PRINTED CIRCUIT BOARDS AND ELECTRONIC ASSEMBLY

Roadmap

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European Space Agency

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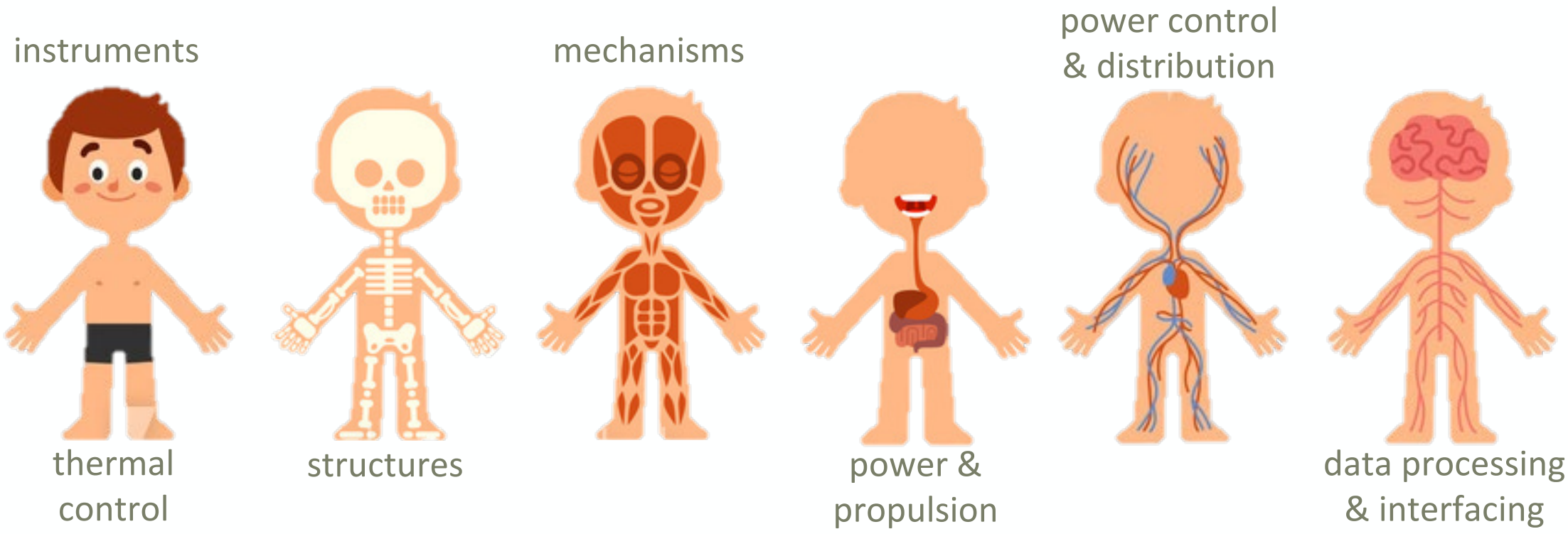
European Space Components Conference ESCCON

Anatomy of a spacecraft

PCB and Electronic Assembly are a complex combination of materials and processes to provide a stable **mechanical** and **thermal** platform for the **electrical** interconnection of components.

PCB & EA are the **nerves and veins** of the spacecraft.



Technologies Covered

Electronic packaging can be organized by the following levels of integration, interconnection and protection:

Level 0 - Chip, bare semiconductor die

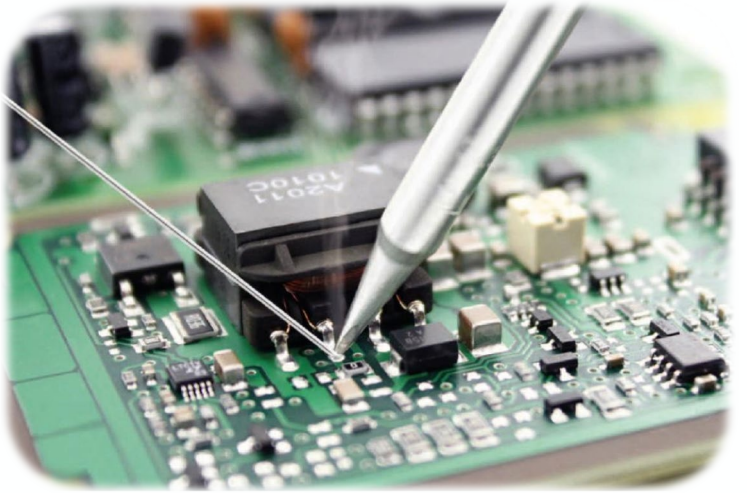
Level 1 - EEE component, single or multichip

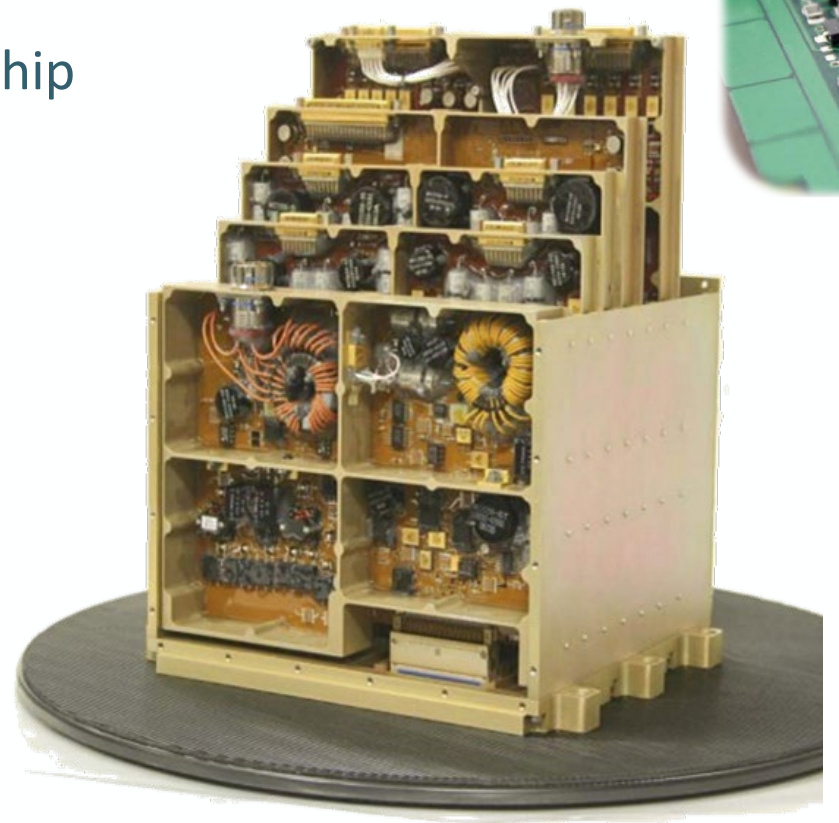
Level 2 – bare PCB

Level 3 - Assembled PCB(s)

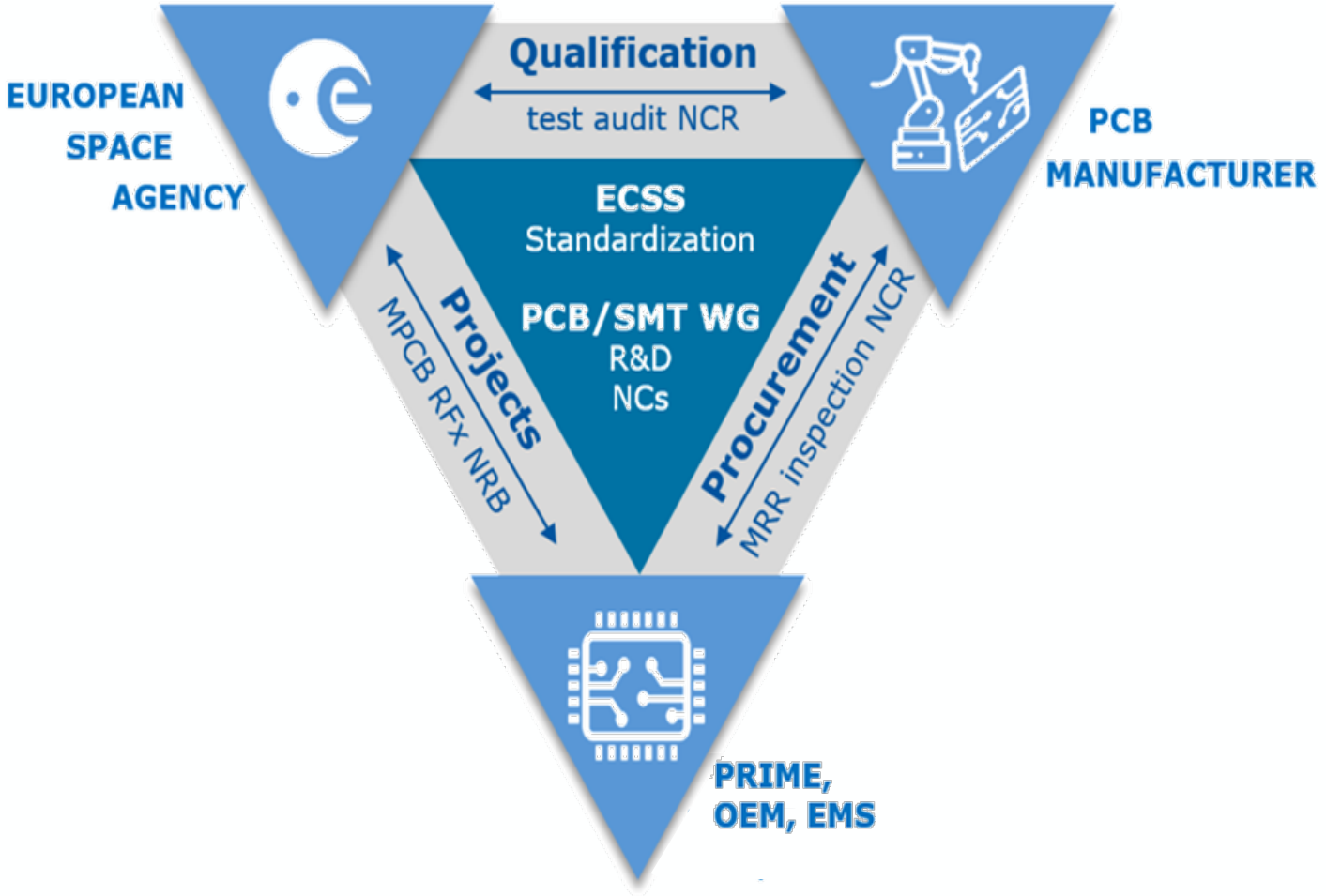
Level 4 - Modules, assemblies integrated in an overall enclosure

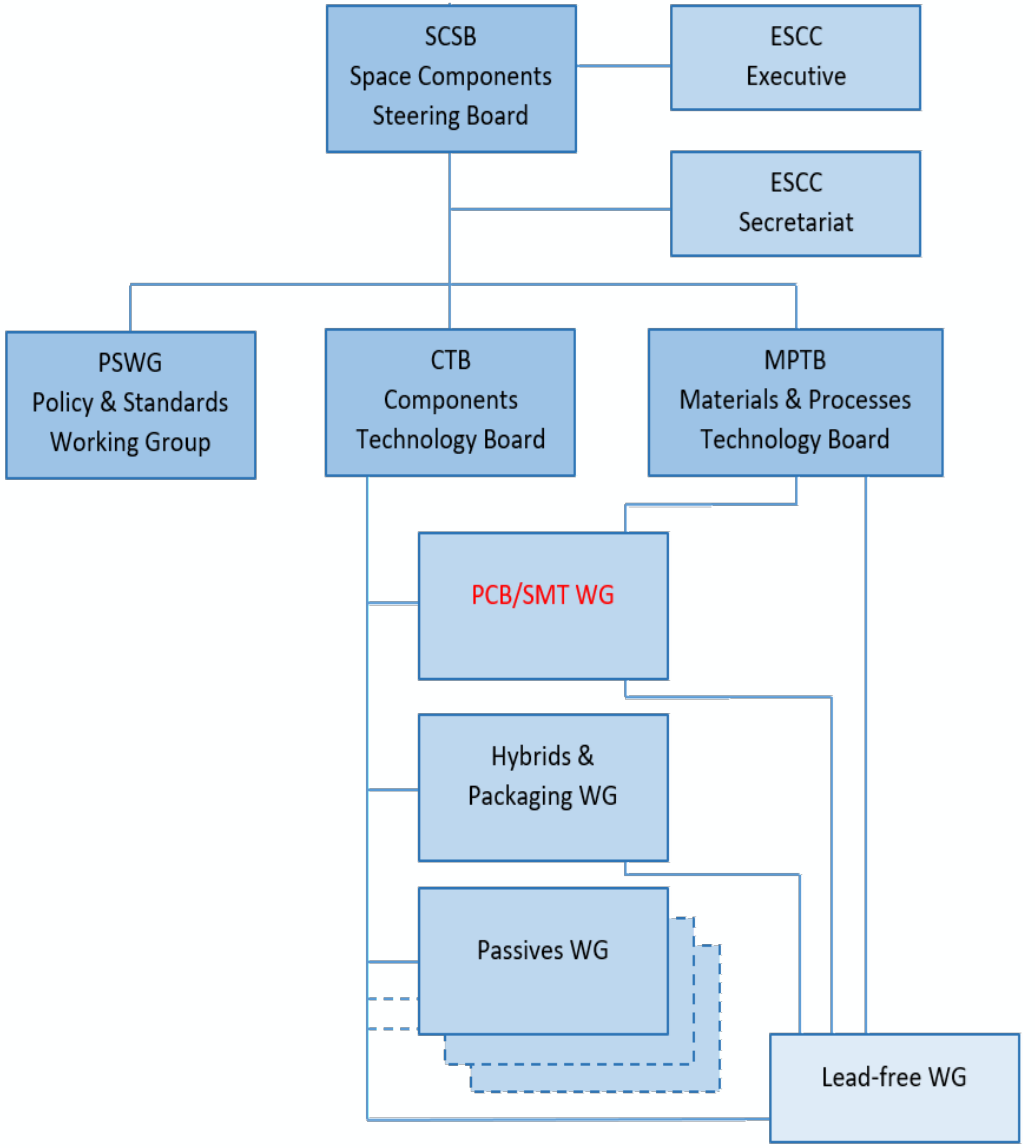
Level 5 - System/equipment, set of modules for a specified purpose





PCB/SMT WG of the Components Technology Board





PCB/SMT working group

esa

cnes

DLR

ThalesAlenia Space
A Thales / Finmeccanica Company

OHB

AIRBUS DEFENCE & SPACE

sodern
arianeGROUP

SENER

RUAG

KONGSBERG

LEONARDO

imec

MEREDIT

… and… the qualified PCB manufacturers

ESA qualified PCB manufacturers

Amphenol invotec

ACB
ADVANCED CIRCUIT BOARDS
ATLANTEC CIRCUIT BOARDS

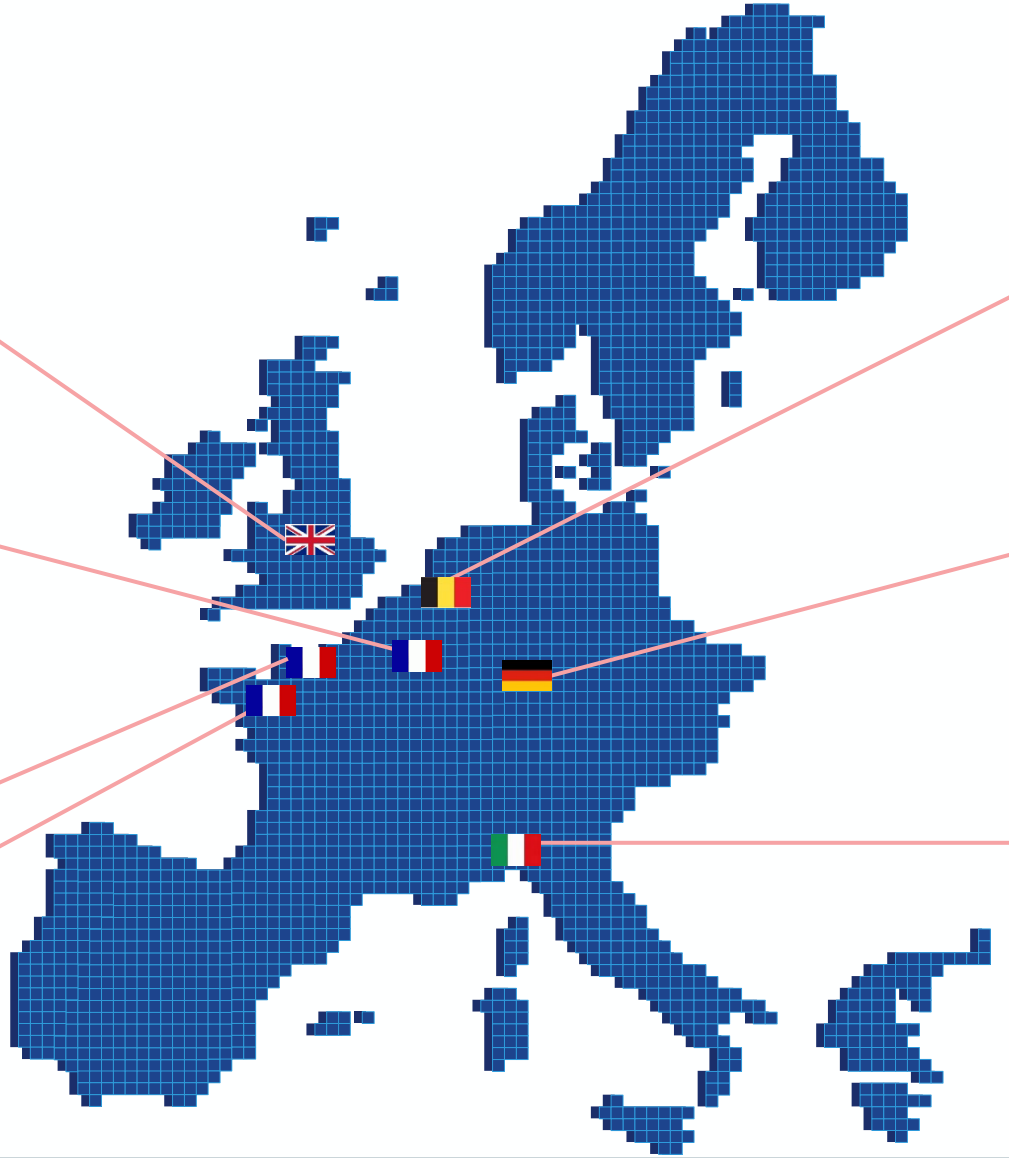
SYSTRONIC
Groupe CIMULEC

TESAT

elvia
PRINTED CIRCUIT BOARDS

Coutances
A&P Lithos Chateaubourg
Qualification in progress

CISTELAIER
Qualification in progress



Harmonisation

European Space Harmonisation of PCB and Electronic Assembly completed in 2022 for the first time.

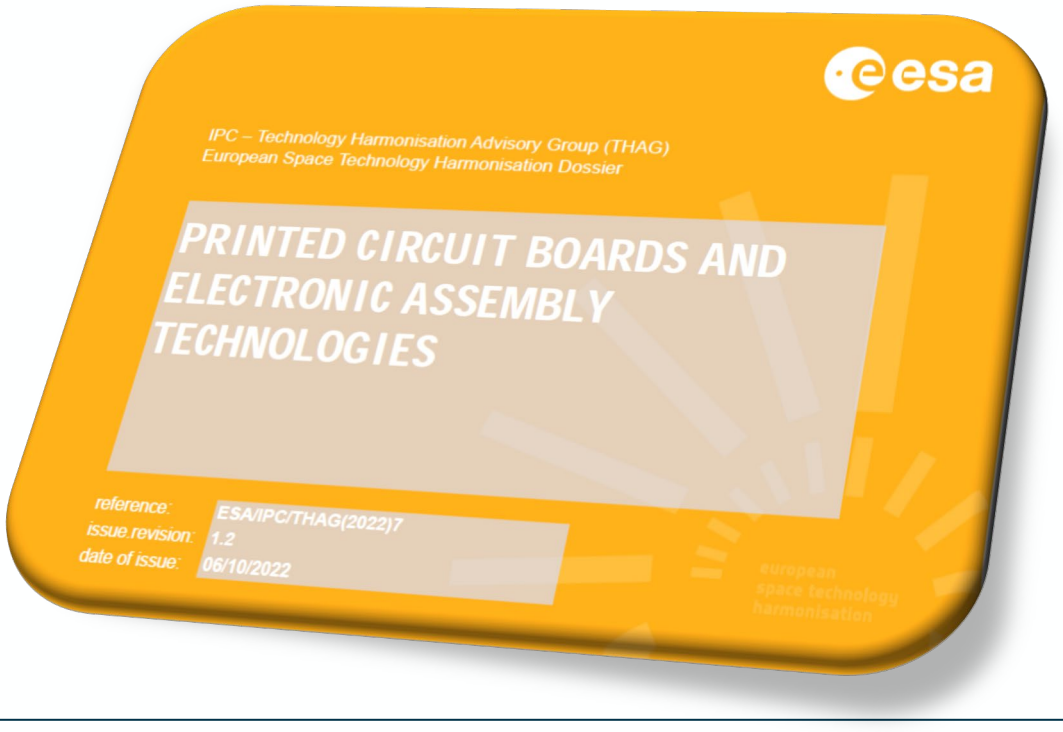
Technology dossier and Roadmap available on Harmonisation Data Management System (HDMS).

Send email to harmo@esa.int to obtain login credentials.

https://tec-polaris.esa.int/eclipse/public/redirect?url=/eclipse/i-layout?applicationId=dccm&projectId=1303&goto=/web/document/document-edit!view?document.id=35849&configFile=true

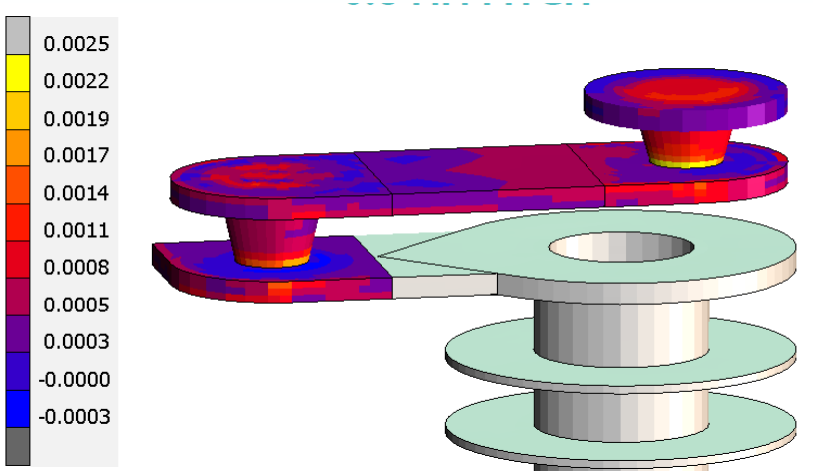
https://tec-polaris.esa.int/eclipse/public/redirect?url=/eclipse/i-layout?applicationId=dccm&projectId=1303&goto=/web/document/document-edit!view?document.id=35848&configFile=true

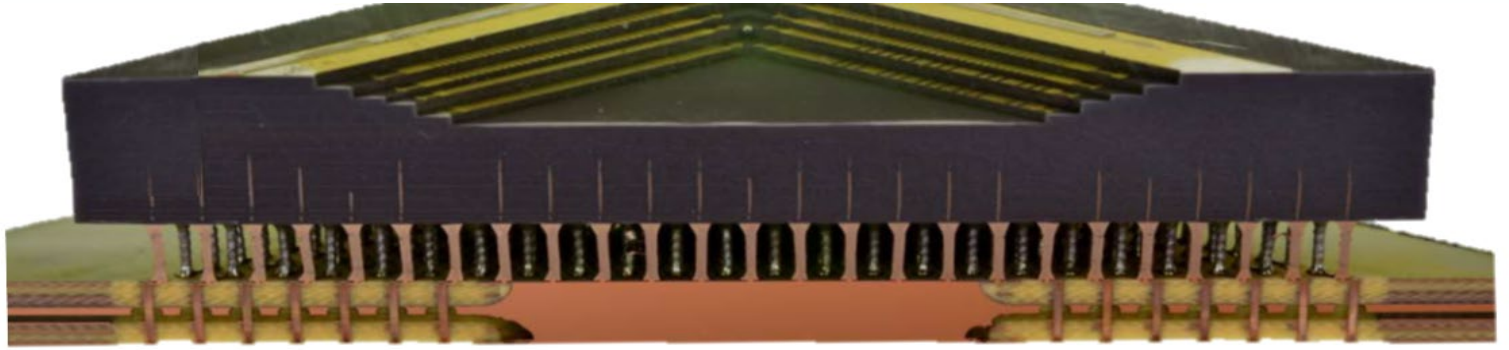
- ✓ Technology description
- ✓ Critical supply chain analysis
- ✓ Market drivers and market assessment
- ✓ Legislative drivers
- ✓ Technology drivers and development
- ✓ Roadmap



State of Art in Europe

- HDI High Density Interconnection technology (microvias)
- Extreme space environmental conditions (e.g. Rosetta, BepiColombo, Exomars)
- Increased power dissipation from assembled components and resulting CTE mismatch
- High speed compatible dielectrics and surface finish
- Re-usability
- Modelling of PCBA
- Digital twin





Key Issues - Technical

- Highly tailorable and **complex processes**.

  Optimization for certain aspects usually goes hand in hand with a negative impact elsewhere.

- Limited sample inspection relying on **representativeness**.

- **Dispersed technology** prevents a common review across various customer chains.

- **Non-conformances** cause poor yield, long lead time, poor On Time Delivery.

  Or worse: failures after assembly putting into question the remainder of the batch.

- Electro-chemical migration can cause **latent short-circuit failure**, which is difficult to screen.

- Assembly **verification** is expensive, difficult to master for sensitive components and places high demands on representativity.

Key Issues – Market drivers

- **Legislation:** RoHS, REACH, etc.
  This is driving lead-free directly (in case exemptions are no longer in place for space)
  and indirectly (because space must follow other volume markets).

- **Economical drivers:** Technology, availability and standardization are driven by volume markets.
  Far East leads because of cost competitiveness, and now also because of capability/quality.
  Incomplete supply chain in EU. Investment is high and market volume is low.

- **COTS, NewSpace, mission classification:**
  COTS is driven by EEE component capability, and by cost (and lead-time) reduction.
  New (for ESA) standardization systems from IPC (global electronics industry association).

Competitiveness and Benchmarking

Overseas modules have been used (GAIA VPU) due to EU unavailability. Assessment hampered by ITAR.

US electronics industry (including NASA) provides a benchmark because:

- Volume market, also in high-rel segment
- Completer end-to-end supply chain
- In-shoring (national independence, Chinese trade conflict, COVID)
- United in several associations. IPC (industry association) is global, but firmly based in US.

Far East / China is very competitive because of low cost and (meanwhile) high capability.

Medical, automotive and military markets (EU) offer synergies and transfer opportunities.

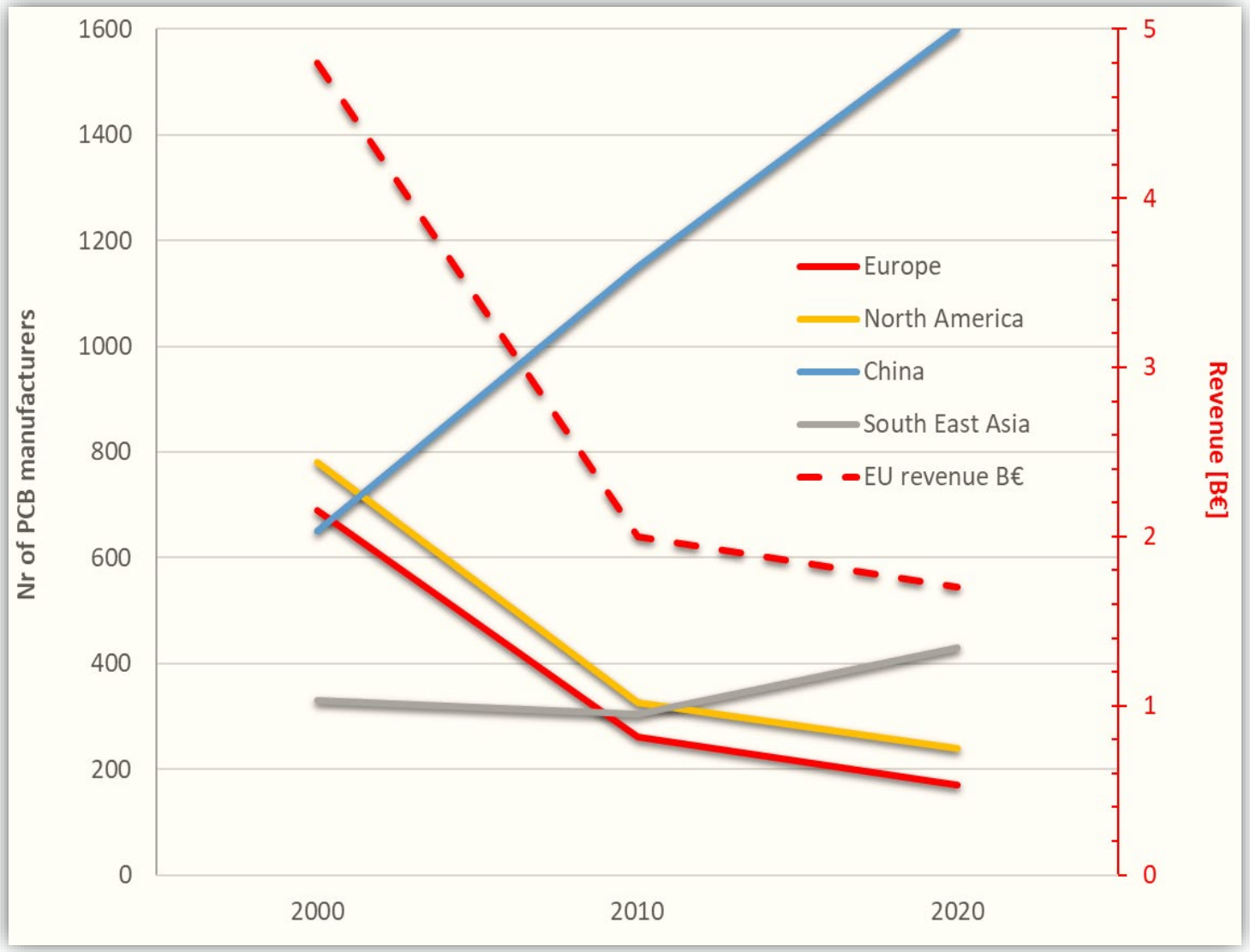
Printed Electronics is low TRL, but potentially disruptive technology, explored by several markets.

Market Perspectives – PCB Survey

Steep decline of PCB manufacturers in EU !

Small EU market volume of 2.4% (1.8 B€)
vs 4.3% in US; 67% in China

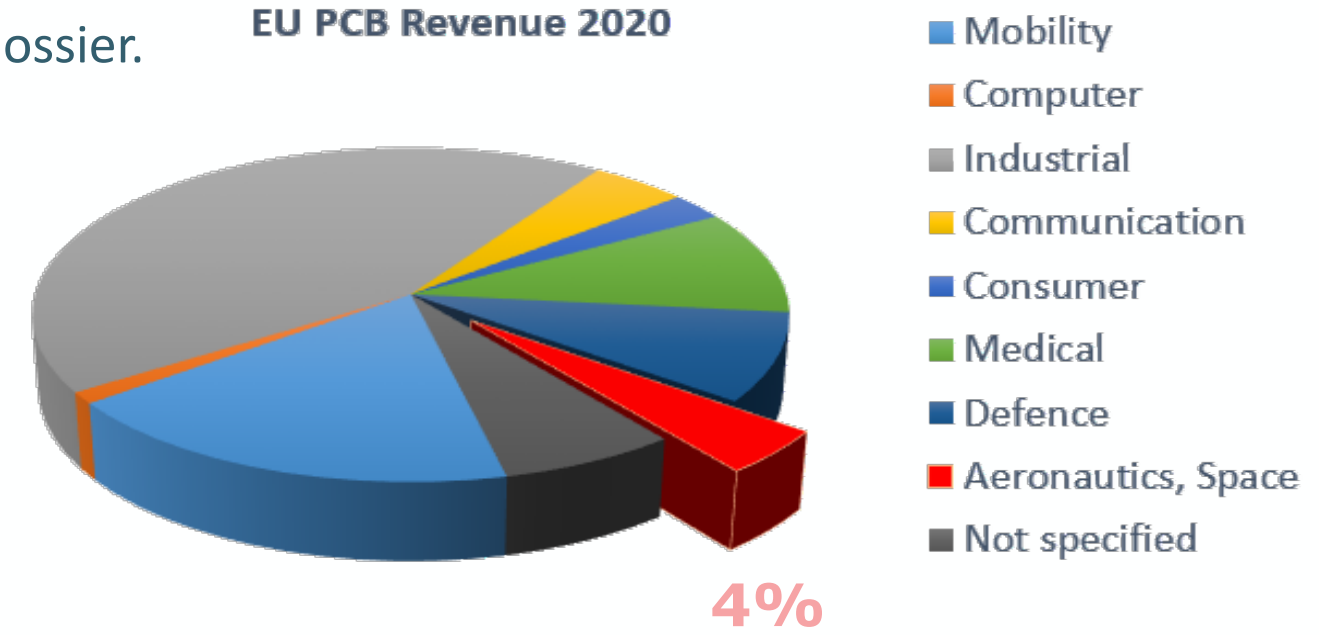
Incomplete EU supply chain for resin, glass, laminate, copper foil, chemistry, equipment, educated personnel.



Market Perspectives – PCB Survey

Supply chain development is a critical topic with its own development AIM in the harmonisation dossier.

But difficult to solve through R&D for space.



How can European PCB supply chain be improved for the benefit of all industry (not just space)?

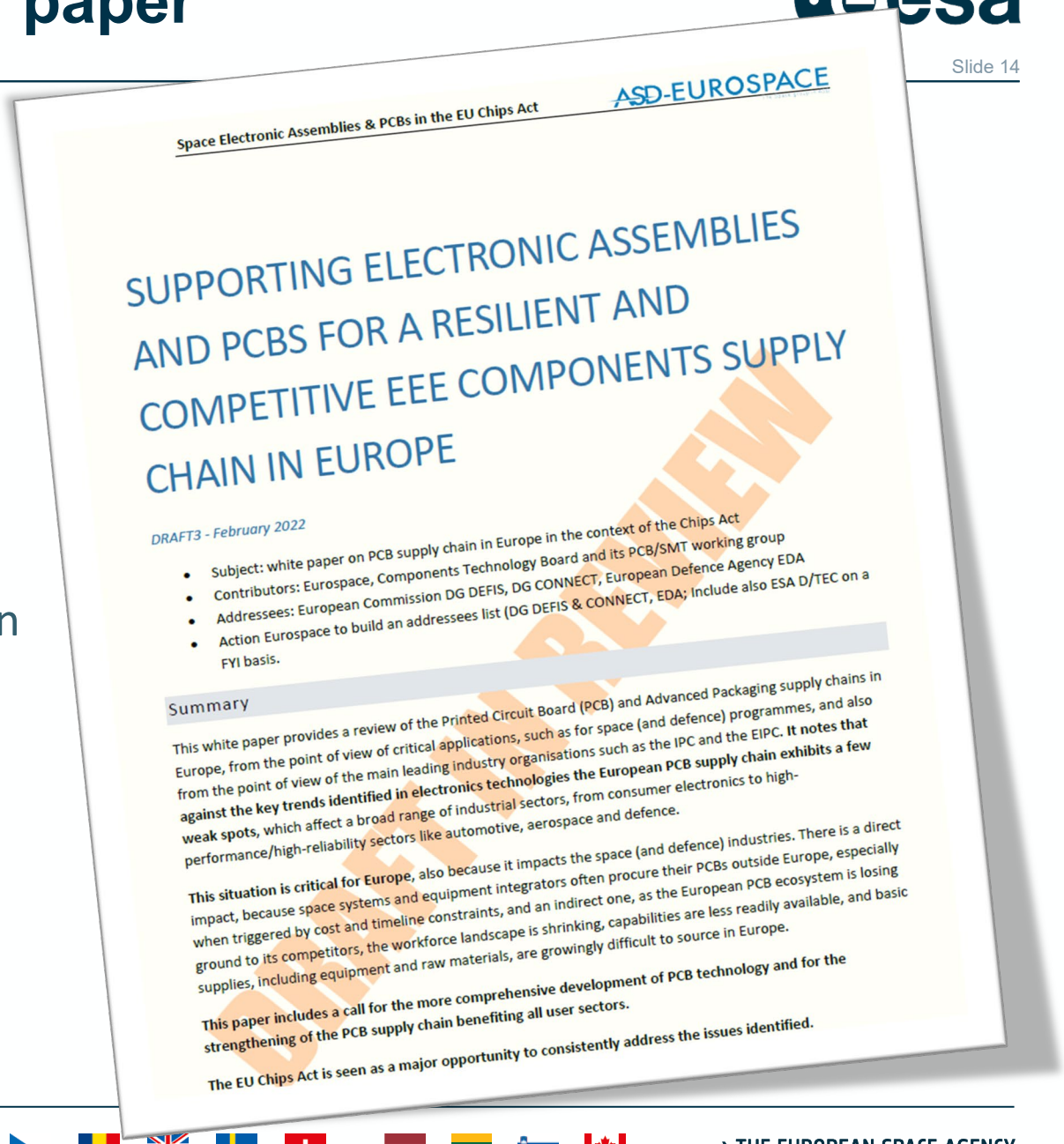
Eurospace PCB Supply Chain position paper

EU PCB supply chain needs support for all market segments (not only in high-rel supply chain).

PCB and system level packaging is not included in the current formulation of the Chips Act.

EC, ESA, EDA implement R&D for high-rel segment.
But this does not address the supply chain deficiencies in the broad fundament of the volume market segments (consumer electronics, automotive, aeronautics).

✓ Position paper request support from EC for the broad development of the PCB supply chain.



Space Electronic Assemblies & PCBs in the EU Chips Act

ASD-EUROSPACE

SUPPORTING ELECTRONIC ASSEMBLIES AND PCBS FOR A RESILIENT AND COMPETITIVE EEE COMPONENTS SUPPLY CHAIN IN EUROPE

DRAFT3 - February 2022

- Subject: white paper on PCB supply chain in Europe in the context of the Chips Act
- Contributors: Eurospace, Components Technology Board and its PCB/SMT working group
- Addressees: European Commission DG DEFIS, DG CONNECT, European Defence Agency EDA
- Action Eurospace to build an addressees list (DG DEFIS & CONNECT, EDA; Include also ESA D/TEC on a FYI basis.

Summary

This white paper provides a review of the Printed Circuit Board (PCB) and Advanced Packaging supply chains in Europe, from the point of view of critical applications, such as for space (and defence) programmes, and also from the point of view of the main leading industry organisations such as the IPC and the EIPC. **It notes that against the key trends identified in electronics technologies the European PCB supply chain exhibits a few weak spots**, which affect a broad range of industrial sectors, from consumer electronics to high-performance/high-reliability sectors like automotive, aerospace and defence.

This situation is critical for Europe, also because it impacts the space (and defence) industries. There is a direct impact, because space systems and equipment integrators often procure their PCBs outside Europe, especially when triggered by cost and timeline constraints, and an indirect one, as the European PCB ecosystem is losing ground to its competitors, the workforce landscape is shrinking, capabilities are less readily available, and basic supplies, including equipment and raw materials, are growingly difficult to source in Europe.

This paper includes a call for the more comprehensive development of PCB technology and for the strengthening of the PCB supply chain benefiting all user sectors.

The EU Chips Act is seen as a major opportunity to consistently address the issues identified.

DRAFT IN REVIEW

Proposed Development Approach

AIM A	High Density Interconnect technology	microvias, back-drilling, assembly, embedded components
AIM B	Lead-free technology	surface finish, solder alloy & processes, physics of failure
AIM C	Strengthening the end-to-end supply chain	REACH, environmental, availability of raw materials
AIM D	Smart manufacturing	automated inspection, digital twin, machine learning
AIM E	Modelling	thermomechanical modelling of PCBA
AIM F	Power management	conductive dielectrics, metal inserts, thermal vias
AIM G	Extreme environmental conditions	thermal &mechanical endurance, CTE mismatch
AIM H	High speed materials	high speed digital, RF, antennae
AIM I	Flexible materials	rigid-flex, new flex materials, properties of coverlay
AIM J	Solderless assembly	press-fit, spring loading, mechanical mounting
AIM K	Printed Electronics	3D PE, additive layer & in-orbit manufacturing
AIM L	Optical interconnects	high(est) speed flexible optical interconnects
AIM M	Harness technology	long flex, printed harness on structure, (cryo) sensor harness

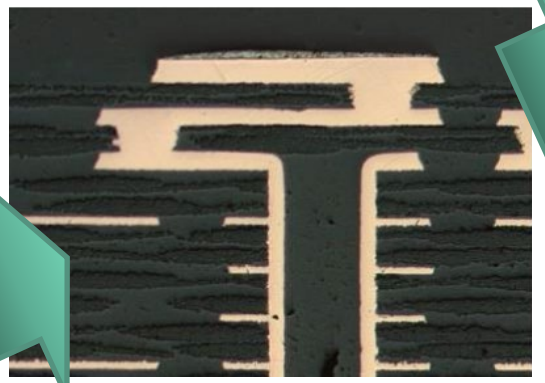
HDI roadmap

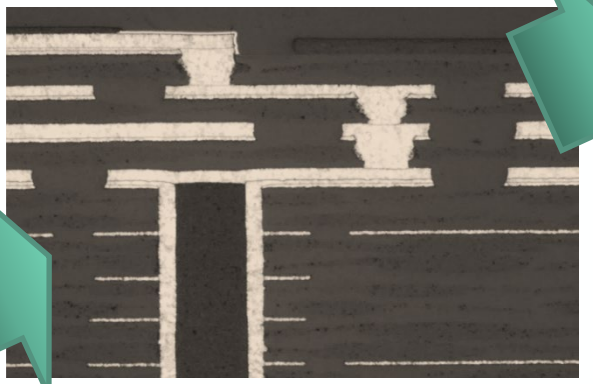
Complexity

1 mm pitch CGA
1752 I/Os
V5, RTG4

Single uvias
Polyimide
SnPb

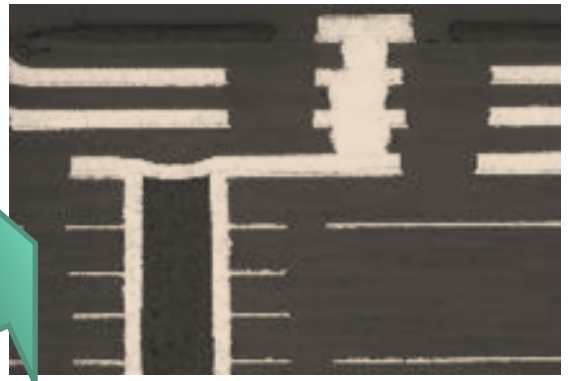
Staggered uvias





Semi-stacked uvias
High speed dielectric
Backdrilling on core vias
ENIG and solder mask

0.8 mm pitch COTS
CBGA 323
PBGA ~3000 I/Os



3 stacked uvias
Spread glass weave
Smooth copper foil
Ni-free finish?

6.25 Gbps
15 Gbps
28 Gbps
56 Gbps
Data rate

HDI activities

The **“hidden reliability threat”** in uvias led to a global IPC alert (electronics industry association). Also, two EU space industry alerts impacted ESA projects in 2019 and 2020.

HDI/uvias are not covered by generic ESA qualification yet. Qualification is expected in 2023. Currently, this is project qualified case-by-case under RFA.

- GSTP basic HDI qualification, complex HDI evaluation in Belgium ongoing
- GSTP basic HDI qualification, complex HDI evaluation in France ongoing
- GSTP basic HDI qualification, complex HDI evaluation in Italy to be initiated
- GSTP high speed HDI in Belgium to be initiated

EU IPC WG on UVIA reliability with high-rel OEMs and their suppliers

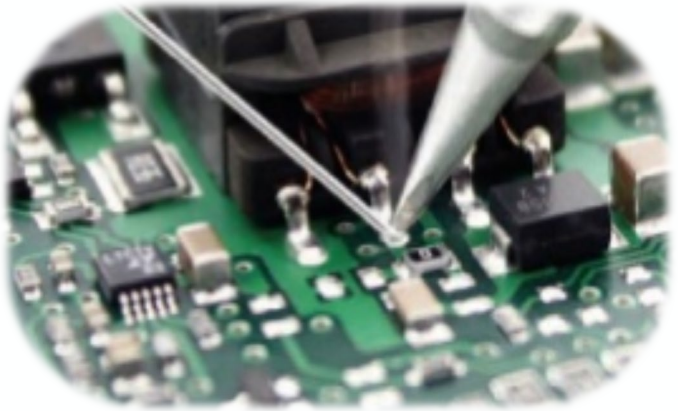
EEE Sovereignty – PCB&EA Priorities #1 #2

#1 HDI

High Density Interconnect

- ✓ Microvias
- ✓ Fine pitch track & gap
- ✓ High pin count assembly

Driven by e.g. microprocessors



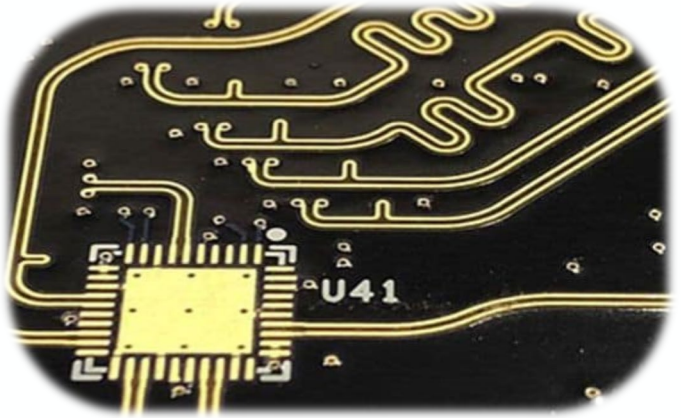
#2

Pb-free

- ✓ Lead-free assembly
- ✓ Lead-free surface finish
- ✓ Validation

Driven by legislation, market trends, COTS

EEE Sovereignty – PCB&EA Priorities #3 #4



#3 High Speed

- ✓ Low loss dielectrics
- ✓ Low loss surface finish
- ✓ Solderless assembly

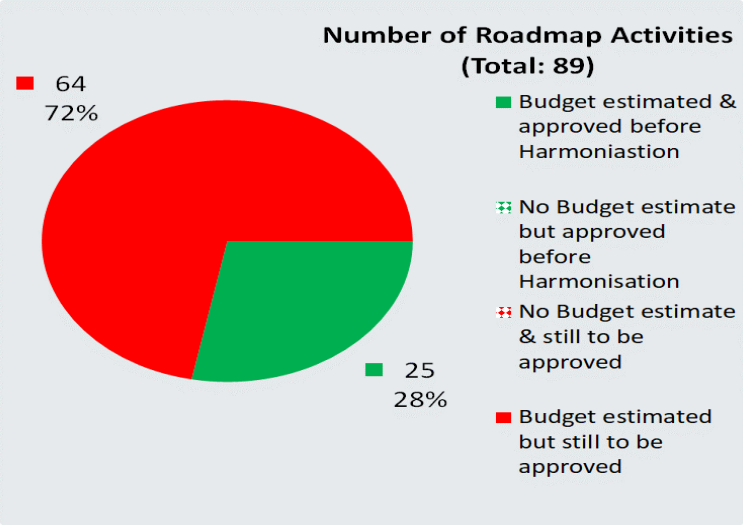
Driven by digital and RF applications

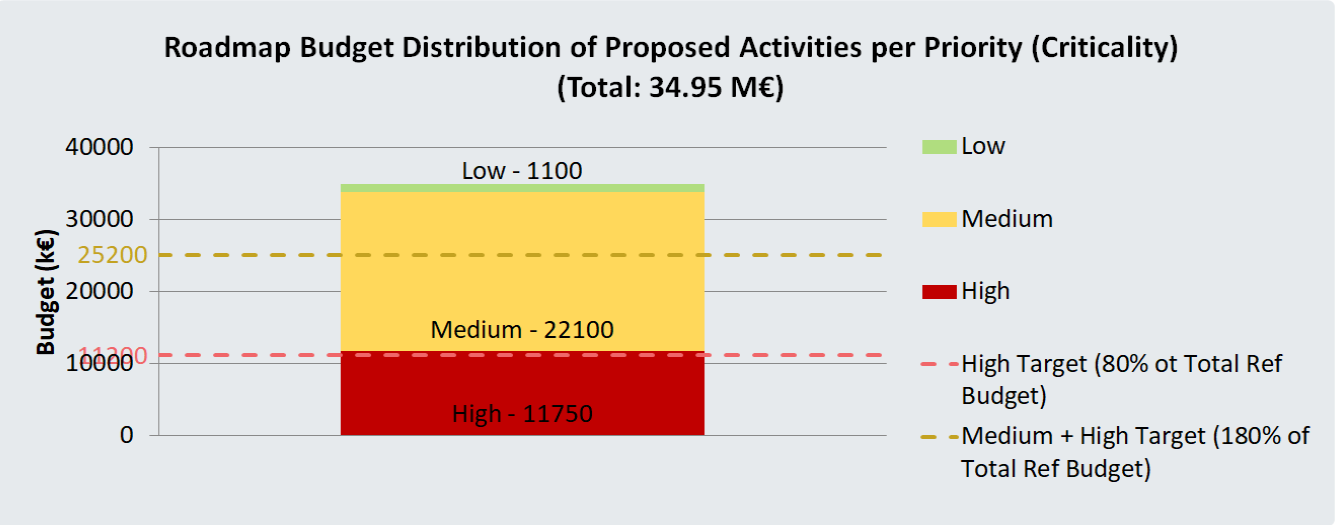
#4 Thermal Management

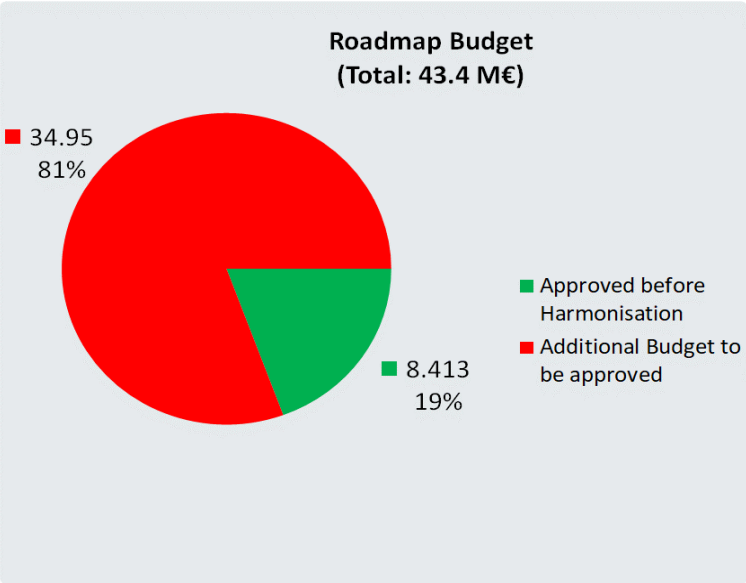
- ✓ Internal: heat sinks, copper coins, thermal vias, conductive dielectrics
- ✓ External: conductive adhesive, heat sink on package
- ✓ Thermal endurance of assembled modules

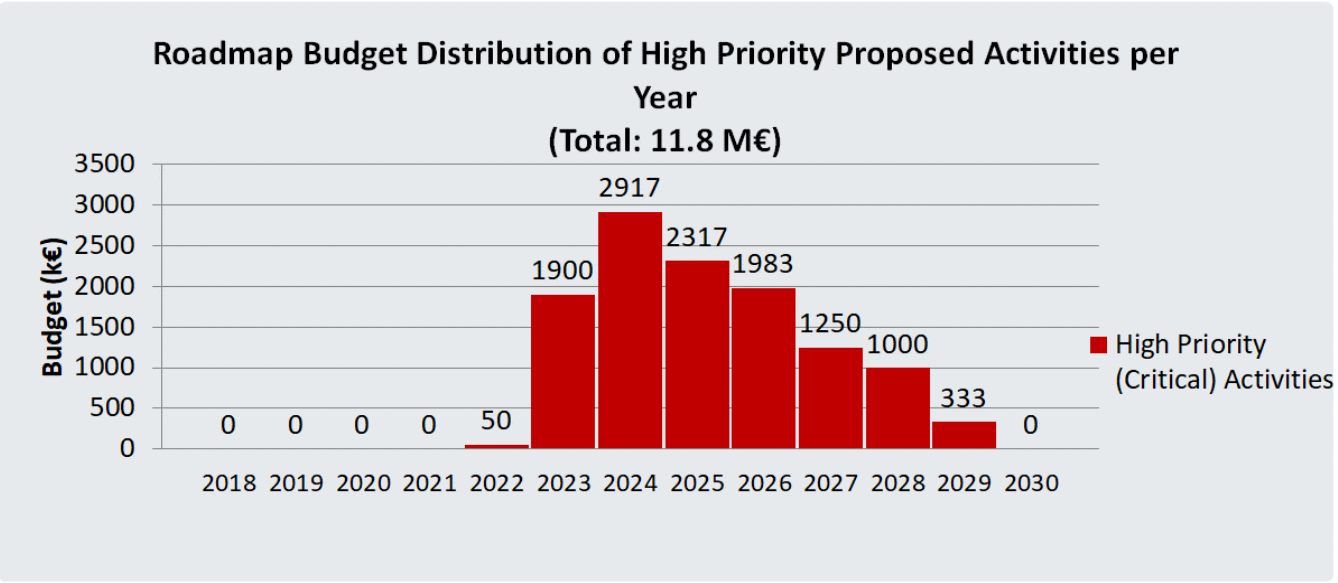
Driven by high power dissipation

Proposed Roadmap – Overview









Conclusions on Europe's Strategic Interests for PCB

PCB and EA provide key **building blocks** for electronic equipment for all space projects.

Space projects **significantly impacted** due to high effort of development, qualification and procurement.

Supply chain is vulnerable due to legislative and economical market drivers.

Process control is notoriously difficult; expected to benefit tremendously from Industry 4.0.

COTS, NewSpace and mission classification drive **novel approaches for standardization and qualification**.

Operational drivers include 5G/6G, on board processing, power electronics and extreme space environmental conditions, among others.

Miniaturization of electronics is an enabling capability, most evident in consumer electronics. Spin-in to space market is already imminent due to COTS. **Pb-free** transition needs to be implemented.

European (New)Space programmes require wide availability of PCBEA technology, building competencies and influencing global standardization.

Thank you for your attention !

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http://www.escies.org/pcb/

https://technology.esa.int/lab/materials-electrical-components-laboratory

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