MGS 2-CELL CPV NiH_2 BATTERIES

JPL

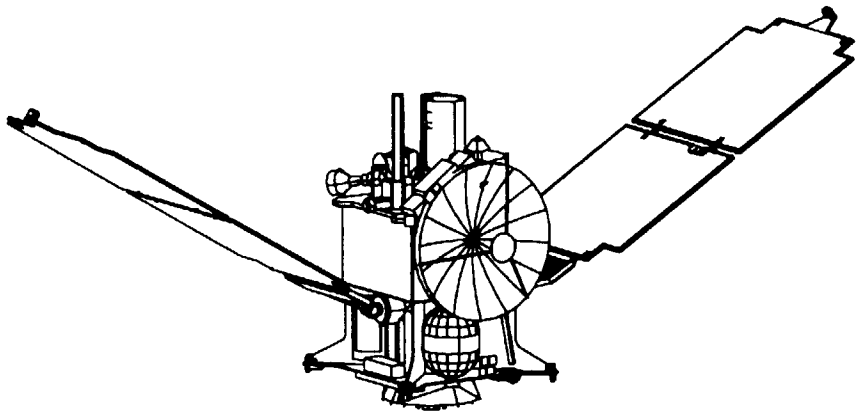
PRESENTED
BY
SAL Di STEFANO

NASA AEROSPACE BATTERY WOKSHOP
MARSHALL SPACE FLIGHT CENTER
OCTOBER 27-29
HUNTSVILLE, ALABAMA

CONTRIBUTORS:
D. PERRONE, B.V. RATNAKUMAR,T. VALDEZ, L. WHITCANACK - JPL
R. ZERCHER, J. BYERS, S. WALKER - LMA

TOPICS

- BACKGROUND
- MGS BATTERY DESCRIPTION
- TYPICAL PERFORMANCE CHARACTERISTICS
- IN-FLIGHT PERFORMANCE
- OUTLOOK



Mars Global Surveyor

After a mission elapsed time of 659 days from launch, Surveyor is 223.34 million miles (359.43 million kilometers) from the Earth and in an orbit around Mars with a high point of 11,098 miles (17,861km), a low point of 108.0 miles (173.8 km), and a period of 11.6 hours.

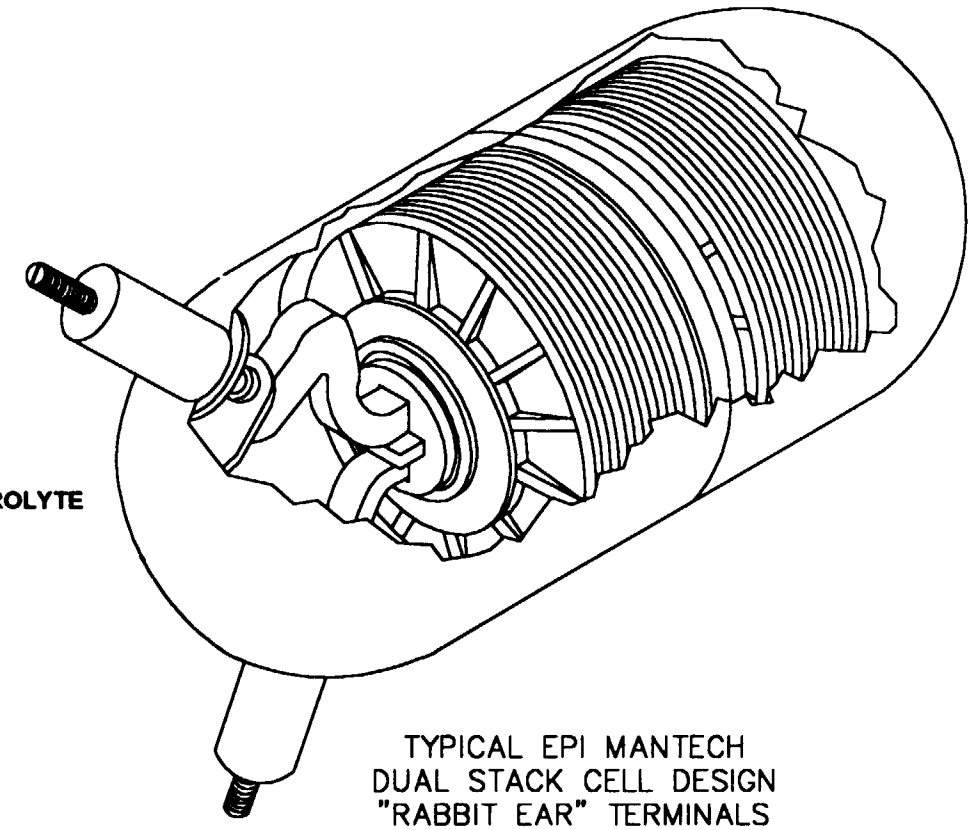
http://mars.jpl.nasa.gov

MARS GLOBAL SURVEYOR(MGS)
Electric Power Subsystem

- **Much of the hardware was modified from the Mars Observer Mission Flight spares**
- **Direct Energy Transfer System with Boost Regulator**
  - **Regulated to 28 Volts ±2% (+0.56/-0.3 Volts)**
  - **361 Watt Orbital Average Load (Mapping Phase)**
- **Hybrid GaAs/Si Solar Array Provides Energy Balance During Mission**
  - **12 M2 Panel Produces > 664 W at Mapping Aphelion**
- **NiH2 2-Cell CPV Batteries (2) Provide 20 AH Each**
- **Linear Battery Charger Controls Battery Recharge**
  - **Charge Rates of 0.85A, 7.5A, 10.0A and 12.5A**
  - **8 VT Limits with Capability to Shift All Down for 1 Cell Failure**
- **C/100 Trickle Charge Circuit from Regulated Bus**
- **Boost Regulator Processes up to 24 A With 4 out of 5 Redundancy**
- **Partial Shunt Assemblies Dump Excess Energy - Up to 3.3 A Each**
- **Fuse Board Assemblies (2) Protect Pwr Bus with Redundant Fuses**

MGS 20 AH Cell Design

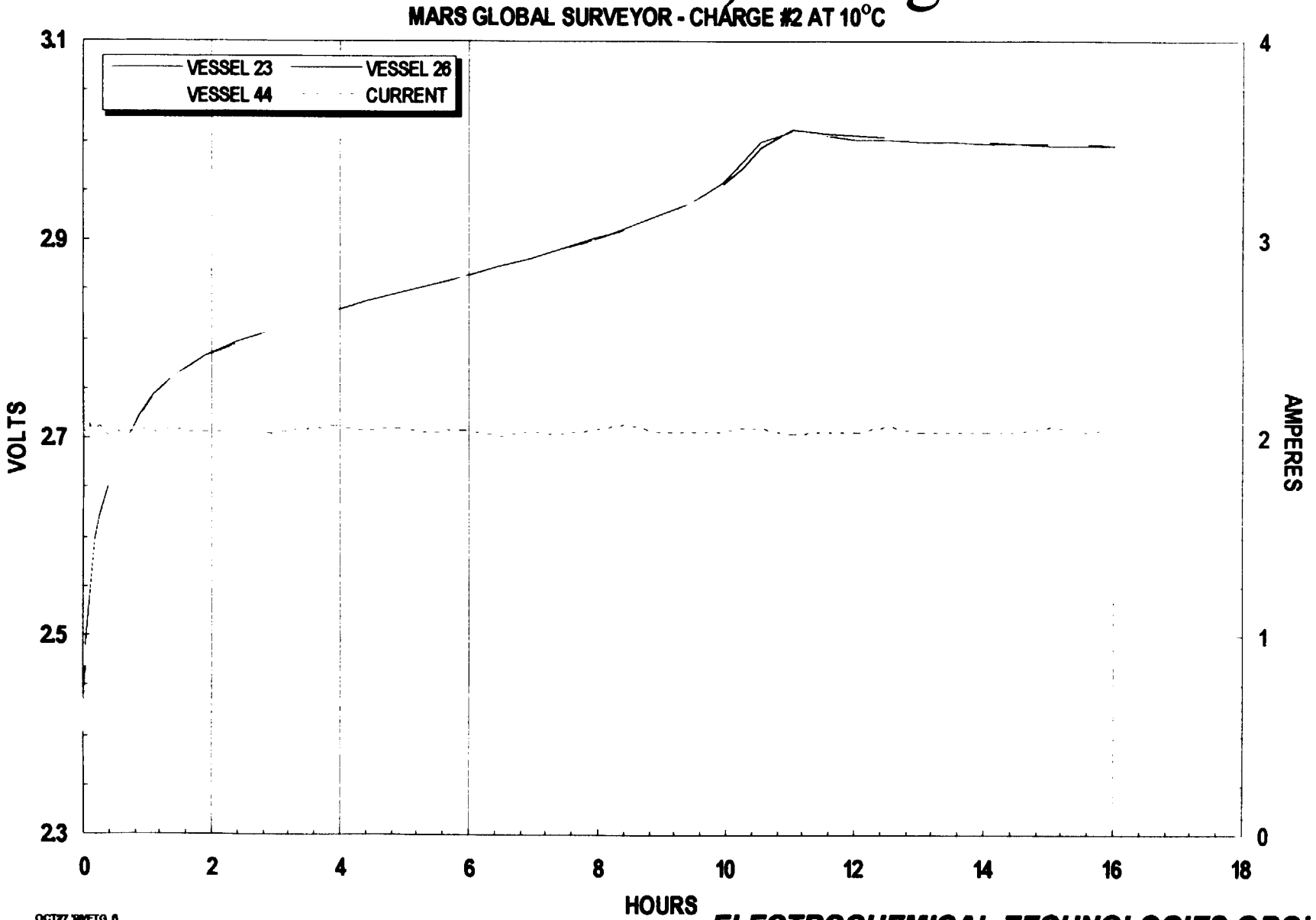
- **EPI MANTECH**
- **23 mil PRESSURE VESSELS**
- **COMMON PRESSURE VESSEL**
- **RABBIT EAR TERMINALS** (60° INCLUDED ANGLE)
- **30 mil SLURRY POSITIVES**
- **32 ELECTRODE COUPLES** (16 PER STACK)
- **DOUBLE LAYER ZIRCAR**
- **ZIRCONIUM WALL WICK**
- **TEFLON COATED WELD RING** (INHIBITS ELECTROLYTE MIGRATION)
- **31% KOH**
- **NICKEL PRECHARGED**
- **800 PSI @ MAXIMUM EXPECTED**
- **MASS: 1291g MAX / CELL**



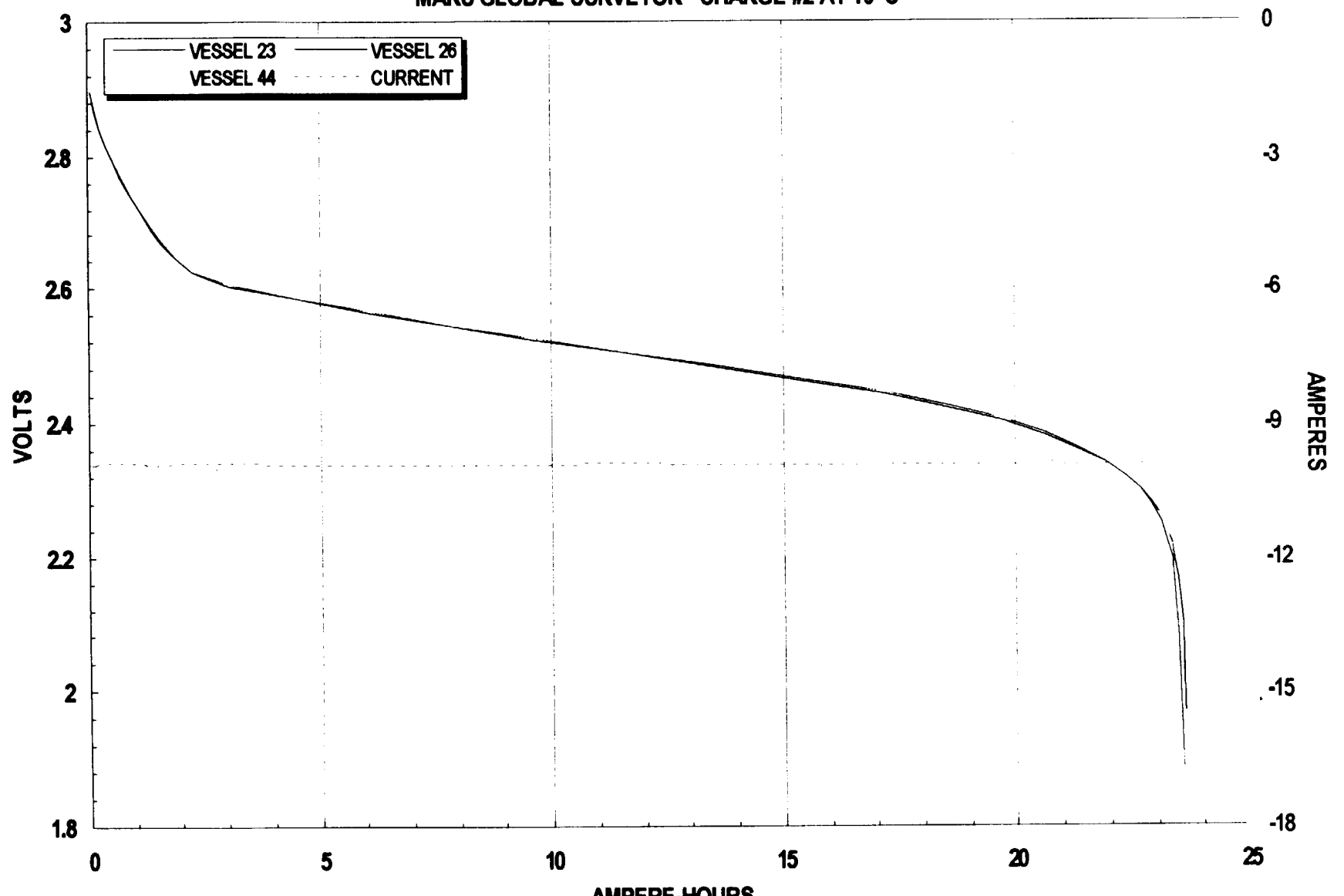
TYPICAL EPI MANTECH
DUAL STACK CELL DESIGN
"RABBIT EAR" TERMINALS

JPL

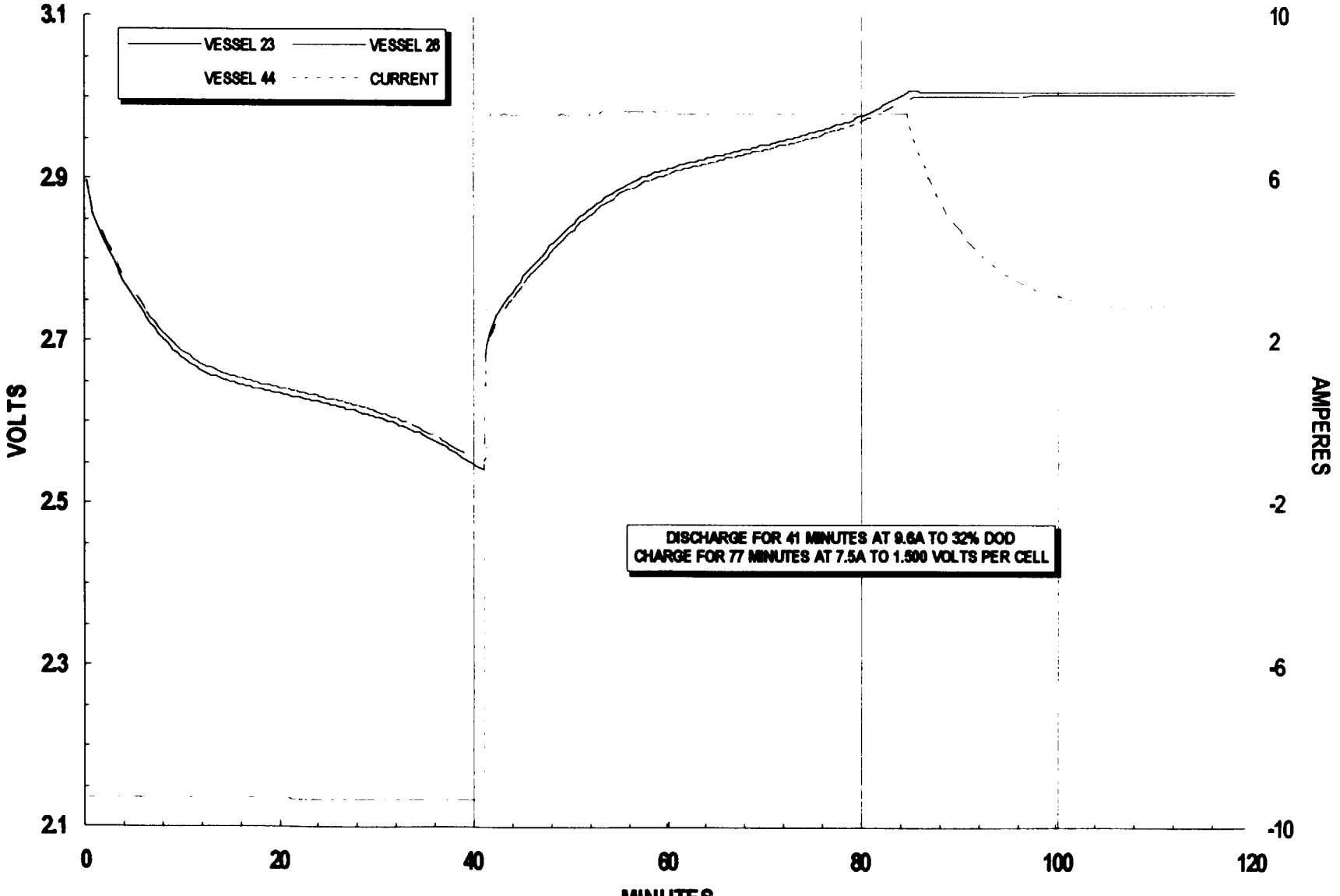
Characteristic C/10) Charge @ 10°C



Characteristic C/2 Discharge @ 10°C

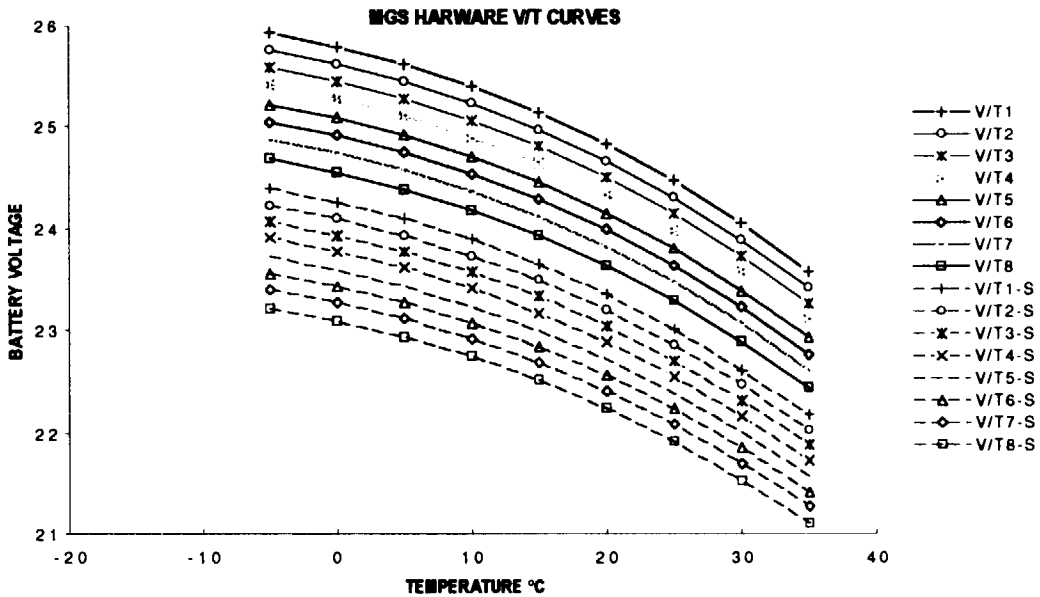


MARS GLOBAL SURVEYOR – CHARGE CHARACTERIZATION OF EPI NiH_2 CPV CELLS - CYCLE 2220 AT 5°C



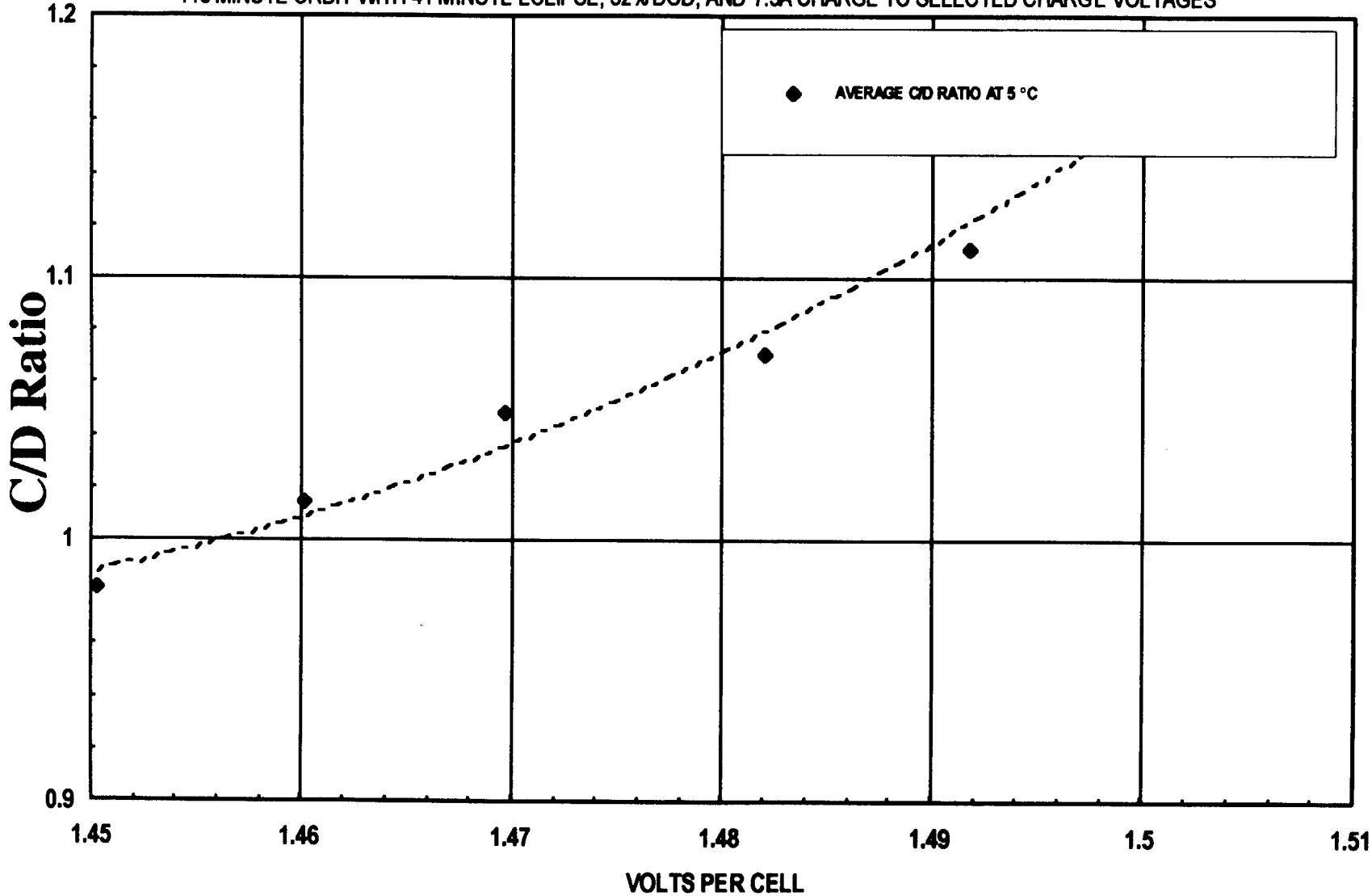
V/T curves

- Developed for charge control of LEO (Low Earth Orbit) satellites using NiCd batteries
- Allows for fast charging of batteries
  - minimizes overcharge
  - prevents thermal runaway
- Relatively simple to implement in hardware
- Range of V/T curves can be constructed to take battery aging into account



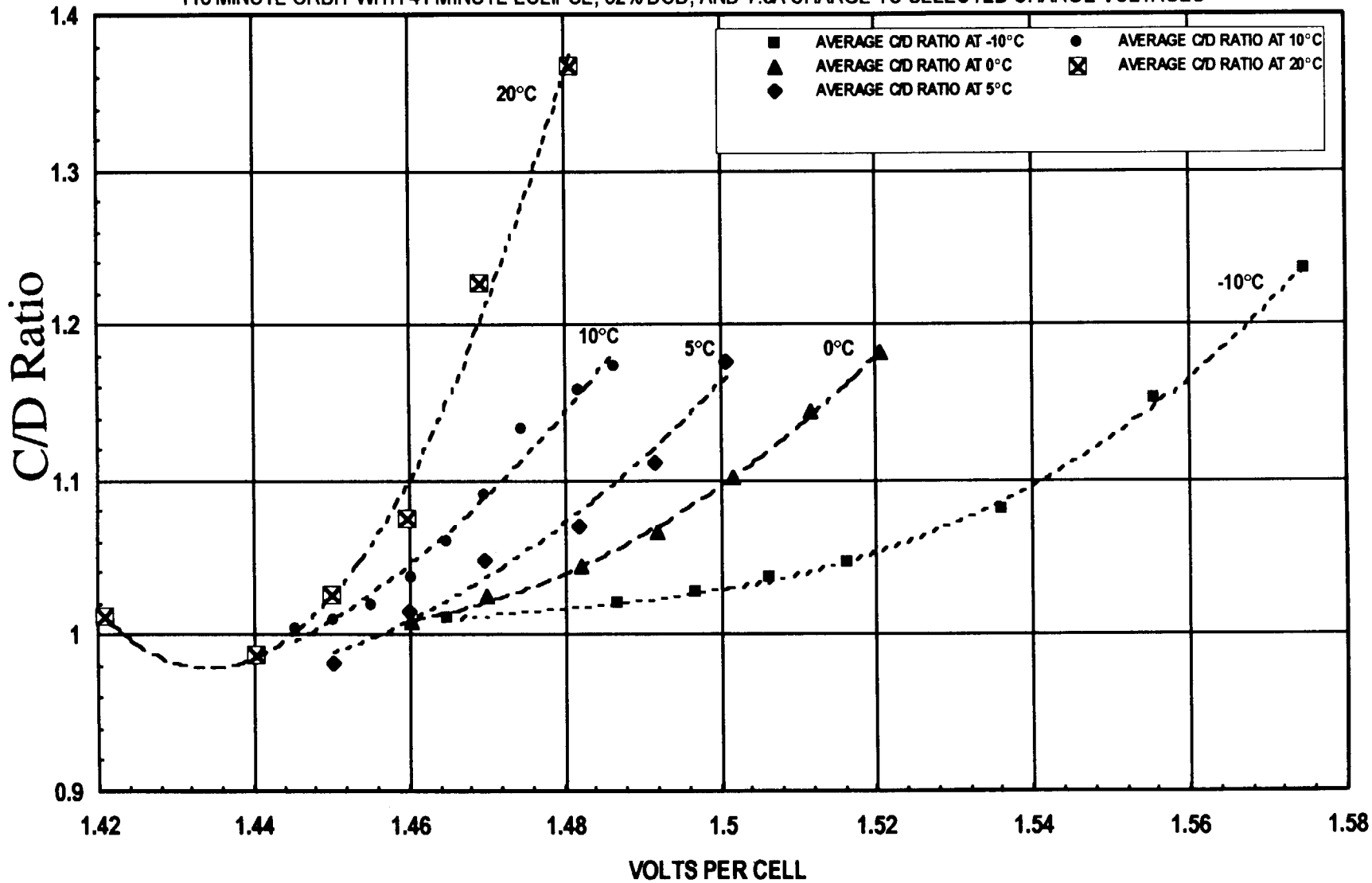
MARS GLOBAL SURVEYOR – CHARGE TO DISCHARGE AMP-HR RATIO OF EPI NiH_2 CPV CELLS

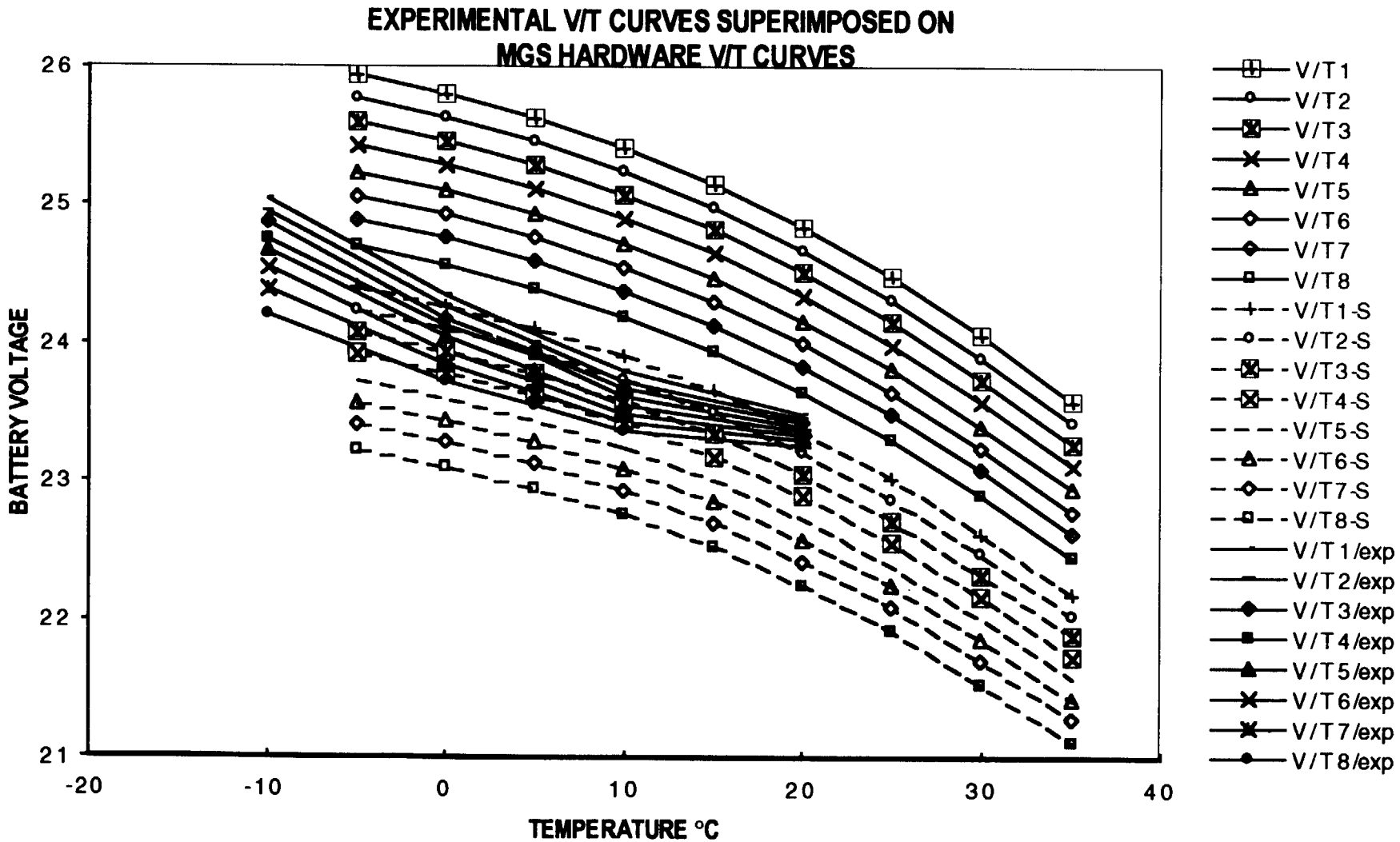
118 MINUTE ORBIT WITH 41 MINUTE ECLIPSE, 32% DOD, AND 7.5A CHARGE TO SELECTED CHARGE VOLTAGES



MARS GLOBAL SURVEYOR – CHARGE TO DISCHARGE AMP-HR RATIO OF EPI NiH_2 CPV CELLS

118 MINUTE ORBIT WITH 41 MINUTE ECLIPSE, 32% DOD, AND 7.5A CHARGE TO SELECTED CHARGE VOLTAGES



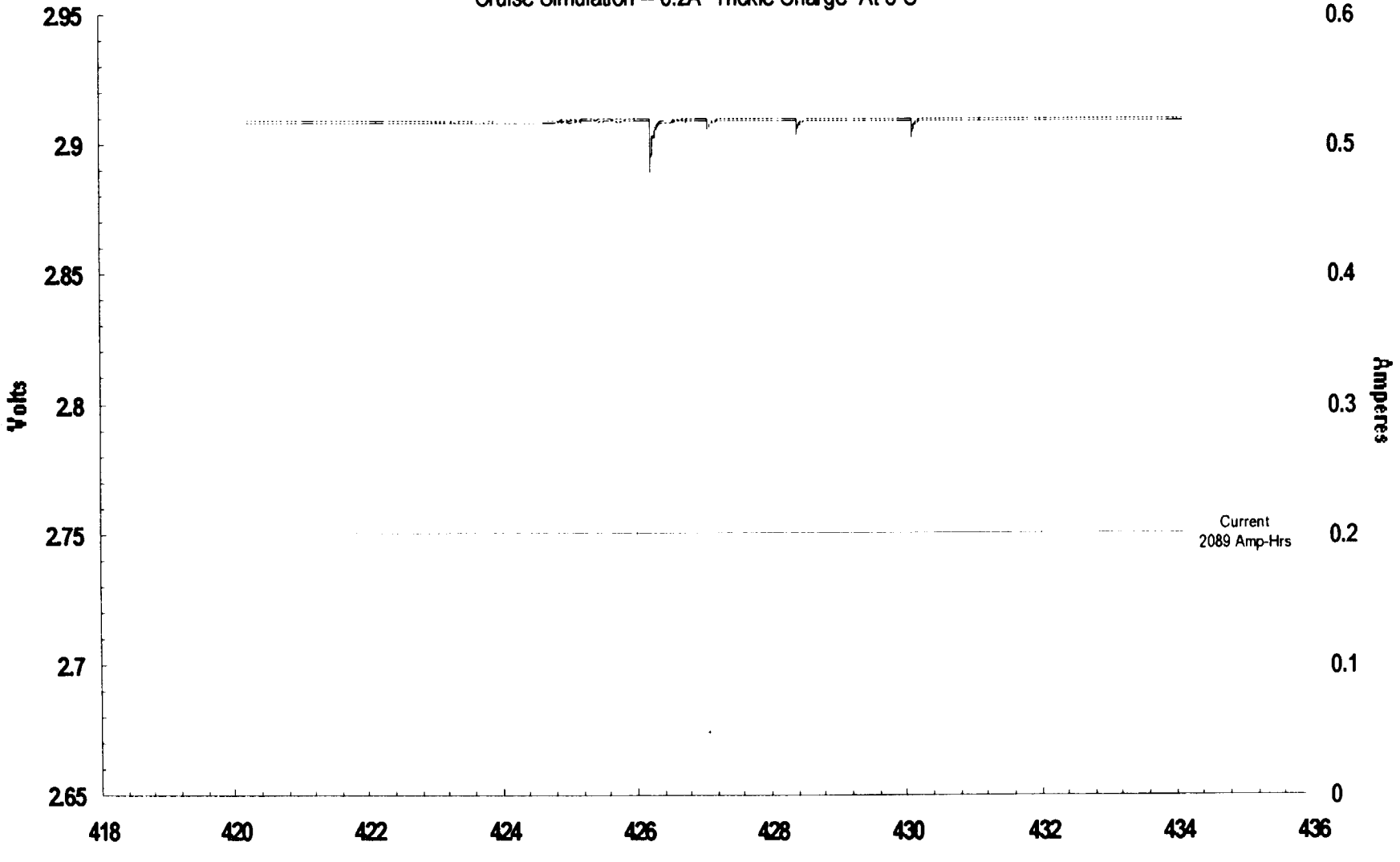

EXPERIMENTAL V/T CURVES SUPERIMPOSED ON
MGS HARDWARE V/T CURVES
BATTERY VOLTAGE
26
25
24
23
22
21
-20
-10
0
10
20
30
40
TEMPERATURE °C
V/T1
V/T2
V/T3
V/T4
V/T5
V/T6
V/T7
V/T8
V/T1-S
V/T2-S
V/T3-S
V/T4-S
V/T5-S
V/T6-S
V/T7-S
V/T8-S
V/T1/exp
V/T2/exp
V/T3/exp
V/T4/exp
V/T5/exp
V/T6/exp
V/T7/exp
V/T8/exp

JPL

Characteristic Cruise Performance

Mars Global Surveyor – EPI 20 Ampere-Hour CPV NiH_2 Cells

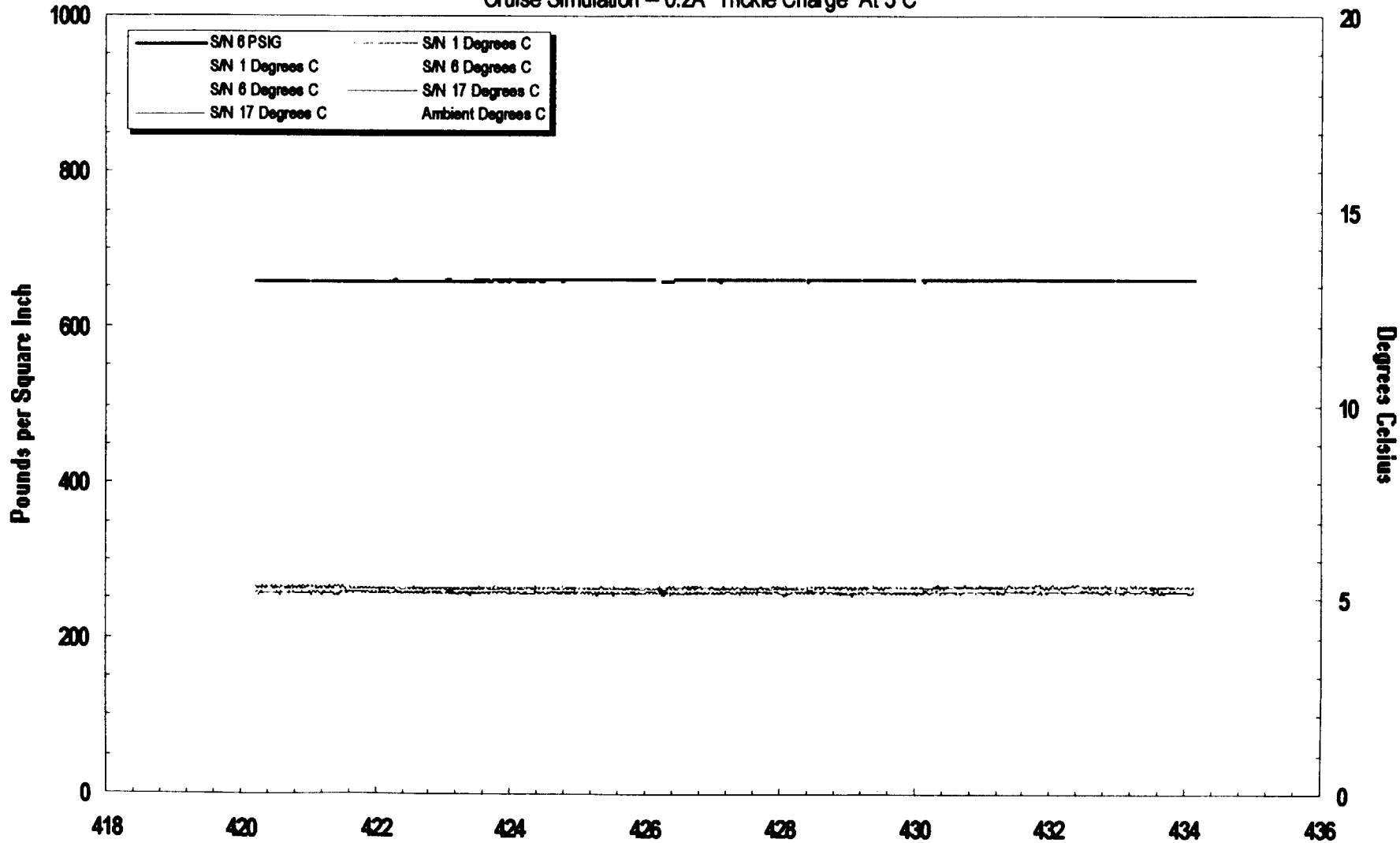
Cruise Simulation – 0.2A "Trickle Charge" At 5°C



Characteristic Cruise Performance

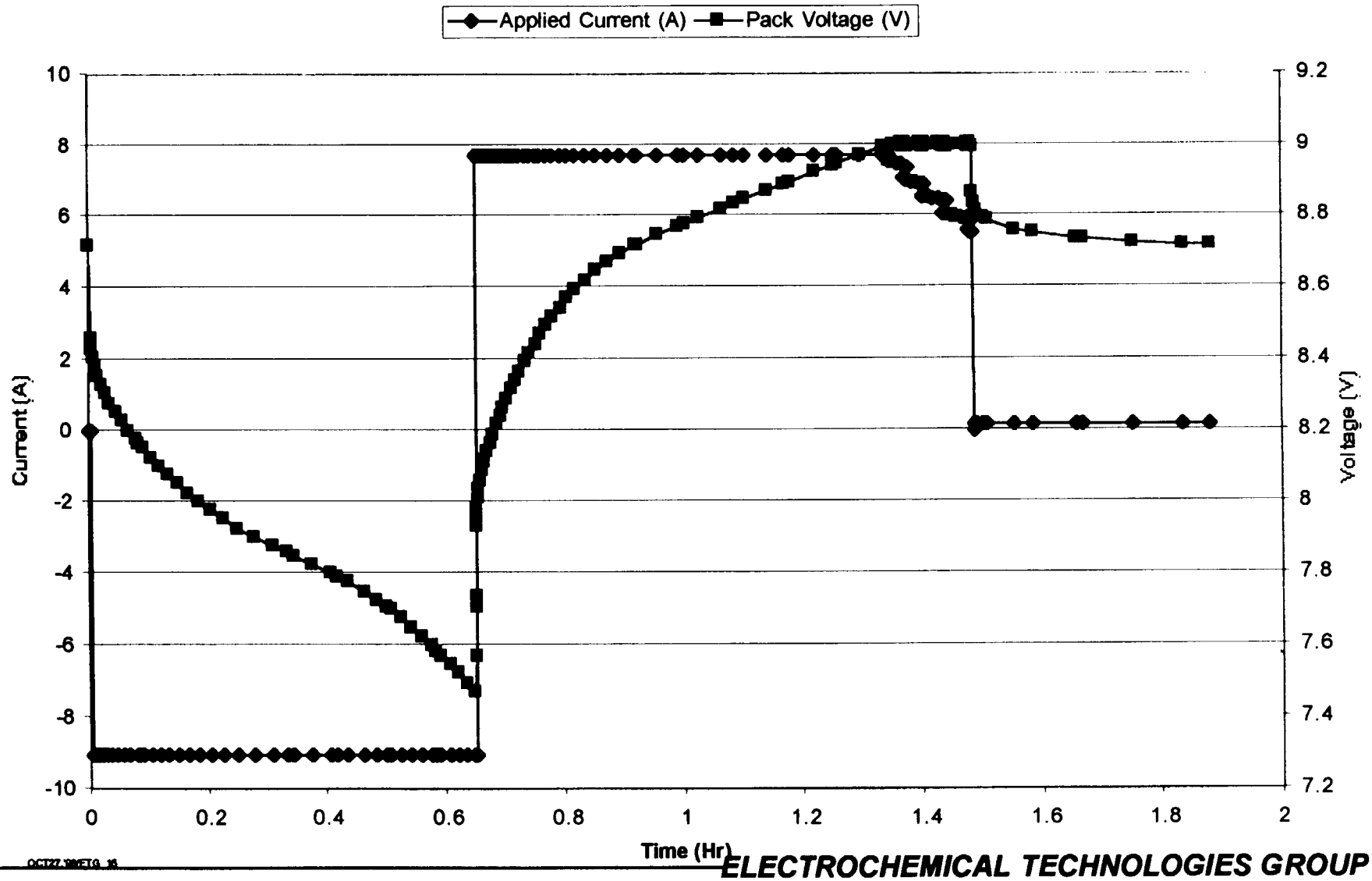
Mars Global Surveyor – EPI 20 Ampere-Hour CPV NiH_2 Cells

Cruise Simulation – 0.2A "Trickle Charge" At 5°C



Characteristic Aerobraking Orbit Simulation

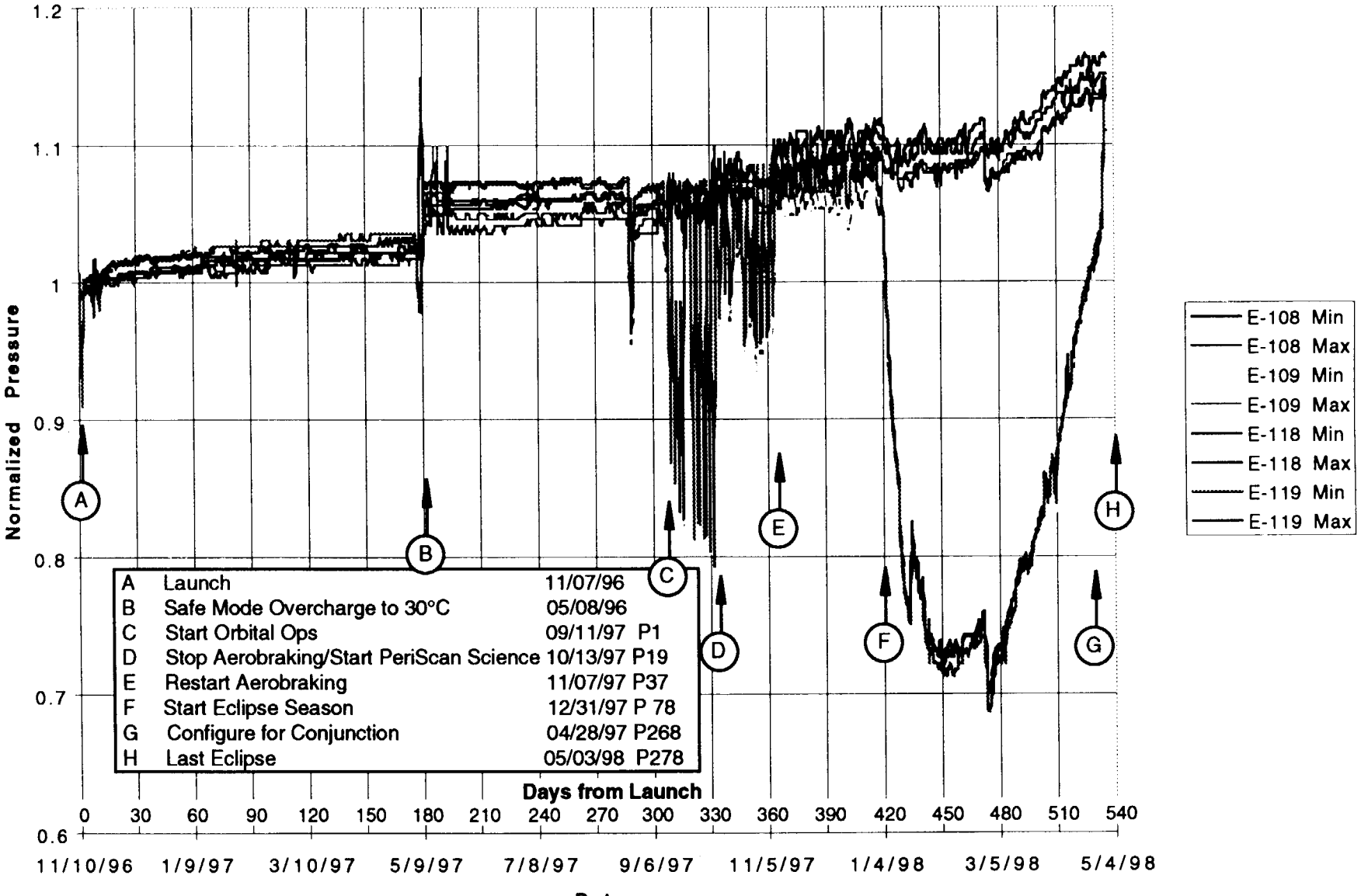
MGS Simulation(Ni-H2) Orbit # 392



Trend Analysis

- For Each Day The Highest and Lowest Value for Each Telemetry Channel is Recorded
  - Pressure (4), Temperature (2 of 4), Voltage (2) Follow
- Pressures Have Been Normalized by Dividing Subsequent Readings by the Initial Post-Launch Values
  - Show a 15% Increase Over Time
    - ~4% Due to Trickle Charging for 560 Days
    - ~4% Due to Single Event Overcharge at 7.5 amps to 30°C Overtemperature Cutoff Upon Entering Safe Mode During Cruise
    - 7% Due to 200 Discharge/Charge Cycles Averaging ~30% DOD, 50% Maximum

NORMALIZED PRESSURE HISTORY CHART



SUMMARY OF PRESSURE TREND DATA

- Data Below Reflects Pressures at Constant Charge Rate (C/100) & Temperature (~2°C) from Beginning of Life to Present
- MGS Pressure Measurements Saturate at 792 psi (6.6%) 812 psi (1.5%), 817 psi (5.4%) and 861 psi (4.5%)

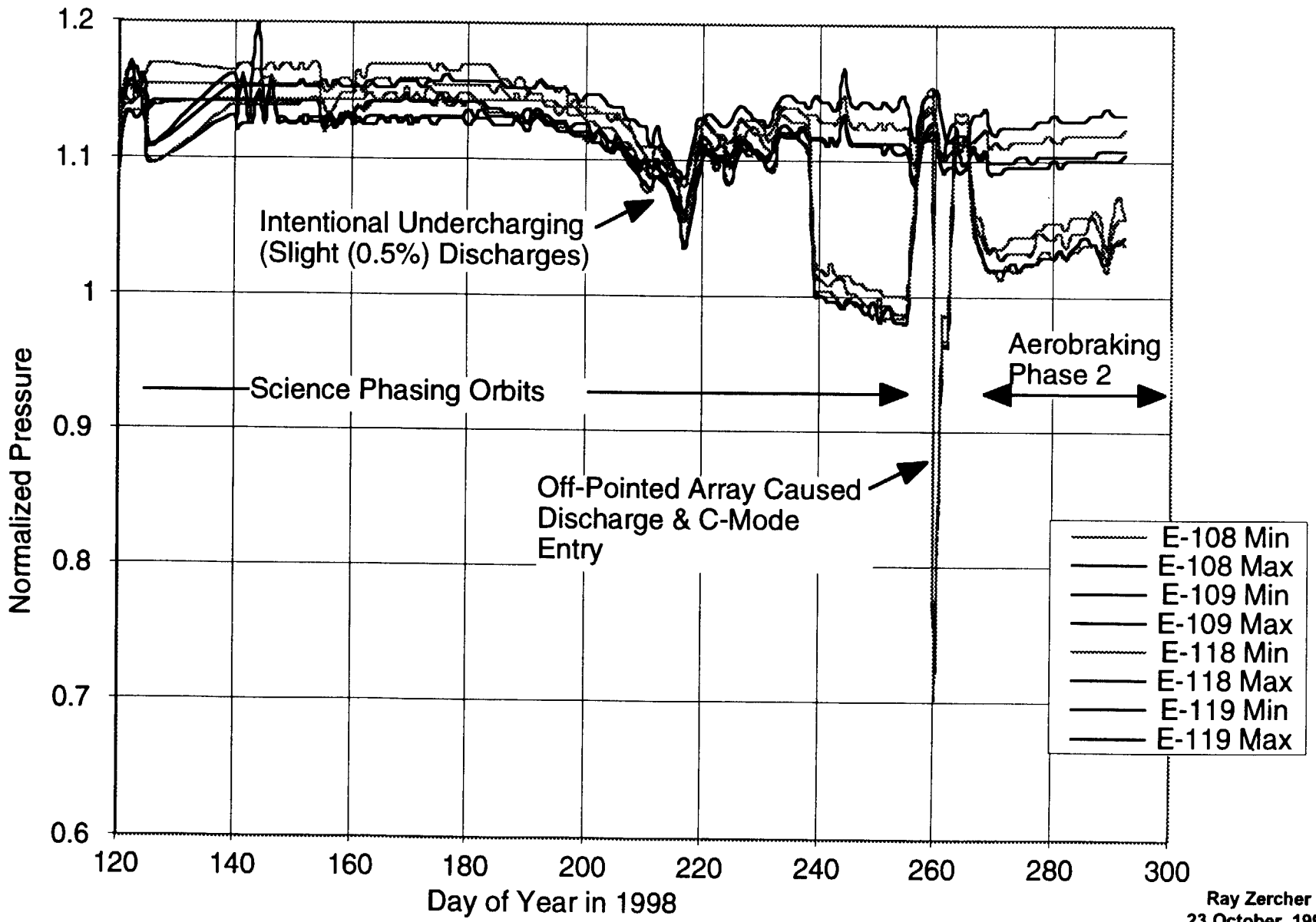
	Beginning of Mission			Current Values (PSI)			Delta Increases (%)		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Battery 1									
Temperature:	2.6°/2.4° on D97-017			1.4°/0.5° on D98-124					
Pressure 1 (E-0108)	621.8	652.9	628.3	705.8	743.1	712.6	13.5%	13.8%	13.4%
Pressure 2 (E-0109)	656.1	681.5	663.2	745.2	800.7	750.0	13.6%	17.5%	13.1%
Battery 2									
Temperature:	3.2°/1.8° on D96-319			1.6/1.7° on D98-124					
Pressure 1 (E-0118)	628.2	663.5	638.5	734.0	775.7	738.9	16.8%	16.9%	15.7%
Pressure 2 (E-0119)	668.9	699.3	681.9	790.5	824.3	799.0	18.2%	17.9%	17.2%
AVERAGE							15.5%	16.5%	14.9%
AVERAGE								15.6%	

Summary

- Charge control of MGS 2-Cell CPV NiH_2 Battery using modified NiCd charge control system appears to be working well - Not recommended
- Unexpected increase in pressure observed in flight
- Operations have been modified to further minimize overcharge
- The pressure increase not expected to impact mission

Mars Surveyor Operations

Pressure History Since 5/1/98

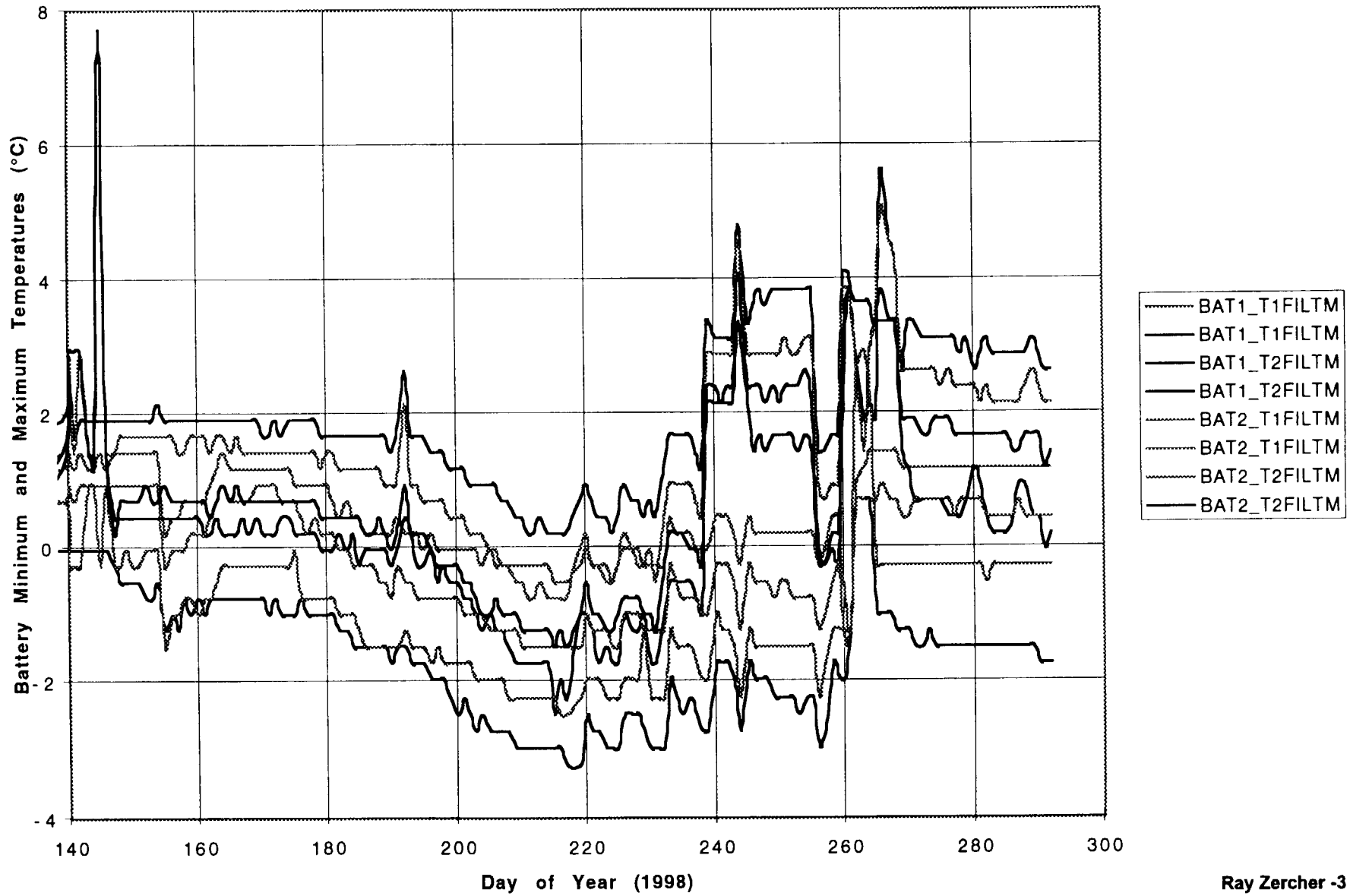


MGS Battery Pressure Data

Ray Zercher -2
23 October, 1998

Mars Surveyor Operations

Temperature History Since 5/1/98



Ray Zercher -3
23 October, 1998

MGS Battery Pressure Data

ACKNOWLEDGMENT

This work was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration and was sponsored by:
NASA Code QT (Office of Safety and Mission Assurance)
NASA Code AE (Chief Engineer's Office) and the
MGS Project.

MGS Battery