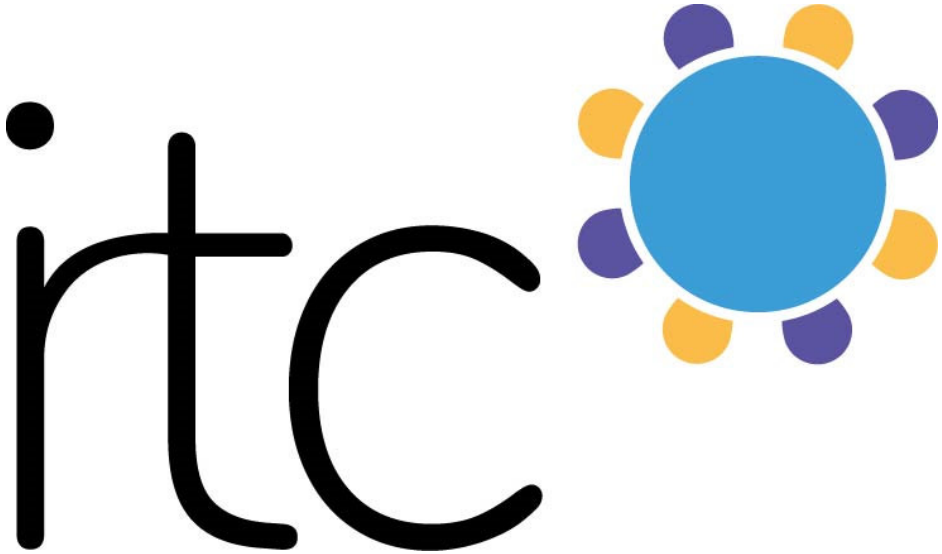
HOW METHODOLOGY DETERMINES WHAT IS CRITICAL



June 19, 2018

Resources for Future Generations Conference, Vancouver

eit RawMaterials
Connecting matters

Granta Product Risk

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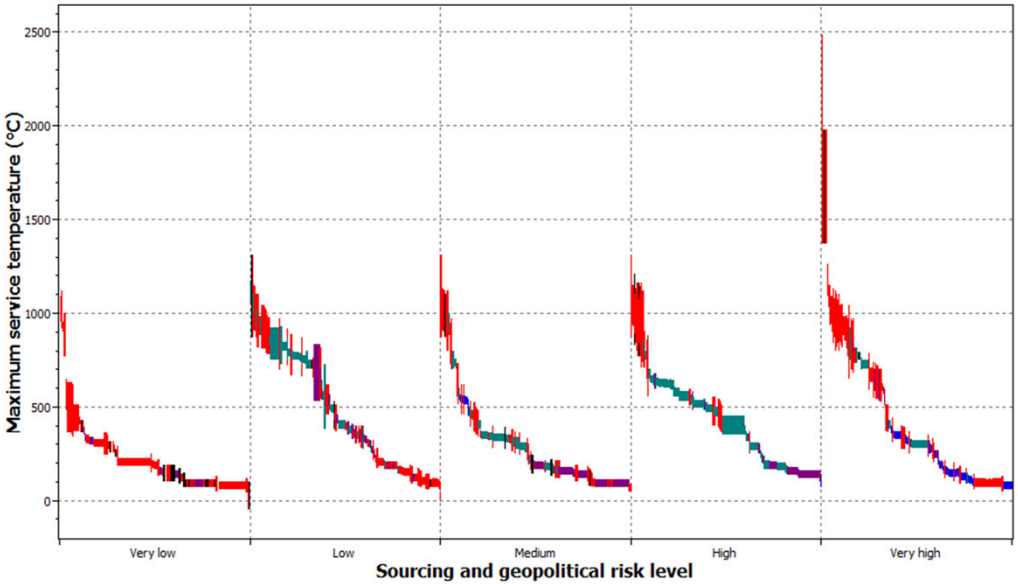
Goal and Scope

Goal:

To equip advanced engineering organisations with the data needed to identify their business and product specific risks from materials, manufacturing processes & suppliers.

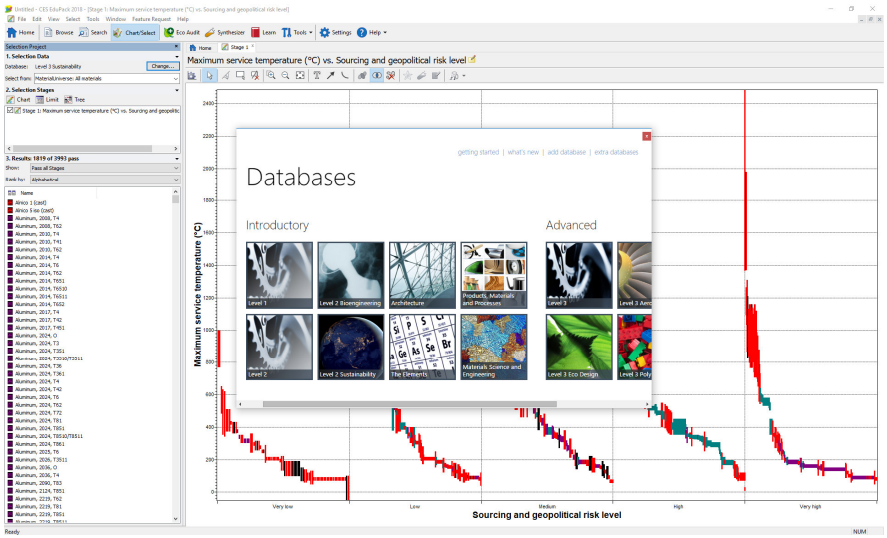
Scope:

- Evaluate materials, processes, parts, products and portfolios.
- Identify risks linked to product performance and delivery.
- Risks linked to traceable engineering materials data (reference & in-house).
- Coverage:
  - 65 abiotic elements
  - 10,500 substances
  - 4,000+ commercially available materials

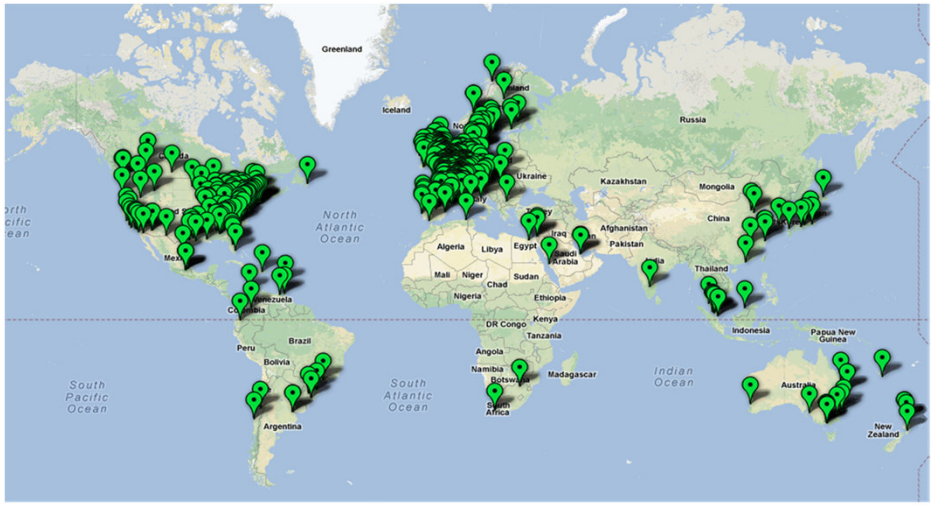


Goal and Scope

As part of materials education:



Materials selection software
Teaching resources…



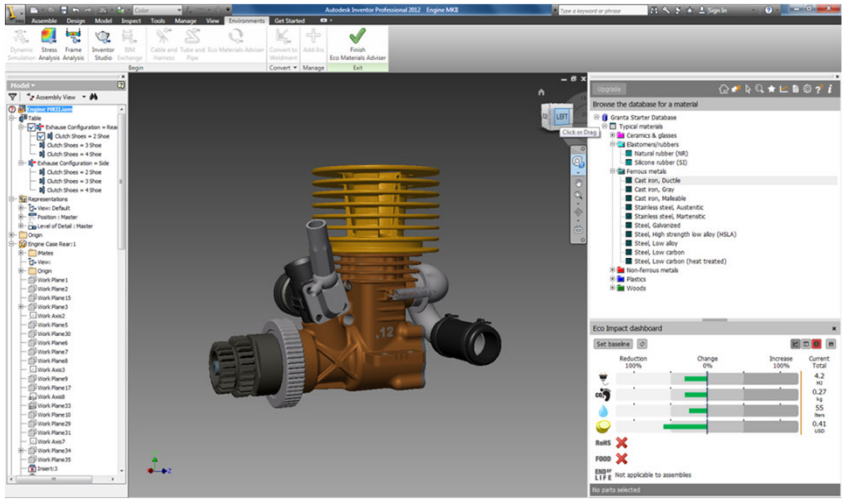
Over 1,000 Universities and Colleges

Goal and Scope

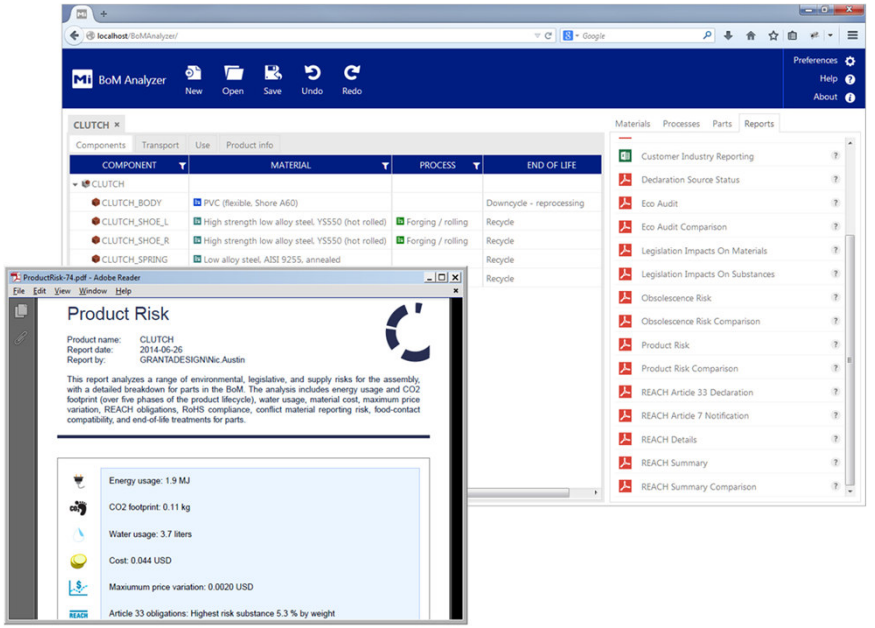
For industry:

Delivering the right data to the right person in their native environment:

- Alongside the secure, approved, access controlled engineering design data they use everyday.



CAD & PLM integrated reporting



Web-based BoM reporting

Goal and Scope

Metrics:

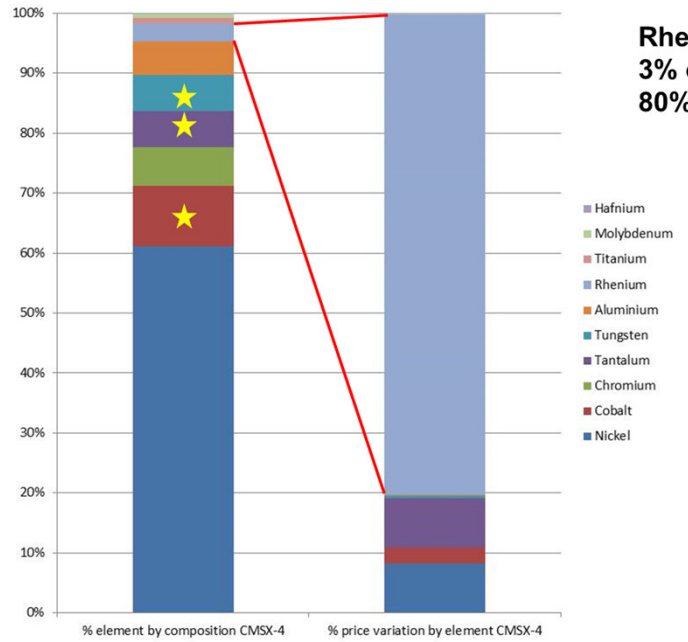
- *Restricted Substances (data maintained quarterly by Granta)*
  - *10,500+ substances, 125+ legislations, lists & standards*
- *Critical & Conflict Minerals – maintained annually*
  - *Monopoly of supply - HHI*
  - *Geopolitical Risk - HHI(WGI)*
  - *Environmental Country Risk - HHI(EPI)*
  - *Conflict minerals risk (Dodd Frank and EU legislation)*
  - *Price volatility*
  - *Crustal Abundance*
- *Environmental Impacts*
  - *Energy*
  - *CO_2*
  - *Water*
  - *EcoInvent*
- *Product Circularity – circularity indicators, Multiple life-cycle LCA.*

Scope explanation

Access to Resources

Industry concerns over existing methodology

- **The 14 materials identified in the EU report are being used as a de-facto list of "critical" materials for all industries**
  - Can give a "false negative" as the impact part of this assessment was carried out at an EU level
  - Ideally, the impact of a supply disruption needs to be assessed at a business and then sector level to establish 'critical resources' for specific industries
  - This will generate more applicable lists for assessing risks
- **Criticality lists can change depending on method used**
- **Factors important to understanding likelihood are missing or inappropriate**
  - Demand scenarios
  - Sustainability of extraction
  - Substitutability



Rhenium:
3% of composition
80% of price variation

For industry, Critical materials are:

- Any material we use which is essential to the performance of our product where
  - A potential for supply chain disruption exists; and
  - The impacts of that disruption would significantly impact our ability to:
    - Produce our product at the volumes we require
    - Sell our product competitively
    - Comply with relevant legislation

Scope explanation

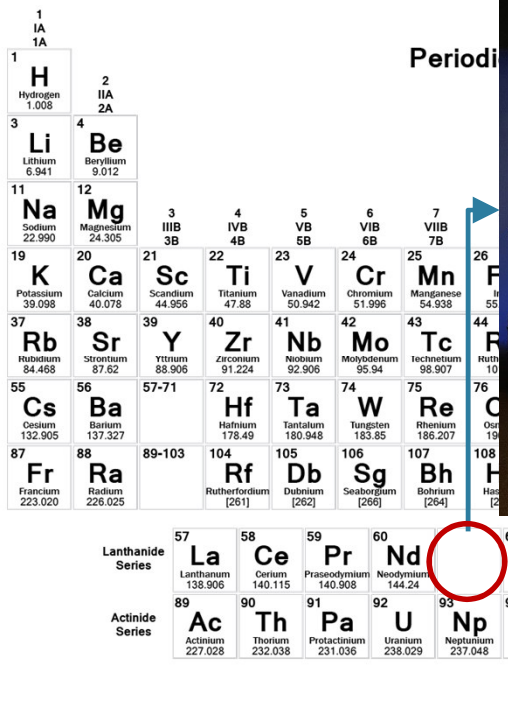
Not all supply chain risks concern everyone:

- Industry want to:
  - Integrate risks into standard business processes.
  - Choose which risks to consider (and add new risks)
  - Understand the context of each risk to make appropriate decisions.
  - Decide how ‘economically significant’ a risk is to their business.
  - Decide how ‘substitutable’ a material is for their product.

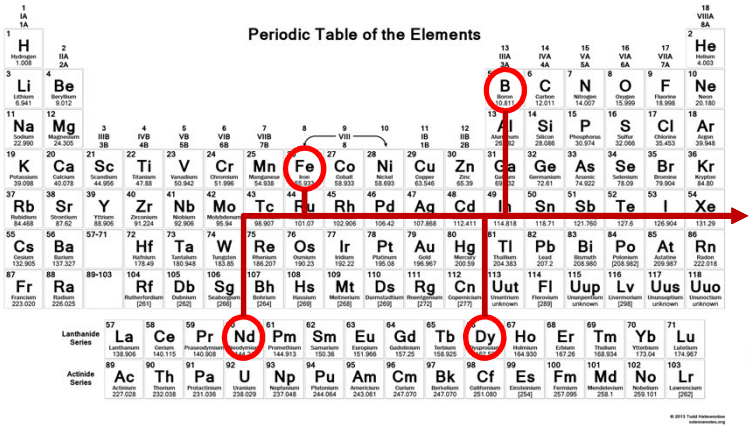
- Granta’s objective is to provide the tools and data needed to enable this assessment
  - An ever changing landscape.
  - Need to respond quickly.
  - Minimise and appropriately target expensive data gathering.

Factor explanation

- Abundance
- Monopoly of Supply
- Geopolitical Risk
- Environmental Risk
- Price Volatility
- Conflict Minerals
- Substances legislation



Factor explanation



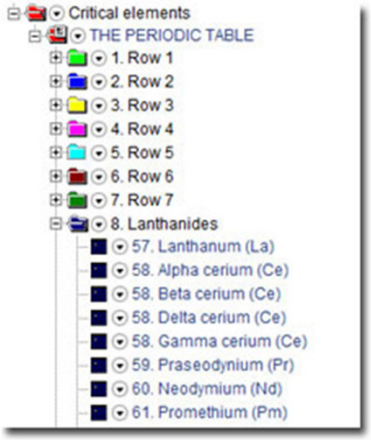
The supply of the element may be the cause of a risk.

The real business risk is a Product Risk, i.e. an inability to deliver a product:

- At cost
- At volume
- In line with legislation or customer expectations.

This is about more than individual elements.

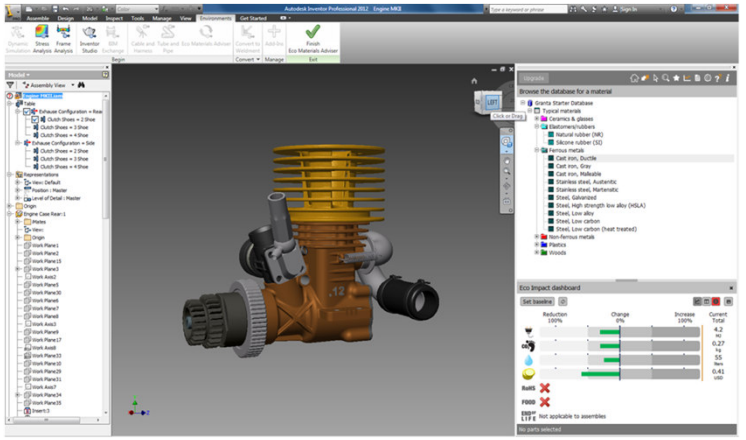
Factor explanation



60. Neodymium (Nd)

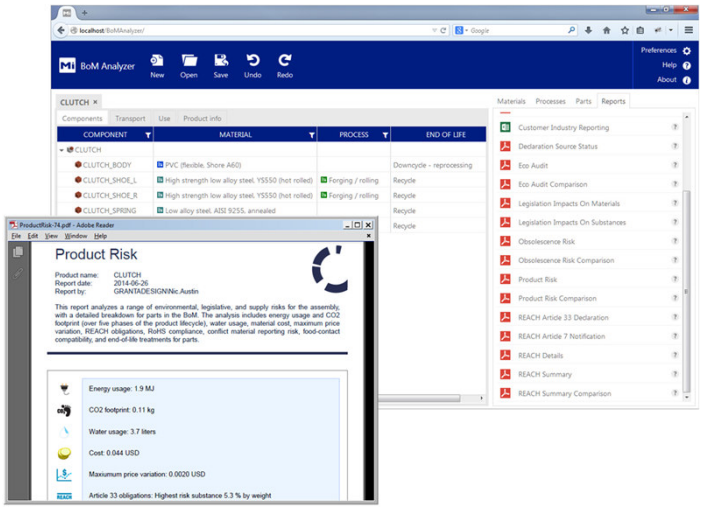
Critical materials - risk levels

Abundance in the Earth's crust	20 to 41.5	ppm
Abundance risk level	Medium	
Sourcing and geopolitical risk Herfindahl-Hirschman Index (HHI)	5.57	
Sourcing and geopolitical risk level	Very high	
Environmental country risk Herfindahl-Hirschman Index (HHI)	4.09	
Environmental country risk level	Very high	
Conflict material risk	Low	
Price volatility	1640	%
Price volatility risk	Very high	
Elemental price variation	113	GBP/kg
Herfindahl-Hirschman Index (HHI)	9130	



Magnesium, EZ33A, cast, T5 [v6]

Element name	Abundance risk level	Sourcing and geopolitical risk level	Environmental country risk level	Price volatility risk level
Zirconium	Low	Very low	Very low	Medium
Copper	Medium	Very low	Very low	Medium
Magnesium	Very low	Medium	Low	Low
Neodymium	Medium	Very high	Very high	Very high
Nickel	Medium	Very low	Very low	Very high



Aggregation

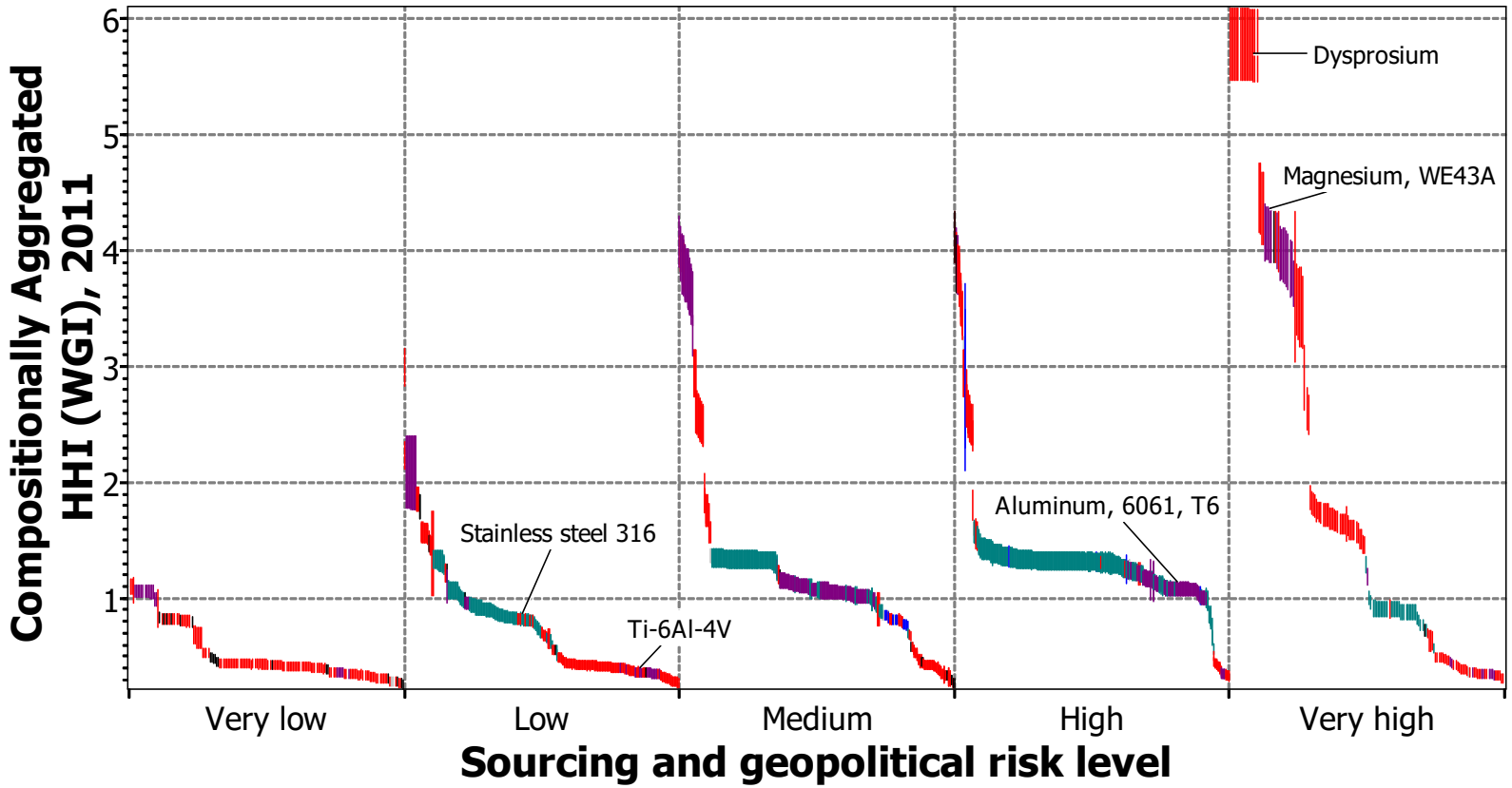
- As a general rule Granta doesn't aggregate risks.

  (*we do however support customer specific aggregation*)

- We find aggregation often masks the cause of the risk → Inhibits development of a suitable response.

- An exception exists for some material or product level reporting:
  - Where we need to consider the aggregate risk arising from multiple elements.
  - This is still optional.

New method: Considers overall risk of composition
Aggregating sourcing of each element

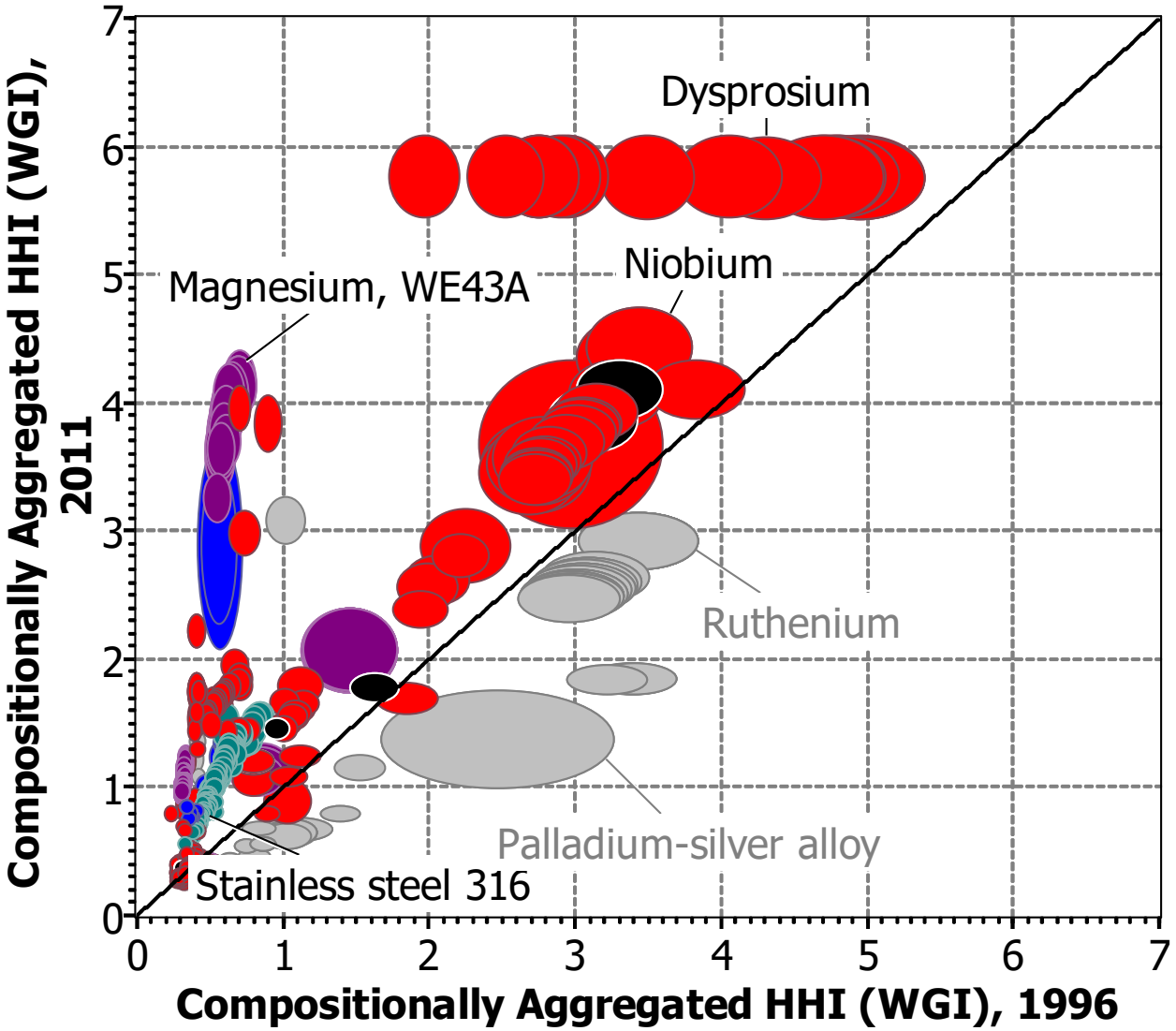


Old method: Material adopts highest risk of all elements in composition

Need to differentiate between:

1. High concentration, High Risk materials (generally important)
2. Low concentration, High risk materials (more important to high volume uses)

This allows us to do some unique analyses



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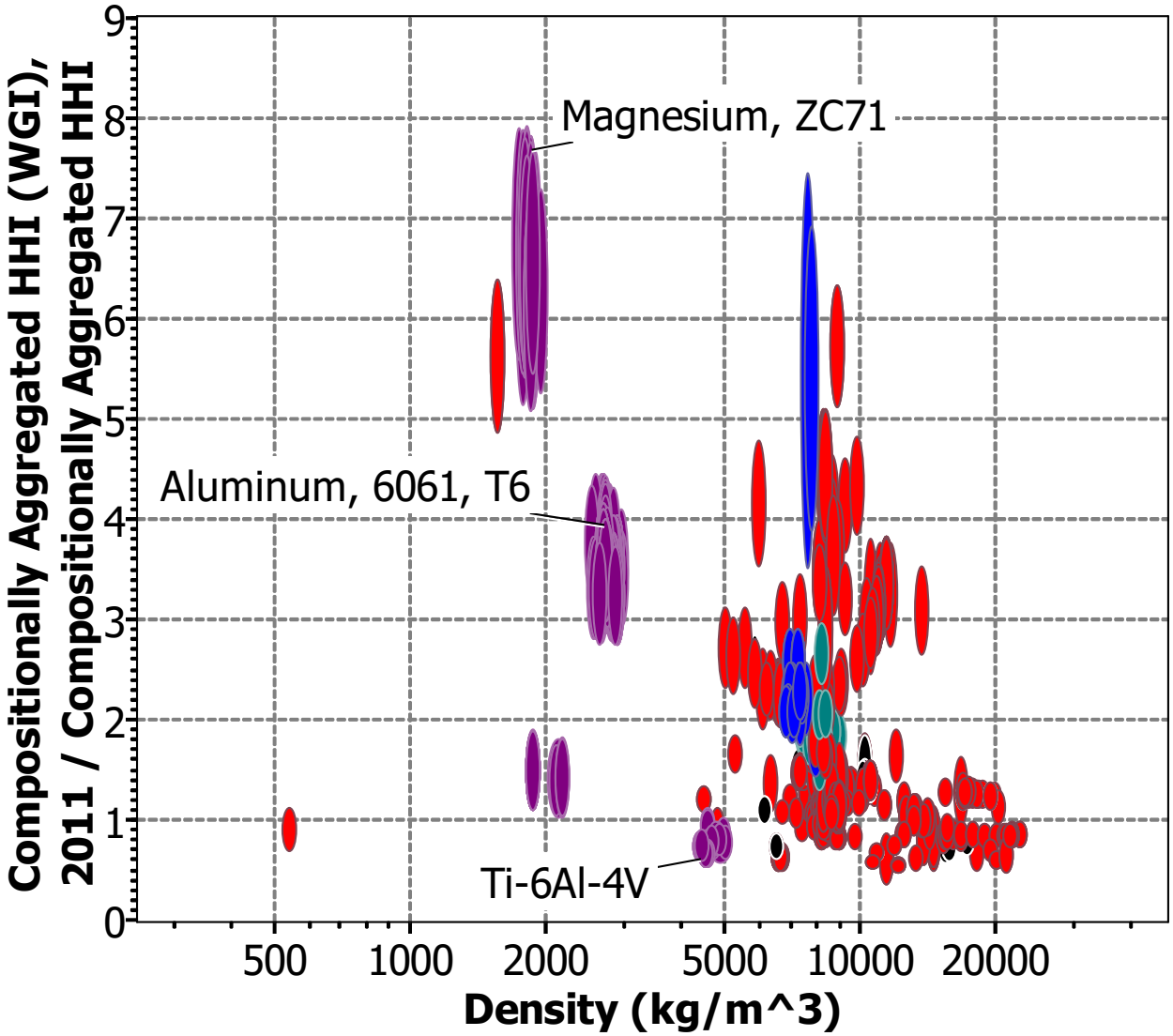


Unique features

- Our data is specifically linked to the material properties.
  - These are what is at risk – the product function fulfilled by the material.
  - Our data is reputable and traceable (reference and customer data).
  - GRANTA MI manages the pedigree of materials data more generally within the business.
- Risks are material, product, business specific.
  - Regulatory risks – e.g. REACH, Conflict Minerals
  - Supply and reputational risks – e.g. geopolitical, environmental, price, conflict
  - Environmental risks – energy, CO2, water, cost.
- We don’t pre-determine what is critical to the user.
- Assessments are quick to conduct – push of a button!
  - Means we can rapidly repeat assessments once the risks have changed.

Results and implications

- General lists of critical materials are not useful to business.
  - Need specific clarity over the materials that they use directly.

- Feedback from users has been very positive.
  - Solution was developed in direct collaboration with industry users from EMIT.

EMIT CONSORTIUM

Members

Airbus Helicopters
Boeing
Bombardier
Emerson Electric
GKN Aerospace
Honeywell
NASA
NPL
Pratt & Whitney
Rolls-Royce
Sandia National Labs
US Army Research Labs

https://www.grantadesign.com/emit/

- Currently in use by many and investigating additional risk factors.

Results and implications

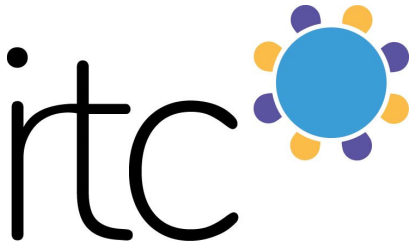
REACHing out for new materials

With hexavalent chrome recently placed on the REACH list of restricted substances, the aerospace industry is searching for replacement materials for surface treatments. David Richards, Head of Surface Engineering at Rolls-Royce, UK, explains how the REACH CP- HTEA project is addressing the issue.

- Consortium of 17 leading UK aerospace partners
  - Identification of substitutes to Hexavalent Chromium (REACh)
- Distributed test programme
  - Shared burden, shared benefit
  - Strong standardisation activity
  - Significant high value data

- All data collated and shared in GRANTA MI
  - All coating systems screened against emerging legislation
  - Identified candidate solutions known to be subject to risk
  - Reduction in long-term risk.
  - Long-term traceability over all data.

Limitations



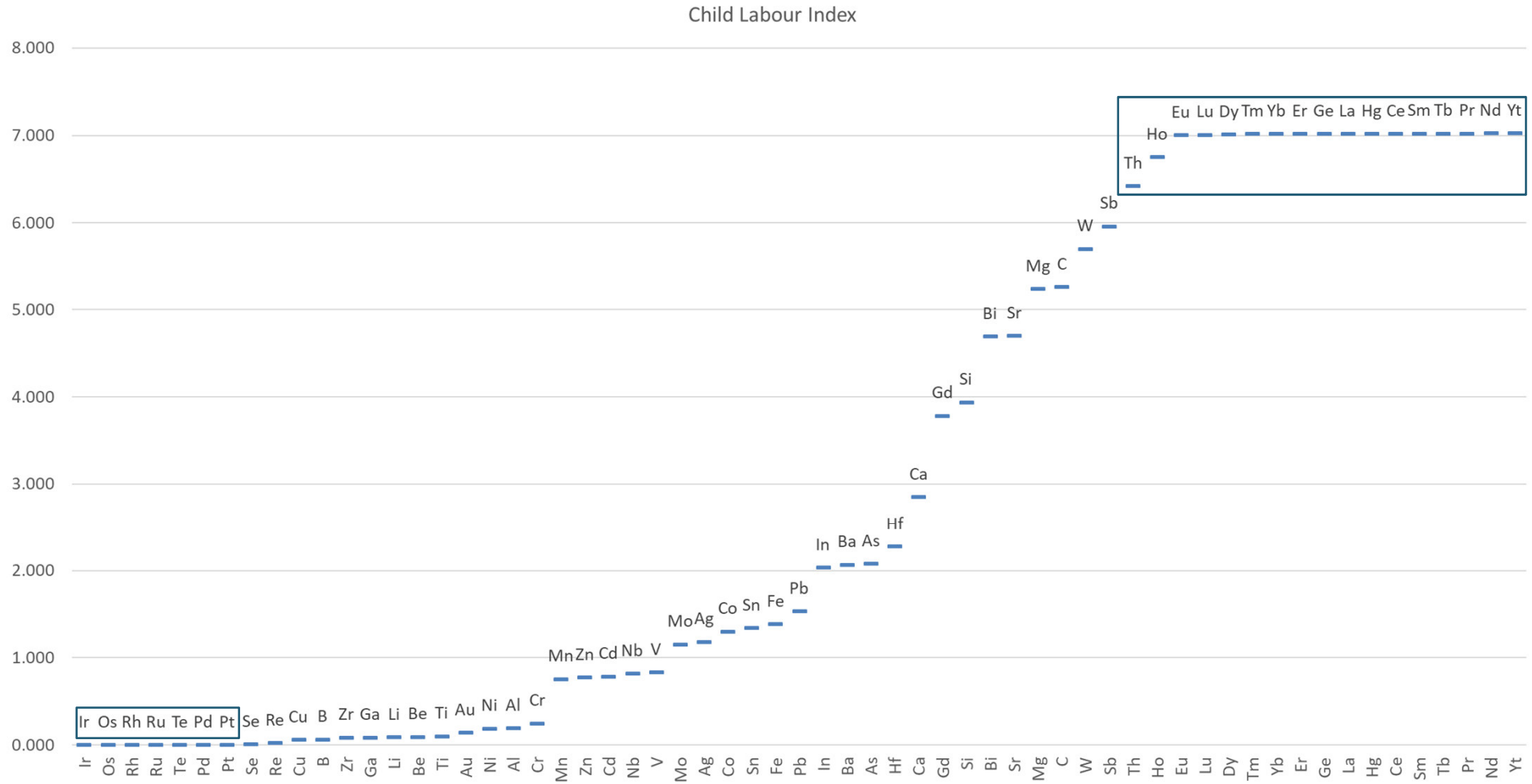
- Commercially licenced tool and data.
  - We are pretty flexible and open to collaboration though.

Outlook

- Very positive.

- Currently investigating:
  - Climate risks e.g. Natural disasters, severe weather, coastal disruption.
  - Social risks e.g. Child labour:

Risk Metric Calculations



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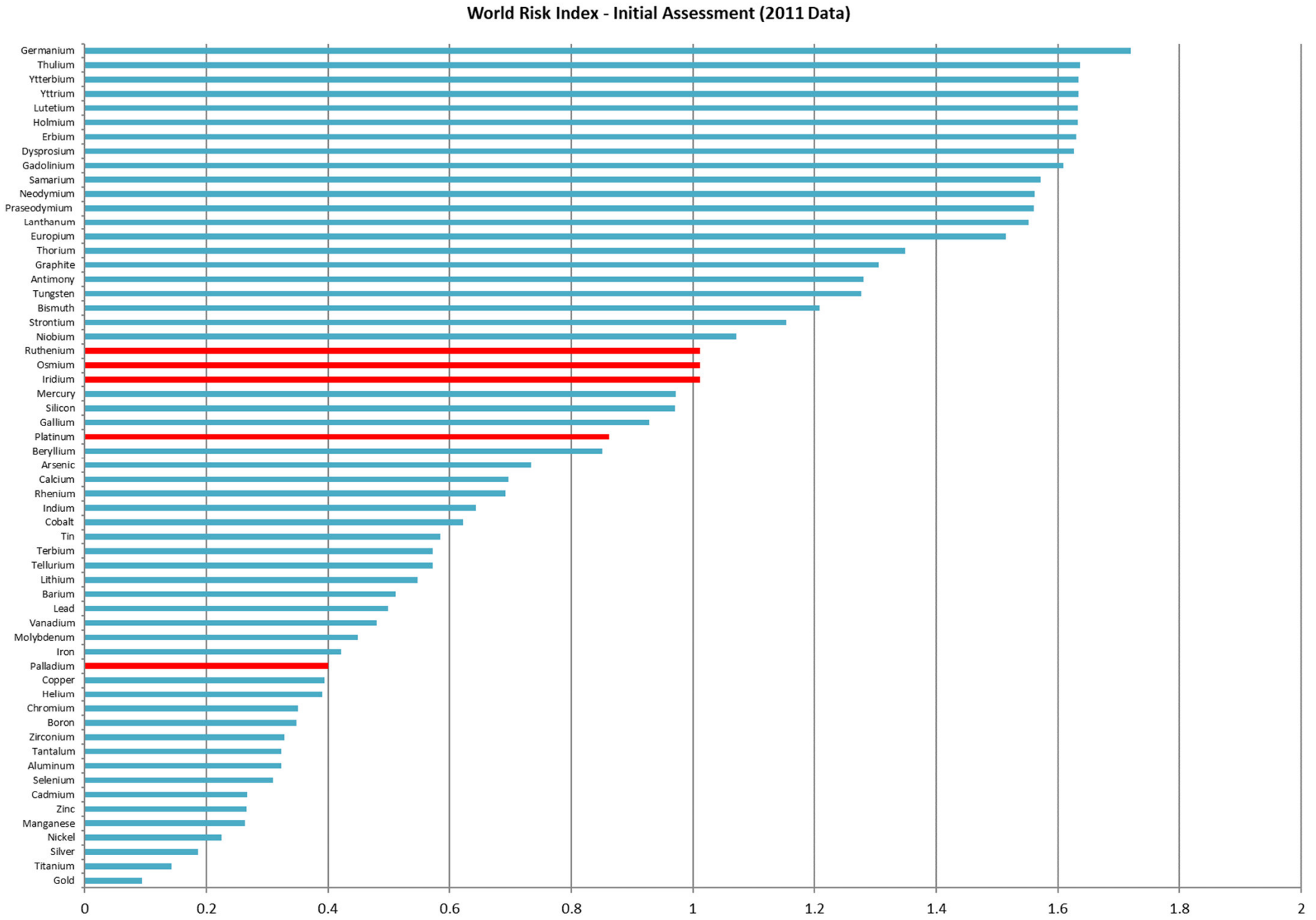

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