Criticality assessment of the EU space systems' supply chains

Initial findings and identification of further data needs

ESA Clean Space Industry days

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Joint Research Centre

This work is carried out in the context of an administrative arrangement between the Joint Research Centre (JRC) and the Directorate General for Internal Market, Industry, Entrepreneurship, and SMEs (DG GROW) – AA CT-EII

JRC Mission

*“As the **science and knowledge service** of the **European Commission** our mission is to **support EU policies** with independent evidence throughout the whole policy cycle”*

JRC

Policy neutral: has no policy agenda of its own
Independent of private, commercial and national interests
Works for more than **20 EC policy departments**

More than 50 **large scale research facilities**
More than 110 **online databases**

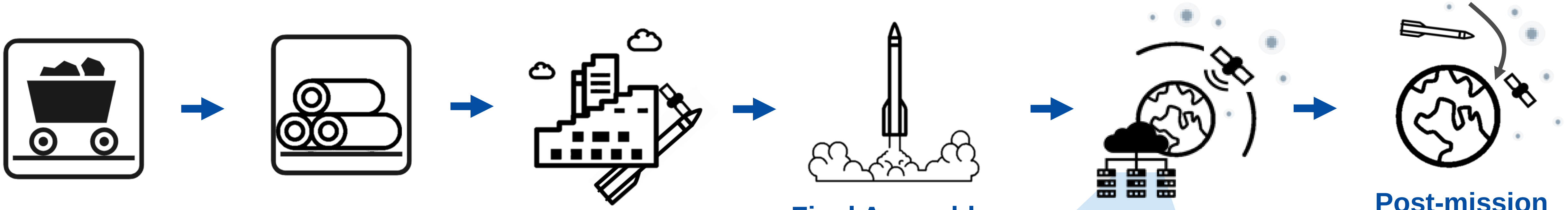
About 2 800 **staff,** nearly 70 % of whom are **scientific/technical staff**

83 % of core **research staff with PhDs**

Over 1 400 **scientific publications per year**

Context

Space sector is an **enabler** for downstream applications & European citizens



Raw Materials → Advanced materials & components → Design & Manufacturing → Final Assembly Lift-off → Use phase – data generation & storage → Post-mission disposal (space debris mitigation)

More particularly:

➔ The **EU space value chain** is recognised as a **strategic industrial ecosystem** for the EU economy

Updated new industrial strategy – *COM(2021) 350 final*

+ Action Plan on synergies between civil, defence and space industries – *COM(2021) 70 final*
+ Preparation of the EU launcher alliance *(technology roadmap)*
+ EU secure connectivity programme – *COM(2022) 57 final*

Source: JRC

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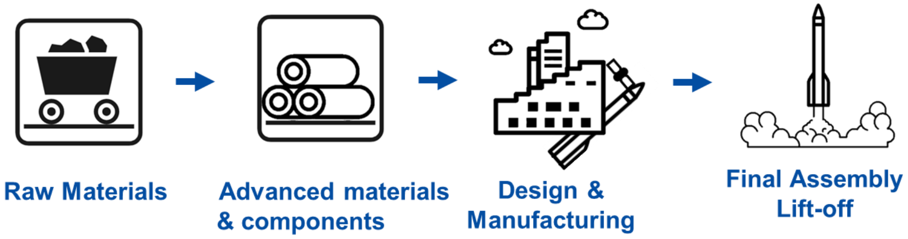
New geopolitical context



- Covid crisis and Russia's invasion of Ukraine highlighted EU industrial **dependencies** and the need to strengthen the **EU open strategic autonomy**

- European space sector is directly impacted:
  - Direct supply disruptions: Soyuz, Vega upper stage engine
  - Growing competition between spacefaring nations and continue militarisation of Outer Space over the last decade[1]

"We must avoid becoming dependent again, as we did with oil and gas. […] We will identify strategic projects ***all along the supply chain****, from extraction to refining, from processing to recycling. And we will build up* ***strategic reserves*** *where supply is at risk. This is why today I am announcing a* ***European Critical Raw Materials Act."***

State of the Union address by President von der Leyen (14.09.2022)

[1] 600t of military satellites launched for 2002-2011 vs 900t for 2012-2021 (source: ASD)

JRC past and forthcoming report

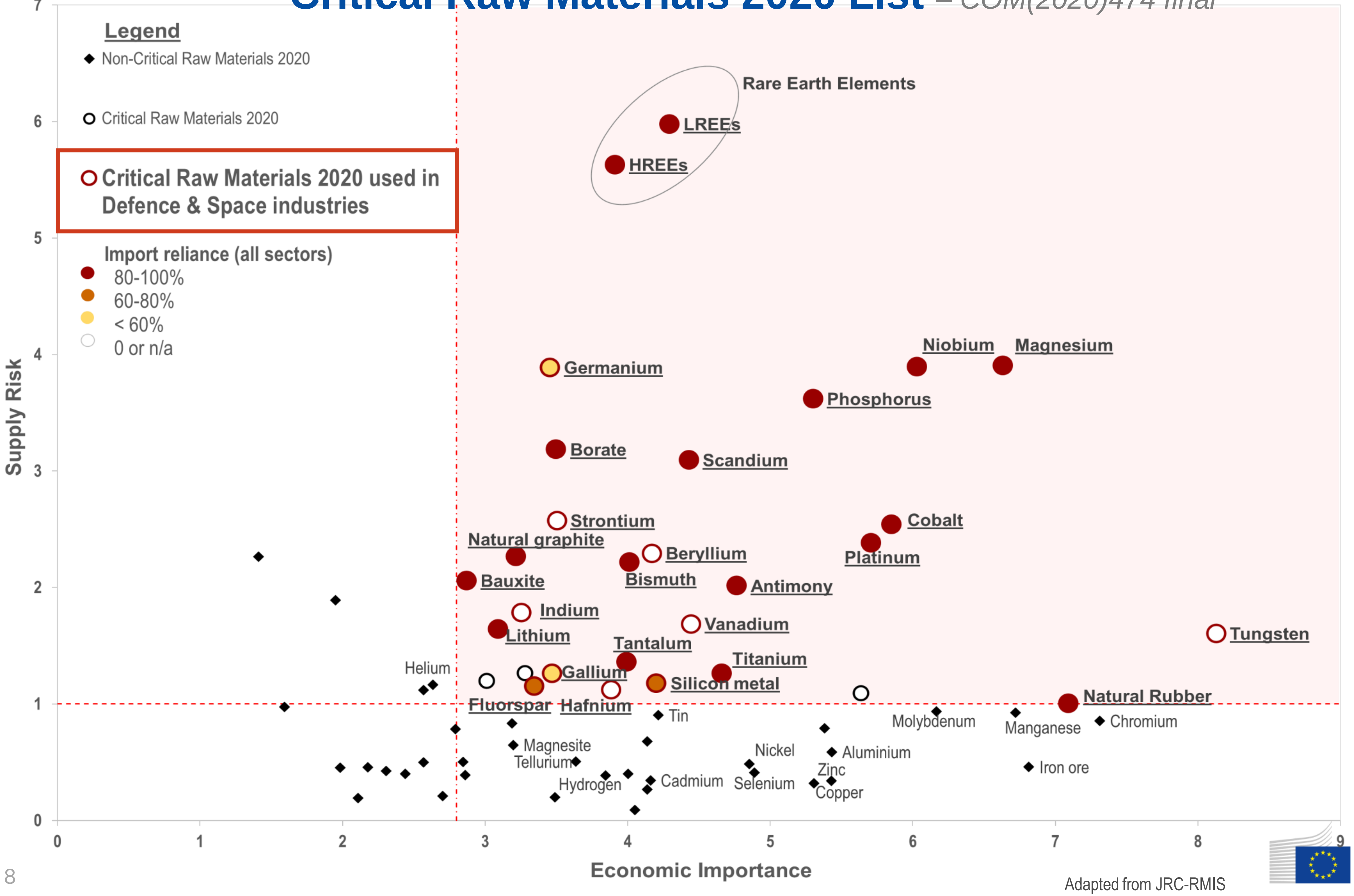
2020 report: 9 technologies in 3 sectors

2023 report: 15 technologies in 5 sectors

Technologies		Sectors
Solar PV	Data storage & servers	**Renewables**
Wind turbines	Smartphones/tablets/laptops	**E-mobility**
Fuel cells	Data transmission networks	Energy industry
Batteries	**Robotics**	ICT
Traction motors	**3D printing**	**Defence and aerospace**
Electrolysers	**Drones**	
Heat pumps	Rocket launchers and satellites	
Direct Reduction of Iron w/ H2	***(ICT)***	

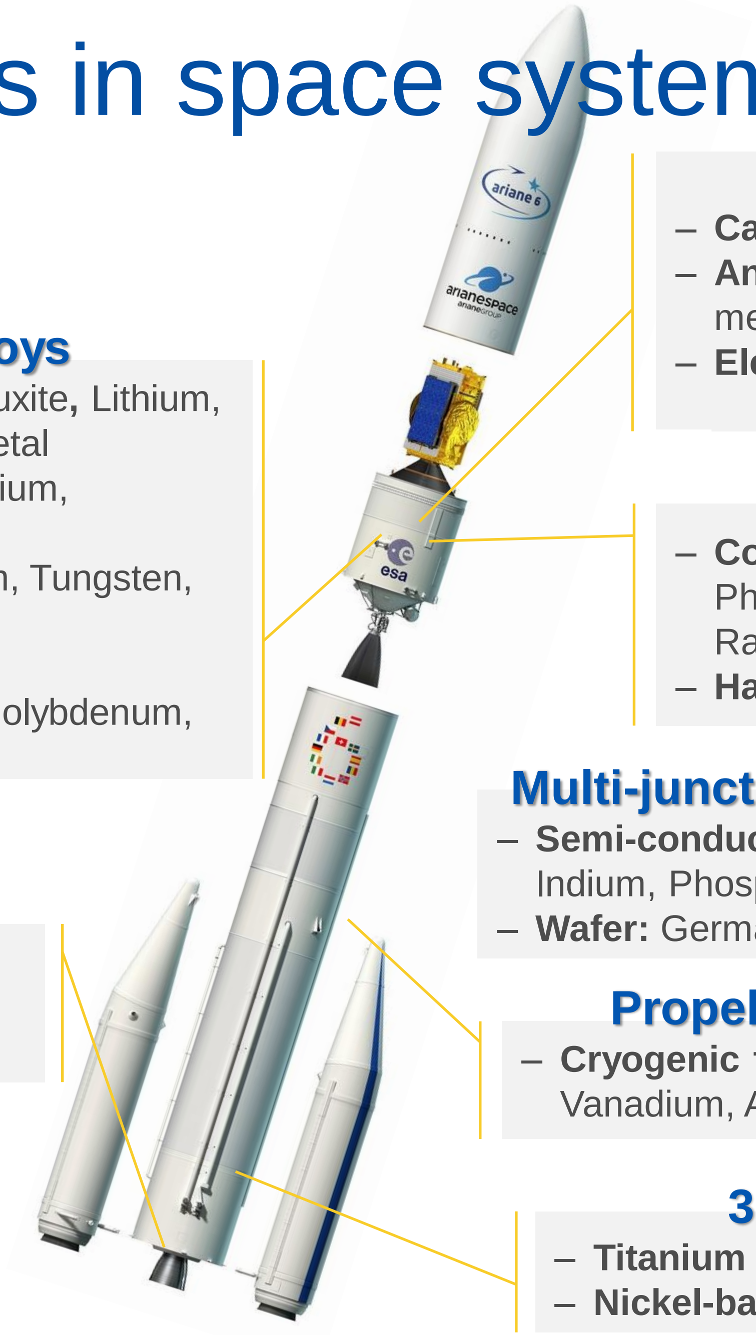
Critical raw materials

Critical Raw Materials 2020 List – *COM(2020)474 final*



Adapted from JRC-RMIS

CRMs in space systems



Metallic alloys
- **Aluminum alloys:** Bauxite**,** Lithium, Magnesium, Silicon metal
- **Titanium alloys:** Titanium, Vanadium, Tungsten
- **Nickel alloys:** Niobium, Tungsten, Cobalt
- **Cobalt alloys**
- **Molybdenum alloy:** Molybdenum, Titanium, Zirconium

Nozzles
- **Composite materials**: Silicon (Yttrium?)

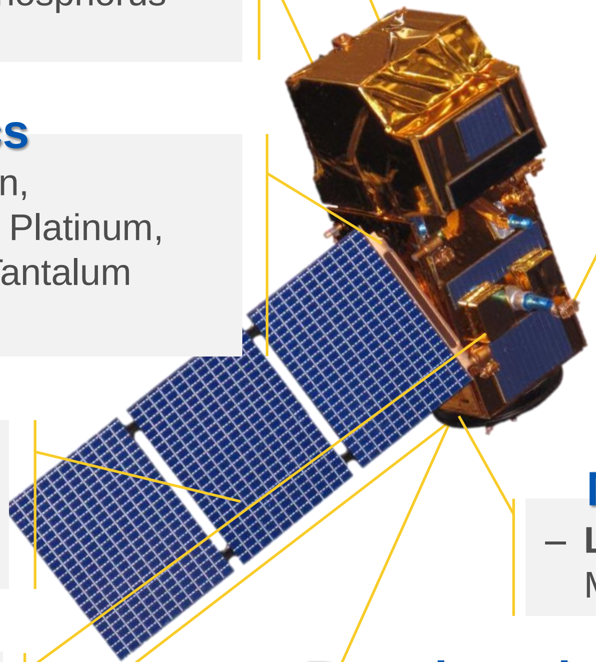
Li-ion batteries
- **Cathode:** Lithium, Cobalt
- **Anode:** Natural Graphite, Silicon metal, (Titanium?)
- **Electrolyte:** Lithium, Phosphorus

Electronics
- **Components:** Tungsten, Phosphorus, Beryllium, Platinum, Rare Earth Elements, Tantalum
- **Harness:** Fluorspar

Multi-junction solar cells
- **Semi-conductors:** Gallium, Indium, Phosphorus
- **Wafer:** Germanium, Fluorspar

Propellant Tanks
- **Cryogenic tanks:** Titanium, Vanadium, Aluminium

3D printing parts
- **Titanium alloys powder**
- **Nickel-based alloys powders:** Niobium



Optical instruments
- **Glasses and ceramics:** Phosphorous, Borate, Germanium, Rare Earth Elements, Antimony, Lithium

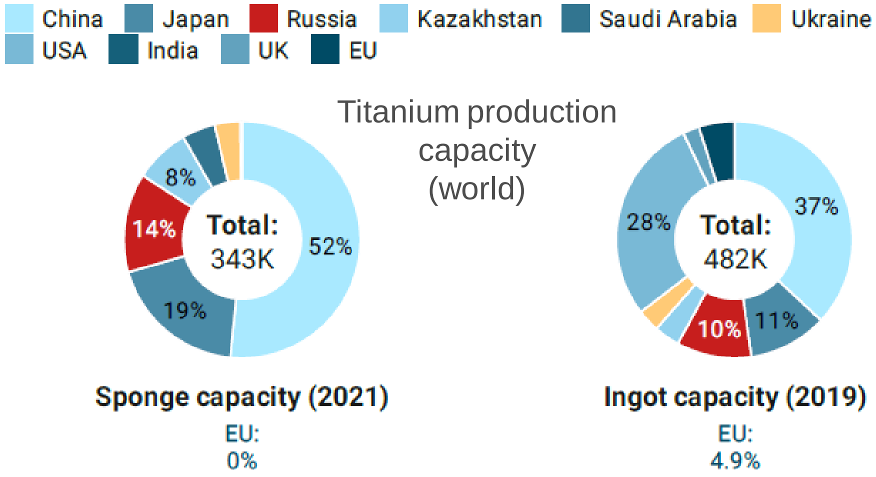
Sensors
- **Thin films:** Platinum group metals
- **Superalloy substrates:** Cobalt, Titanium, Niobium, Tantalum

Metallic alloys
- **Light alloys:** Magnesium, Beryllium

Reaction wheel
- **Magnets:** Cobalt-Samarium or other Rare Earth Elements (Nd)

Source: JRC
Image credits: CC

Zoom on Titanium & Cobalt



Source: JRC based on Louvigné (2021), Roberts (2018), USGS (2022)

Titanium alloys:

- **Aerospace-grade** for Ti sponge: only 40% of the global production capacity, concentrated in 3 countries (Japan, Russia and Kazakhstan)
- Europe is also exposed to import of **semi-finished products** from Russia (16% share of EU Ti import <u>in value</u> in 2020).

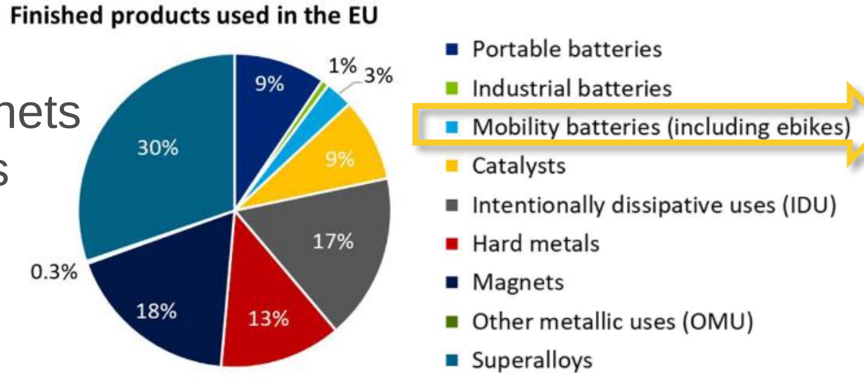
➔ Medium-term **mitigation measure** is to shift supply from Russia to Kazakhstan and Japan for unwrought titanium, and the US and the UK for wrought products.

Cobalt for space applications (and associated grades):

Advanced materials & components

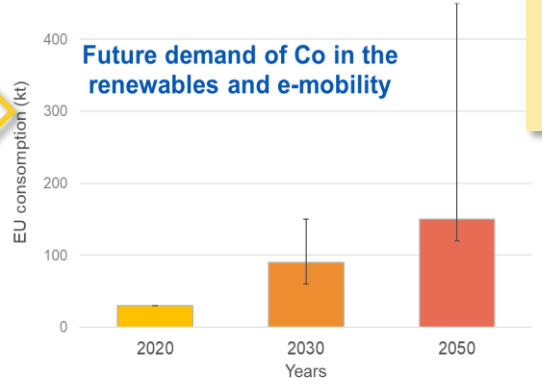
- Super alloys
- Permanent magnets
- Battery cathodes

Raw Materials



33 kt of Co

source: Matos et al. 2020 (JRC)



source: Bobba et al. 2020 (JRC foresight study)

➔ Cross-sectorial competition? ... or synergies?

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Value chain assessment

Generic value chain assessment

Proposed methodology

- Assessing **supply risk** for Space Systemsrequires **a full value chain approach**, considering also the required **quality grade** and the **existing supplier(s)**

- Complexity of space systems results in a huge amount of processed materials and components gathered in a generic assessment (non-exhaustive)

Processed materials	Components	Assemblies	Sub-systems	Systems
32 elements identified *Semi-conductors compounds, composite materials, metallic alloys, germanium substrate etc.*	**45 elements identified** *(electronics, permanent magnets, batteries' cathodes, actuators, cable harnesses etc.)*	**34 elements identified** *(CPU, engines, nozzles, Gyroscopes, lasers, sensors, solar panels, cryogenic tanks etc.)*	**11 elements identified** *(structural frame, payload, AOCS, com. tracking system,, thermal and power sub systems, data handling system, etc.)*	• **4 elements** *EU manufactured satellites &* *EU launchers*

➔ Bottom-up analysis relying on trade/generic industrial data should be complemented with other more qualitative, ecosystem-specific assessments (at a more granular level)

Colour code = qualitative assessment
Red: at risk; yellow: might be at risk; green: no risk identified

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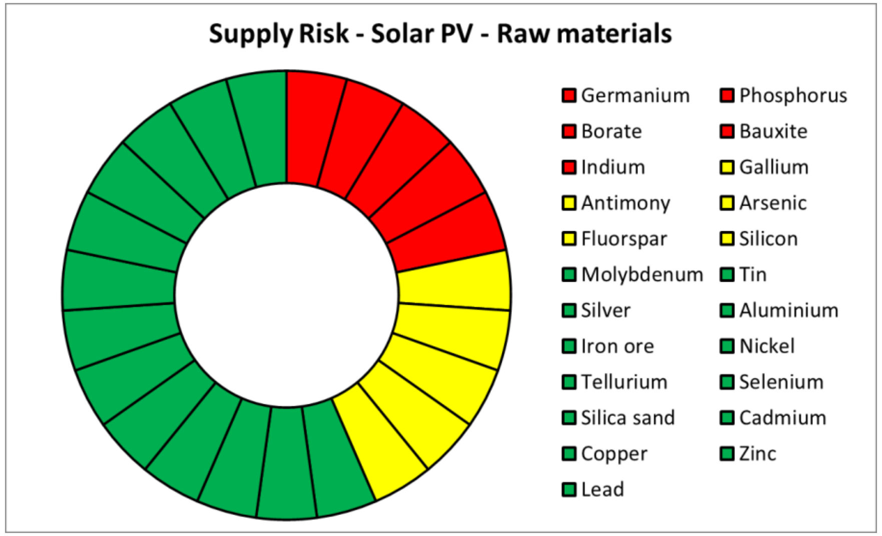
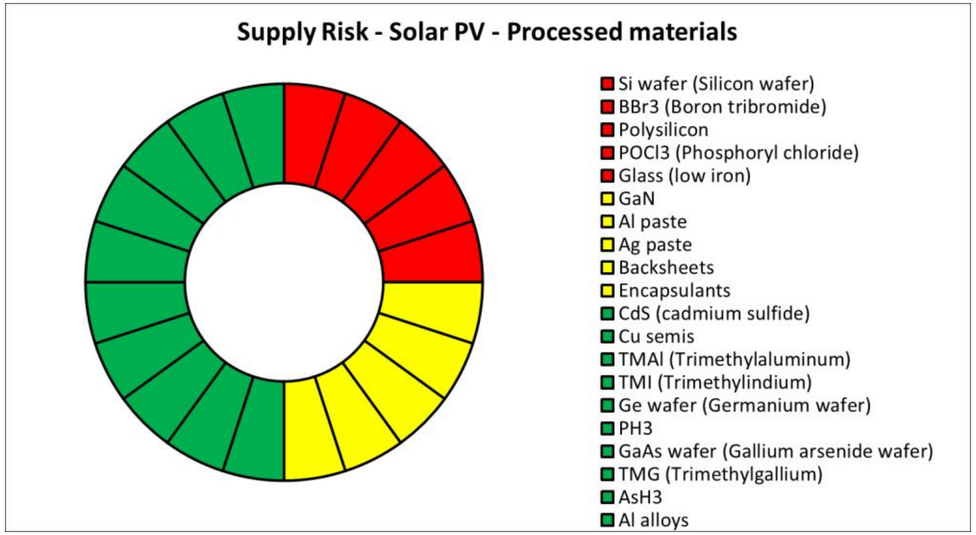
Source: JRC

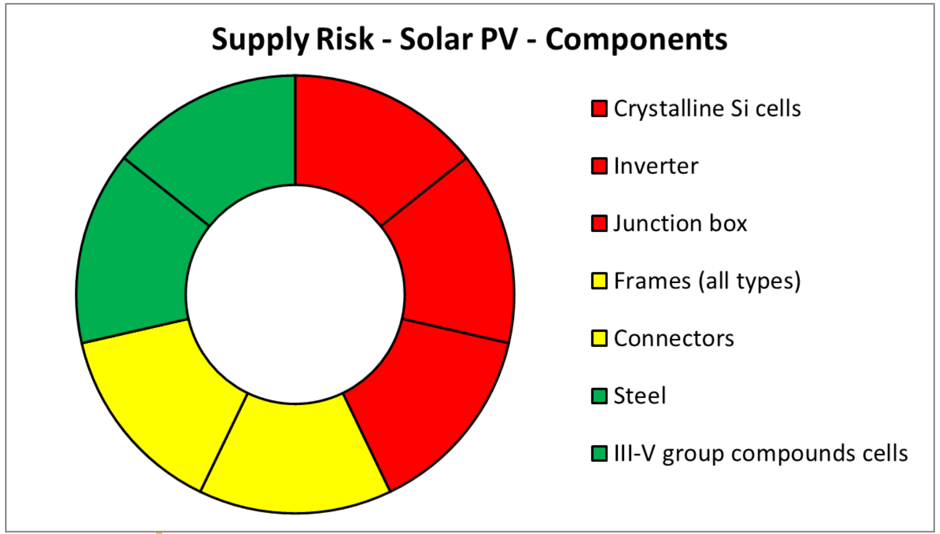
Generic value chain assessment

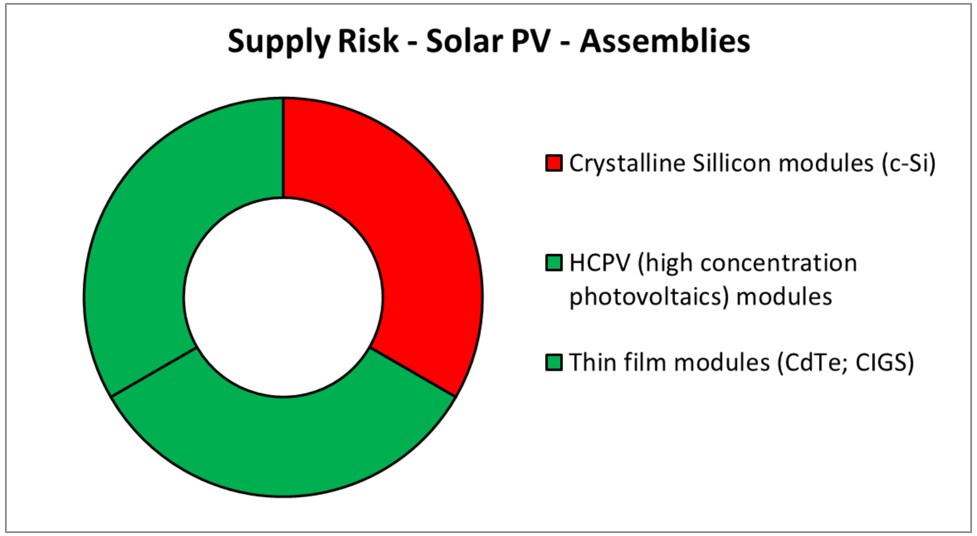
Proposed methodology for Supply risk

Example from energy value chain









Drivers in the risk assessment

- Concentration of supply
- Quality of governance
- Trade conditions
- Recycling

Supply Risk levels

High
Medium
Low

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Source: JRC

Generic value chain assessment

Potential hotspots

Processed materials → **Components** → **Assemblies** → **Sub-systems** → **Systems**

Titanium alloys — *Titanium mill products **(?)***

Gallium arsenide — *wafer/semiconductors* — *Central Process unit **(?)***

Germanium — *Ge wafer* — *Multi-junction cells* ··· *Power systems*

Space-grade Xe, Kr, Helium — *Propellant components* — *Electric thrusters* ··· *Propulsion system* — *Vega*

*Space-grade Ceramics **(?)*** ··· *Launcher Nozzles*

*Carbon Fibers **(?)***

*Gyroscope **(?)***

*Antenna **(?)***

Systems: *Soyuz*, *Ariane*, *Vega*, *EU satellites*

Colour code = qualitative assessment
Red: at risk; yellow: might be at risk; green: no risk identified
Dashed line: potential link with upstream components/assemblies

Sectorial considerations

Sectorial analysis of supply dependencies

Potential mitigation measures for space industry

Stockpilling

Well adapted to space industry

- Strategic materials & components
- Short term protection from supply disruption

Substitution

Challenging

- Performance-driven choices
- R&D effort and long qualification process
- Role of the COTS components?

Diversification of the supply

Challenging

- Highly-specialised materials & components
- Long qualification process
- EU/Int. trade agreements for raw materials

Circularity & Resource efficiency

Untapped potential

- EoL dissipation
- Reusability of launchers stages
- Generalisation of 3D printing
- Domestic scrap recycling capacities

Reinforced domestic production

Untapped potential

- Adapted for downstream categories (components and assemblies)
- Technology roadmaps with targeted research and innovation efforts
- Joint Public-Private strategic investments

Economic & Industrial intelligence

To be generalised

- Foreign Direct Investment monitoring (Regulation (EU) 2019/452)
- Intellectual & Industrial property rights

COTS: Commercial off-the-shelf

source: JRC

Take home messages

Europe at night, T.Pesquet
Credits: ESA/NASA

1. EU is a space power with a significant industrial capacity & know-how but its **value chain is exposed to supply risks / industrial dependencies**

2. More **targeted** criticality assessment is needed for **key components and materials**.

3. This **monitoring** requires an **adapted methodology** based on a life-cycle thinking approach.

The sector has been already successful with supply chain management, e.g. with obsolescence risk management programme…

Feedbacks from European space industry about their readiness and good practices are welcomed (➔ stakeholders are invited to contact EC-DG DEFIS)

European Commission

Thank you

Europe at night, T.Pesquet
Credits: ESA/NASA

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Disclaimer: *Views expressed are those of the individuals and do not necessarily represent official views of the European Commission*

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