VL10ES High Energy Space Cell Development

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Agenda

1. VL10ES main objectives
2. Key R&D orientations
3. Feasibility & Qualification test plan
4. EM0 design steps
5. EM0 cycling tests results
6. EM0 preliminary safety tests
7. Conclusions & Perspectives

1. VL10ES OBJECTIVES

VL10ES development : our goals

→ Address LEO & GEO markets, including Constellations, with a new Safe High Energy density cell, able to sustain long range space cycling.

→ Develop an innovating electrochemistry able to reach more than 220 Wh/Kg at cell level and able to sustain long range cycling in LEO (20% DOD - 30%DOD) & GEO (70% DOD targeted).

→ Use innovating & industrial active materials/components for electrode densification in synergy with Saft Corporate Solid State program.

→ Use a similar stainless steel casing than VES16, to keep advantages regarding robustness & safety, even for a High Energy density cell.

→ Reduce cell number in large batteries, reduce overall cost at battery system, that will answer the satellite builder targets, and propose an alternative with low cost approach for constellation systems

→ BoL VL10ES Qualification Review for mid-2021.

VL10ES global Development Plan

PDR : Nov 13, 2019

On going

Ckv /Poitiers
EM0
(VES16)

Janv 2020
EM1
(VL10ES)

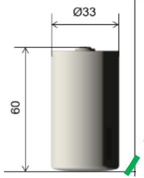
CDR : July 2020
EM2
(VL10ES)

QR :August 2021
QM
(VL10ES)

Full qualification program

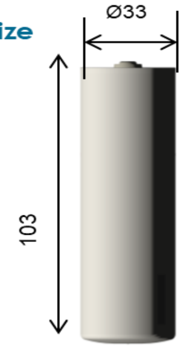
Screening of electrochemical formulations

D size



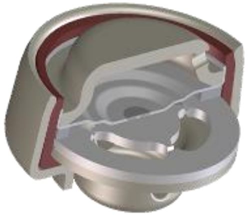
F Cell Format

F size



2. KEY R&D ORIENTATIONS

VL10ES : robust casing & safety devices ; VES16 continuity

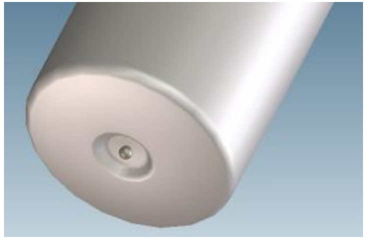


Circuit breaker

- Similar to VES16
- New plastic parts for T° robustness

Symmetric double vent safety device

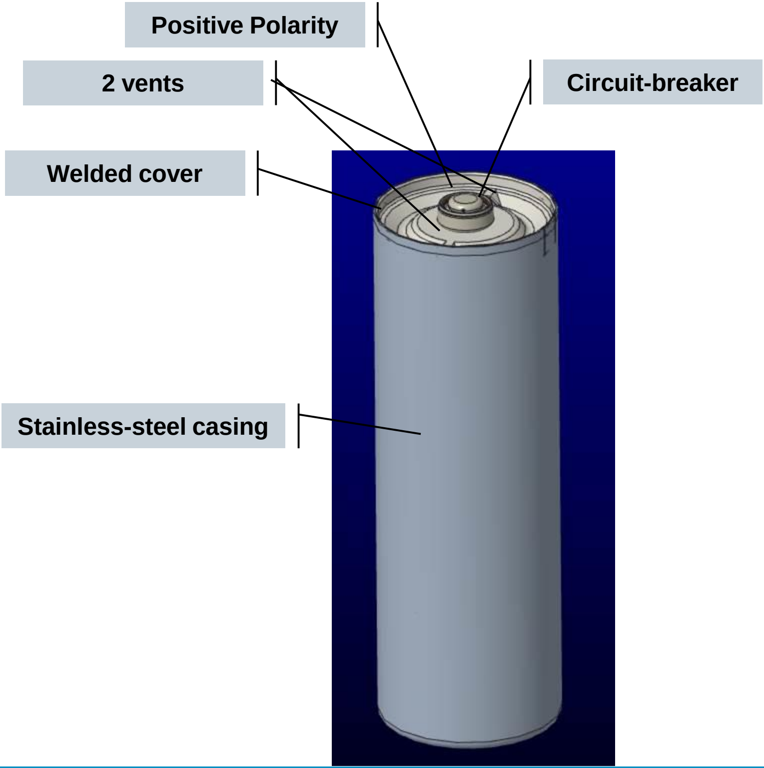
- Similar to VES16
- Pressure release in case of local significant gas generation



Cell Bottom

- Similar to VES16
- Fill-in hole / closing ball
- Stainless-steel Bottom Cover

VL10ES : summary of targeted performances versus VES16



Cell type	VES16 (D-size)	VL10ES (F-size)
Dimensions (Ø x H)	33 x 60 mm (D-size)	103 x 60 mm (F-size)
Weight	≤ 115 g	≤ 215 g
Volume	0.051 dm^3	0.086 dm^3
Voltage range	2.7 V - 4.1 V	2.7 V - 4.2 V
Nominal capacity	4.5 Ah @ 4.1V, 20°C	> 12 Ah @ 4.2V, 20°C
Nominal energy	16 Wh @ 4.1V, 20°C	> 47 Wh @ 4.2V, 20°C
Specific energy	> 140 Wh/kg	> 220 Wh/kg
Internal resistance	≤ 35 mΩ @ 20% DoD	≤ 25 mΩ @ 20% DoD / TBC
Operating temperature	+10°C / +40°C	+10°C / +40°C
Mechanical design margins	EWR & ECSS compliant	EWR & ECSS compliant

3. VL10ES CELL QUALIFICATION PLAN

VL10ES Cell Qualification plan content

EM0 selection in D VES16 format

Electrical	Mechanical	Thermal	Space life Tests	Safety
Accelerated 80-100% DOD			LEO real time	Overcharge
			GEO real time	Over temperature

VES10ES cell qualification (QM) F final format

	Electrical	Mechanical	Thermal	Space life Tests	Safety
EM1	Accelerated 80-100% DOD	Vibration	T/V	LEO real time	Overcharge
	DST	Shock	Dissipation	GEO real time	Overdischarge
	Dch vs T°	DPA	Capacity	LEO accelerated	Ext. short
	Impedance, Ri	Strains Measures/Model	Thermoneutral potential	GEO accelerated	Over temperature
	EMF vs SoC			Storage vs T° & SOC	ARC test
				Radiation Test	Safety test vs VES16

4. EM0 DESIGNS STRATEGY

EM0 prototypes : 2 development phases

Design & electrodes densification step 1

Design step 1 retrofit

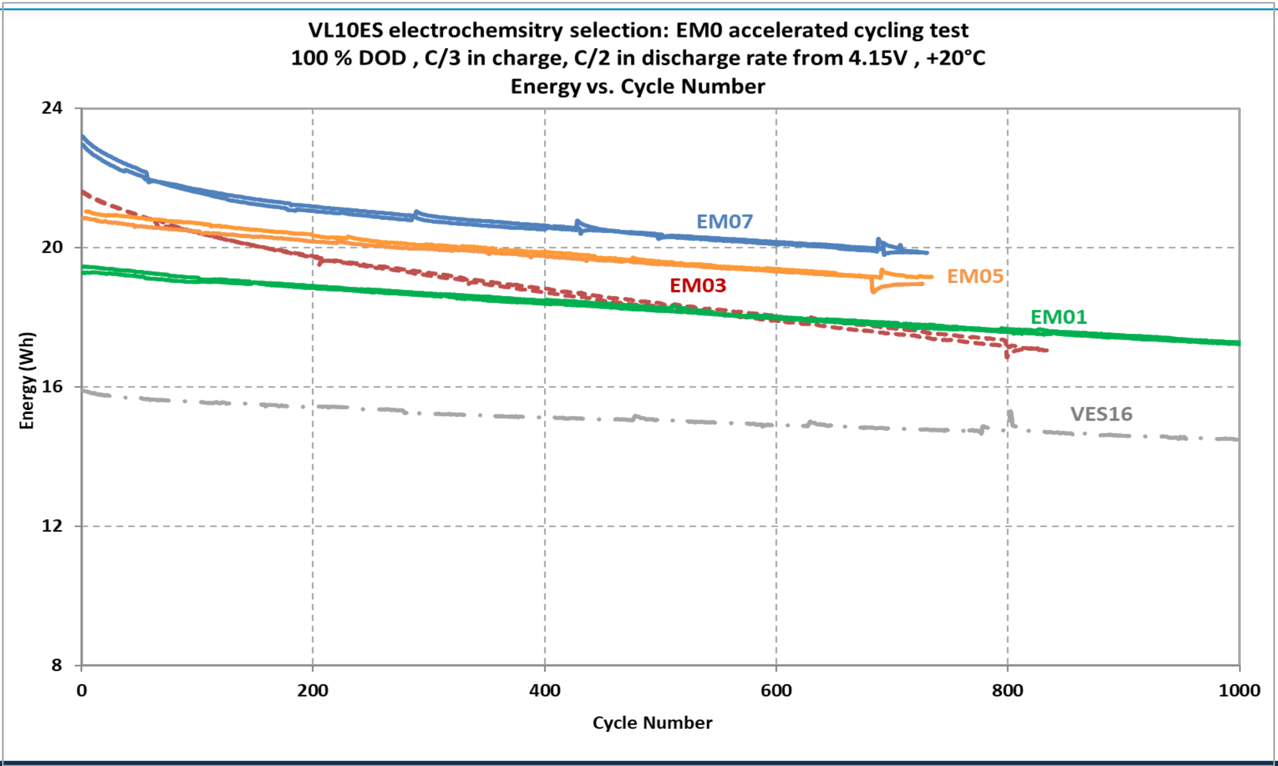
Design step 2

EM0	EM01, EM02	EM03	EM05	EM07 (a,b,c)	EM08	EM012	EM013
Design	Positive step 1 Negative A & B Separators Electrolytes	Positive step 2 Negative A Separators Electrolytes	Positive step 3 Negative C	Positive step 4 Negative C Porosity range Σ Electrolytes	Positive step 4 Negative D (with SiOx)	Positive step 5 Negative C	Positive step 5 Negative D (with SiOx)
Targeted Energy in final F format (C/2)	190-195 Wh/Kg	205-210 Wh/kg	200-205 Wh/kg	215-220 Wh/Kg	220-225 Wh/Kg	220-225 Wh/kg	≥ 225 Wh/Kg
Cycling 100% DOD C/3 - C/2 (criteria : -20% capacity at 1000 cycles)	1000 cycles (-11%)	830 cycles (-16%)	720 cycles (-7%)	720 cycles (-12%) Stabilization	Similar trend to EM07 at 350 cycles	Better trend than EM07 240 cycles (-2%)	Better trend than EM07 240 cycles (-5%)

**** VES16 /155 Wh/Kg [100% DOD 4.1V] = 1000 cycles (-10%)***

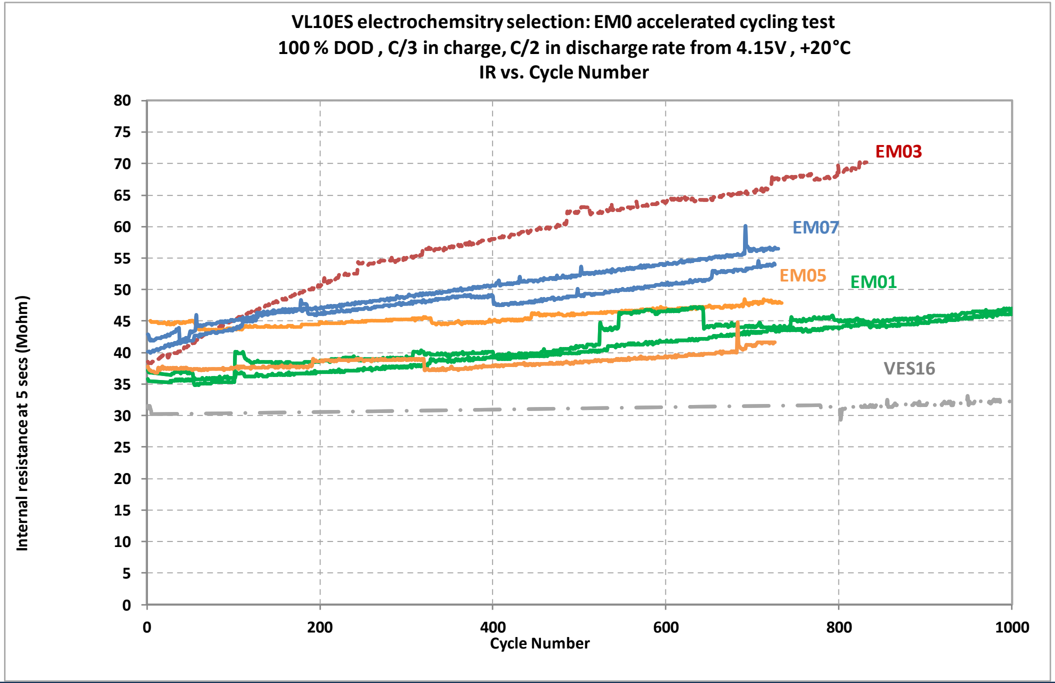
5. EM0 CYCLING TESTS RESULTS

EM0 second first step selection : 100% DOD accelerated cycling
(C/3, D/2 , 20°C and 4.15 V)



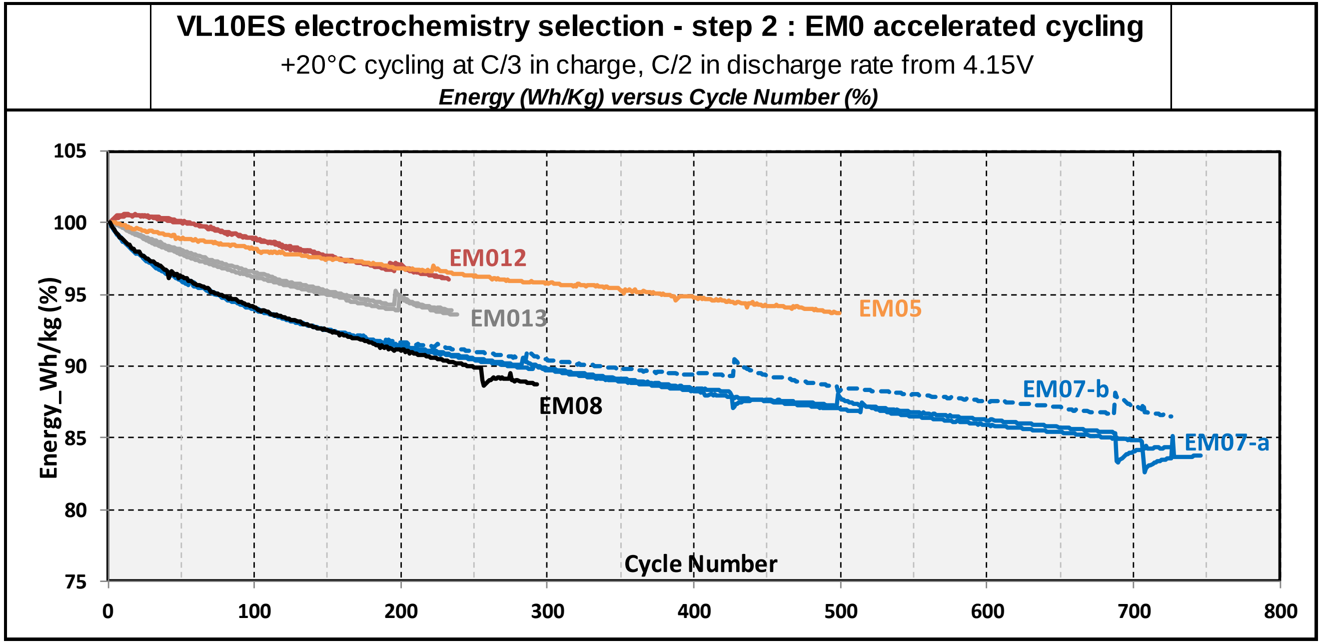
- ***Fading ranking : EM03 > EM07 > EM01 ~ EM05 ~ VES16 ; EM07 stabilization after 100 cycles***

EM0 second first step selection : 100% DOD accelerated cycling
(C/3, D/2 , 20°C and 4.15 V)



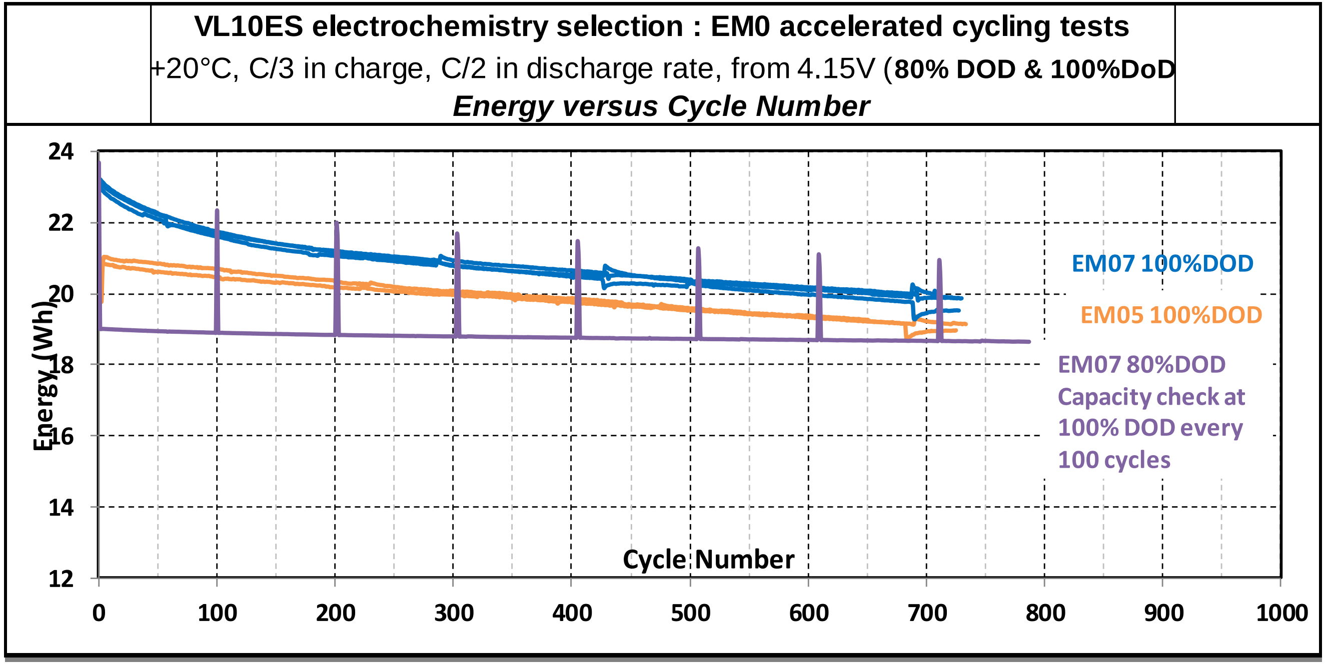
- *Internal resistance stability over 1000 cycles υ*
- *Same ranking as per fading : EM03 > EM07 > EM01 ~ EM05 ~ VES16*

EM0 second step selection : 100% DOD accelerated cycling
(C/3, D/2 , 20°C and 4.15 V)



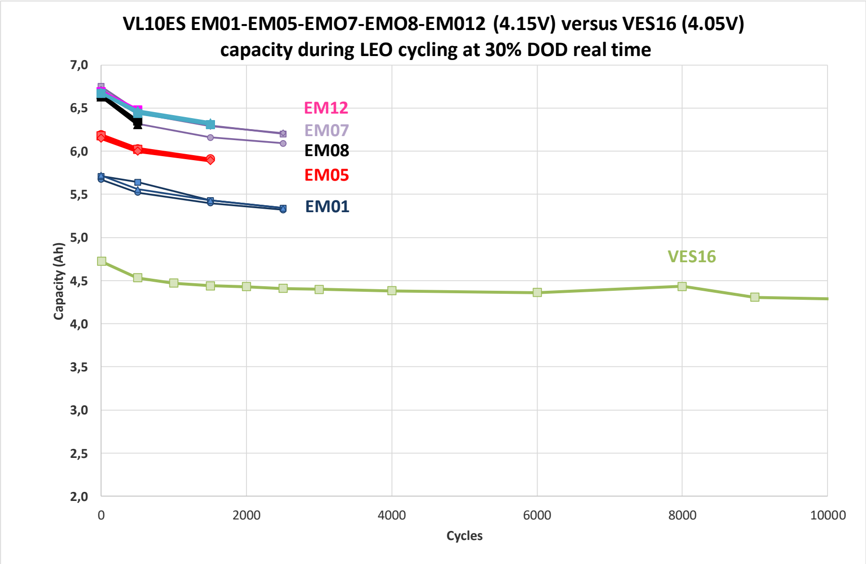
- *Low fading in 100% DOD accelerated cycling for last EM012 & EM013 designs*
- *Slight fading increase using SiOx additive in EM013 versus EM012 (wo SiOx) / TBC on cycling*

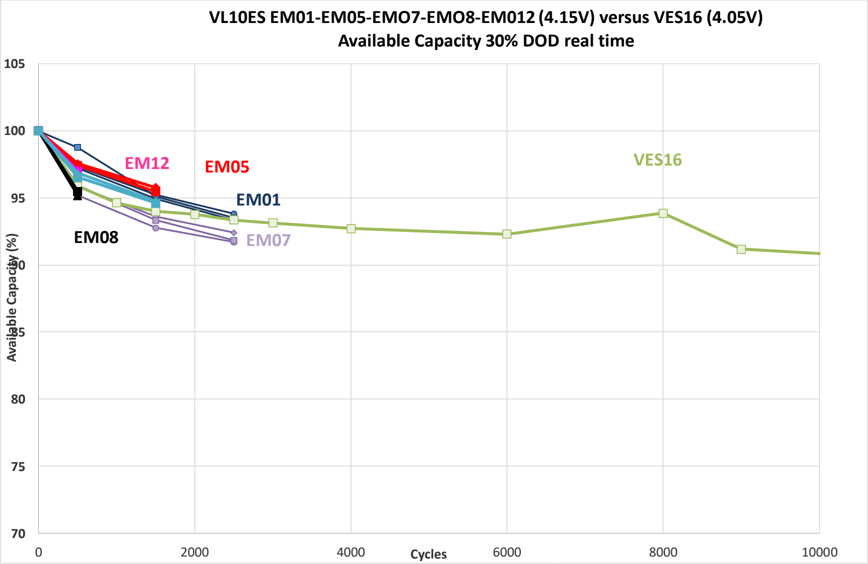
EM0 selection : 80% DOD accelerated cycling
(C/3, D/2 , 20°C and 4.15 V)

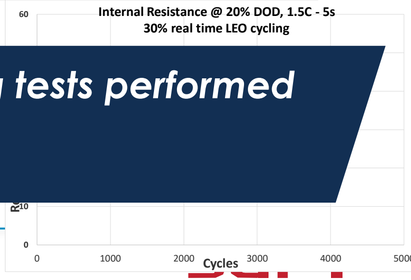


- *EM07 capacity loss improvement in cycling at 80% DOD versus 100% DOD*

EM0 : LEO 30% DOD cycling trend (C/3, D/2

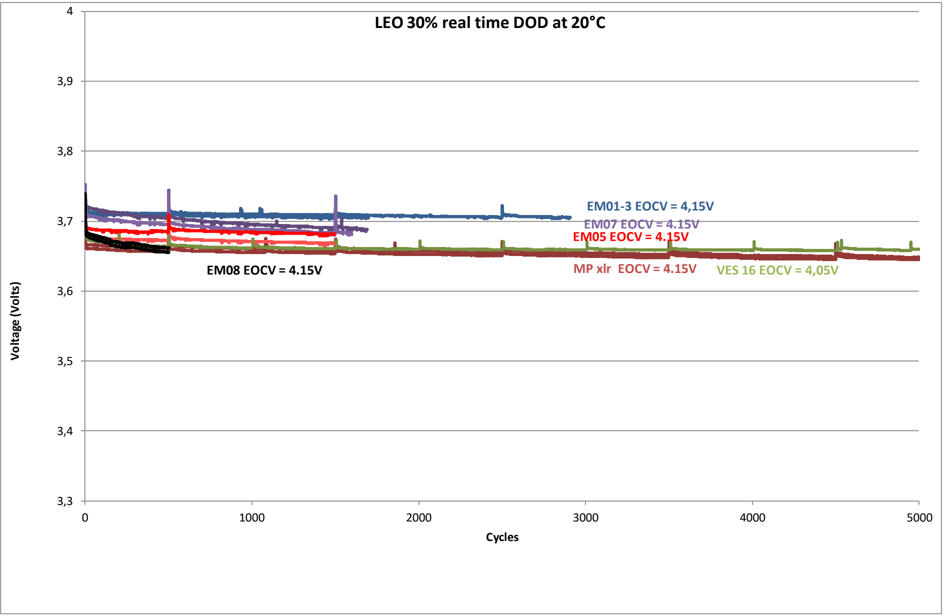


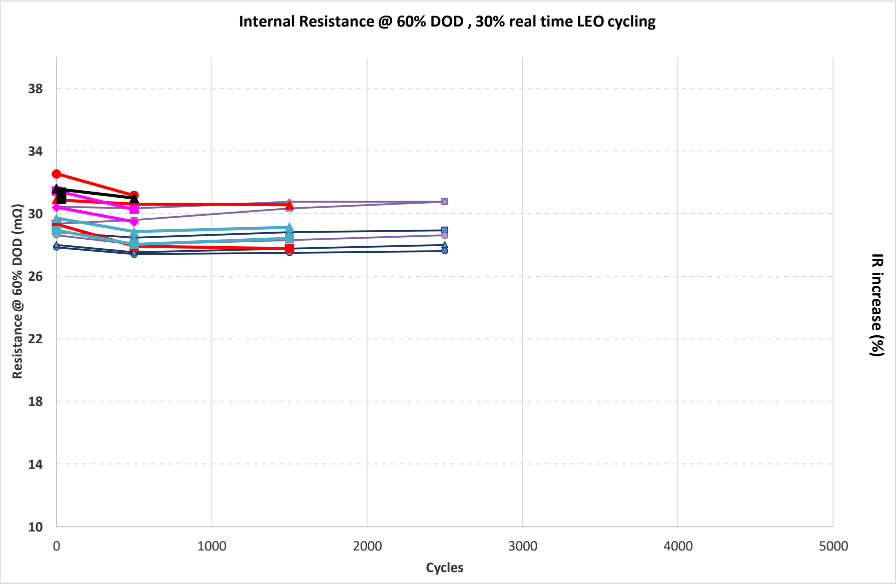


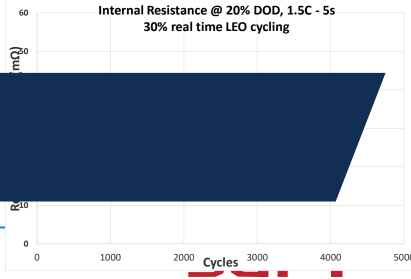


- *Similar fading ranking in LEO real time (3000 cycles) versus accelerated cycling tests performed at 80-100% DOD*
- *Similar trend as per VES16*

EM0 : LEO 30% DOD cycling trend







- *EODV stabilization in 2000 cycles as per VES16*
- *Good trend in energy and internal resistance in LEO 30% at 3000 cycles*

6. EM0 PRELIMINARY SAFETY TESTS RESULTS

Cell safety status - (VES16 size- EM07)

Pin test @ 4.2V

6 cells tested

No rupture, no explosion, no flying part



Over-heating test @ 4.2V

6 cells tested

No rupture, no explosion, no flying part



- ***Robustness of stainless-steel casing* / Symmetric opening of the 2 vent devices / cell depressurization**

7. CONCLUSIONS & PERSPECTIVES

CONCLUSIONS

→ 12 months R&D works and EM0 prototyping-testing has permitted to select three VL10ES-EM1 series within disruptive electrochemical concepts for High Energy / Long Life & Safety trade-off.

→ Innovating formulation & design concepts are associated to dense electrodes industrial process and a new cell assembly line is under qualification for VL10ES production.

→ EM0 testing has shown very promising results in terms of capacity loss, stability of internal resistance and safety. The VL10ES cell will deliver the lifetime and power requirements for either GEO or LEO applications (including constellations).

→ From preliminary results, the VL10ES mission usable specific energy will be *60-70 Wh/Kg in LEO* and *150-155 Wh/Kg in GEO*

→ VL10ES will allow to reduce battery weight and cost, still maintaining long mission time. VL10ES has been designed to be used at higher DOD than VL18650 cells both in LEO and GEO cycling.

→ The BoL Qualification Review of the VL10ES cell is targeted for mid-2021.

Acknowledgement

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