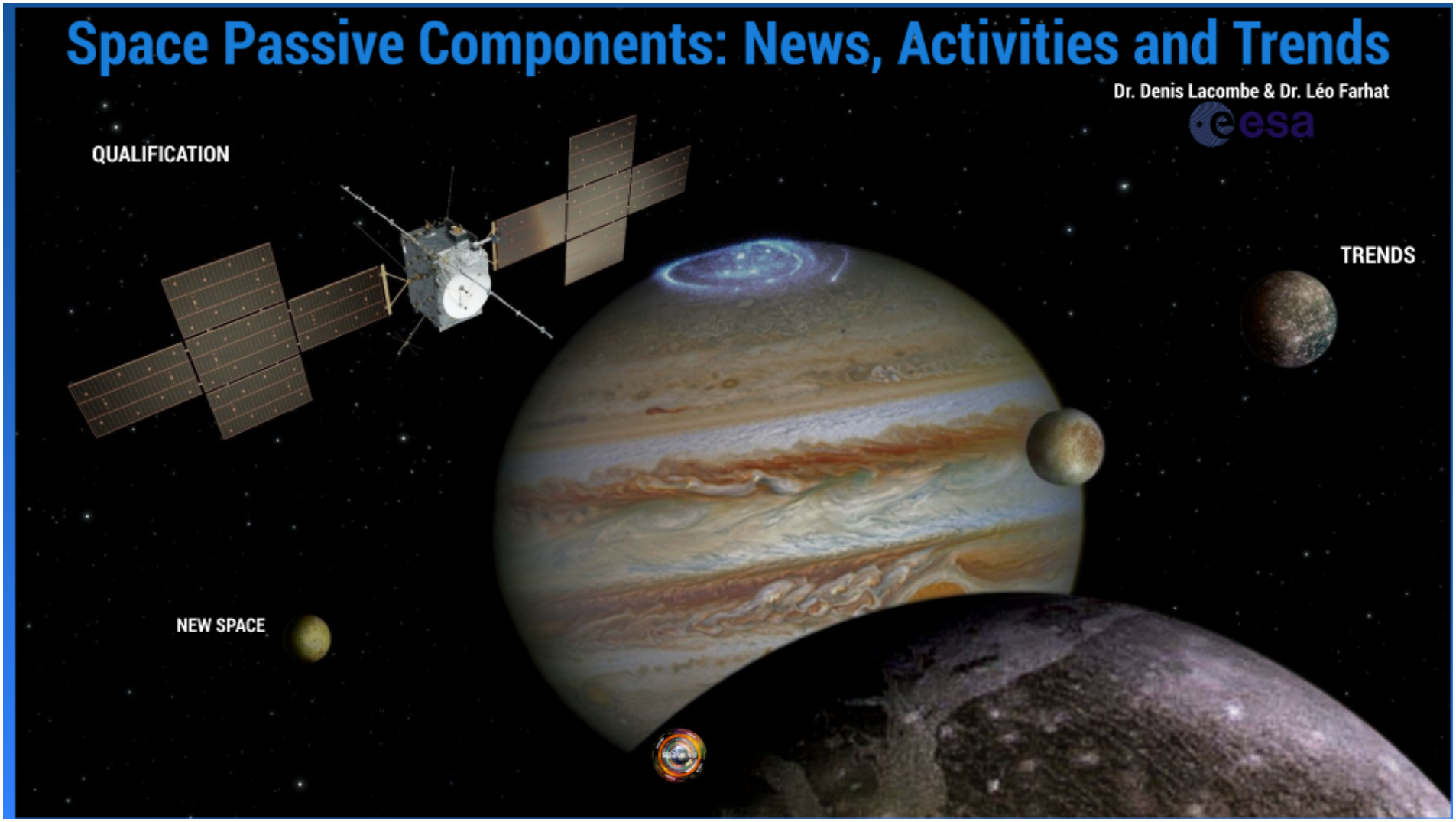
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Dr. Denis Lacombe & Dr. Léo Farhat
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QUALIFICATION
TRENDS
NEW SPACE


NEW SPACE
NEW ERA
COTS


Space Passive Components Days
3rd SPCD edition
Space Passive components: Activities, News and Trends
Dr. Denis Lacombe & Dr. Léo Farhat
Passive Component Engineers
ESA/ESTEC – 10/10/2018
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European Space Agency

New Commercial Era

New era in the space market

esa

! We are living in **an important milestone era** in the space industry !

For the first time, private actor are taking leading role in for shaping space industry community.

The first step is launchers, either in US or in Europe, launchers will be designed and manufactured by independent private companies.

European Space Agency

New era in the space market

esa

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For the first time, private actor are taking leading role in for shaping space industry community.

The second one is the arrival of new private actors, profit-oriented, that would like to challenge the current space market and want to drastically reduce the cost of satellites for mega- constellation.

European Space Agency

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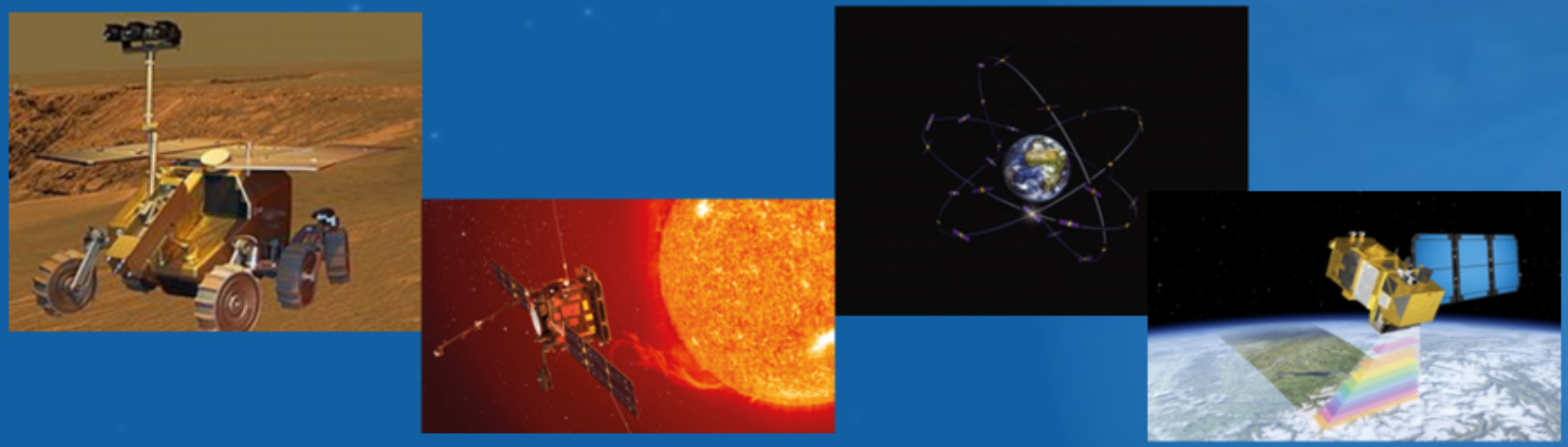
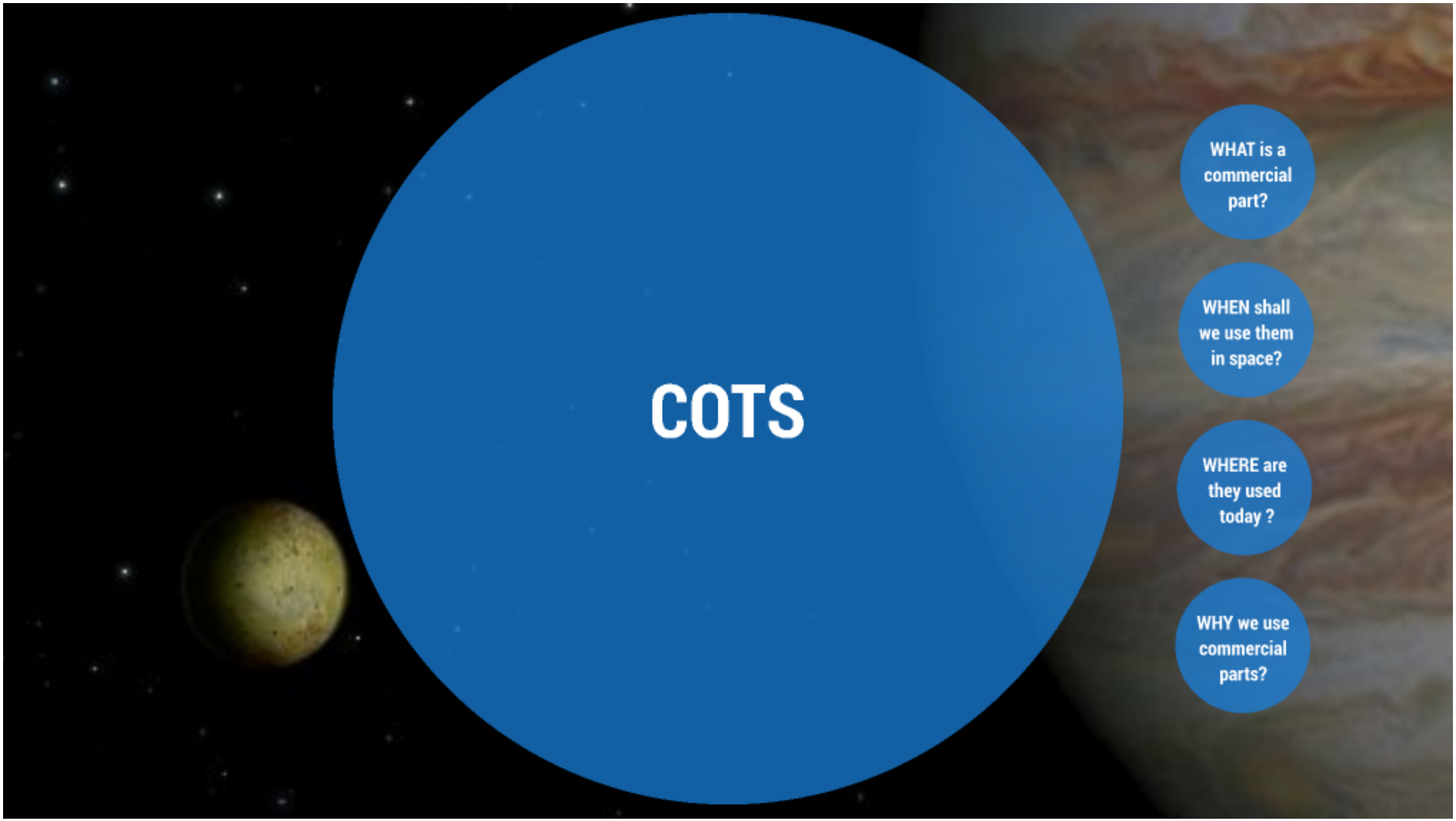
European Space Agency

Telecommunication ecosystem is evolving...

New Commercial Era



The space market is opening up for new commercial era called...


COTS
WHAT is a commercial part?
WHEN shall we use them in space?
WHERE are they used today ?
WHY we use commercial parts?

What is a commercial part?

How is defined a commercial part in EEE Parts Assurance space standards:

NASA-STD-8739.10

A classification for an assembly, part, or design for which the item manufacturer or vendor establishes performance, configuration and reliability, including design, materials, processes, and testing pursuant to market forces rather than by enforceable compliance to a government or industry standard.

ESA ECSS-Q-ST-60C

Parts neither designed, nor manufactured with reference to military or space standards defined in this document.

What is a commercial part?

Each project specify which class shall be used:

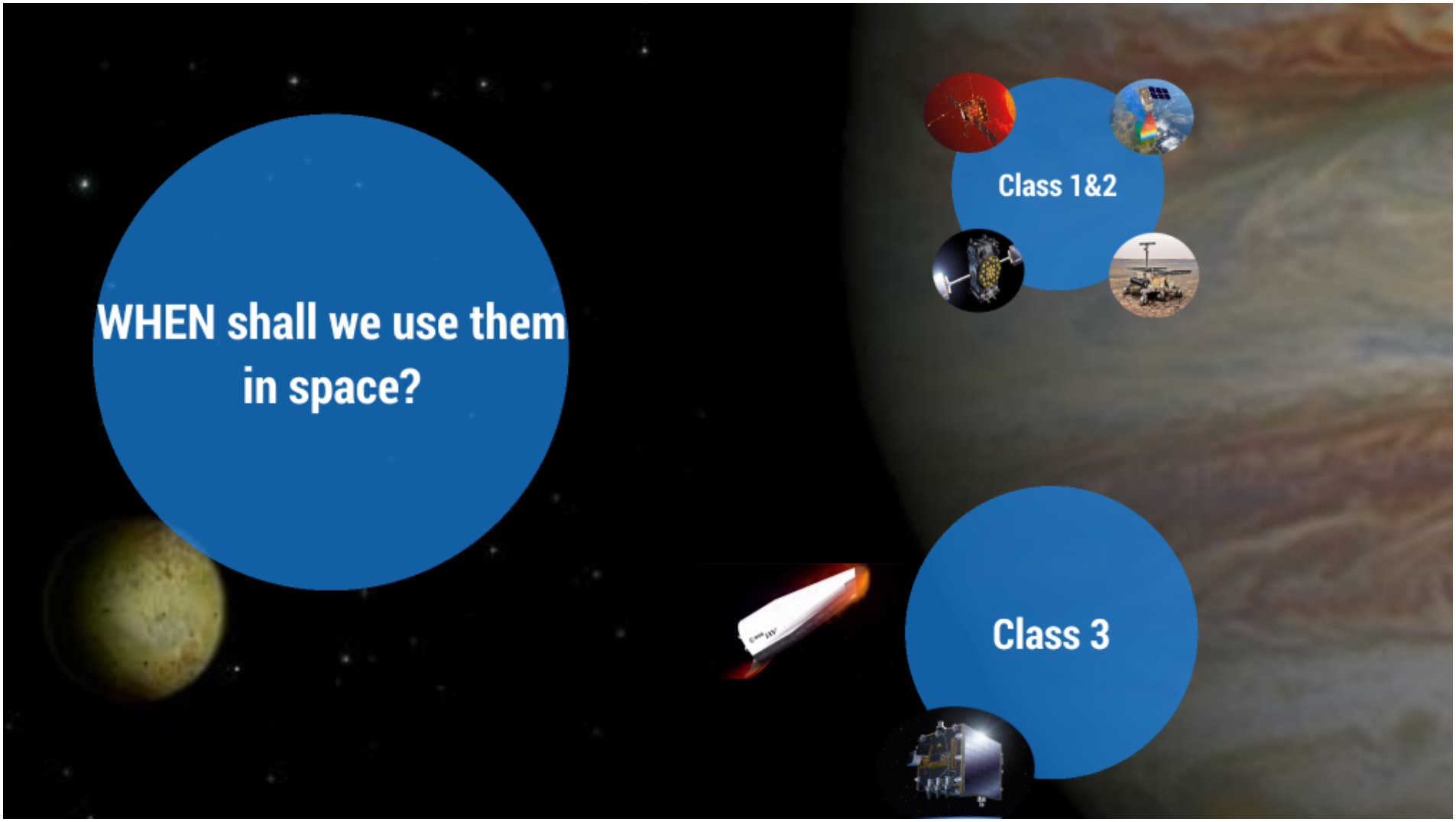
ESA ECSS-Q-ST-60C

Class	Summary
1	Highest assurance and lowest risk
2	High assurance and low risk
3	Low assurance and High risk

ESA ECSS-Q-ST-60-13

Commercial electrical, electronic and electromechanical (EEE) components standard:

Standard covering active components only and it is not applicable to passive components YET!


WHEN shall we use them in space?
Class 1&2
Class 3

CLASS 1&2 Missions

No available Qualified Parts (QPL) for the required performance.

Greatest amount of evaluation, traceability, testing and procurement is provided.
But it is expensive then rarely used for commercial parts.

Up-screening of commercial parts is mandatory.

COTS
+
Up-screening Tests
=
COTS ++

>

Qualified Part

CLASS 3 Missions

Low cost budget

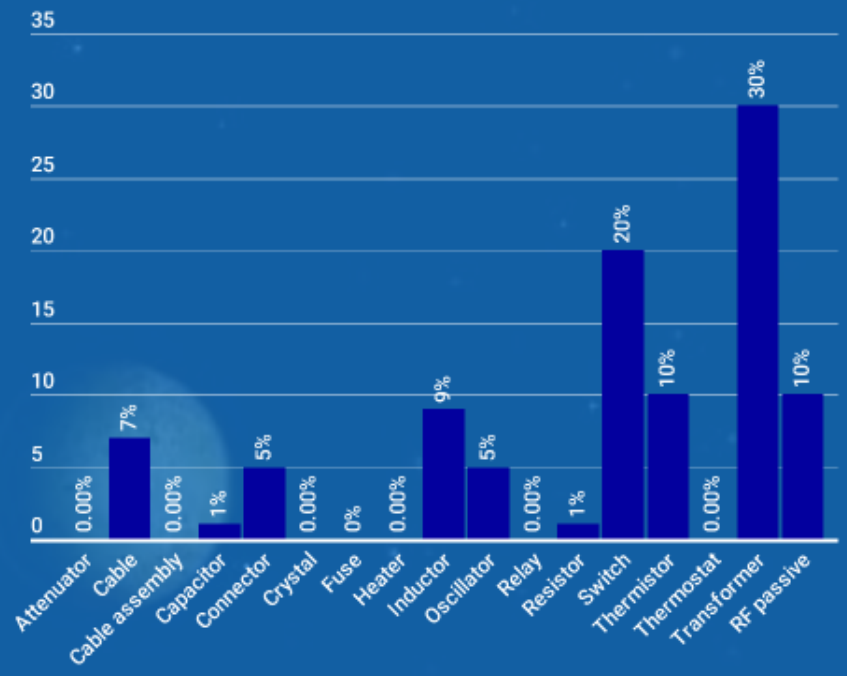
Component Type	Quality Level	Total Cost per Board [EUR]
PCB	ESCC	152
Integrated Circuits	QML-V	1 914
MOSFETs	JANS	872
Bipolar Transistors	ESCC Level B	1 028
Diodes	JANS	1 784
Capacitors	ESCC Level C + MIL FR R/S	725
Resistors	MIL FR R/S + standard	206
	EUR	6 678

Component Type	Quality Level	Total Cost per Board [EUR]
PCB	IPC-3	71
Integrated Circuits	QML-Q	458
MOSFETs	AEC-Q101 + standard	213
Bipolar Transistors	AEC-Q101	276
Diodes	AEC-Q101 + standard	245
Capacitors	MIL FR R/S + AEC-Q200 + standard	230
Resistors	MIL FR R/S + standard	204
	EUR	1 695

Commercial parts are used in low cost project but feedback on reliability (good or bad) are uncommon and investigation is kept at a minimum.

Where are they used today in space?

Class 1: commercial parts <5% up-screened 100%



Unavailable Qualified parts with the required performances:

Most of High voltage and flexible cable assemblies.

High capacitance values for capacitors (BME capacitors from Murata)

Low or high ohmic values for resistors

In-house transformer for low voltage

Non critical applications/equipment (monitoring, observation, etc.):

Special design of connectors (e.g. Pressfit, etc.)

Thermistors for monitoring

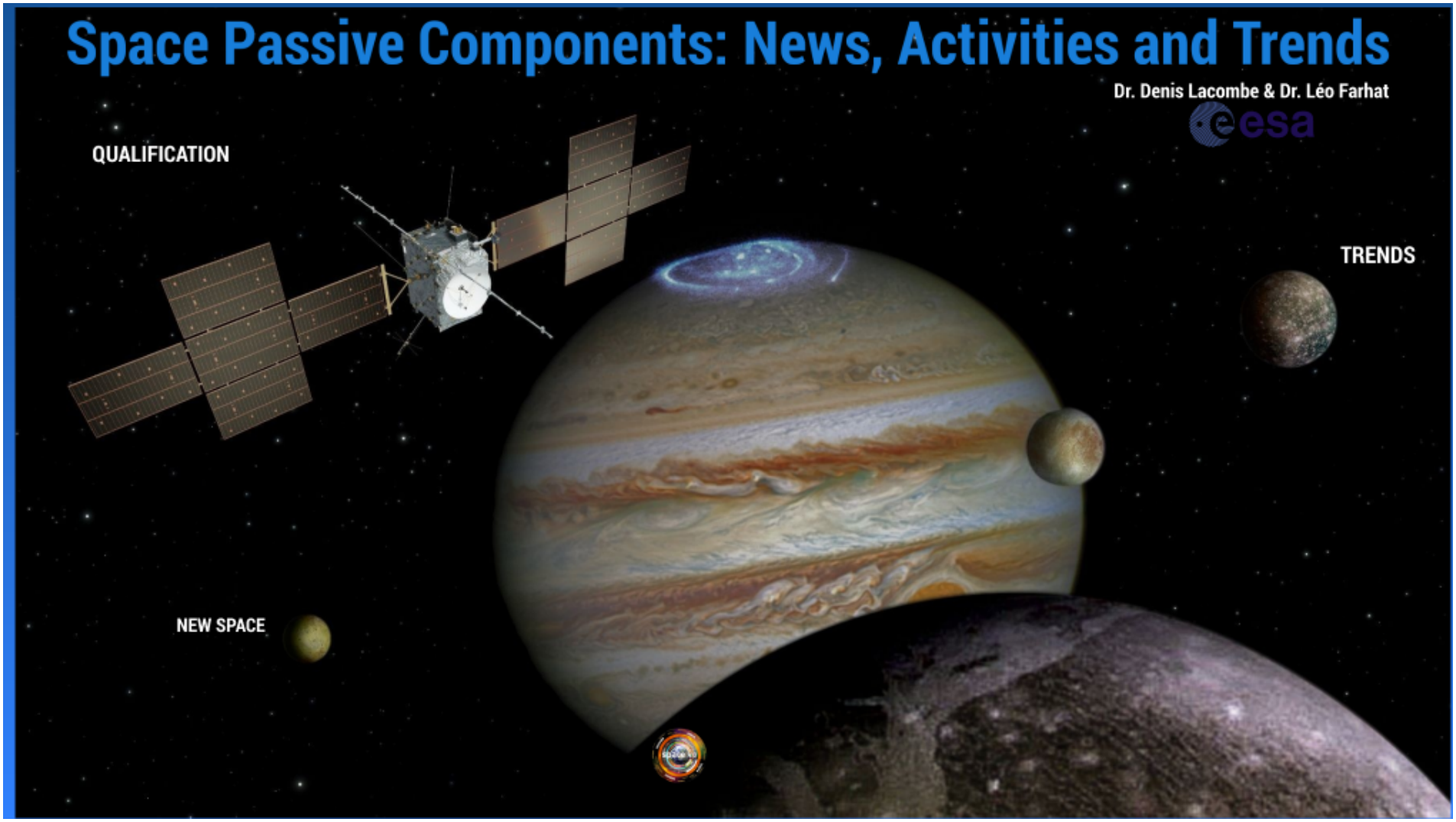
Mechanical switch

Reed switch

Why we use commercial parts ?

Commercial space-ready to use components bring the following benefits:

Nevertheless there is a high risk of: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QUALIFICATION

- Qualification remains as the best way to ensure the reliability of components!

PROJECT QUALIFICATION

Janus:
the two faces

GENERIC (ESCC, MIL) QUALIFICATION

PROCUREMENT APPROACH

CONCLUSION

Procurement Approach

For ESA class 1 missions, the order of preference according to ECSS-Q-ST-60 is:

EPPL (European Preferred Parts List) : The EPPL is a list of preferred and suitable components to be used by European manufacturers of spacecraft hardware and associated equipment.

Part I:

Components included in the QPL and QML issued by ESCC
MIL QPLs/QMLs

Part II

Relevant and up to date information on the manufacturing, assembly and test facilities
A component detail specification (ESCC format content)
Constructional analysis report + Electrical characterisation data + Endurance test results.

Components having passed an ESCC Evaluation are candidates to the EPPL.

Project Qualification

An Approval, on a case by case basis, which is an individual and limited authorization for one specific application.

The component meets the specific project needs:

- Orbit / Environment (e.g. cryogenic temp., very long term storage, etc.)
- Mission Class (from Microsats to Telecom Sats)
- Lifetime (from hours to decades)
- Performances (qualified parts may not be available)

But it is impacted by the project constraints:

- Project schedule
- Cost

Project Qualification

What are the constraints for the procurement at equipment level ?

The project approved components are NOT space-qualified in the ECSS-Q-ST-60C sense.

- Lot acceptance (LAT) are systematically required

The LAT content is based on an ESCC Generic Specification (also known as Chart “F4”) or comparable QCI (US)

- in addition, a possible Component Evaluation may be required
- A Part Approval Document (PAD) is systematically necessary

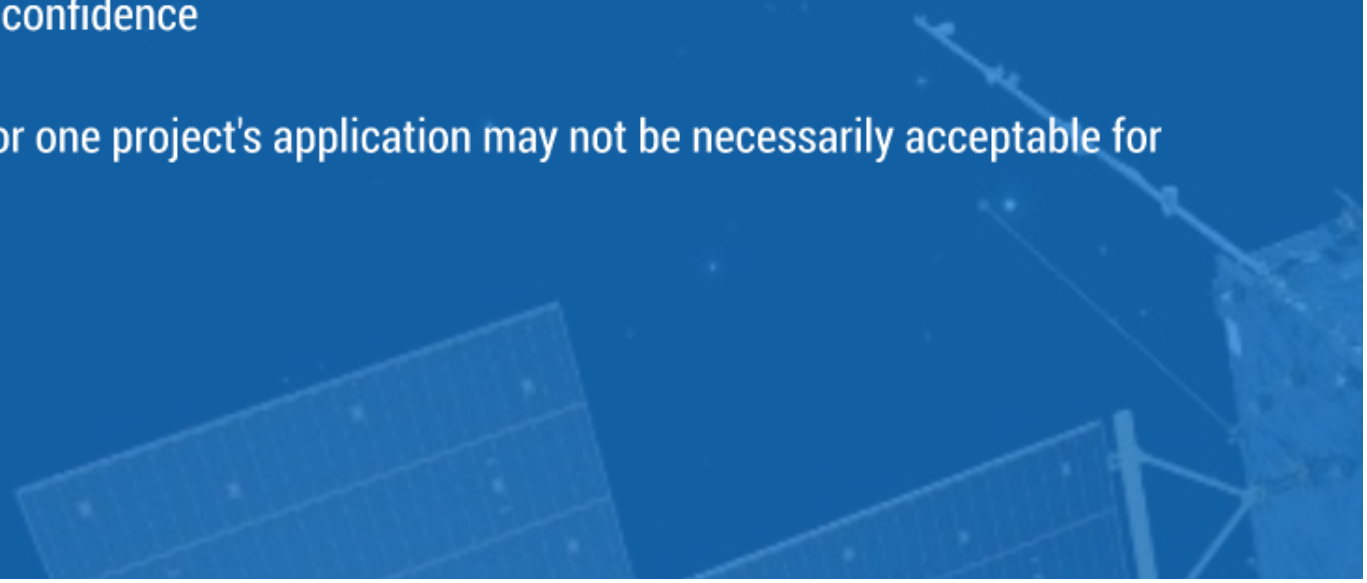
The notion of heritage is to be considered carefully:

- Heritage does not mean necessarily relevant heritage
- Waiver / Deviation in the previous applications ?

Project Qualification

To sum-up:

- The cost is not necessarily reduced
- Shortcuts mean less confidence
- What is acceptable for one project's application may not be necessarily acceptable for another application



ESCC QUALIFICATION

A systematic approach that provides an established, stable and common set of
" rules of the game"

ESCC qualification approval is a status given to components that are manufactured **under controlled conditions.**

Unlike the US MIL System, ESCC is based on 2 steps :
Evaluation + Qualification

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1. Evaluation Phase:

- Failure / Failure Mechanisms oriented
- Evaluation of the Product AND of the Manufacturer
- Establishment of a Baseline (PID, Specification, QA system, etc.)

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- Success oriented (tests have to be passed)
- Verification of the first production lot

3. Maintenance of the Qual. Status:

The components/technologies are re-assessed every 2 years

ESCC QUALIFICATION

Improvements:

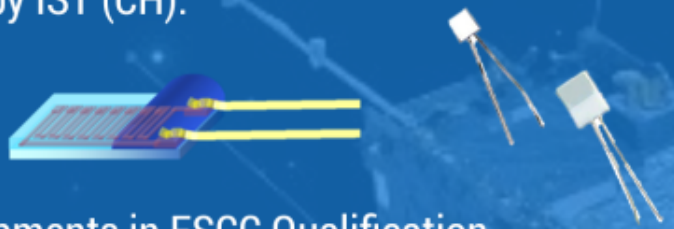
ESCC QUALIFICATION

Improvements:

Evaluation and Qualification tests can now be performed in parallel **under certain conditions:**

Single Phase Qualification

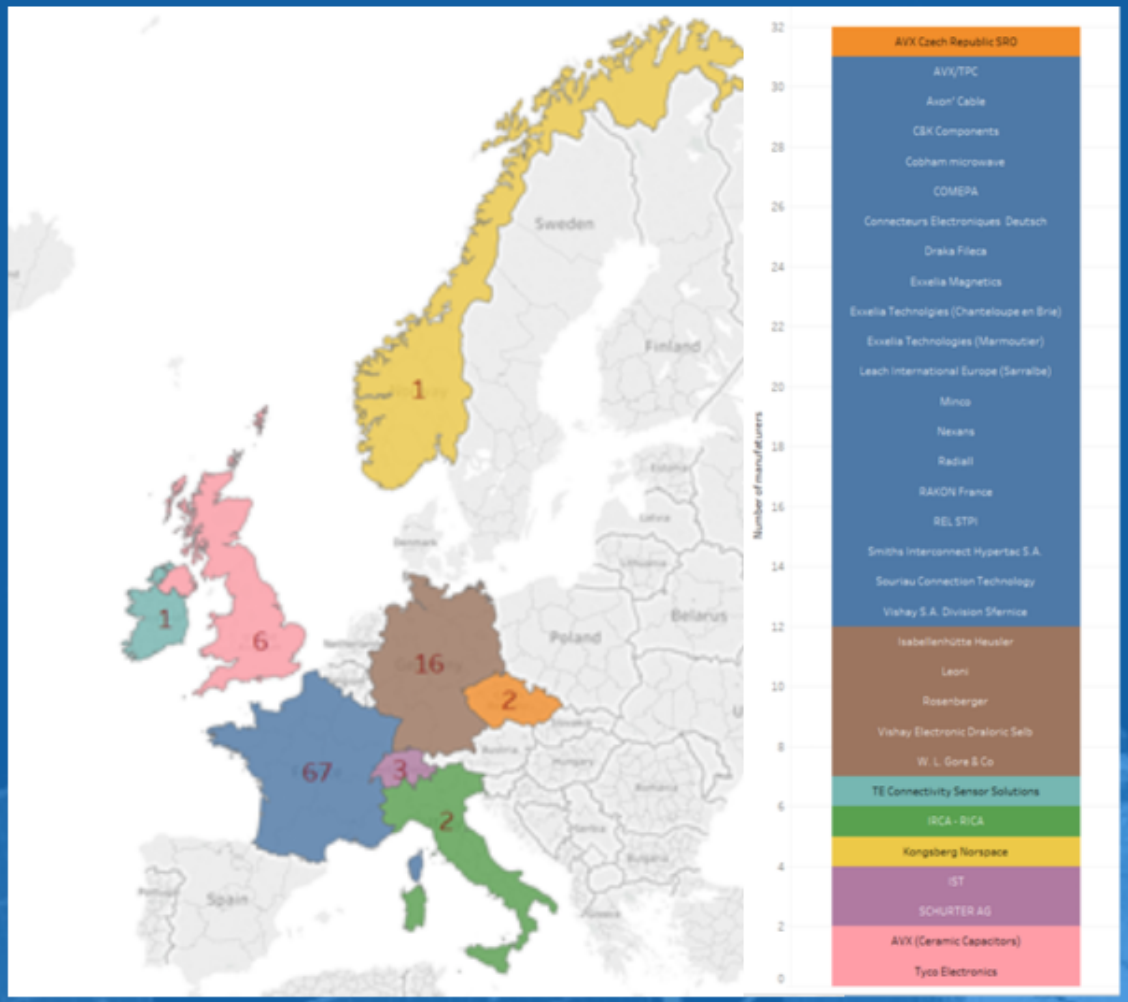
1st experience: successful with the qualification of thin-film based series of platinum temperature sensors manufactured by IST (CH).

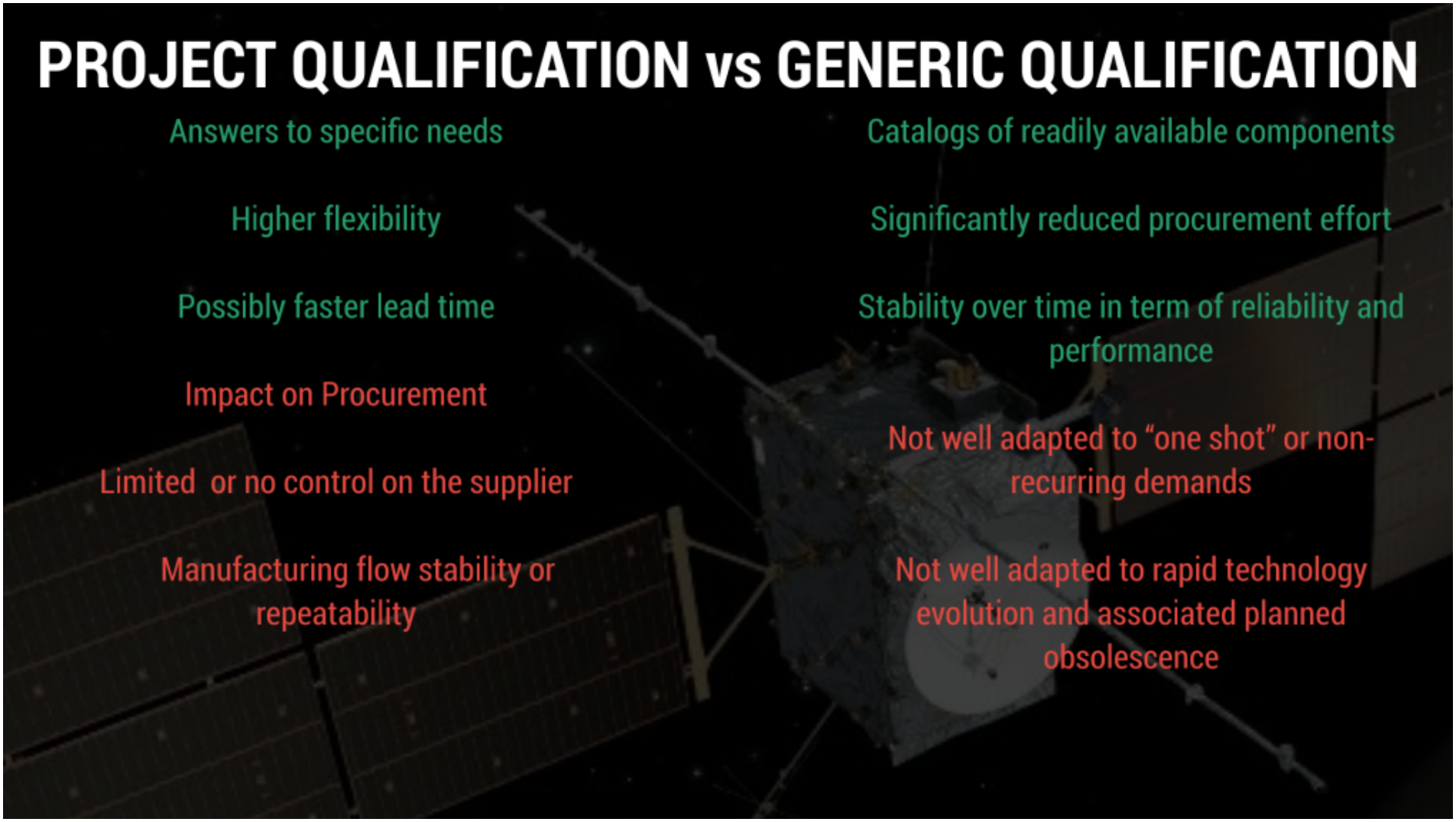


"Recent developments in ESCC Qualification Methodology. Experience in Implementation with passive components"

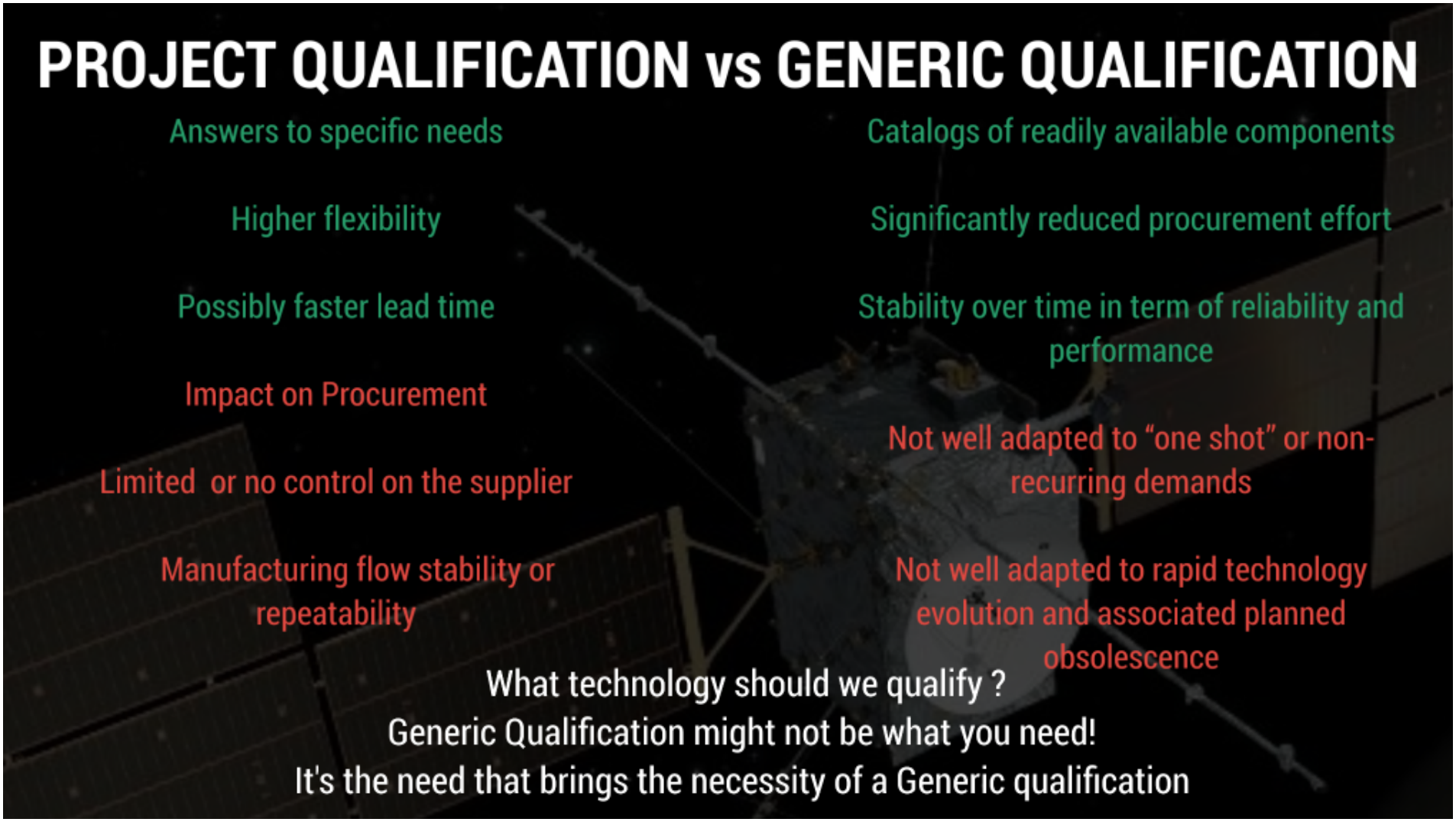
Fernando Martinez, ESCC Executive, ESA

Number of certificates : 98
Number of part Types : 135
Manufacturers : 32




PROJECT QUALIFICATION vs GENERIC QUALIFICATION
Answers to specific needs
Higher flexibility
Possibly faster lead time
Impact on Procurement
Limited or no control on the supplier
Manufacturing flow stability or repeatability
Catalogs of readily available components
Significantly reduced procurement effort
Stability over time in term of reliability and performance
Not well adapted to “one shot” or non-recurring demands
Not well adapted to rapid technology evolution and associated planned obsolescence

PROJECT QUALIFICATION vs GENERIC QUALIFICATION



Answers to specific needs	Catalogs of readily available components
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Impact on Procurement	
Limited or no control on the supplier	Not well adapted to “one shot” or non-recurring demands
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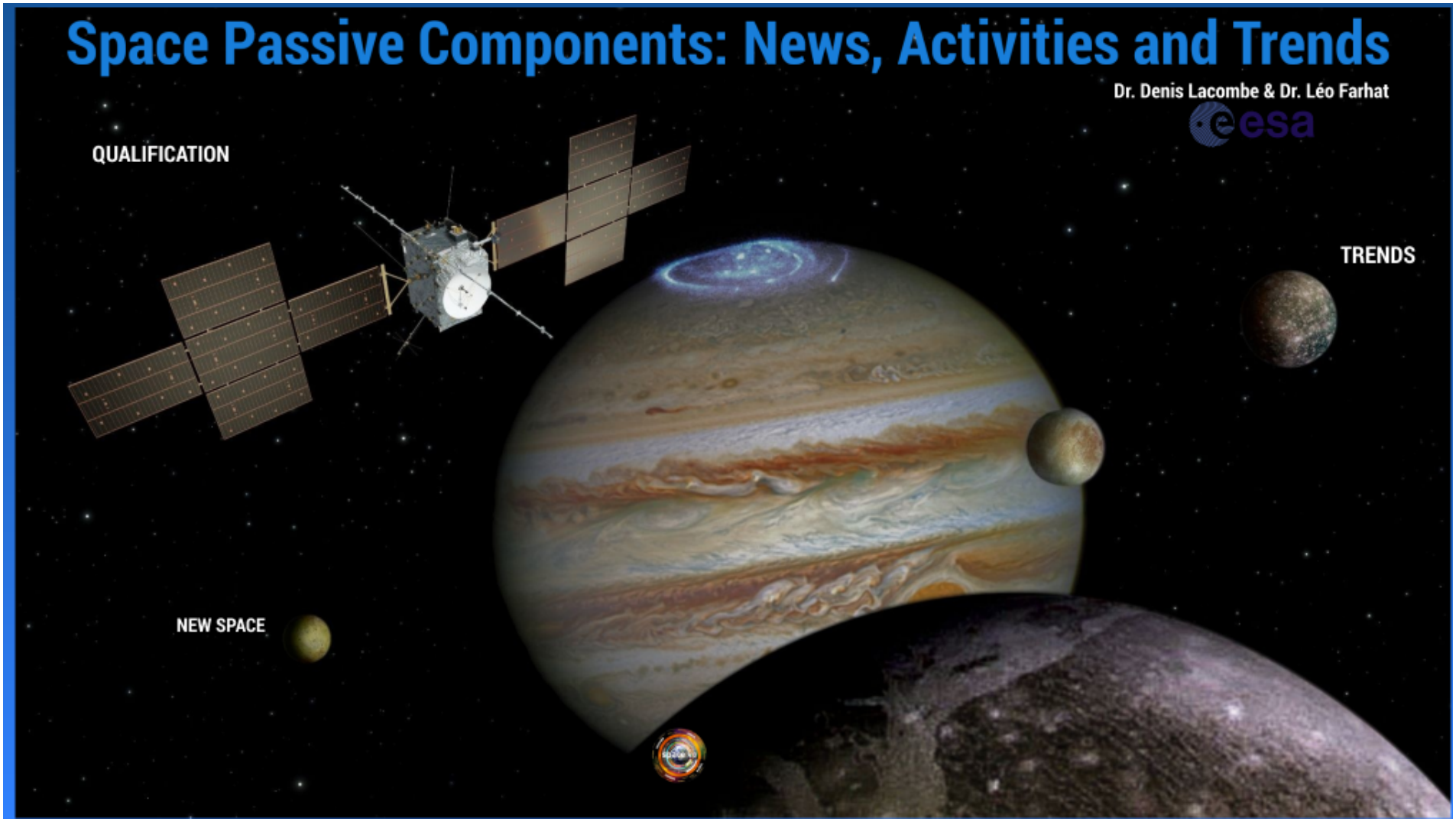
What technology should we qualify ?

Generic Qualification might not be what you need!

It's the need that brings the necessity of a Generic qualification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DIGITALISATION
space 4.0
innovate
inform
inspire
interact
innovieren
informieren
inspirere
interagere
IMPACT ON
PASSIVE
COMPONENTS

DIGITALISATION

Digitalisation is NOT Digitization.

Digitization is creating a digital (bits and bytes) version of analog/physical things such as scanning a letter document (analog) into a pdf file (digital).

Digitalisation is the use of digital technologies to change a business model. It refers to enabling, improving or transforming business operations, functions, models and processes by exploiting digital technologies.

DIGITALISATION

Digitalisation means that Satellite Business will now use digital technology.

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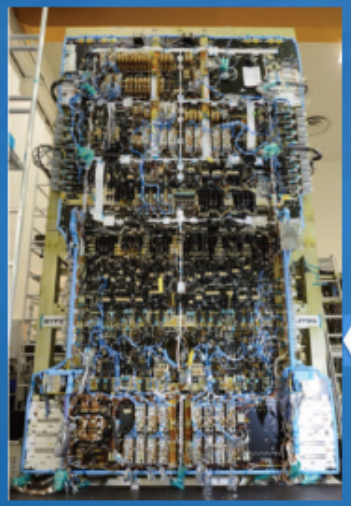
DIGITALISATION

Traditional payloads architecture:

- Several hundred low noise amplifiers and converters
- Hundreds of input/output RF passive devices (filters, RF switches, isolators,...)
- Complex and costly production process
- Thousands of cabling and switches



VS

Digitalised Satellite Payload

- Software defined Payloads
- Real Time Resource management
- Flexibile bandwidth, frequency and Power
- Dynamicy coverage allocation
- Cost and mass reduction

DIGITALISATION

Fundamental changes in the way of building telecommunications satellites.

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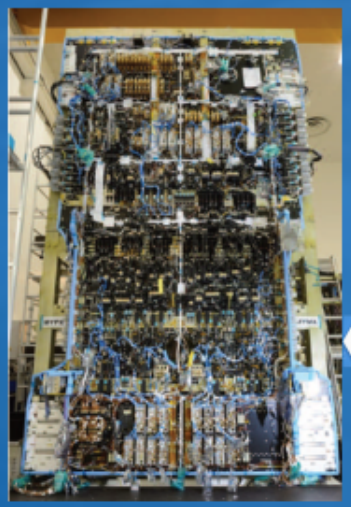

VS

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DIGITALISATION

QUANTUM is presented as the first software driven telecom satellite.

Unlike the custom-made production of traditional satellites, which are configured during construction,
Digitalised Satellites built according to a standard specification and configured in orbit could be mass produced.

Flexibility, not only in terms of coverage, but also in terms of power, frequency and bandwidth.

DIGITALISATION

Modifying the Satellite in Orbit is fantastic!

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Digitalised Satellites built according to a standard specification and configured in orbit could be mass produced.

Flexibility, not only in terms of coverage, but also in terms of power, frequency and bandwidth.

IMPACT on PASSIVE COMPONENTS?

The digitalisation of electronics and data exchange between electronics is an important factor of evolution or obsolescence of passive components.

Decentralized thermal management:
Smart passive components as wireless thermistor or self control heaters or integrated sensors.

Wireless technologies and **Optical Links:**
Wires, cables (DC, Power?) will be replaced by optical fibers.
The field of the harness is about to change...
Is it the case for the other types of passive components?

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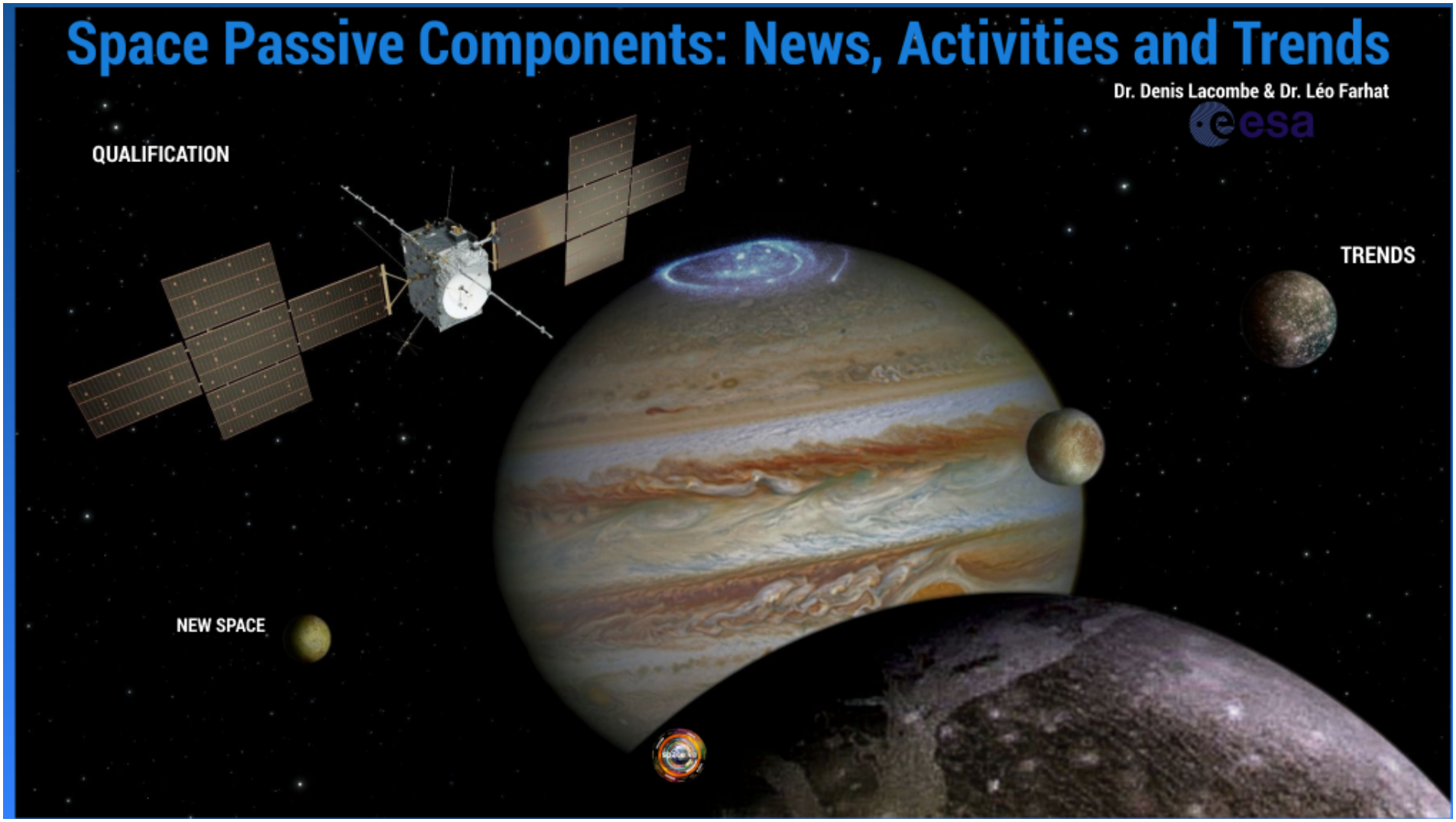
Panel Discussion: "Impact of on-board Digitalisation on Passive components"
Thursday 11th October @17h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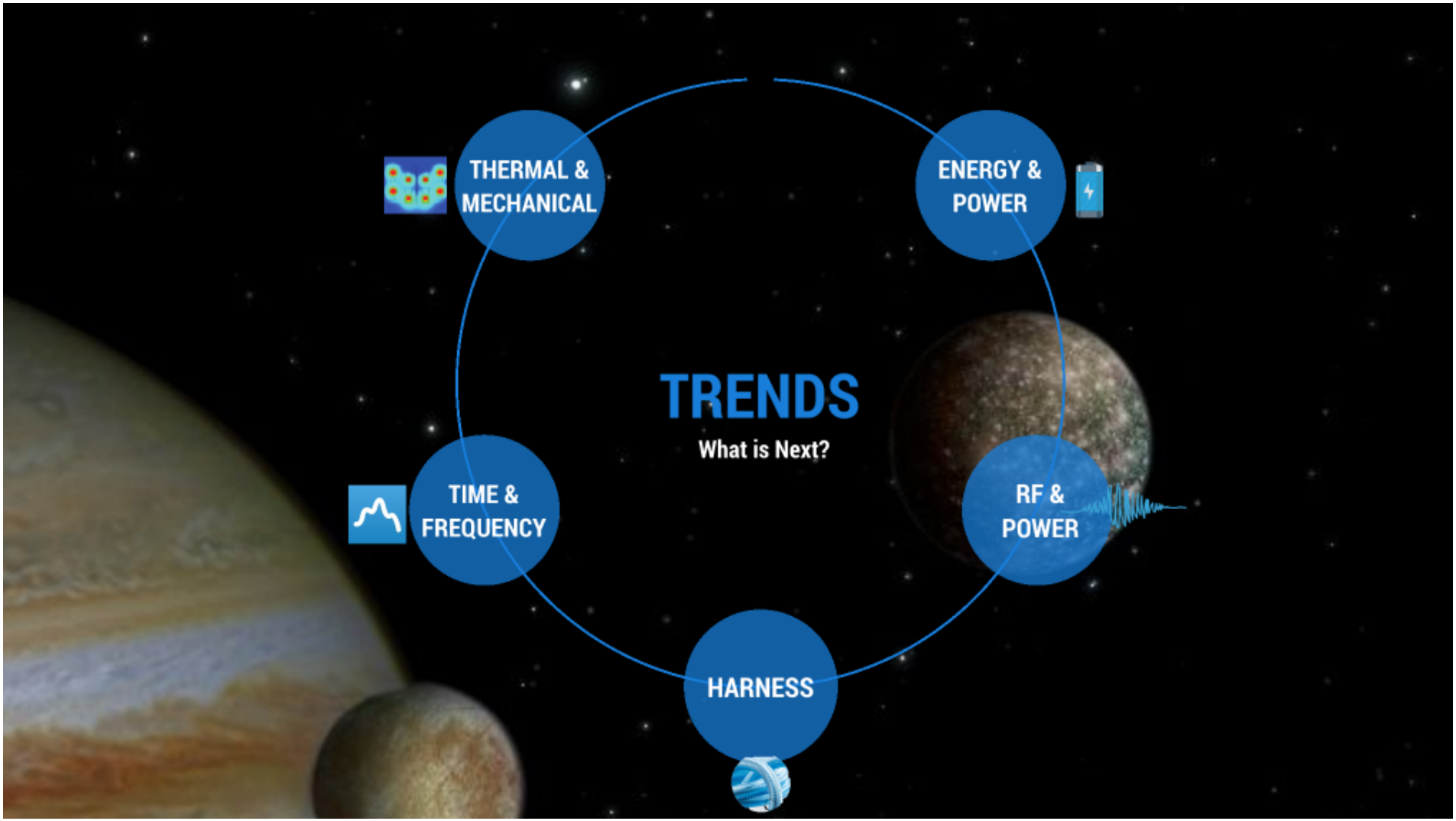
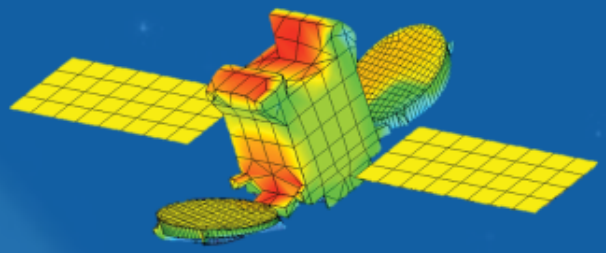

THERMAL & MECHANICAL
ENERGY & POWER
TRENDS
What is Next?
TIME & FREQUENCY
RF & POWER
HARNESS

THERMAL & MECHANICAL

More complex architecture management (including cross-strap), are being built.

Peltier module (Thermoelectric cooling devices) are only COTS



RELAYS

HEATERS

RELAYS

Improved switching performances for relays (and thermostats) for 100V power bus

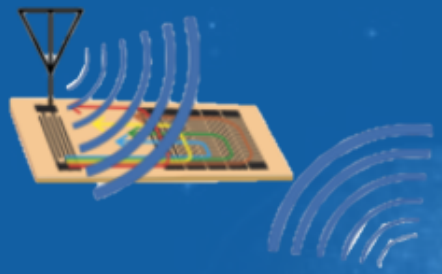
High level vibration relays for new systems

Electro-mechanical relays operating under high voltage (up to 2KV) and current conditions

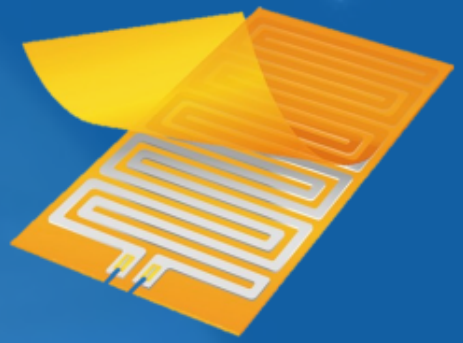
HEATERS & SENSORS

Recently qualified Platinum Sensors

Integrated heaters into flex PCB Harness



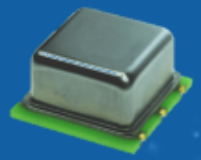
Wireless solutions for sensors and heaters



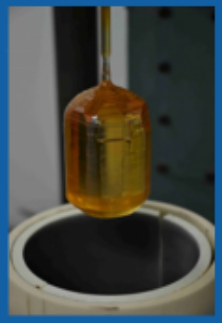
New Rule for derating of Heaters

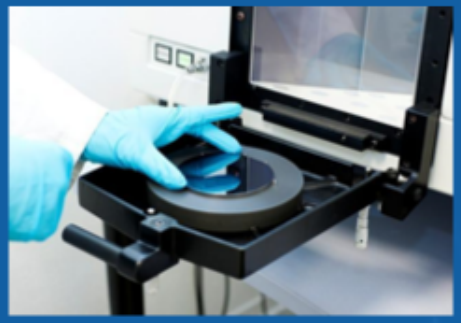
Currently, the power density is derated for heaters in still air. This is not applicable for **glued** heaters. Proposal is to derate the maximum temperature (glue/PSA + heater):
-> Higher Power densities values are expected

TIME & FREQUENCY



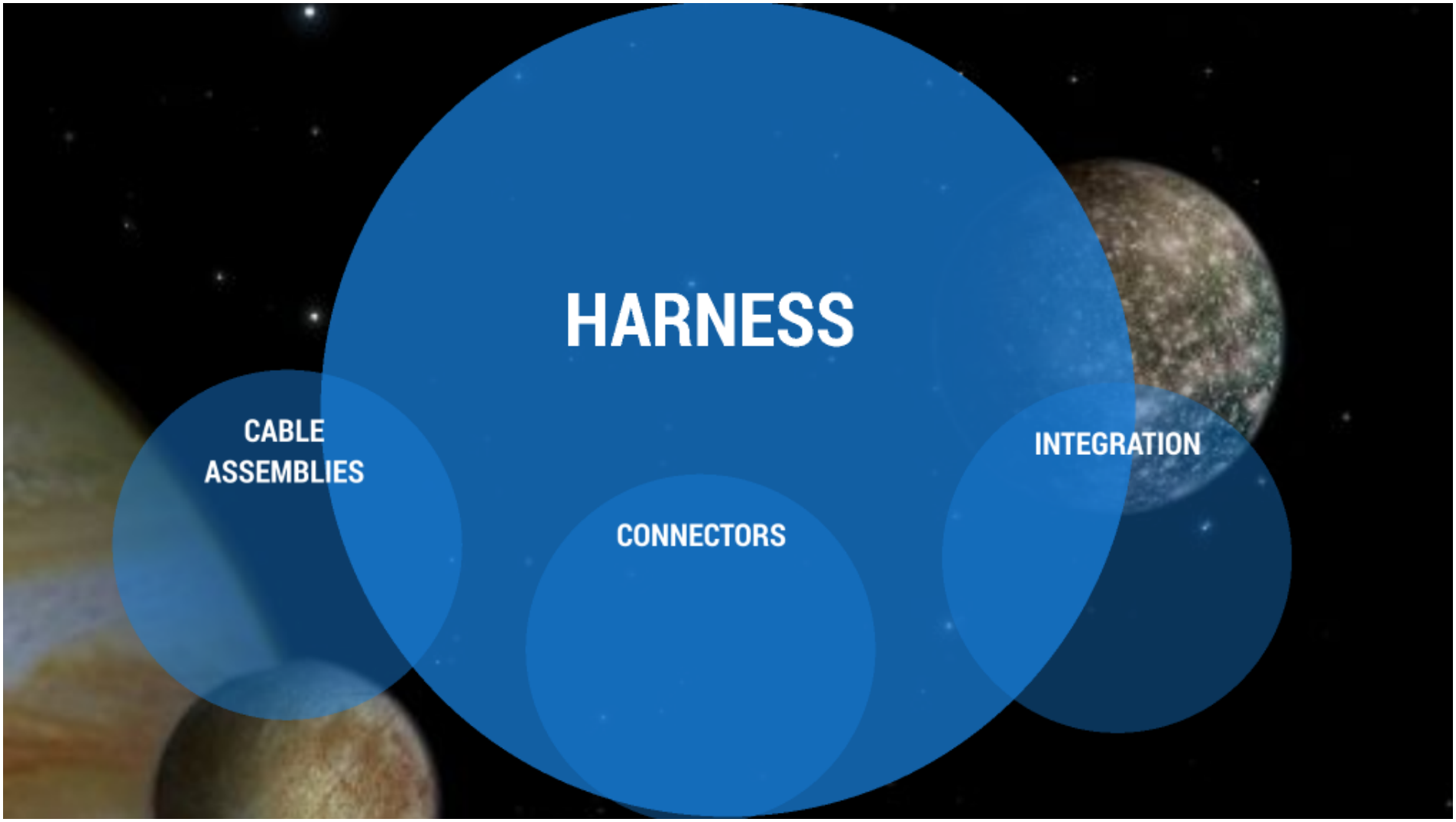
Low cost and rad hard quartz oscillators are critical items for LEO missions like PNT (Positioning, Navigation and Timing), commercial telecommunication and any application requiring high spectral purity (e.g. Radar).

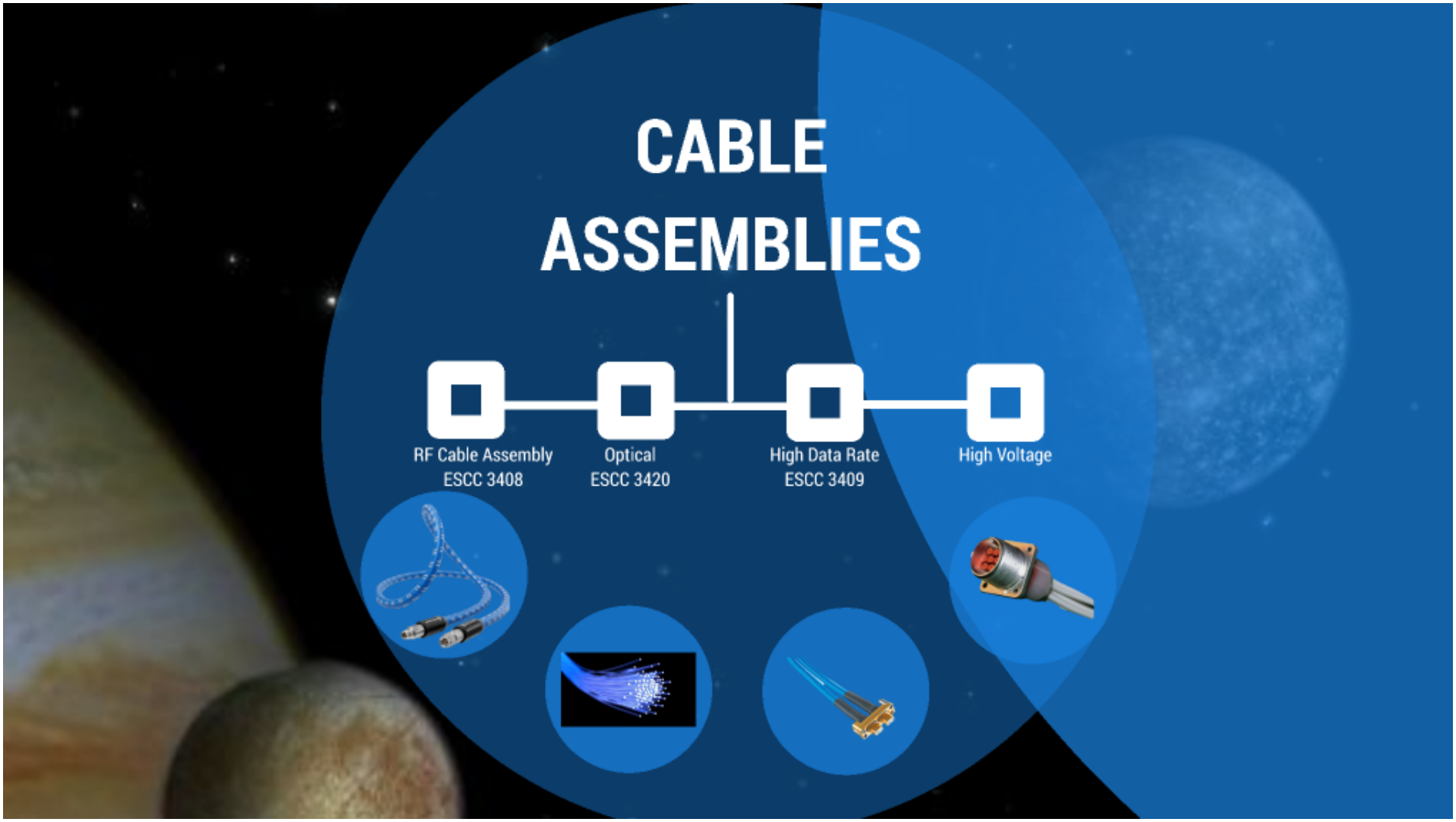




Quartz sweeping or pre-radiation are considered costly and time consuming processes. Those manufacturing processes are not compatible with low cost devices.

- Cost effective technologies for crystal growing and/or resonator process for reducing the sensitivity to radiation.


HARNESS
CABLE ASSEMBLIES
CONNECTORS
INTEGRATION

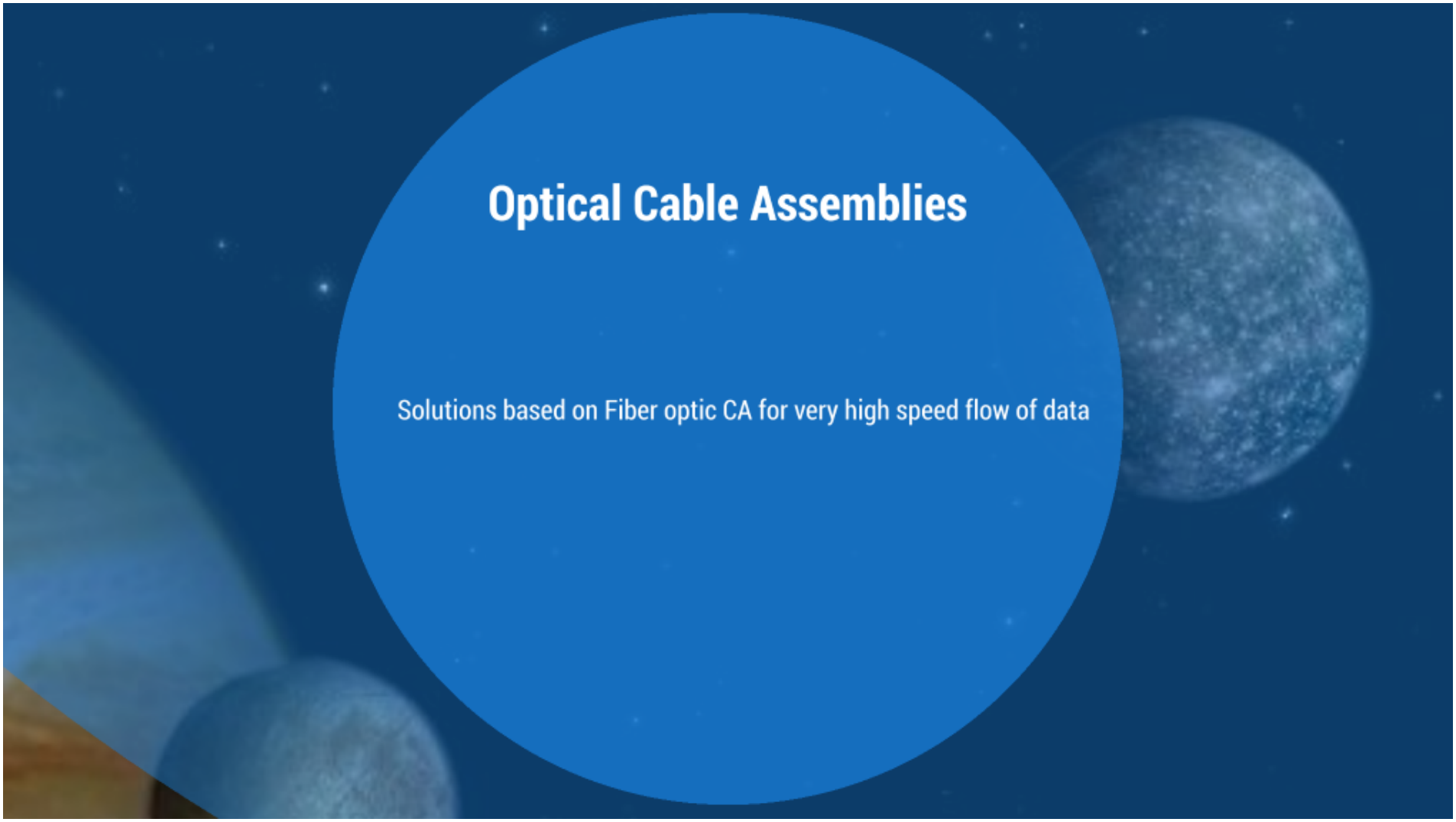

CABLE
ASSEMBLIES
RF Cable Assembly
ESCC 3408
Optical
ESCC 3420
High Data Rate
ESCC 3409
High Voltage

RF Cable Assemblies

Today:
TNC Very High Power

What is next?
Development, Evaluation and/or Qualification of

- RF cable assemblies including SMA (up to 18GHz) , 2.4 (up to 50GHz) and 1.85 connectors (up to 65GHz)
- SMP-Lock connectors (DC – 32GHz)
- Super High power connectors (L, S & >300W C band)


Optical Cable Assemblies
Solutions based on Fiber optic CA for very high speed flow of data

High Data Rate Cable Assemblies

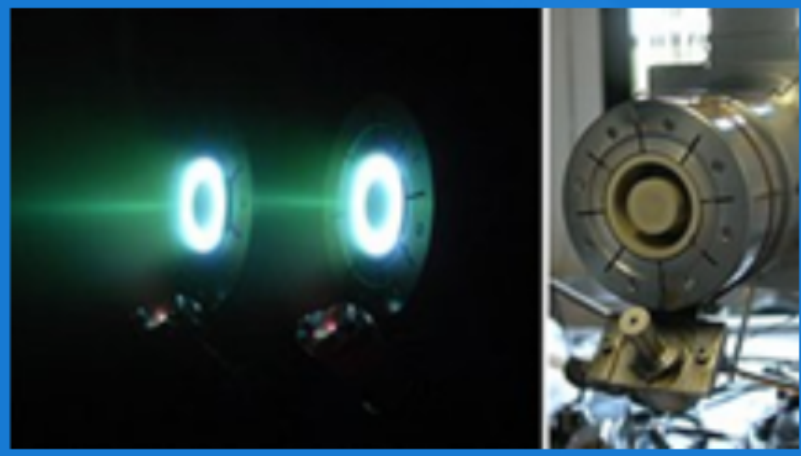
Today:
ESCC Generic specification has been *just* published .

What is next?
Evaluation and Qualification for Wizardlink, SpaceWire and SpaceFibre (data rates of up to 5 Gbps)

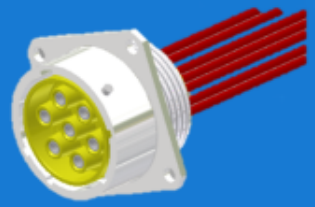
New solutions shall help by improving the data rate (by a factor of 10) and reducing the cable mass.

High Voltage Cable Assemblies

Electrical Propulsion High Voltage cables for thrusters



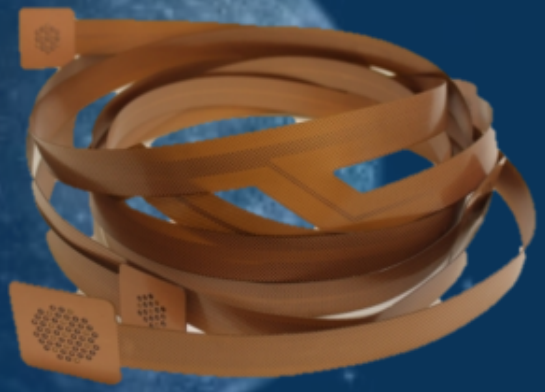
- Operating voltage up to 15 kV DC
- Radiation resistance up to 200 Mrad.
- Resistant to high temperatures:
  from min -55°C to max +125°C for dynamic applications




CONNECTORS
• Versatile and Modular: Power + Signal + RF
• Solderless solutions:
Pressfit Connectors
Spring Probe Connectors and Board to board mating plug & receptacle Connectors
RF Interposer (up to ka band) & Ka band RF probes
• Fast locking
SMA fast-locking compatible with standard jack Connectors
Latching and locking mechanism Micro-D

BETTER INTEGRATION & ROUTING

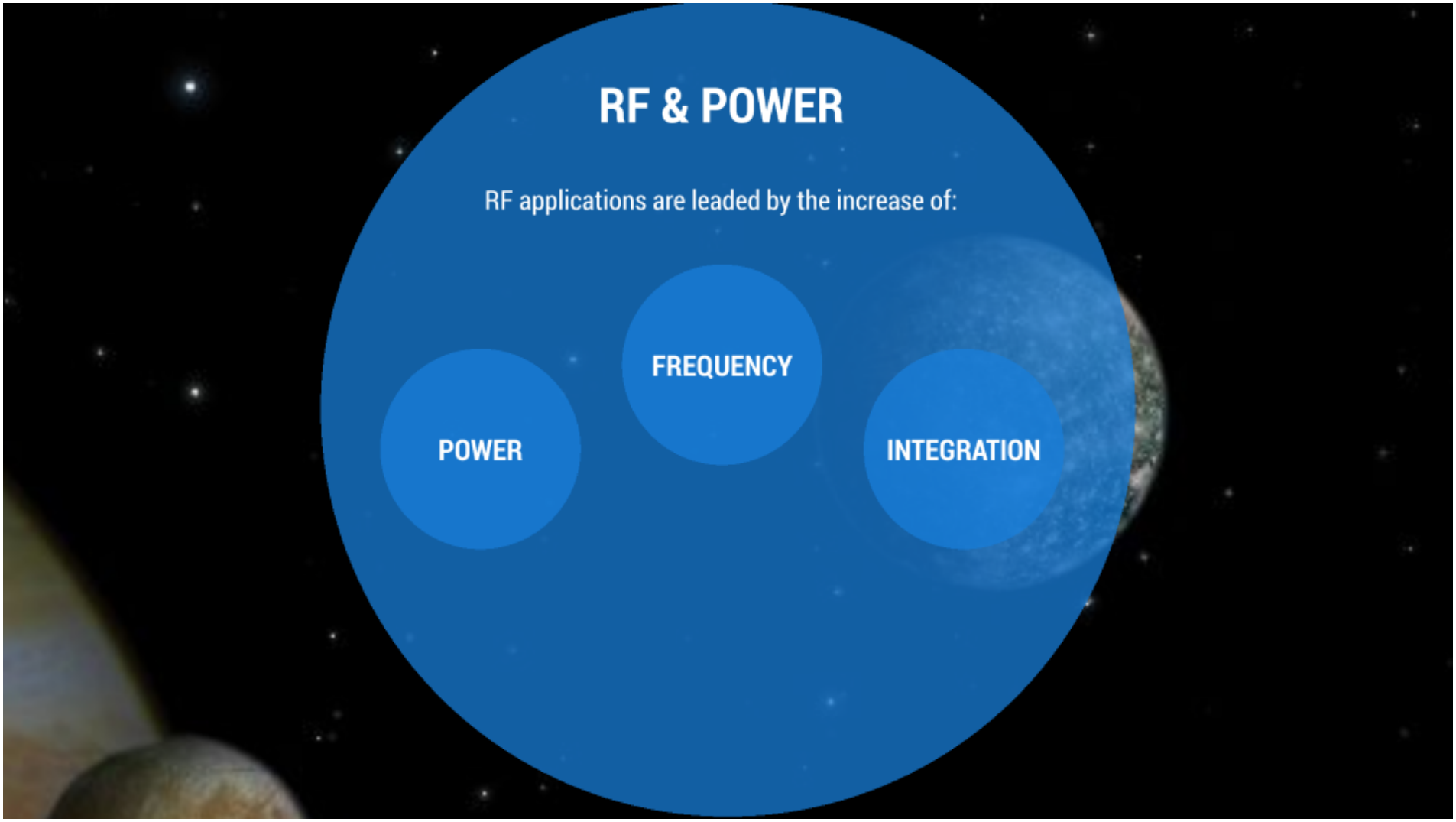
Flexible / Semi rigid PCB Harness



Mass savings target up to 30%
Reduction of cost by reduction of the number of devices
Better shielding and impedance characteristics
Drastic reduction of AIT integration time

New Rules for the derating of wires and cables

Upgrade of the rating and derating rules for wires and cables in ECSS-Q-ST-30-11
Mass savings are expected from 20% up to 50%


RF & POWER
RF applications are leaded by the increase of:
POWER
FREQUENCY
INTEGRATION

High Power Levels

Very High power coaxial Circulators and Isolators
400W @ L band
360W @ S band
300W @ C band

New Materials & Process (e.g loads, gluying, etc.) are needed for better dissipation at higher frequencies (Ku, Ka, Q, V & W bands)

Higher Frequencies

Higher frequencies are needed for Telecom Satellite: Q, V and W bands.
New technologies for Circualtors and Isolators based on:

- **S**ubstrate **I**ntegrated **W**aveguide (SIW)
- Microstrip LTCC/Hexaferrite

New technologies for SAW devices based on GaN/Si substrates at S & C bands

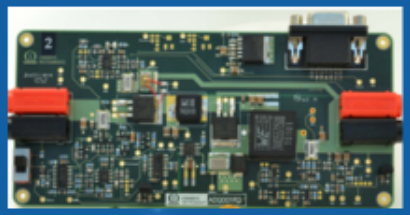
Faster & Better Integration

- RF Passive components with fast locking connectors
- Microstrip technologies for mega-constellations
- Power dividers with integrated Isolators / high isolation 2-way dividers at Ka band
- Circulators and Isolators based on SMT and SIW at Ka- band
- Development of iso-dividers with N-ways (N>8) at higher frequencies

ENERGY & POWER

Global Trends: Higher Power density & Better Integration

- High Power resistors with smaller designs (>1 Watt in 1206)
- 0201 chip resistors for digital designs
- Multi-anode polymer tantalum capacitor (330/470 microF, 6,3V in smallest package)



Point of Load:

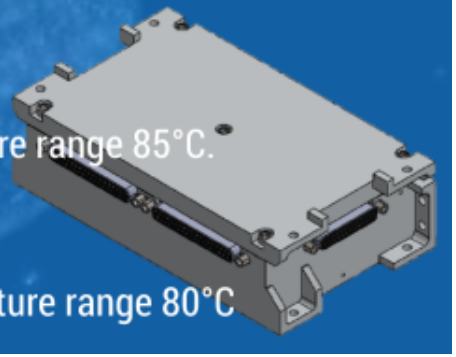
- Development of high voltage planar transformer
- High current chip inductors

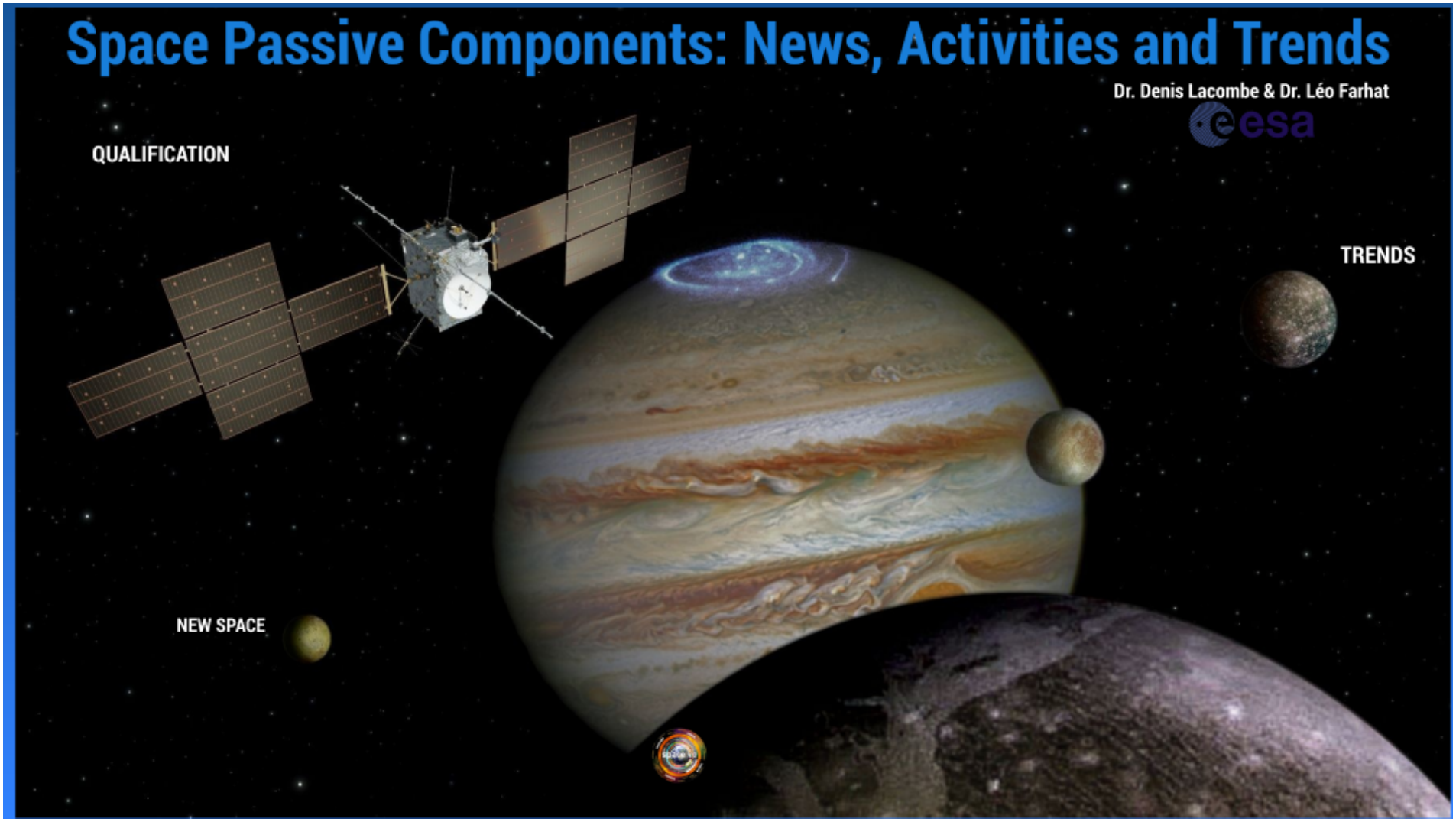
High power actuators, high power Lidar, High power radar :

- Supercapacitors with small capacitance (tens of F) and High operational temperature range 85°C. Number of cycling (> 3 millions) and Lifetime (15 years)

Launchers (pyro, EMTVAS, telemetry) :

- Supercapacitors with high specific Energy (>10WJ/Kg) & High operational temperature range 80°C

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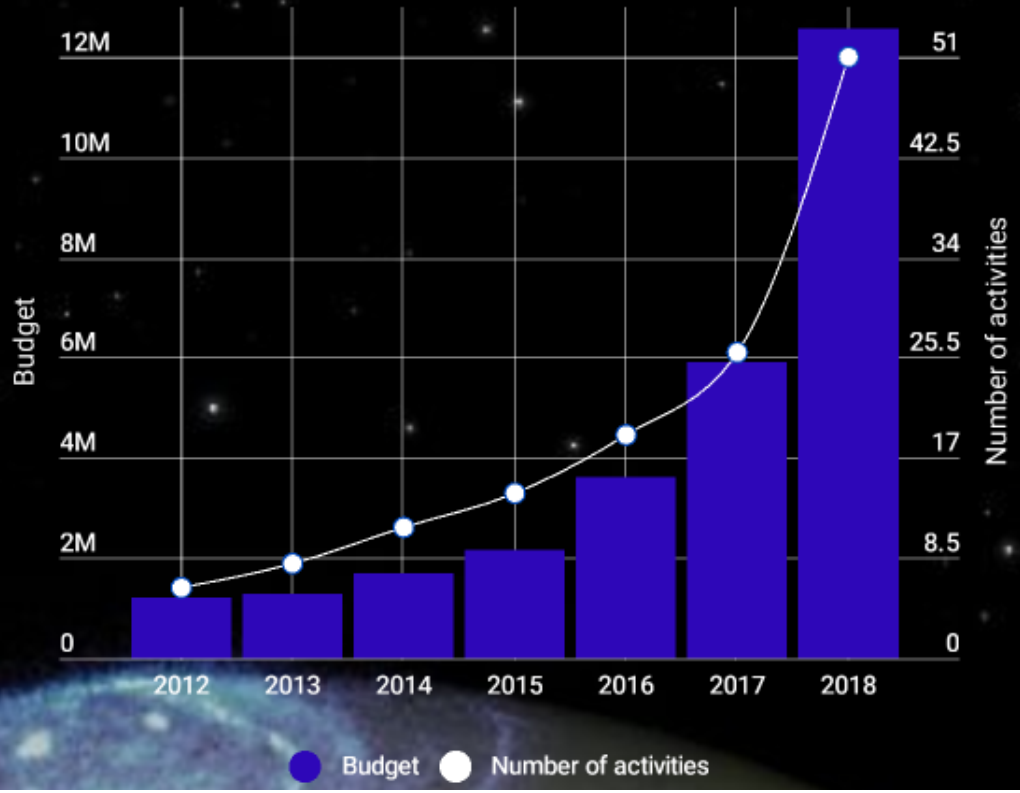
QUALIFICATION
TRENDS
NEW SPACE

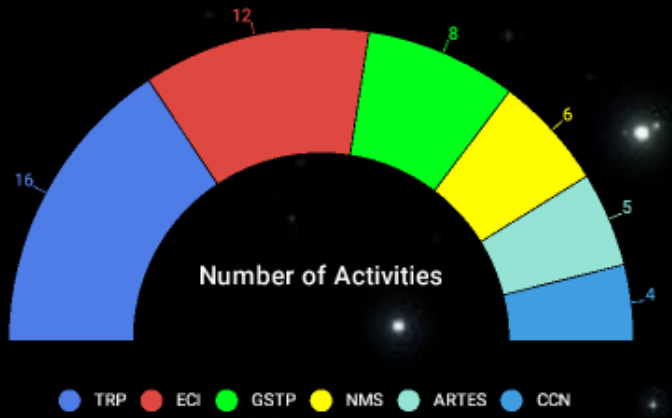
ACTIVITIES

ESA has funded 51 activities (including CCNs) involving Passive components since 2012.



Total Budget : 12.55 M€.
~270K€ per activity
~7 new activities per year

2018: 15~on-going activities

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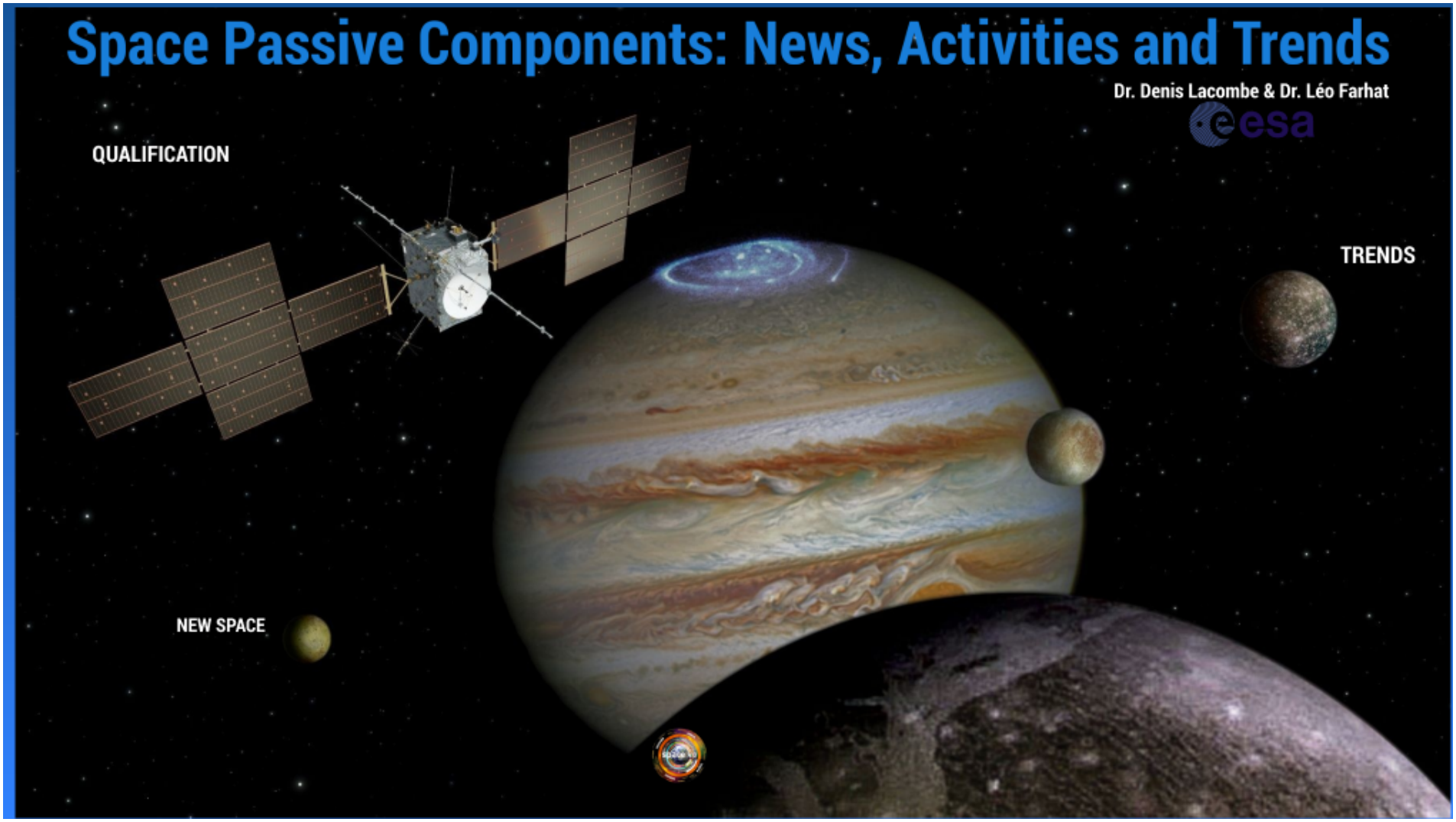
QUALIFICATION
TRENDS
THANK YOU
NEW SPACE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