



UNIVERSAL
TECHNOLOGY
CORPORATION

SPACECRAFT CHARGING TECHNOLOGY-THE EARLY DAYS

C. P. PIKE

OUTLINE

- 1973-1974
 - SATELLITE RELIABILITY PROBLEM
 - ANOMALY REVIEW GROUP

- 1975-1980
 - AF/NASA TECHNOLOGY PROGRAM

OUTLINE 1973-1974:

- **Early 1970s NUMEROUS UNEXPECTED, UNEXPLAINED PERFORMANCE ANOMALIES ON GEO SPACECRAFT**
 - **CONNECTIVITY LOST, FALSE SIGNALS**
- **1973 SAMSO SPO CALLED..FORMING “TIGER TEAM”**
 - **GATHERING ENGINEERING/SCIENTIFIC EXPERTS**
 - - **Chaired by Dr. Max Weiss, Aerospace Corp. GM**
 - - - **AFGL SPECIFIED THE SPACE ENVIRONMENT**
- **NASA’s ATS-5 (UCSD) SAW KV POTENTIALS AT GEO**
- **AFGL CORRELATED ANOMALIES-SUBSTORMS**

THE PHONE CALL THAT STARTED THE PROGRAM

ANOMALY REVIEW GROUP

- **ENVIRONMENTAL DATA SOURCES QUERRIED**
- **AFGL ANALYSIS INFERRED STRONG CORRELATION BETWEEN TIMES OF GEOSYNCHRONOUS SATELLITE ANOMALIES AND INTENSE SUBSTORMS AS SEEN IN DMSP WEATHER SATELLITE AURORAL IMAGES**

Table I-1-3. List of Disciplines Incorporated into the Environmental Data Base and the Participating Organizations

Type	Source
DOSP	GWC
MAGNETOMETER	
Goose Bay	AFCRL/ETAC
Thule	AFCRL/ETAC
Loring	ETAC
Eielson	ETAC
Churchill	NRC
RIOMETER	
Goose Bay	AFCRL
Great Whale	Boulder
Churchill	CRC
Val dor	CRC
Moosonee	CRC
Ottawa	CRC
Alaska	GWC/U. of Alaska
SCINTILLATIONS	
Goose Bay	AFCRL
Hamilton	AFCRL
Narsarssuaq	AFCRL
TEC	
Goose Bay	AFCRL
Hamilton	AFCRL
Narsarssuaq	AFCRL
IONOSONDE	
Churchill	CRC
Goose Bay	AFCRL
Ottawa	CRC
SOLAR RADIO NETWORK	AFCRL
SOLAR OPTICAL NETWORK	AFCRL
PARTICLE FLUXES	
ISIS	NASA/U. of Texas
OV5-6	AFCRL
AE-C	NASA/GSFC
IMF + SOLAR WIND	AFCRL/U. of California
SOLAR X-RAYS	NRL
VELA	LASL
Geopole - Thule	AFCRL

OUTLINE 1975-1980:

- **AF/NASA TECHNOLOGY PROGRAM**
 - **DEVELOP A PROGRAM PLAN**
 - - **INTERDEPENDENCY, MANAGEMENT, REPORTING**
 - **DOD STP's SATELLITE CHARGING EXPERIMENT**
 - **CHARGING CONFERENCES**
- **SAMSO/DYS TASKING LETTER, DEC 1974**
- **GPS SPO LETTER, DEC 1974**

SAMSO/DYS LETTER

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS SPACE AND MISSILE SYSTEMS ORGANIZATION (AFSC)
LOS ANGELES AIR FORCE STATION, PO BOX 92960, WORLDWAY POSTAL CENTER
LOS ANGELES, CALIFORNIA 90009



REPLY TO
ATTN OF: DYS (Capt Schober 30773)

6 January 1975

SUBJECT: Spacecraft Charging Executive Committee

TO: AFGRL/LIB (Dr Pike)

1. SAMSO/DYS was tasked at the 11 Dec AFSC/NASA (OAST) Space Technology Meeting to develop a joint AF/NASA technology roadmap of the area by March 1975. This roadmap will encompass all aspects of the spacecraft charging problem. We are forming an executive committee to scope the problem and establish working groups in the different areas of the technology.

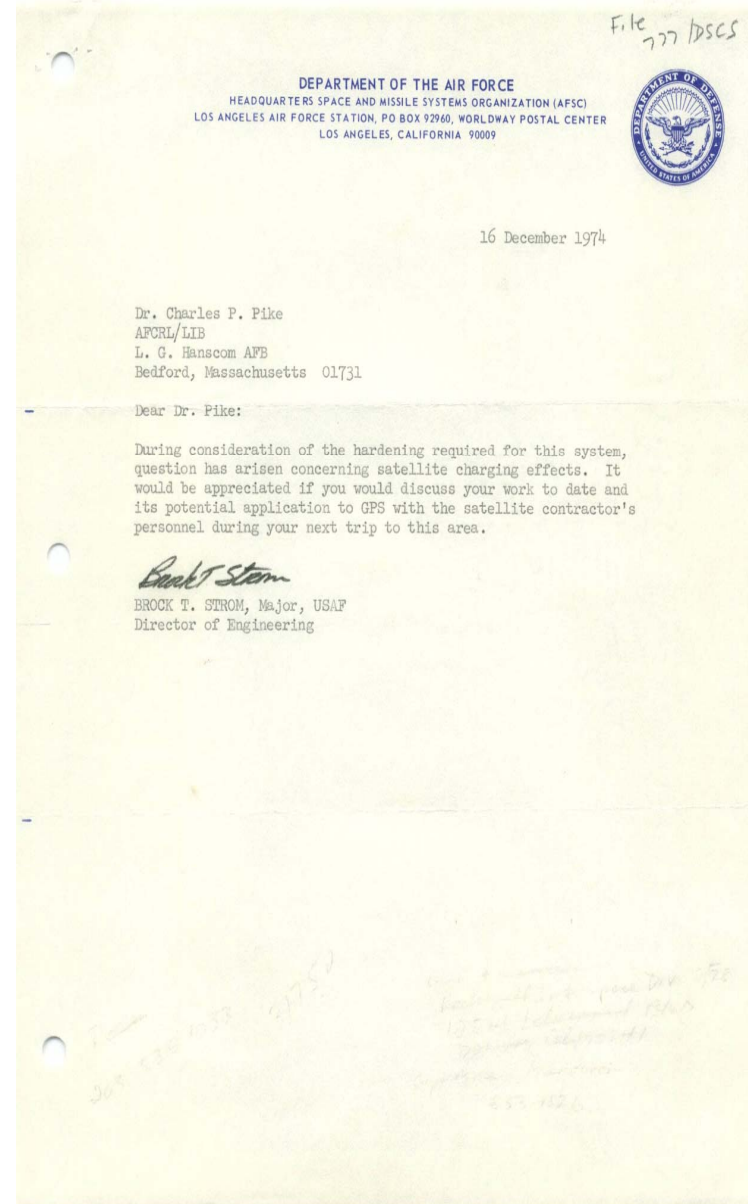
2. I would like to ask you to be a member of the executive committee along with Don McPherson, Dave Cauffman, Fred DeMeritte, and one other NASA representative. We would like to meet at NASA HQ on 13 January if possible.

FOR THE COMMANDER

Wayne R Schober

WAYNE R. SCHOBER, Capt, USAF
Project Officer
Survivability Directorate

GPS SPO LETTER



AF/NASA Technology Program Milestones

- **1975 MOA SIGNED:**
 - **AF/NASA INTERDEPENDENT SPACECRAFT
CHARGING TECHNOLOGY PROGRAM**
- **1976 1st SPACECRAFT CHARGING CONFERENCE**

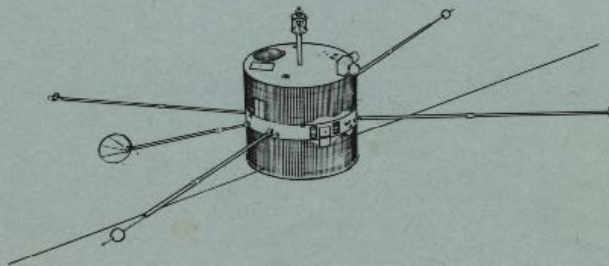
AF/NASA PROGRAM

- **AFGL PARTICIPANTS:**
 - **“PHYSICS” OF CHARGING**
 - Parker, Laframboise, Ruben, Cooke, Lai
 - **GEOSYNCHRONOUS ENVIRONMENT ATLAS**
 - Garrett, Hardy, Mullen, Gussenhoven, Burke
 - **NASCAP CHARGING CODE**
 - - S-Cubed/Katz
 - **CHARGE CONTROL SYSTEM**
 - Hughes Malibu Lab/Cohen
- **USAF, NASA, CONTRACTORS - TECHNOLOGISTS, SCIENTISTS & ENGINEERS WORKING AS A TEAM**

SCATHA

- **1975 DOD SPACE TEST PROGRAM P78-2 MISSION**
 - **SAMSO-402 Spacecraft Charging at High Altitudes**
 - **MISSION: UNDERSTAND/DESIGN/TEST**
 - **GOAL: SURVIVABLE S/C**
 - **MARTIN PRIME/DELTA 2914 LAUNCH VEHICLE**
 - **PIs: AF, AEROSPACE, NASA, NAVY,
UNIVERSITY, INDUSTRY S&Es, 12 EXPERIMENTS**
- **1979 SCATHA LAUNCHED (30 JAN)**

Description of the Space Test Program P78-2 Spacecraft and Payloads



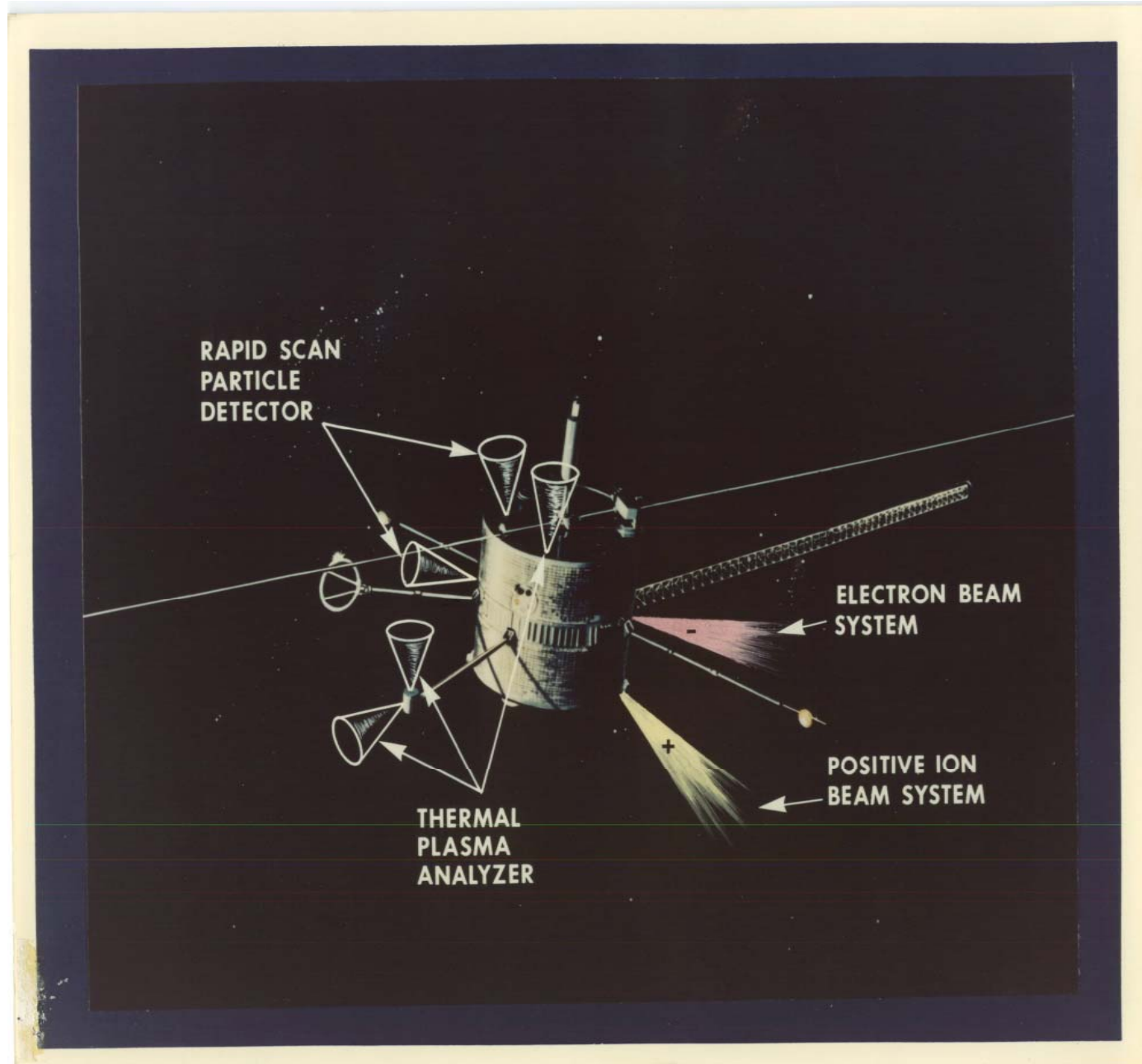
31 October 1978



Table 1.2. Principal Investigators/Sponsors

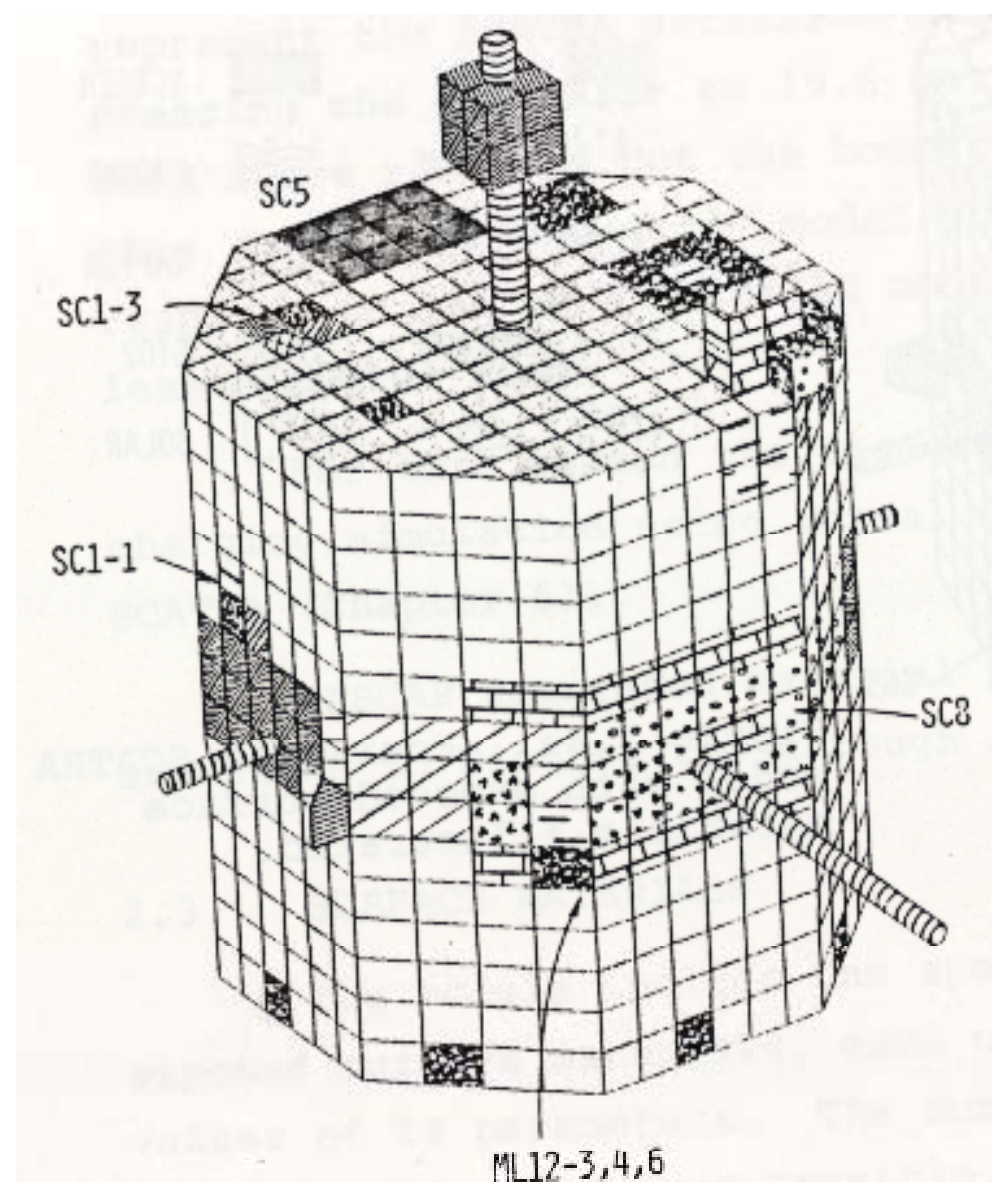
Experiment Number	Title	Principal Investigator/Sponsor	Address
SC1	Engineering Experiments	Dr. H. C. Koons/ USAF/AFSC/SAMSO	The Aerospace Corporation P.O. Box 92957 Los Angeles, CA 90009
SC2	Spacecraft Sheath Electric Fields	Dr. J. F. Fennell/ USAF/AFSC/SAMSO	The Aerospace Corporation P.O. Box 92957 Los Angeles, CA 90009
SC3	High Energy Particle Spectrometer	Dr. J. B. Reagan Office of Naval Research	Lockheed Palo Alto Research Lab, 3251 Hanover Street Palo Alto, CA 94304
SC4	Satellite Electron and Positive Ion Beam System	Dr. H. A. Cohen/ USAF/AFSC	Hanscom AFB/LKB Bedford, MA 01731
SC5	Rapid Scan Particle Detector	Lt. D. Hardy/ USAF/AFSC	Hanscom AFB/PHE Bedford, MA 01731
SC6	Thermal Plasma Analyzer	Dr. R. C. Sagalyn/ USAF/AFSC	Hanscom AFB/PHR Bedford, MA 01731
SC7	Light Ion Mass Spectrometer	Dr. D. L. Reasoner/ Office of Naval Research	NASA Marshall Space Flight Center, Code BS-23 Huntsville, AL 35815
SC8	Energetic Ion Composition Experiment	Dr. R. G. Johnson/ Office of Naval Research	Lockheed Palo Alto Research Lab, 3251 Hanover Street Palo Alto, CA 94304
SC9	UCSD Charged Particle Experiment	Dr. S. E. Deforest/ Office of Naval Re- search/USAF/AFSC/ SAMSO	University of California B019 Dept. of Physics La Jolla, CA 92093
SC10	Electric Field Detector	Dr. T. L. Aggson/ Office of Naval Research	NASA Goddard Space Flight Center, Code 625 Greenbelt, MD 20771
SC11	Magnetic Field Monitor	Dr. B. G. Ledley/ Office of Naval Research	NASA Goddard Space Flight Center, Code 625 Greenbelt, MD 20771
ML12	Spacecraft Contamination	Dr. D. F. Hall/ USAF/AFSC/AFML	The Aerospace Corporation P.O. Box 92957 Los Angeles, CA 90009





SCATHA LAUNCH 30 JAN 1979





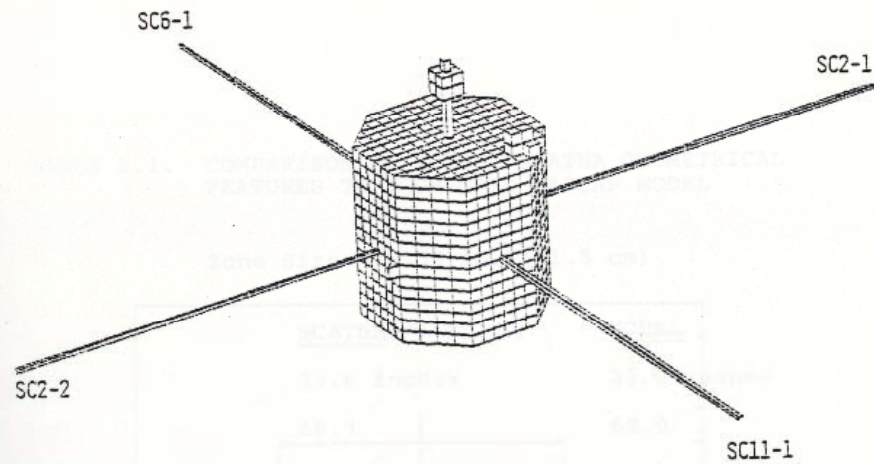


Figure 2.1. Four-grid SCATHA model: side view. The 50 m antenna and the SCl-4 boom are not included in this model.

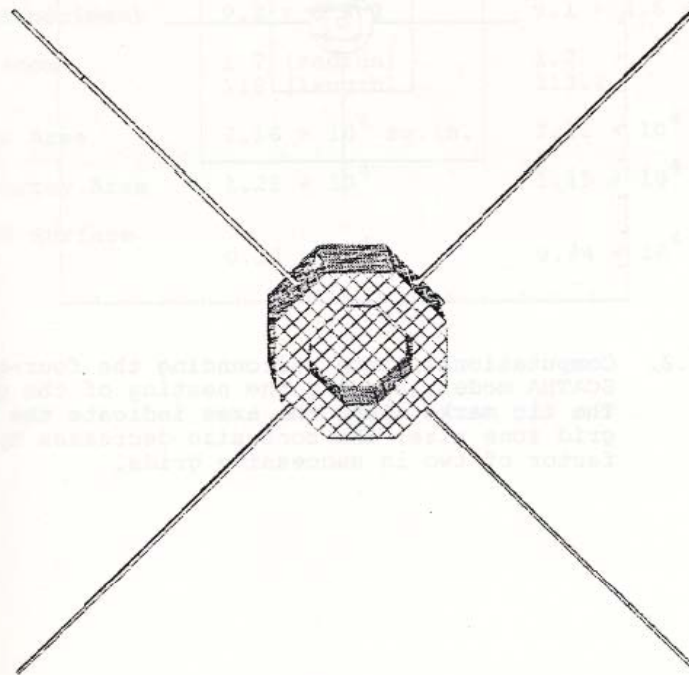
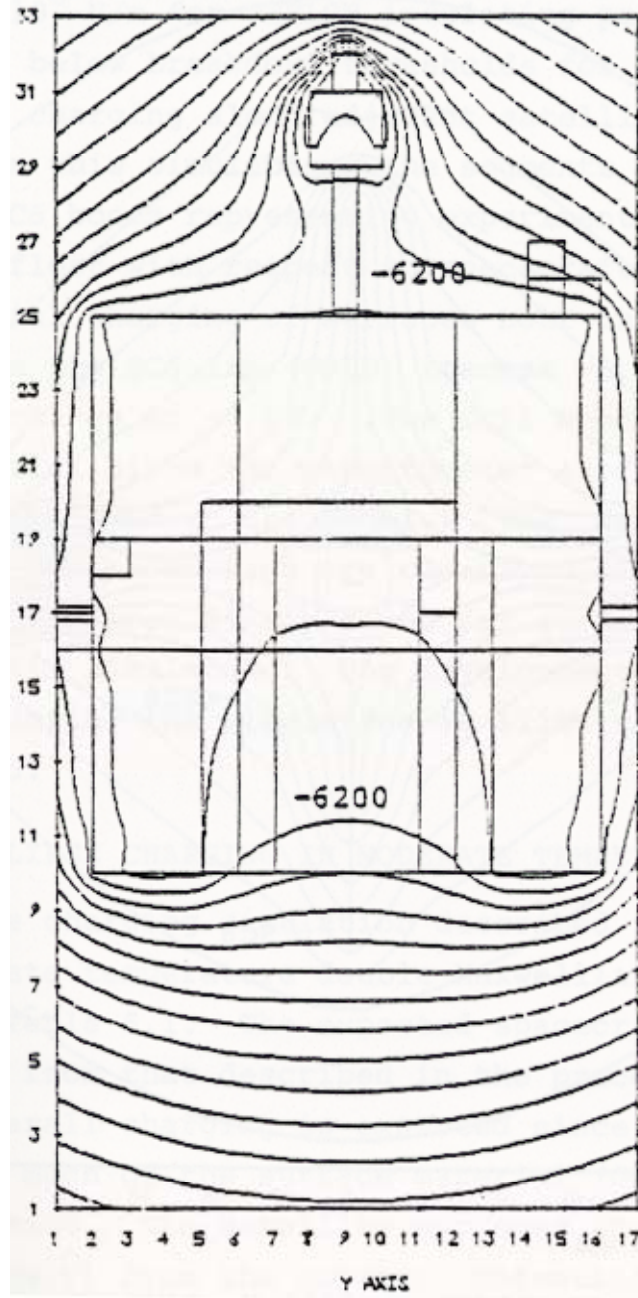
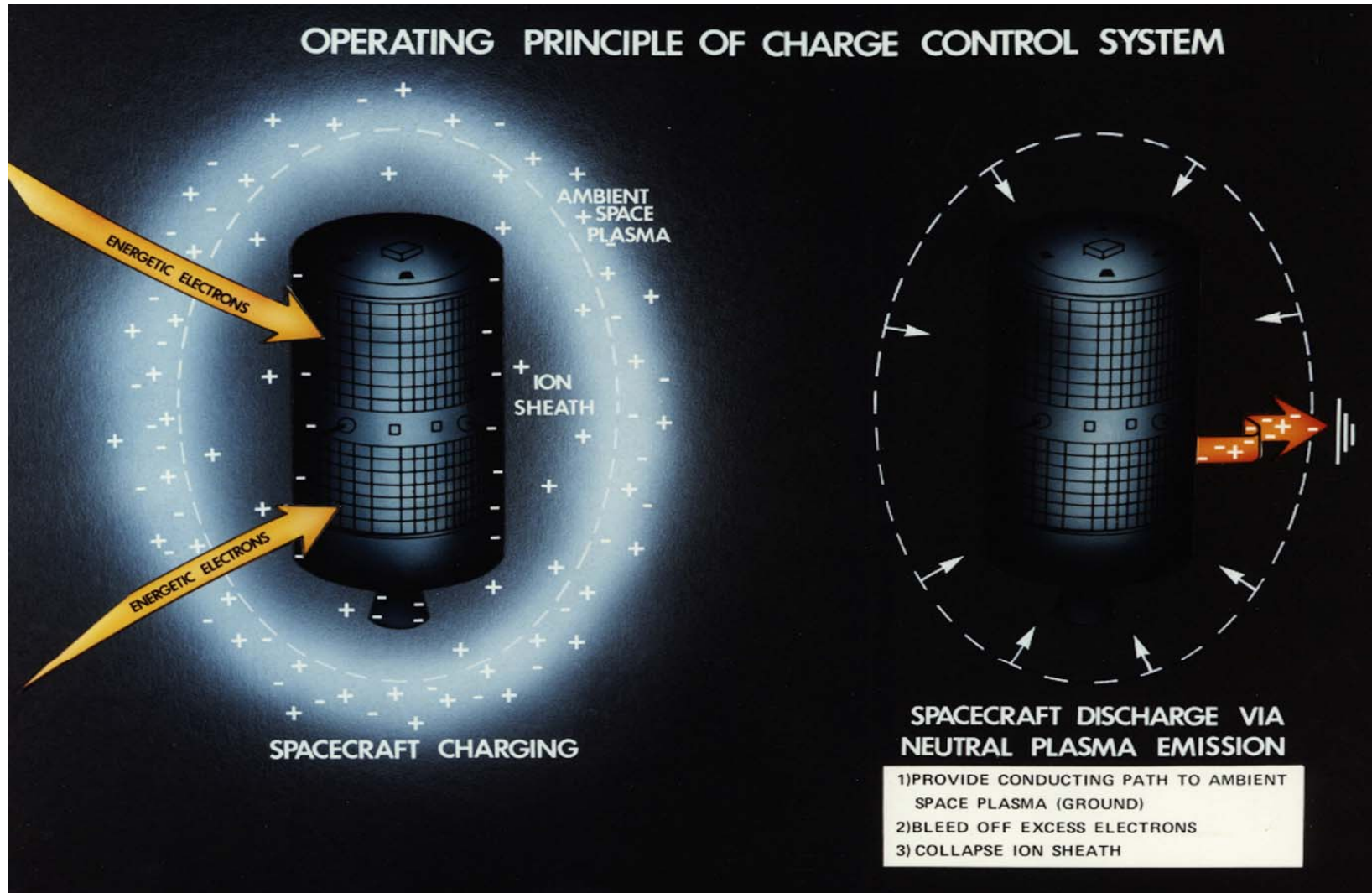


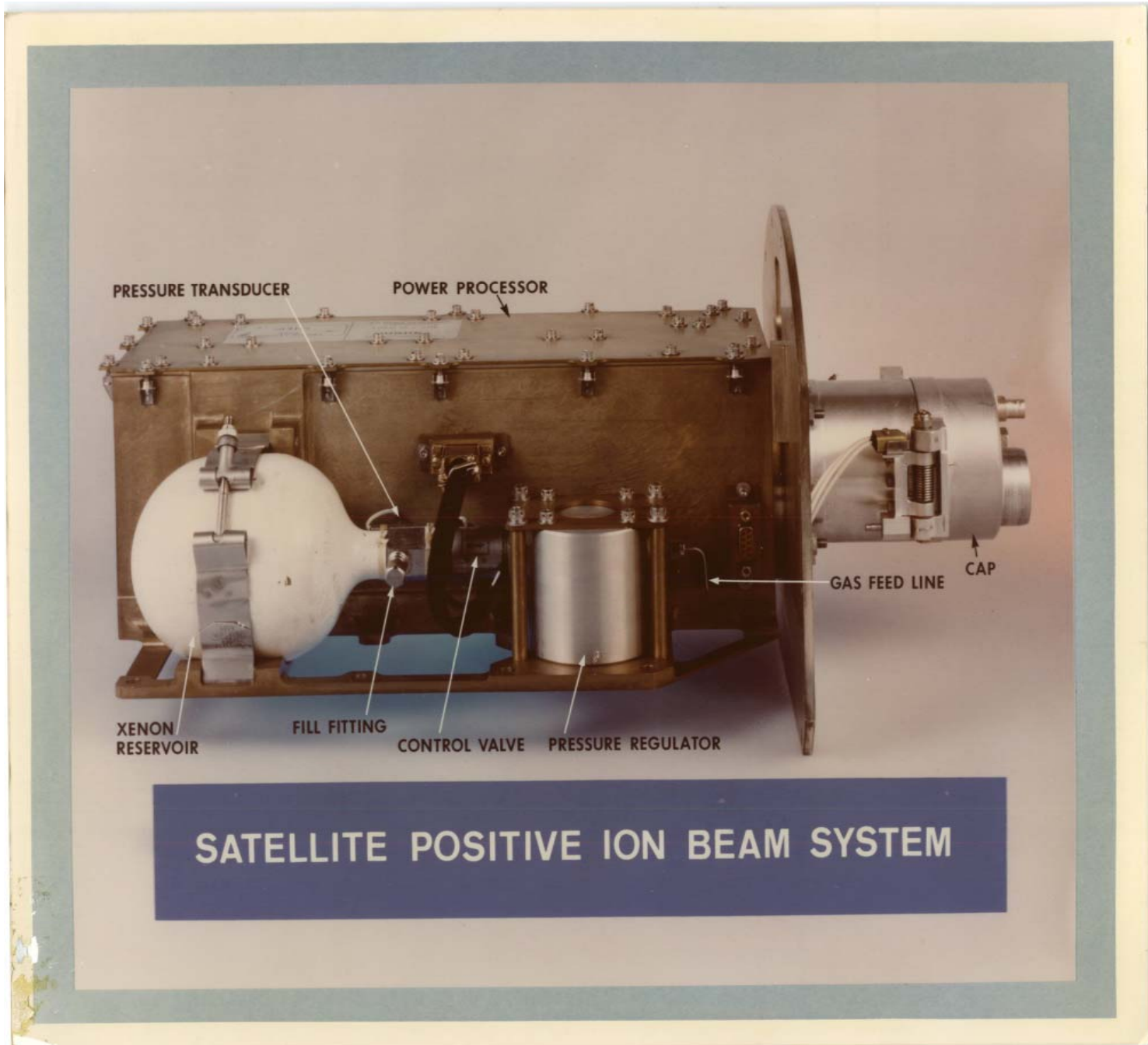
Figure 2.2. Four-grid SCATHA model; bottom view with aft cavity visible.





CHARGE CONTROL SYSTEM





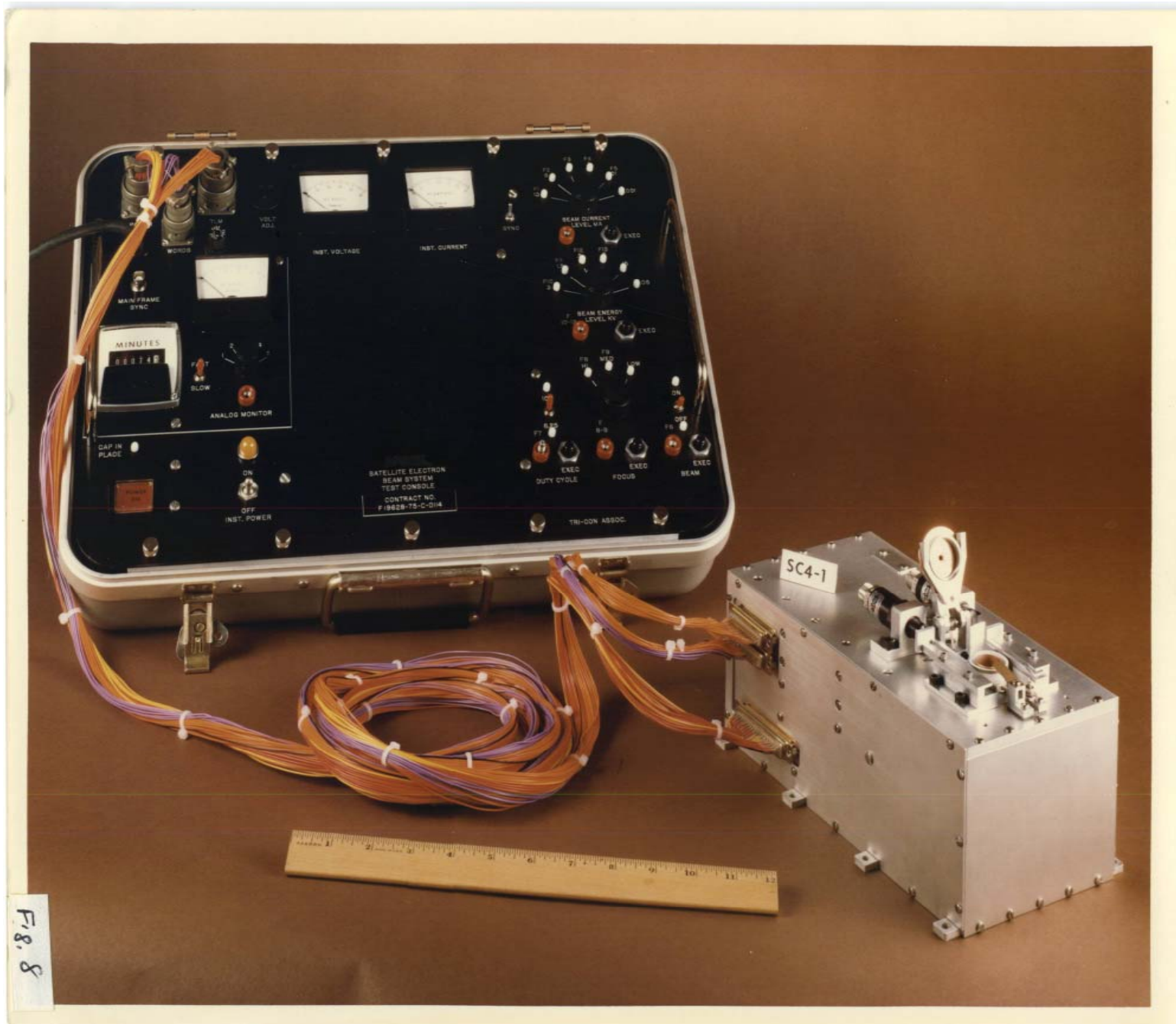


Fig. 8

SCATHA SATELLITE

- **RESULTS :**
 - **CONTROLLED VEHICLE POTENTIAL**
 - - **ELECTRON/XENON ION BEAM SYSTEMS**
 - **MEASURED ELECTRON/PROTON FLUXES**
 - - **CHARACTERIZED GEO ENVIRONMENT**
 - - **THERMAL PROBES/ESAs**
 - **NASCAP VALIDATION**
 - **DISCHARGES CHARACTERIZED**

PROGRAM RESULTS & TECHNOLOGIES

- **GEO SPACE ENVIRONMENT SPECIFICATION**
- **CHARGE CONTROL SYSTEM**
- **NASCAP CHARGING CODE**
- **DESIGN GUIDELINES**
- **CEASE “ WARNING SENSOR”**
- **SPACE WEATHER’S OPERATIONAL IMPACT**
 - **NEW AF FUNDING LINE PE63410F**

ACKNOWLEDGEMENTS

- **Hank Garrett, Herb Cohen, Alan Rubin, Arthur Besse, David Hardy, Gary Mullen, Susan Gussenhoven-Shea, William Burke, Rita Sagalyn, William Huber, Fred Rich, Paul Rothwell, Arthur Pavel, Ludwig Katz, William Lehn**
- **Col. John Brooke, Col. Bernard Morgan, Col. Donald Wippermann, Joseph Hess, Joseph Kelley, Wayne Schober, Maury Bunn**
- **Dale Ferguson, N John Stevens, Carolyn Purvis, Bob Lovell, Wayne Hudson, Bob Finke**