Evaluation of Lithium Polymer Technology for Small Satellite Applications

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15th August 2007

Introduction

- In 2003, ESA commissioned a study into the state of the art Lithium Polymer technology
- The main objectives of the study were to:
  - Identify space applications already using lithium ion technology that would benefit by switching technology.
  - To evaluate the state-of-the-art and their suitability for the identified applications
- The results point strongly to small to miniature spacecraft.

Study Structure

- Space applications
- Selection of 5 cells
- Evaluation of 5 cells

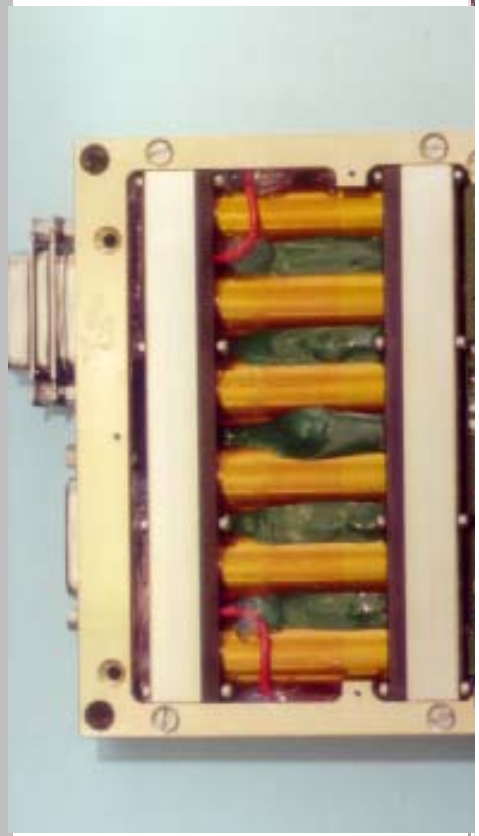
} Study by SSTL and ABSL

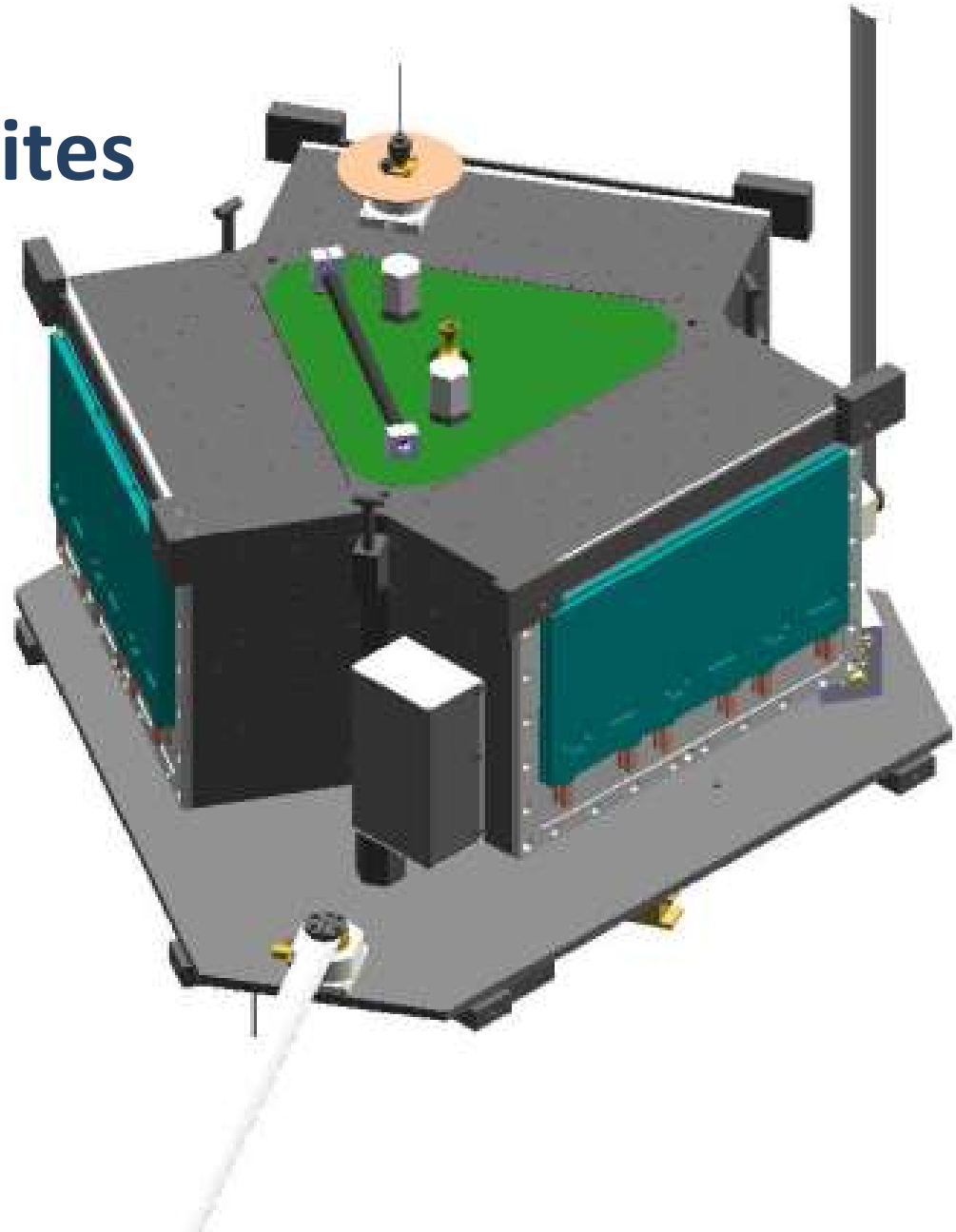
- Life Testing

} ESA Internal Testing

Potential Space Applications

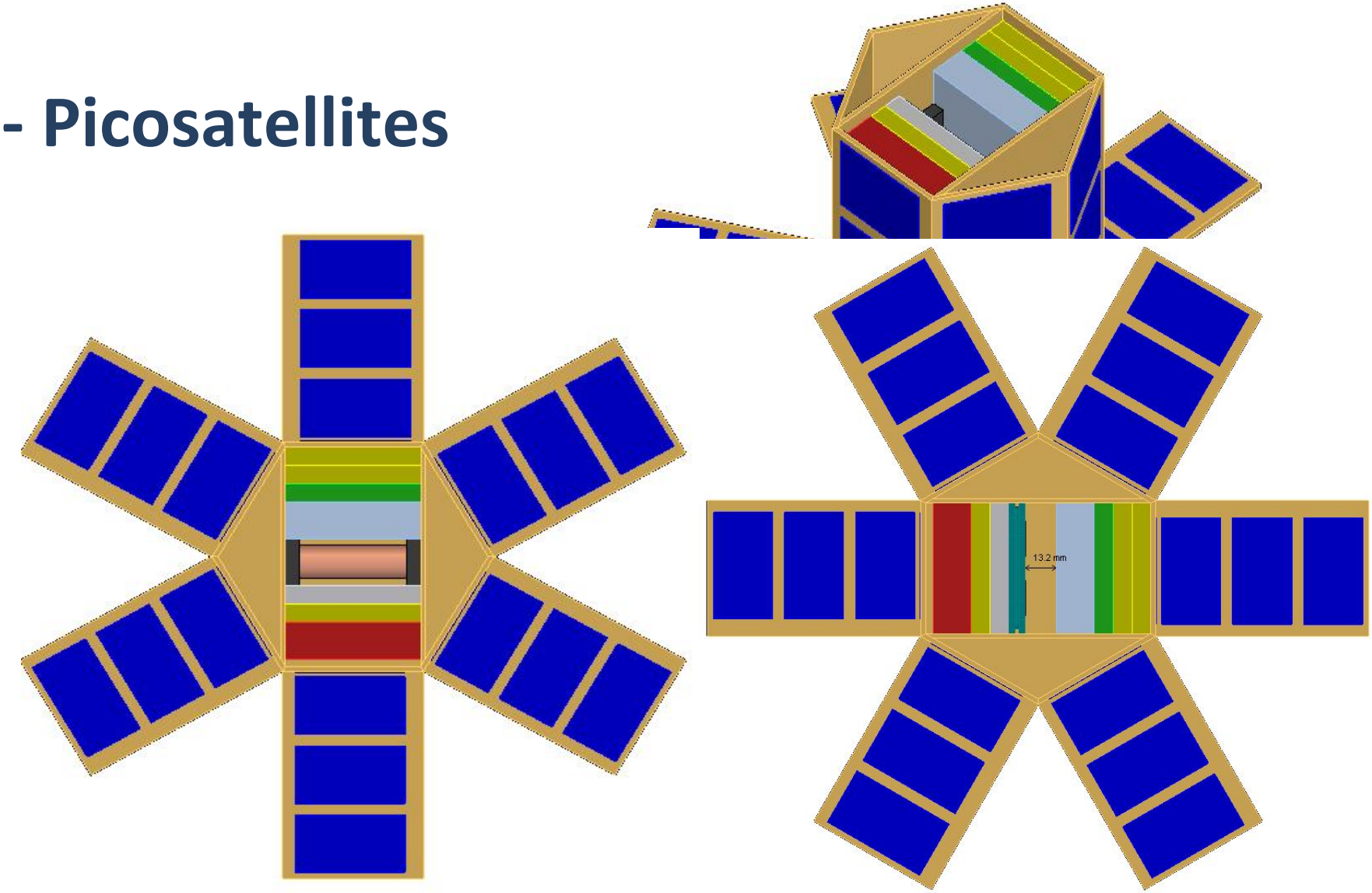
- Nanosatellites





Potential Space Applications

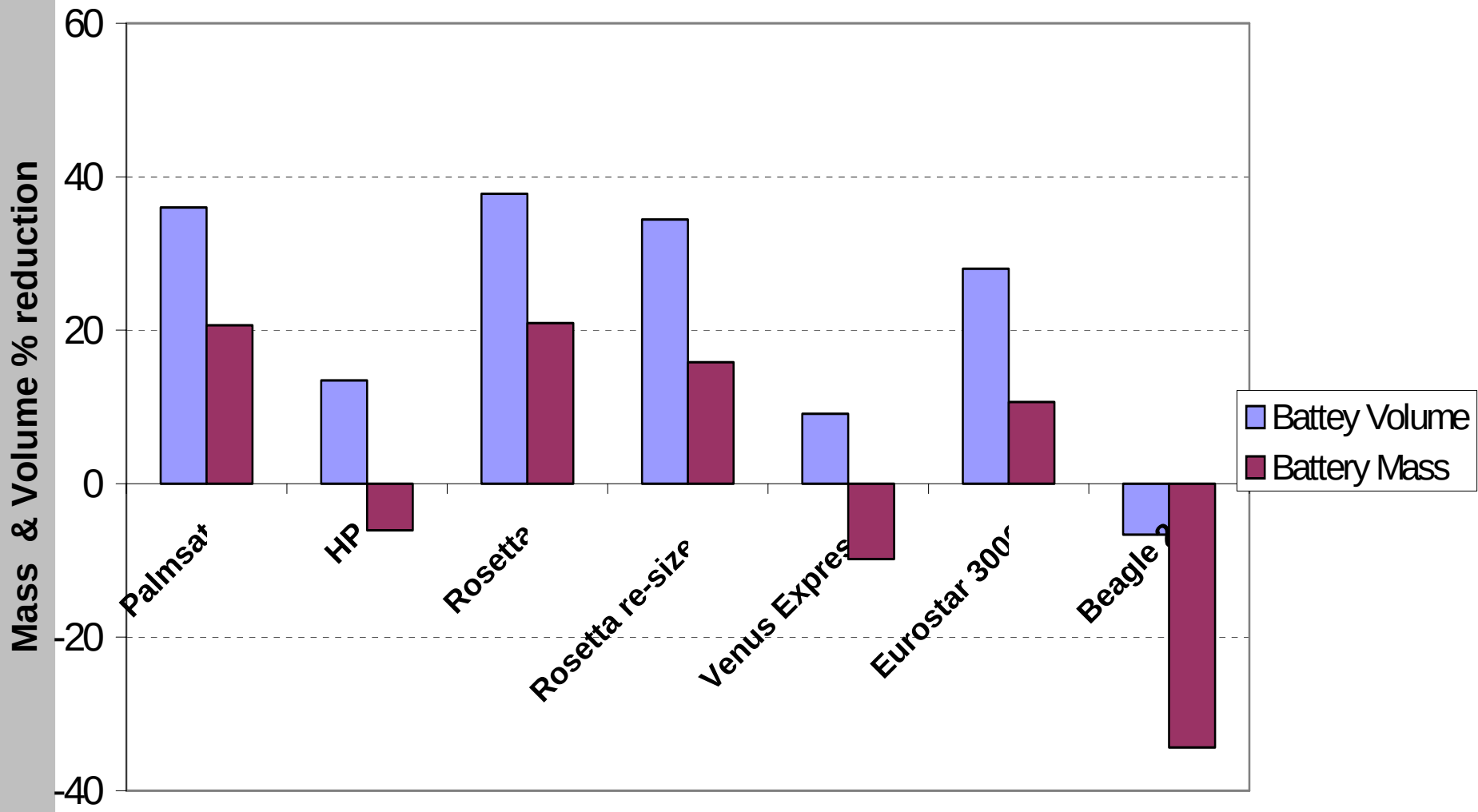
- Picosatellites



Comparative Performance Evaluation

- Palmsat
- Herschel Planck
- Rosetta (as flown)
- Rosetta (redesigned to optimise for Lithium Polymer)
- Venus Express
- Eurostar3000
- Beagle2

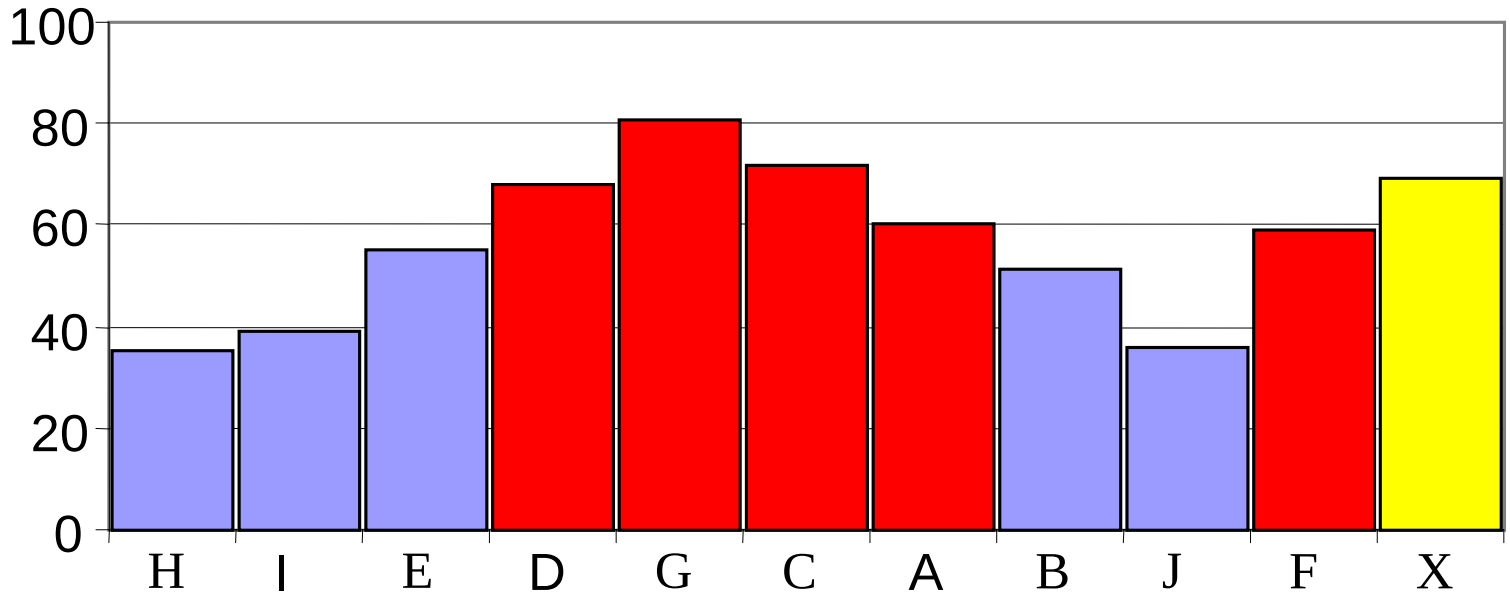
Comparative Performance Evaluation



Cell Selection

Evaluation Criteria	Weight	Scoring
Technical Energy Density Cycle Life Radiation Tolerance Outgassing	 10 5 10 5	Total of 30 points for technical
Survey Responsiveness	15	Willingness to participate in space applications
Commercial	20	Geopolitical factors, economic stability
Flexibility	10	Capability to manufacture different chemistry and size variants.
Manufacturing Volume	10	Favours small production volumes over prototyping/high vol.
Space Heritage	15	Cell heritage

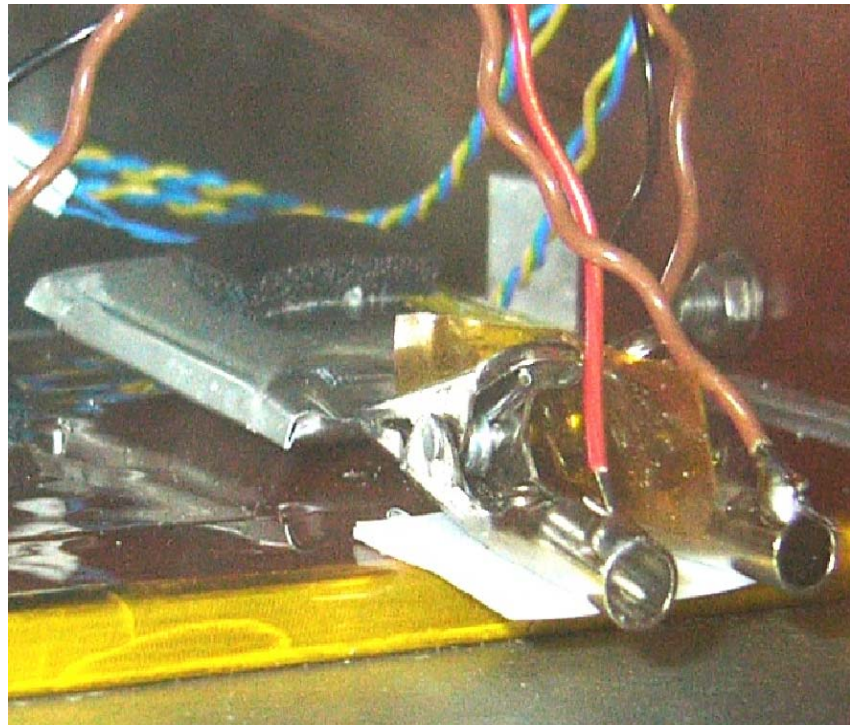
Cell Selection



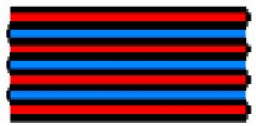
Code	Weight / g	Dimensions / mm	Capacity / A hr	Voltage / V	Energy Density / W hr kg^{-1}	/ W hr litre^{-1}
A	65.5	5.3 x 64.0 x 95.0	3.30	3.70	186	383
C	33.0	3.4 x 55.0 x 85.0	1.60	3.70	179	372
D	44.0	4.8 x 55.0 x 84.5	2.00	3.70	168	332
F	22.0	5.0 x 37.0 x 59.0	1.02	3.70	172	346
G	175	6.4 x 94.0 x 127.0	9.13	3.70	197	454

Evaluation Testing

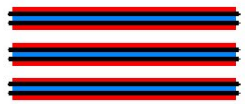
DPA
Vacuum
Radiation



A and C



D



F

G

60Co radiation test up to 500 Krad: No effect noticed

Evaluation Testing

Capacity (@ C/10)
Resistance
Self Discharge

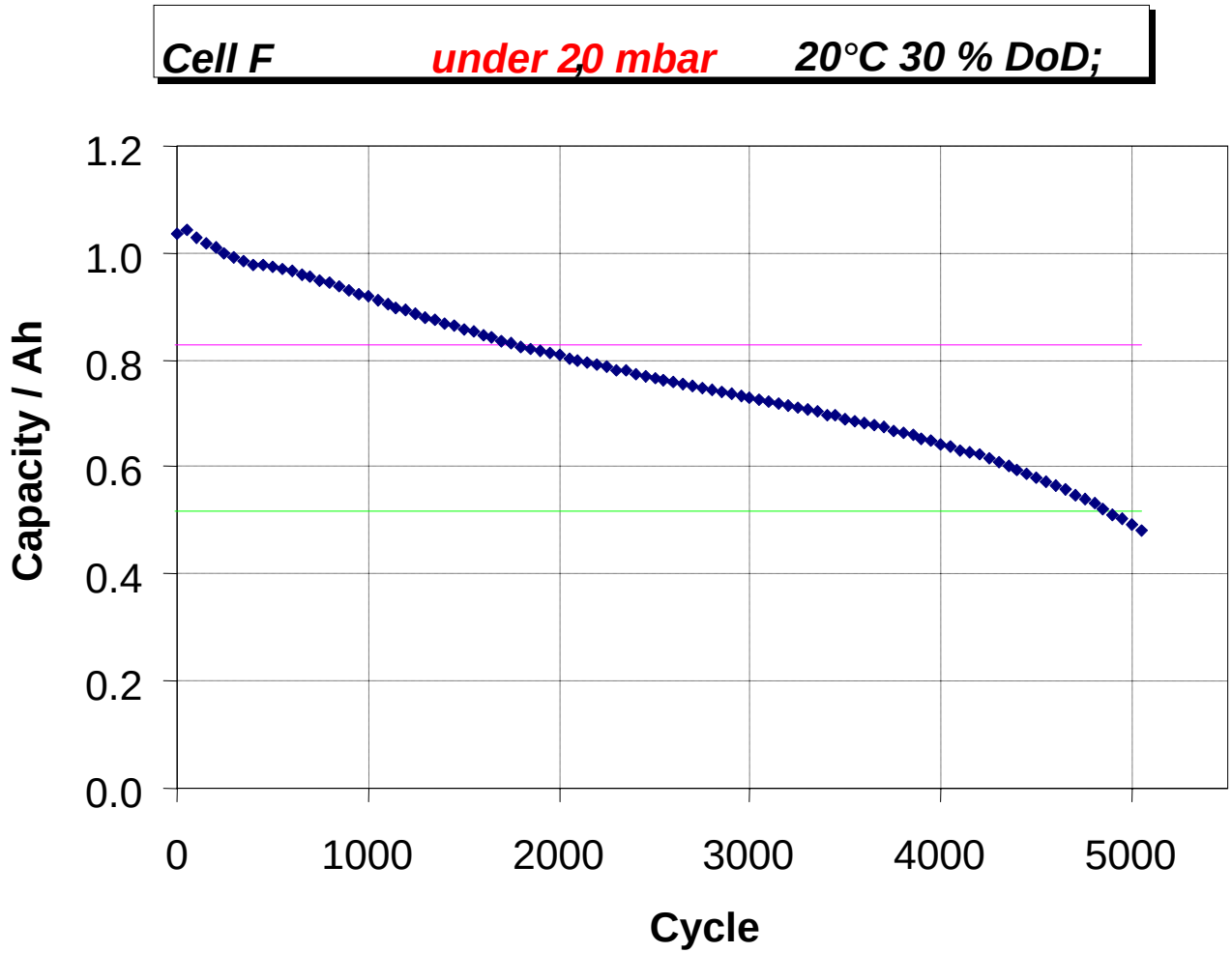
Test	24hr storage	-10ºC	0ºC	20ºC	40ºC
A	✓	✓	✓	✓✓	✓✓
C	✓	✓	✓✓	✓✓	✓✓
D	✓	✓	✓	✓✓	✓✓
F	✓	✓	✓✓	✓✓	✓✓
G	x	x	✓	✓✓	✓✓

Evaluation Testing

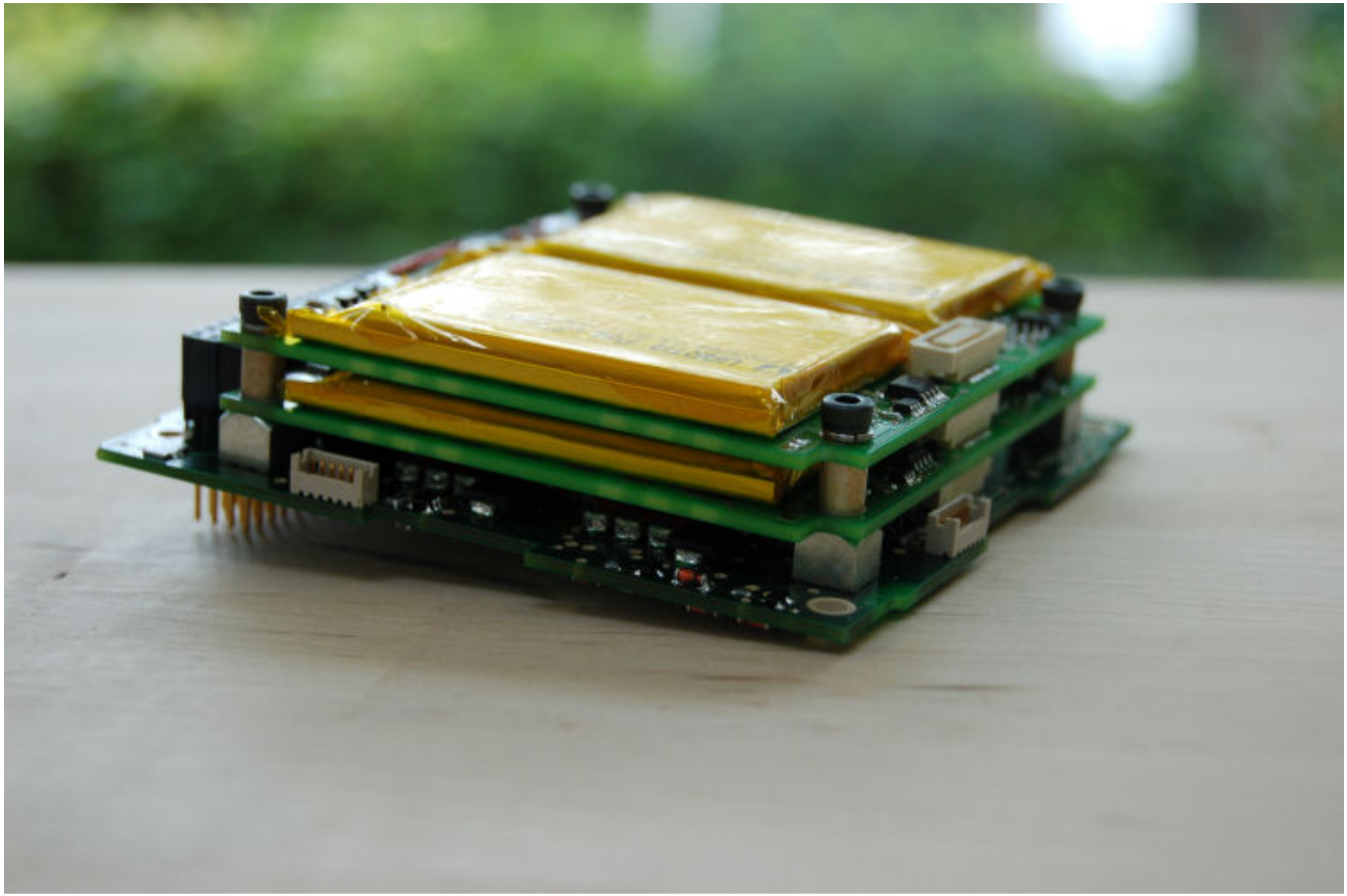
Test	A	C	D	F	G
Vacuum	x	x	x	✓	x
DPA	✓	✓	✓	✓	✓
Radiation	✓	✓	✓	✓	✓
Capacity	✓	✓✓	✓	✓✓	x
Resistance	✓	✓✓	✓	✓✓	x
Self discharge	✓	✓	✓	✓	x
Mission scenario	✓	✓	✓	✓	x
EMF vs SOC	✓	✓	✓	✓	✓

Life Testing

- Under reduced pressure (15-20 mbars)
- 30 % DoD cycling at 20°C, capacity check every 50 cycles.
- Discharge rate: C
- Charge rate: C/2 + tapering



Clyde Space CubeSat EPS with Integrated Lithium Polymer Battery



Conclusion

- Small and miniature spacecraft have been identified as applications where lithium polymer has significant advantages over lithium ion technology.
- From a technical perspective, the technology is ready for use on missions with a design life of at least one year.
- Clyde Space is continuing to develop the technology to prove longer mission life capability and more variety in battery configurations.
- Please visit if you are in Scotland:
  - IAC2008 is in Glasgow!!