SAFT

High Specific Energy NiH_2 Batteries for GEO Satellites

Y. Borthomieu*, M.Fabre**

* Defense and Space Division SAFT POITIERS

** Alcatel Space Industries CANNES

AGENDA

- Qualification Status
- Cell modifications
- Battery changes
- Conclusions

SAFT

Qualification Status

- **Development started in 91**
- **Based on VHS design**
- **Qualification acquired in November 93**
  - 3.5 inches cells
  - 12 to 32 cells per battery
  - 50 to 104 Ah
  - Adaptation to AN cells in 95

SAFT

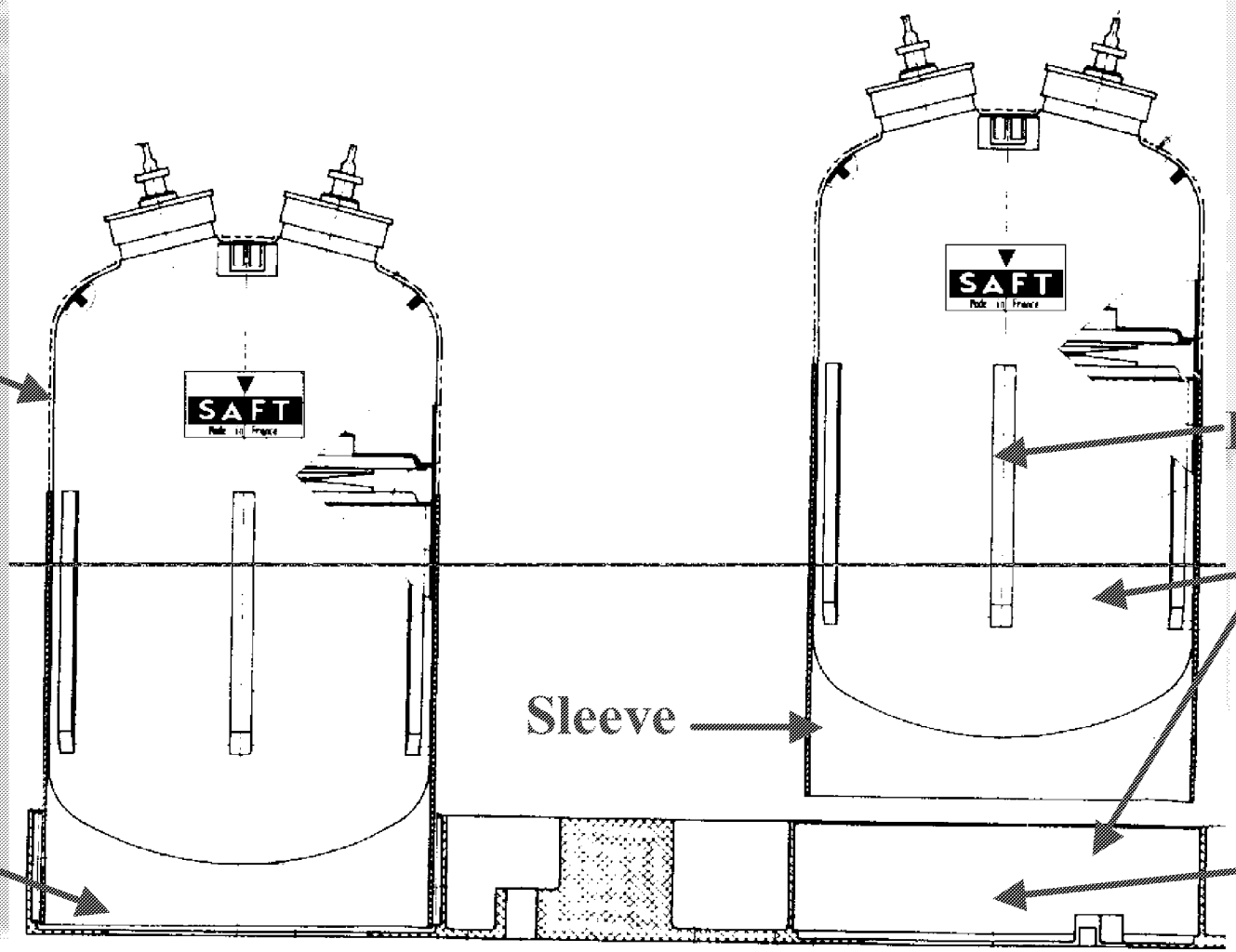
Qualification Status

Battery concept :

- Cell equipped with tubular aluminum sleeve
- Aluminum base-plate with alveolus
- From 12 to 32 cells
- Individual by-pass system
- Two redundant heater circuits
- Cells equipped with strain gages
- Thermistor and connectors
- Aluminum or Copper wiring

SAFT

NiH_2 Battery for GEO



Main characteristics

- Specific energy : 48 Wh/kg for 27 cells of 63 Ah
- Weight ratio cell/battery : 82 %
- Volume : 61*44*21 cm3 (2.4*1.7*0.82 inch3) for 27 cells battery
- DOD max : 80 % with one failed cell
- Thermal gradient (in failed case conditions) :
  - Maximum Internal cell : 2.5 °C
  - Maximum Between 2 cells : 9 °C
- Vibration : qualification up to 20 G both sine and random

PROGRAMS

Satellite	Battery Type	Nb Battery per Satellite	Status
ARABSAT 2A	27*50 VHS	4+1 QM	Launched
ARABSAT 2B	27*50 VHS	4	Launched
ARTEMIS	23*60 VHS	2+1QM	Delivered
INDOSTAR (CAKRAWARTA)	22*52AN	2+2 IM	Launched
SINOSAT	27*56AN	4	Launched
SIRIUS 2 A	27*63AN	4 including 1 PFM	Launched
SIRIUS 2 B	27*63AN	4	Launched on EutelsatW4
ARABSAT 3A FM1	27*71AN	4 including 1 PFM	Launched
ATLANTIC BIRD 2	27*71AN	4	in manufacturing
HISPASAT1C	27*63AN	4	Launched
EURASIASAT	27*93AN	4 including 1 PFM	Delivered
ATLANTIC BIRD 1	23*97AN	2	In manufacturing
HOT BIRD 6	27*101AN	4 including 1PFM	In Design
STELLAT	27*93AN	4	In Design
GE12	27*89AN	4	In Design

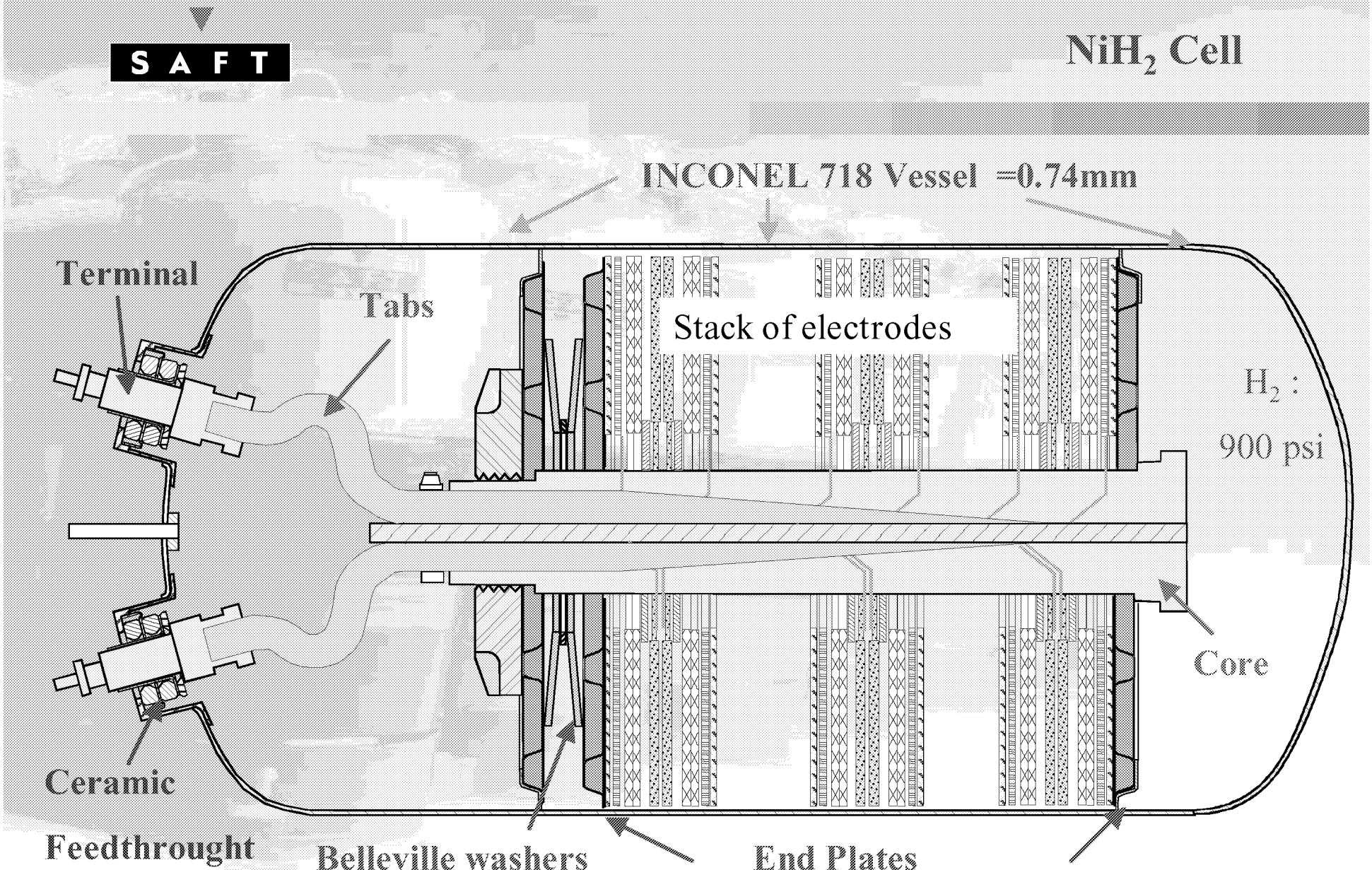
32 Batteries in operation

To Improve specific energy at battery level :

- Increase cell specific energy
- Optimize battery mounting

SAFT

NiH_2 Cell

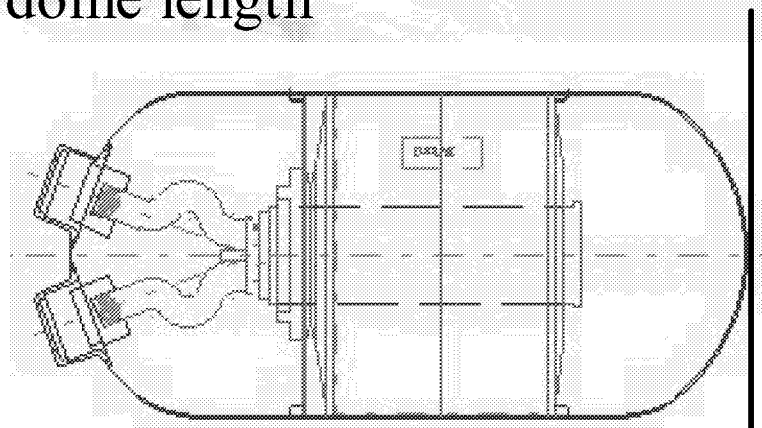


SAFT

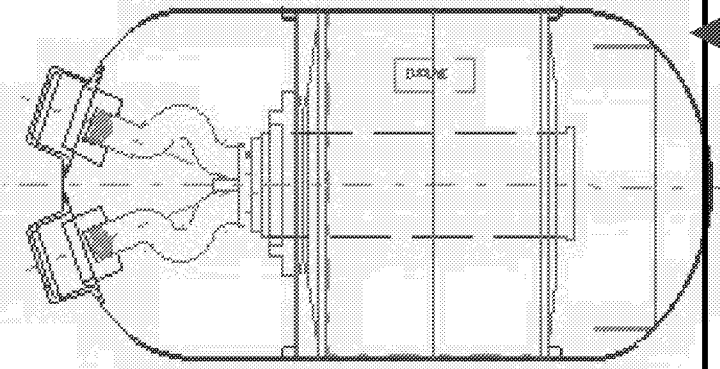
NiH_2 Cell change 1

- Reduction bottom dome length

900 PSI
k=3.2



1000 PSI
k=2.8



Already use on 4.5

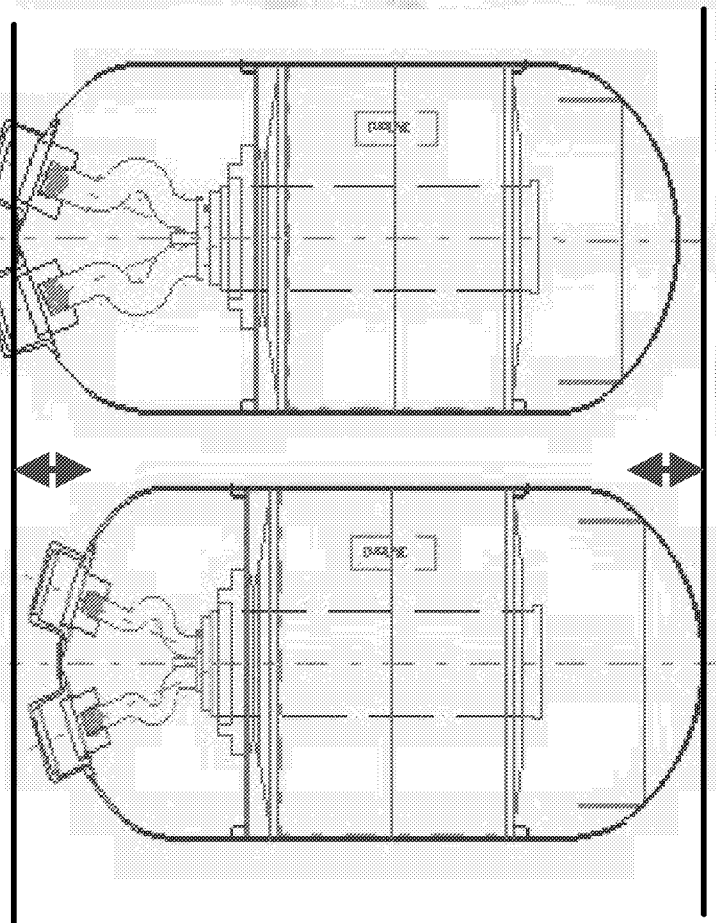
SAFT

NiH_2 Cell change 1

- Impact of bottom dome length reduction:
  - At cell level for AN 101 :
    - 2.5 % Weight reduction over 2 294 g
  - At battery level for 9 kW satellite with 4 packs of 27AN101 :
    - 2.2 % Weight reduction over 291.6 kg

NiH_2 Cell change 2

- Transfert from top dome cyclindrical part to bottom dome



Reduction of tabs length

SAFT

NiH_2 Cell change 2

- Impact of transfering top dome cyclindrical part to bottom dome
  - At cell level for AN 101 :
    - 5.8 % Weight reduction over 2 236 g
  - At battery level for 9 kW satellite with 4 packs of 27AN101 :
    - 4 % Weight reduction over 285 kg

SAFT

NiH_2 Cell change 3

- Decrease of width and/or thickness of tabs

  - Tabs were oversized considering current
    - Criteria : voltage drop less than 45 mV at C rate

  - At cell level for AN 101 :
    - 2 % Weight reduction over 2 105 g

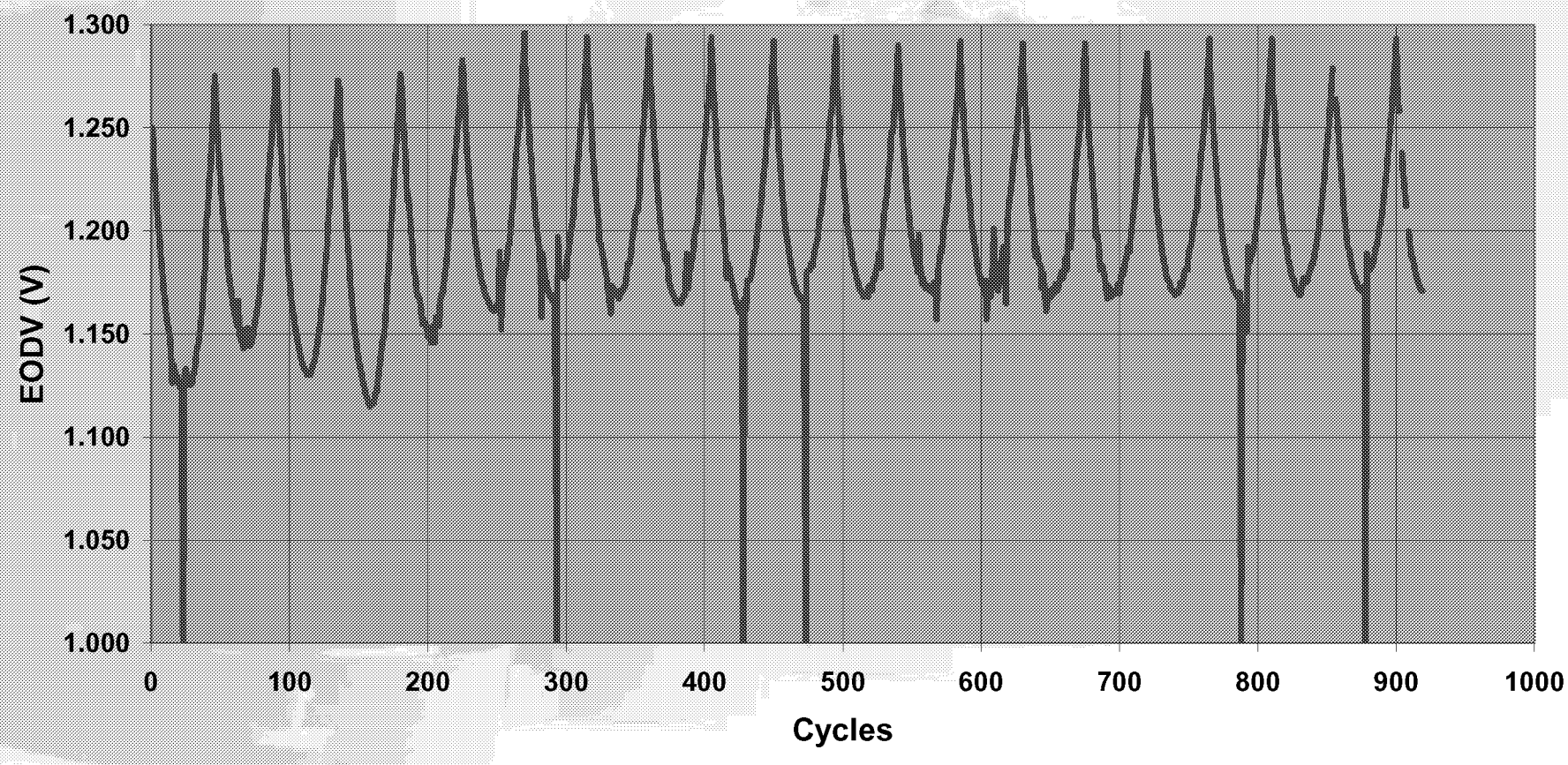
  - At battery level for 9 kW satellite with 4 packs of 27AN101 :
    - 1.7 % Weight reduction over 274 kg

SAFT

NiH_2 Cell changes

- Change 1 and 2 have been used for Eurasiasat batteries
  - Life test performed to validate the change
    - 4 cells tested
    - Semi-accelerated conditions :
      - charge C/10 k=1.15 + Trickle charge C/100
      - discharge C/1.5, 72 min, 80 % DOD
      - 2 cycles per day
      - no solstice
- Change 3 is using on current programs
  - Life test will be performed on HB6

Average End of discharge voltage



SAFT

Battery change 1

- Use of the Aluminum wiring instead of Copper
  - Qualification acquired in 96
  - Use of the ESA rules forderating
  - Weight saving at battery level for 9 kW :
    - 2.2 % over 280 kg

SAFT

Battery change 2

- Charge management modification :
  - Decrease of the charge temperature from 0 °C to -10 °C
    - Increase of the delivered capacity
  - Weight saving at battery level for 9 kW :
    - 3 % over 274 kg
  - Is planned to be used on Hot Bird 6

SAFT

Battery Performances

- By performing ASPI test :
  - One orbital cycle 80 % DOD
  - Recharge k=1.15 and discharge C/1.5 down to 1 V

FIRST DESIGN WITH ALUMINUM WIRING

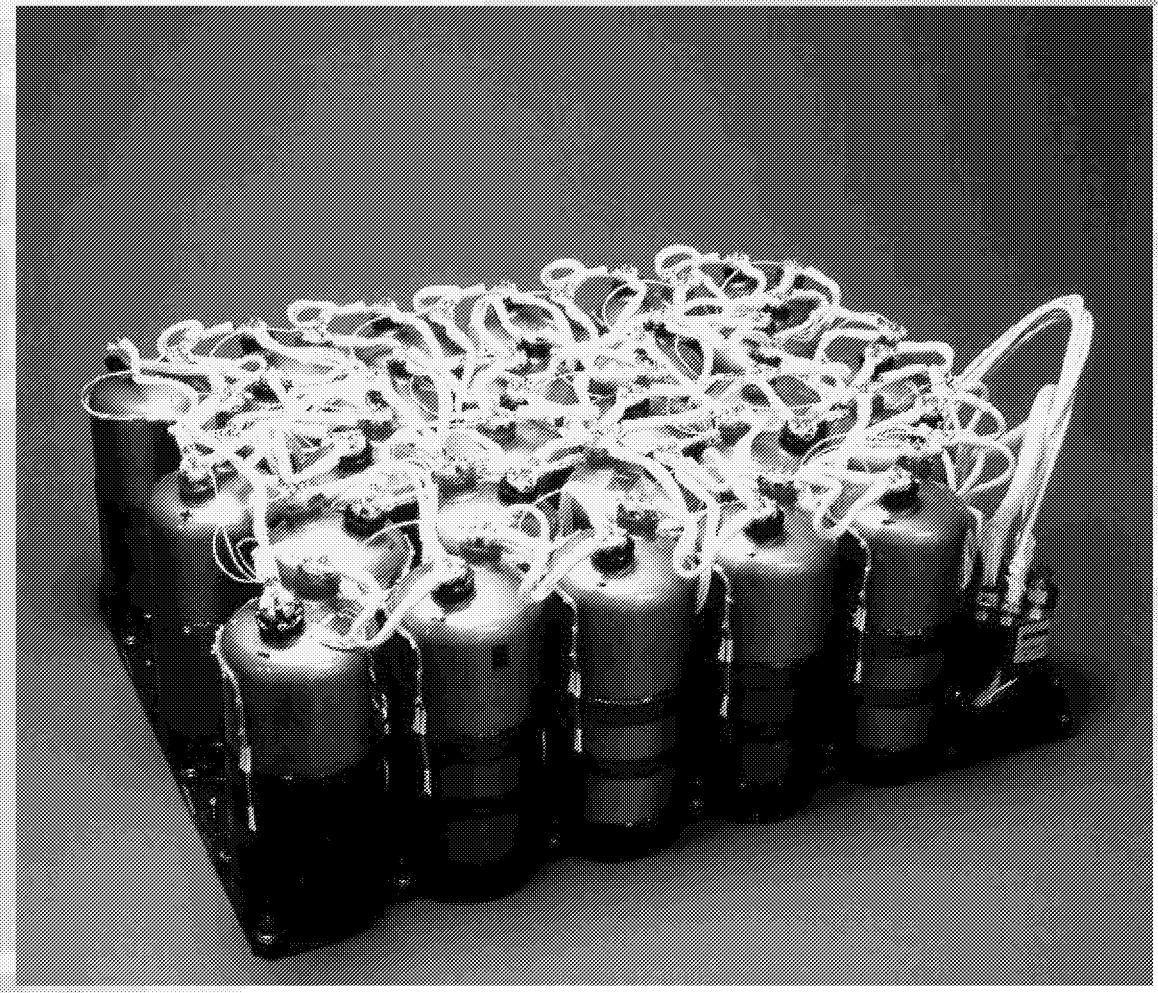
	C Ah	T °C	Weight (kg)	Sp En (Wh/kg)
Sirius II : AN63	65.2	0 °C	186	47.3
Arabsat 3 : AN71	72	0 °C	204	47.6

SAFT

Battery Performances : Arabsat 3 A

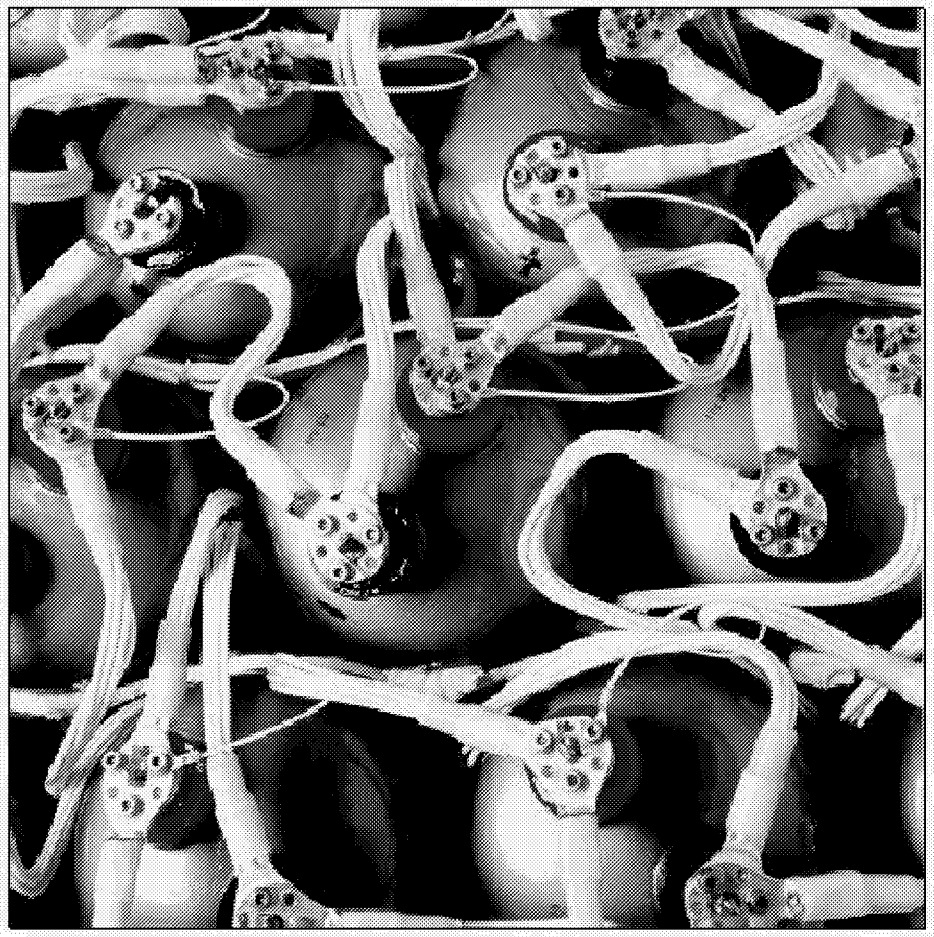
SAFT

Battery Performances : Arabsat 3 A



SAFT

Battery Performances



SAFT

Battery Performances

DESIGN WITH CHANGES 1 and 2 AT CELL LEVEL

(MOP and Upper Stack)

ALUMINUM WIRING

	C Ah	T °C	Weight (kg)	Sp En (Wh/kg)
Eurasiasat : AN93	99	-2.5 °C	255	51

MORE THAN 8 % SPECIFIC ENERGY INCREASE

SAFT

CONCLUSION

- First phase of improvement done on EURASIASAT (changes on MOP and upper stack)
  - weight gain over the prediction (8 % over 6 %)

- Second phase in validation on current programs, Hot Bird 6, (changes on tabs, charge management) will give 5 % weight gain more to reach

53 Wh/kg at battery level