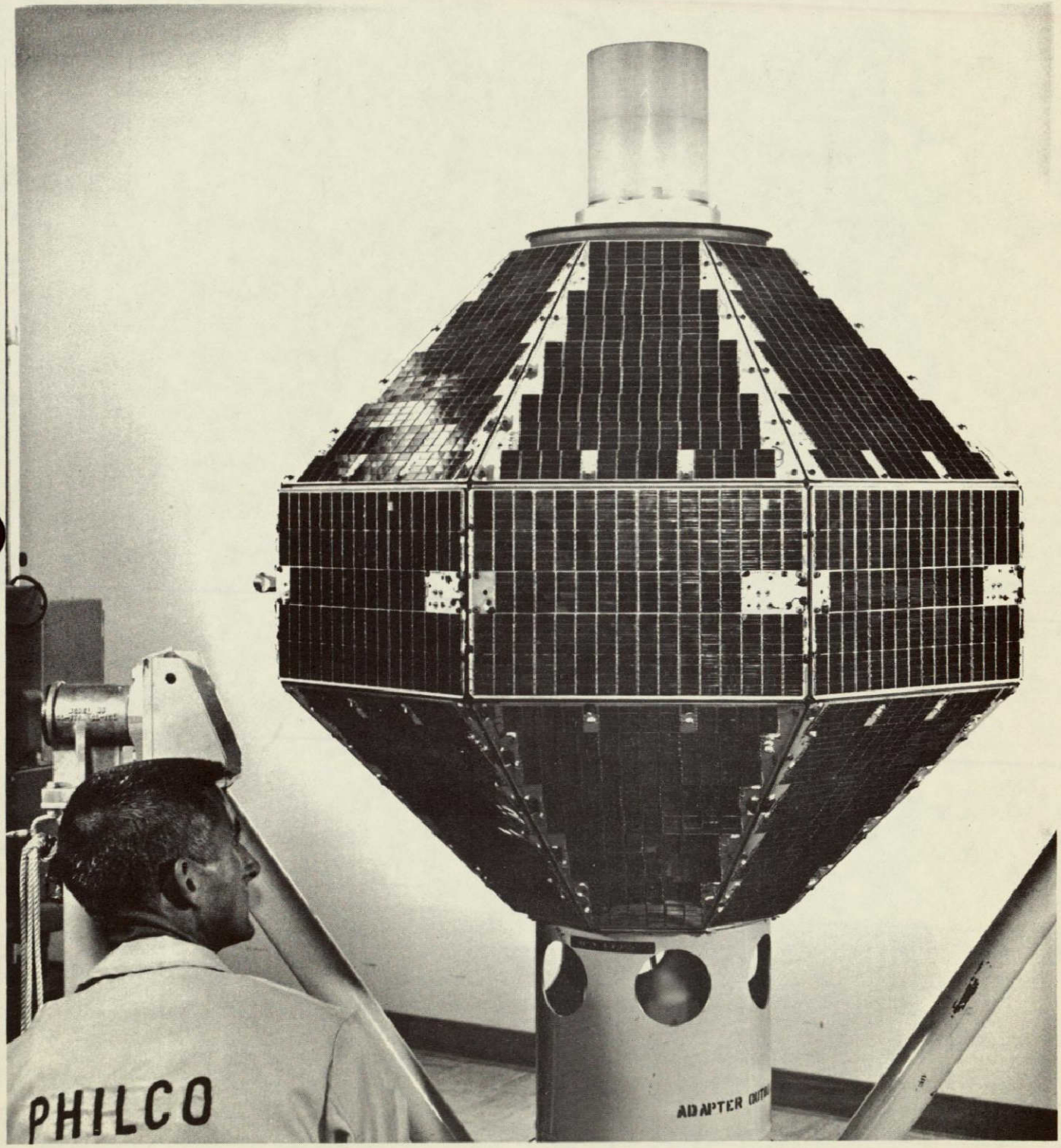
*Third launch also included a DODGE satellite, a DATS satellite and an LES-5 satellite.

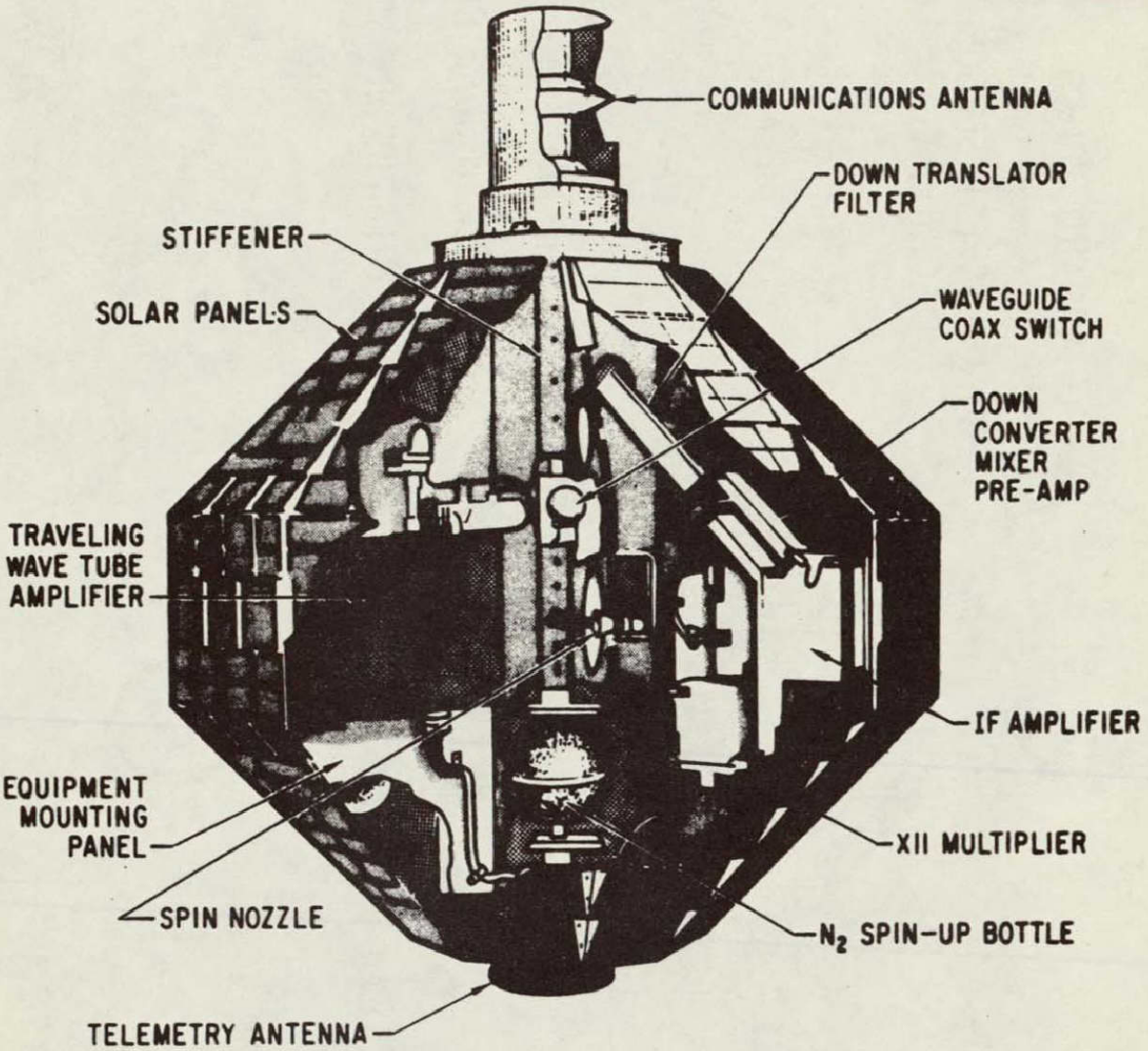
S/C telemetry is transmitted only during sun side passes.

DODGE (DOD Gravity Experiment) - test bed of possible future DOD Communication Satellites.

DATS (Despun Antenna Test Satellite)

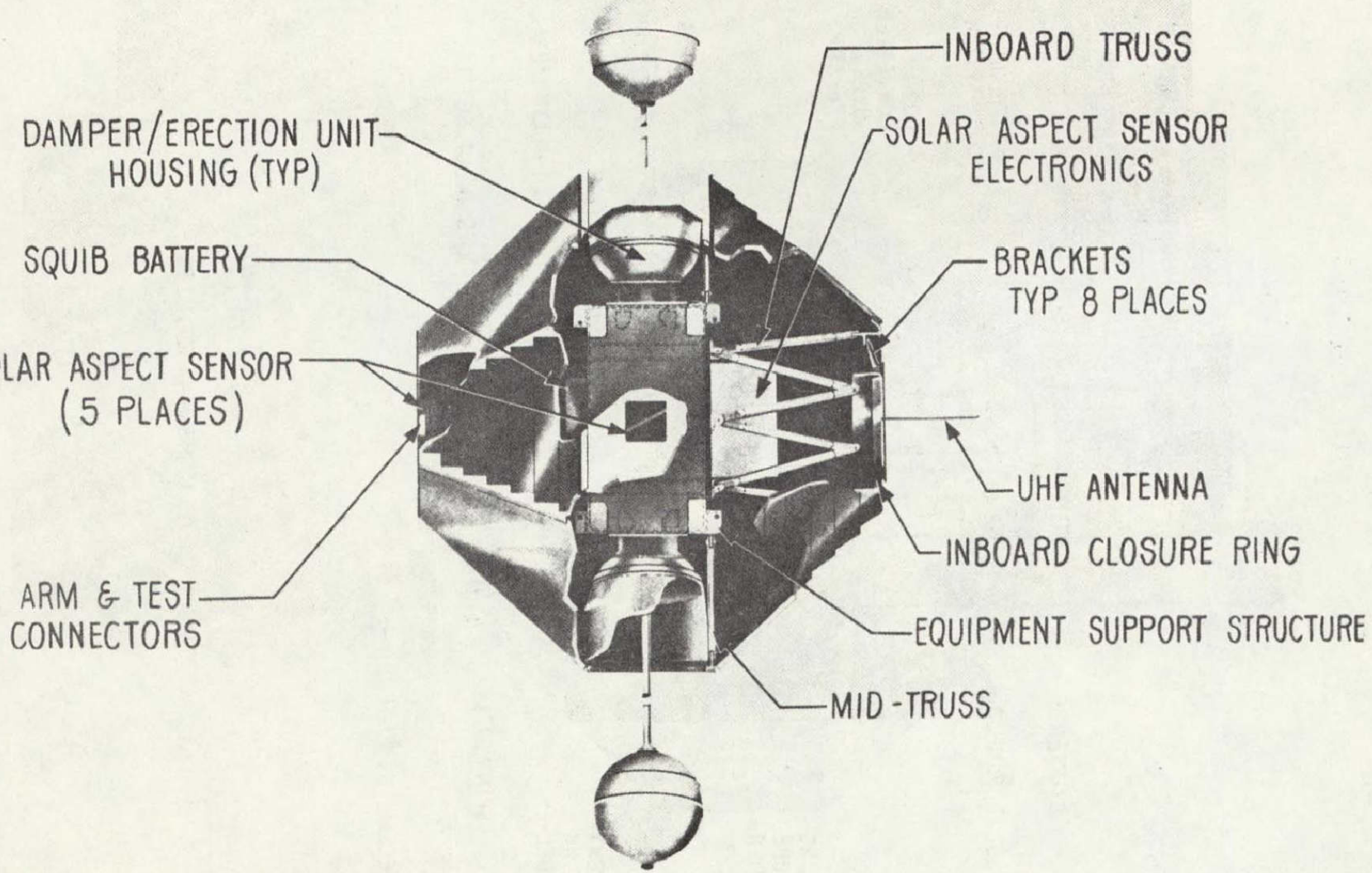
LES (Lincoln Experimental Satellite) an experimental flight program initiated to test all types of communications devices for potential scientific and military defense satellites (similar to ATS program).


PHILCO



COMMUNICATIONS SATELLITE

GRAVITY GRADIENT TEST SATELLITE



DSCS (PHASE 2)

(INTERIM SYSTEM)

PURPOSE: To place improved payloads into orbit to support and augment the present IDCSS.

ORBIT: Geostationary

STABILIZATION: Probably spin

LOCATION: Unknown, system will utilize 3, 4, or more satellites

DESIGN LIFE:

OPERATING FREQUENCY RANGE:

MODULATION:

DEVELOPER: TRW has a $37,653,000.00 contract to build the phase 2 satellite.

SYSTEM: Active repeater

CIRCUIT CAPABILITY: At least 500 channels

ONBOARD POWER: Probably solar cell array and battery power.

LAUNCH DATES: Launches should begin in late 1970 or early 1971.

USERS: Department of Defense agencies
United Kingdom

ANTENNA: System will have earth coverage antenna's as well as narrow beam capability.

REMARKS: S/C will be similar to the IDCSP-A being developed for the United Kingdom's SKYNET system, although more sophisticated.

FY 68 budget is $16.7 million.
RFP's were issued during September by the U. S. Air Force's Space and Missile Systems Organization to cover procurement of the satellites and the development of new terminals. All other major items will be procured in FY 1970 or later.

ADCSP (DSCS PHASE 3)

PURPOSE: To provide a truly operational system to meet the unique and vital command and control communications requirements of the Department of Defense. System will be utilized to furnish high quality trunking between switches and/or direct user-to-user circuits between major command elements.

ORBIT: Geostationary

STABILIZATION:

LOCATION: Exact location unknown, best estimate is four satellites located at approximately 145°W, 65°W, 45°E, and 135°E.

DESIGN LIFE: Lifetime goal of 10 years in orbit.

OPERATING FREQUENCY RANGE:

MODULATION:

DEVELOPER: Currently in study phases.

SYSTEM: Improved active repeaters

ONBOARD POWER:

LAUNCH DATES: Launches could start in late 1971 or early 1972 with an operational network available within one year.

CIRCUIT CAPABILITY: Greatly increased over Ø 2 in high traffic areas.

USERS: Department of Defense Agencies

ANTENNA: S/C will be equipped with earth coverage antennas which direct most of the radiated power to earth, thereby covering more uniformly that portion of the earth visible to the satellite. S/C will also be equipped with steerable narrow beam antennas capable of directing beams to selected areas of earth 1000 to 2000 miles in diameter.

REMARKS: FY 69 budget provides 60.4M for development work.

System will have greater protection against interference and jamming than Ø2.

35 Million dollars was provided in FY 1970 to implement the improved DSCS.

TAC SATCOM

TACTICAL SATELLITE COMMUNICATIONS PROGRAM (TSCP)

PURPOSE: To provide a Defense Tactical Communications System which will allow communications directly between the Pentagon and the Field Commanders in a war zone. The System will be utilized by all three military services. Early launches will be for the purpose of performing Tactical Communications Research and Development.

ORBIT: Geostationary

STABILIZATION: Spin stabilized with the solar panels rotating while the antennas and inner structure remain in a fixed position.

LOCATION: Over Pacific, 105° west longitude.

DESIGN LIFE: Unknown; however, a 2 year operational satellite would be acceptable at first with longlived satellites to follow.

OPERATING FREQUENCY RANGE: Both UHF (240 - 315 MHz) and X-band (7 - 8 GHz) capabilities.

MODULATION: Ground Stations will use DPSK

DEVELOPER: Hughes Aircraft Company is the prime contractor for development of the satellite repeater.

SYSTEM: Active repeater with approximately 10 MHz bandwidth.

CIRCUIT CAPABILITY: Specifics unknown, but the system will have a communications capacity comparable to 10,000 two-way telephone channels.

LAUNCH DATES: LES-5, R&D preparatory launch - 28 June 1967, successful
LES-6, R&D preparatory launch - 20 August 1968, successful
TACSAT 1, experimental TRI-SERVICE launch - 9 Feb 1969, successful
A fully operational network is planned by 1971-72.

USERS: Department of Defense, Army, Navy, and Air Force.

ANTENNA: A Quint-helix UHF array, each approximately 8' long featuring beryllium tubes with dual aluminum windings; 2 microwave horns for SHF communications, and a pancake beam bi-conical horn for telemetry and commad. The UHF antenna will probably have a beamwidth in the vicinity of 50° and a gain of around 16 db.

REMARKS: The TAC SATCOM will be the largest and most powerful communications satellite ever built and will weigh approximately 1600 pounds and be 16' high and 9' in diameter.

The satellite system is designed to communicate with aircraft, ships, and mobile field units.

Development responsibility of the Director of Defense Research and Engineering (DDR&E); the U. S. Air Force, Electronic Systems Division (ESD) is conducting the feasibility test program for the satellite and will oversee development of the mobile ground, air, and shipboard UHF terminals.

Collins radio received $3.4 million contract to design, develop, fabricate, and install the UHF ground terminals. These transportable terminals are being built by Technical Appliance Corp. and have a 15 db gain and a 10 watt to 1 KW variable power output. Five ground stations have been delivered to operate in the battlefield.

The U. S. Army's Electronics Command at Fort Mammouth, New Jersey, will procure the SHF microwave terminals through a $2 million plus contract with RCA-Camden for ground and airborne terminals in the following configurations:

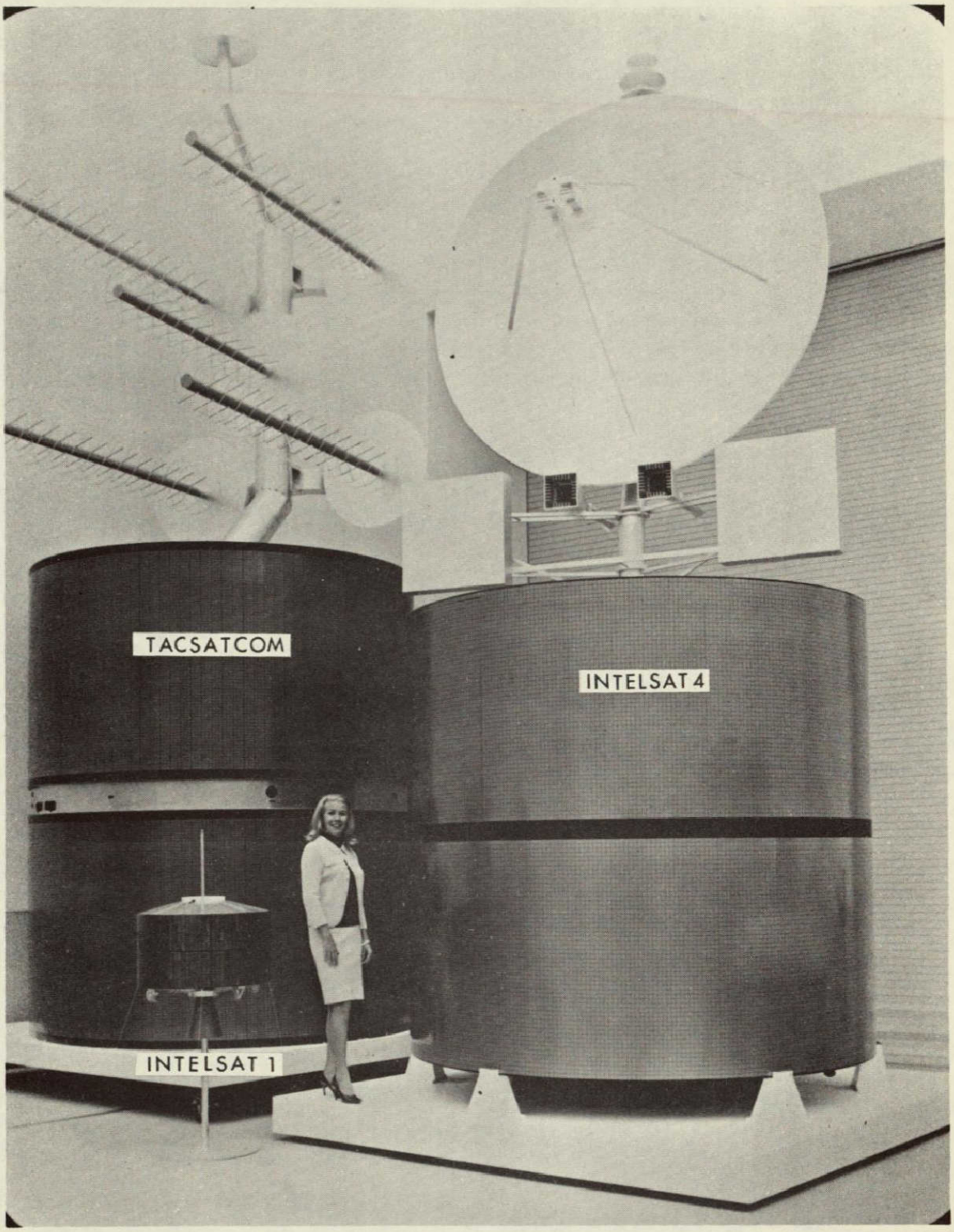
1. 3 airborne using 4' parabolic antennas.
2. 6 on 1 1/4 ton trucks using 5' antennas.
3. 4 on jeeps using 3' antennas.
4. 3 team packs using 3' erectable antennas.
5. 2 receive only, 1 man pack using 1' antenna.

Sylvania is building the MODEM (modulator/demodulator) for the digital encoding and decoding of data.

Hughes is building the tri-service experimental model satellite under a $23.5 million contract awarded by the U. S. Air Force, Space and Missile Systems Organization (SAMSO).

S/C will be launched by a Titan III booster.

The LES-6 launch will be used for testing experimental Pentagon ground, sea, and air terminals in the UHF spectrum.


TACSATCOM
INTELSAT 4
INTELSAT 1

DBS-TV

Direct Broadcast Satellite - Television

PURPOSE: To provide a direct Broadcast Television network covering the United States.

ORBIT: Synchronous

DEVELOPER: A proposal was submitted by NASA Electronic Research Center to define requirements and identify potential users. There were 15 bidders including COMSAT Corporation.

Alaska will initiate an experimental DBS-TV system. The ATS-1 satellite will be used two to six hours a day to broadcast educational TV to College and Bethel, Alaska. Emphasis will be placed on reaching the native population.

COMSAT proposes a domestic Satellite System with a capability equivalent to 48 TV channels (no telephone). System would consists of two satellites. Each would handle the total load in case of failure of the other. System would be operational two years after approval by the FCC.

DBS

Direct Broadcast Satellite

PURPOSE: To provide communications broadcasts directly to home receivers. Current studies have been centered around a direct broadcast television satellite in lieu of the other mentioned systems(i.e. DBS 4).

ORBIT: DSB 1 - Medium Altitude
DBS 2 - Geostationary
DSB 3 - Medium Altitude
DSB 4 - Synchronous

STABILIZATION: Unknown

LOCATION: For use over Western and Eastern Europe

DESIGN LIFE: Unknown, probably long lived

OPERATING FREQUENCY RANGE: DBS 1 - 15-30 MHz Range (HF)
DBS 2 - 88-108 MHz Range (UHF)
DBS 3 - 88-108 MHz Range (UHF)
DBS 4 - 470-890 MHz Range (UHF)
G. E. recommends 650 MHz UHF for U. S. and 175 MHz VHF for underdeveloped countries.

MODULATION: DBS 1 - AM
DBS 2 - FM
DBS 3 - FM
DBS 4 - FM

DEVELOPER: General Electric and RCA completed original feasibility studies for NASA.
General Electric completed a 9 month, $100,000 study for NASA--Lewis on the technical feasibility of an unmanned TV broadcast satellite.
TRW was issued a $100,000 contract in July by NASA-Lewis to further investigate a TV satellite system.
Issuance of a NASA-Marshall DBS-TV study contract is presently being held up because of a freeze on advanced mission funds.
Bidders for this study are General Dynamics Convair, Booz-Allen-Hamilton, and RCA

SYSTEM: Active Repeater

CIRCUIT CAPBILITY: DBS 1 - transmit and receive standard shortwave, HF, and AM broadcasts
DBS 2 - transmit and receive standard VHF-FM broadcasts
DBS 3 - transmit and receive standard VHF-FM broadcasts

DBS 4 - transmit and receive home TV

ON BOARD POWER: DBS 1 - 15 KW from solar array
DBS 2 - 11.38 KW from solar array
DBS 3 - 1.36 KW from solar array
DBS 4 - 2.53 KW from solar array

LAUNCH DATE: 1972-73 vicinity originally

USERS: Commerical carriers and home receivers

ANTENNA: S/C Antennas: DBS 1 - approximately 104' x 104' x 15'
DBS 2 - approximately 45' x 45' x 12'
DBS 3 - approximately 34.5' diameter parabolic
DBS 4 - approximately 23' diameter parabolic
G. E. recommends a 2.5° x 6° beam for U. S. telecasting and a 12° beam for underdeveloped countries.

REMARKS: Only one of the above systems will be incorporated.
The DBS/AM-FM Study which was to be initiated with $2.3 million funding has been halted because of the House Space Committees elimination of the request from the FY 68 Budget.
S/C Weight: DBS 1 - approximately 4118 lbs.
DBS 2 - approximately 2194 lbs.
DBS 3 - approximately 773 lbs.
DBS 4 - approximately 1012 lbs.
The current TRW study will include satellites in the 1000-4000# weight class. Smaller satellites would broadcast to community centers, schools, or central antenna systems. Larger satellites are for direct home reception.

BELL SAT

PURPOSE: To provide a multi-purpose integrated Space/Earth Communications system designed to meet long-range communications requirements in the United States through 1980.

ORBIT: Synchronous

STABILIZATION: Phase one - Spin
Phase two - Spinning outer shell for spacecraft stabilization with a de-spinning motor to keep the central core and the antennas oriented toward a point on Earth

LOCATION: Over continental U.S.

DESIGN LIFE:

OPERATING FREQUENCY RANGE: K-Band, 27.525 to 31.300 GHz for telephone and TV trunkline reception
K-Band, 17.7 to 19.3 GHz and 19.4 to 19.7 GHz for telephone and TV trunkline transmission

BASEBAND MODULATION: FM for TV program material; one transponder for each TV channel; PCM for telephone and TV trunkline signals; time division multiplexing of individual channels.

DEVELOPER: AT&T proposal

SYSTEM: Active

CIRCUIT CAPABILITY: Phase One - S/C has capability of 9600 voice circuits or 12 TV channels. Initial ground system facilities for 3200 two-way voice circuits, 8 full period TV channels and 12 TV channels for "occasional" use.
Phase Two - S/C has capability of 12 TV channels and more than 30,000 voice circuits simultaneously. Ground System facilities to provide 80,000 two-way voice circuits, 27 TV channels and 61 protection and/or occasional TV channels.

ON BOARD POWER: Solar Cell Array with no batteries for operation during Solar Eclipse. Battery for eclipse stabilization only.

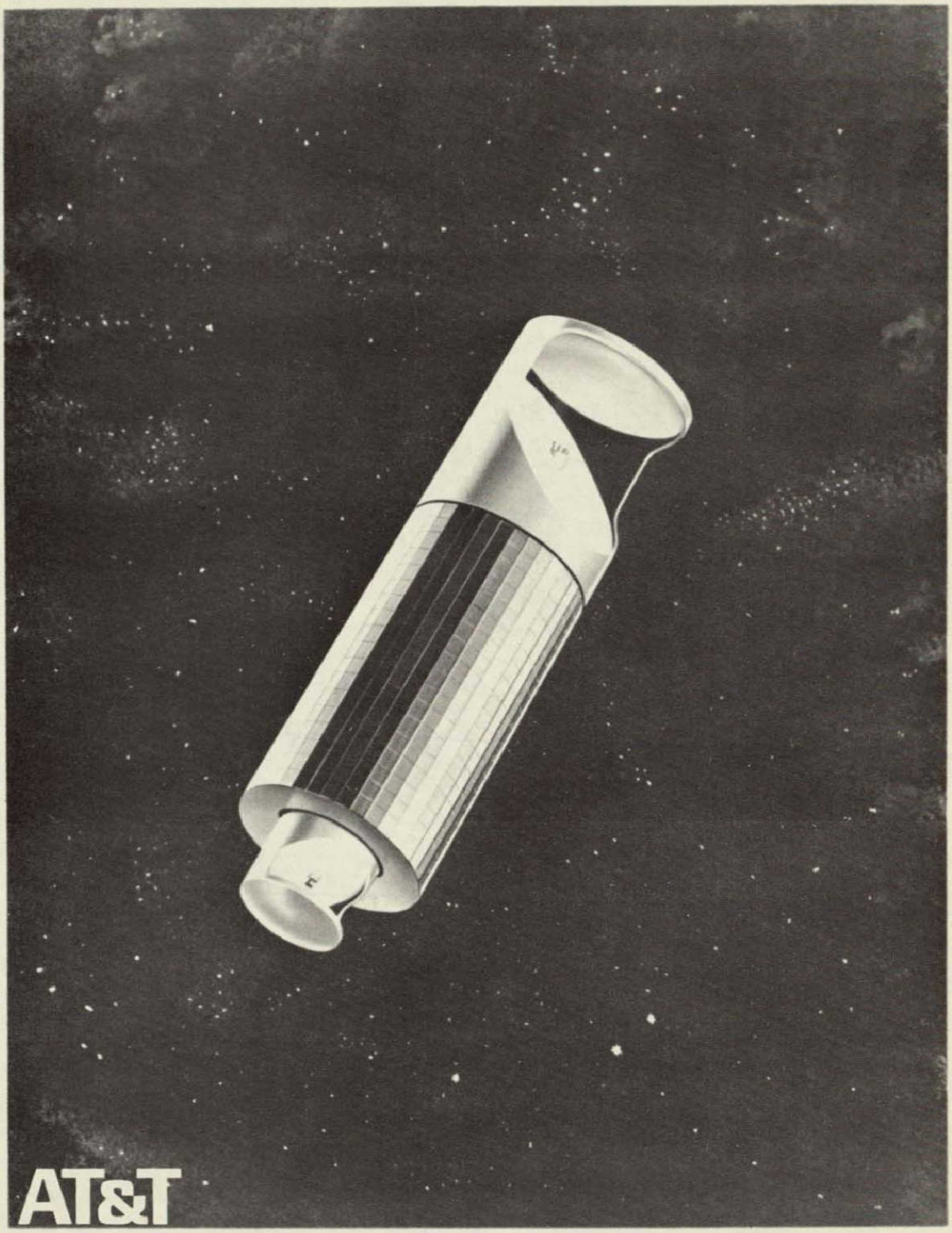
LAUNCH DATES: Phase One - Two satellites in 1969; Third in 1970-71
Phase Two - Two in 1972; Third in 1975; Fourth in 1976

USERS: Commercial carriers

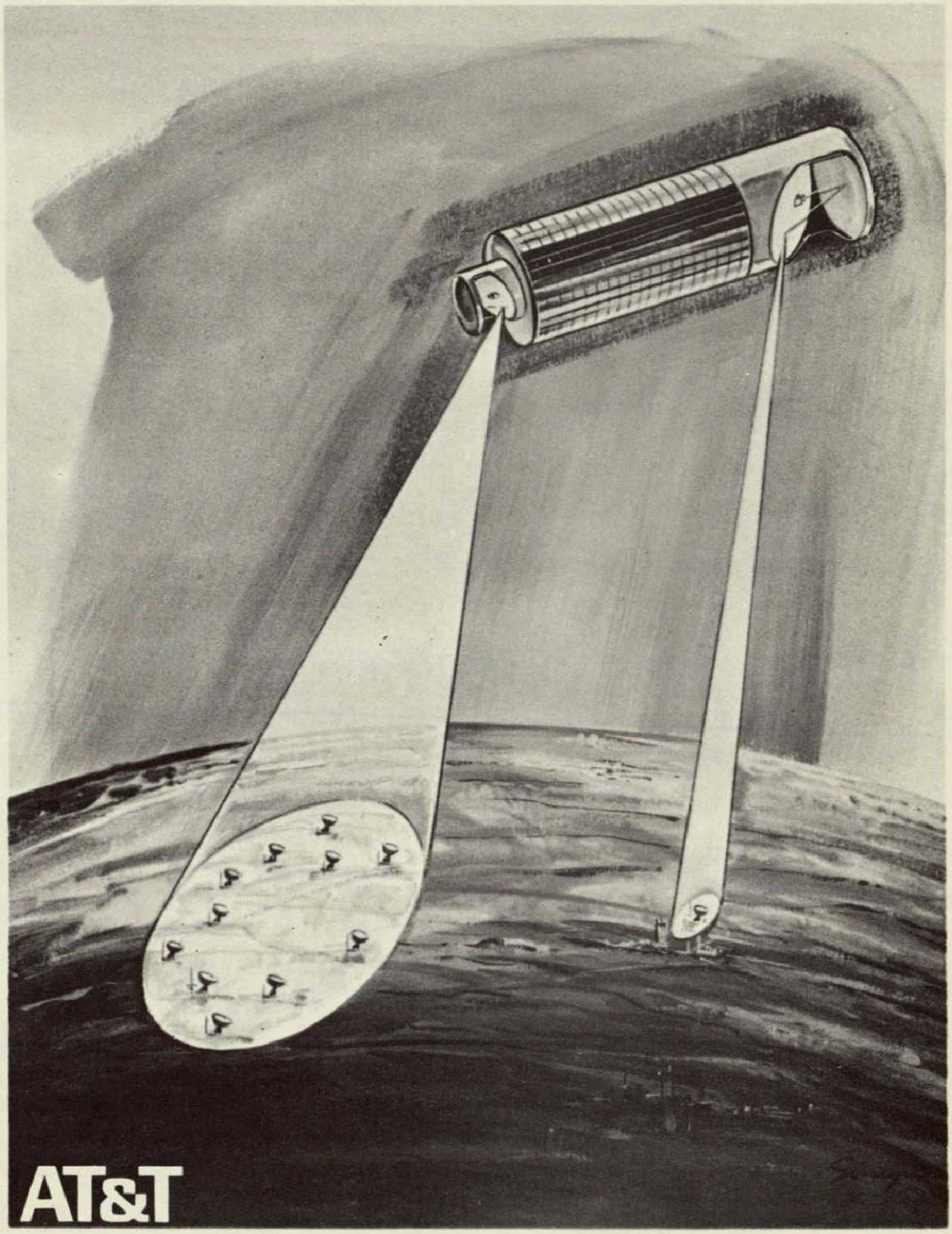
ANTENNAS: 5.5' S-Band Parabolic with single feed for approximately 1200 X 1700 mile area coverage
10' K-Band Spherical with 7 feeds for approximately 35 x 50 mile coverage.

REMARKS: S/C weight approximately 3,000 lbs
S/C size approximately 35' long and 10' diameter
S/C antenna beams to be maintained to within 0.1 degree
4 satellite system required 12° of Orbital Space over U.S.
Initial system would utilize 3 multi-purpose and 73 ground TV receiving stations.
Advanced system would utilize 26 multi-purpose and 73 ground TV receiving stations.

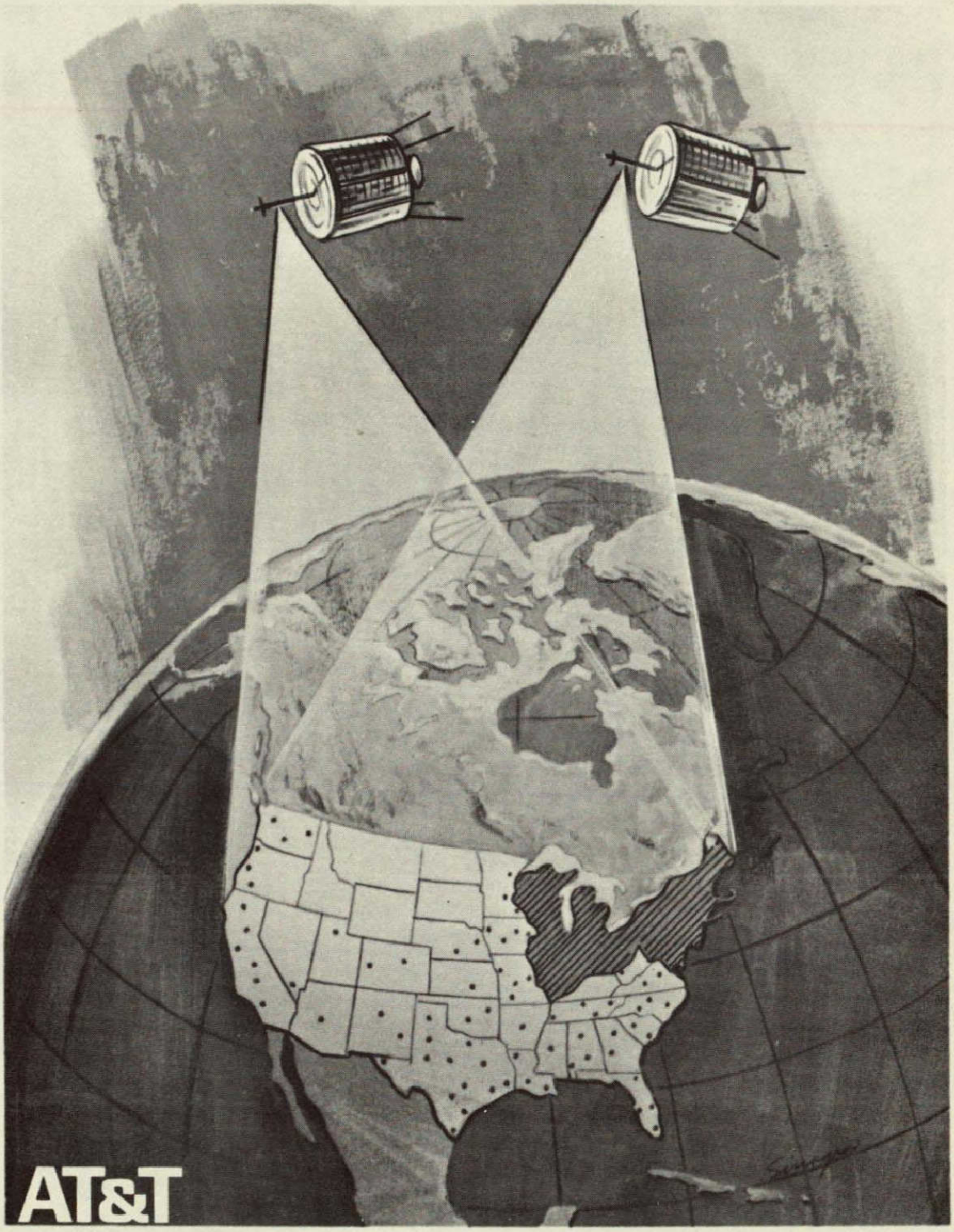
NOTE: This program has not been approved by the Federal Communications Commission.



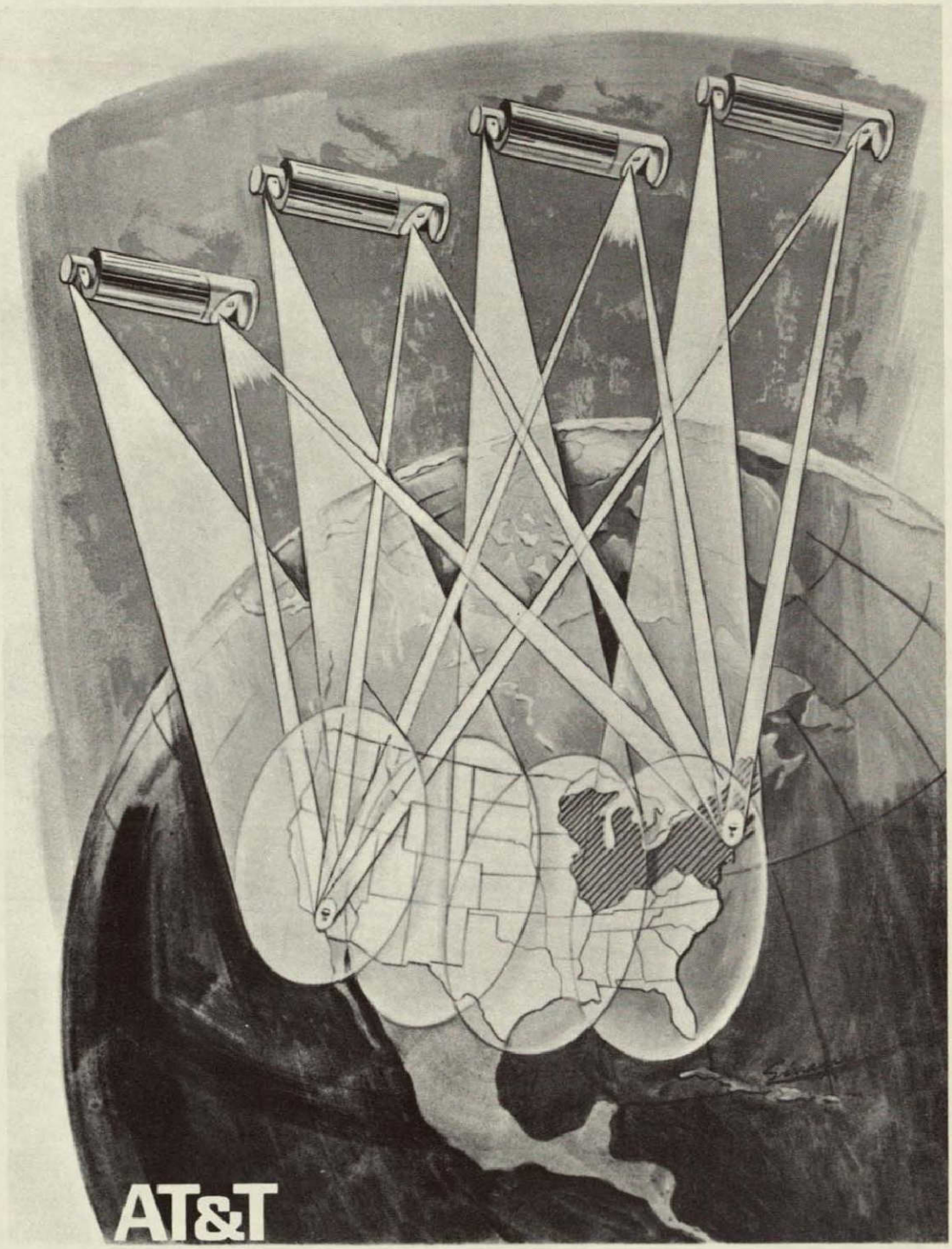
This is an artist's conception of the advanced-design satellite. The introduction of new technology, utilization of higher frequencies, and adaptation of Pulse Code Modulation (PCM) and frequency modulation (FM) transmission techniques would make this satellite capable of simultaneously providing 12 TV channels and over 30,000 duplex voice circuits.



An artist's conception of the advanced-design satellite shows the wide area coverage potential (left) of the Frequency Modulation (FM) beam and the small point-to-point type coverage (right) of the Pulse Code Modulation (PCM) beam. This is the first time that a satellite has been proposed with a dual FM-PCM capability.



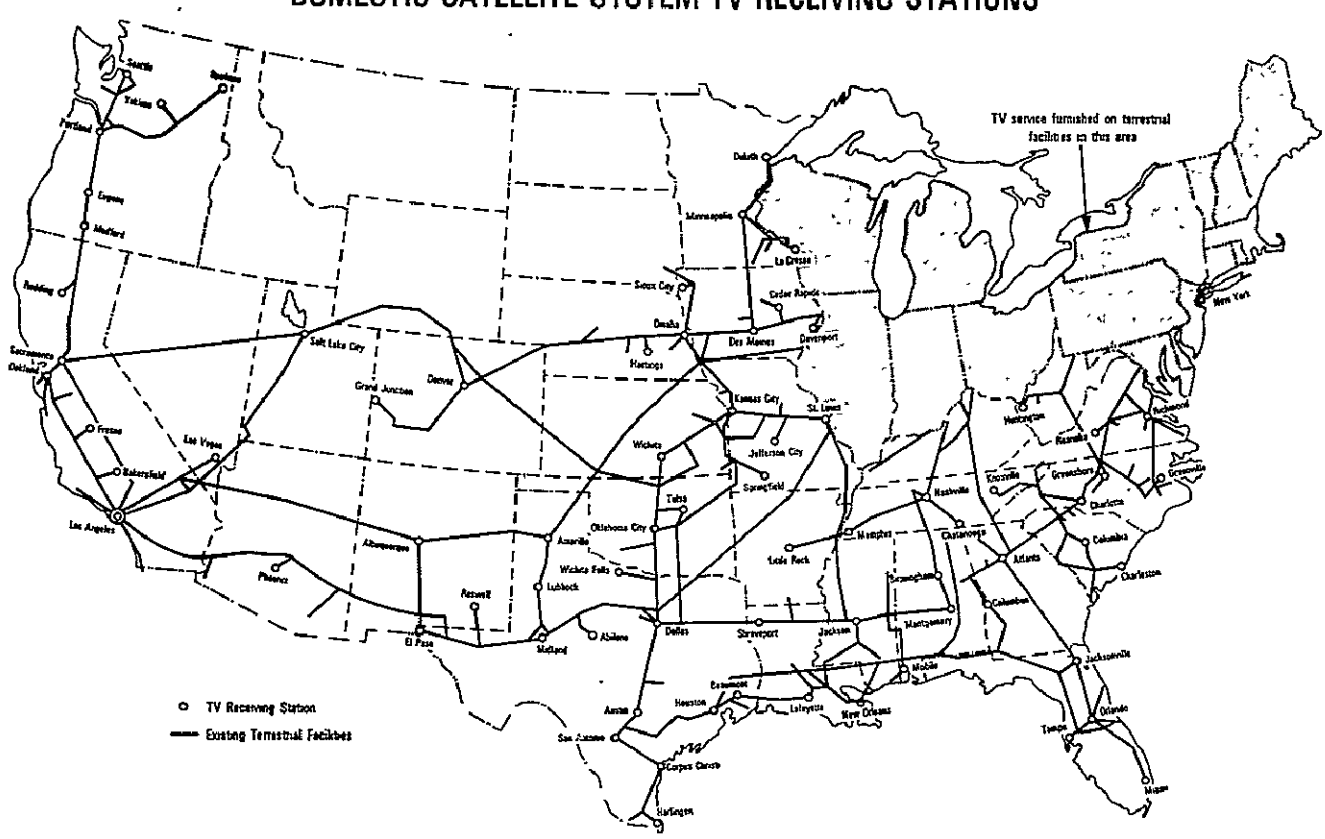
The initial phase of the Bell System proposal would be operative in 1969 and calls for two synchronous satellites to provide network television service for the continental United States. TV service for the northeast portion of the country (cross-hatched) would continue to be handled by terrestrial facilities. There are two reasons for this. First, serving the high concentration of TV broadcast stations in this area would double the number of satellites and require 30 additional TV receiving earth stations. This would be uneconomical. Second, heavily congested microwave facilities in the northeast would pose difficult frequency interference problems.



From 1976 through 1980, the system would be served exclusively by four advanced-design satellites. During this period it would provide for 83,000 equivalent two-way voice circuits, 24 TV channels, and 64 spare or occasional TV channels.

NASA — MSC
MSC 0084-71

DOMESTIC SATELLITE SYSTEM TV RECEIVING STATIONS



AT&T

The map shows how 73 TV receiving stations, built in selected locations across the country, would effectively serve the nation. Sites were chosen to facilitate interconnection with microwave routes.

NASA — MSC