Supercapacitor Supply chain

ESCCON 2021

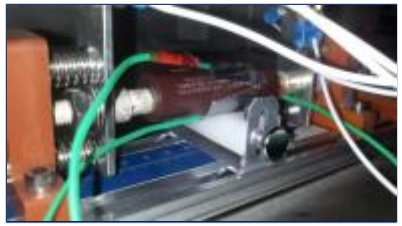
DEFENCE AND SPACE

Gabriel Beulaguet
09/11/21

AIRBUS

Introduction

- **Overview**



R&T and new energy technology research

Lithium-ion technology
Lithium-Sulfur and Lithium-Metal technology
Super-capacitors
Li-cap

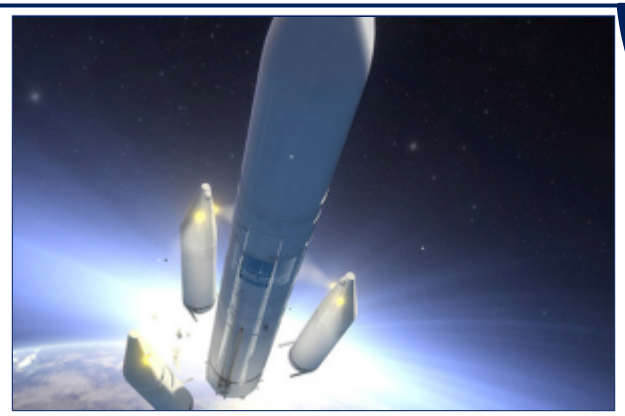
Innovation

Structural batteries
New energy storage
New Battery Management System

TESED

Battery System for Airbus DS

NeoSat
Ariane 6
OneWeb
New Space



Aeronautics

Demonstrators for CTO
Demonstrators for A3
Airbus Helicopters
Airbus Aircraft
Urban Air Mobility

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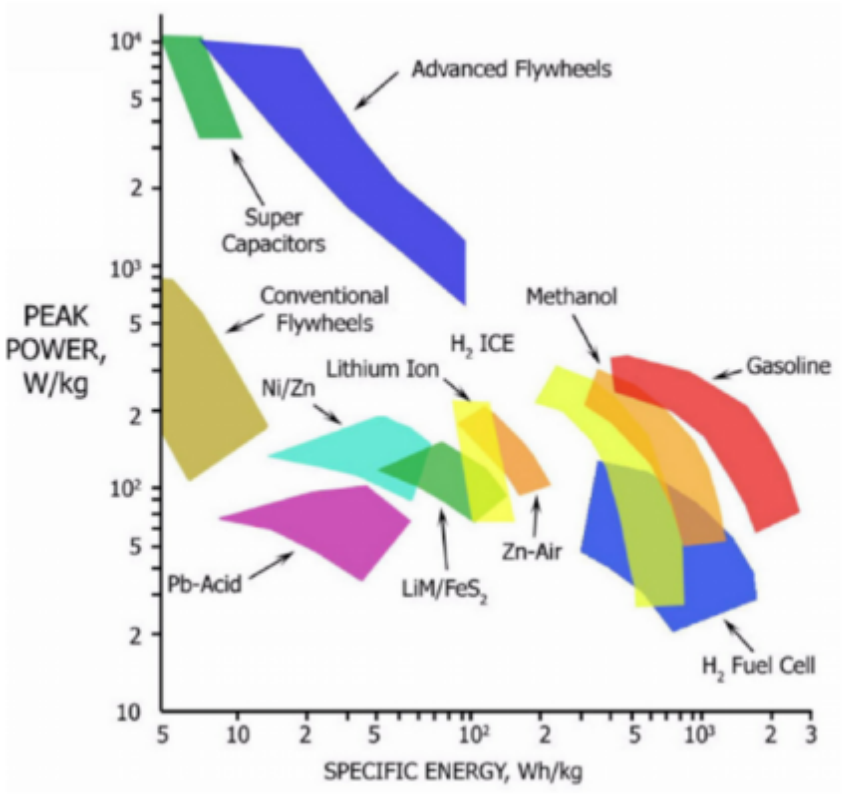
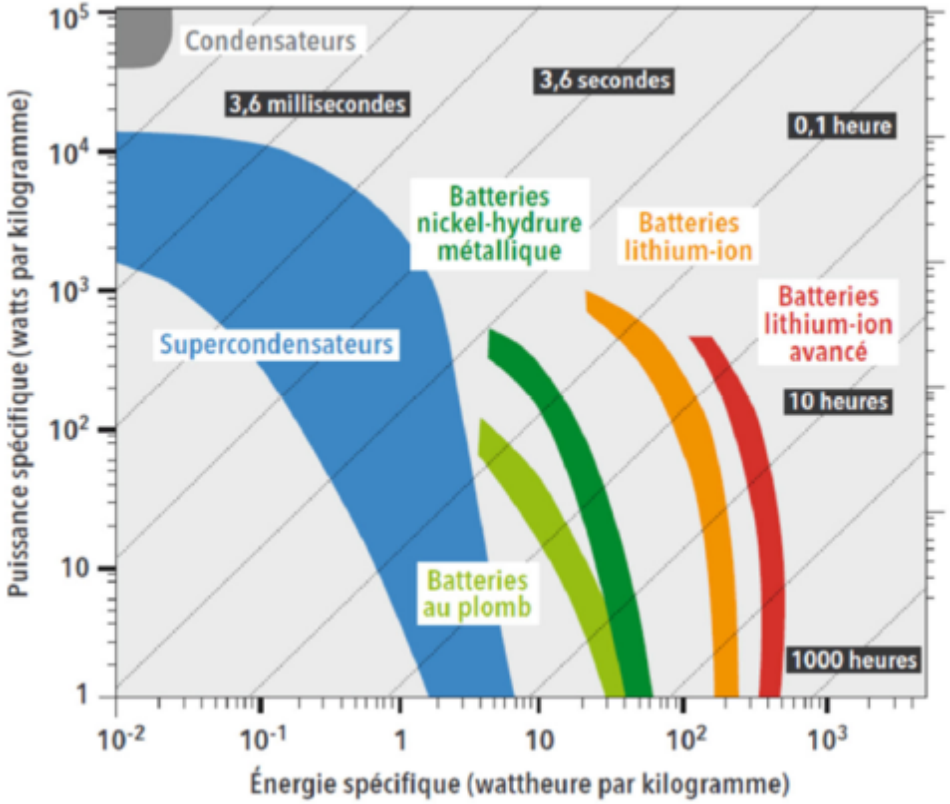
Introduction

- **Cells techno**





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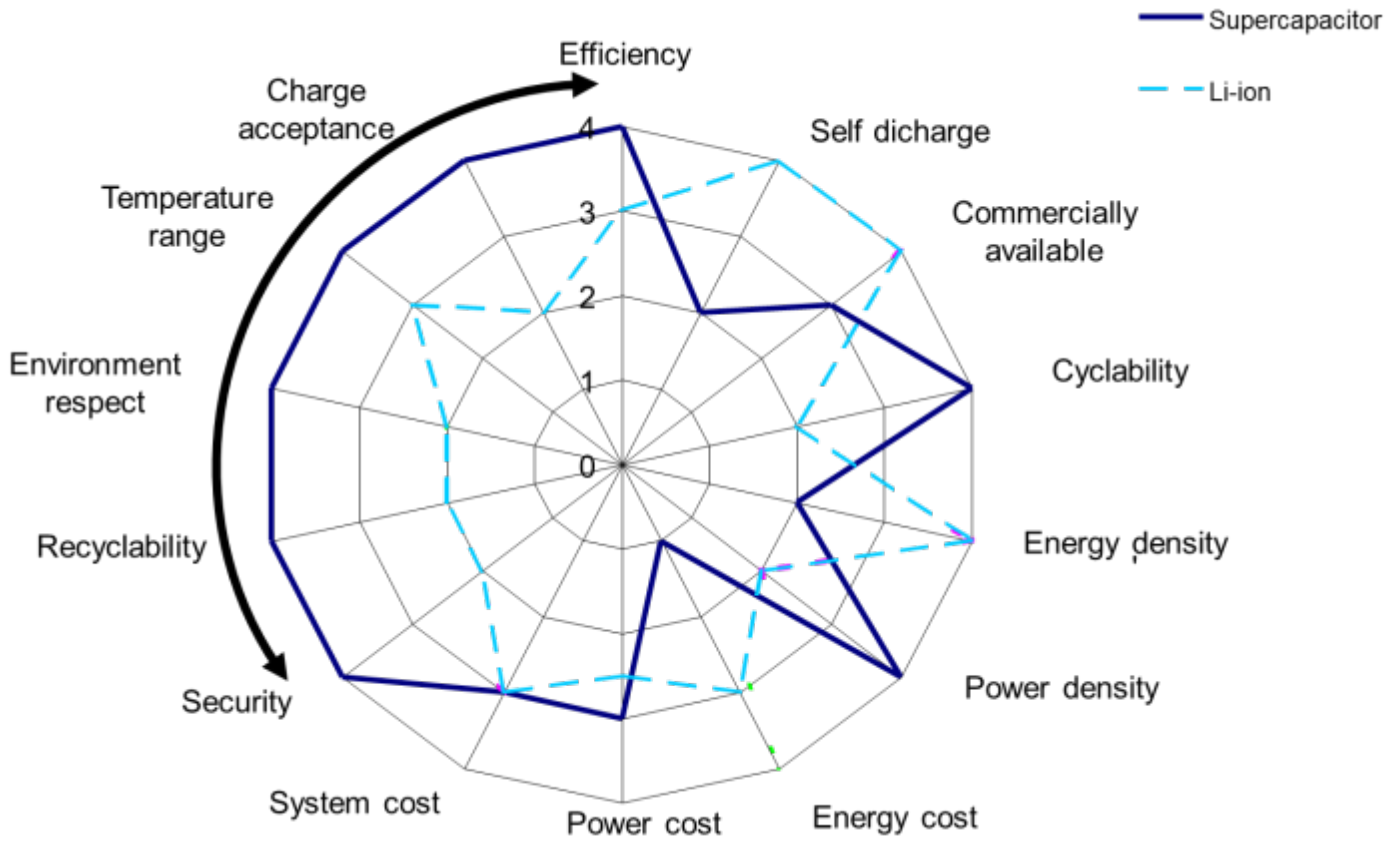
Introduction

- Satellite and launchers power subsystems are based on batteries (State of the Art = Li-ion), source of energy.
- For some applications, oversizing of the battery on power peaks → embarked mass increase
- Supercapacitor fills the gap between batteries and capacitors, featuring very high power density (up to 100kW/kg) with lower stored energy than that of batteries (up to 7 Wh/kg).



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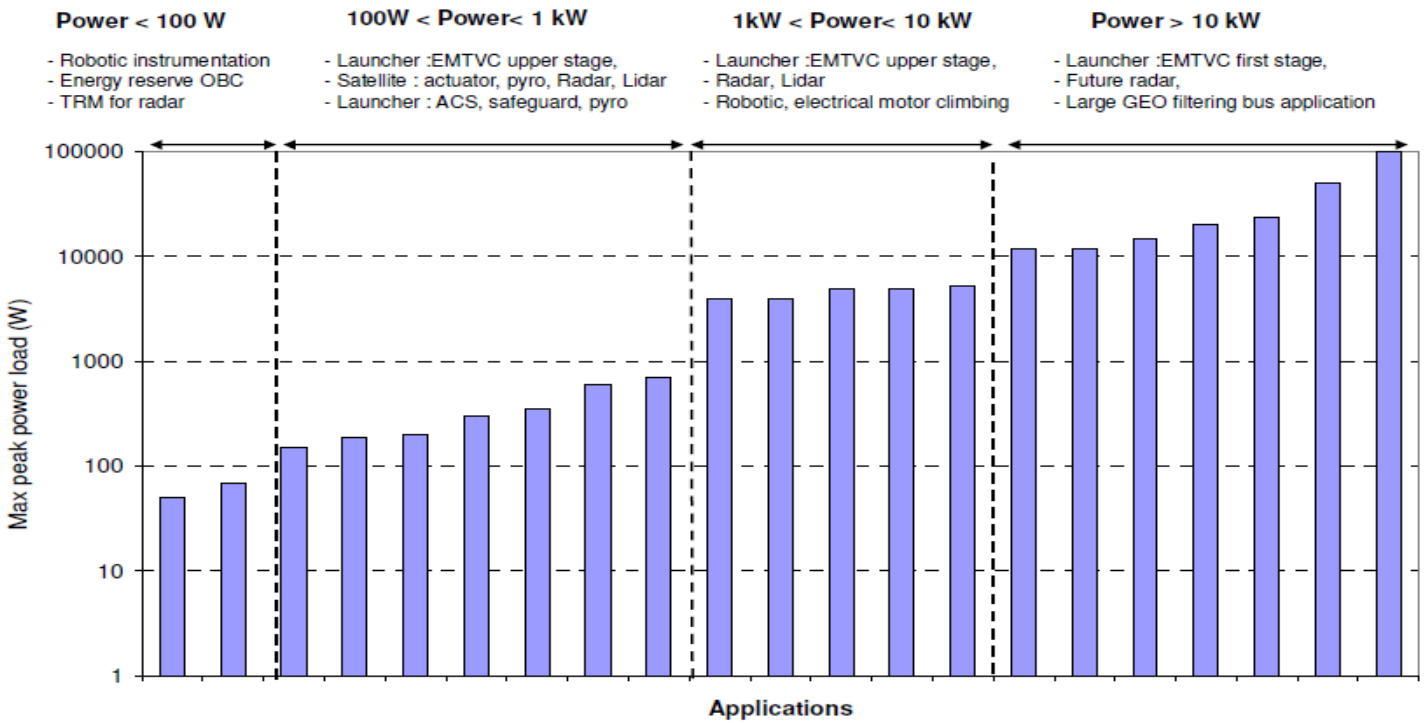
Introduction

- ESA Study Contract No. 21814/08/NL/LvH entitled “High Power Battery Supercapacitor study” completed in 2010
- Potential space applications for supercapacitors:



- Supercapacitors have the potential for hybridization with batteries (power peaks < 10s)

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Agenda

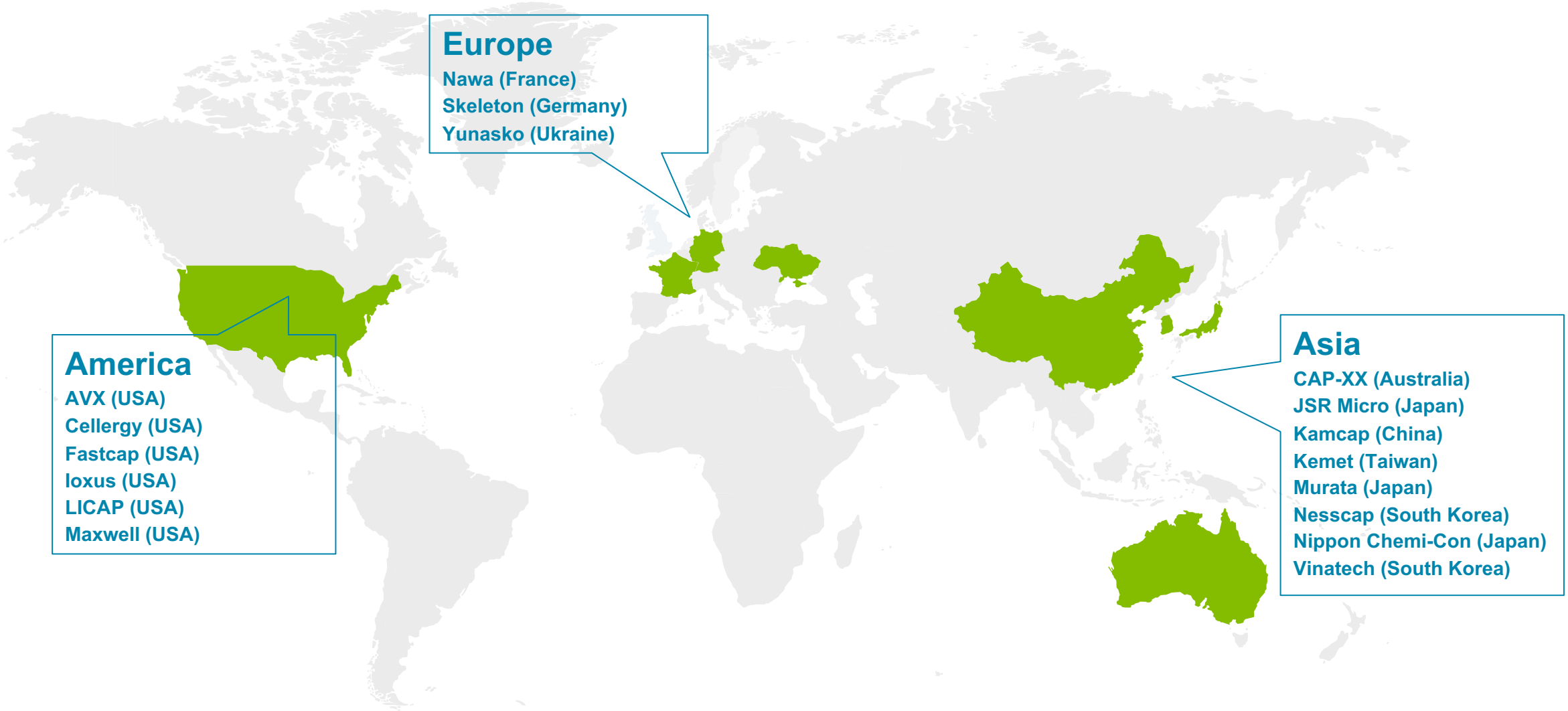
Supercapacitor market

- Geographic mapping
- Nesscap selection
- Company takeover

Supply chain establishment

- Consortium
- ESA study
- Status

Supercapacitor Market – Geographic mapping



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Supercapacitor Market – Nesscap Selection

- Components with capacitance of tenth of Farad are identified to cope with the most promising applications

Cap XX®
HS130 (2.4 F)

Maxwell®
PC10 (10 F)

Nesscap®
EHSR 0010C0-002R7 (10 F)

Maxwell®
BCAP0010 P270

	Cap XX® HS130	Maxwell ® PC10	Nesscap ® EHSR 0010C0-002R7	Maxwell ® BCAP0010 P270
Capacitance BoL	1.92F–2.88F	9F-12F	9F-12F	8F-12F
DC ESR BoL	< 31 mΩ	< 180 mΩ	< 34mOhms	< 80mOhms
AC ESR BoL	-	-	< 26mOhms	< 60mOhms
Rated voltage	2.75V	2.5V	2.7V	2.7V
Absolute Maximum Voltage	2.75V	2.7V	2.85V	2.85V
Maximum RMS Current	6A	-	-	-
Maximum Continuous Current @ ΔT = 15°C	-	2.4A	3.4A	2.2A
Maximum Continuous Current @ ΔT = 40°C	-	3.8A	5.6A	3.5A
Leakage Current	< 5µA	< 40µA	< 23µA	< 30µA

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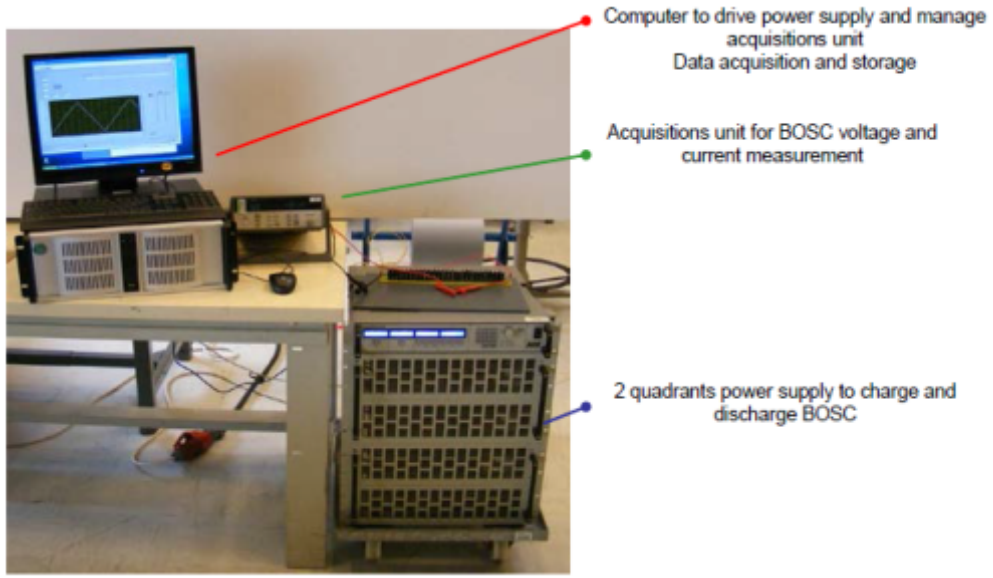
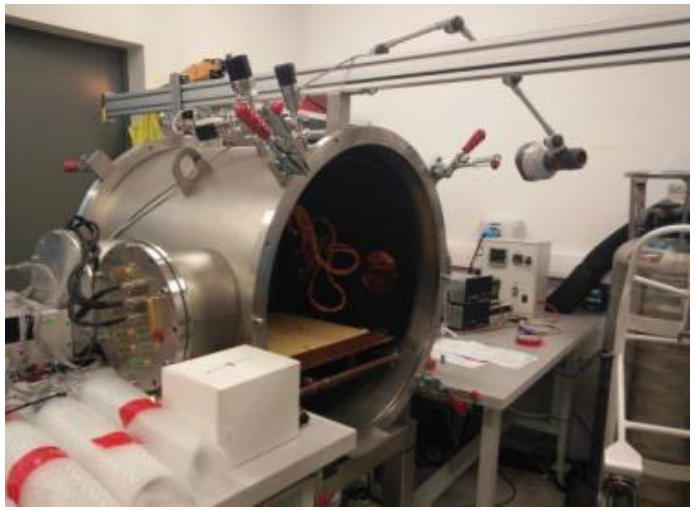
Supercapacitor Market – Nesscap Selection

- Supercap evaluation performed on several components in:
  - ESA project
  - TESED internal R&T
- Development of supercap test facilities in Airbus D&S electrical lab
- Supercap test campaigns in Airbus D&S electrical lab



Supercap test bench developed in Airbus DS electrical lab

Long duration primary vacuum



Short duration deep vacuum

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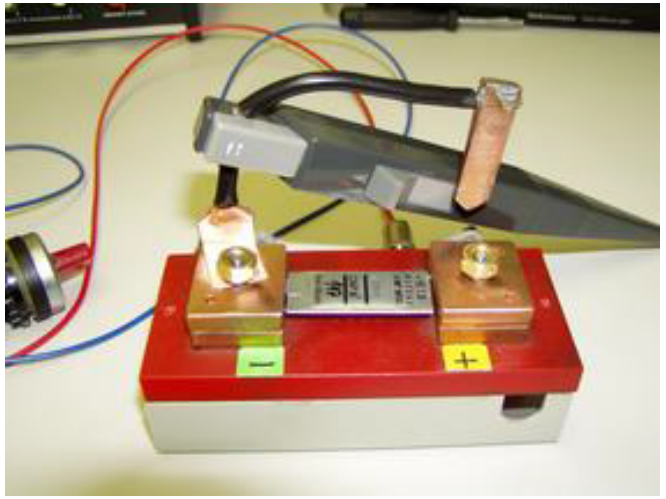
Supercapacitor Market – Nesscap Selection

- Mechanical, thermal and electrical tests

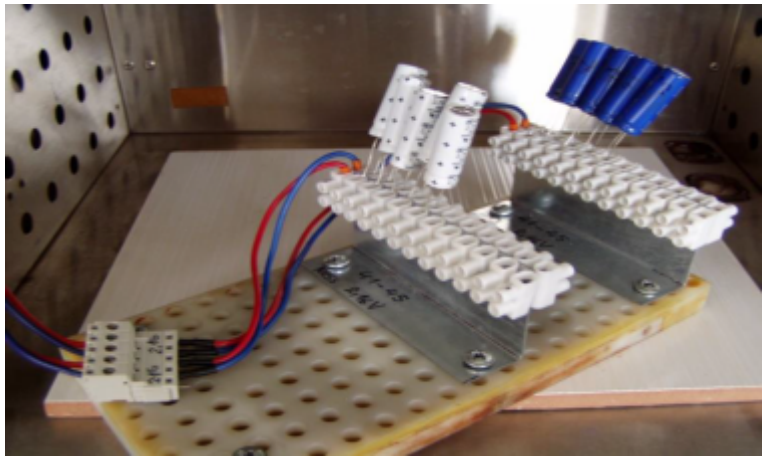
Mechanical tests



Abusive tests

Floating life tests

Thermal tests



Cycle life tests

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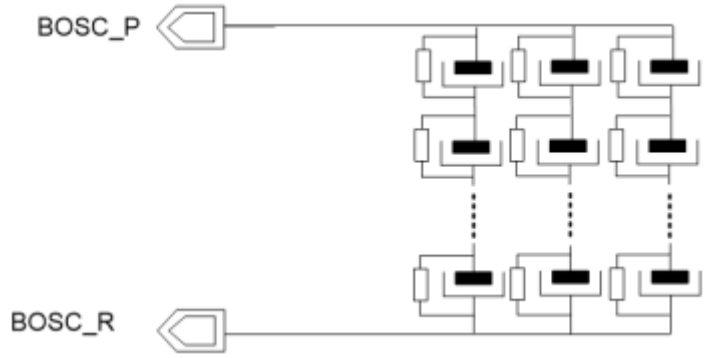
Supercapacitor Market – Nesscap Selection

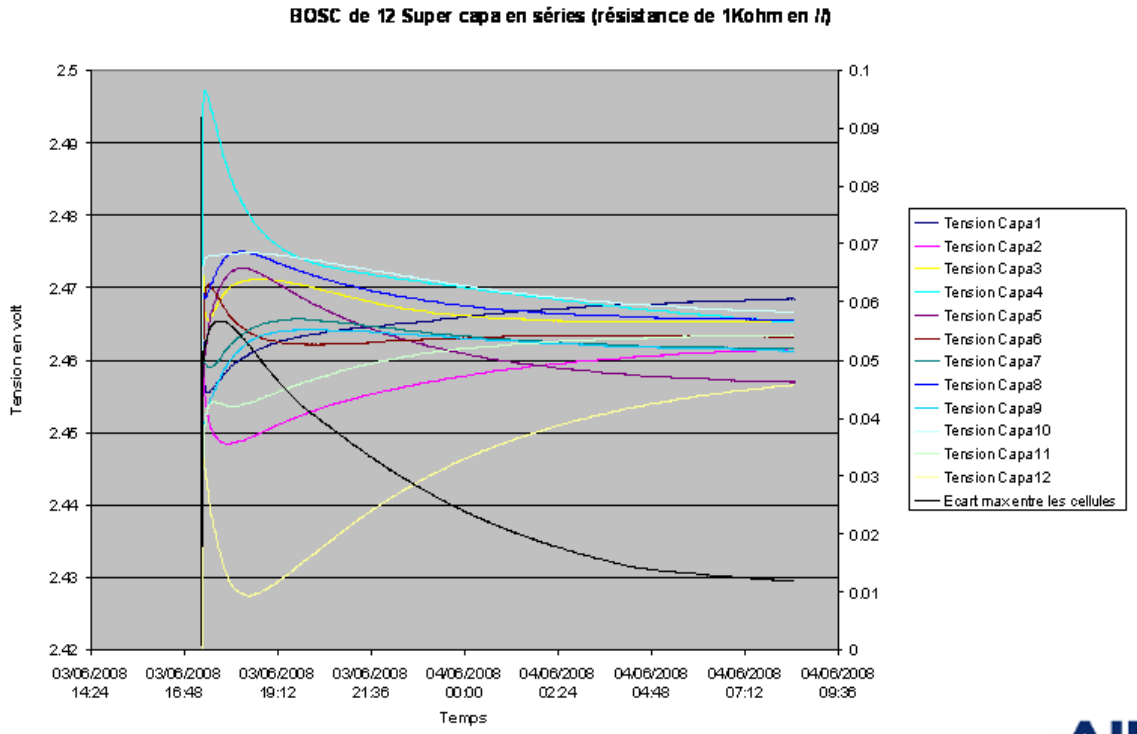
- Demonstrate the suitability of supercapacitors assembled in battery (3P34S)

BOSC assembly



BOSC architecture

- Static balancing using resistors



BOSC balancing

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Supercapacitor Market – Nesscap Selection

- COTS supercapacitors: interest and suitability for space applications

- In particular, excellent performances of Nesscap® 10F in terms of:
  - ageing (when submitted to life test and space environments including vacuum at both cell and system levels and enabled to identify the part as a good candidate for future space qualification.

- In 2015, Nesscap® has improved the sealing performance of the 10F part (ESHSR-0010C0-002R7**UC** – XP products family).
  This product is mass produced and commercially available since April 2016 and will be maintained in production at least up to 2021.
  Moreover, in case of any change in the material, process or design of the part, Nesscap® will submit a PCN for approval.

- In 2015, GSTP6.2 proposal initiated by Airbus D&S selected by ESA to qualify Nesscap 10F supercapacitor and associated BOSC

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Supercapacitor Market – Company takeover

2007. Nesscap Energy company is founded

2014. Collaboration started between Airbus DS and Nesscap motivated by an ESA study. Product selected and guaranteed for long term production

2017. Nesscap becomes Maxwell but the factory remains in South Korea. And Nesscap products don't change.

2019. Maxwell is taken over by Tesla. But no impacts on Maxwell in terms of supercapacitor activities

NESSCAP ULTRACAPACITORS

POWERED TO MOVE

Nesscap Energy GmbH
Bearingarten 4
D-88630 Schondorf
Germany

Jürgen Auer
VP EMEA Sales & Business Development
Managing Director

Phone: +49 8192 9969420
Mobile: +49 1728657027
E-Mail: ja.auer@nesscap-energy.de

http://www.nesscap.com/

Airbus Defence & Space SAS
Att: Mr. Bertrand Faure
31, Avenue des cosmonautes
31 402 Toulouse Cedex
France

1.JUNE 2015

Assurance of Production Continuity of Nesscap 10F products

Hallo Mr. Faure,

Thank you for all the discussion regarding our ultracapacitor products.

Concerning the assurance of production continuity of our Nesscap 10F products we hereby agree as follows:

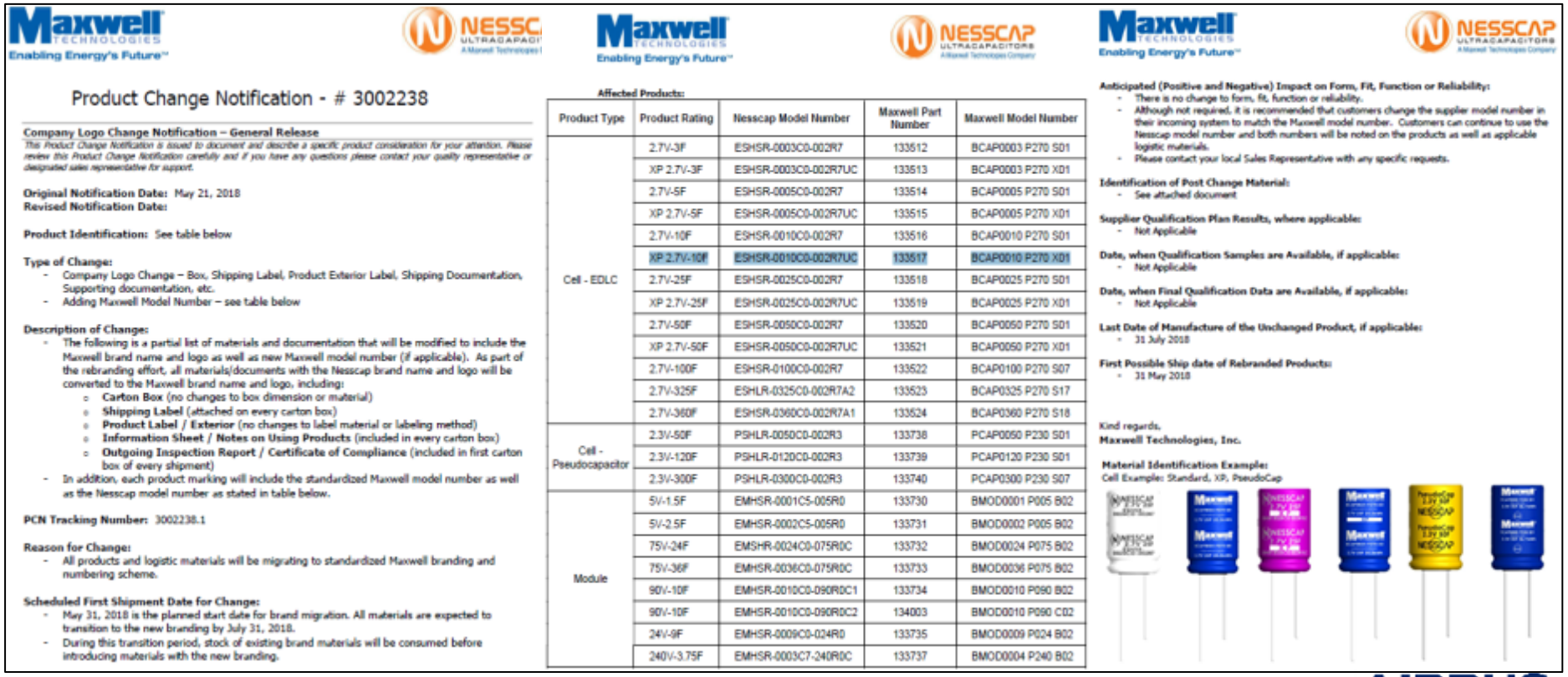
- To continue the production of the components listed hereunder until at least January 2021:
  - 10 F Supercapacitor, 2.7V 10 F, reference ESHSR-0010C0-002R7
  - 10 F Supercapacitor, 2.7V 10 F, reference ESHSR-0010C0-002R71
- Any intention to discontinue production will be notified as a minimum 18 months prior to the planned end date and opportunity provided for a last time buy.
- Any change in the process affecting the form, fit and function, shall be managed by a PCN according to TS16949 requirement and agreed by Airbus Defence and Space.
- In case of obsolescence of one of the elements or compound, affecting the performance of the component or the qualification status, Nesscap shall inform Airbus Defence and Space as soon as possible.

In case you have here any questions please feel free to ask.

Best regards

Robert Thesser
Chief Business Development Officer

Jürgen Auer
Managing Director & VP EMEA Sales & Biz.Dev.



Maxwell TECHNOLOGIES
Enabling Energy's Future™

NESSCAP ULTRACAPACITORS

Product Change Notification - # 3002238

Company Logo Change Notification – General Release

This Product Change Notification is issued to document and describe a specific product consideration for your attention. Please review this Product Change Notification carefully and if you have any questions please contact your quality representative or designated sales representative for support.

Original Notification Date: May 21, 2018
Revised Notification Date:

Product Identification: See table below

Type of Change:
- Company Logo Change – Box, Shipping Label, Product Exterior Label, Shipping Documentation, Supporting documentation, etc.
- Adding Maxwell Model Number – see table below

Description of Change:
- The following is a partial list of materials and documentation that will be modified to include the Maxwell brand name and logo as well as new Maxwell model number (if applicable). As part of the rebranding effort, all materials/documents with the Nesscap brand name and logo will be converted to the Maxwell brand name and logo, including:
  - **Carton Box** (no changes to box dimension or material)
  - **Shipping Label** (attached on every carton box)
  - **Product Label / Exterior** (no changes to label material or labeling method)
  - **Information Sheet / Notes on Using Products** (included in every carton box)
  - **Outgoing Inspection Report / Certificate of Compliance** (included in first carton box of every shipment)
- In addition, each product marking will include the standardized Maxwell model number as well as the Nesscap model number as stated in table below.

PCN Tracking Number: 3002238.1

Reason for Change:
- All products and logistic materials will be migrating to standardized Maxwell branding and numbering scheme.

Scheduled First Shipment Date for Change:
- May 31, 2018 is the planned start date for brand migration. All materials are expected to transition to the new branding by July 31, 2018.
- During this transition period, stock of existing brand materials will be consumed before introducing materials with the new branding.

Affected Products:

Product Type	Product Rating	Nesscap Model Number	Maxwell Part Number	Maxwell Model Number
Cell - EDLC	2.7V-3F	ESHSR-0003C0-002R7	133512	BCAP0003 P270 S01
	XP 2.7V-3F	ESHSR-0003C0-002R7UC	133513	BCAP0003 P270 X01
	2.7V-5F	ESHSR-0005C0-002R7	133514	BCAP0005 P270 S01
	XP 2.7V-5F	ESHSR-0005C0-002R7UC	133515	BCAP0005 P270 X01
	2.7V-10F	ESHSR-0010C0-002R7	133516	BCAP0010 P270 S01
	XP 2.7V-10F	ESHSR-0010C0-002R7UC	133517	BCAP0010 P270 X01
	2.7V-25F	ESHSR-0025C0-002R7	133518	BCAP0025 P270 S01
	XP 2.7V-25F	ESHSR-0025C0-002R7UC	133519	BCAP0025 P270 X01
	2.7V-50F	ESHSR-0050C0-002R7	133520	BCAP0050 P270 S01
	XP 2.7V-50F	ESHSR-0050C0-002R7UC	133521	BCAP0050 P270 X01
	2.7V-100F	ESHSR-0100C0-002R7	133522	BCAP0100 P270 S07
	2.7V-325F	ESHLR-0325C0-002R7A2	133523	BCAP0325 P270 S17
	2.7V-360F	ESHSR-0360C0-002R7A1	133524	BCAP0360 P270 S18
Cell - Pseudocapacitor	2.3V-50F	PSHLR-0050C0-002R3	133738	PCAP0050 P230 S01
	2.3V-120F	PSHLR-0120C0-002R3	133739	PCAP0120 P230 S01
	2.3V-300F	PSHLR-0300C0-002R3	133740	PCAP0300 P230 S07
Module	5V-1.5F	EMHSR-0001C5-005R0	133730	BMOD0001 P005 B02
	5V-2.5F	EMHSR-0002C5-005R0	133731	BMOD0002 P005 B02
	75V-24F	EMSHR-0024C0-075R0C	133732	BMOD0024 P075 B02
	75V-36F	EMHSR-0036C0-075R0C	133733	BMOD0036 P075 B02
	90V-10F	EMHSR-0010C0-090R0C1	133734	BMOD0010 P090 B02
	90V-10F	EMHSR-0010C0-090R0C2	134003	BMOD0010 P090 C02
	24V-9F	EMHSR-0009C0-024R0	133735	BMOD0009 P024 B02
	240V-3.75F	EMHSR-0003C7-240R0C	133737	BMOD0004 P240 B02

Anticipated (Positive and Negative) Impact on Form, Fit, Function or Reliability:
- There is no change to form, fit, function or reliability.
- Although not required, it is recommended that customers change the supplier model number in their incoming system to match the Maxwell model number. Customers can continue to use the Nesscap model number and both numbers will be noted on the products as well as applicable logistic materials.
- Please contact your local Sales Representative with any specific requests.

Identification of Post Change Material:
- See attached document

Supplier Qualification Plan Results, where applicable:
- Not Applicable

Date, when Qualification Samples are Available, if applicable:
- Not Applicable

Date, when Final Qualification Data are Available, if applicable:
- Not Applicable

Last Date of Manufacture of the Unchanged Product, if applicable:
- 31 July 2018

First Possible Ship date of Rebranded Products:
- 31 May 2018

Kind regards,
Maxwell Technologies, Inc.

Material Identification Example:
Cell Example: Standard, XP, PseudoCap

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Agenda

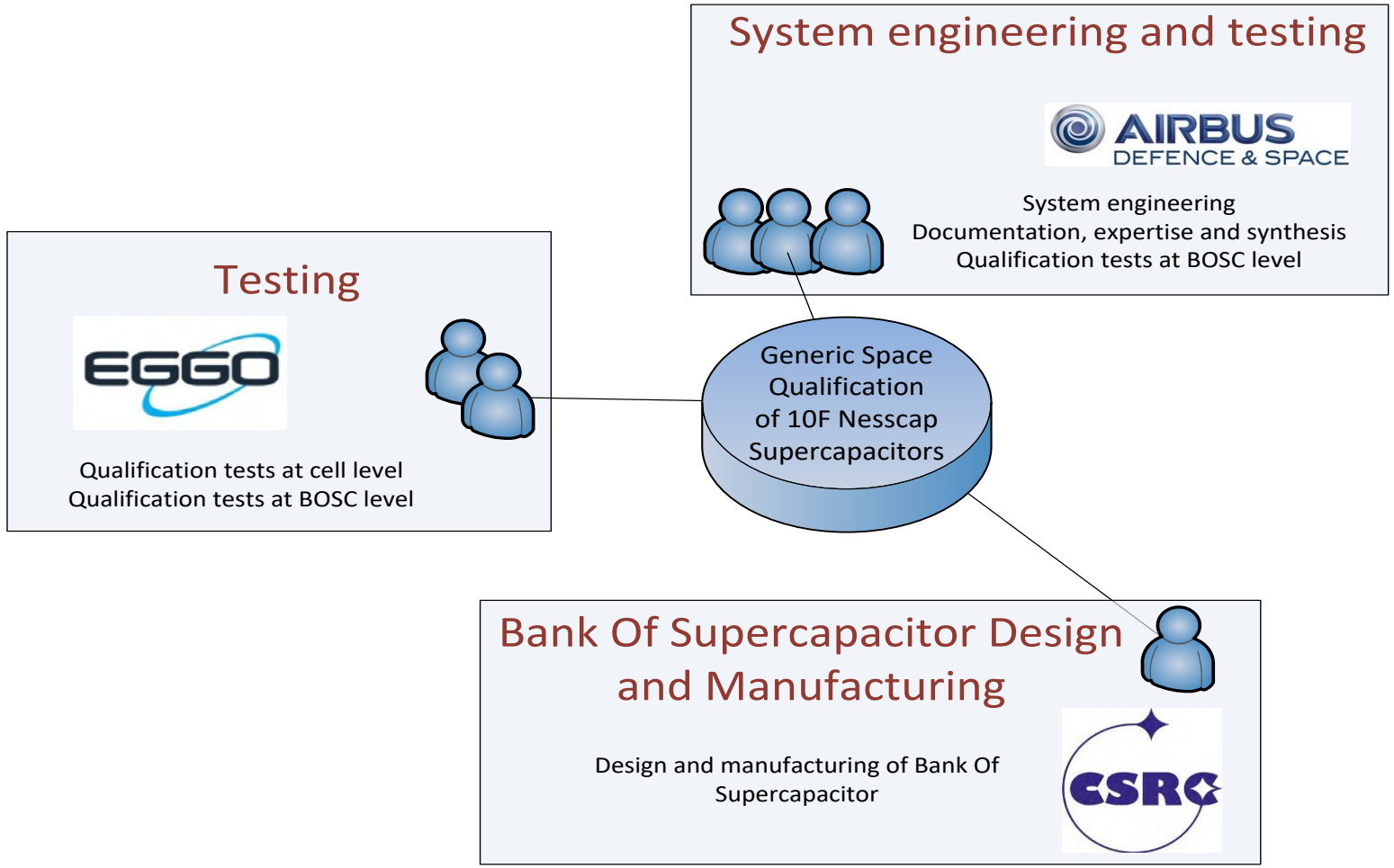
Supercapacitor market

- Geographic mapping
- Nesscap selection
- Company takeover

Supply chain establishment

- Consortium with European companies
- ESA study
- Status

Supply Chain Establishment – Consortium



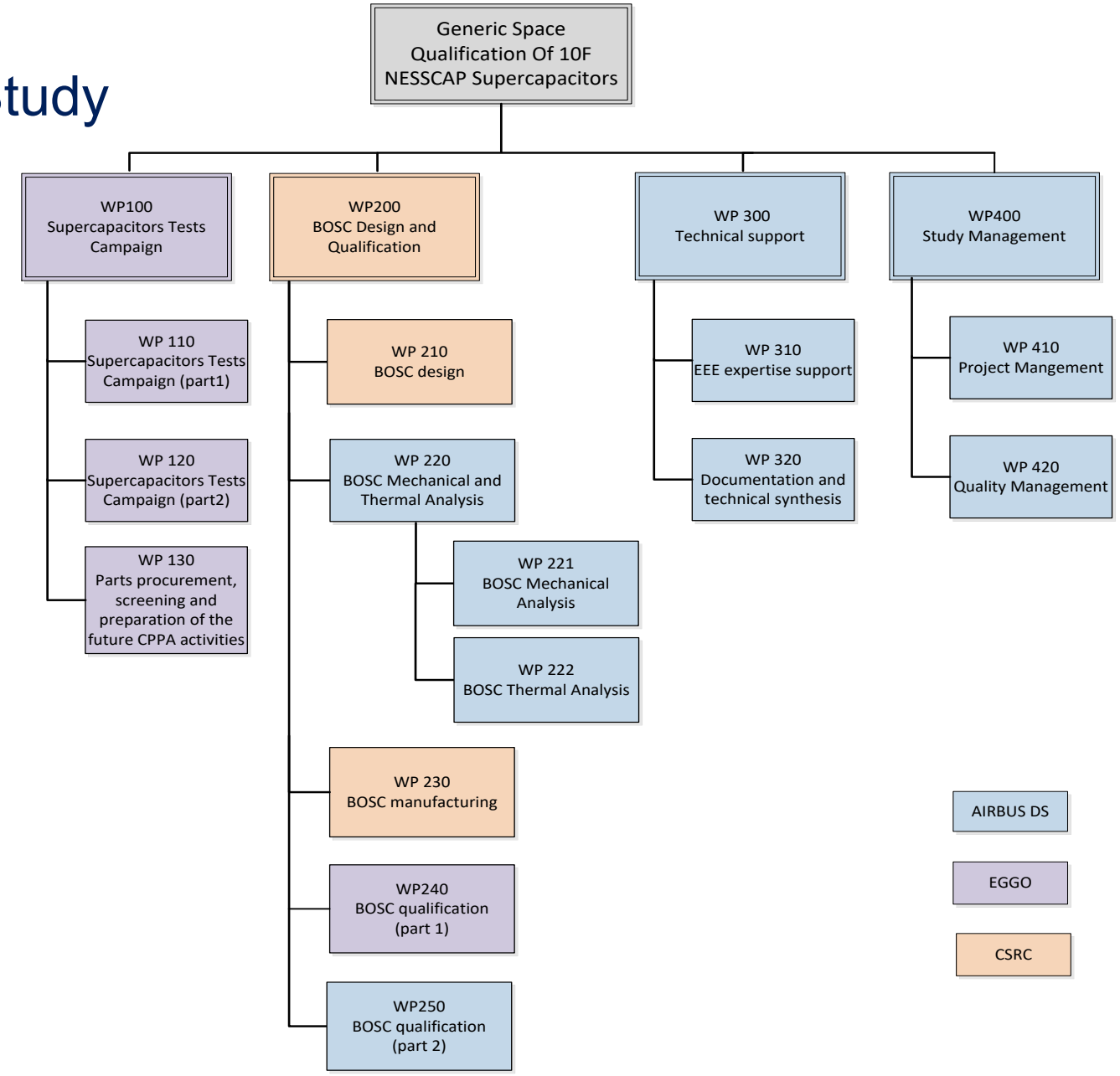
1. **Airbus D&S**
   - Prime on the project
   - Documentation, expertise, synthesis
   - BOSC electrical tests campaign

2. **BD Sensors (former CSRC)**
   - BOSC design
   - BOSC manufacturing
   - BOSC acceptance tests

3. **EGGO Space**
   - Procurement of supercapacitors
   - Supercapacitors tests campaign
   - BOSC mechanical tests campaign

Supply Chain Establishment – ESA Study

- **4 Work Packages**
  - WP100 owned by EGGO Space
  - WP200 owned by BD Sensors (ex CSRC)
  - WP300 & WP400 owned by ADS



Supply Chain Establishment – ESA Study

- Supercapacitor is a product which fills the gap between batteries and capacitor. Its electric performances in power peak make it possible to optimize our functions of distribution and order.
- Major drawback is a calendar deterministic ageing which depends on the temperature and the charging voltage. It is manageable by applying derating in voltage and limiting the use temperature to 40°C.
- R&T activities necessary to improve power density and high temperature lifetime

2000

Achievement of ESA study Survey of Required Characteristics for Super Capacitors in Space applications

2000-2010

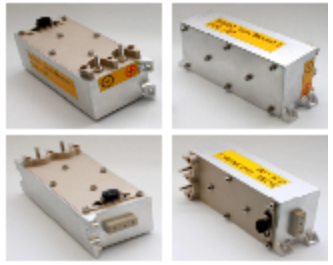
Internal survey of supercapacitors

2010

Achievement of ESA study High Power Battery Supercapacitor study.
Identification of best candidates.

2014

Achievement of ESA study under the lead of EGGO (Czech republic) “Evaluation of supercapacitor and impacts at system level” (**COTS approach)**
BOSC EM manufacturing and test



2015 - 2016

Test campaign of **Nesscap 10F** components under **vacuum**

2015-2020

ESA Study
Test campaign on **Nesscap 10F** for the entry in ESA **EPPL** Part II
Qualification of BOSC unit

2021 - …

Space and Aero applications.

timeline

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Conclusion and next steps

- Most of supercapacitor manufacturers located in Asia and USA
- Implementation of a supply chain in Europe between Eggo Space, BD Sensors and Airbus Defence and Space in order to manufacture BOSCs for Space applications.

- Nesscap ESHSR-0010C0-002R7UC is the first supercapacitor space qualified (into the EPPL II ESA).
- BOSC based on this supercapacitor is a space qualified product
- Integration of this BOSC in equipment that will take part of a new project ➔ 17 BOSC to be manufactured

- This equipment is baselined in others RFP
- The goal is to increase the number of supercapacitors space qualified in order to cover other applications and mission profiles

Thank you
Any questions ?

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