Calipso and Corot Lithium-Ion Battery Flight Return Experience

Dr Y.Borthomieu, D.Prévot Saft

P.Tastet, J.Massot CNES

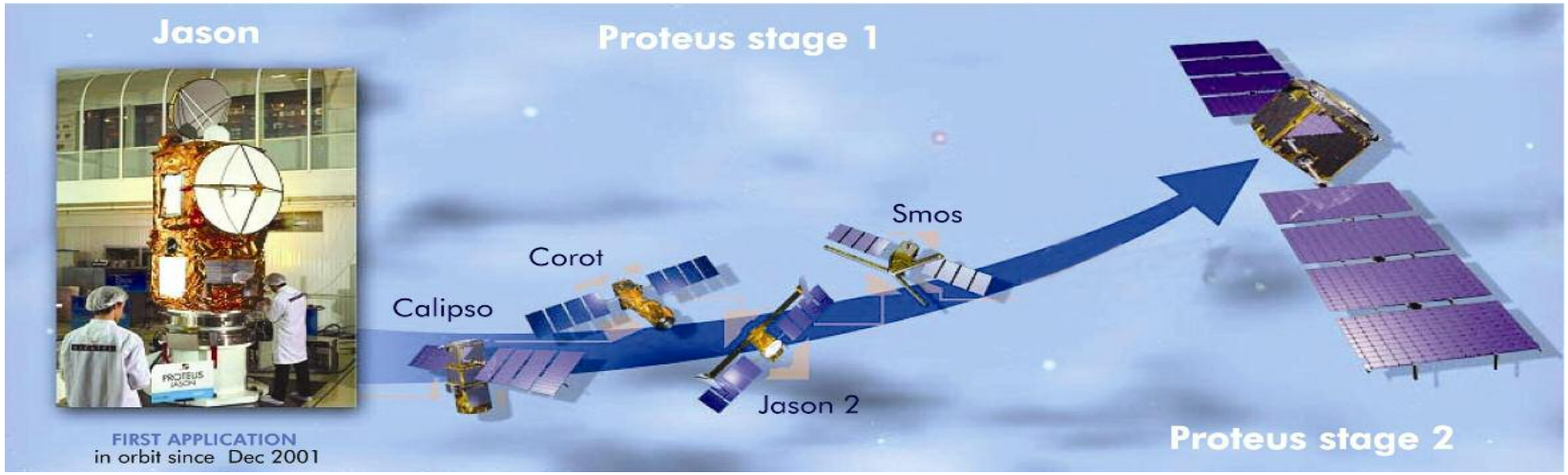
2008 Nasa Aerospace Battery Workshop

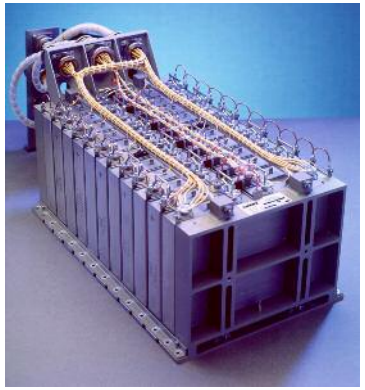
November 18-20, 2008

Hunstville, Al

Photos D.R.

LEO Satellites

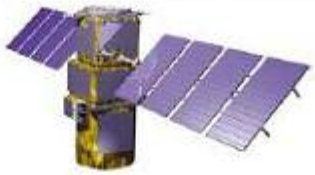




Ni-Cd VOS40

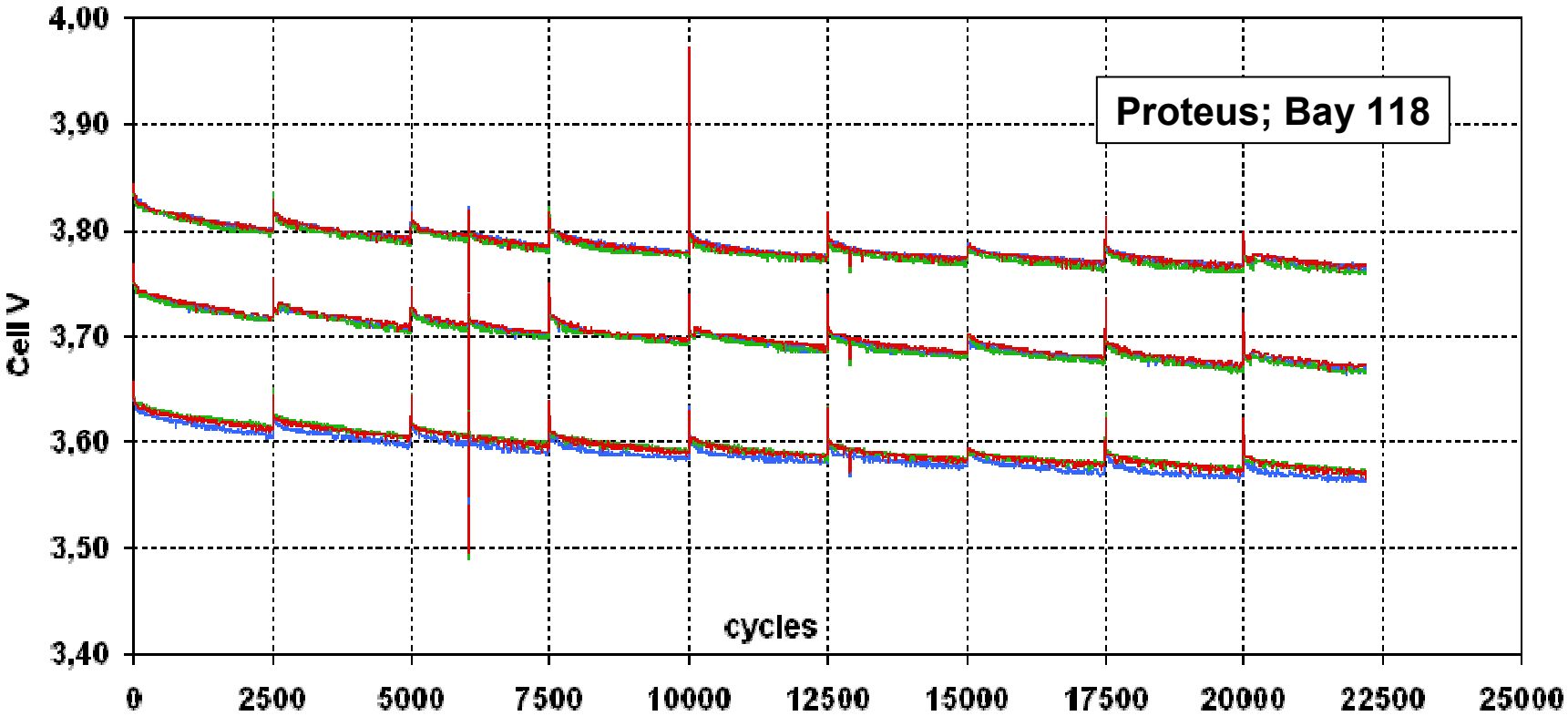
Li-Ion VES100

Proteus Family

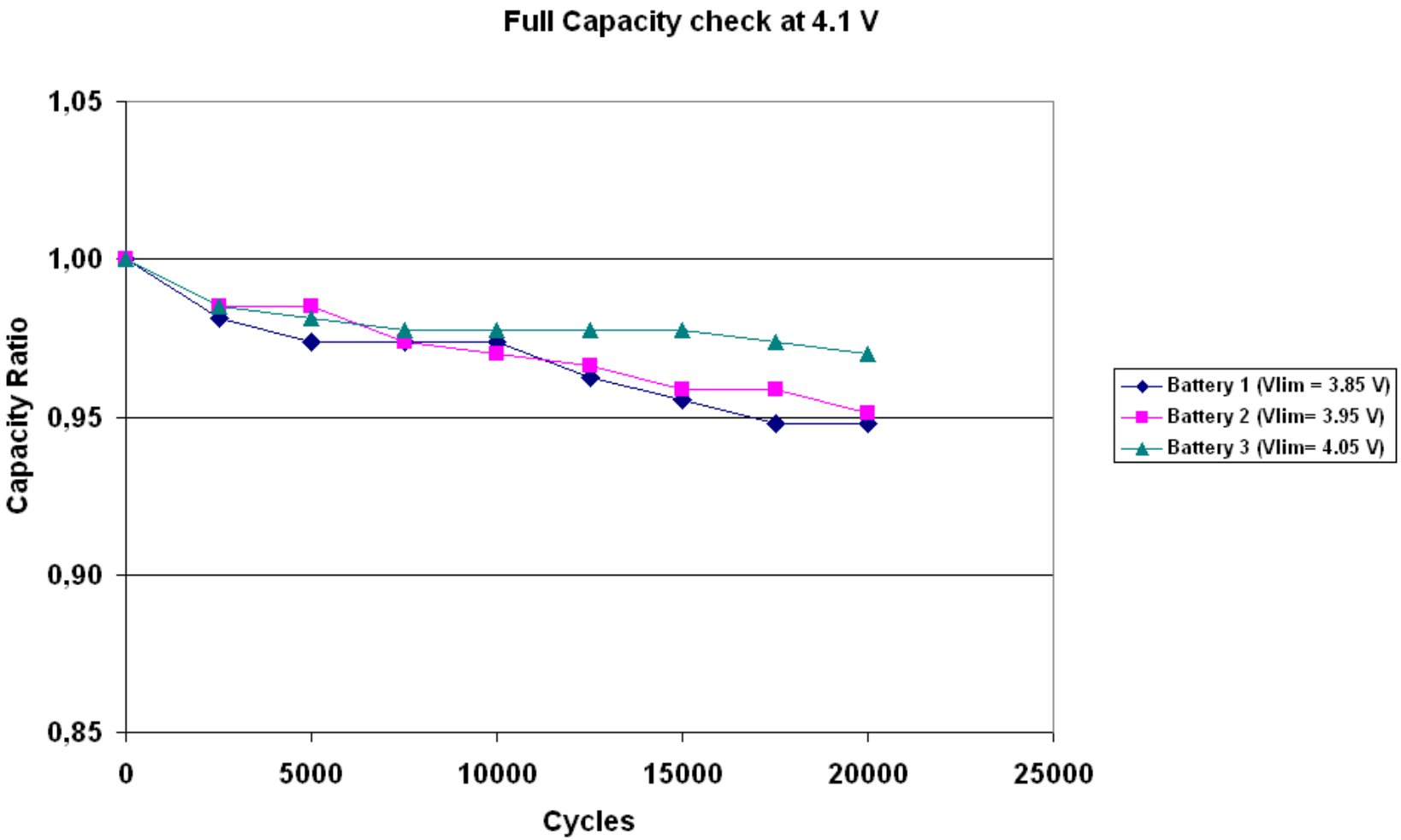
JASON-1	CALIPSO	COROT	SMOS	JASON-2
				
NASA / CNES	**NASA**	**ESA/CNES**	**ESA**	**NASA / CNES**
Ocean Altimeter 1336 km/ 66°	Atmosphere (optical / Lidar) 14 Hr orbit	Astronomy (optical) Polar orbit	Ocean salinity (RF) 6-18Hr orbit	Ocean Altimeter 1336 km/ 66°
Launched in 2001 by Delta 2	Launched in 2006 by Delta 2	Launched in 2006 by Soyouz	To be launched in 2009 by Rockot	Launched in 2008 by Delta 2

LEO Cycling : VES100 Proteus test

- 20 % DOD, 20°C
- 3 EODV : 4.05, 3.95 and 3.85 V



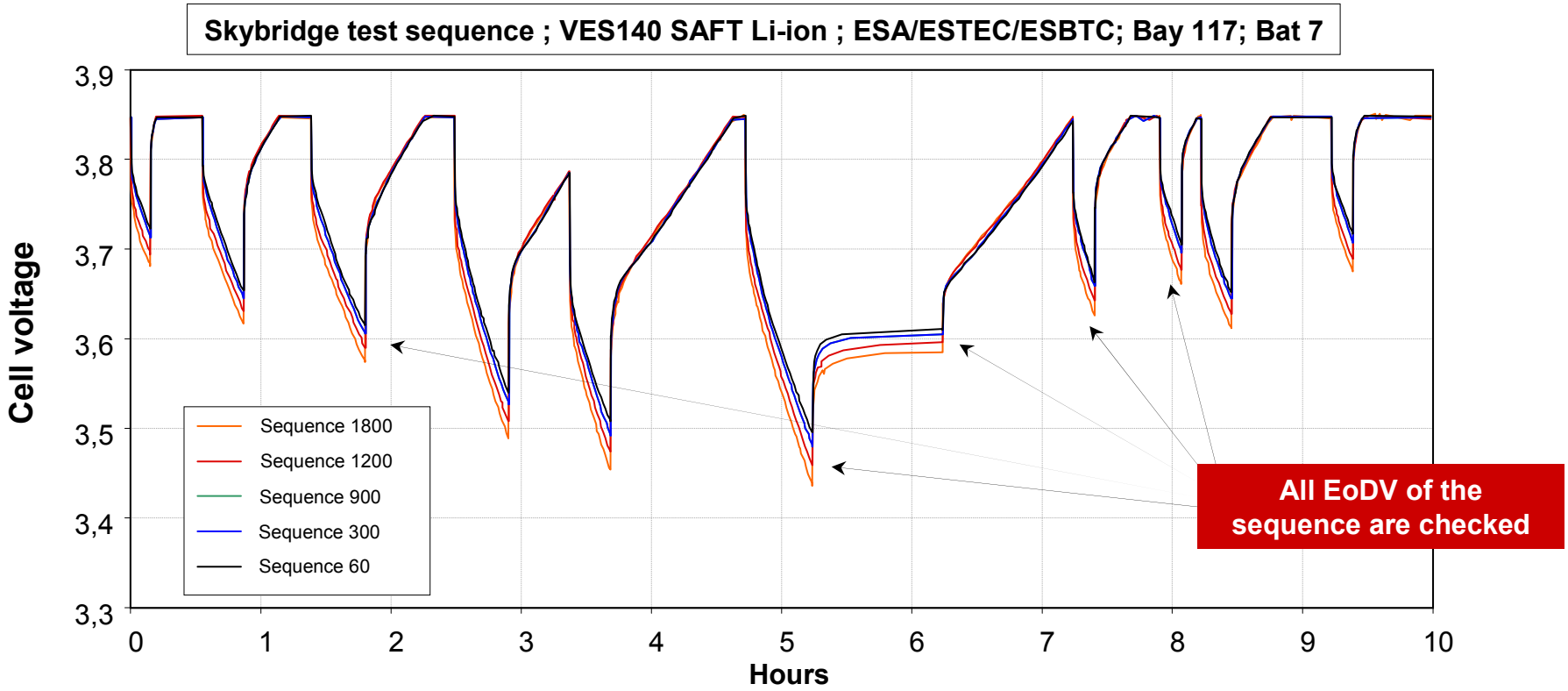
LEO Cycling : VES100 Proteus test



- **5 % loss after 20.000 cycles**

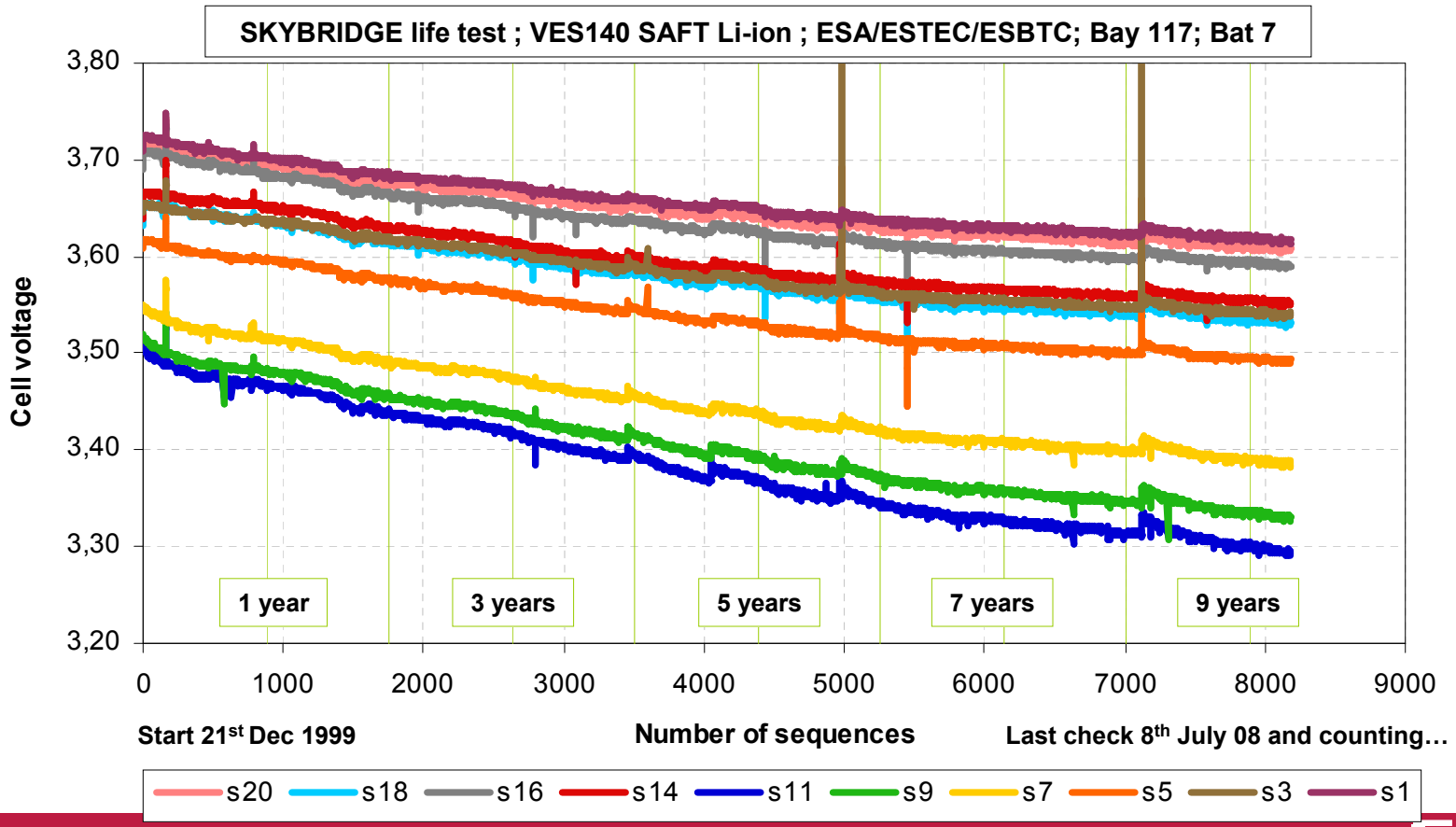
VES LEO batteries: Skybridge life test 1/2

- **Life test characteristics**
  - Non constant DoD test at 20°C, started in 1999
  - End of Charge: 3.85 V
  - 10 variable cycles per sequence, one sequence = 10 h
  - Checks: end of discharge voltages (EoDV) of each discharge in the sequence



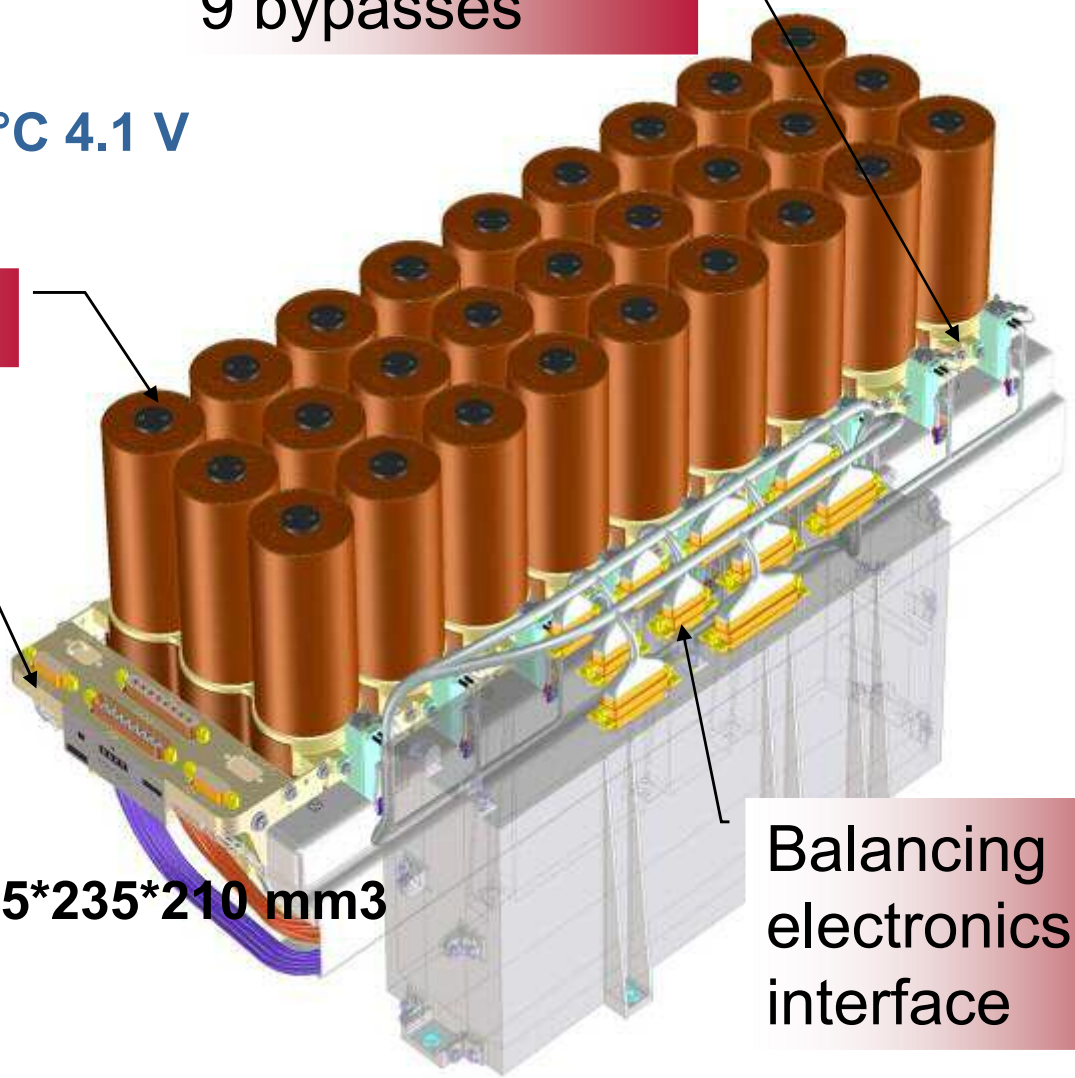
VES LEO batteries: Skybridge life test 2/2

- **Life test results:**
  - More than 9 years or 82 000 cycles (8200 sequences) and counting…
  - Average DoD 18%, non constant from 10 to 30%
  - Total loss = 20 % equivalent to 0.24 % for 1.000 cycles



Proteus LEO battery design

- **3P-9S VES100 battery**
- **Energy 2650 Wh at 20°C 4.1 V**



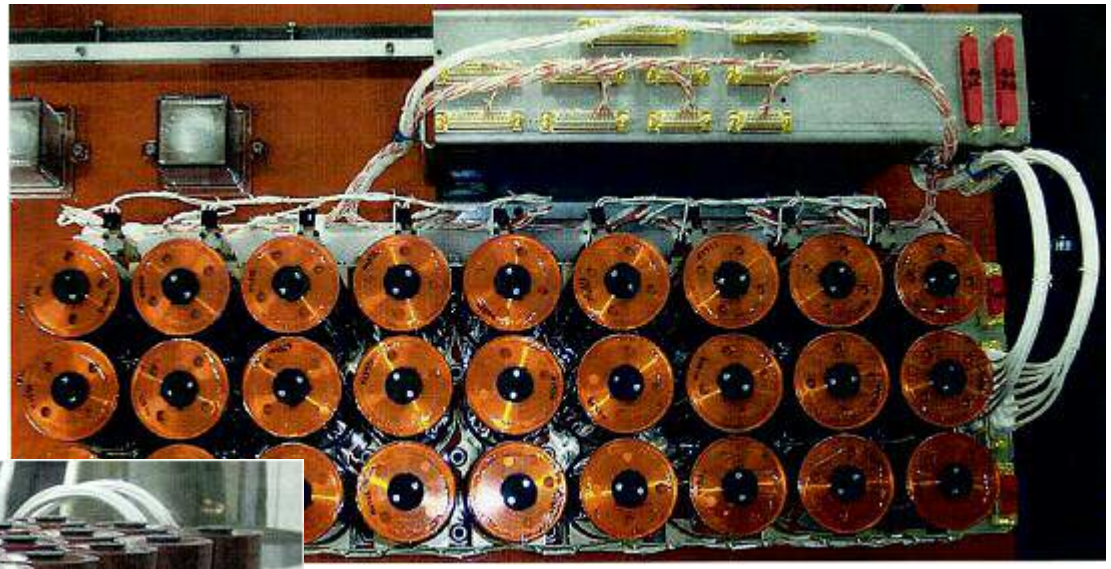
- **Dimensions L*l*h < 615*235*210 mm3**
- **Mass : 28.3 kg**

Proteus LEO battery Characteristics

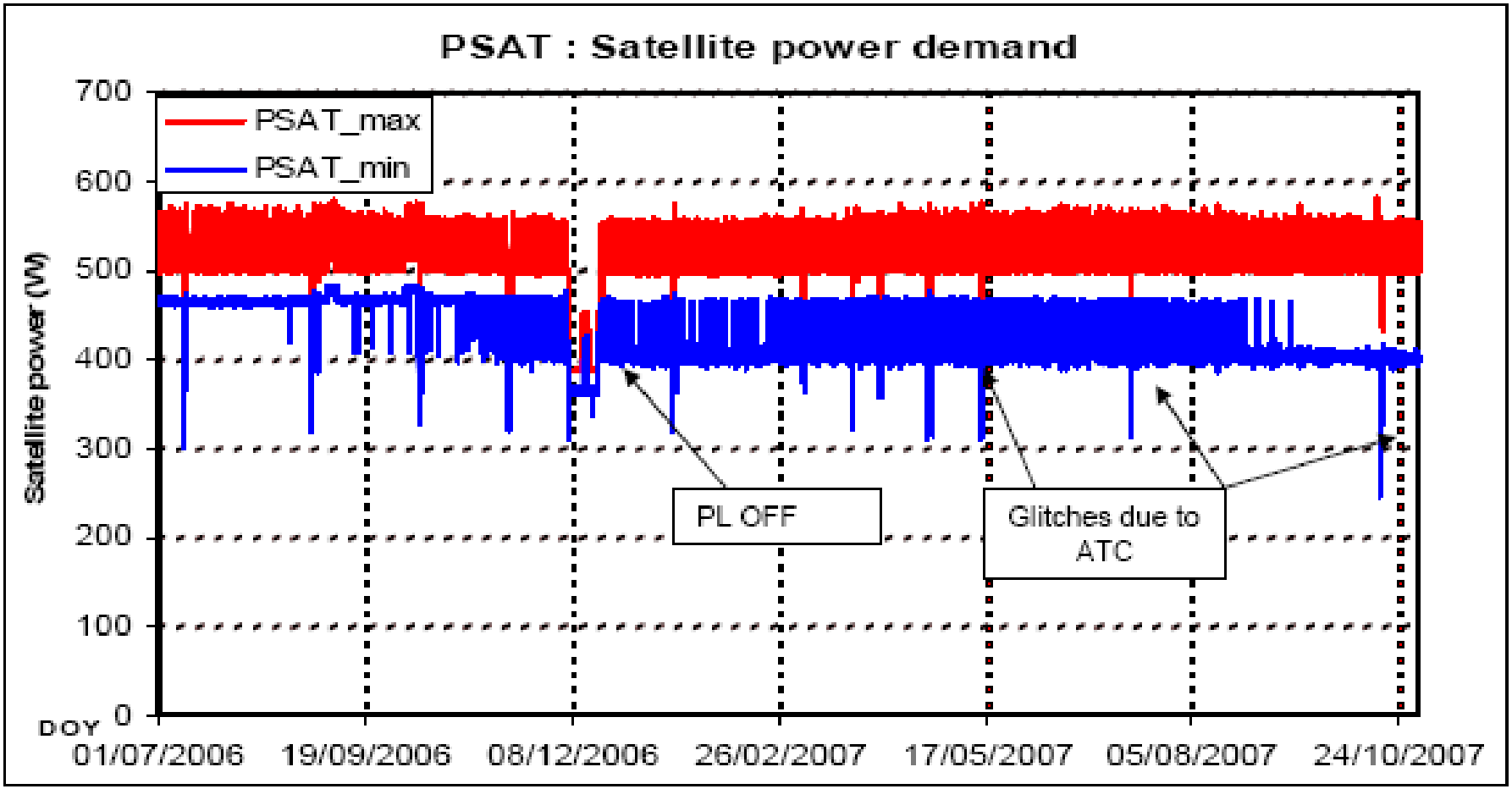
9S3P VES 100 S Configuration

	Criterion	Calipso Battery
Stored Energy cold @ 10°C		
Energy @36.9V – C/2	*2285 Wh*	2438 Wh
Ri 20% DOD	*30 mΩ*	29.1 mΩ
Ri 60% DOD	*30 mΩ*	27.6 mΩ
Stored Energy cold @ 20°C		
Energy @36.9V – C/2	*2539 Wh*	2620 Wh
Ri 20% DOD	*25 mΩ*	22.9 mΩ
Ri 60% DOD	*25 mΩ*	21.8 mΩ
Stored Energy hot @ 40°C		
Energy @36.9V – C/2	*2793 Wh*	2909 Wh
Ri 20% DOD	*25 mΩ*	14.5 mΩ
Ri 60% DOD	*25 mΩ*	14.2 mΩ

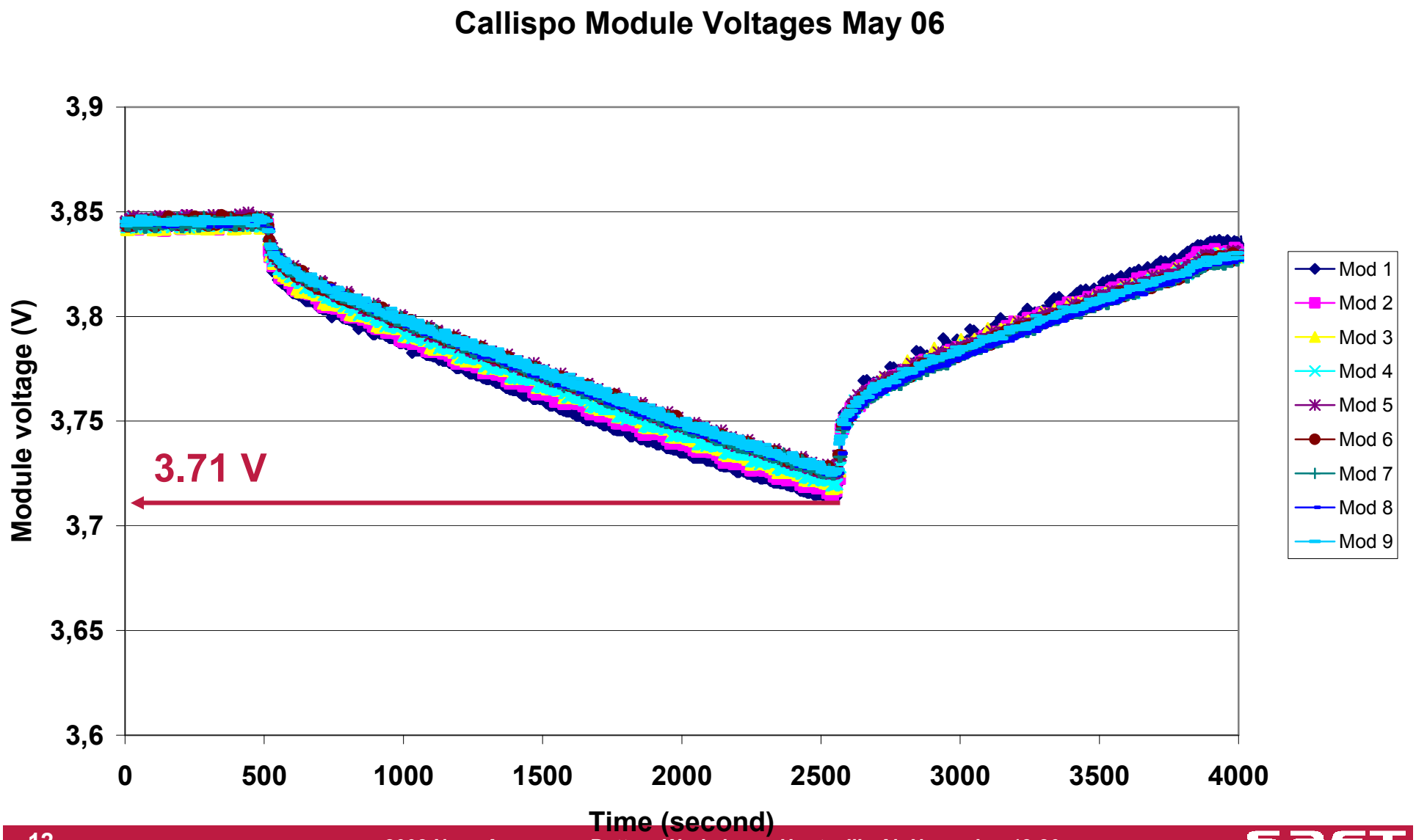
Batteries for the Proteus platform



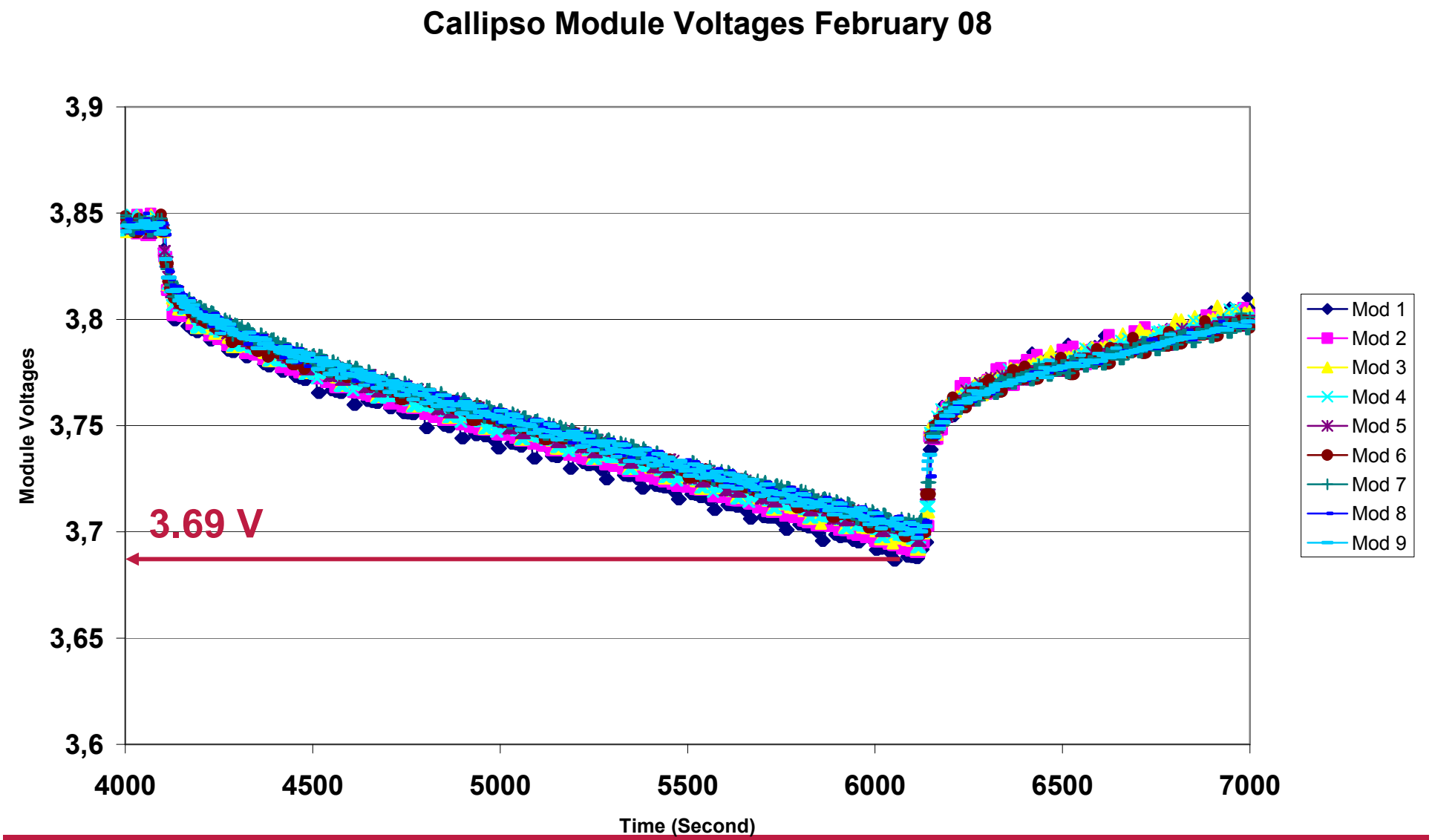
Calipso Power demand



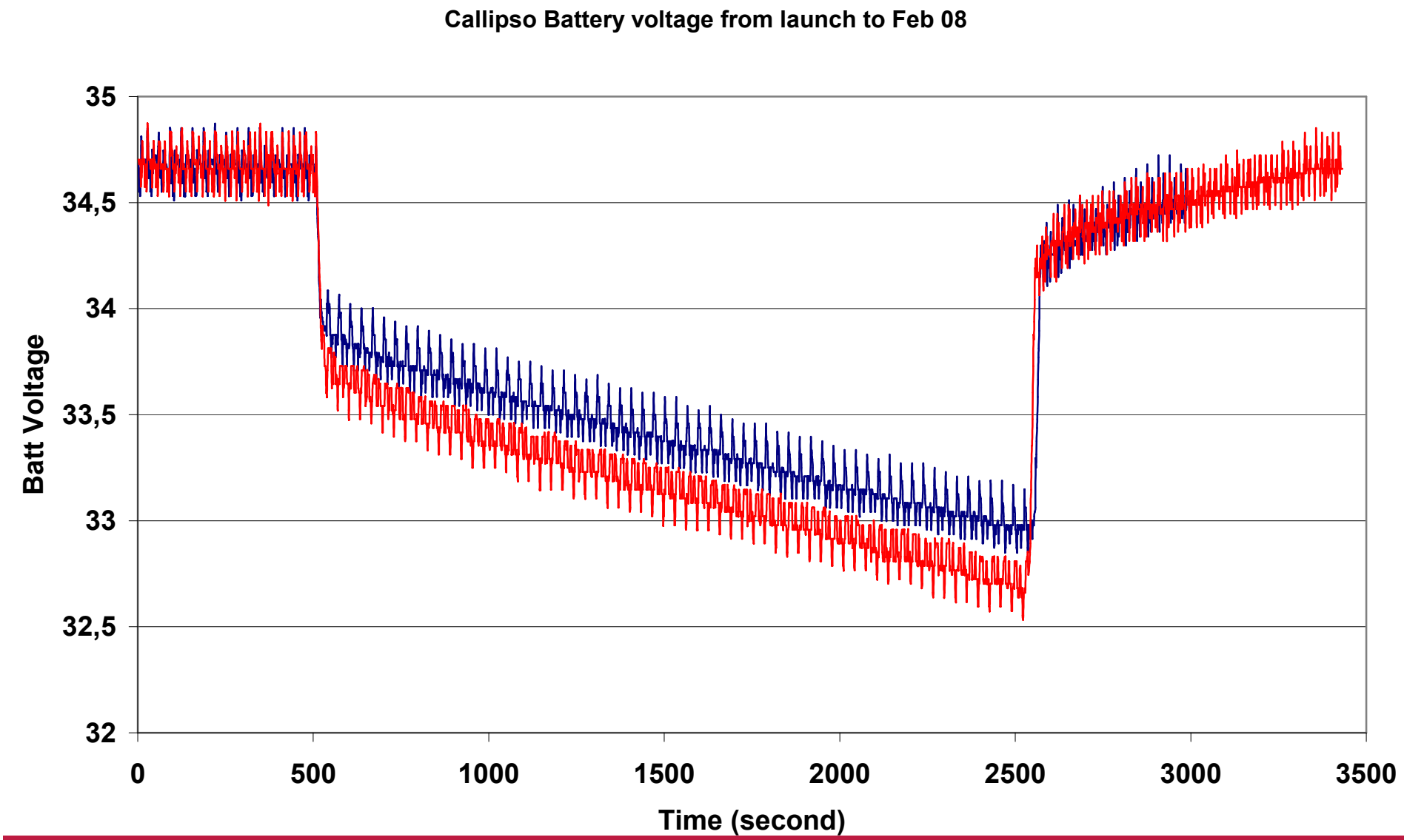
Calipso Module voltages May 06



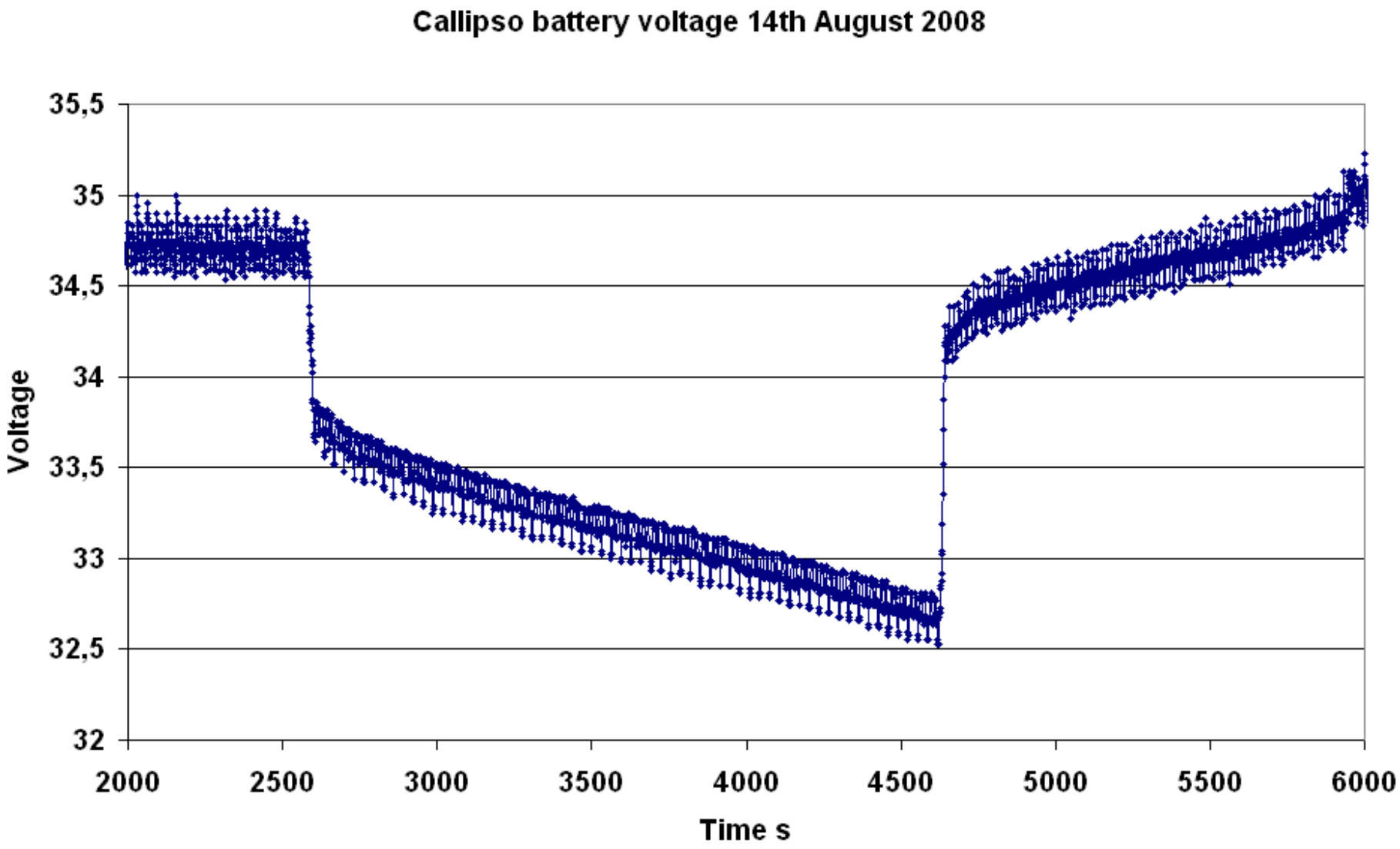
Calipso Module voltages Feb 08



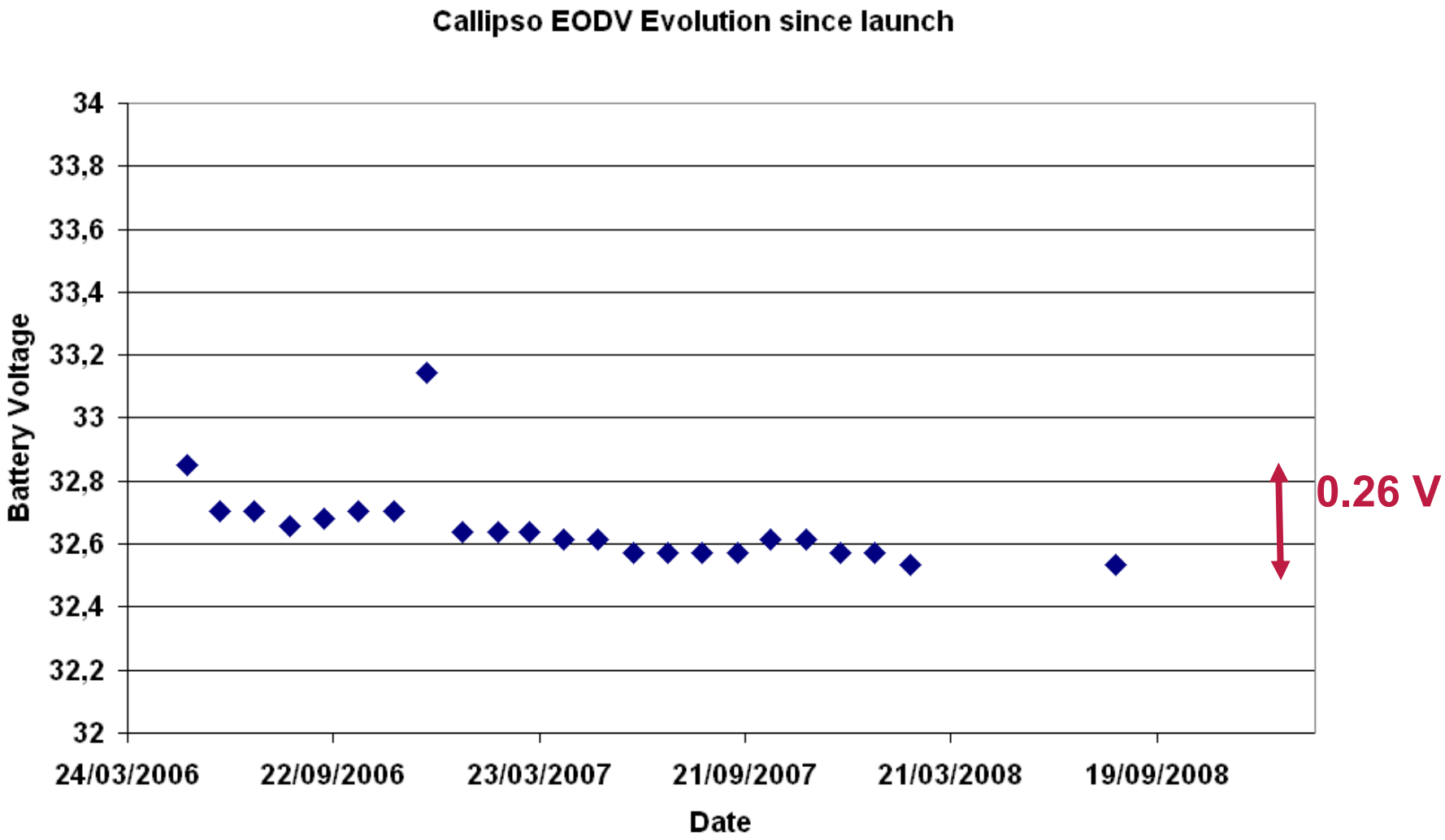
Calipso Battery voltage from Launch to Feb 08



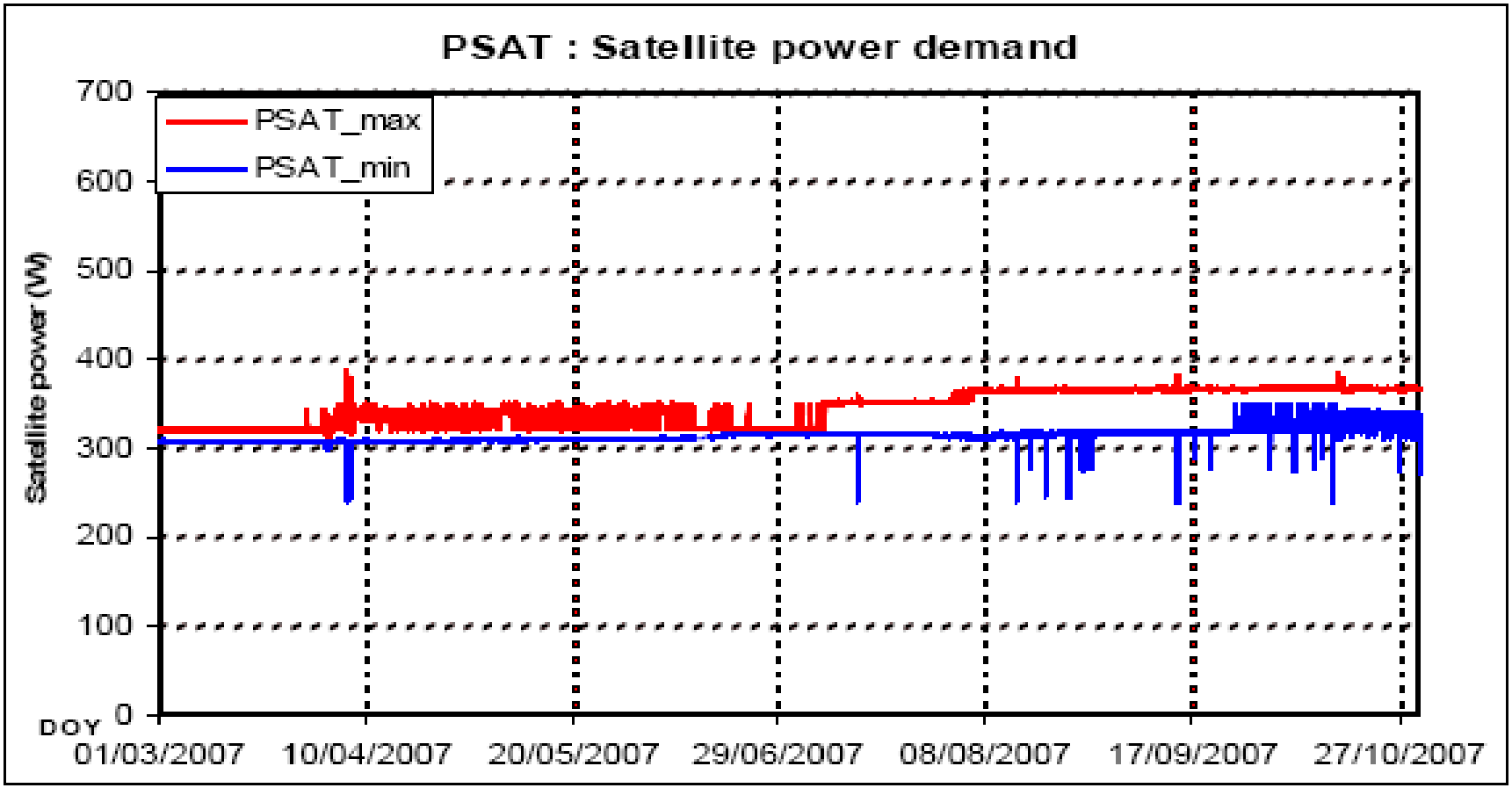
Calipso Battery voltage 14th August 2008



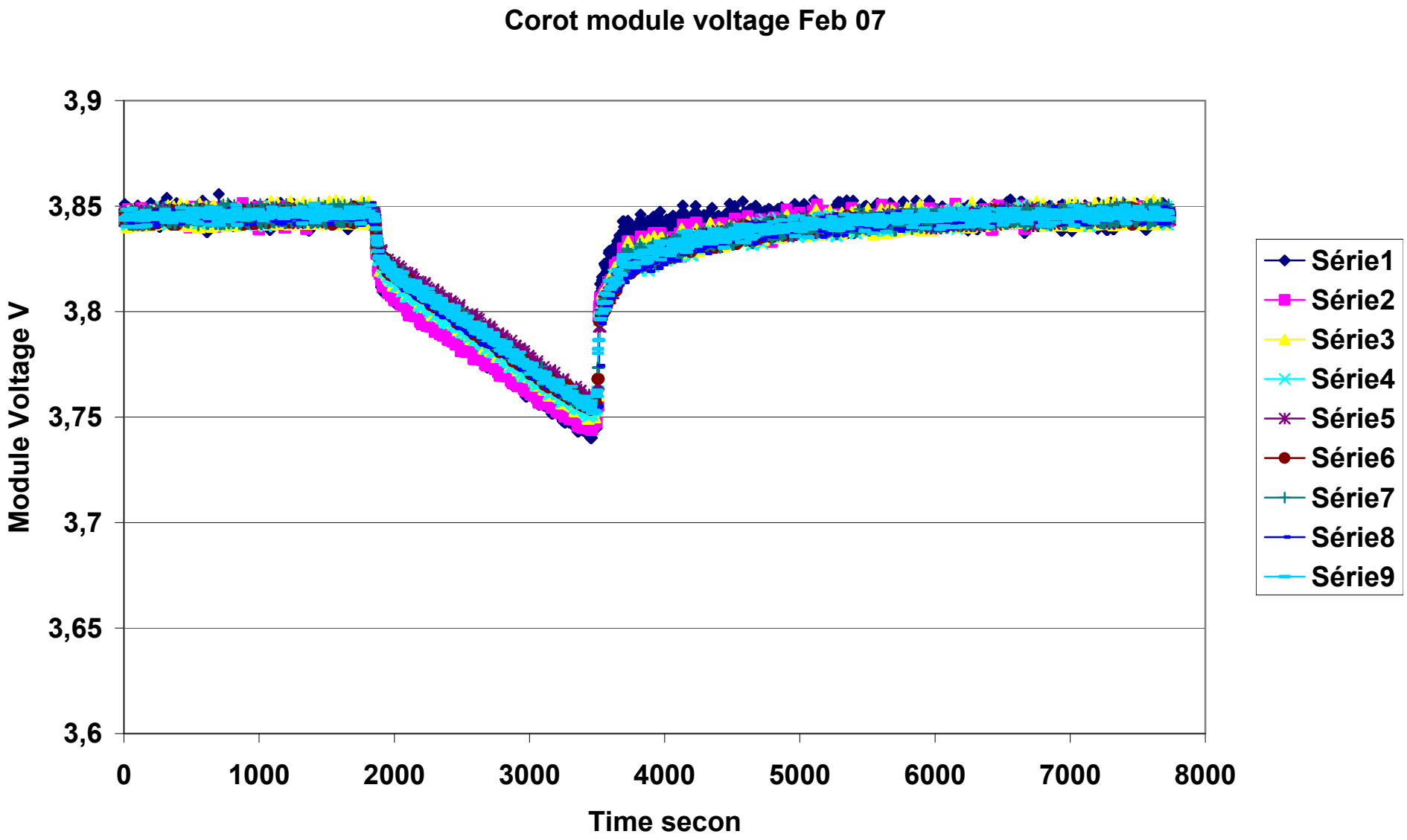
Calipso Battery EODV Evolution



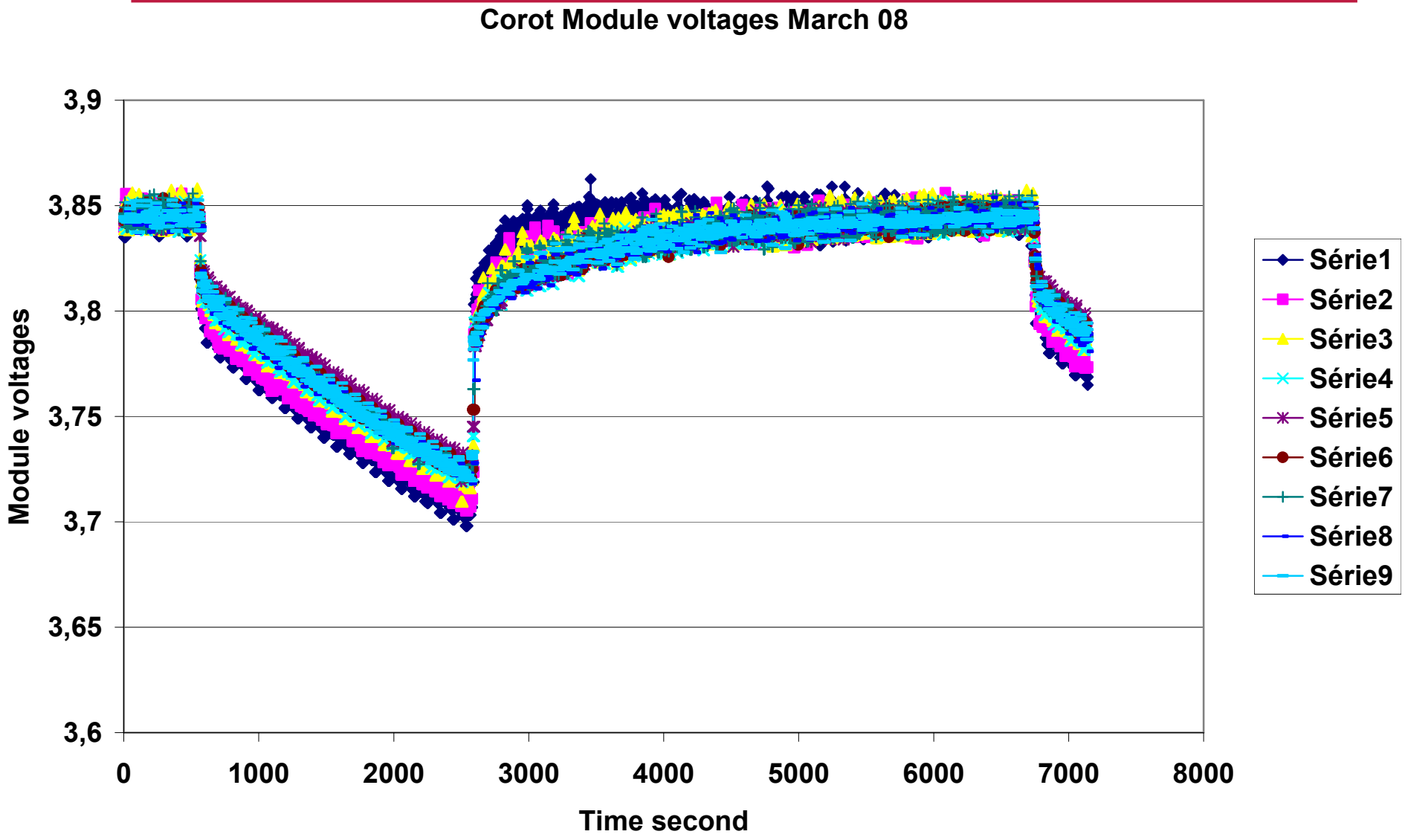
Corot satellite power demand



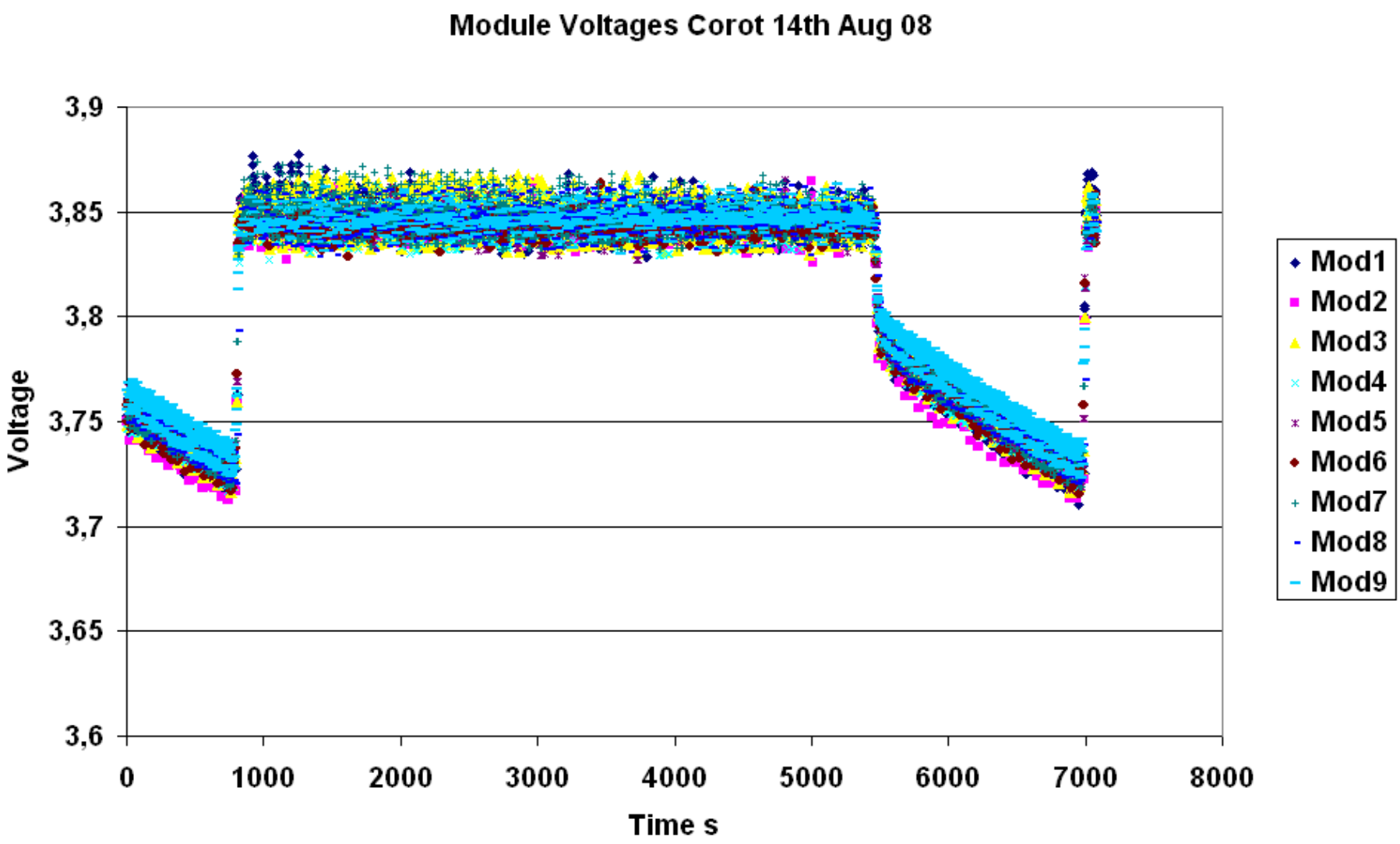
Corot Module voltages February 07



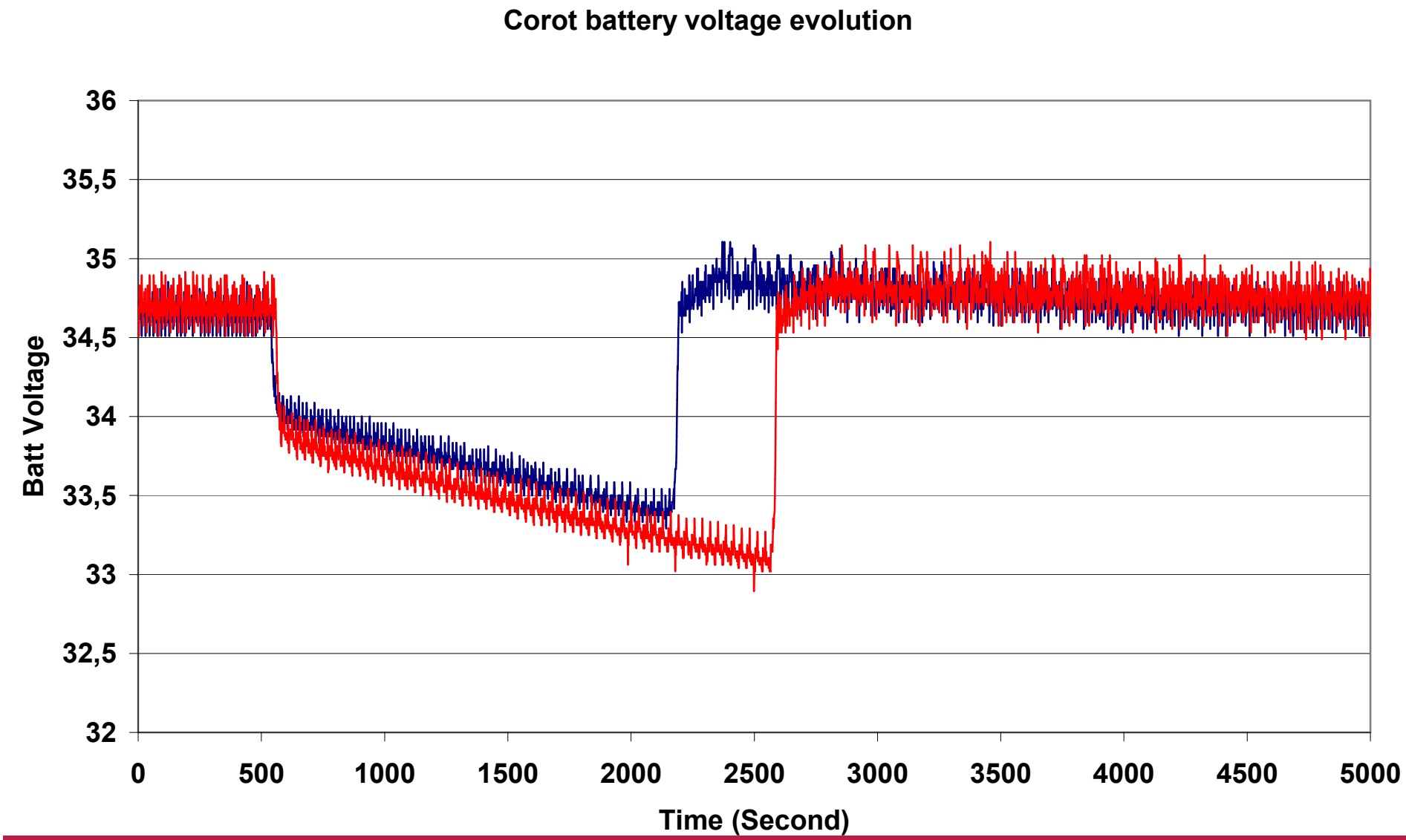
Corot Module voltages March 08



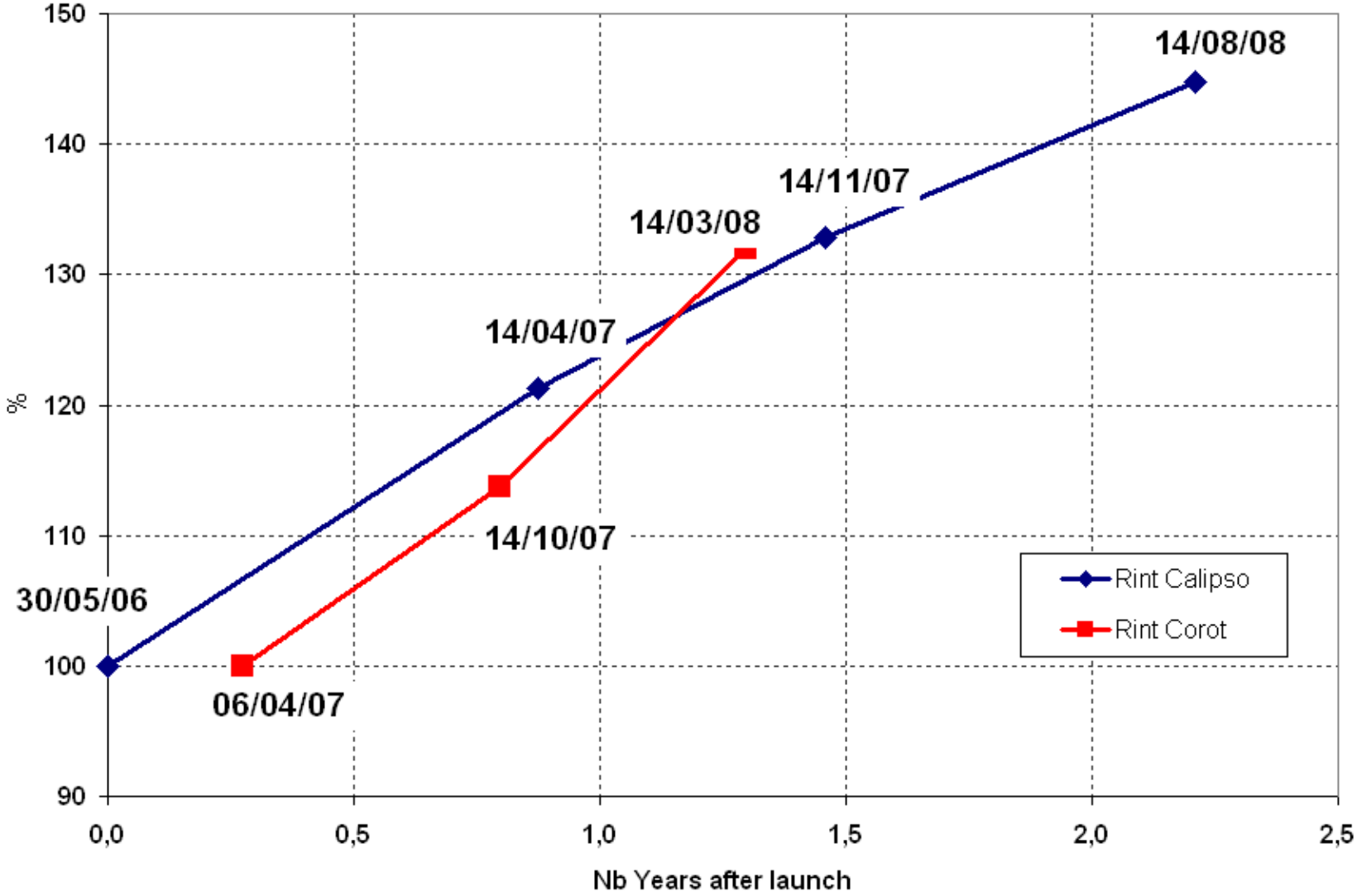
Corot Module voltages August 08



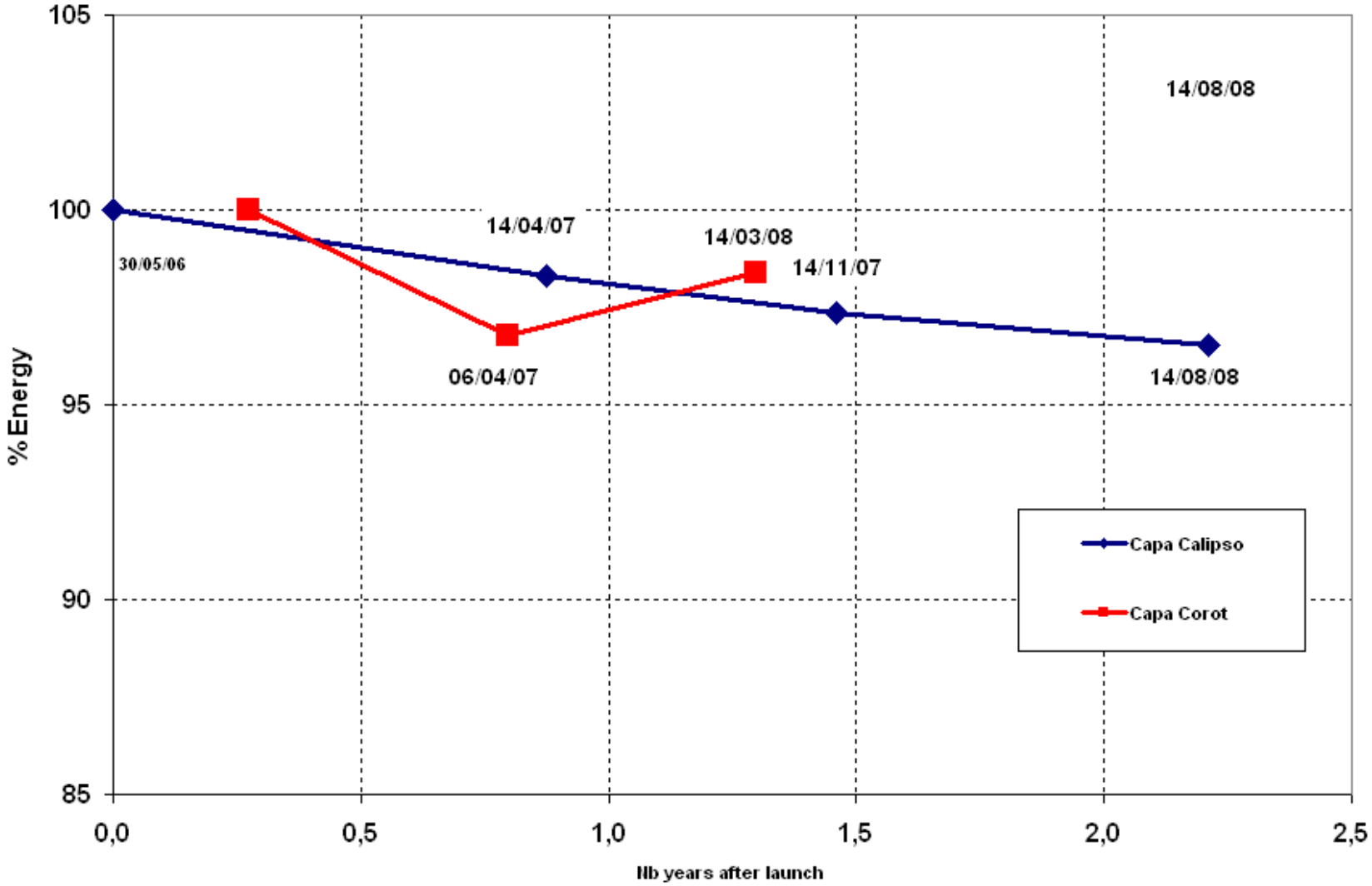
Corot Battery voltage evolution



Callipso and Corot Internal resistance Evolution



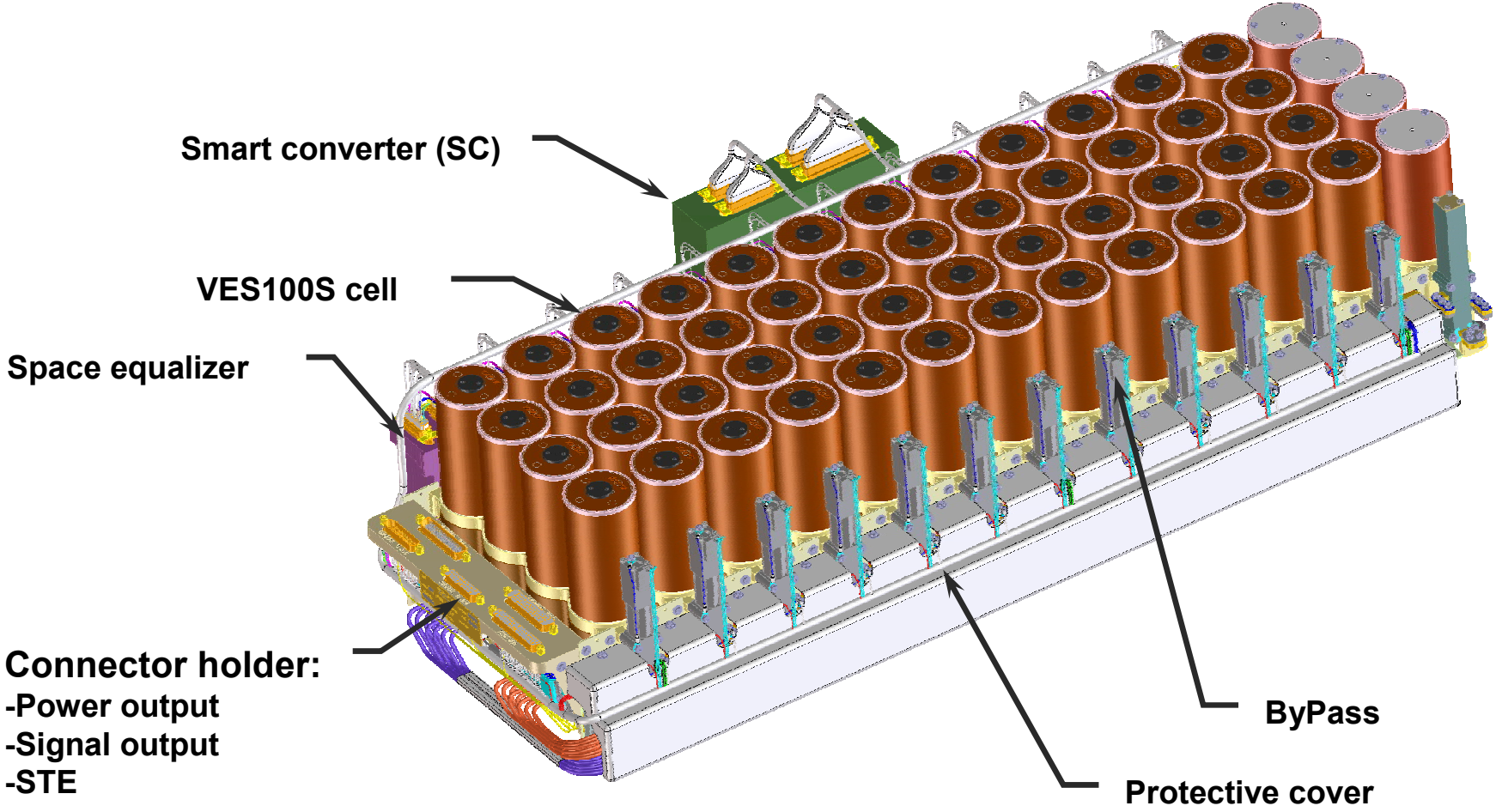
Callipso/Corot Energy Evolution



Conclusion

- **VES cells degradation for LEO missions are very low thanks to the Nickel based Oxide**
- **VES cells in-orbit results are extremely good and incomparable :**
  - 3% degradation after 2.5 years in LEO orbit
- **In orbit results are in accordance with the Saft Li-Ion SLIM Model**

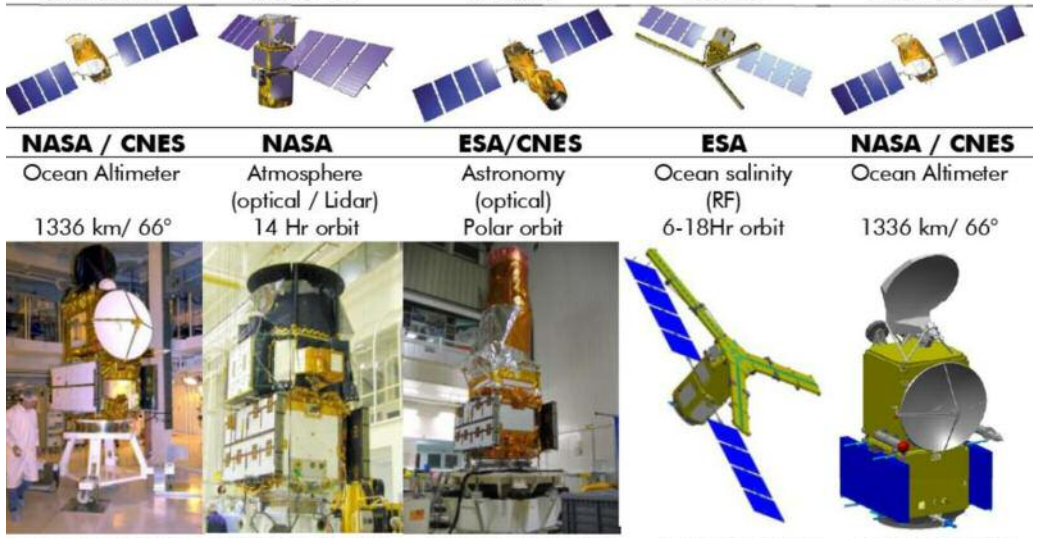
Next : Autonomous VES batteries for large LEO platforms



4P13S = 13 serial connected cells package composed of 4 cells connected in parallel

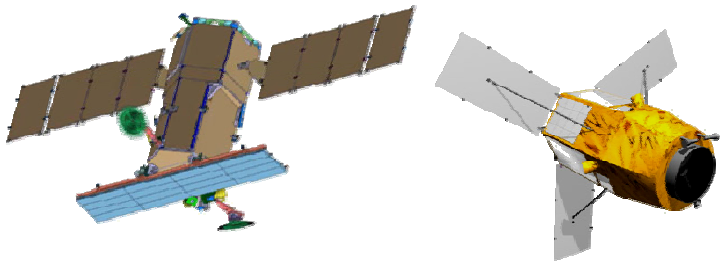
VES LEO heritage

JASON-1	CALIPSO	COROT	SMOS	JASON-2
NASA / CNES	NASA	ESA/CNES	ESA	NASA / CNES
Ocean Altimeter	Atmosphere (optical / Lidar)	Astronomy (optical)	Ocean salinity (RF)	Ocean Altimeter
1336 km/ 66°	14 Hr orbit	Polar orbit	6-18Hr orbit	1336 km/ 66°



Launched in 2001 on Delta 2	Launched in 2006 on Delta 2	Launched in 2006 on Soyuz	Launch in 2008 on Rockot	Launch in 2008 on Delta 2

KOMPSAT-5	KOMPSAT-3
KARI	KARI



Launch in 2011	Launch in 2010

ThalesAlenia Space
A Thales / Finmeccanica Company

KARI
Korea Aerospace Research Institute
1989

Acknowledgements

cnes
CENTRE NATIONAL D'ÉTUDES SPATIALES

ThalesAlenia Space
A Thales / Finmeccanica Company

esa