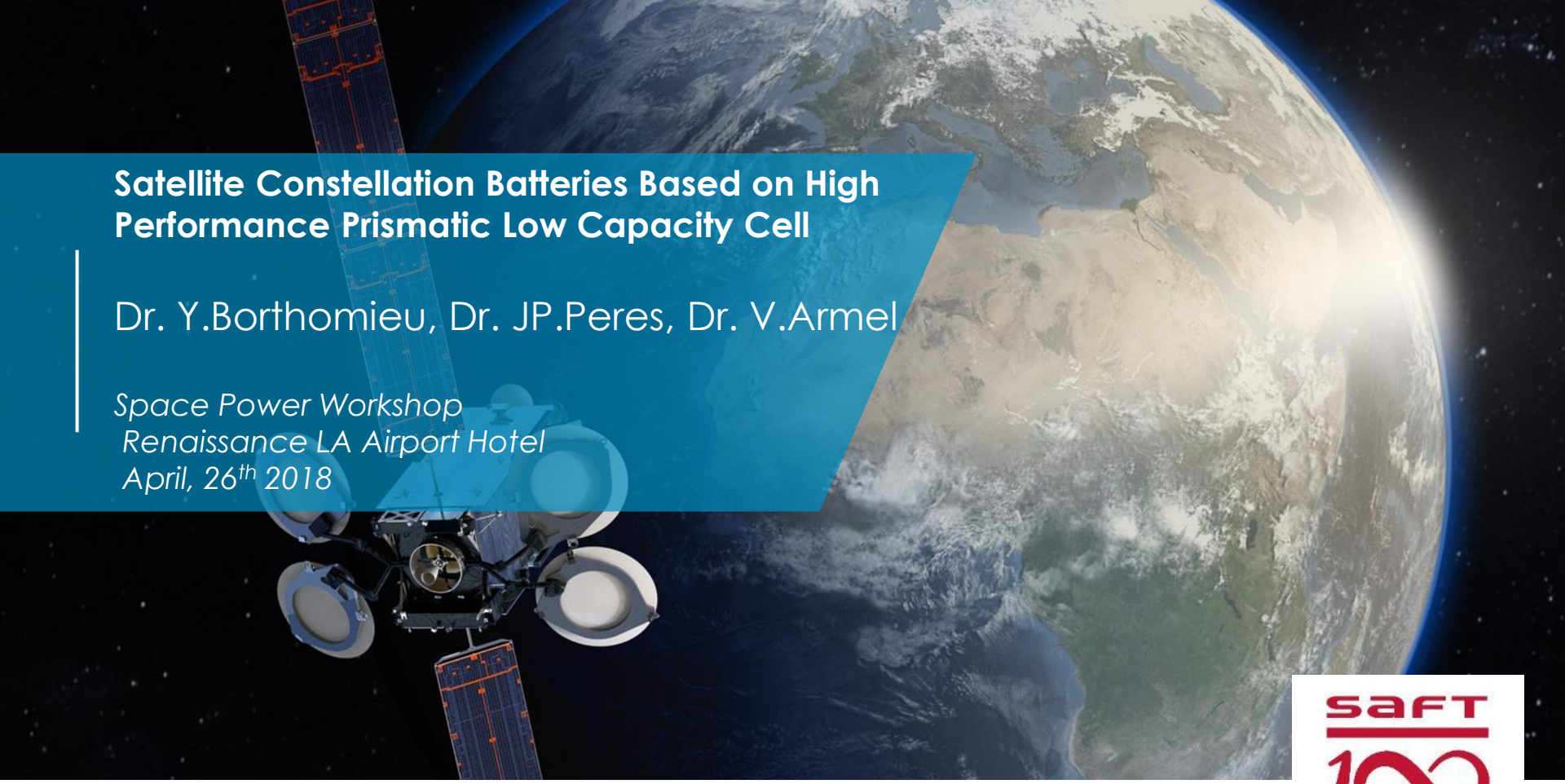


# Satellite Constellation Batteries Based on High Performance Prismatic Low Capacity Cell

Dr. Y.Borthomieu, Dr. JP.Peres, Dr. V.Armel

*Space Power Workshop*
*Renaissance LA Airport Hotel*
*April, 26th 2018*

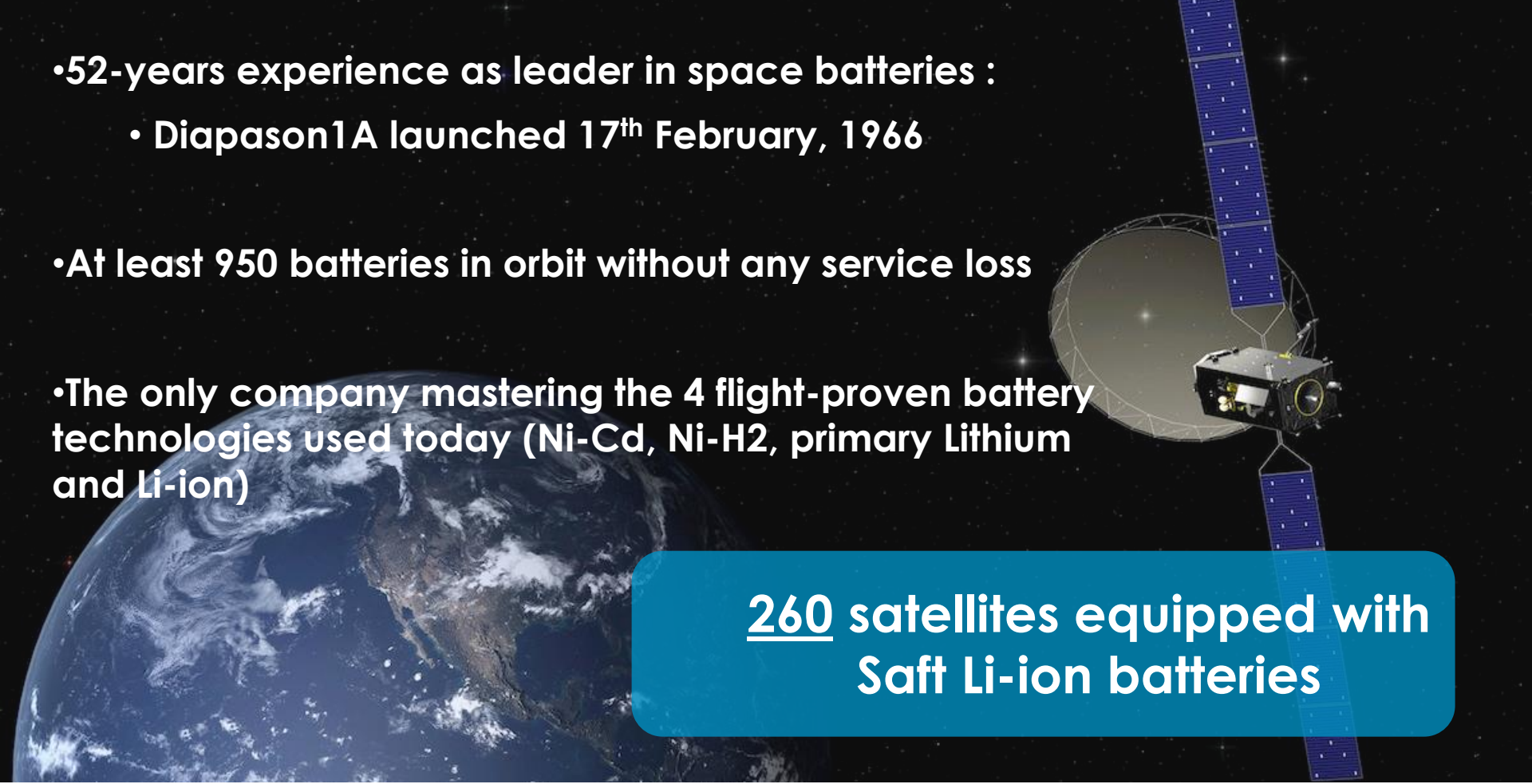
# Saft's Common Purpose

•52-years experience as leader in space batteries :

- Diapason1A launched 17th February, 1966

•At least 950 batteries in orbit without any service loss

•The only company mastering the 4 flight-proven battery technologies used today (Ni-Cd, Ni-H2, primary Lithium and Li-ion)



**260 satellites equipped with Saft Li-ion batteries**

# Low Capacity space cells for different applications

## VES16 : LEO High DOD

- 4.5 Ah **space designed** Li-ion cell
- Designed for LEO satellite batteries
  - **>60000 cycles up to 40% DoD**
- **51** Satellites already launched


## MP176065 Xtd

- 5.6 Ah design for extended temperatures ranges : **from -40 to +85°C**
- For **Exploration missions**


## MP176065 Xlr

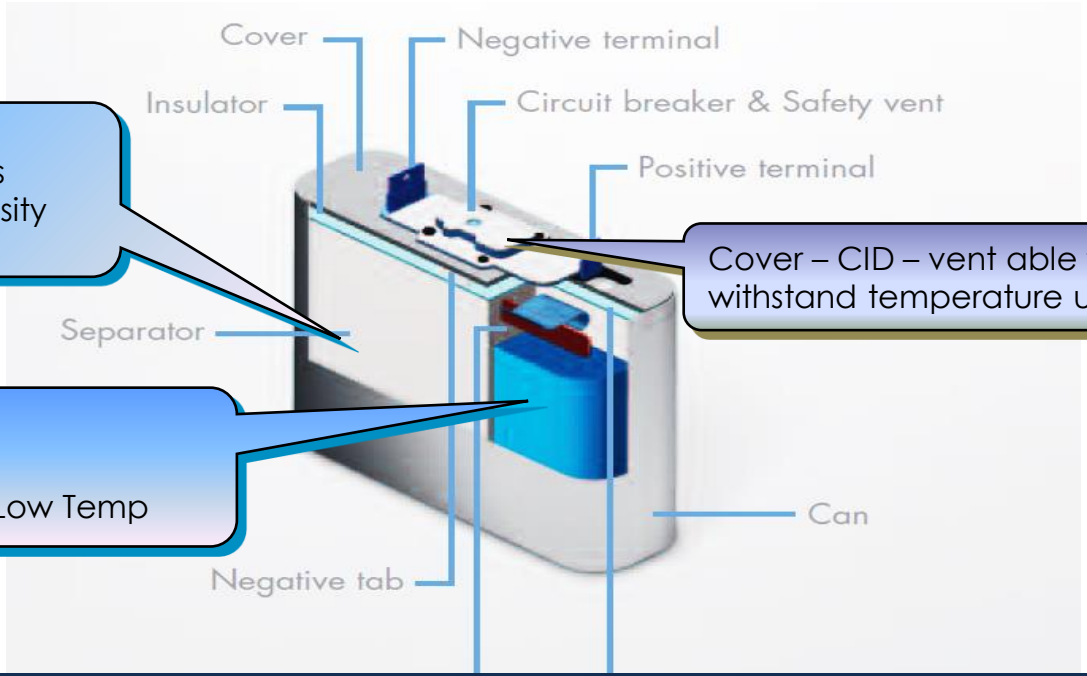
- 6.8 Ah COTS design for long cycle life
- Already qualified with Gen 4 Co
- Adequate for **LEO Constellations**


**Cell choice is mission dependent**

# MP-Xtd and Xlr : key for differentiation vs 18650

## Unique electrochemistry & circuit-breaker

- Blend of Carbons
- Specific coating & additives
- Electrode process and porosity

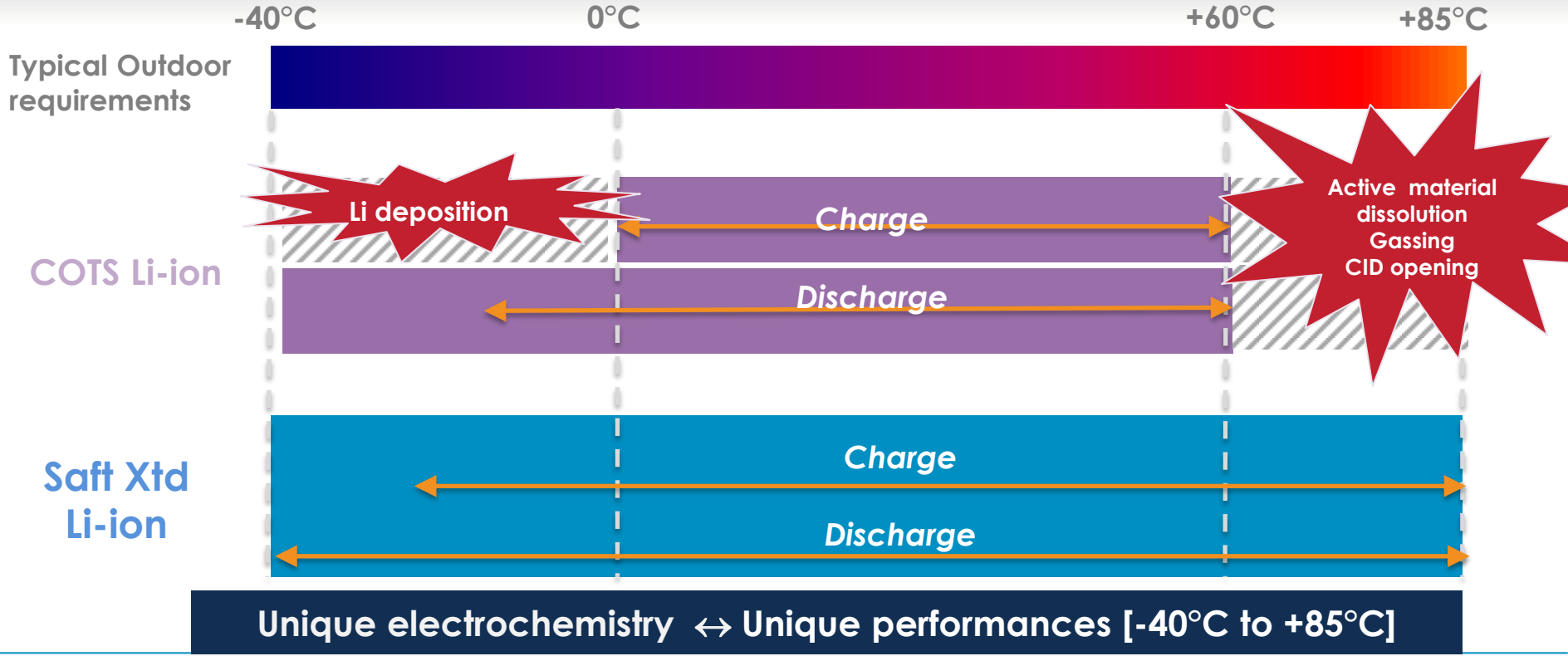



Cover – CID – vent able to able to withstand temperature up to +85°C

- Ni based cathode
- Specific additives
- Optimized electrolyte for Low Temp

**Unique design ↔ [-40°C to +85°C] and stable internal resistance on life**

# MP Xtd for Low and High Temperatures



# MP Xtd/Xlr Typical Qualification plans

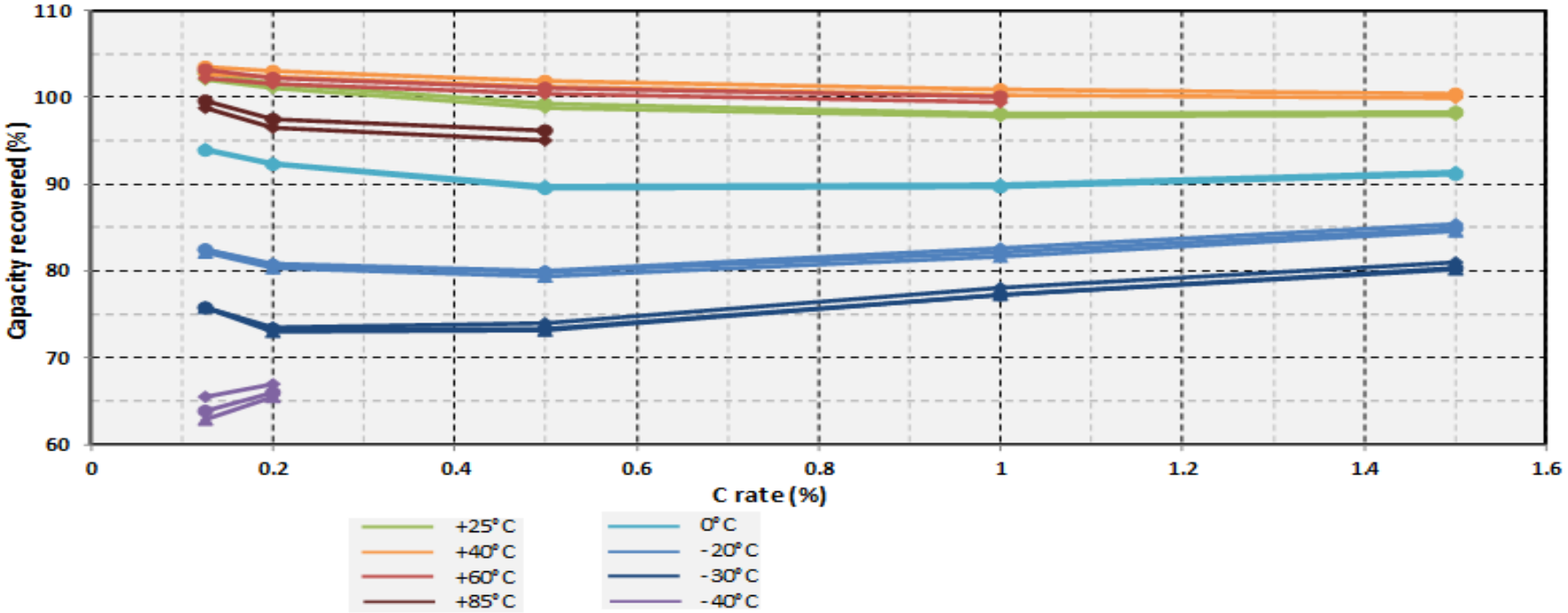
- Electrical characterization (T, I, P, EOCV..)
- Storage-Calendar (-20°C, 20°C, 60°C)
- Cycling DOD from 15 to 100 %
- Vibrations and shocks
- Thermal vacuum

| Test Type | UN 38.3 (Transport) | UL 1642 (Safety) | IEC 62133 Ed2 (Safety) |
|---|---|---|---|
| External Short Circuit | ✓ | ✓ | ✓ |
| Internal Short Circuit | | | ✓ |
| Abnormal Charging | | ✓ | |
| Abusive Overcharge | ✓ | | |
| Forced Discharge | ✓ | ✓ | ✓ |
| Low rate charging | | | ✓ |
| Crush Test | | ✓ | ✓ |
| Drop Impact | | ✓ | |
| Shock Test | ✓ | ✓ | |
| Vibration Test | ✓ | ✓ | |
| Heating Test | | ✓ | ✓ |
| Temperature Cycling Test | ✓ | ✓ | |
| Altitude Simulation | ✓ | ✓ | |
| Projectile | | ✓ | |
| Free Fall Test | | | ✓ |
| Impact | ✓ | | |

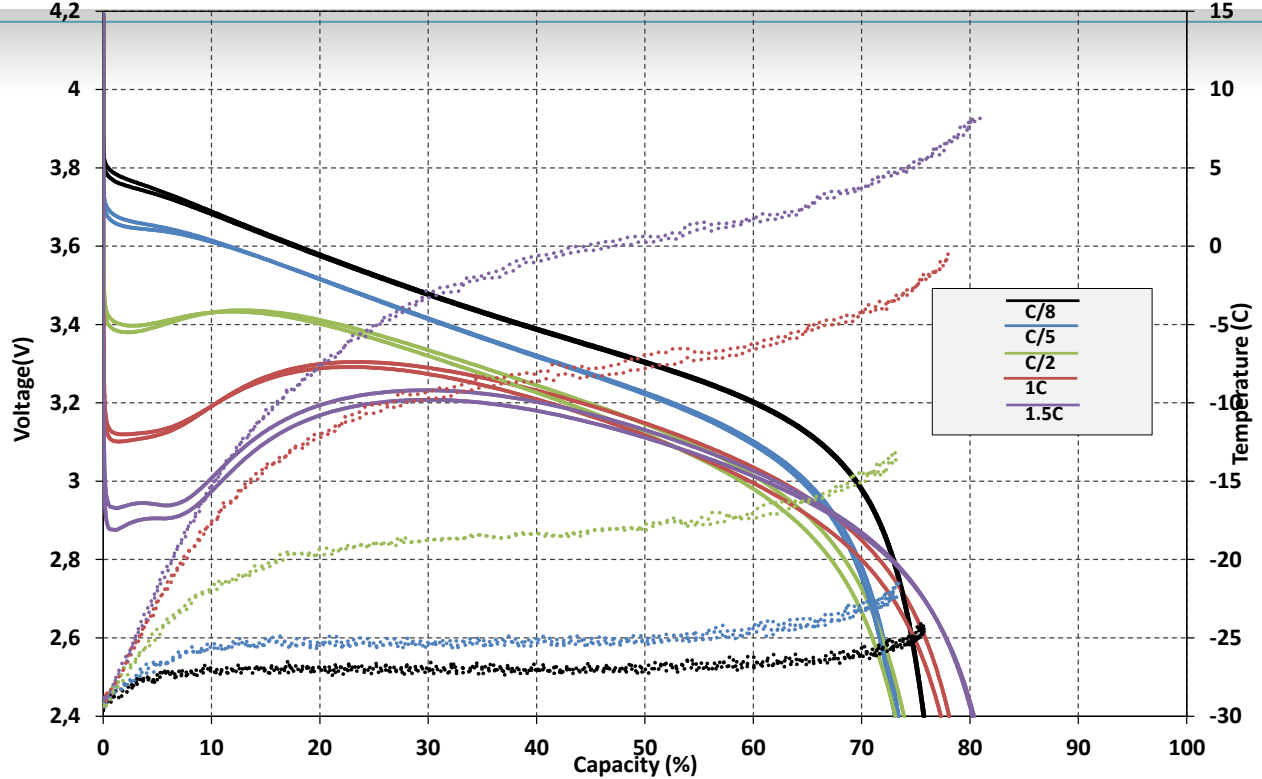
**Fully compliant to UN and UL**

# MP Xtd Performances :

## Capacity at different rates and temperatures



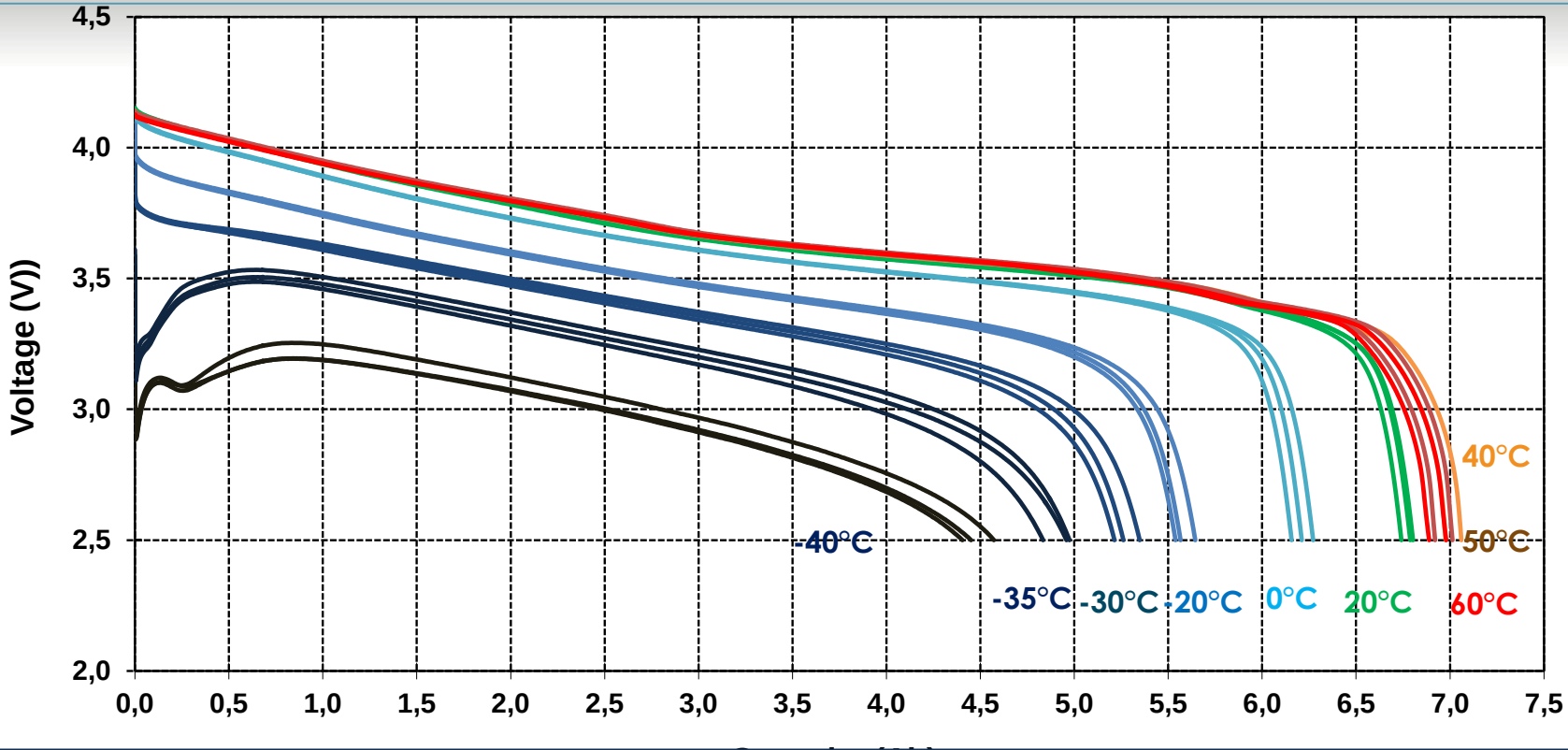
# **MP Xtd Performances :** Discharges at extreme Low Temperature




**-30°C**

⇒ Up to 1.5C rate from 0°C to -30°C
⇒ Voltage drop is 3.4V at C/2 & -30°C (far better than 18650)

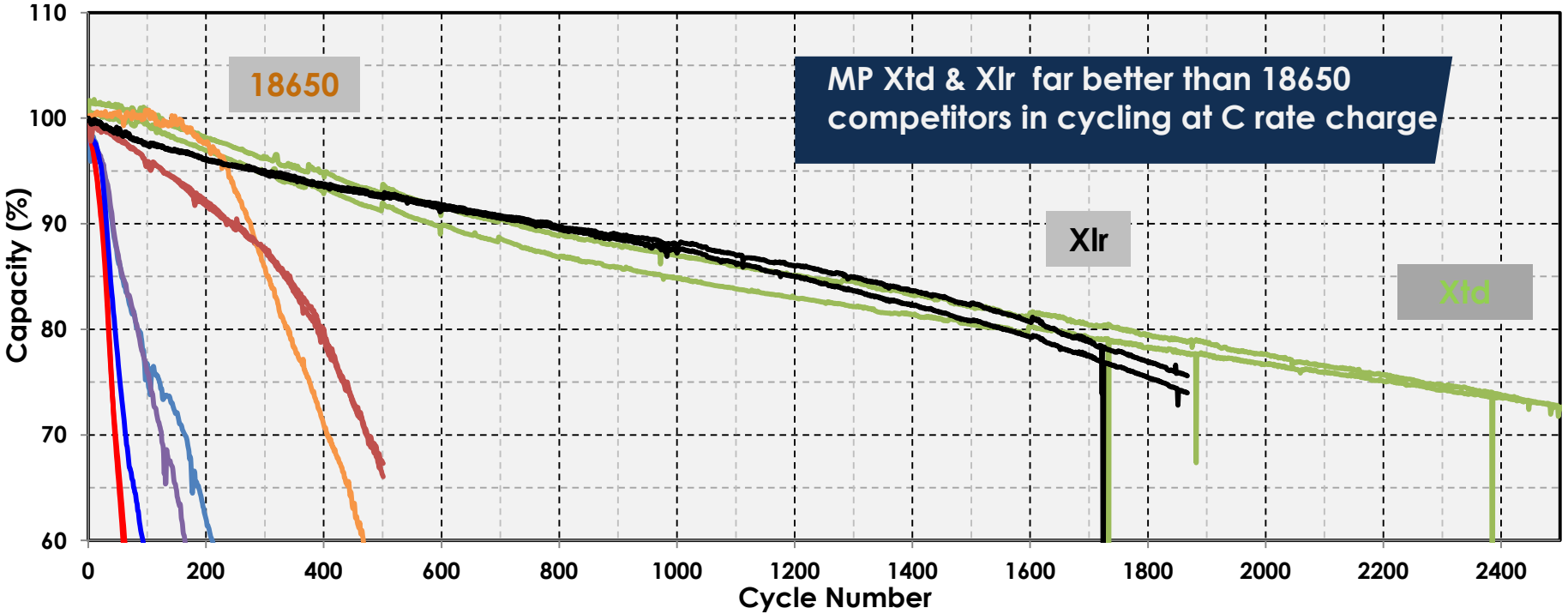
# XLR discharge curves vs temperature C/2 discharge rate




Discharge from -35°C to +60°C at C/2 rate

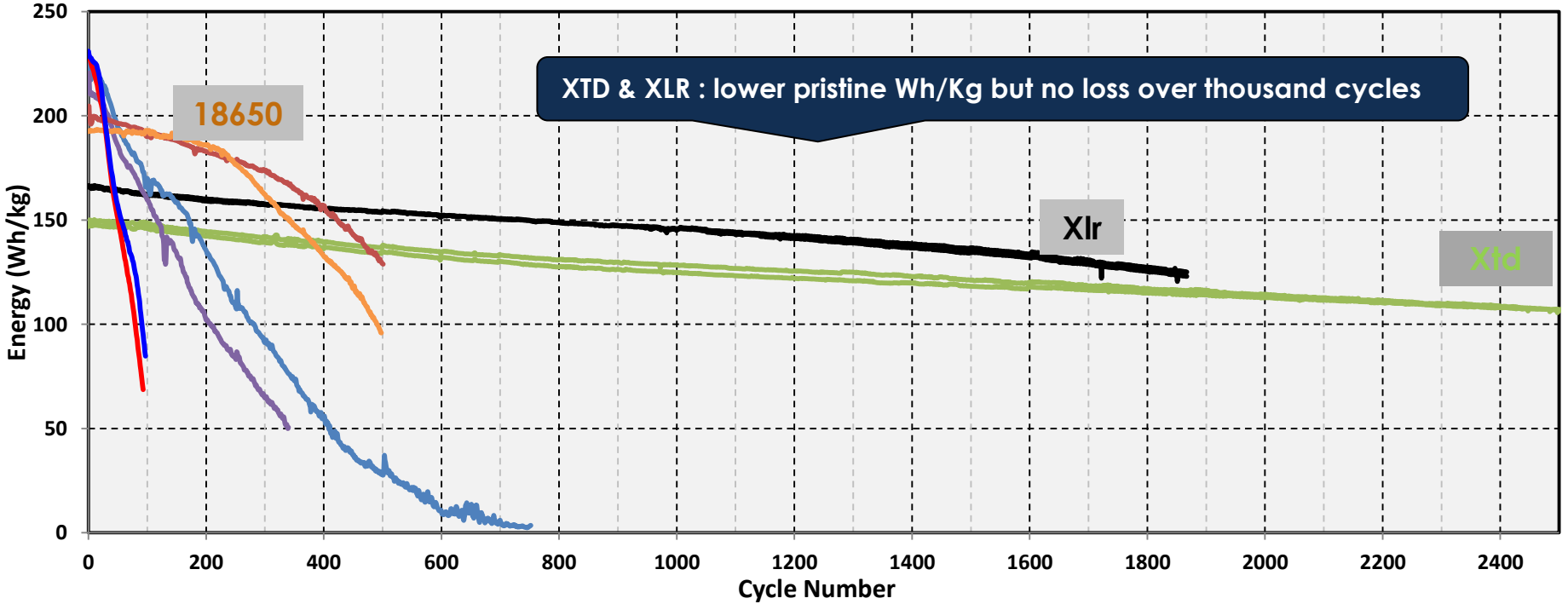
# MP Xtd and Xlr cycle life vs 18650 : Capacity retention

Charge **C rate** , Discharge C/2 rate ,100 % DOD 20 °C



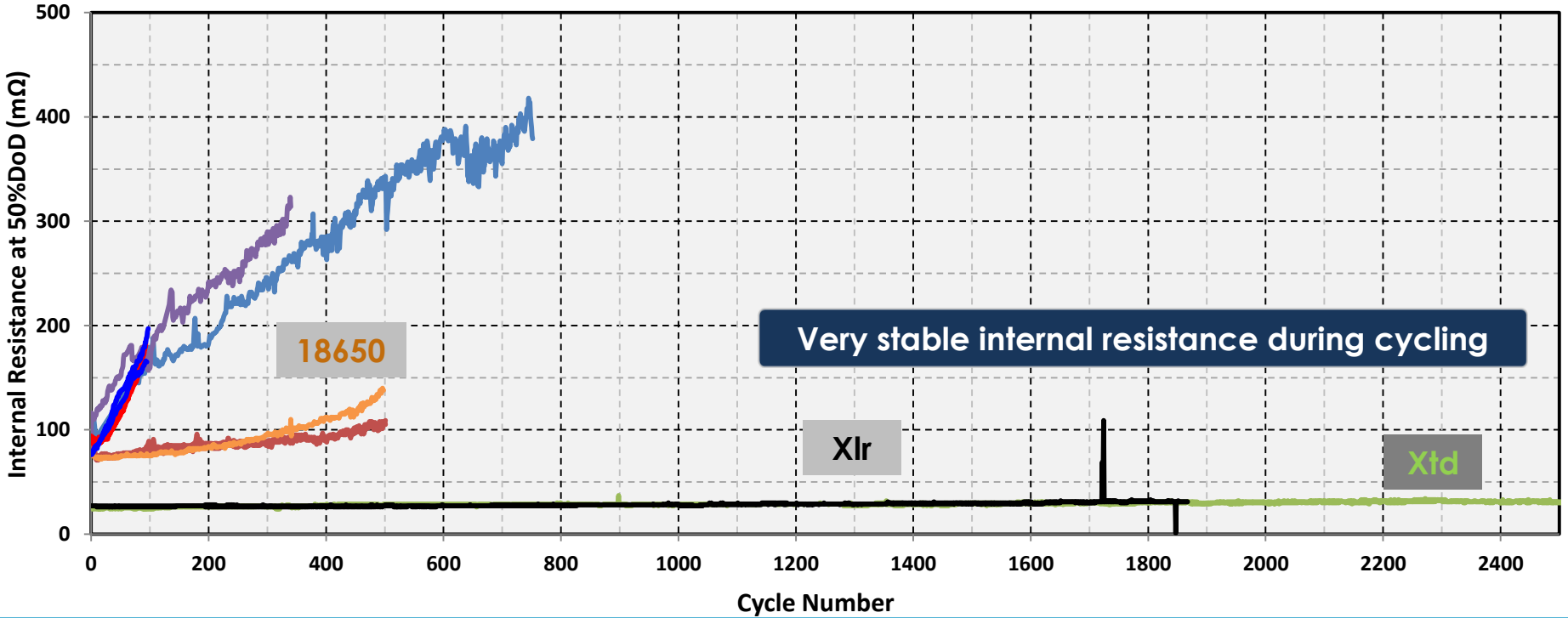
# MP Xtd and Xlr cycle life vs 18650 : Specific energy Wh/kg

Charge **C rate** , Discharge C/2 rate ,100 % DOD 20 °C



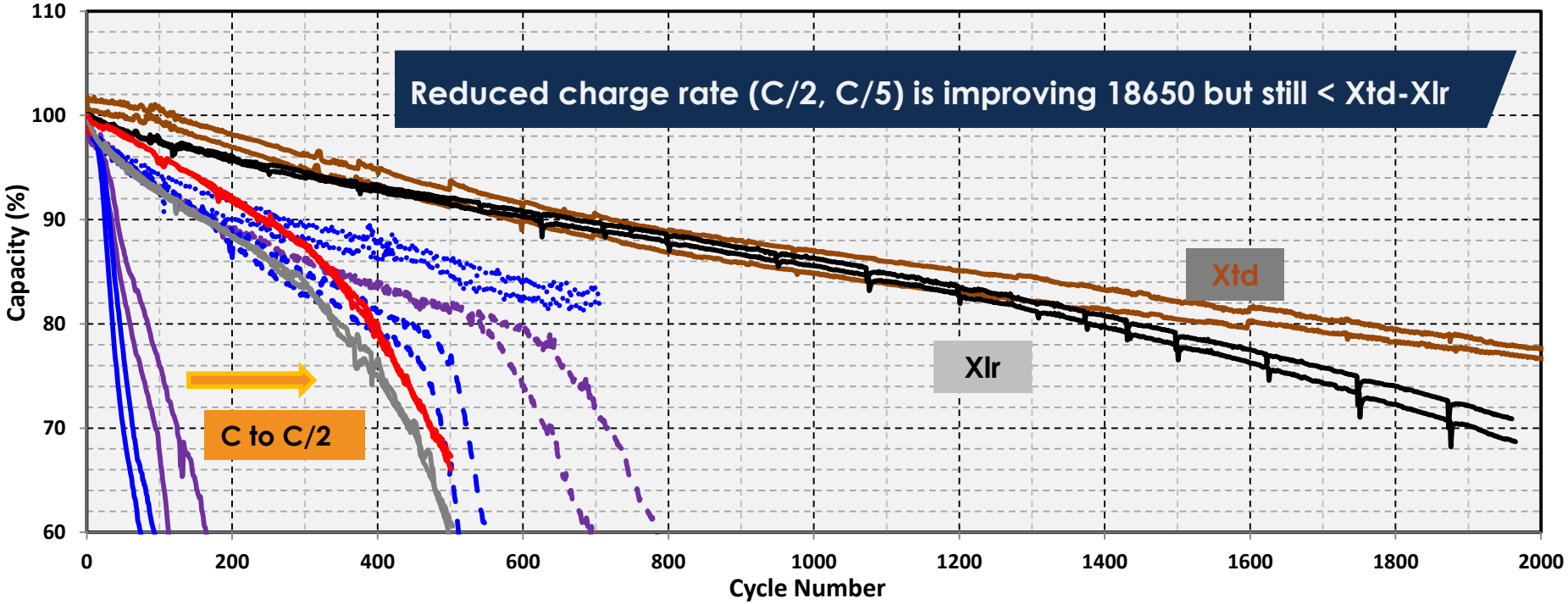
# MP Xtd and Xlr cycle life vs 18650 : Internal resistance

Charge **C rate** , Discharge C/2 rate ,100 % DOD 20 °C



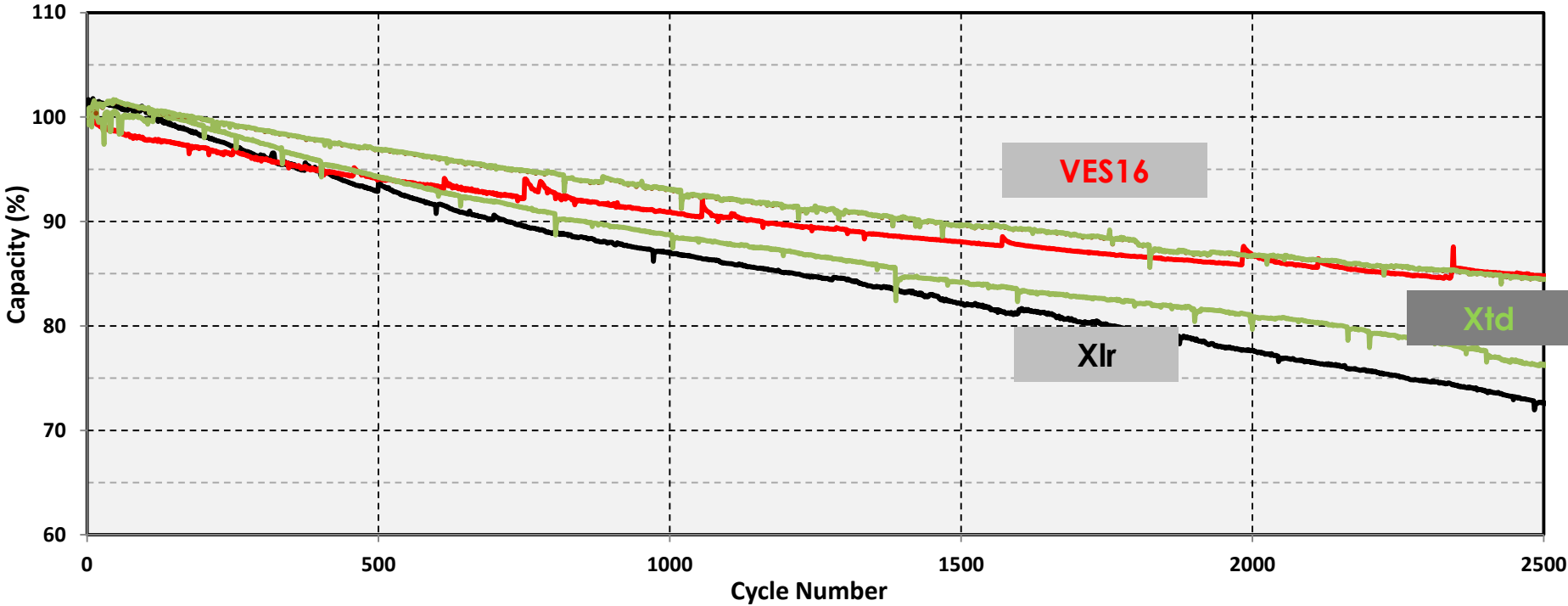
# MP Xtd and Xlr cycle life vs 18650 : Capacity retention

Charge **C/2 rate** , Discharge C/2 rate ,100 % DOD 20 °C



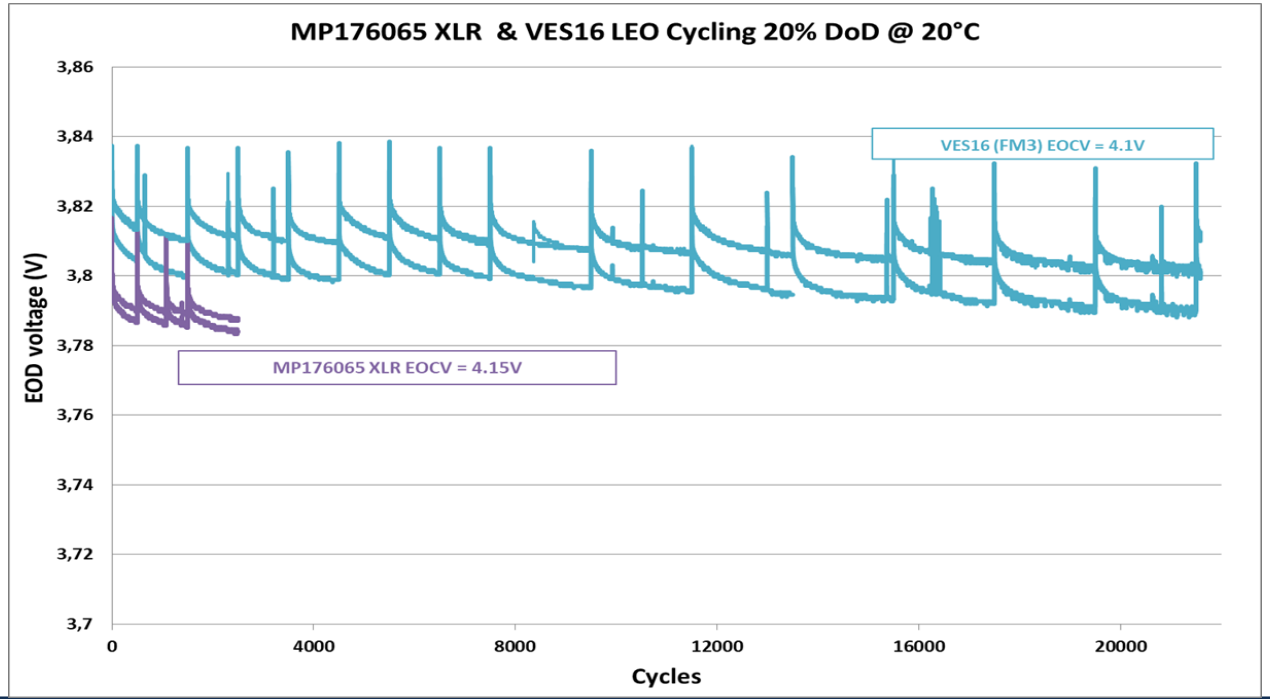
# MP Xtd/Xlr compared to VES16

## Charge **C rate** , Discharge C/2 rate ,100 % DOD 20 °C



# Real time LEO cycling : 20% DoD

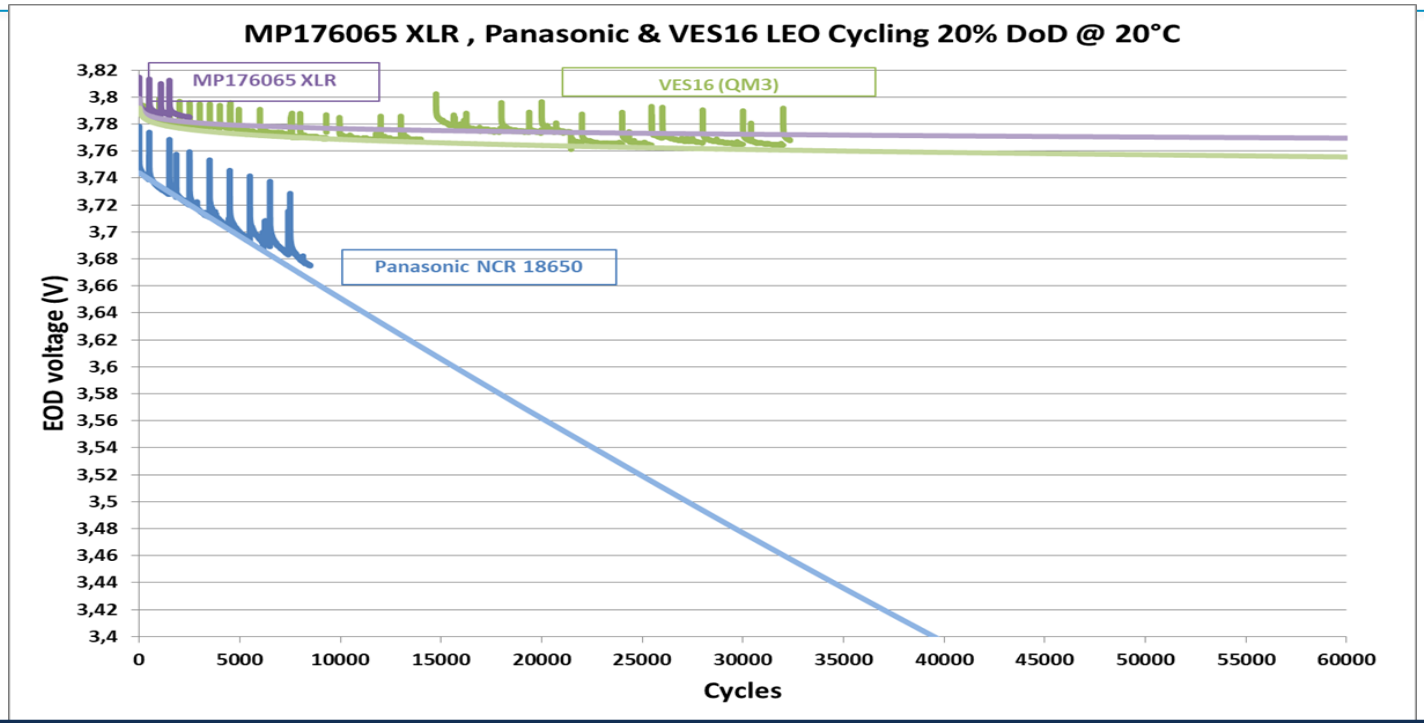
## Comparison of LEO cycling for MP176065 XLR and VES16




- VES16 & MP176065 XLR cells show stable EODV

# Real time LEO cycling : 20% DoD

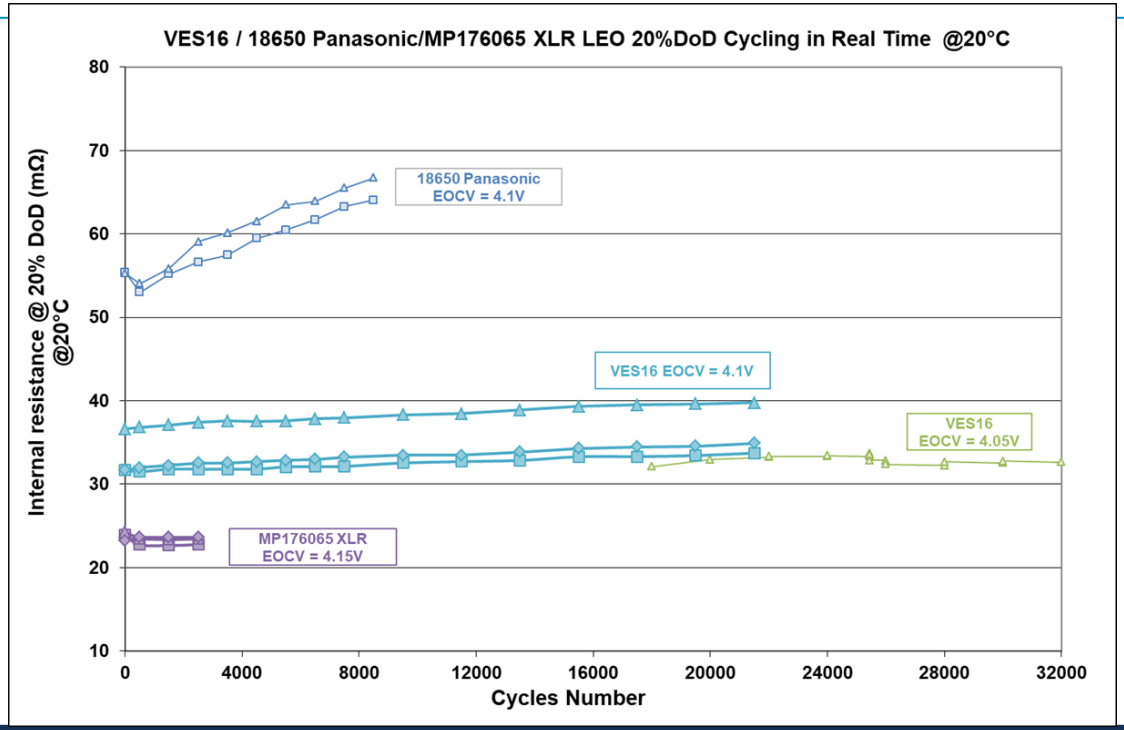
## Comparison of LEO cycling for MP176065 XLR , VES16 and Panasonic cells




- Panasonic cells shows constant decrease in EODV due to significant increase in internal resistance

# Real time LEO cycling : 20% DoD

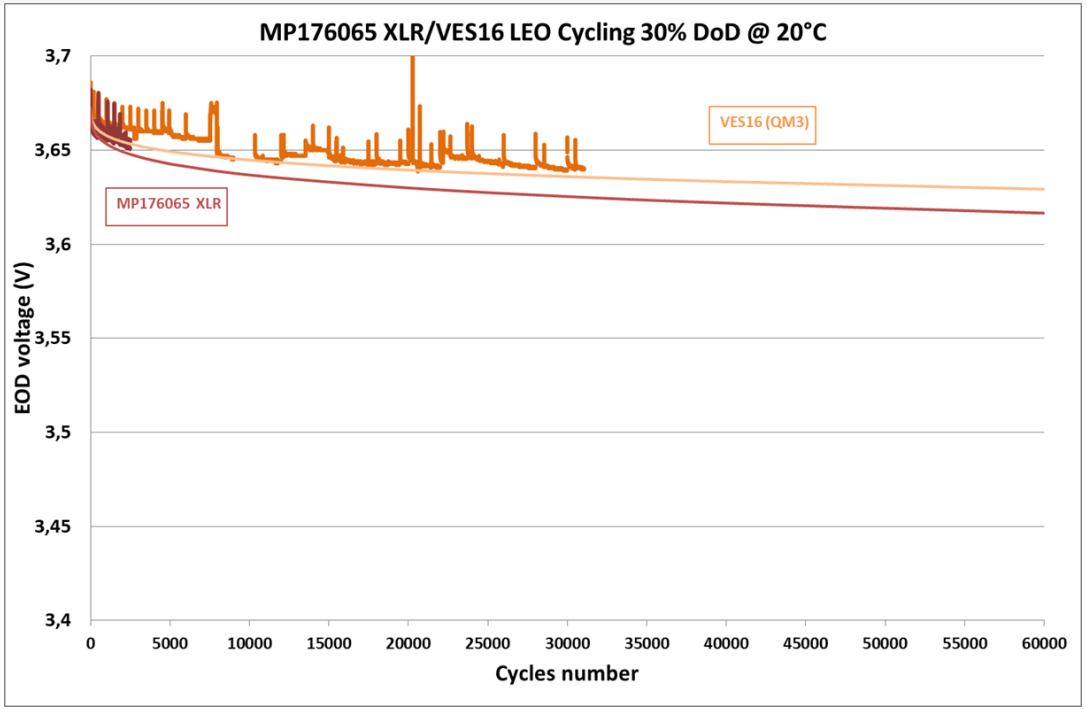
## Internal Resistance evolution in cycling for MP176065 XLR , VES16 and Panasonic cells




- Lower internal resistance values for MP Xlr and VES16
- High internal resistance increasing for Panasonic cells limits LEO cycle life

# Real time LEO cycling : 30% DoD

## Comparison of LEO cycling for MP176065 XLR and VES16

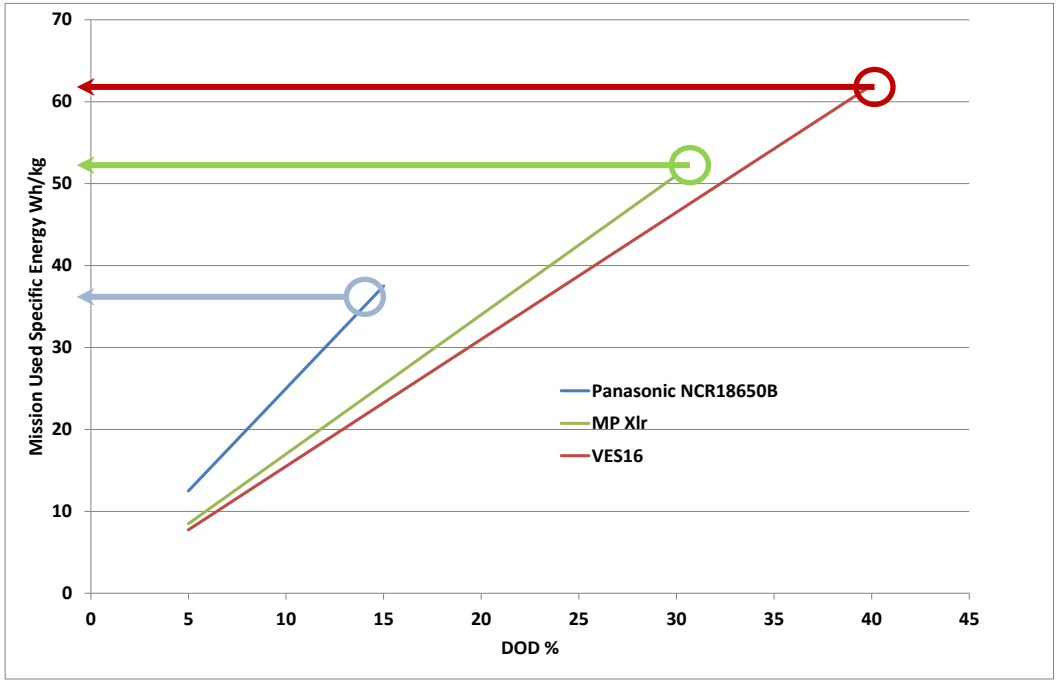



Promising trend for 30 % DOD on MP176065 XLR cells to sustain 12 years in LEO

# Mission used specific energy (Wh/kg) comparaison

## Panasonic , MP176065 XLR and VES16 cells

- **Mission DOD** impacts the used specific energy in Wh/kg



# MP-Xtd long life & robustness …

## Under qualification for 2020 Exomars Rover mission

AIRBUS DEFENCE & SPACE

esa

**Extreme temperatures mission**

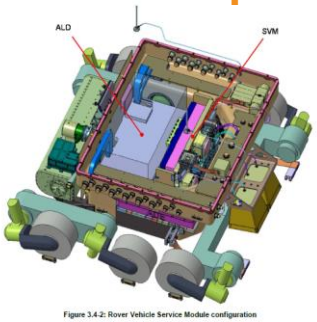
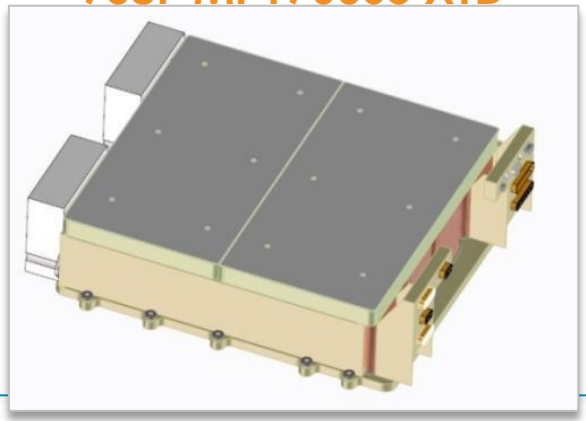



Figure 3.4-2: Rover Vehicle Service Module configuration

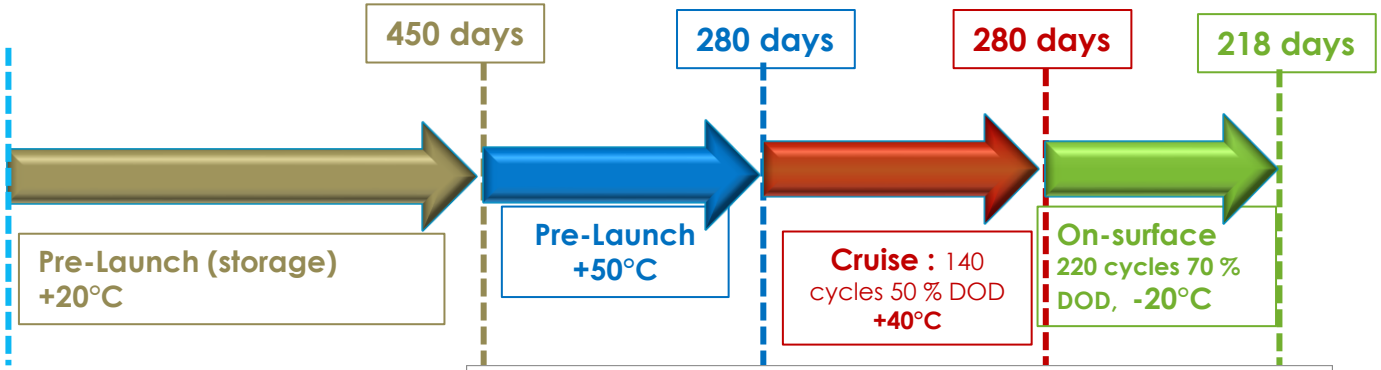

**MP-Xtd under qualification for Exomars 2020**

→ **EXOMARS mission :**
1/ 15 months at +20°C
2/ 9 months at +50°C
3/ Cruise : 9 months (+20°C/+40°C)
4/ Mission : 2 years 220 cycles at -20°C

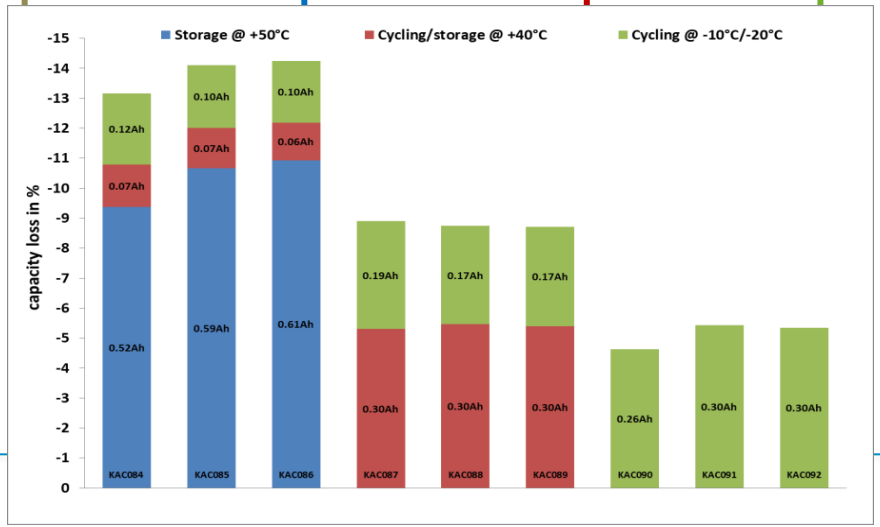
**7S8P MP176065 XTD**



# Exomars mission phases

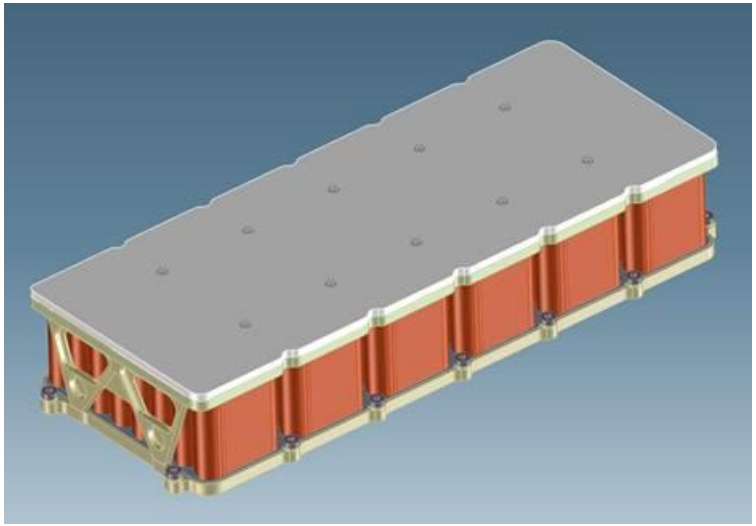


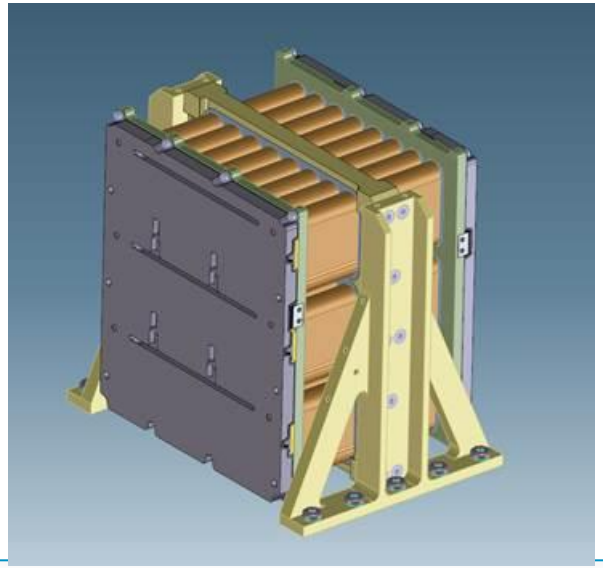

– Cell Energy Evolution



# MP XIr Battery design range for LEO constellation

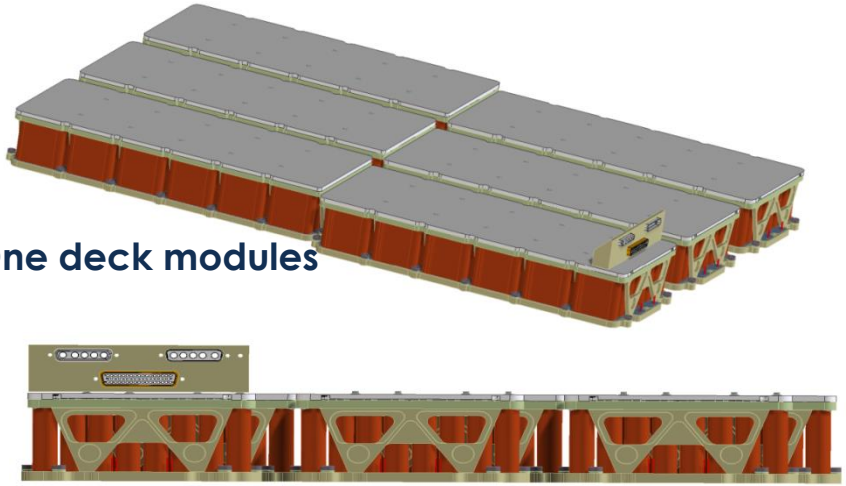
- Qualified battery blocks covering :
  - Bus voltages from 28 V up to 120 V
  - Power from 200 W to 4 kW
  - Constellation price target





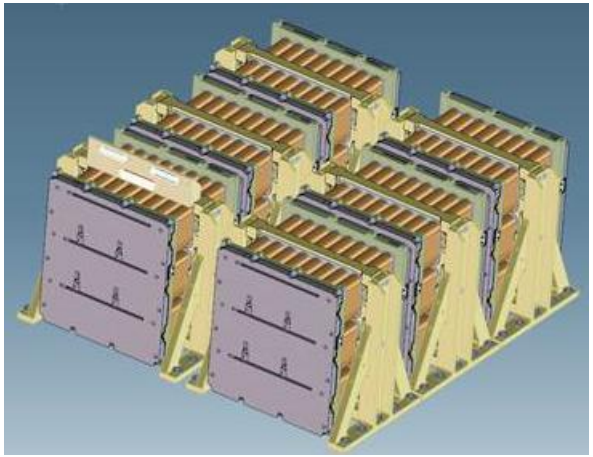
# MP XIr Battery design range for LEO constellation

- Battery blocks/modules includes :
  - Low cost electronics for balancing
  - Thermal management
  - Connectors



**One deck modules**

**Stacked Modules**




Merci
Vielen Dank
תודה, תודה לך!
Dekuji
Thank you
谢谢
Tack