SUMMARY OF JPL ACTIVITES

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NASA BATTERY WORKSHOP - 1999

Outline

JPL Program Summary
Ni-H2 Cell Testing
Li-Ion Technology
NASA Telecons
Battery Laboratory

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JPL Flight Program Summary

Solar System Exploration

Deep Space 1 - Asteroid Rendezvous
Deep Space 2 - Mars Penetrator
Mars Global Surveyor
Mars Surveyor '98
Stardust - Comet Sample Return
Europa Orbiter - Jupiter Lunar System Explorer
Mars Surveyor 2001
Mars "03 Lander and Rover

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JPL Flight Program Summary (cont'd)

Earth Sciences

ACRIMSAT - Active Cavity Radiometer Irradiance Monitor
TOPEX/Poseidon - Ocean Topography Experiment
Jason-1 - Ocean Topography Experiment Follow-On
QuikScat /Seawinds - Ocean Winds Tracking

Astrophysics

Genesis - Solar Dust Return

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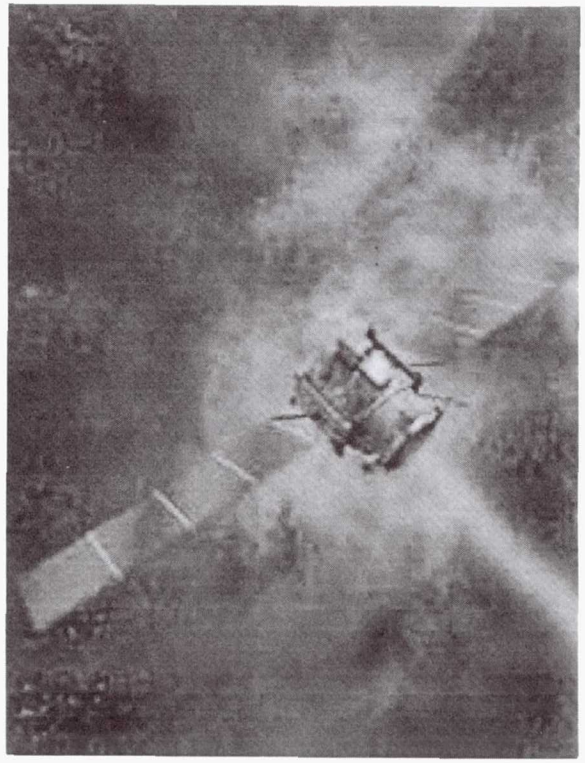
Deep Space 1



Mission:
Its first destination was the near-Earth steroid Braille. Deep Space 1 flew by this asteroid on July 28, 1999. The New Millennium Program is conducting to demonstrate new technologies in the environment of space.

Launch:
October 24, 1998 from Cape Canaveral, Florida.

Completion:
Deep Space 1 began thrusting toward Comet Wilson-Harrington less than 36 hours after encountering Braille.

Batteries: CPV NiH2, 12AH, 11-Cell, Dual String

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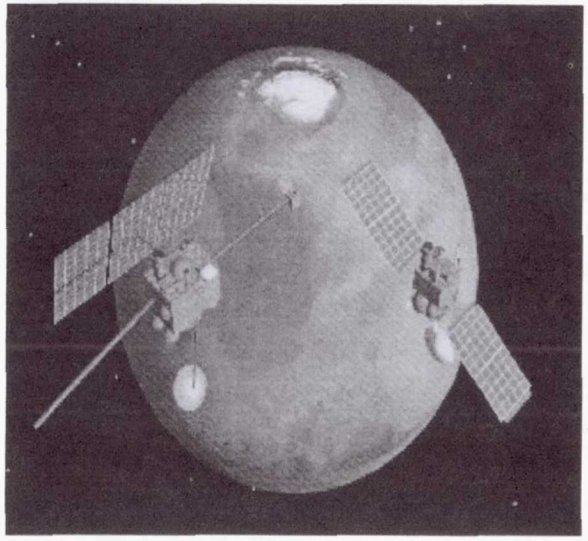

MARS GLOBAL SURVEYOR

Launched 6 Nov. 1996

Regulated Direct Energy Transfer System

- 4 Solar Array Panels (2 GaAs, 2 Si) Capable of Generating 667 W @ Aphelion
- 2 - 20 Amp-hr Nickel Hydrogen (NiH2) Batteries
- 28 Vdc +/-2% Regulated Bus

BATTERY

- 2 BATTERIES / 8 NiH_2 CP V'S PER BATTERY
- VOLTAGE MONITORED AT BATTERY AND HALF BATTERY LEVEL
- 2 STRAIN GAUGES AND 2 TEMPERATURE SENSORS PER BATTERY
- CHARGE CONTROL: V/T WITH PRESSURE AND AHR INTEGRATION

REGIME

- 11 MONTH CRUISE (THREE 40% DOD CYCLES)
- MODIFIED AEROBRAKING (TO MAINTAIN S/A INTEGRITY)
- ~8500 MAPPING CYCLES (29% DOD) AND ~14,000 RELAY CYCLES (24% DOD)

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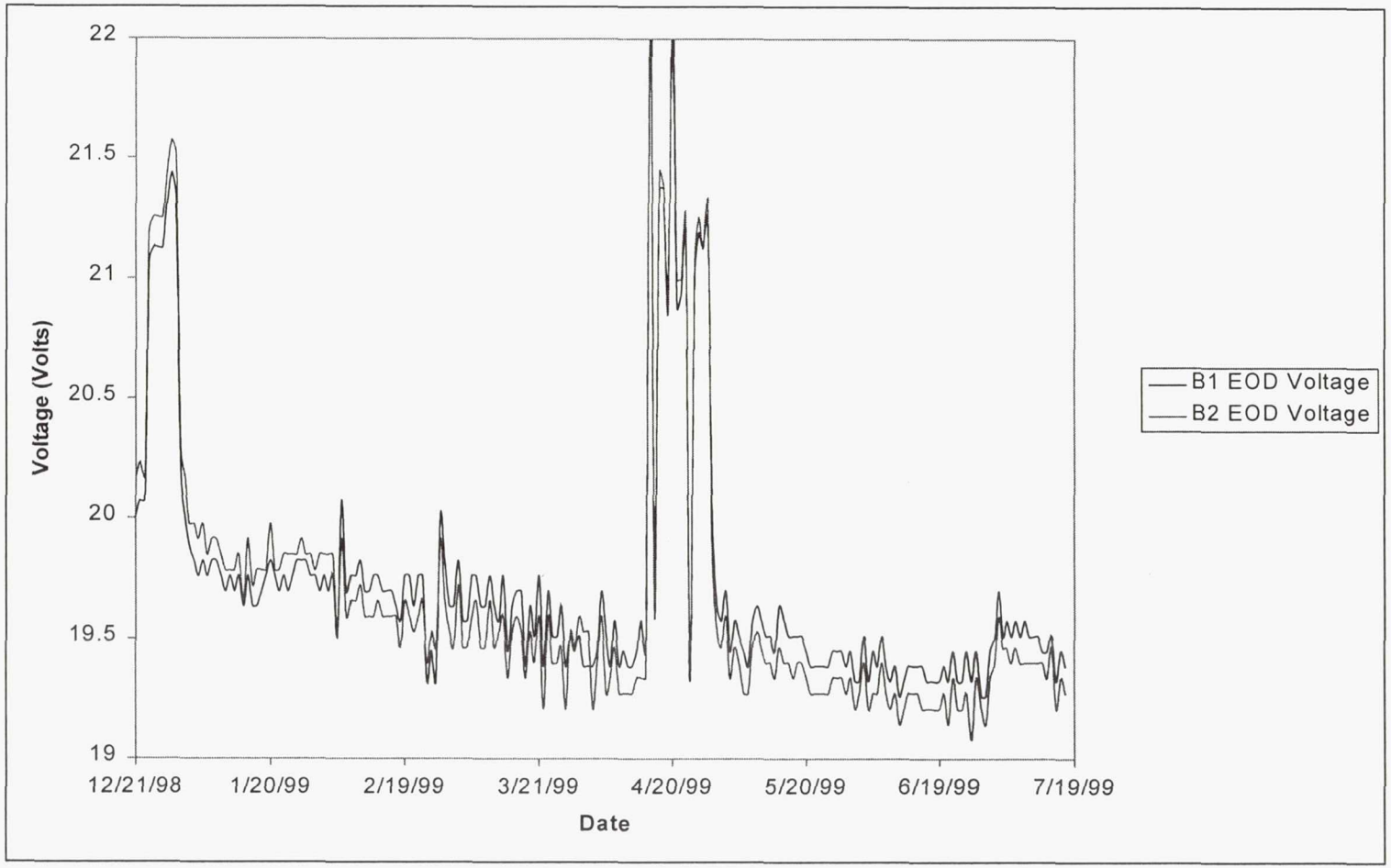
MGS EONV TREND



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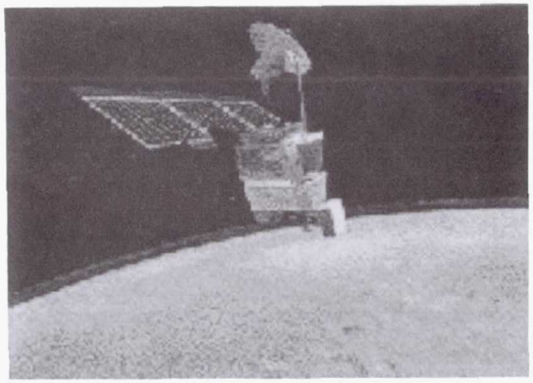
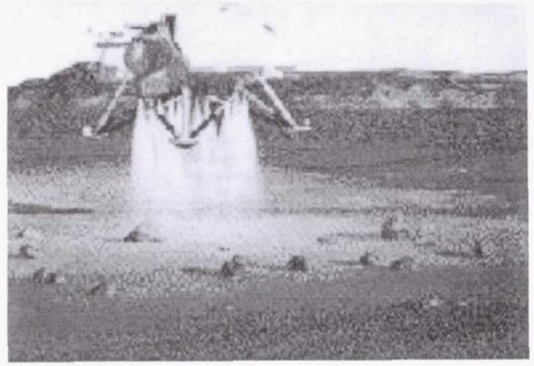
MARS SURVEYOR '98

Mars Climate Orbiter
Launch: Dec 10, 199
Mars Orbit: Sep 23, 1999



Mars Polar Lander
Launch: Jan 3, 1999
Mars Landing: Dec 3, 1999



ORBITER BATTERY REQUIREMENTS 13,500 CYCLES @ 50% DOD

BOTH ORBITER AND LANDER WILL USE 2.5" 2-CELL CPV NiH_2 BATTERIES

- **16 Amp-Hour capacity (RNHC-16-1, Lot 5)**
- **11 CPVs for the orbiter and 11 CPVs and one IPV for the lander**
- **Rabbit Ear, Teflon coated wall, 31% KOH**

LANDER WILL CARRY TWO PROBES FOR THE DS-2 MISSION

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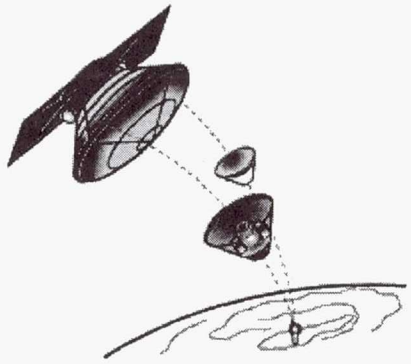
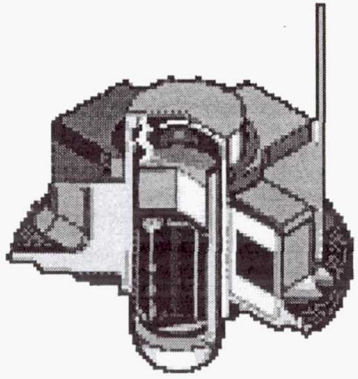
MARS MICROPROBE DS-2

Mission:
Characterize Martian Sub-surface soil
Aft body plus forebody ~2Kg
Demonstrate Key Technologies for future missions
(low temp performance, flex cabling, Telecom-on-a-chip)





Batteries:
Lithium-Thionyl Chloride
- 80°C Environment
80,000 g shock,
Voltage 6-14 V,
550 mAhr capacity @ -80°
Yardney Technical Products

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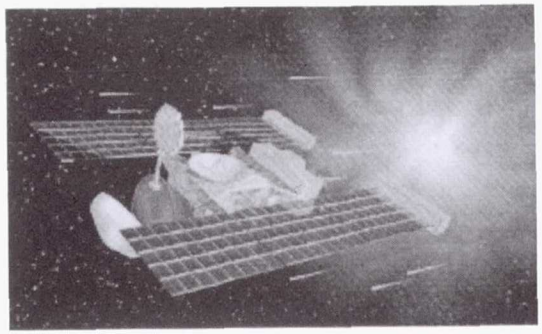
STARDUST



Sample Return Mission -- The STARDUST mission will fly within approximately 100 kilometers (62 miles) of the comet Wild-2 in early 2004 and collect cometary dust and volatiles. The comet samples are made up of ancient pre-solar interstellar grains and nebular condensates that were incorporated into comets at the birth of the solar system. During cruise, STARDUST will collect contemporary particles that recently came to our solar system from the interstellar medium. This interstellar dust was first discovered by Ulysses in 1993 and later confirmed by the Galileo mission. STARDUST will return to the Earth in January of 2006 and drop off the samples using a streamlined, low-cost reentry capsule.

BATTERY REGIME

LOW CYCLE LIFE (~200 CYCLES @<71% DOD)

7 YEAR CRUISE + 1 YEAR PRELAUNCH

BATTERY DESIGN

2.5" 2-CELL CPV NiH_2 BATTERIES

16 AMP-HOUR CAPACITY(RNHC16-1 Lot 6)

CELL DESIGN SIMILAR TO MSP '98

SAMPLE RETURN CAPSULE BATTERY

LITHIUM/SULFUR DIOXIDE

SAFT AMERICA

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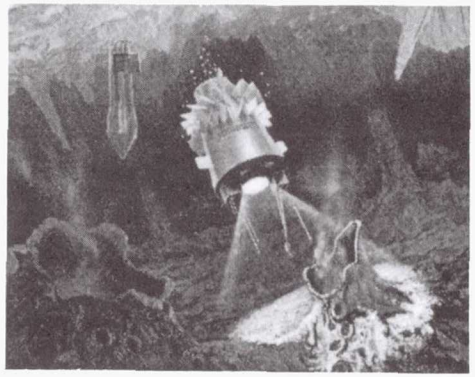

Europa Orbiter

Missions:
Explore the Frozen Oceans on
Moon of Jupiter and look for signs of Life

Batteries: Cold and Wet

Solar Probe

Mission:This first exploration mission to the Sun's Corona seeks a new understanding of a star by flying through its corona.

Batteries: Hot and Dry

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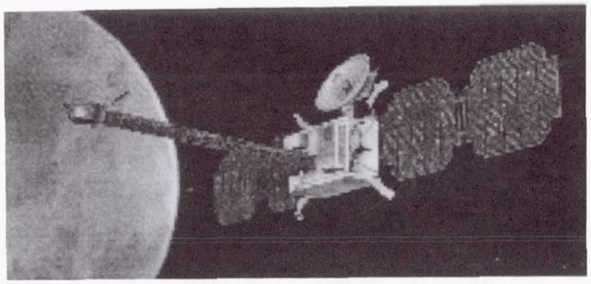
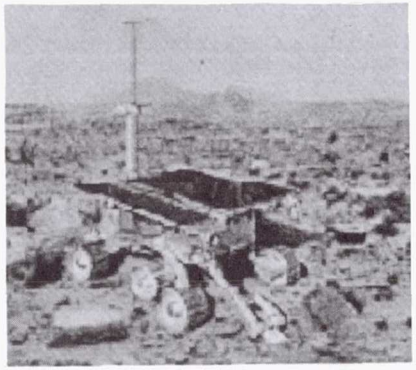
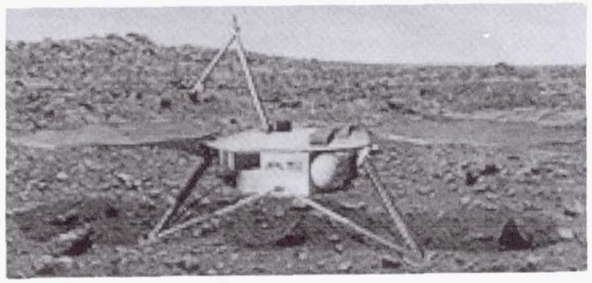
Mars Surveyor 2001

This mission will allow scientists to study the ancient climate and geologic history of Mars,investigate the role water may have played on Mars in the past and search for evidence of ancient life.







The Mars Surveyor 2001Orbiter

Mission:

Orbiter launches on March 7, 2001.

It will arrive at Mars on Dec. 10, 2001.

Battery:

NiH2 2.5" CPV RNHC16-1 or 16-9

Mars Surveyor 2001 Rover / Lander

Mission:

Launch on April 3, 2001.

Land on Mars on Jan. 27, 2002.

Batteries:

Lander: Li-Ion batteries, 7AH size

Rover: Same Li-SO_4 D-Cells as used in "98

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ACRIMSAT - Active Cavity Radiometer Irradiance Monitor:

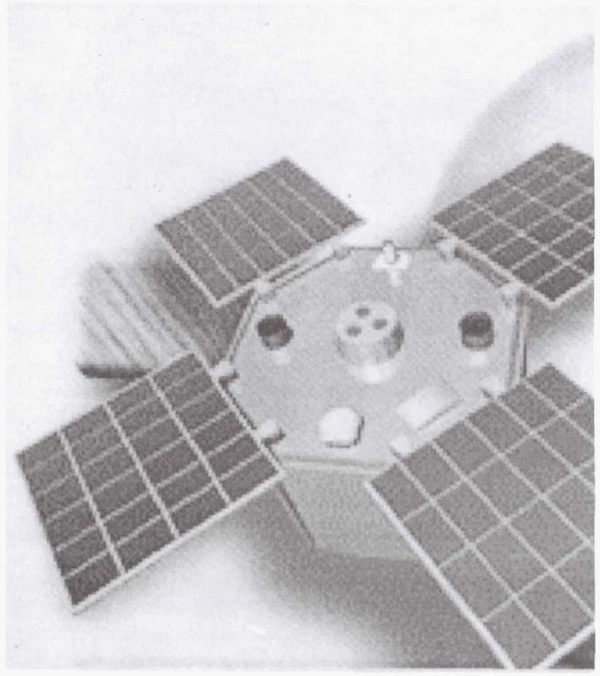
Mission: Study of the Solar Activity

System Contractor: Hughes (in STV)

Launch: 2000

Completion: TBD

Batteries: Ni-H_2 ?



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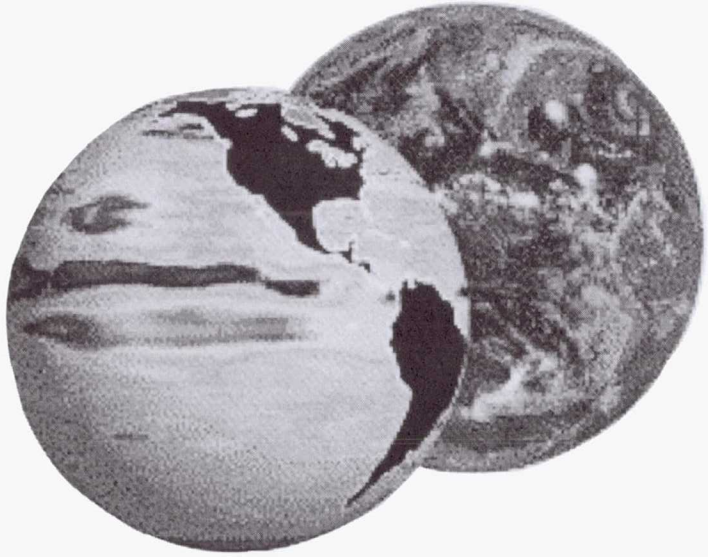
TOPEX

TOPEX/POSEIDON



PRIME CONTRACTOR - FAIRCHILD
MODULAR POWER SUBSYSTEM / McDac
NASA STANDARD BATTERY (3 x 22 CELL)
50 Amp-Hr CELLS / GATES AEROSPACE
PELLON 2505 SEPARATOR / Eagle-Picher
NONPASSIVATED POS / TEFLONATED NEG

LAUNCH AUGUST 10, 1992

BATTERY OPERATIONAL STRATEGY

- **LIMIT PEAK CHARGE TO LESS THAN 24 AMPS**
- **LIMIT RECHARGE RATIO (C/D) TO 105 (+/-3%)**
- **OPERATE AT LOWEST PRACTICAL (V/T 3 FULL SUN, V/T 4 ECLIPSES)**
- **AVOID HIGH CHARGE CURRENTS DURING FULL SUN PERIODS**
- **CURRENT STATUS - OVER 85 MONTHS SUCCESSFUL OPERATION**

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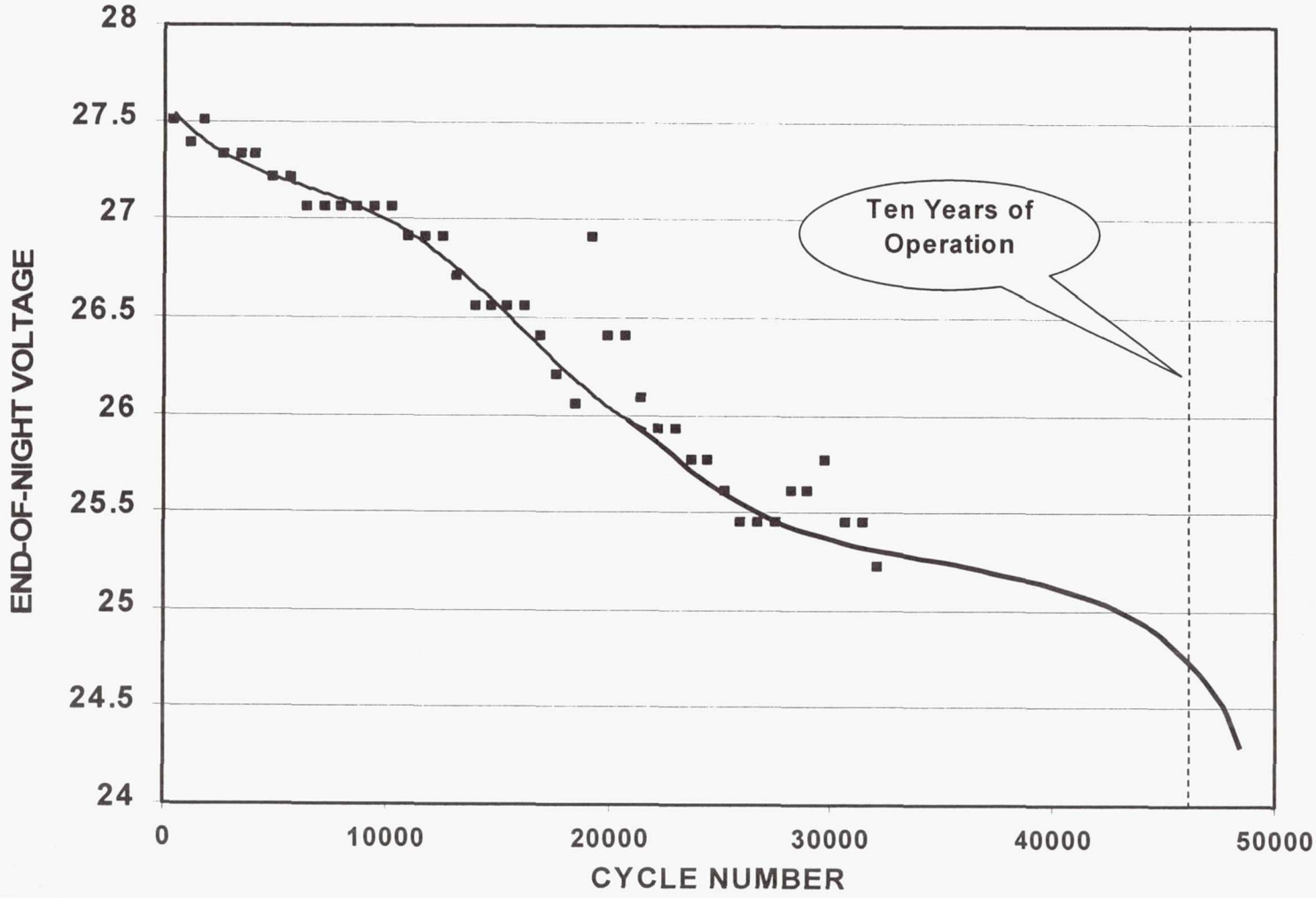
TOPEX END OF NIGHT BATTERY VOLTAGE PREDICTION



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Jason-1

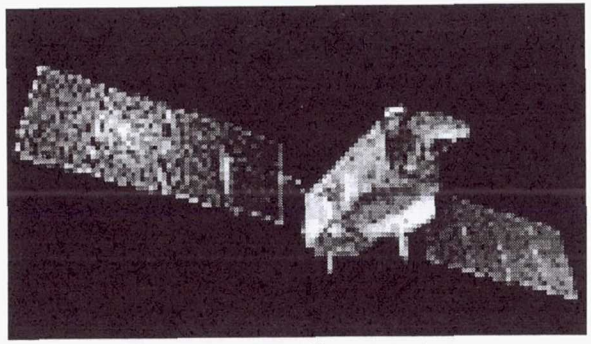
Mission: Follow-up Mission to TOPEX

Spacecraft Contract: ESA/France/AS

Launch: 2000

Completion: TBD

Batteries: Single String Ni-H_2 IPV / SAFT



Beyond 2000:
Jason-1

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QuikScat /Seawinds

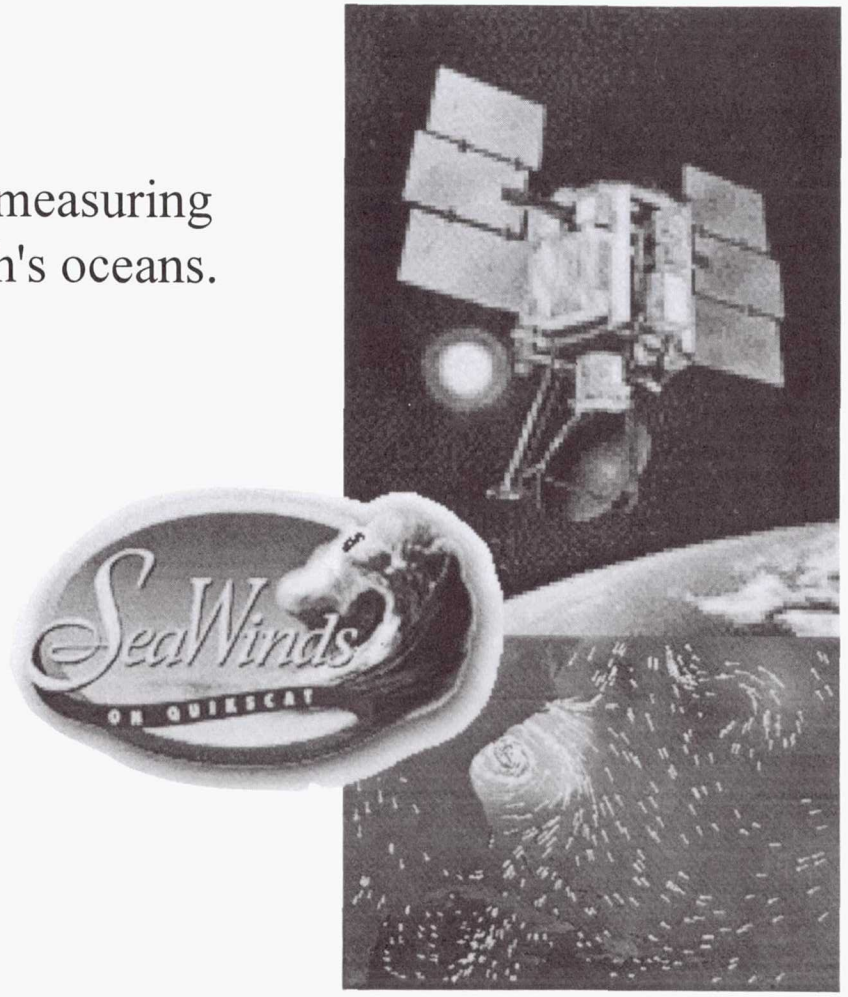
Mission: Microwave radiometery - measuring wind speed and direction over Earth's oceans.

System Contractor: Ball Aerospace

Launch: June 19, 1999

Completion: TBD

Batteries: E.P. CPV Ni-H_2



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Genesis

Mission:

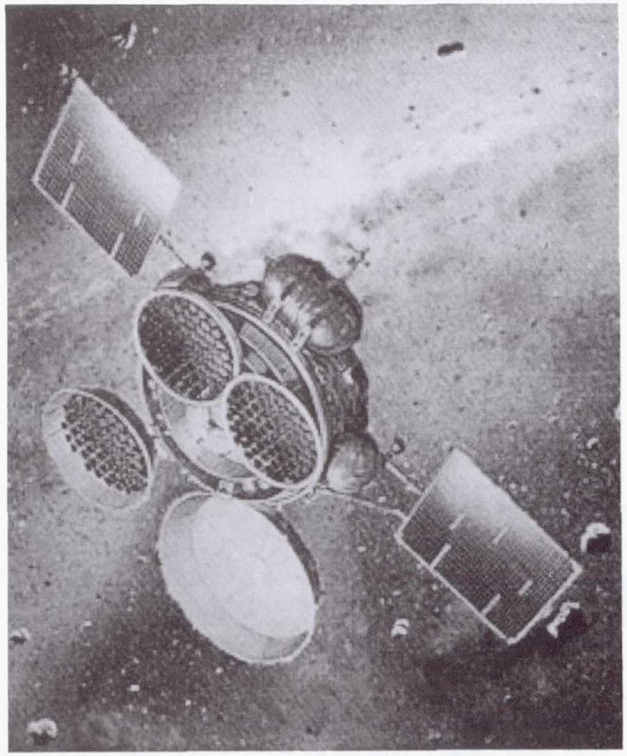
Return solar matter for compositional analysis in terrestrial laboratories. Ultra pure materials will be exposed to the solar wind for two years.

System:

This system is to use the New X2000 power subsystem under development at JPL.

Batteries:

RNH16-9, 11 Cell, CPV Ni-H_2



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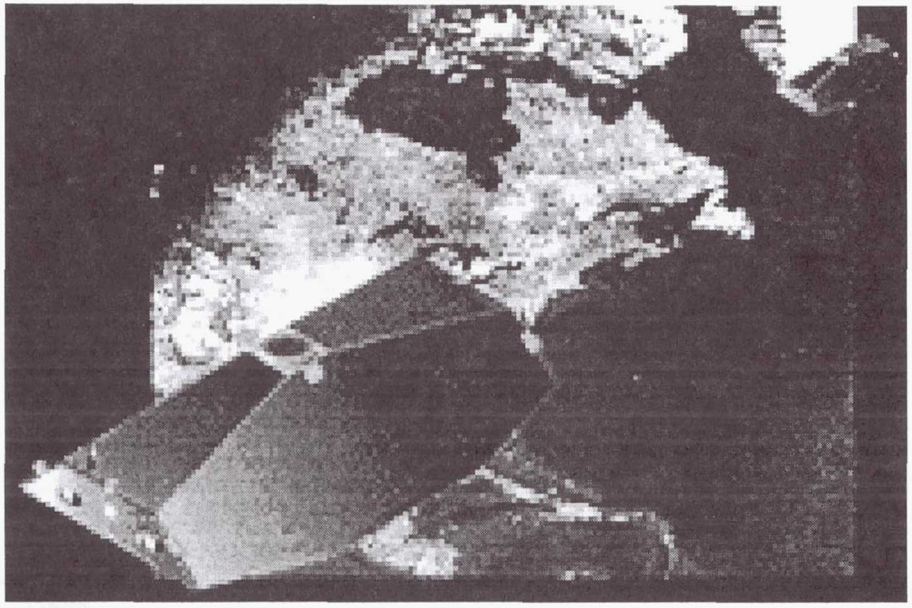
GRACE (Gravity Recovery and Climate Experiment) Produce a new model of the Earth's gravity field with unprecedented accuracy every 12 to 15 days for five years. Launch 2001,



System Contract: German

Battery: CPV NiH2

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CELL TESTING

Ni-H_2

2.5" CPV Characterization - On Going

3.5" CPV Characterization - On Going

MGS Simulation - Over 2300 Cycles

Ni-Cd

Topex Simulation - 21Occultations on Zero Degree Pack

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CPV EVALUATION

TECHNOLOGY STATUS

NUMEROUS BATTERIES FLYING OR BEING BUILT

PREVIOUS MECHANICAL PROBLEMS HAVE BEEN ELIMINATED

MISSIONS USING CPV

NEW MILLENIUM DS-1, MARS '98 (ORBITER AND LANDER), MARS 2001 ORBITER

STARDUST, GENESIS, GRACE,SIRTF, GOES

PROGRAM

PROCURE REPRESENTATIVE SAMPLES FROM FLIGHT LOTS

DEVELOP A PERFORMANCE DATABASE - CHARACTERIZATION TESTS

PERFORM MISSION SIMULATION TESTING

PROVIDE SUPPORT TO PROGRAMS THROUGH TELCONS AND WORKSHOP

FOLLOW DEVELOPMENT OF NEW DESIGNS

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2.5'' CPV DESIGNS

SIZES CURRENTLY MANUFACTURED BY E.P.

RNHC 4-1	**(12 UNITS)**
RNHC 6-1	**(77 UNITS)**
RNHC 10-1	**(335 UNITS)**
RNHC 12-3	**(81 UNITS)**
RNHC 16-1	**(147 UNITS)**

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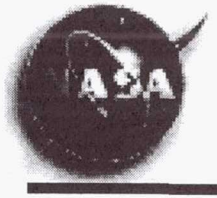

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2.5'' CPV EVALUATION

BACKGROUND

HISTORY OF FAILURES DURING VIBRATION AND REDESIGNS

STATUS

OBTAINED THREE (RNHC 10-1) CPV UNITS FROM EAGLE-PICHER

CHARACTERIZATION TESTS IN PROGRESS

INITIAL CAPACITY 11.3 AHR

PLANS

CONTINUE ELECTRICAL CHARACTERIZATION

COMPILE RESULTS AND ISSUE REPORT

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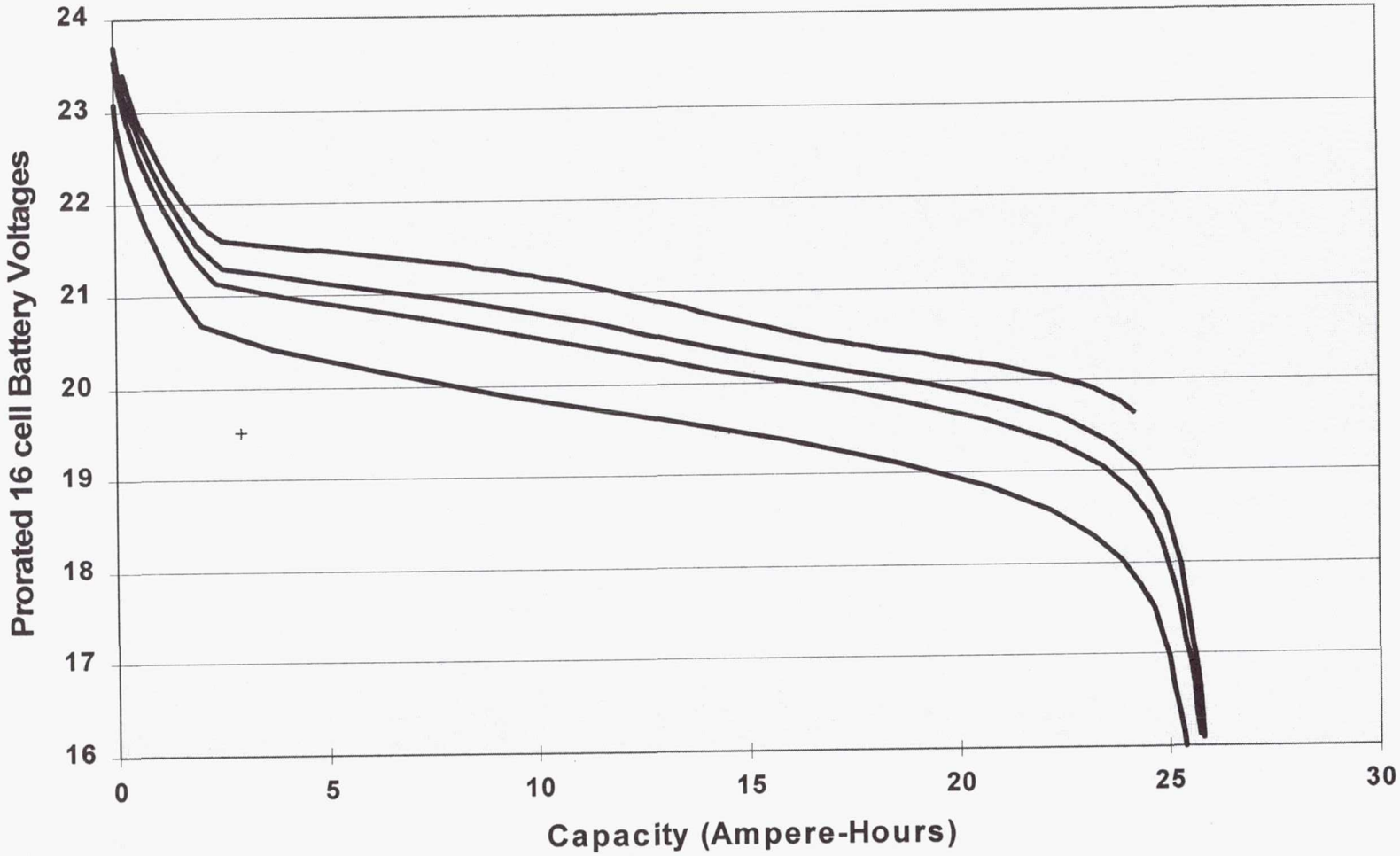
20 AH CPV Prorated Battery Discharge for Four Rates
Following 10 degree C/10 16 hour charge



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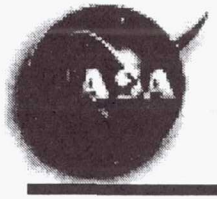

3.5" CPV EVALUATION

3 Cells in MGS Characterization Tests

Insert Information Here

3 Cells in MGS Simulation Test

Provides Mission Leading Information

Shows Characteristic Pressure Decline

Unusual Charge Control Regime Uses VT and Switch to Trickle

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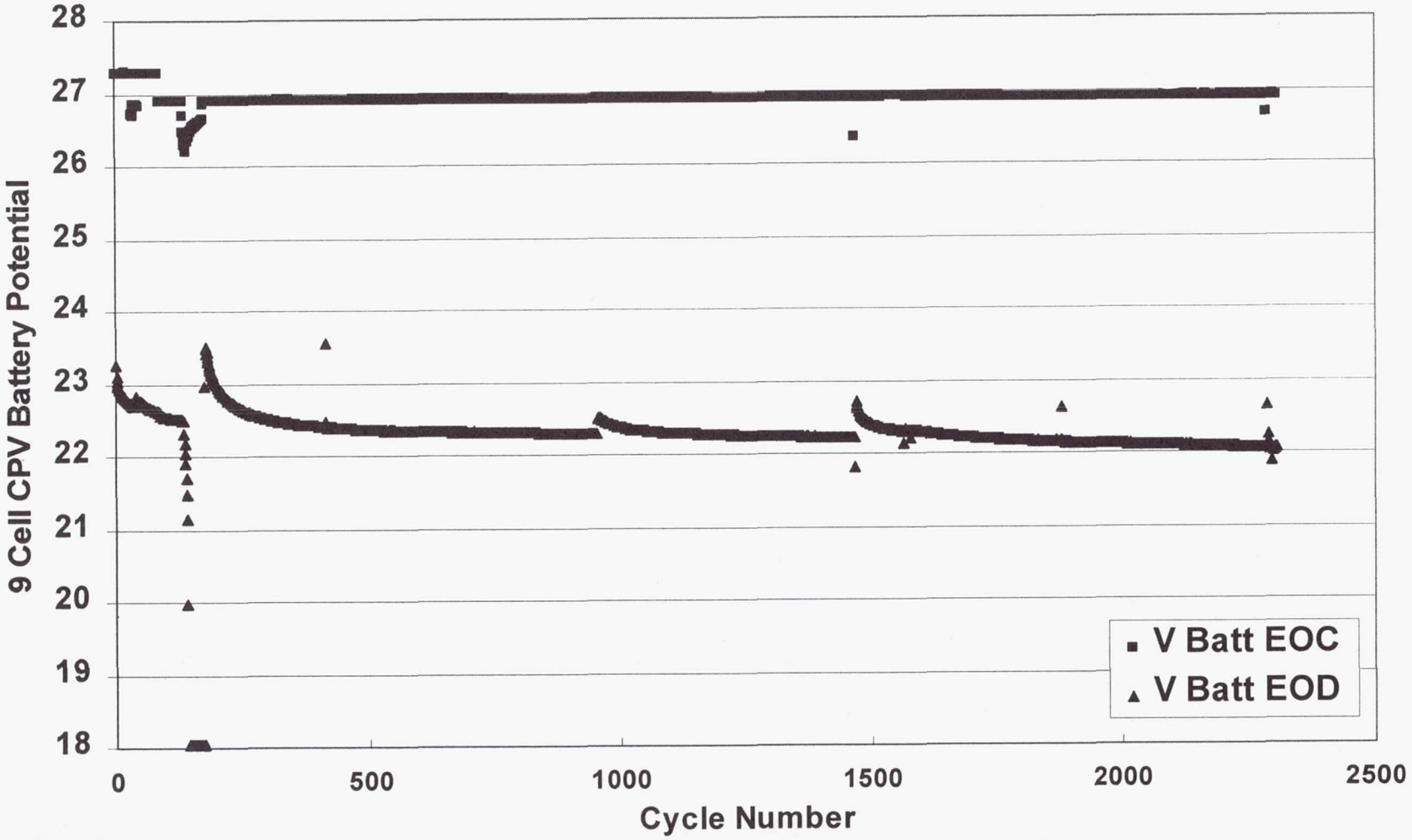
MGS Simulation Prorated Battery Voltages



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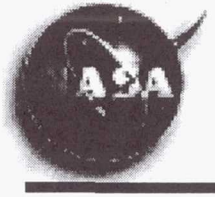

NASA BATTERY WORKSHOP - 1999

Ni-H2 Modeling

GOALS

DEVELOP A NIH_2 BATTERY PERFORMANCE MODEL

MODEL FLIGHT TYPE CELLS WITH INTERNAL DETAILS

COMBINED ELECTROCHEMCIAL / ELECTRICAL / THERMAL MODEL

APPROACH

COMPUTATION FLUID DYNAMICS (CFD)

EXCELLENT INDUSTRY SUPPORT (S/W TOOLS)

EASIER TO IMPLIMENT EQUATION THAN PREVIOUS MODELS

QUICK SOLUTIONS PROVIDED

PROVIDES FIRST CONVECTION SOLUTION

EASY TO CHANGED GRANULARITYOF MODEL - DETAILS

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NASA BATTERY WORKSHOP - 1999

Li-Ion ASSESSMENT

OBJECTIVES

GENERATE PERFORMANCE CHARACTERIZATION DATA

IDENTIFY POTENTIAL ISSUES AND WORK TOWARD RESOLUTION

DETERMINE FLIGHT READYNESS OF TECHNOLOGY

APPROACH

PARTICIPATE IN THE JOINT AIR FORCE / NASA PROGRAM

CHARACTERIZE CELL PERFORMANCE FROM MULTIPLE VENDORS

DOCUMENT MANUFACTURING PROCEDURES

DEVELOP METHODS/FACILITIES FOR EVAULATION

DEVELOP MODELS FOR BATTERY PERFORMANCE PREDICTIONS

COMMUNICATE FLIGHT INFORMATION TO BATTERY COMMUNITY

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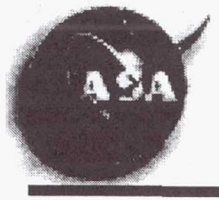

NASA BATTERY WORKSHOP - 1999

Li-Ion ASSESSMENT

STATUS

BASELINE CHEMISTRY SELECTED WITH LOW TEMP ELECTROLYTE
EVALUATION OF FOUR VENDORS FOR MARS "01 LANDER COMPLETED
YARDNEY SELECTED FOR "01 LANDER BATTERY DEVELOPMENT
EVALUATION OF TWO VENDORS FOR MARS "03 ROVER IN PROGRESS
EXTENDED LIFE CYCLE TESTING AND STORAGE TESTING IN PROGRESS
IMPROVED COMPONENTS RESEARCH ONGOING

PLANS

CONTINUE THE EVALUATION OF CELLS FROM 5AH to 25 AH INCLUDING:
CONTINUE COLD TEMPERATURE CYCLING
STORAGE / CRUISE TESTING
RATE AND TEMPERATURE EFFECTS / VARIABLE TEMP CYCLING
PULSE TESTING
CHARGE CONTROL DEVELOPMENT
AC IMPEADANCE
FAILURE ANALSYS

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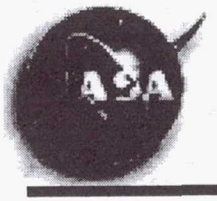

NASA BATTERY WORKSHOP - 1999

TELECONS

NASA Ni-Cd BATTERY OPERATIONS TELECON

FUNCTIONING FOR ~5 YEARS

CONCENTRATION IS ON MPS S/C

TOPEX,GRO,UARS,EUVE

ALSO LOOKS AT NEWER EXPLORERS

GSFC, BERKELY, JPL PARTICIPATION

BENEFITS ALL PARTIES INVOLVED

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NASA BATTERY WORKSHOP - 1999

TELECONS

Ni-H2 BATTERY OPERATIONS TELECON

NEW ACTIVITY IN 1999
DAVE PICKETT CONSULTS ON CALLS
LARGE PARTICIPATION BY NASA AND CONTRACTORS
DETAILED ANALYSIS OF S/C PERFORMANCE
DISCUSSIONS OF GENERAL INTEREST
ONGOING "WORKSHOP ATMOSPHERE"
PARTICIPANTS BRING IN THEIR ISSUES/QUESTIONS

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NASA BATTERY WORKSHOP - 1999

FLIGHT BATTERY STORAGE PROGRAM

GOALS

DEVELOP FLIGHT BATTERY REUSE PROGRAM

BUILD BATTERY STORAGE FACILITY

COLLECT FLIGHT SPARE BATTERIES FROM FPO'S

MAINTAIN SPARES UNDER QC PROGRAM (FHLP)

PROVIDE BATTERIES TO NEW PROGRAMS - FAST!

BRIDGE THE PROGRAM GAP

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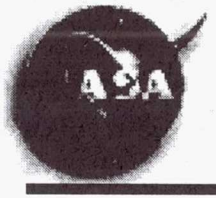

NASA BATTERY WORKSHOP - 1999

FLIGHT BATTERY STORAGE PROGRAM

PLAN

SECURE MONEY TO BUY/LEASE FACILITY

CO-OPERATE WITH FLIGHT HA/W LOGISTICS PROG

SOLICIT FPO'S FOR SPARES

MAINTAIN SPARES INVENTORY AND LOGS

ADVERTIZE AVAILABILITY TO NEW PROGRAMS

EXTRACT COMPENSATION FROM FPO TO FUND

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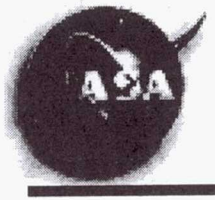

BATTERY LABORATORY

STATUS

THREE MACCOR CYCLERS OPERATING

OVER ONE HUNDRED CHANNELS AVAILABLE

LAB OPERATING AT NEAR CAPACITY

BATTLAB SERVER OPERATING

REMOTE CONNECTIONS TO SERVER IN PLACE

ROOM TEMP FACILITY UPGRADE COMPLETED

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