NASA CENTER UPDATE
JET PROPULSION LABORATORY

PRESENTED BY
Sal Di Stefano

JPL

1992 NASA AEROSPACE BATTERY WORKSHOP
November 17-19, 1992
U. S. Space and Rocket Center
Huntsville, Al

JPL

AGENDA

- FLIGHT PROJECT SUPPORT ACTIVITIES
  - TOPEX
  - MARS OBSERVER
- RESEARCH / DEVELOPMENT AND ENGINEERING ACTIVITIES
  - NiCd MODEL DEVELOPMENT
  - SECONDARY LITHIUM BATTERY DEVELOPMENT
  - SODIUM - $NiCl_2$ MODERATE TEMPERATURE BATTERY
  - Li-$SOCl_2$ BATTERIES FOR CENTAUR LAUNCH VEHICLE
  - DIRECT HYDROCARBON / METHANOL FUEL CELLS

TOPEX MISSION / BATTERY DEFINITION

- PRIME CONTRACTOR - FAIRCHILD / McDONNELL DOUGLAS MPS (BATT)

- BATTERY DESIGN
  - MODULAR POWER SUBSYSTEM (3 x 22 CELL 50 Amp-Hr BATT)
  - CELL DESIGN
    - GATES AEROSPACE - NASA STANDARD
    - 16 POS / 17 NEG
    - PELLON 2505 SEPARATOR
    - NONPASSIVATED POS / TEFLONATED NEG

- BATTERY CYCLE REGIME
  - MEDIUM ALTITUDE ORBIT - VARIABLE OCCULTATIONS AND SOME ÍFULL SUN PERIODS

TOPEX STATUS

- LAUNCH AUGUST 10, 1992
- BATTERY OPERATIONAL STRATEGY
  - ° LIMIT PEAK CHARGE CURRENTS TO 20 AMPS (OFFSET ARRAY)
  - ° LIMIT OVERCHARGE BY MAINTAINING RECHARGE RATIO (C/D) TO 103% @ 0°C (OPERATE AT LOWER V/T LEVELS)
  - ° AVOID HIGH CHARGE CURRENTS DURING FULL SUN PERIODS (OPERATE AT LOWER V/T LEVELS)
- CURRENT STATUS - NOMINAL OPERATION

JPL

MARS OBSERVER MISSION / BATTERY DEFINITION

- PRIME CONTRACTOR - GE ASTROSPACE

- BATTERY DESIGN
  - TWO 17 CELL / 42 Amp-Hr BATTERIES
  - CELL DESIGN
    - GATES AEROSPACE
    - 13 POS / 14 NEG
    - PELLON 2505 ML
    - NONPASSIVATED POS / TEFLONATED NEG
- BATTERY CYCLE REGIME
  - 11 MONTH CRUISE
  - ~ 120 Min ORBIT 41 Min ECLIPSE (max)
  - REQUIRE 9000 CYCLES

JPL

MARS OBSERVER STATUS

- LAUNCH - SEPTEMBER 25, 1992
- BATTERY OPERATIONAL STRATEGY
  - DEVELOP METHOD FOR MINIMIZING EFFECT OF 850 mA TRICKLE CHARGE DURING CRUISE
  - MINIMIZE TRICKLE CHARGE BY BATTERY SWITCHING - SWITCH ONE BATTERY OFF LIE FOR 12 HOURS AND THEN REVERSE
- CURRENT STATUS - NOMINAL PERFORMANCE

JPL

NiCd MODEL DEVELOPMENT

OBJECTIVE: TO DEVELOP A NiCd BATTERY PERFORMANCE MODEL BASED ON FUNDAMENTAL ELECTROCHEMICAL PRINCIPLES AND CAPABLE OF PREDICTING BATTERY VOLTAGE UNDER SPACECRAFT OPERATING CONDITIONS OVER MISSION LIFE

STATUS: BEGINNING OF LIFE BATTERY LEVEL PREDICTION MODEL IS OPERATIONAL - CELL DESIGN ENGINEERING DATABASE DEVELOPED ALLOWING FOR COMPREHENSIVE CELL SPECIFICATION

PLANS: INCORPORATION AND VERIFICATION OF DEGRADATION FEATURES - FINALIZE DOCUMENTATION - SUBMIT FOR FIELD EVALUATION

JPL

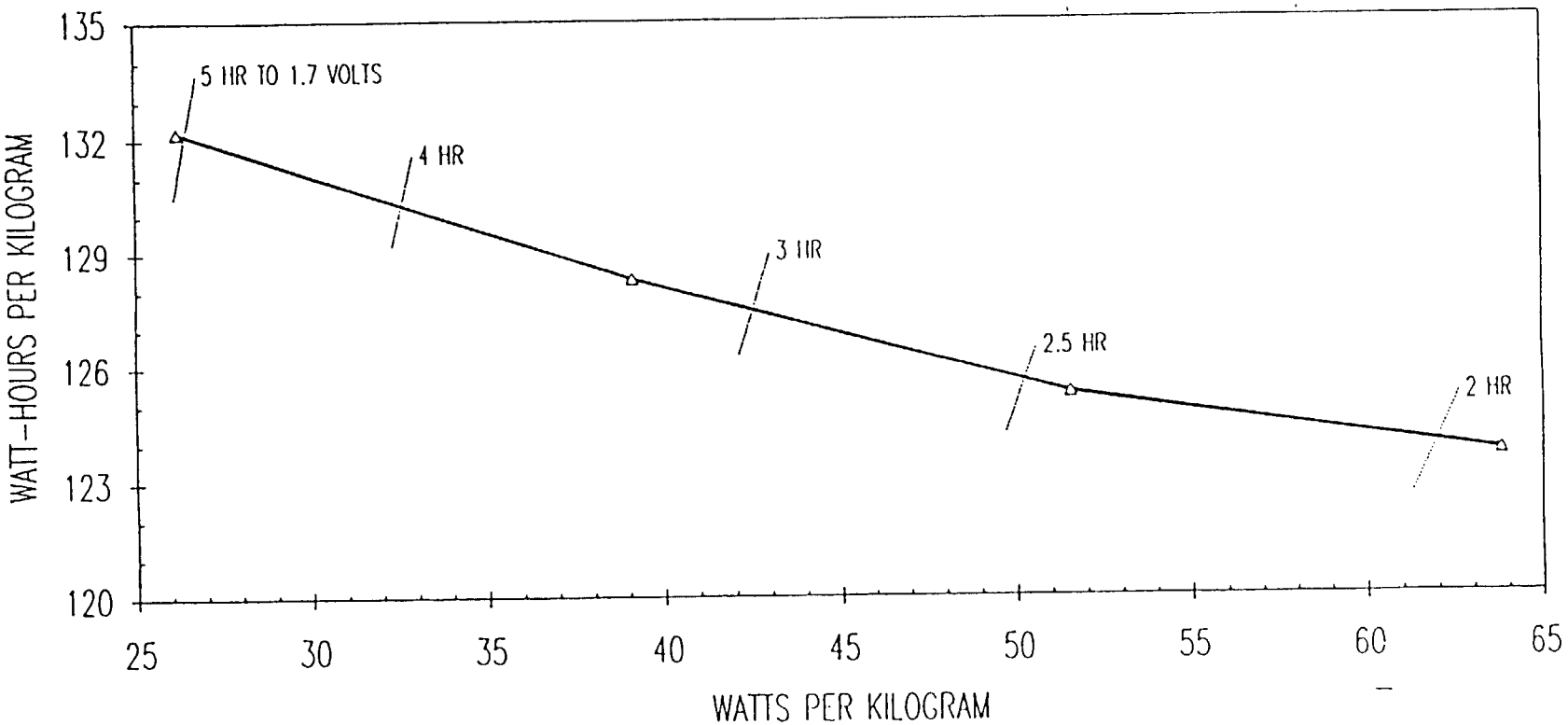
SECONDARY LITHIUM CELLS

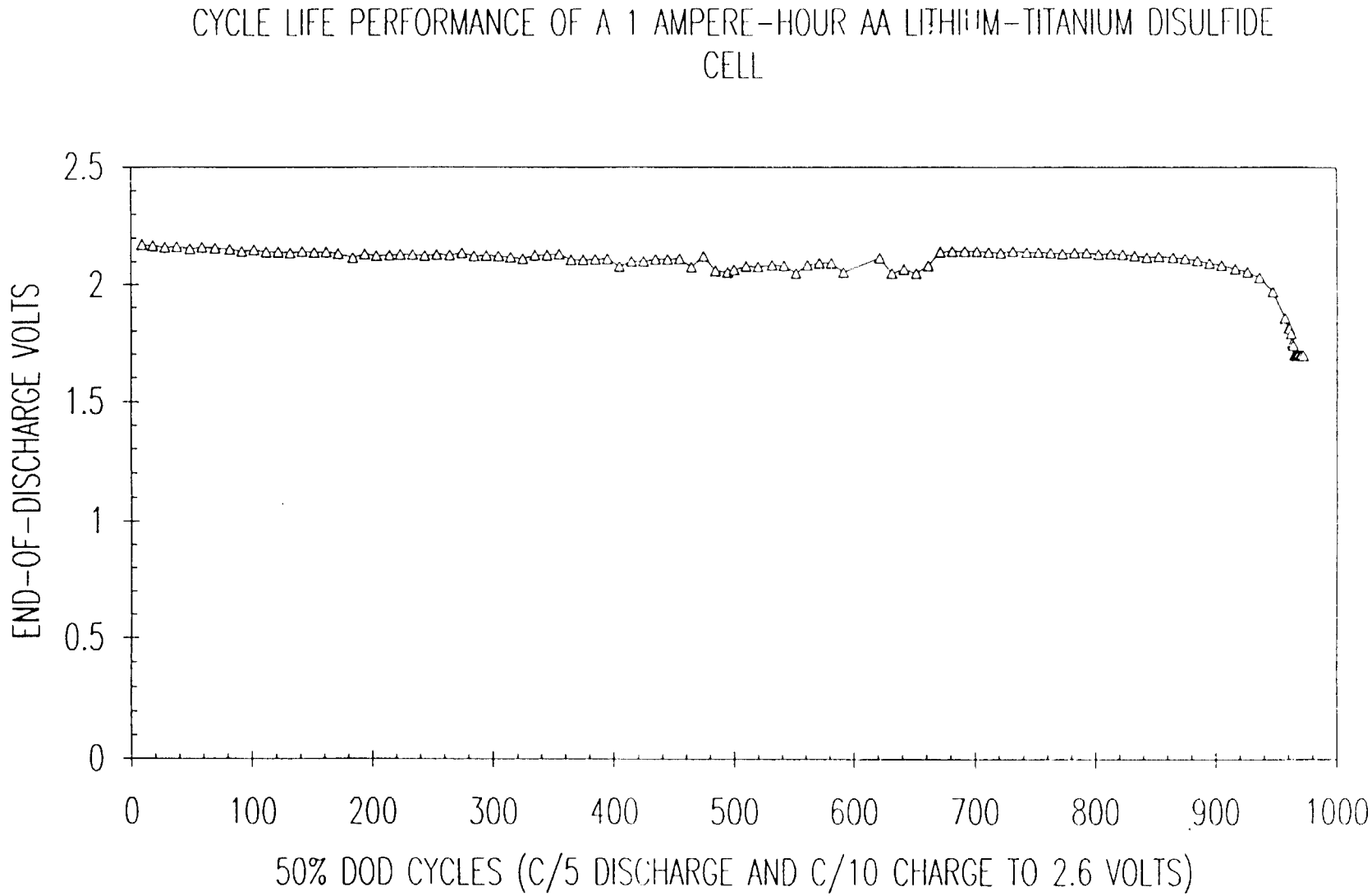
OBJECTIVE: TO DEVELOP AND DEMONSTRATE A 100 WH/Kg $LiTiS_2$ RECHARGEABLE CELL CAPABLE OF 1000 CYCLES AT 50 % DEPTH OF DISCHARGE AND A 5 YEAR STORAGE LIFE

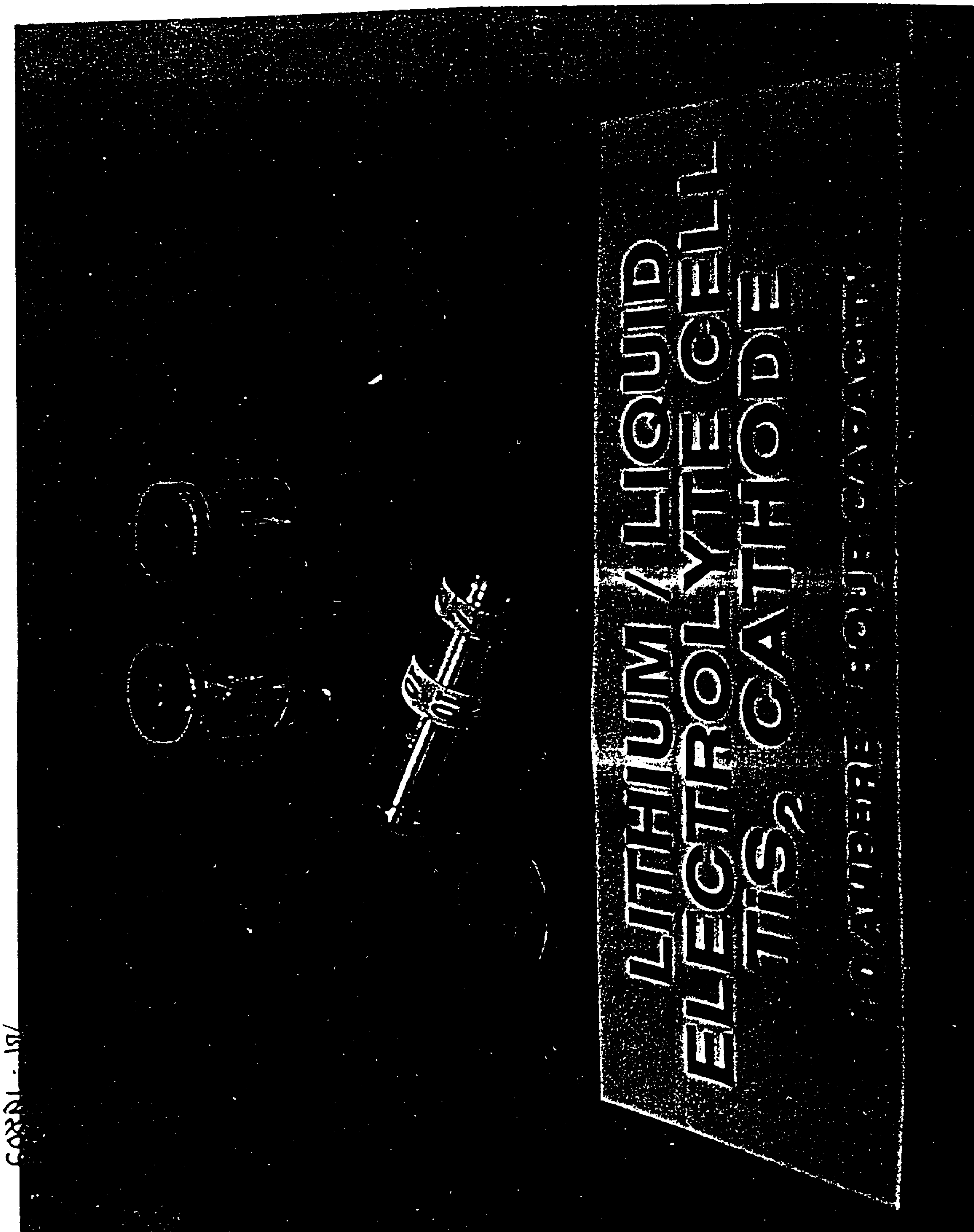
STATUS: 965 CYCLES AT 50 % DEPTH OF DISCHARGE IN 1 AH 'AA' SIZE $LiTiS_2$ CELLS AT 50% DOD - DEMONSTRATED 125 WH/Kg

PLAN: DEMONSTRATE 1000 CYCLES IN 5 AH PRISMATIC CELLS - VERIFY OVERCHARGE MECHANISM - COMPLETE SAFETY TESTING - DETERMINE OPERATING LIMITS

PERFORMANCE OF A TYPICAL 1 AHR (AA) LITHIUM TITANIUM DISULFIDE CELL




CYCLE LIFE PERFORMANCE OF A 1 AMPERE-HOUR AA LITHIUM-TITANIUM DISULFIDE CELL
END-OF-DISCHARGE VOLTS
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
600
700
800
900
1000
50% DOD CYCLES (C/5 DISCHARGE AND C/10 CHARGE TO 2.6 VOLTS)


LITHIUM / LIQUID
ELECTROLYTE CELL
TiS2 CATHODE

JPL

SODIUM METAL HALIDE CELLS

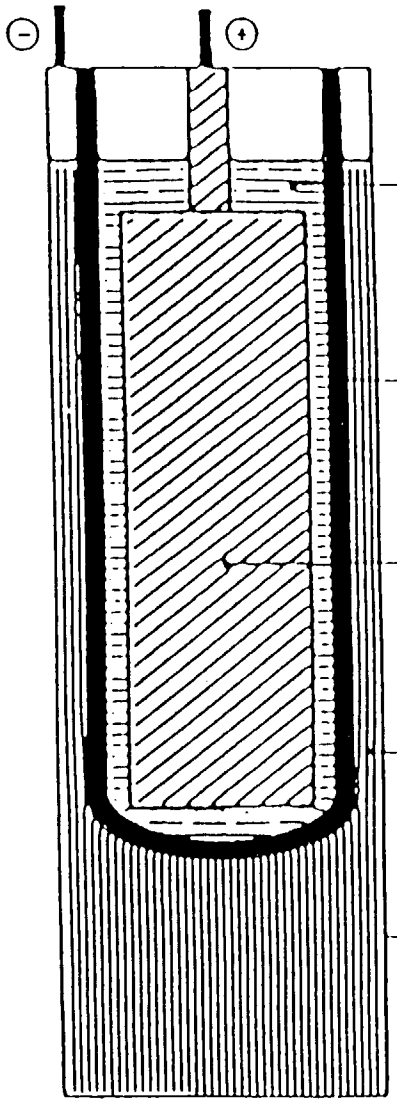
OBJECTIVE: TO DEVELOP A HIGH SPECIFIC ENERGY (>150 WH/Kg) BATTERY FOR FUTURE NASA SPACE MISSIONS

STATUS: $NiCl_2$ SELECTED FROM SEVERAL METAL CHLORIDES - EXPERIMENTAL CELL TESTS REVEAL OPTIMAL OPERATION AT 275°C - LONG CYCLE LIFE IN LEO CYCLING INDEPENDENTLY VERIFIED AT IN ESA SPONSORED TESTS

PLANS: FABRICATE LABORATORY CELLS AND INVESTIGATE LIFE LIMITING MODES

JPL

ADVANCED BATTERY CONCEPTS
SODIUM-METAL HALIDE CELLS



CONFIGURATION

Na (l) / BETA ALUMINA (s) / $NaAlCl_4$ (l) / MCl_2 (s)

CELL REACTION

$Na = Na^+ + e^-$ (ANODE)

$MCl_n + n\,e^- = M + n\,Cl^-$ (CATHODE)

$MCl_n + n\,Na = M + n\,NaCl$ (OVERALL)

WHY Na-MCl_2 BATTERIES?

- HIGH ENERGY AND POWER DENSITIES COMPARABLE TO Na - S BATTERIES
- SEVERAL POTENTIAL ADVANTAGES OVER Na-S
- LONG CYCLE AND ACTIVE LIFE
- SEVERAL IMPROVED CATHODE MATERIALS POSSIBLE

JPL

SODIUM- METAL HALIDE CELL PROGRAM

ACTIVITY	88 89 90 91 92 93 94 95 96 97 98 99 2000	
SCREENING STUDIES	Evaluate organic and inorganic cathodes Down select to Na/MCl2	IDENTIFY SYSTEM CAPABLE OF PROVIDING > 1000 CYCLES AND 150 Wh/Kg
ELECTROCHEMICAL CHARACTERIZATION OF MCl2	Short term studies performance and reversibility Identify suitable materials Identify and overcome rate limiting processes Down select to Na/NiCl2	ESTABLISH MECHANISMS DETERMINE REACTION KINETICS AND IDENTIFY RATE LIMITING PROCESSES
COMPONENT DEVELOPMENT	Develop 5 Ah TEST CELL Study of performing enhancing additives Develop cathode fabication process Identify cell failure mechanism Charge methods Optimize and improve design	DEFINE DESIGN REQUIREMENTS FOR 20-25 Ah CELLS
PERFORMANCE AND SAFETY EVALUATION	Develop performance data base Evaluate safety and environmental effects Identify failure modes	DEMONSTRATE CYCLE LIFE AND PERFORMANCE IN OPTIMIZED 20-25 Ah CELL
PROTO TYPE	Develop eng model cell Demo 1000 cycles and 150 Wh/Kg	FINAL DEMONSTRATION

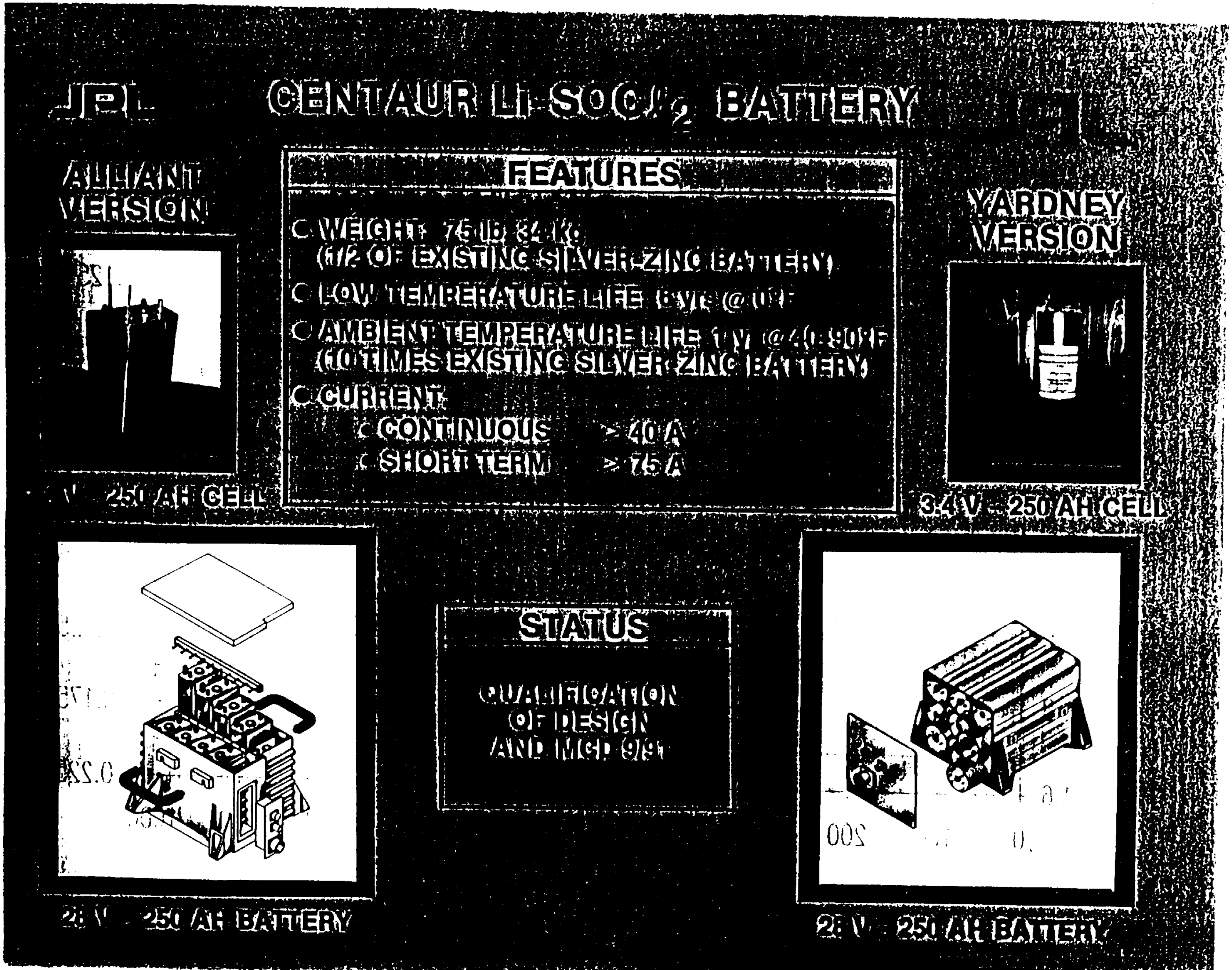
JPL

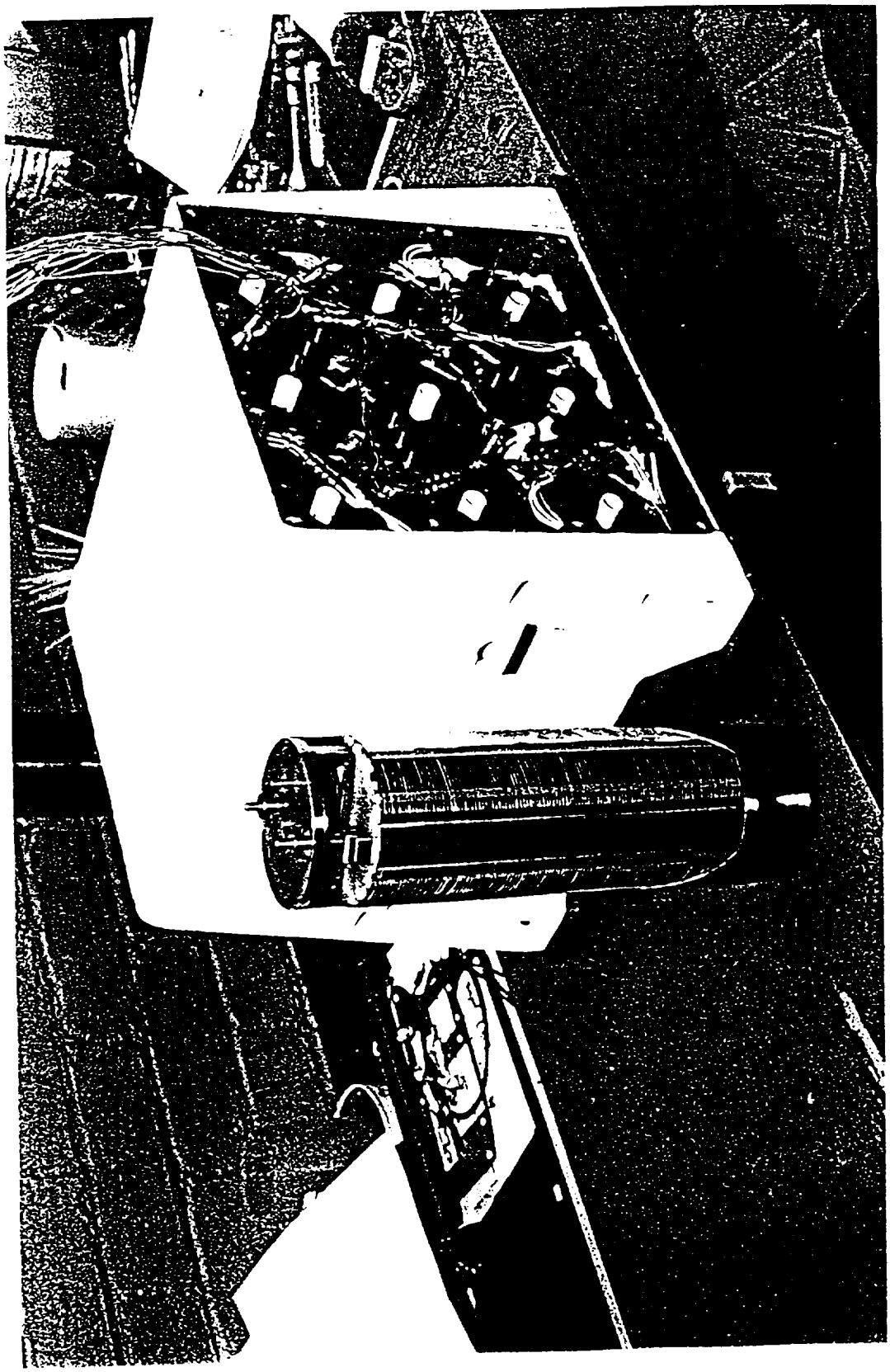
250 AH Li - $SOCl_2$ BATTERY FOR THE CENTAUR LAUNCH VEHICLE

OBJECTIVE: TRANSFER JPL DEVELOPED Li-$SOCl_2$ BATTERY TECHNOLOGY TO 2 CONTRACTORS, FABRICATE CELLS AND BATTERIES AND DEMONSTRATE CAPABILITY FOR MEETING CENTAUR QUALIFICATION REQUIREMENTS

STATUS: DOWN SELECTED TO YARDNEY TECHNICAL PRODUCTS - 5 BATTERIES READY FOR QUALIFICATION - 48 CELLS SUBJECTED TO CHARACTERIZATION TESTS (TEMP, RATE) AND PERFORMED WELL - PDR's. CDR's, AND MRR's COMPLETED

PLANS: COMPLETE CELL / BATTERY TESTS PER CENTAUR REQUIREMENTS - COMPLETE DOCUMENTATION AND DELIVER MCD TO AIR FORCE





JPL

DIRECT HYDROCARBON / METHANOL FUEL CELLS

OBJECTIVE: TO DEVELOP A FUEL CELL SYSTEM CAPABLE OF THE DIRECT OXIDATION OF METHANOL, METHANE OR OTHER HYDROCARBON

STATUS: NEW CONCEPT IN FUEL CELLS (LIQUID FEED FUEL CELL) HAS BEEN DEMONSTRATED AND ACHIEVED 80 mA/cm^2 AT 0.5 VOLTS

PLANS: CONTINUE THE DEVELOPMENT AND EVALUATION OF LIQUID FEED FUEL CELL - EVALUATE NEW CATALYSTS - FAB DEMONSTRATION UNIT

HIGHLIGHTS OF THE

JPL DARPA DIRECT METHANOL FUEL CELL TASK

OBJECTIVE

DEVELOP DIRECT METHANOL FUEL CELL TECHNOLOGY (DMFC) AT THE CELL LEVEL WITH TARGET PERFORMANCE LEVELS BY 1994

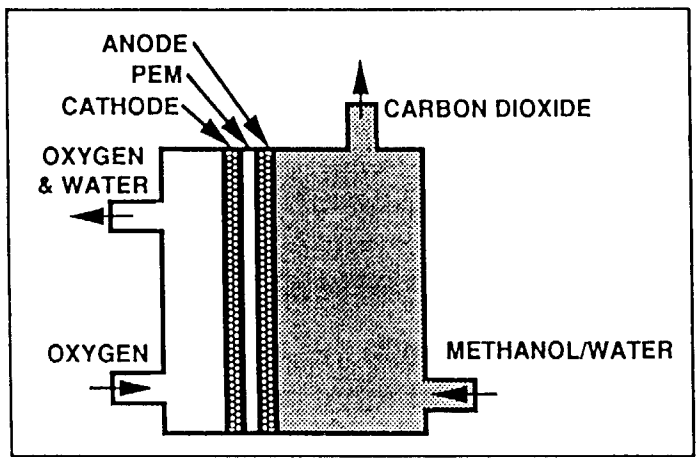
TARGETS (CELL LEVEL)

CURRENT DENSITY	> 150 mA/cm^2
CELL VOLTAGES	> 0.6 VOLTS
LIFE	> 1000 HOURS
TEMPERATURE	< 200°C

ACCOMPLISHMENTS

- SELECTED CATALYSTS AND ELECTROLYTES WITH INPUTS FROM UNIVERSITIES FOR THE INTERIM METHANOL/O2 SYSTEM DEMONSTRATION
  - -PT/RU
  - -NAFION MEMBRANE
  - -C8 ACID
- IDENTIFIED LIQUID FEED DESIGN AS ATTRACTIVE FOR LOW TO MEDIUM POWER APPLICATIONS
- DEMONSTRATED FEASIBILITY OF LIQUID FEED DESIGN WITH SUPPORT FROM GINER 0.54V AT 100 mA/cm^2
- EVALUATION OF ALTERNATIVE FUELS IN PROGRESS
  - -TRIMETHOXYMETHANE
  - -DIMETHOXYMETHANE

SCHEMATIC OF LIQUID FEED CELL



ADVANCES IN DIRECT METHANOL FUEL CELLS