N93-26396

SPACE ENVIRONMENTAL INTERACTIONS FOR THE SPACE EXPLORATION INITIATIVE

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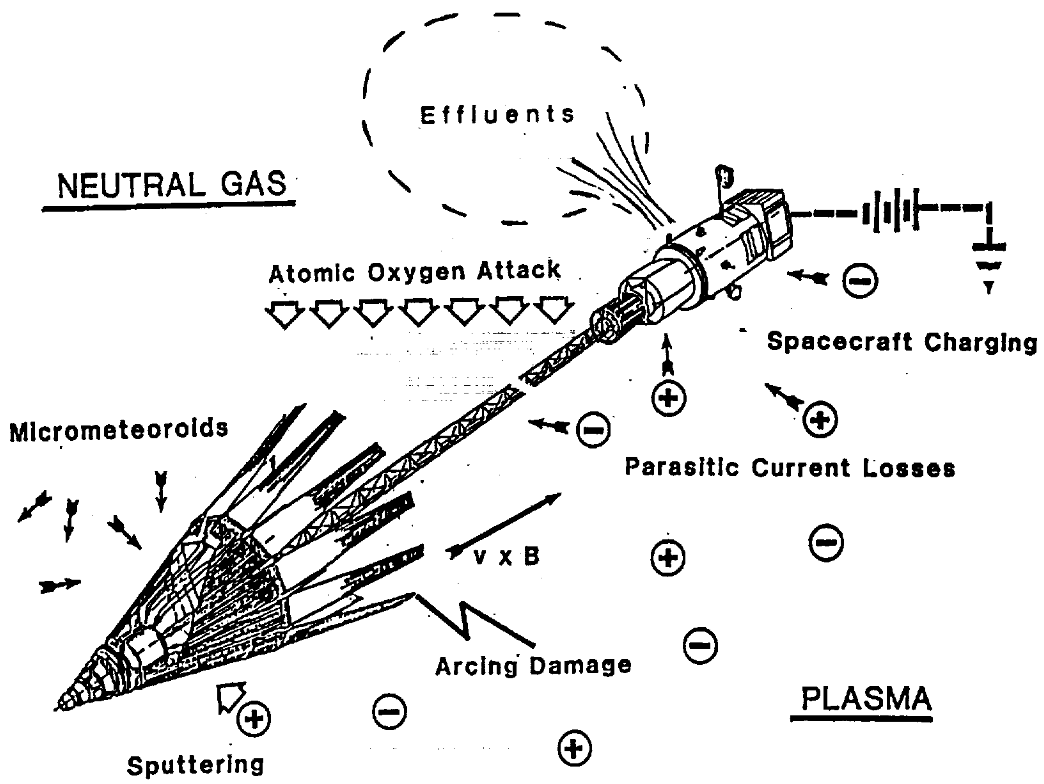
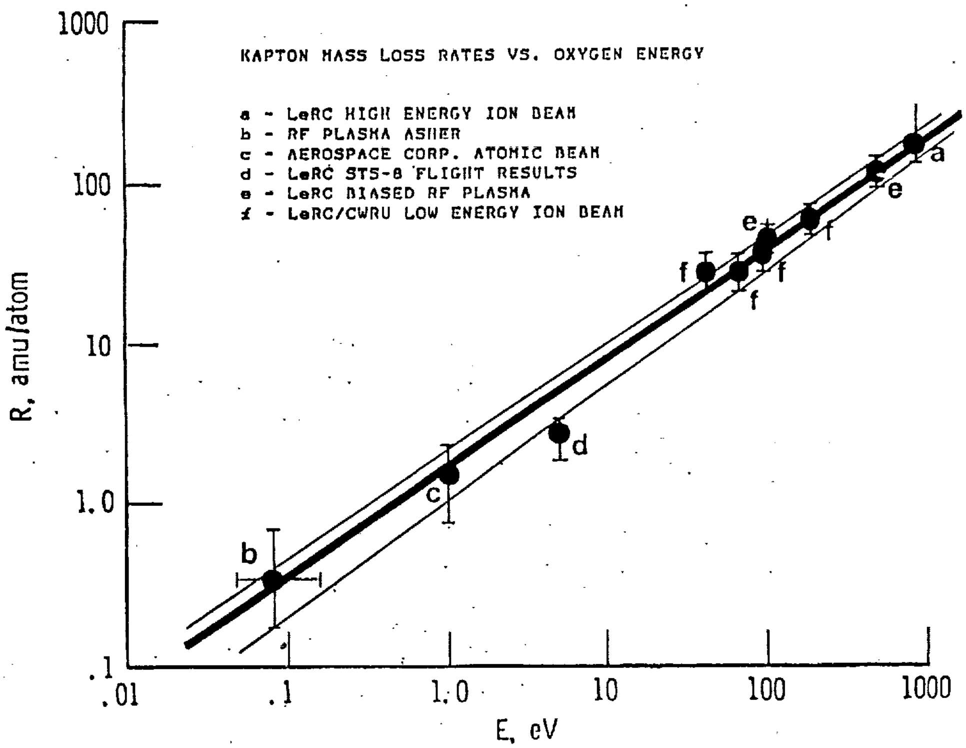
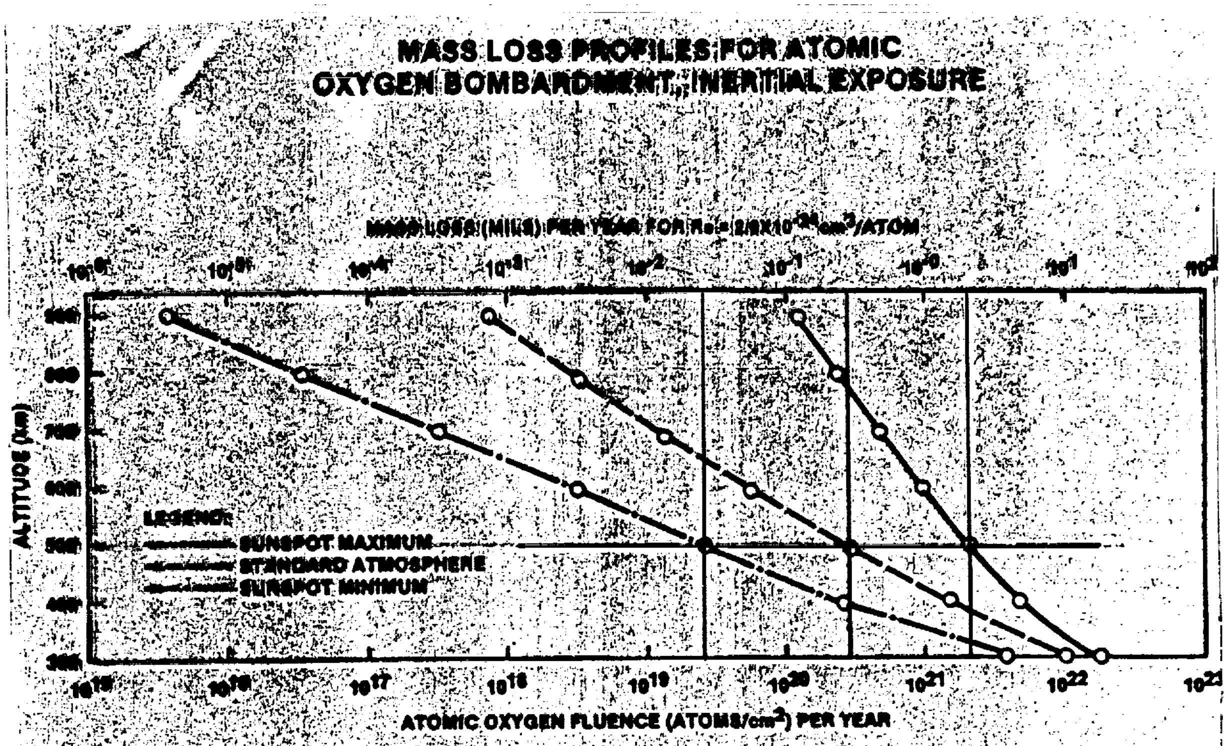
SPACECRAFT ENVIRONMENTAL EFFECTS



Space Environmental Interactions
Atomic Oxygen Attack

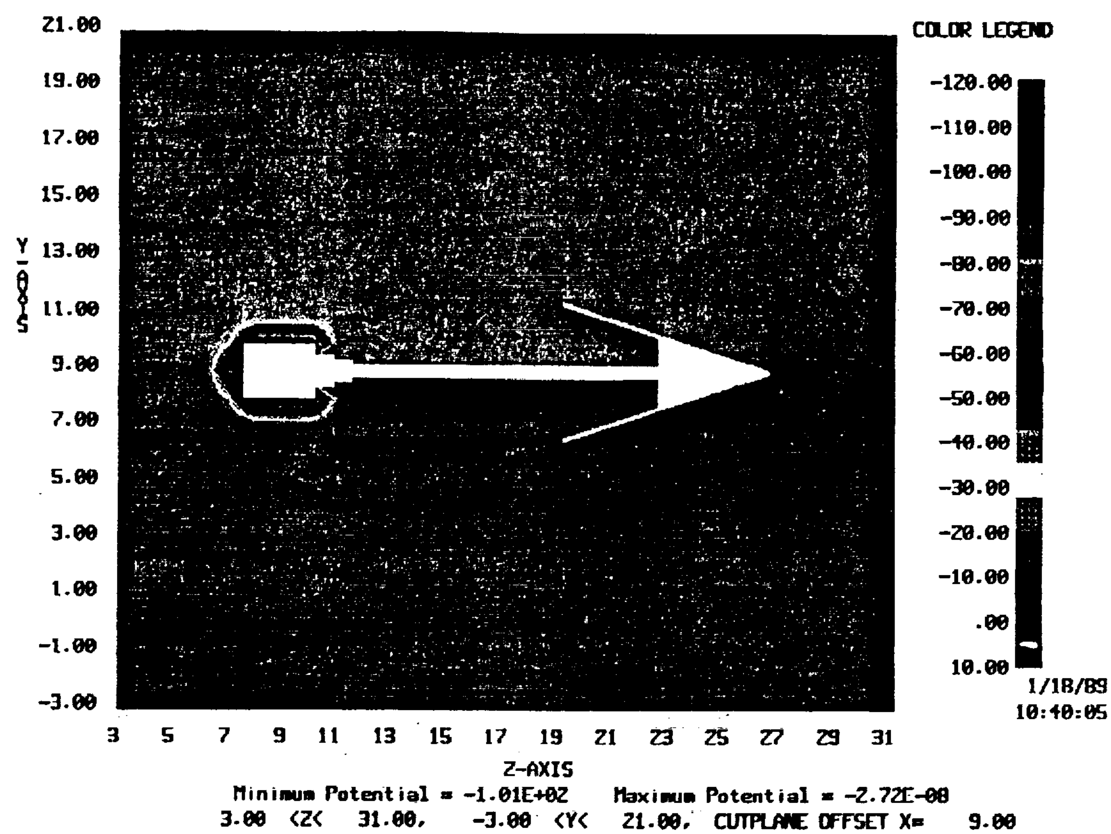
- LOW PLANETARY ORBITS ONLY
  - Material Specific
  - Preferentially in Ram
  - Low Mars Orbit Also Contains AO
  - For Some Materials, Synergy w/ UV
  - Ionized AO Also Reactive.
- CHANGES MATERIAL SURFACE PROPERTIES
  - Optical and Thermal Properties
    Surface Conductivities
    Strength of Exposed Fibers





 Visentine, J.T. and Leger, L.J., A Consideration of Atomic Oxygen Interaction with the Space Station, J. Spacecraft and Rockets, 23, 5, 505-511, 1986.

Load Biased to 100V Neg. w.r.t. Body



Space Environmental Interactions

Arcing and Discharges

- GEOSYNCHRONOUS ENVIRONMENT
  - Differential Charging in Geo Substorms
  - Solar Flares in Interplanetary Space
- LOW PLANETARY ORBITAL ENVIRONMENTS
  - Arcing To or Thru Ionized Plasma
  - Dielectric Breakdown of Anodized Surfaces
  - Arcing at Conductor-Insulator Junctions
- PASCHEN BREAKDOWN - PLANETARY SURFACE
  - Martian Atm Pressure Ideal for Discharges
  - Lunar Camps Create Local Atmospheres

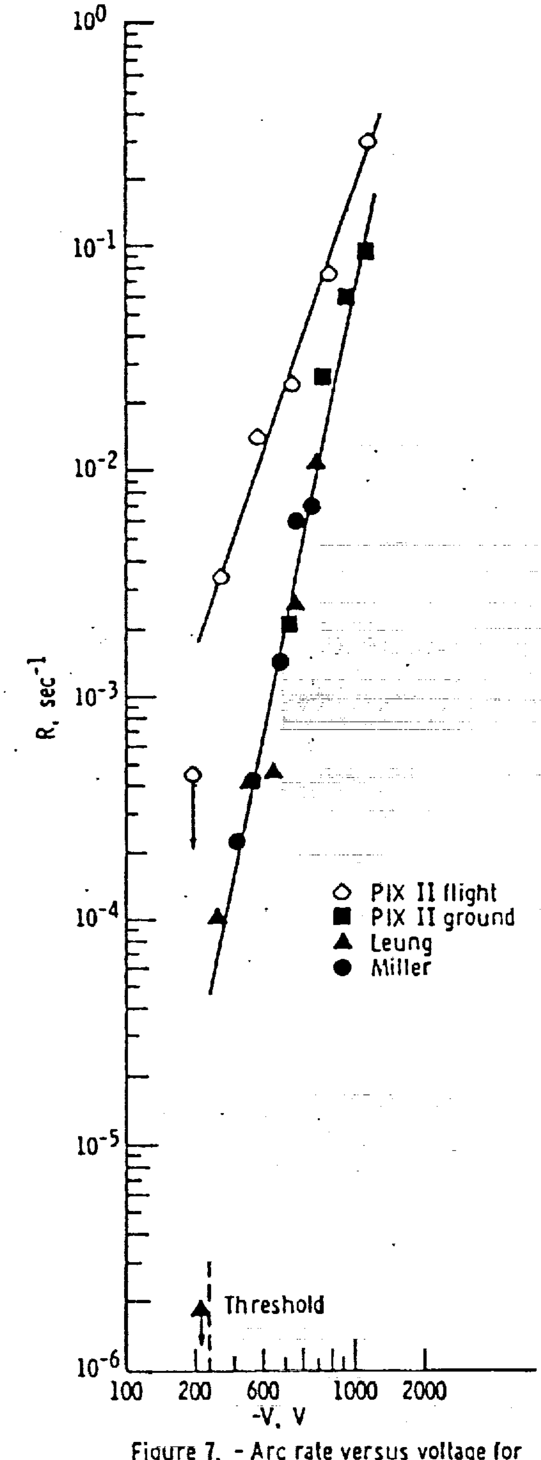
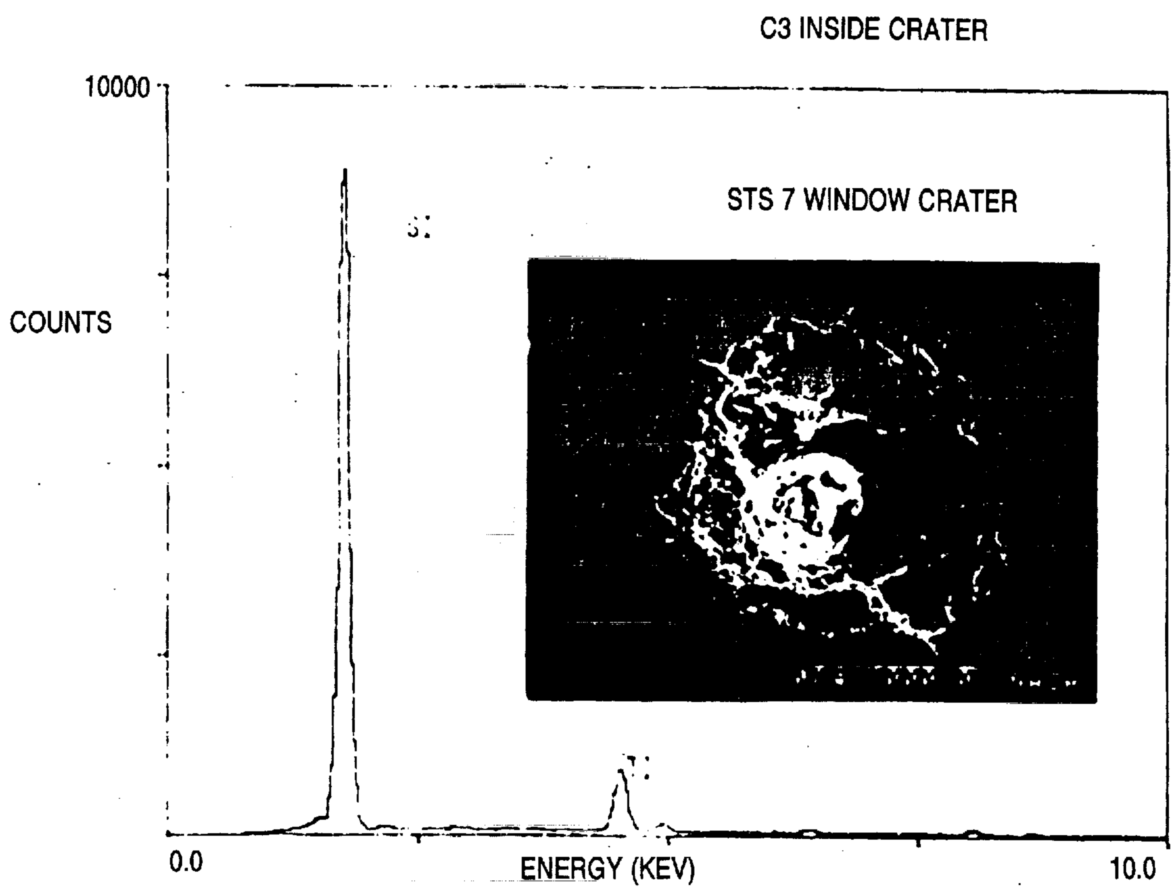


Figure 7. - Arc rate versus voltage for standard interconnect cells. Normalized to LEO ram conditions (see text).

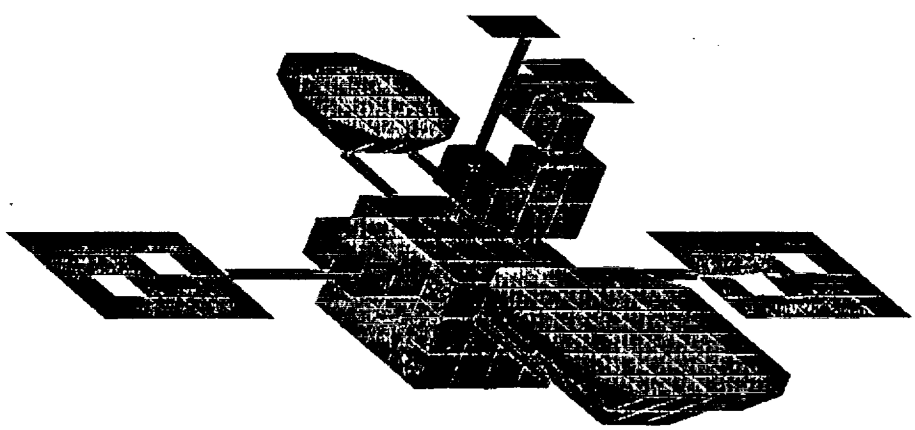
Space Environmental Interactions
Micrometeoroids and Debris

- SURFACE DAMAGE
  - Pinholes in Insulators
  - Change of Thermal Properties
  - Sites for Arcing, Sputtering
  - Possible Site of Kapton Pyrolysis
- NEED FOR REDUNDANCY OR HEALING
  - Fluid Lines and Heat Pipes
- LOCAL PLASMA CREATED AT SITE
  - May Produce Prompt Arcing
  - Arcs Enlarge Damaged Area
- DEBRIS PROBLEM IN PLANETARY ORBITS



Space Environmental Interactions
State-of-the-Art Computer Tools

- S-CUBED DIV. OF MAXWELL LABORATORIES
- NASCAP (3-D, Particle Tracking)
  - Calculates Charging in GEO
  - Obtainable thru COSMIC
  - Mature Code, Industry Standard
- NASCAP/LEO (3-D, Particle Tracking)
  - Calculates Charging, Currents in LEO
  - Release thru COSMIC This Year
  - Under Final Testing
- EPSAT, EWB (1-D, Systems Tools)
  - Evaluate Multiple Interactions
  - Quick, Approximate
  - Under Beta Testing
  - May Be Ideal Starting Point for SEI

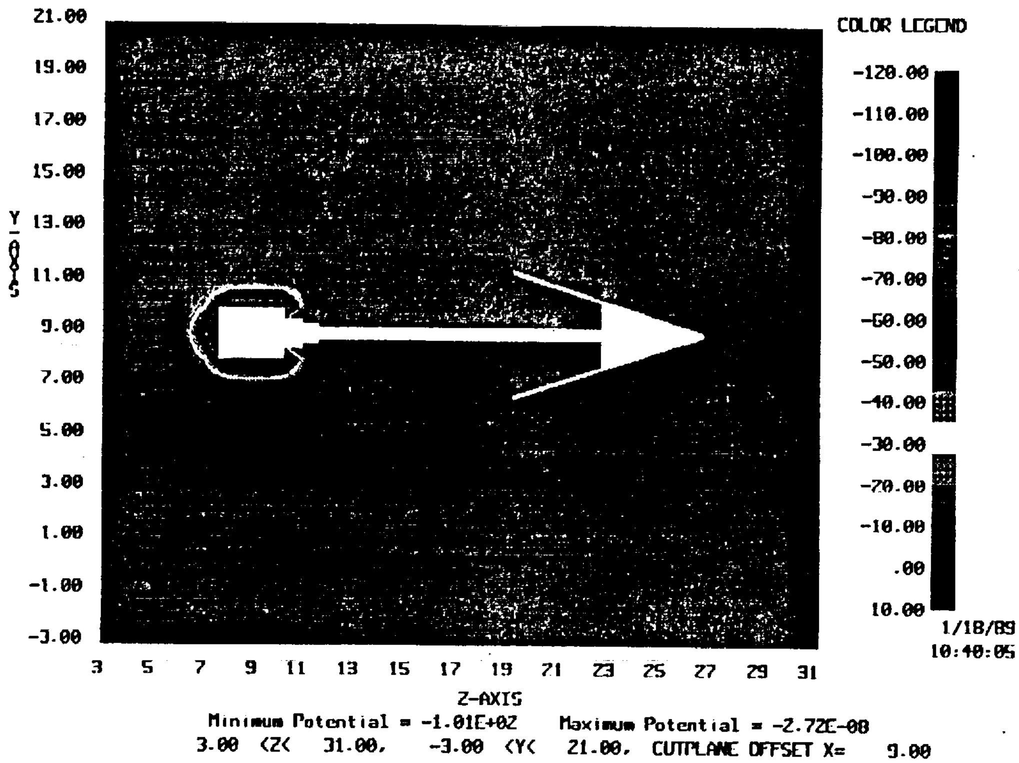


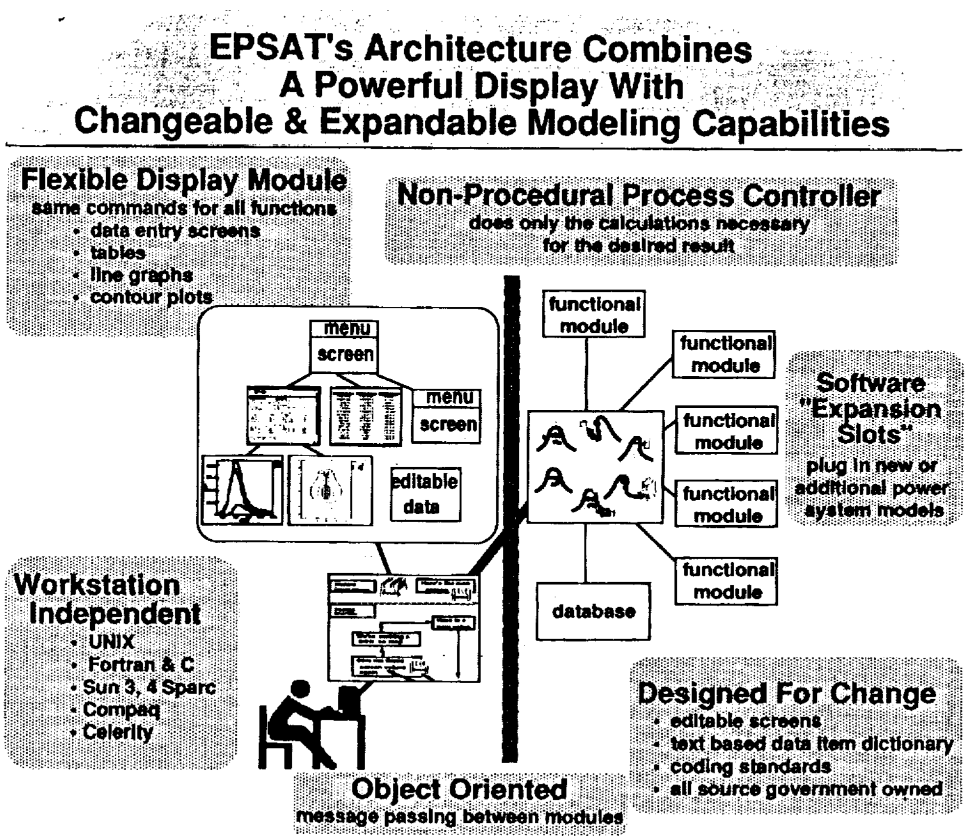
NASCAP model of NASA's
Advanced Communications Technology Satellite.

Figure 6

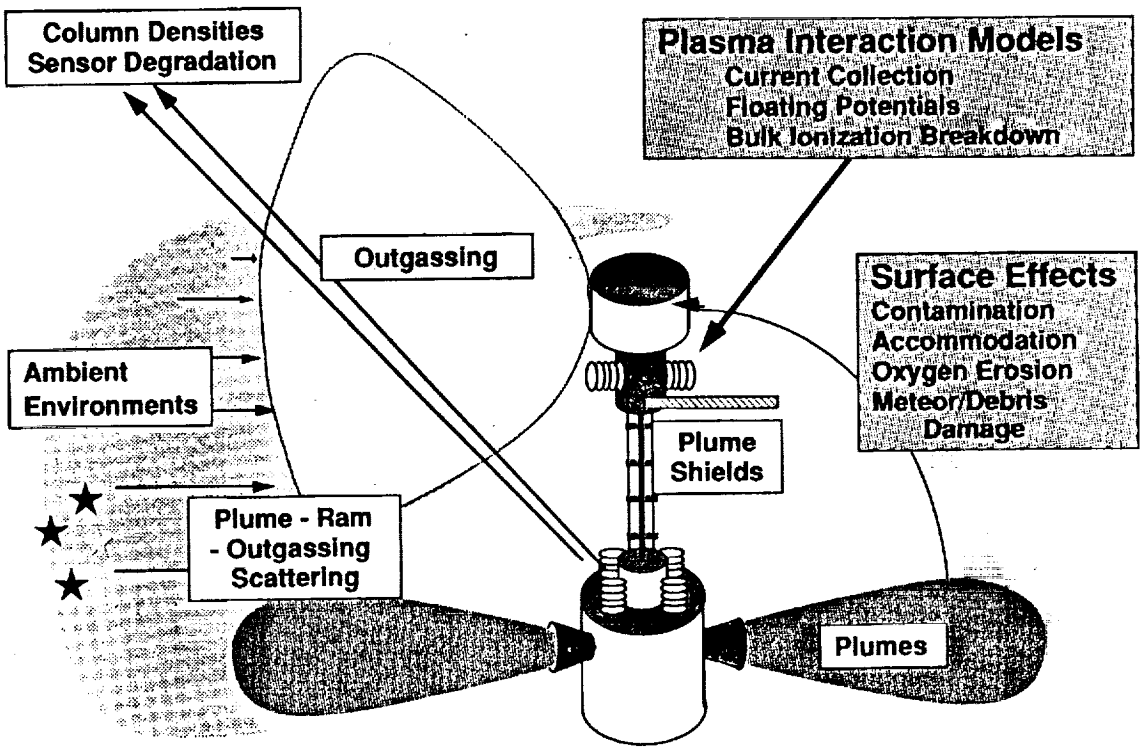
SP-100 Floating Potential

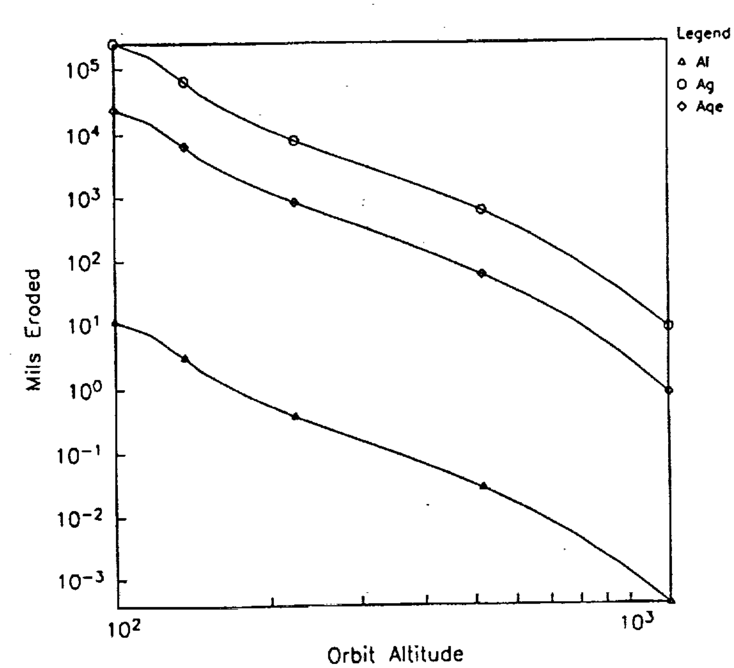
Load Biased to 100V Neg. w.r.t. Body





EPSAT
Power System Models





Total atomic oxygen erosion during a 10-year mission life for three conductive coatings as a function of altitude for 60° inclination circular orbits.

KAPTON 41 HOURS EXPOSURE TO ATOMIC OXYGEN ON STS-8

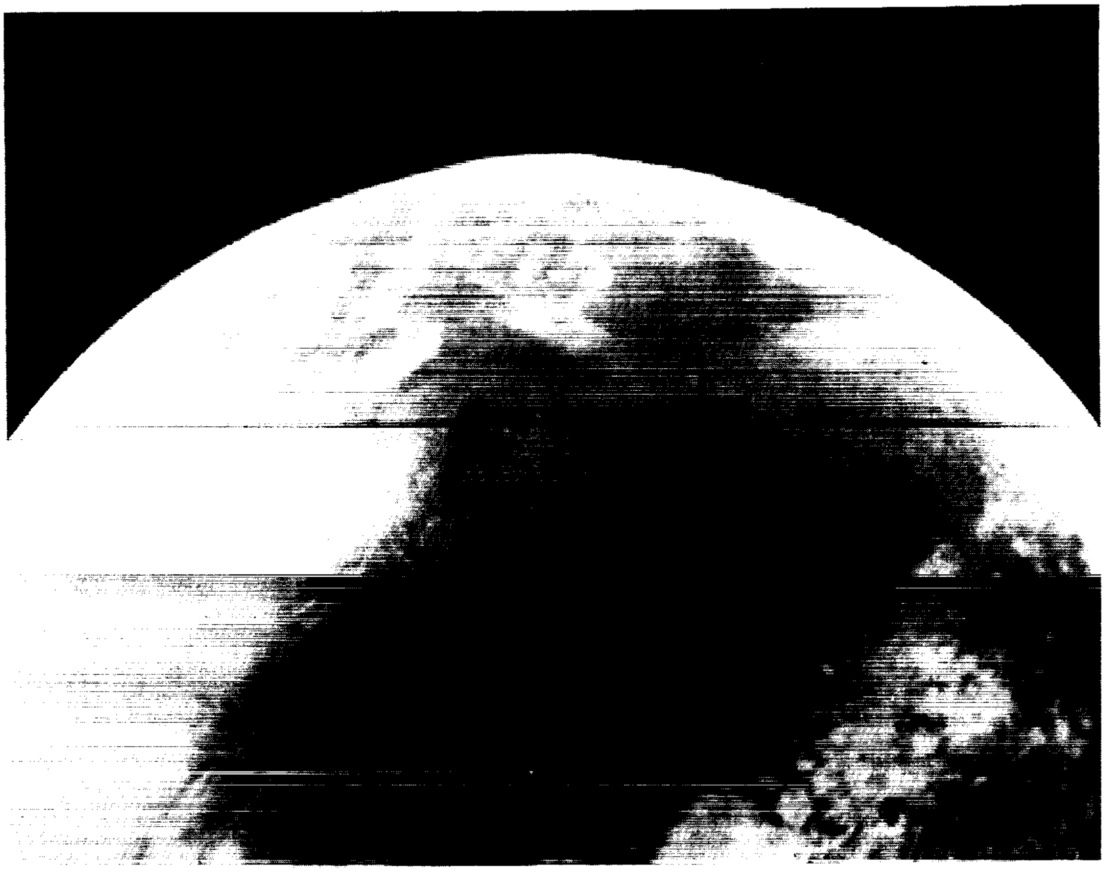
STS-8 FLIGHT SAMPLES

LeRC PRELIMINARY MASS LOSS MEASUREMENTS
(Corrected for mass change of control due to moisture, etc.)

(Assumes 3.87 x 10^{20} atoms/cm^2)

SAMPLE #	DESCRIPTION	MASS CHANGE (g) ERROR	[redacted] ERROR	COMMENT
1	5 mil Kapton, Al backed	-0.0050200 99	-3.88 x 10^{-24} 01	
2	5 mil Teflon, Al backed	-0.0000820 91	-6.34 x 10^{-26} 01	Low loss rate
3	5 mil Mylar, Al backed	-0.0056031 118	-4.34 x 10^{-24} 01	HIGHEST MEASURED
4	MgF_2 anti-reflection on glass	-0.0000204 259	-1.58 x 10^{-26} 2.01	No sig. change
5	ITO on glass	-0.0000190 359	-1.46 x 10^{-26} 2.78	No sig. change
6	96% SiO_2 + 4% PTFE on 5 mil Kapton	-0.0000103 52	-7.98 x 10^{-27} 4.04	Very low loss rate
7	Al_2O_3 on 5 mil Kapton	-0.0005674 52	-4.40 x 10^{-25} 04	LOWEST MEASURED
8	SiO_2 on 5 mil Kapton	-0.0000058 52	-4.50 x 10^{-27} 4.04	No sig. change
9	TiO_2 on quartz	+0.0000437 147	+3.38 x 10^{-26} 1.14	Low gain rate
10	Mo on sapphire	+0.0000760 235	+5.88 x 10^{-26} 1.81	Low gain rate
11	Copper on sapphire	+0.0000764 767	+5.91 x 10^{-26} 5.93	No sig. change
12	Chromium on Kapton, Al backed	-0.0000492 147	-3.81 x 10^{-26} 1.14	Low loss rate

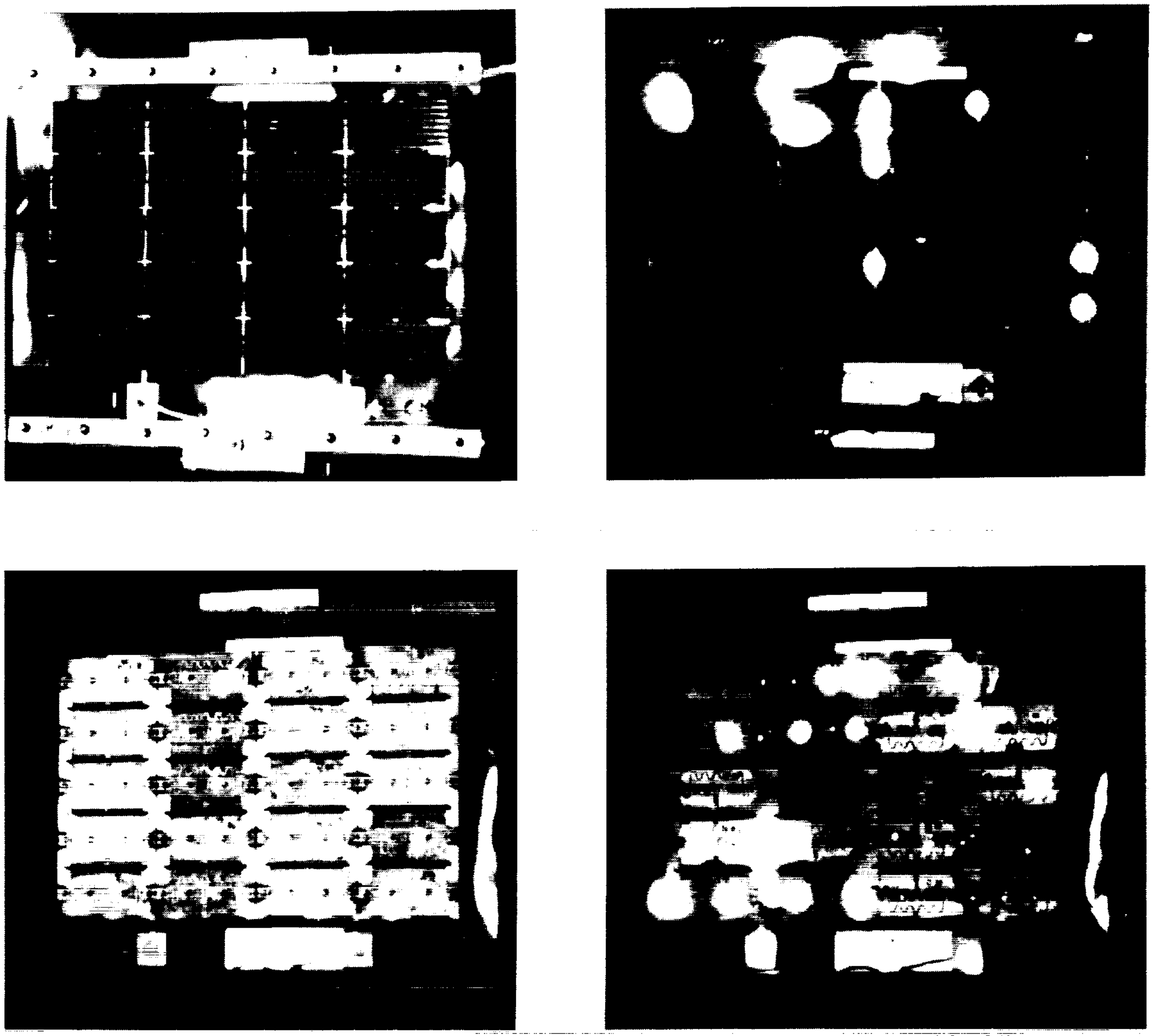
ORIGINAL PAGE IS
OF POOR QUALITY



Space Environmental Interactions

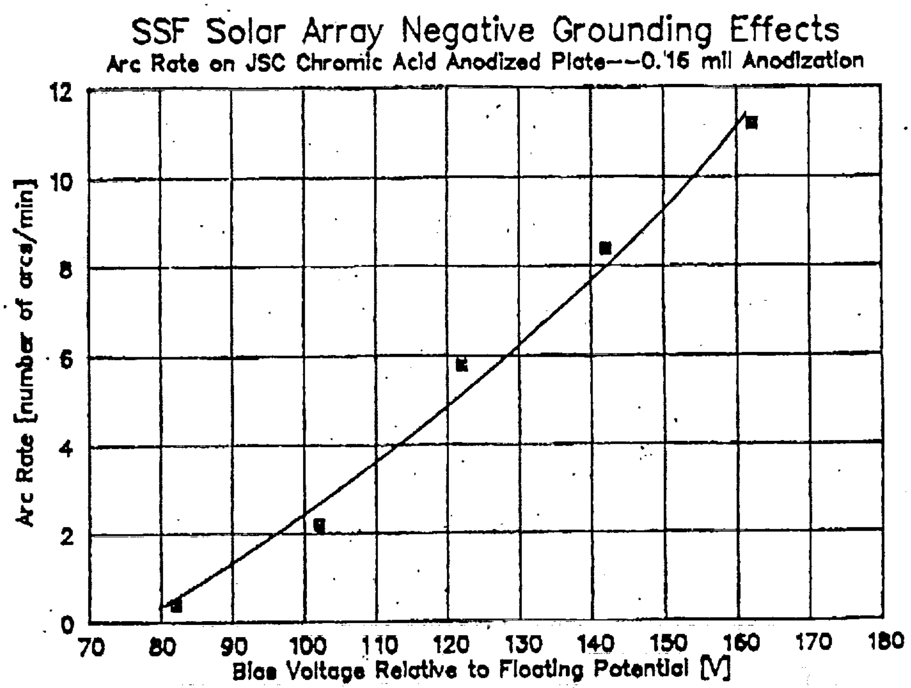
Current Collection and Snapover

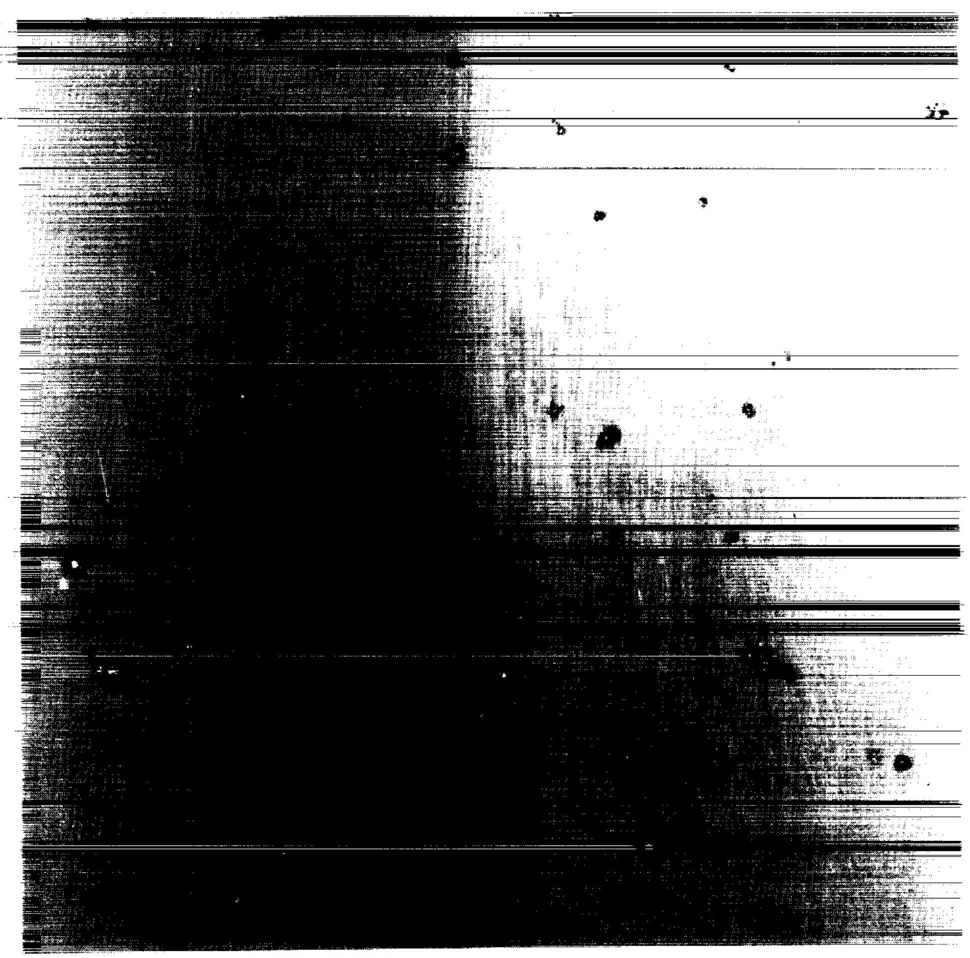
- ELECTRON COLLECTION AND SNAPOVER
  - Snapover at Potentials > +100 V
  - Insulators Act as Electron Conductors
  - Large Power Drains
- ION COLLECTION AND SPUTTERING
  - Ions Focused Onto Insulation Defects
  - Sputtering at Potentials < −100 V
- FLOATING POTENTIALS
  - Ion and Electron Currents Must Balance
  - Ease of Electron Collection Makes Systems Float Negative
- POWER SYSTEM GROUND IMPORTANT
  - Grounds on Moon, Mars Difficult?

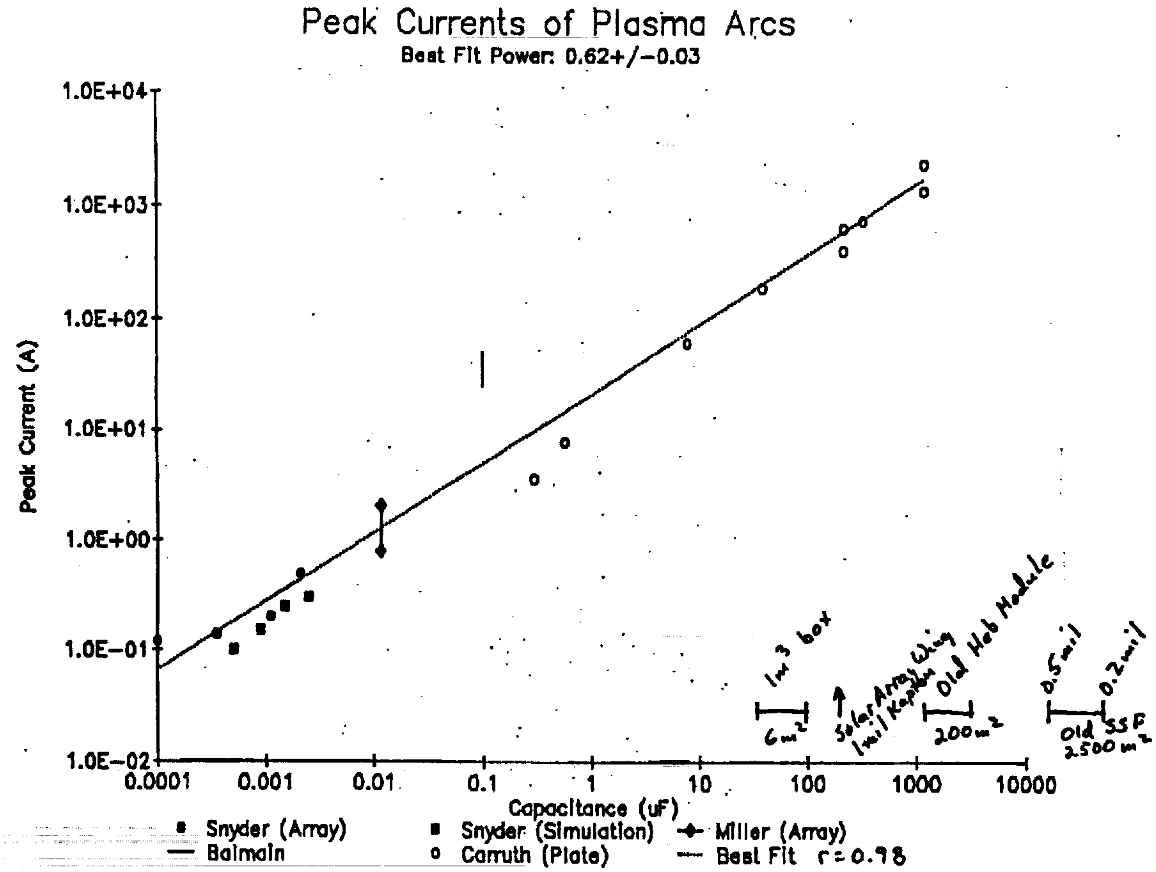


ARCING ON SOLAR CELL ARRAY SAMPLES
2x4 cm WRAPAROUND CELLS ON KAPTON
-1 kV BIASED ARRAY CIRCUIT
10^5 cm^{-3} N PLASMA (25 eV IONS, 3 eV e^-)

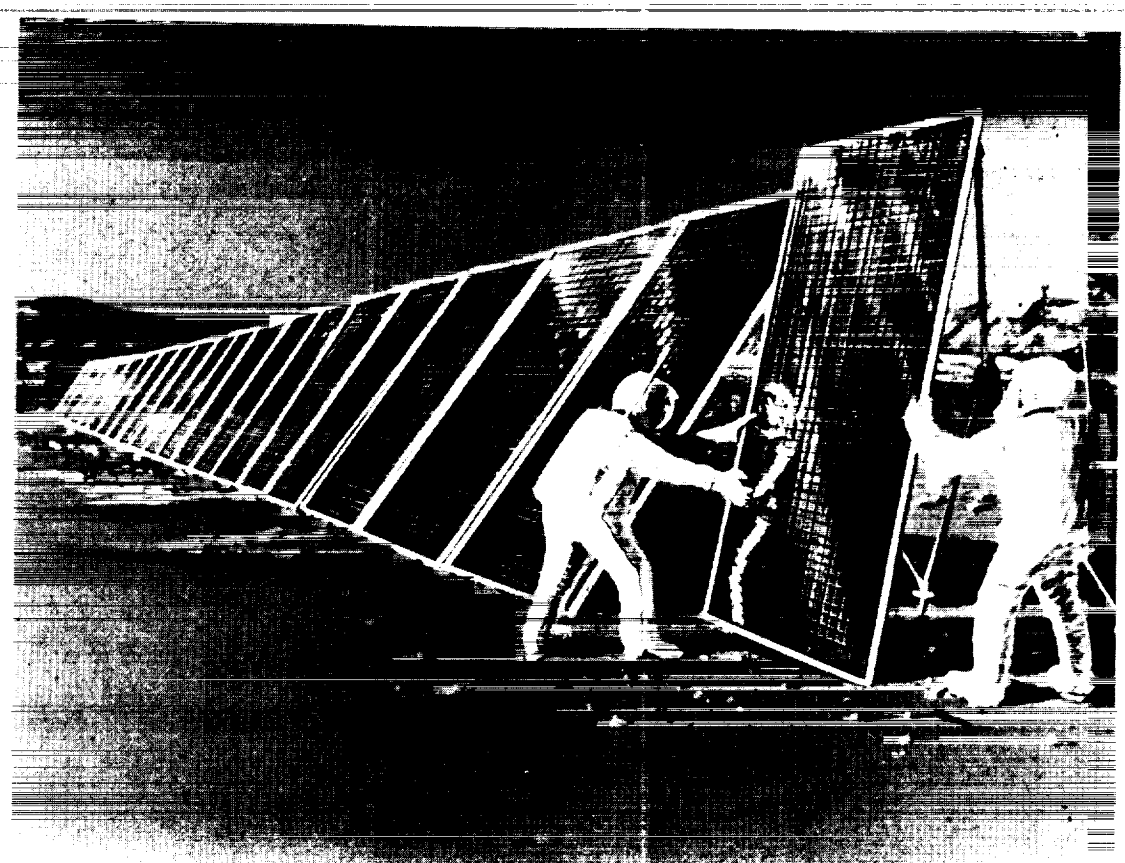
NASA/LEWIS RESEARCH CENTER
ENVIRONMENTAL INTERACTIONS PROGRAM

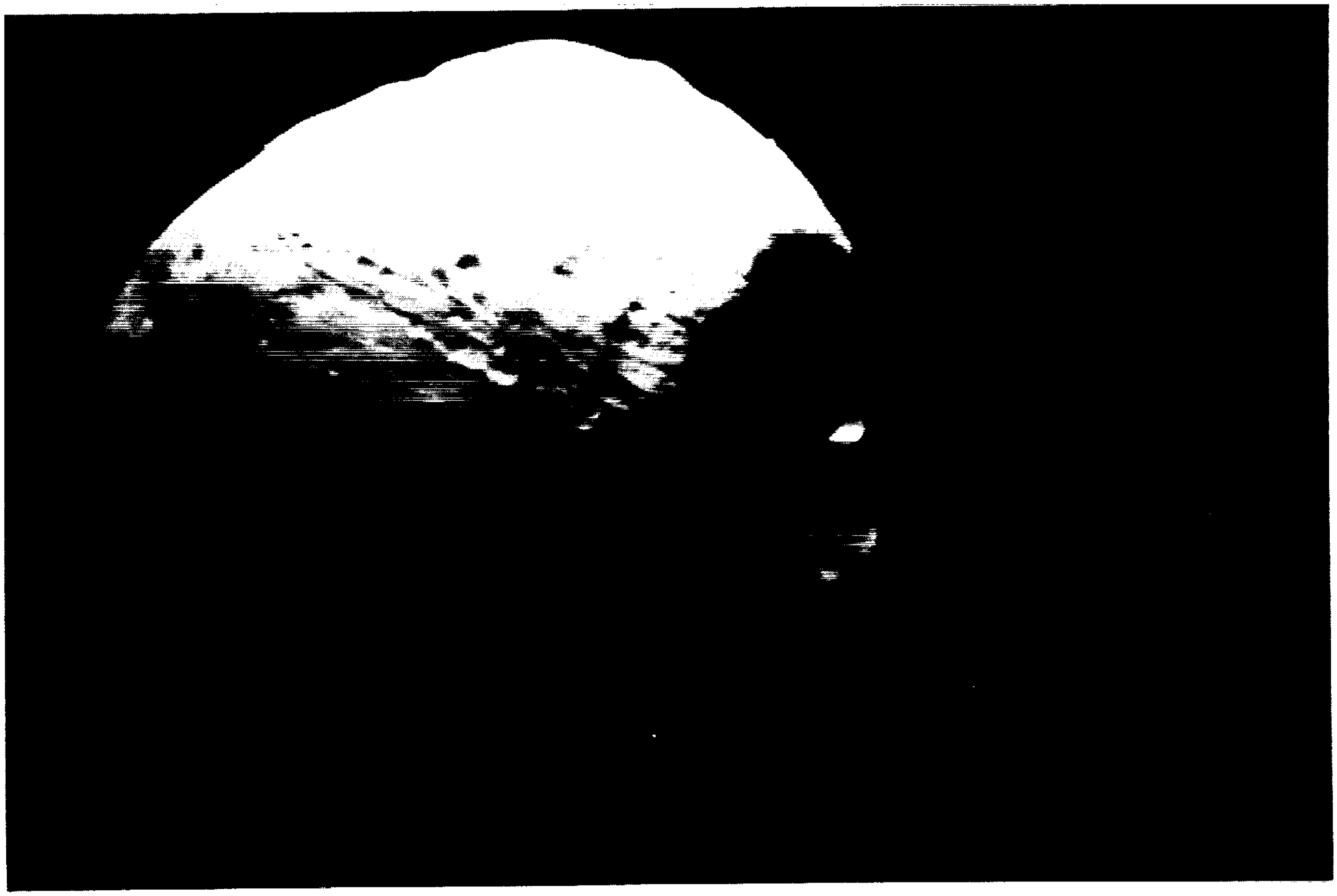

SSF Solar Array Negative Grounding Effects
Arc Rate on JSC Chromic Acid Anodized Plate—-0.15 mil Anodization
Arc Rate [number of arcs/min]
0
2
4
6
8
10
12
70
80
90
100
110
120
130
140
150
160
170
180
Bias Voltage Relative to Floating Potential [V]





Peak Currents of Plasma Arcs
Best Fit Power: 0.62+/−0.03
Peak Current (A)
1.0E+04
1.0E+03
1.0E+02
1.0E+01
1.0E+00
1.0E−01
1.0E−02
0.0001
0.001
0.01
0.1
1
10
100
1000
10000
Capacitance (uF)
Snyder (Array)
Snyder (Simulation)
Miller (Array)
Balmain
Carruth (Plate)
Best Fit
1m³ box
6m²
200m²
Old SSF
2500m²
0.5 mil
0.2 mil

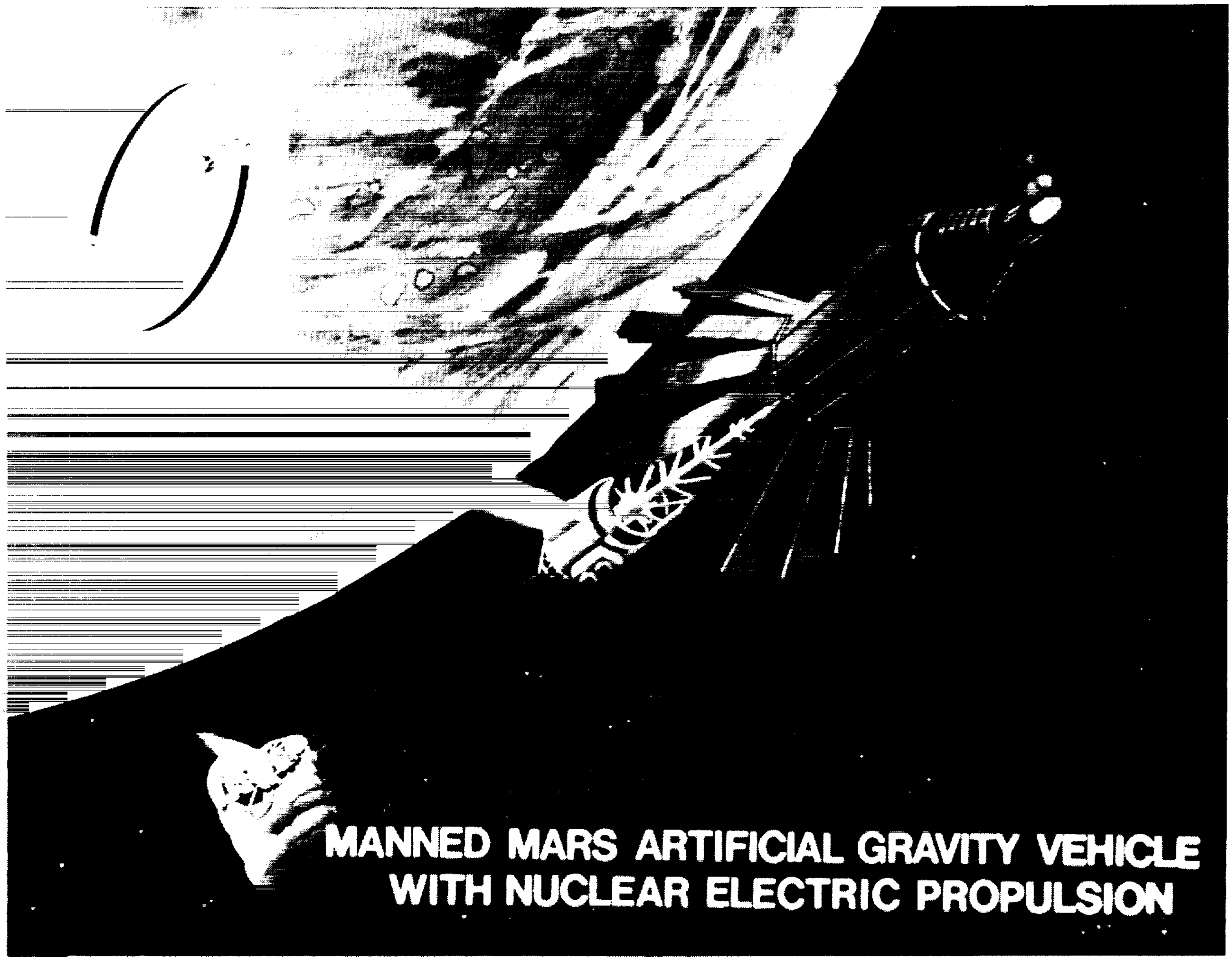




Space Environmental Interactions

Effluents, Neutral and Ionized

- NEUTRAL EFFLUENTS
  - Thruster Firings and Gas Dumps
  - Change Vehicle Floating Potential
  - May Interact Chemically with Surfaces
  - May Become Ionized by UV, Critical Ionization Velocity, Charge Exchange
  - Source of Contamination
- IONIZED EFFLUENTS
  - Ion Thrusters, Radioactive Sources
  - May Be Attracted Back by E Fields
  - Change Vehicle Potential
  - Increase Local Plasma Density, Arcing, Sputtering, etc.



Space Environmental Interactions

Winds, Dust, and Contamination

- NEUTRAL DUST CONTAMINATION
  - Propelled by Winds or Rocket Exhausts
  - May Have High Sticking Factors
  - Can Change Thermal, Optical Properties
  - Attracted to Charged Surfaces by Dipole Attractions
- CHARGED DUST
  - Mars, Moon - Photoelectric Effect
  - Mars - Triboelectric Charging
  - Attracted Strongly to Charged Surfaces