

SAFT Nickel Hydrogen Cell and Battery Update

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OUTLINE

- CELL DESIGNS : VHS and AN TECHNOLOGIES
- BATTERY DESIGN

CELL DESIGNS

SAFT HAS TWO NICKEL HYDROGEN CELL TECHNOLOGIES :

- THE « VHS » TYPE IS THE SAFT DESIGN :
 - DEVELOPED SINCE 88
 - QUALIFIED IN 89
 - FLIGHT EXPERIENCE IN 96

- THE « AN » TYPE IS THE EX-GATES DESIGN :
 - QUALIFIED IN 87
 - IN FLIGHT OPERATION SINCE 89
 - TRANSFERRED SUCCESSFULLY FROM GAINESVILLE TO FRANCE IN 94

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VHS CELL DESIGN :

CELL CONFIGURATION :

- 3'5 RABBIT EARS
- CAPACITY RANGE : 30 TO 104 AH :
- HYDROFORMED INCONEL 718 WITH ONE CENTRAL GIRTH WELD (2 PARTS)
- CERAMIC BRAZED TERMINALS
- NEGATIVE PRECHARGE

STACK CONFIGURATION :

- BACK TO BACK DESIGN
- SINGLE OR DUAL STACK
- TRUNK CIRCLE SHAPE ELECTRODES
- AGEING ACCOMMODATION SYSTEM : SPIDER SPRING
- POLYSULFONE END PLATES MAINTAINED BY A TIE ROD

VHS CELL DESIGN : (cont'd)

ELECTROCHEMISTRY :

- POSITIVE ELECTRODES :
 - WET SINTERED MATERIAL ON STEEL PERFORATED GRID
 - ACTIVE MATERIAL DEPOSITED BY AQUEOUS ELECTROCHEMICAL PROCESS

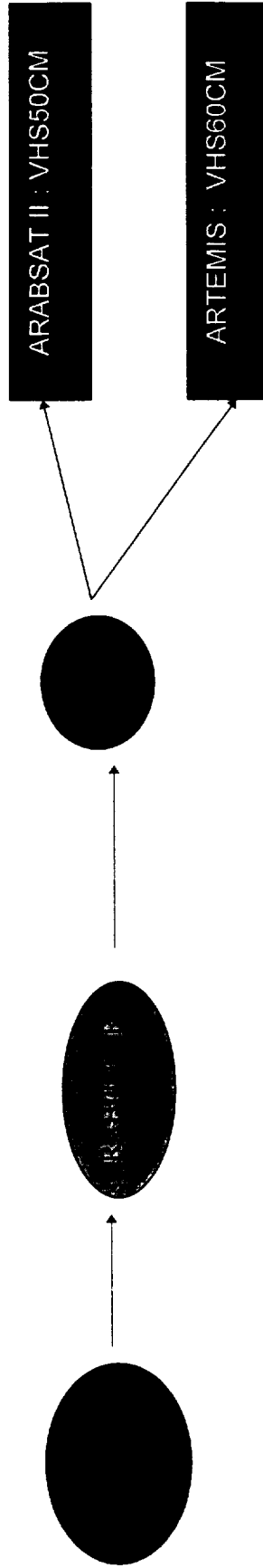
- NEGATIVE ELECTRODES :
 - ACTIVE CHARCOAL WITH PLATINUM ON EXPANDED NICKEL COLLECTOR
 - GORTEX HYDROPHOBIC LAYER WITH POLYPROPYLENE GRID

- SEPARATOR :
 - 3 LAYERS OF NON WOVEN POLYAMIDE FELT

- ELECTROLYTE : 31 % KOH

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VHS CELL DESIGNS : (cont'd)



VHS CELL DESIGN : DESIGN CHANGE

**THE PREVIOUS DESIGN VHS BL HAS BEEN PROVEN 33 GEO SEASONS AT 70 % DOD
THE VHS CM HAS THE SAME ELECTROCHEMISTRY THAN THE VHS BL**

RESULTS OF THE LIFE TEST PERFORMED ON VHS96CM:

- LOW END OF DISCHARGE VOLTAGES
- HIGH INTERNAL RESISTANCE
- HIGH END OF CHARGE PRESSURE

RESULTS OF DPA PERFORMED ON CELLS:

- SOME WATER AT BOTTOM OF CELL DUE TO THERMAL GRADIENT (imposed by test equipment)
- LACK OF ELECTROLYTE INSIDE THE SEPARATOR LAYERS
- INCREASE OF GLOBAL STACK ELECTROLYTE CONCENTRATION

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VHS CELL DESIGN : DESIGN CHANGE (cont'd)

MODIFICATIONS:

- ADDITION OF ONE LAYER OF SEPARATOR TO ENSURE 15 YEARS AT 80 % DOD :
INCREASE FROM 2.9 to 3.3 g of KOH /Ah
- IMPROVEMENT OF THE STACKING PROCESS (Reduction of tolerances on the applied stack preloading)

VALIDATION PLAN:

- MANUFACTURING AND TEST OF VOQ LOT
- SPECIFIC ELECTRICAL TESTING : Overcharge, Internal resistance measurements
 - VIBRATIONS
- ACCELERATED CYCLING (9 cycles per day : 80 % DOD) : 2000 cycles performed without failure
(Test discontinued at 1 V per Cell)
 - DPA

VHS CELL DESIGN : DESIGN CHANGE (cont'd)

DESIGN CHANGE COMPLETELY QUALIFIED BEGINNING OF 96

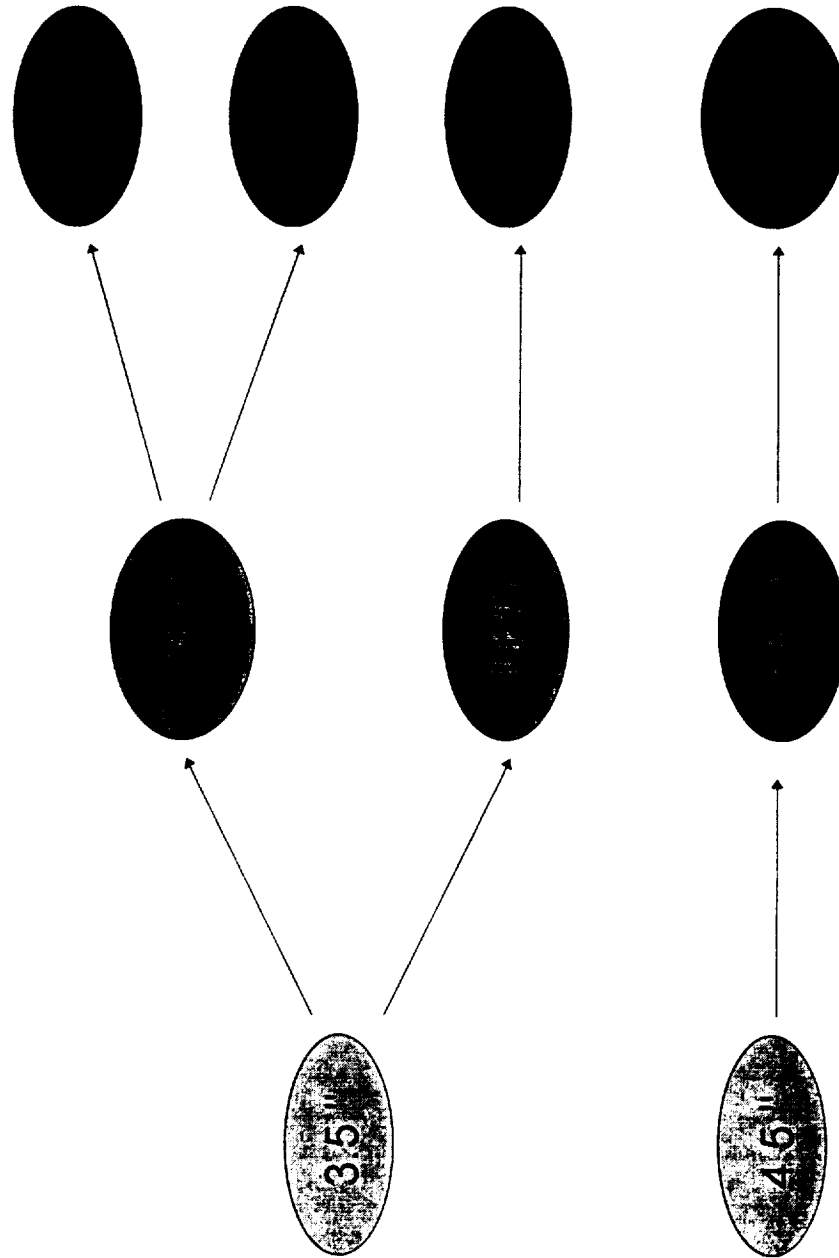
ARABSAT/ARTEMIS BATTERY DESIGN REVISED PER THIS CHANGE

8 BATTERIES IN ORBIT ON ARABSAT II A and B

CONTINUED LIFE TESTING : SEMI-ACCELERATED CYCLING AT ESA
(2 cycles per day, 80 % DOD, reduced solstice)

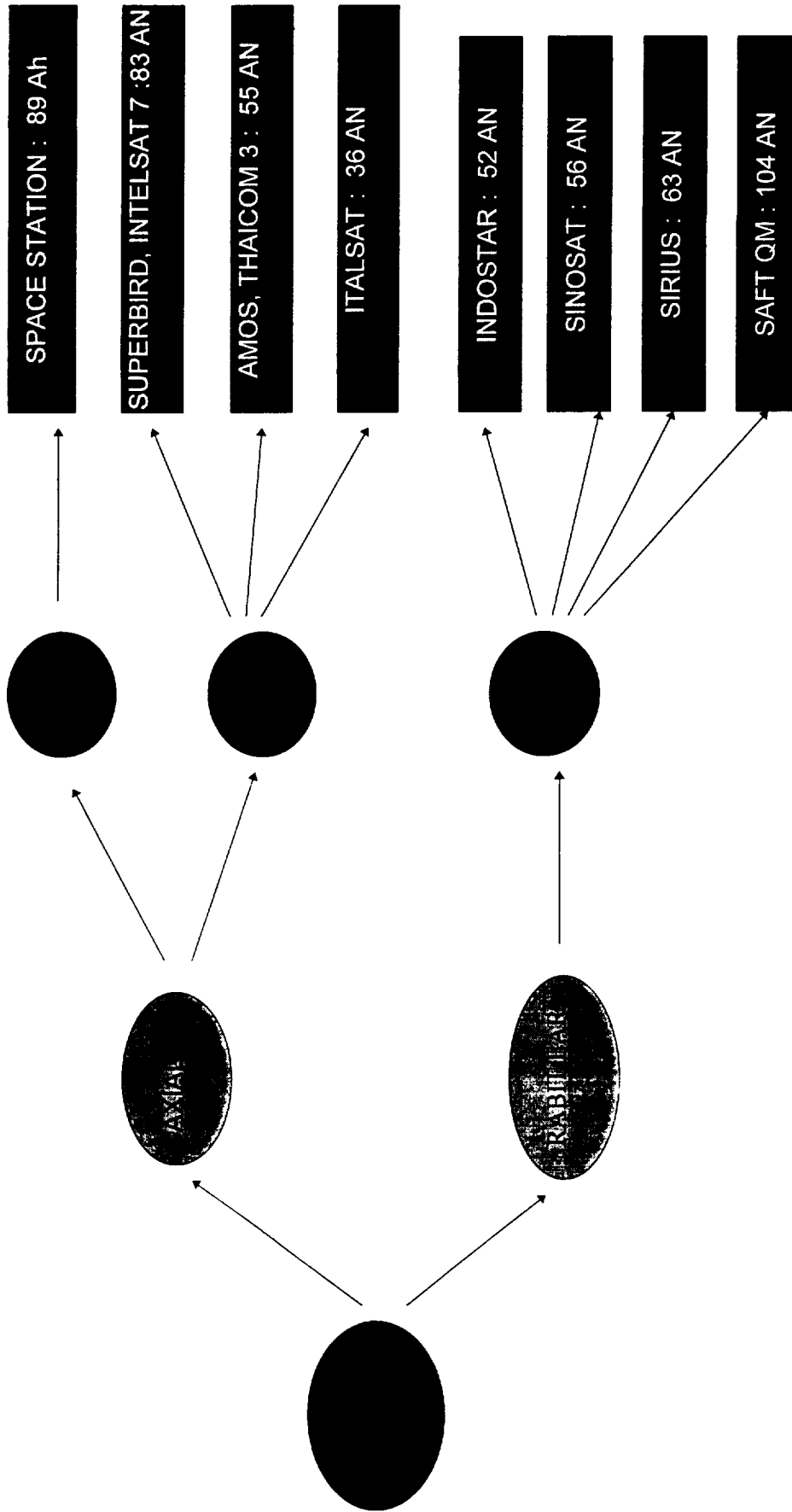
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AN CELL DESIGNS : 4 CONFIGURATIONS



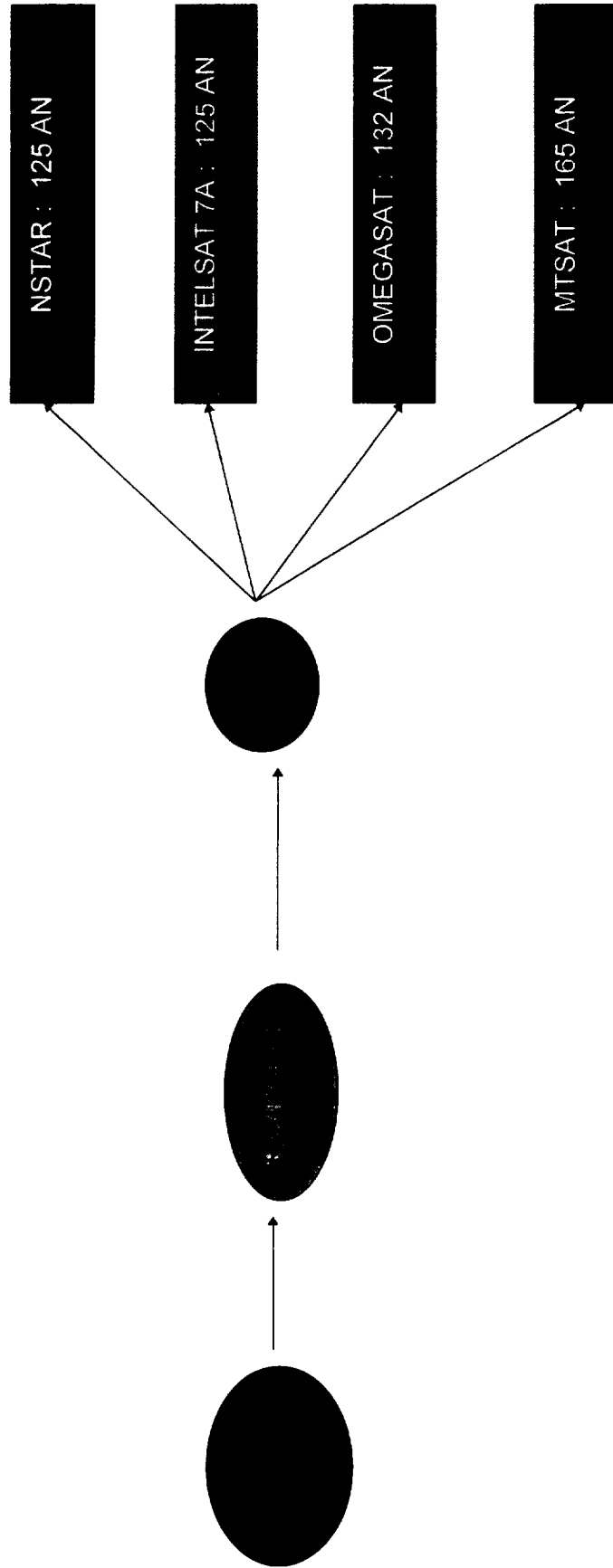
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AN CELL DESIGNS : (cont'd)



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AN CELL DESIGNS : (cont'd)



AN CELL DESIGNS : (cont'd)

CELL CONFIGURATION :

- HYDROFORMED OR ROLLED AND WELDED INCONEL 718 VESSEL (3 PARTS)
 - TWO CENTRAL GIRTH TIG WELDS
 - CERAMIC BRAZED TERMINALS
 - POSITIVE PRECHARGE
 - WALL WICK SYSTEM

STACK CONFIGURATION :

- BACK TO BACK DESIGN
 - SINGLE STACK
- PINEAPPLE SLICE CONFIGURATION WITH POLYSULFONE CENTER CORE
 - AGEING ACCOMMODATION SYSTEM : BELLEVILLE WASHERS
 - INCONEL 718 ENDPLATES SUPPORTING STACK AT BOTH ENDS

AN CELL DESIGNS : (cont'd)

ELECTROCHEMISTRY:

- POSITIVE ELECTRODES :
 - DRY POWDER SINTERED MATERIAL ON NICKEL SCREEN
 - ACTIVE MATERIAL DEPOSITED BY AQUEOUS ELECTROCHEMICAL PROCESS

- NEGATIVE ELECTRODES :
 - PLATINUM PTFE FILM ON PHOTOETCHED GRID
 - GORTEX HYDROPHOBIC TEFLON BACKING

- SEPARATOR : 2 LAYERS OF ZIRCAR

- ELECTROLYTE : 31 % KOH WITH 3.3 G/AH

AN CELL : TRANSFER

- SAFT HAD ALREADY SOME EXPERIENCE IN TRANSFERRING SPACE ACTIVITIES FROM ROMAINVILLE TO POITIERS
- AN CELL TRANSFERT BASED ON :
 - TRAINING OF SAFT TEAMS ON DOCUMENTATION AND PROCESS IN GAINESVILLE
 - REQUALIFICATION PLAN DEFINITION
- REQUALIFICATION AND STARTING MANUFACTURING WITH EX GATES PEOPLE IN POITIERS

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AN CELL : TRANSFER (Cont'd)

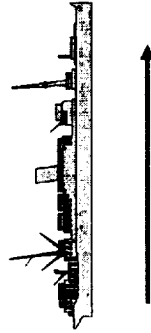
GAINESVILLE

Product

- Freeze the documentation to latest revision
- Review technical documents
- Train and qualify Poitiers operators
- Establish re-qualification plan
- Fabricate qualification samples (considered as reference)

Processes

- Certify each process and equipment
- Disassemble process equipment



POITIERS

Processes

- Re-assemble process equipment
- Re-calibrate process equipment
- Validate each process and equipment

Product

- Fabricate requalification samples
- Compare qualification/re qualification products
- Move of some Gainesville's people to Poitiers to transfer and maintain the know-how
- Final Training and qualification of other operators
- Manufacture and test of a qualification lot (with DPA) : Comparison with Gainesville data
- Keep same suppliers



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AN CELL : TRANSFER (Cont'd)

VALIDATION OF EACH PROCESS
AND GOOD PERFORMANCES OF
THE 6 FIRST CELLS

QUALIFICATION OF
THE TRANSFER



SAFT MANUFACTURING AND DELIVERIES:

3'5

- 200 55AN Axial (Thaicom 3)
- 120 52AN RE (Indostar)
- 120 56AN RE (Sinosat)
- 250 63AN RE (Sirius 2) : In Progress

4'5

- 132AN RE (OmegaSat) delivery in 97/98
- 165AN RE (MTSat) delivery in 97

BATTERY DESIGN

1990

BEGINNING OF THE NiH₂ BATTERY DEVELOPMENT AT SAFT

1993

QUALIFICATION OF THE GENERIC NiH₂ BATTERY WITH VHS CELLS
SELECTION OF THE 27 VHS 50 CM FOR ARABSAT II
SELECTION OF THE 23 VHS 60 CM FOR ARTEMIS

1996

LAUNCH OF 8 BATTERIES ON ARABSAT II A and B
DESIGN CHANGE TO ACCOMMODATE AN CELLS
QUALIFICATION OF AN BATTERY WITH INDOSTAR AND SB3000 PROJECTS

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BATTERY DESIGN

BATTERY CONFIGURATION:

- 12 to 30 Rabbit Ear CELLS PER BATTERY
- BASE PLATE WITH ALUMINUM SLEEVE DESIGN
- INDIVIDUAL BY-PASS SYSTEM PLACED BETWEEN THE CELLS
 - 2 REDUNDANT HEATER CIRCUITS
- BETWEEN 2 and 4 STRAIN GAGE EQUIPPED CELLS
- WIRING MATERIALS : COPPER OR ALUMINUM
- POWER AND MEASUREMENT CONNECTORS
 - CELLS EQUIPPED WITH THERMISTORS



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BATTERY DESIGN (Cont'd)

MAIN CHARACTERISTICS:

- QUALIFIED UP TO 104 Ah
 - ENERGY DENSITY : 48 Wh/kg FOR 27 Cells of 63 Ah
 - WEIGHT RATIO CELL/BATTERY : 80 %
- VOLUME : 59*44*21 cm³ for 27 Cells battery
- DOD max : 80 % with one failed cell
 - THERMAL GRADIENT : Maximum Internal CELL : 2.5 °C
Maximum Between 2 CELLS : 5 °C
 - VIBRATION : QUALIFICATION UP TO 20 G BOTH SINE AND RANDOM

BATTERY DESIGN (Cont'd)

ACCOMMODATION OF AN CELLS:

- CHANGE OF THE DIAMETER OF THE SLEEVES (< 0.5 mm in diameter)
- CHANGE CELL CONNECTION : SCREW FOR VHS → LUG FOR AN
- NEARLY SAME BATTERY CHARACTERICS ARE MAINTAINED WITH AN CELL AS WITH VHS



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CONCLUSION

SAFT NiH₂ PORTFOLIO IS :

- VHS CELLS GEO 3'5
- AN CELLS GEO 3'5/4'5
- AN CELLS LEO 3'5
- VHS AND AN 3'5 BATTERIES

CONCLUSION

FUTURE FOR SAFT :

- **NiH₂** : - EXTEND BY-PASS SYSTEM CAPABILITY
 - HAVE 4'5 INCH BATTERY
 - OBTAIN MORE CYCLING DATA WITH AN
- **LiC** : - DEVELOP LiC TECHNOLOGY FOR SPACE

