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ULTRALIGHT LITHIUM-SULPHUR CELLS FOR SPACE APPLICATIONS: OPPORTUNITIES AND BARRIERS

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PRESENTATION OF ARIANEGROUP

CONTEXT: ENERGY AND POWER REQUIREMENTS FOR SPACE

ULTRALIGHT LITHIUM-SULPHUR CELLS COMPETITORS

RESULTS ON OXIS ENERGY ULTRALIGHT CELLS

BARRIERS AND OPPORTUNITIES SPACE APPLICATIONS

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COMPANY PRESENTATION

WORLD LEADER IN ACCESS TO SPACE

9,000

EMPLOYEES
IN FRANCE
& GERMANY

11

SUBSIDIARIES
& MAIN AFFILIATES

50/50

JOINT COMPANY
BETWEEN
AIRBUS & SAFRAN

€3 BILLION

ESTIMATED PRO FORMA
SALES

CIVIL LAUNCHERS	Ariane 5 Ariane 6 Launch services
DEFENSE	M51 program
EQUIPMENT & SERVICES	For satellites, spacecraft For launchers For defence, security, critical infrastructures and industry

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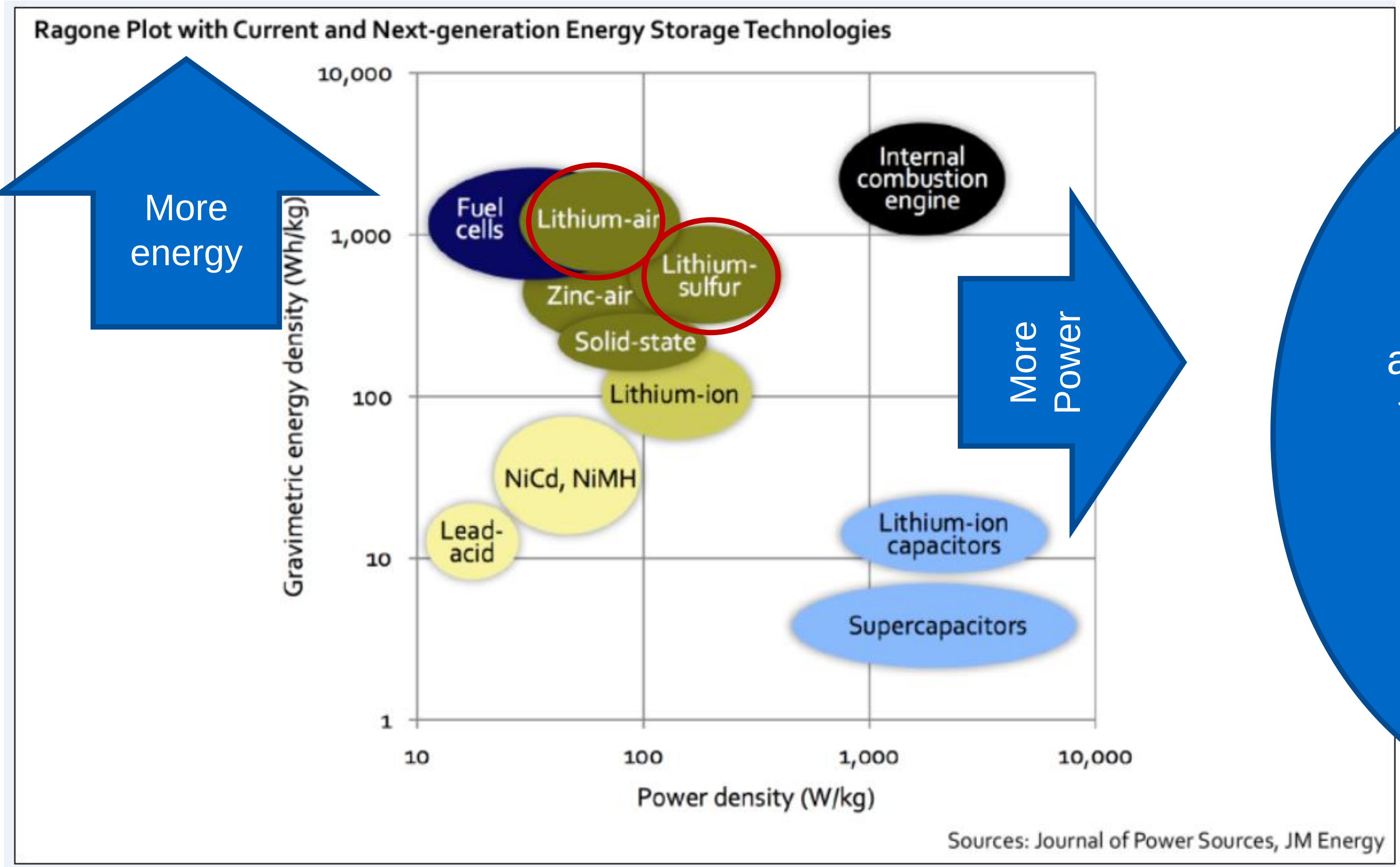
CONTEXT

CONTEXT: INCREASE OF SPACE APPLICATIONS REQUIREMENTS



Space vehicles become more and more electric

Missions durations are increased due to the new challenges of the space exploration

New electrical energy and power needs have to be taken into account

CONTEXT: TECHNOLOGY CANDIDATES AND ASSOCIATED COMPETITORS

At the moment there is a strong interest by all stakeholders related or influenced by the battery markets on two systems:

- Secondary batteries based on Li-O_2 technology
- Secondary batteries based on Li-S technology

Li-S is believed to reach mass commercialization towards 2025 whereas Li-O_2 is expected to be available in 2035

Therefore, discussions follow hereby are focused on Li-S and more particularly on ultralight cells for space applications.

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ULTRALIGHT LITHIUM-SULPHUR CELLS COMPETITORS

2 MAIN WORLDWIDE COMPETITORS

Culham Science Centre
Abingdon (UK)

Tucson, Arizona
(USA)

ULTRALIGHT LI-S CELLS: MAIN SPECIFICATIONS COMPARISON

	Oxis Energy	Oxis Energy	Sion Power
Cell part Number	**POA0084**	**POA0217**	***Licerion®***
Nominal voltage (V)	2.1	2.1	2.1
Cell capacity (Ah) @0.2C – 20°C	6.5	12	20
Cell dimensions • **Length (mm)** • **Width (mm)** • **Heigth (mm)**	 146 76 7 TESTED	 174 112 7.3 TESTED	 100 100 10
Cell mass (g)	55	90	154
Specific energy (Wh/ kg)	**248**	**300**	**500**
Volumetric energy (Wh/ L)	**180**	**197**	**1 000**
Operating temperature (°C)	**[5; 30]**	**[5; 30]**	TBD
Cycles	**100 - 200**	**100 - 200**	**450**

Source: Oxis Energy datasheet and Sion Power datasheet

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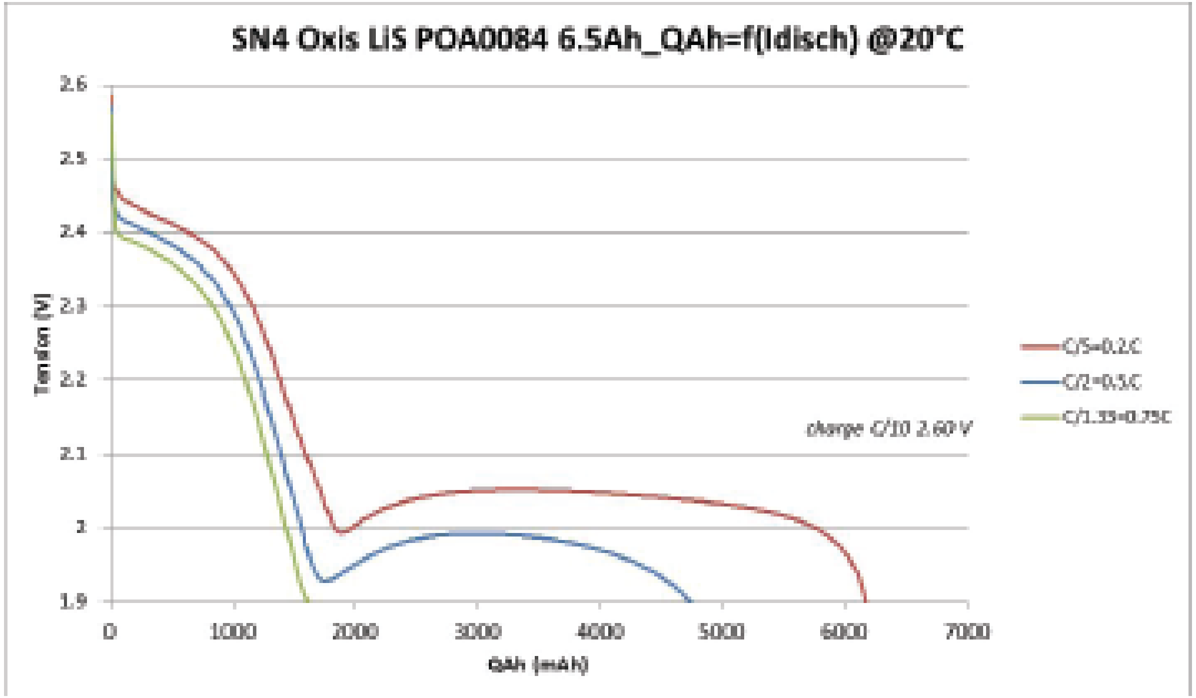
OXIS ENERGY ULTRALIGHT CELL RESULTS

OXIS ENERGY POA0084 RESULTS: C-RATE

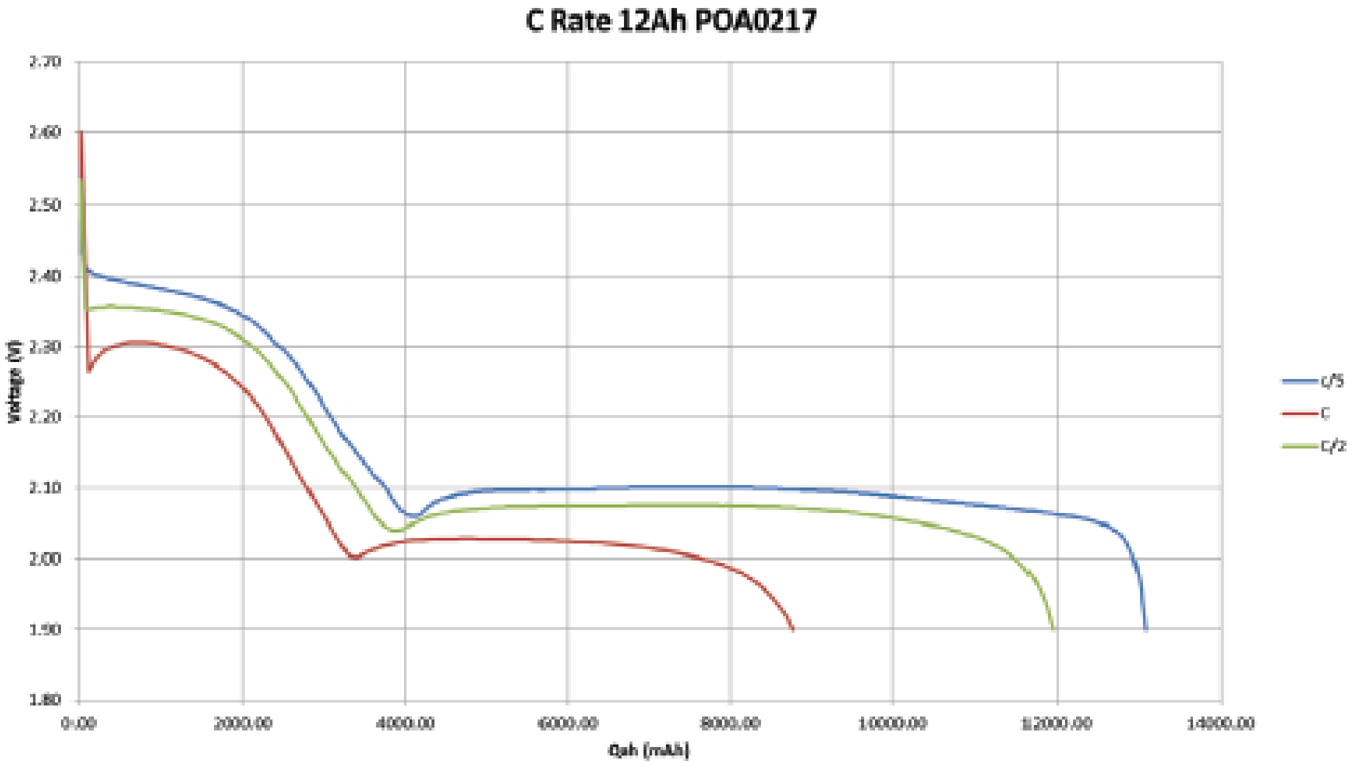


C/5: nominal capacity

0.75C: 25 % of nominal capacity

Source: B. Samaniego and al., «High specific energy Lithium Sulfur cell for space application", ESPC 2016

OXIS ENERGY POA0217 RESULTS: C-RATE



C/5: nominal capacity

0.75C: 73 % of nominal capacity

Source: B. Samaniego and al., «High specific energy Lithium Sulfur cell for space application", ESPC 2016

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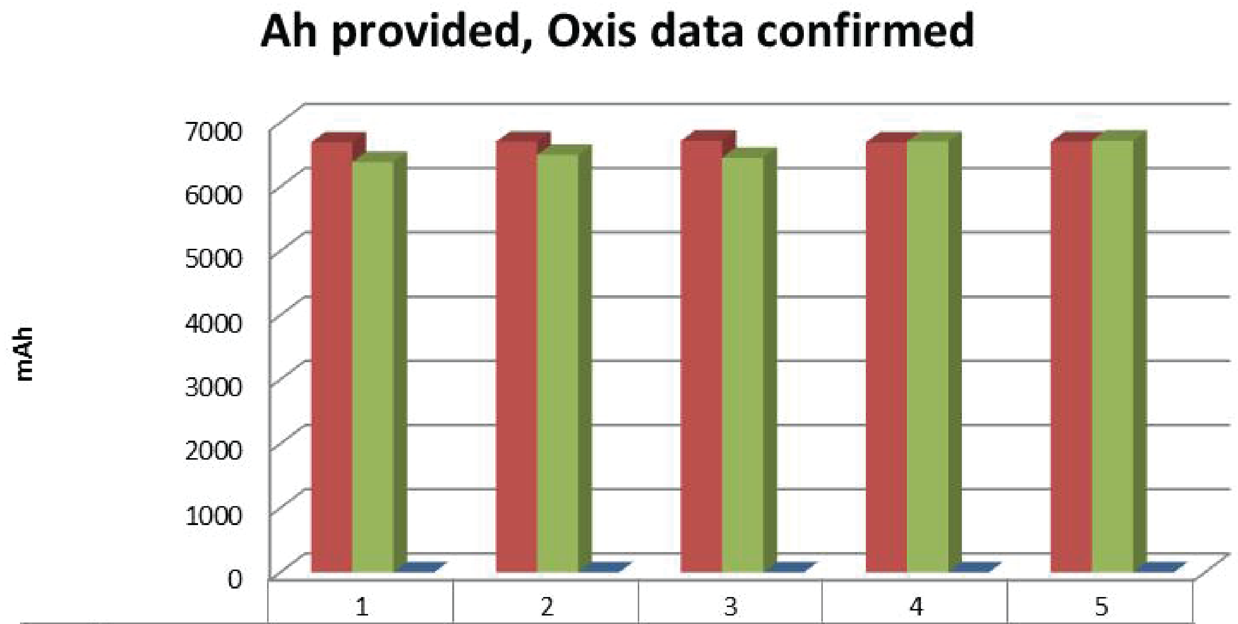
OXIS ENERGY POA0084 RESULTS: SELF-DISCHARGE



	1	2	3	4	5
Dech1	6688	6698	6714	6688	6698
Dech after 1h rest	6381	6493	6451	6698	6714
Loss	4.59%	3.07%	3.92%	-0.15%	-0.24%

Self-discharge after 1 hour rest: 4.60% to 0%

Source: B. Samaniego and al., «High specific energy Lithium Sulfur cell for space application", ESPC 2016

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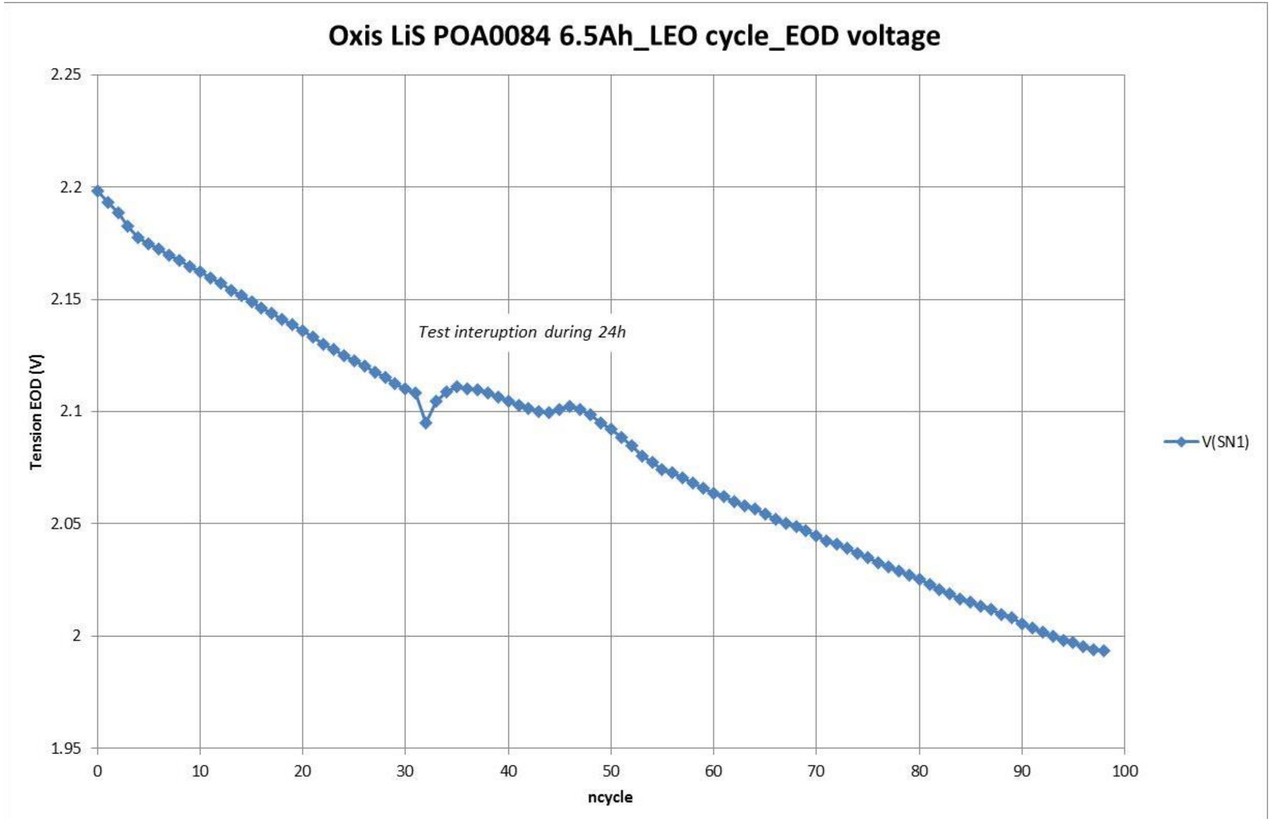
OXIS ENERGY POA0084 RESULTS: CYCLABILITY



Testing conditions:

- discharge at C/3 down to 20% of DoD has been selected
- with a charge rate of C/5.

98 cycles

Source: B. Samaniego and al., «High specific energy Lithium Sulfur cell for space application", ESPC 2016

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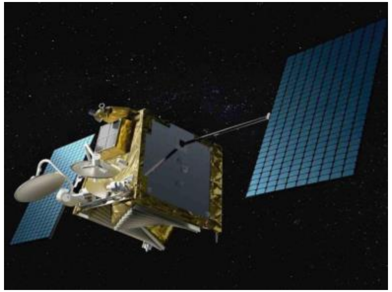
BARRIERS AND OPPORTUNITIES FOR SPACE APPLICATIONS

ULTRALIGHT LI-S CELLS FOR SPACE APPLICATIONS: BARRIERS

Launcher applications:

- High self-discharge
- High dependency of the capacity on the current rate

Spacecraft applications:

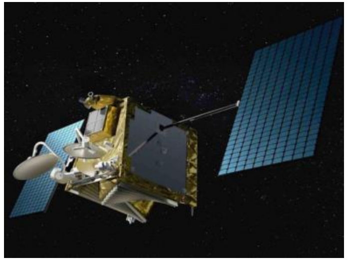


- Poor cyclability (only 98 cycles achieved at 20% DoD)
- High dependency of the capacity on the current rate

ULTRALIGHT LI-S CELLS FOR SPACE APPLICATIONS: OPPORTUNITIES

Launcher applications:

- Expected mass savings : + 20% to + 40%
- Increase of the versatility
- Capability to address new missions



Spacecraft applications:

- Mass savings : + 20% to + 40% for HAPS
- Increase of the versatility


Thank you for your attention
Any questions?