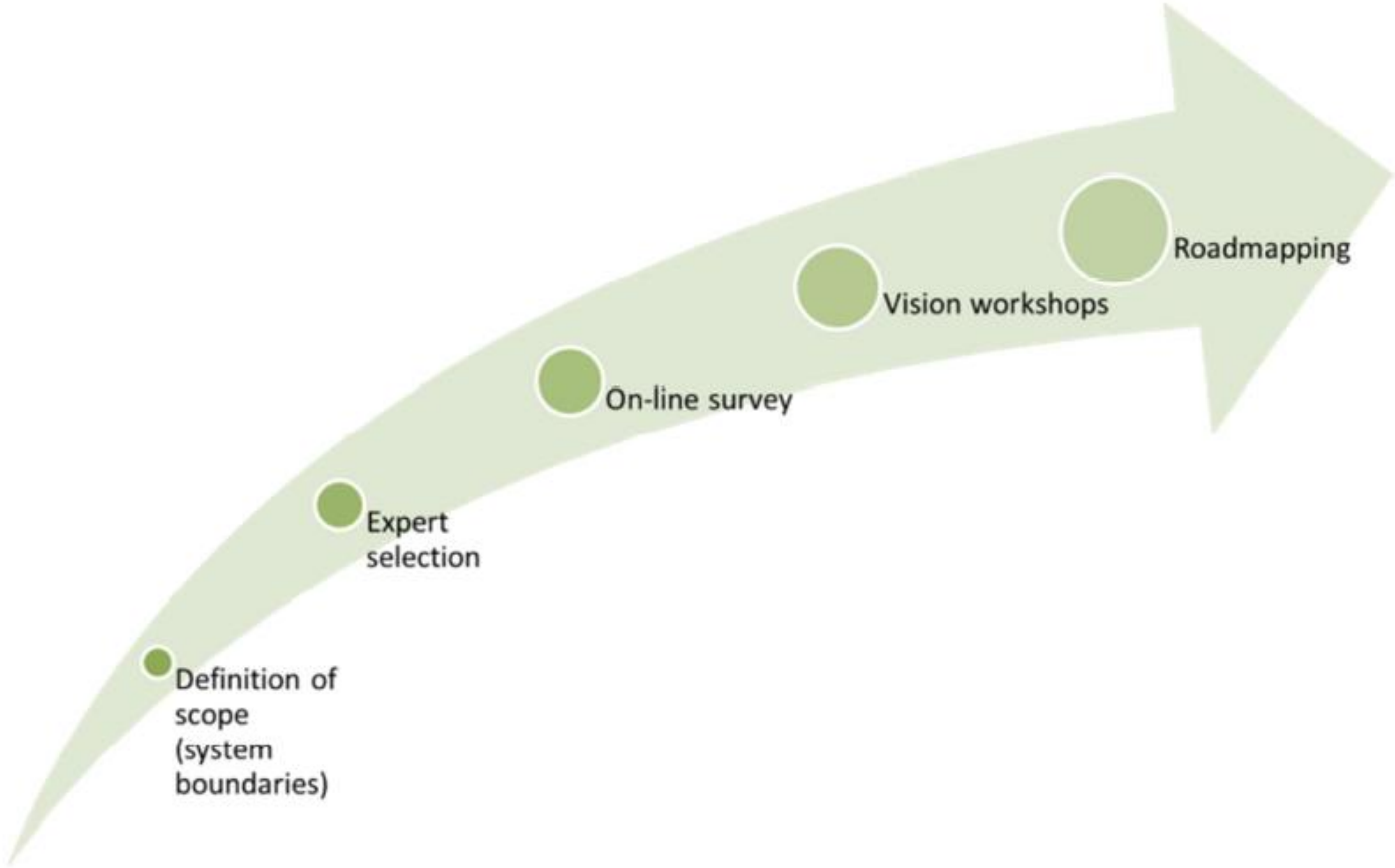
CRM Vision Workshop

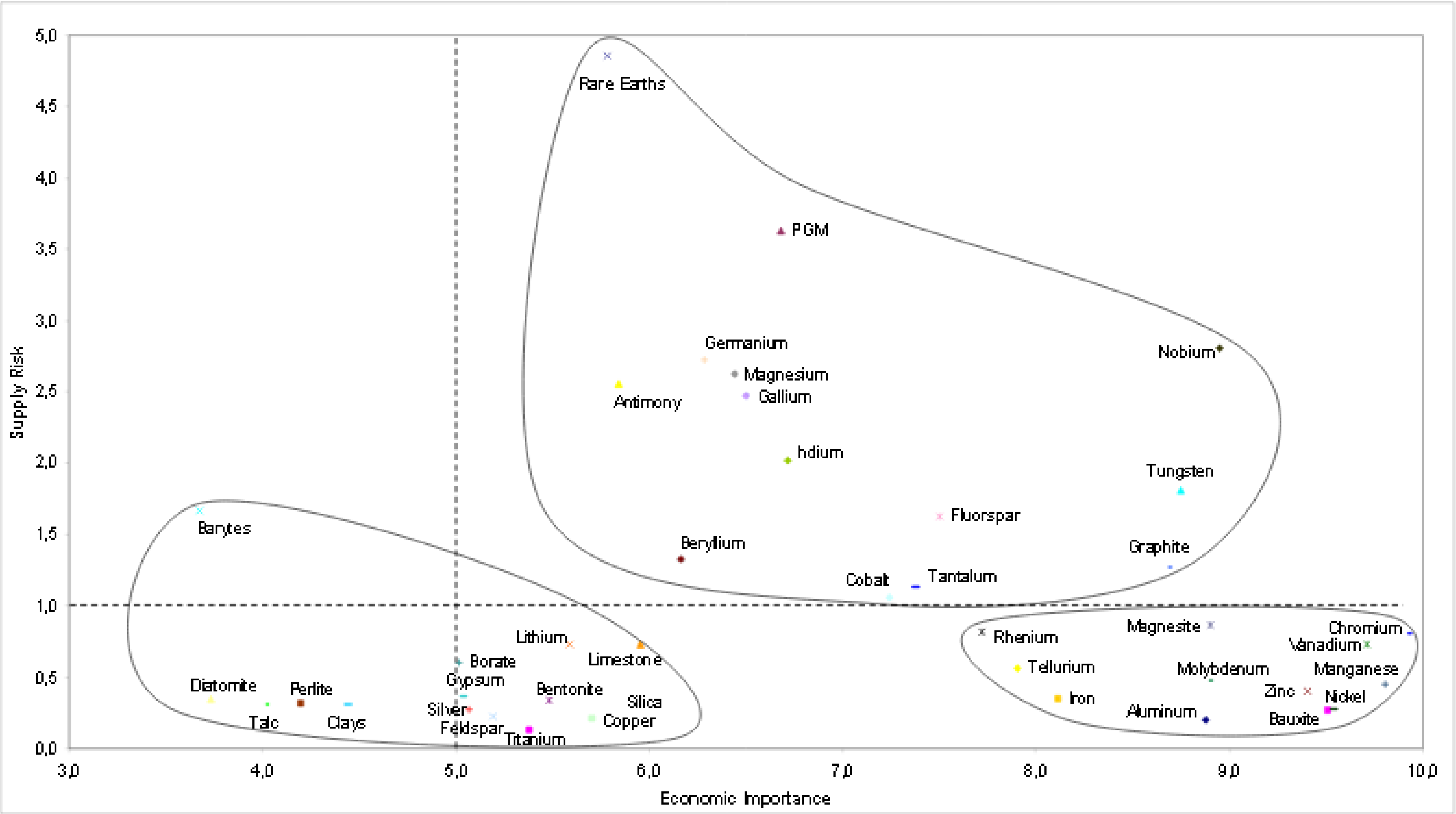
Process for Roadmap Elaboration



EU Policy on Raw Materials

Raw Materials
Alternate
Recycle
Extract

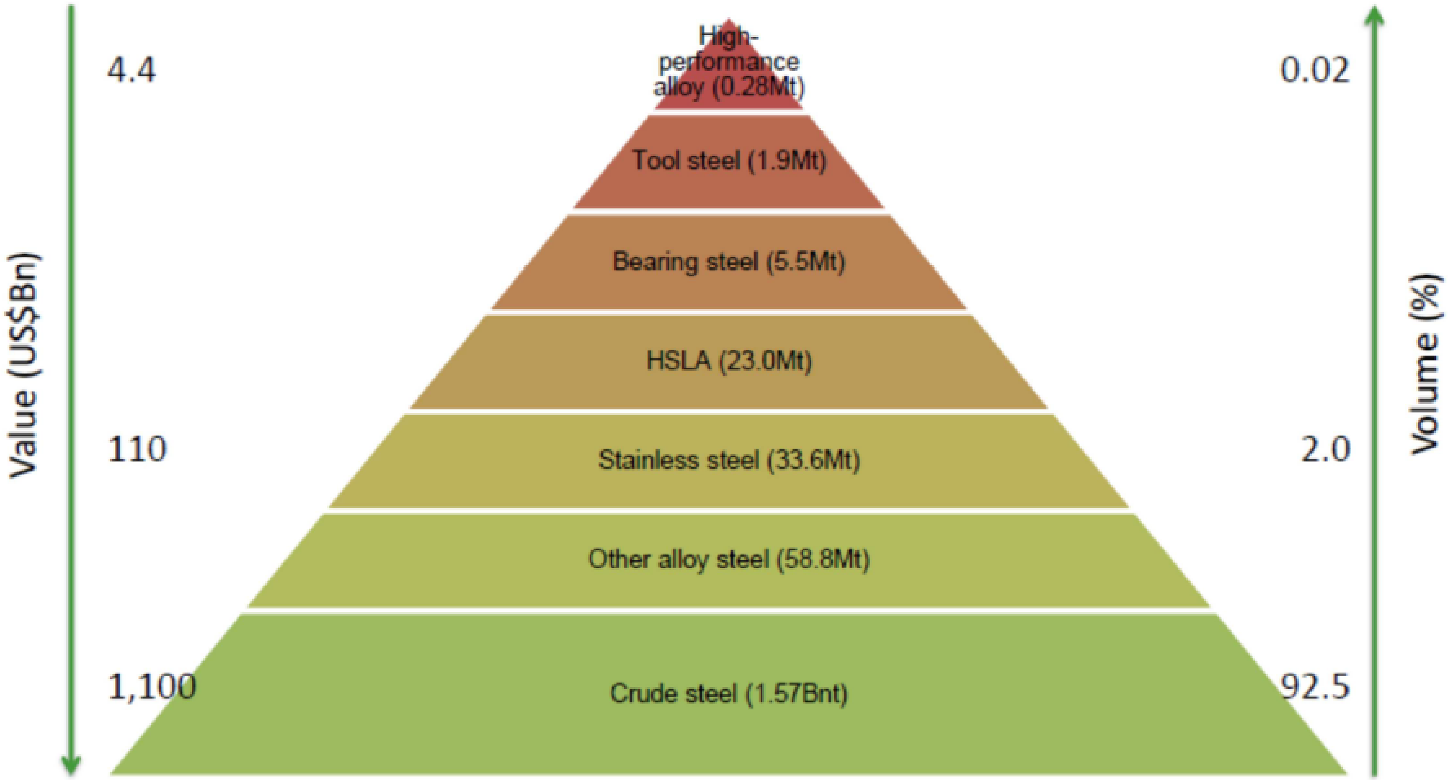
Critical Raw Materials in the EU



Critical Raw Materials in the EU

Antimony	Indium
Beryllium	Magnesium
Cobalt	Niobium
Fluorspar	PGMs (Platinum Group Metals)
Gallium	Rare earths
Germanium	Tantalum
Graphite	Tungsten

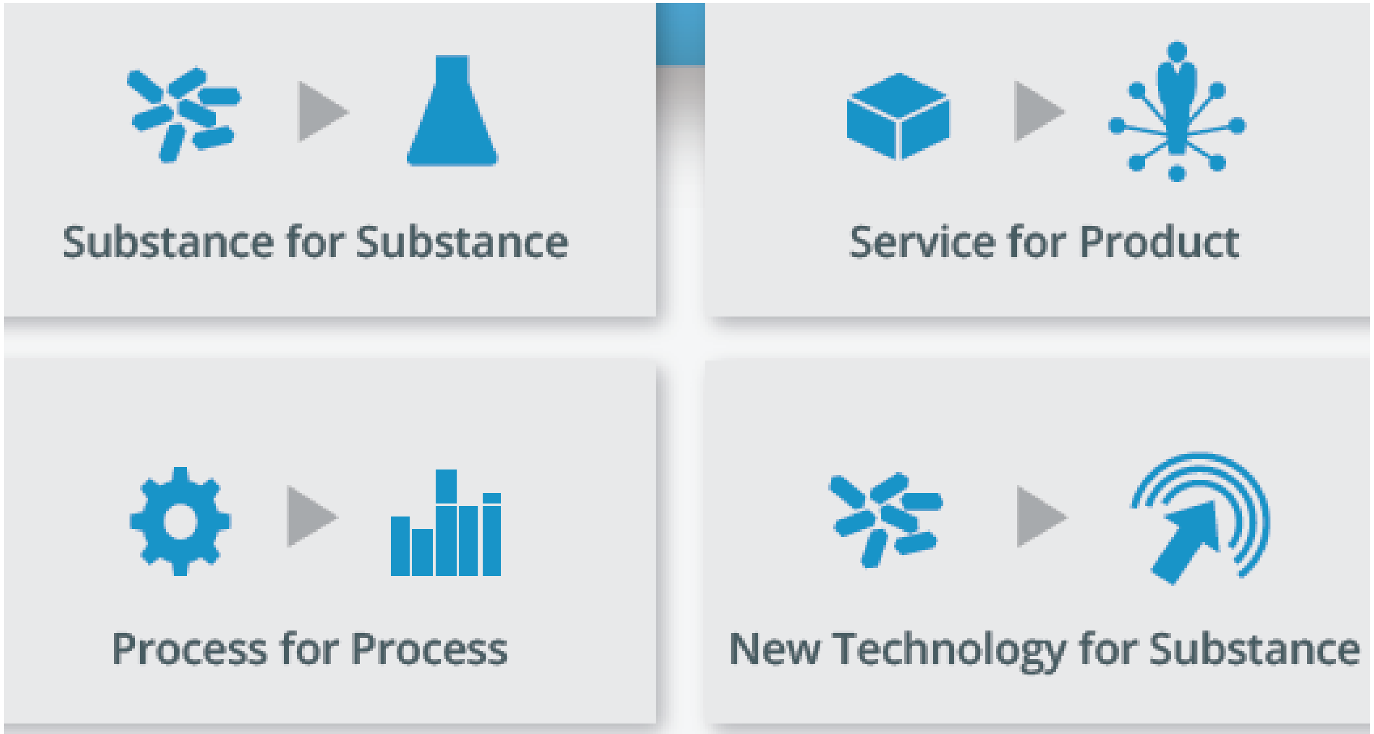
High performance alloys represent the tip of the steel market



Source: WSA; ISSA; SMR; Roskill estimates

System boundaries of the discussion

- The emphasis should be on **substitution** of **Critical Raw Materials**. But it does not need to be limited to it.

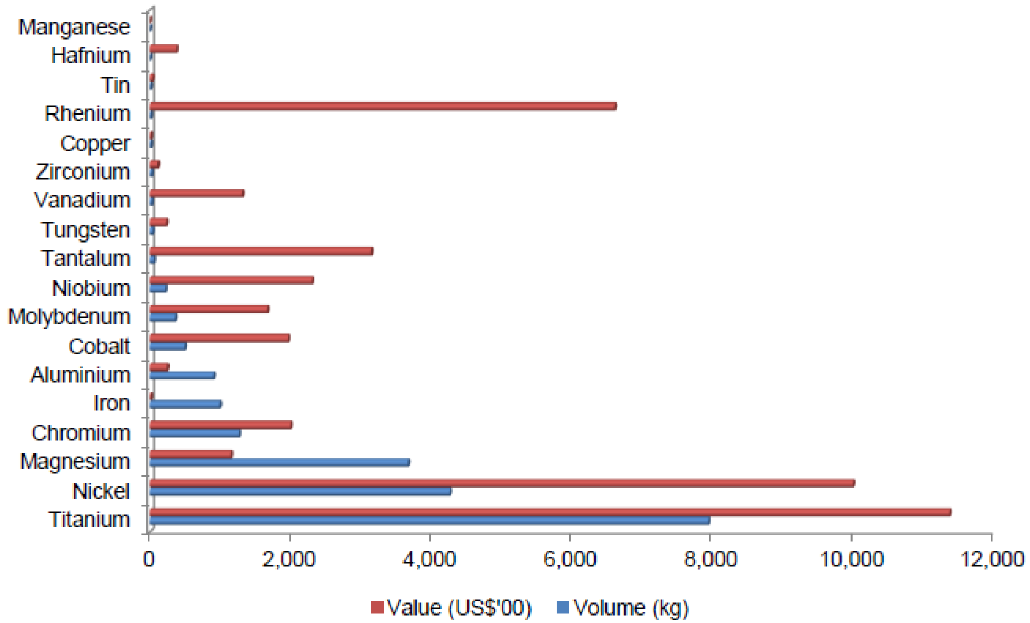


Landscape summary

Landscape: aerospace

Minor metals account for a much higher proportion of engine cost vs. volume

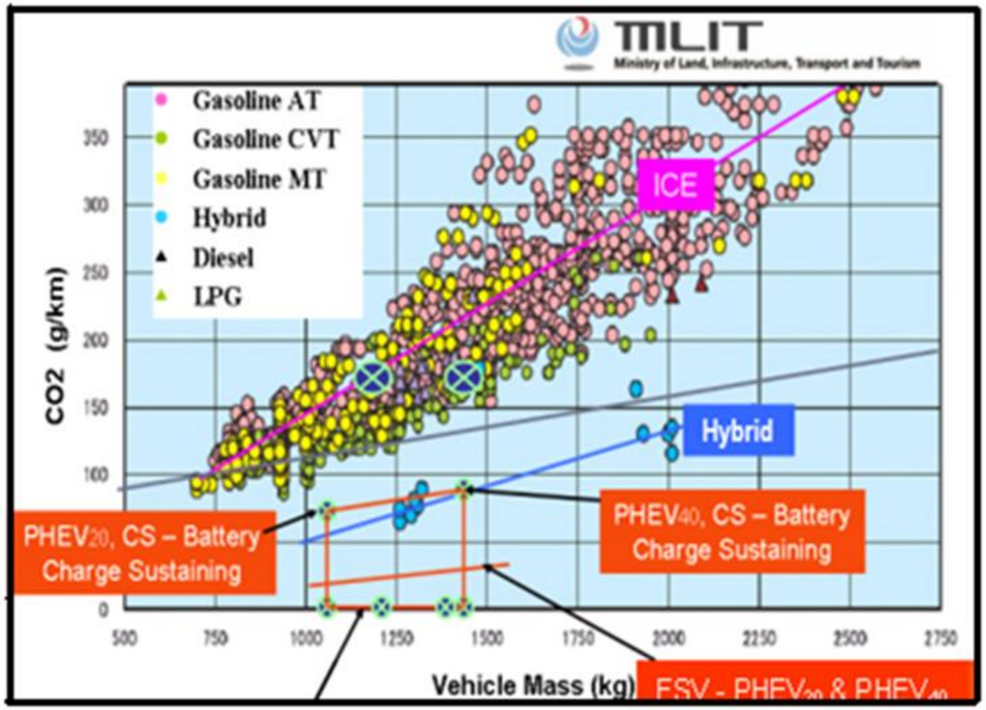
Metallic composition of a typical aeroengine in volume and value terms, 2011



- For specific elements, CRM is an issue. In 2030 (it is known) there is no slow in demand.
- The new solutions are more high technology, more dependant, (but conservative sector, will take time to be introduced).
- When introducing a new material, you need new designs

AHSS Steels for Automobile Industry

- The vehicle weight and CO_2 emissions and amount of fuel consumption are directly related.



- Reduction of weight must be compensated by increasing the strengthen of vehicle materials, particular for the steel framework.

SEVENTH FRAMEWORK PROGRAMME

CRM_InnoNet Substitution of Critical Raw Materials

US Light-weight vehicle roadmap 2025

Vehicle lightweighting in North America

- The average vehicle will be 400 pounds lighter by 2025 [2]
- Average materials content of North American light vehicles (pound/vehicle)

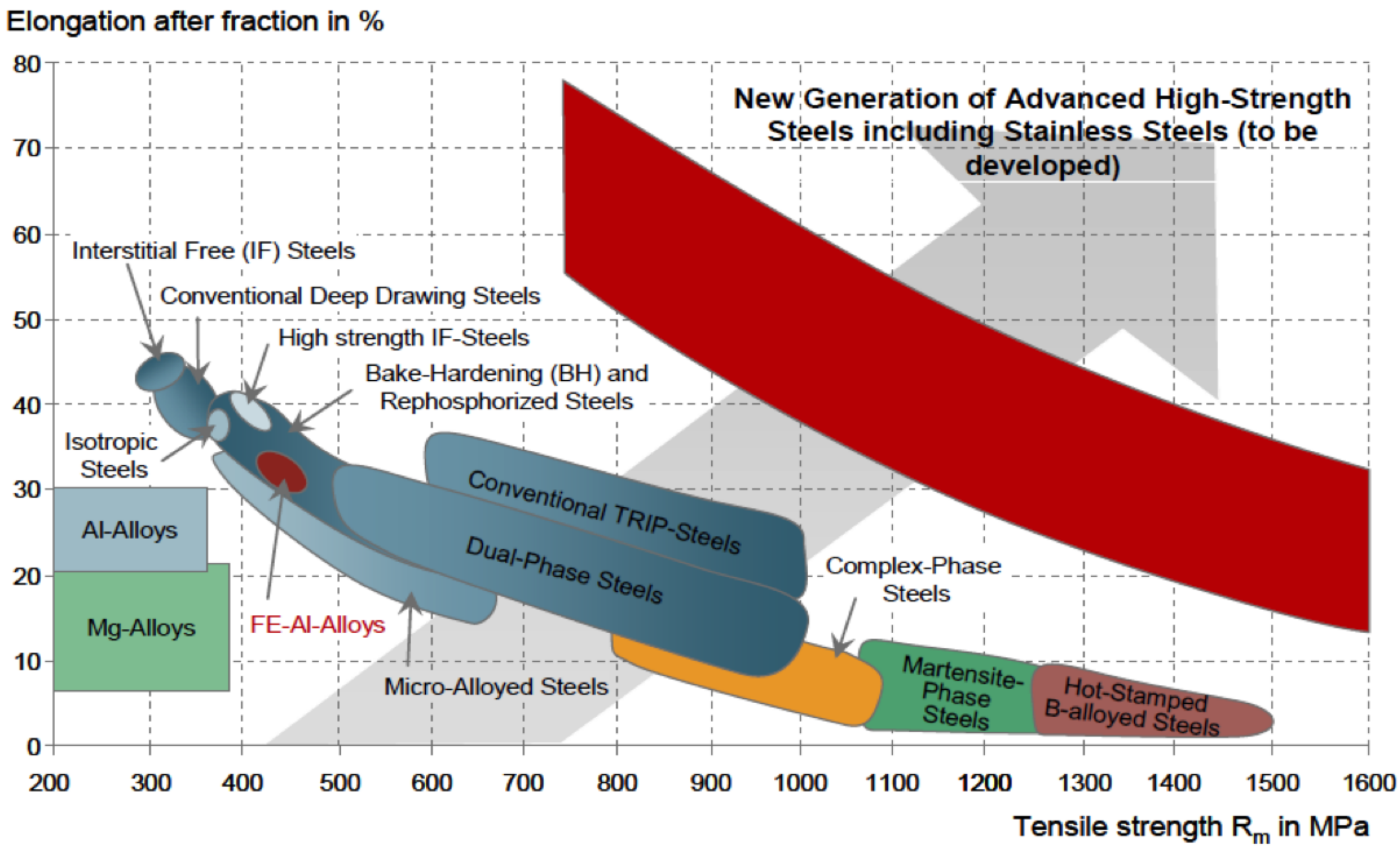
	2009 [1]	2010 [1]	2011 [1]	2025 [2]
Regular steel	1,501	1,542	1,458	950
High & medium strength steel	524	559	608	858
Aluminum	324	344	355	550
Plastics/Composites	369	371	377	400
Magnesium	11	11	12	100

[1] American Chemistry Council
[2] Ducker Worldwide

Henkel

Source: Agarwal 2013

Alloys - technology path



Source: Jean-Pierre Birat, ESTEP

Landscape: Automotive sector

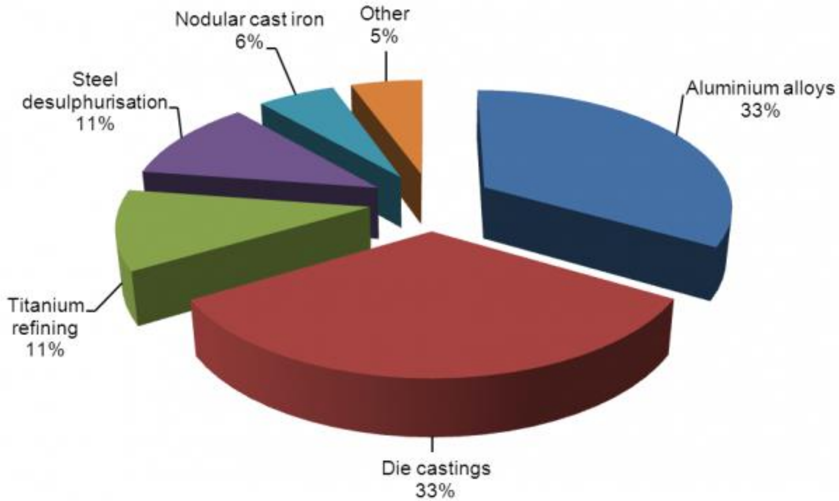
Steel versus Aluminium/carbon/magnesium

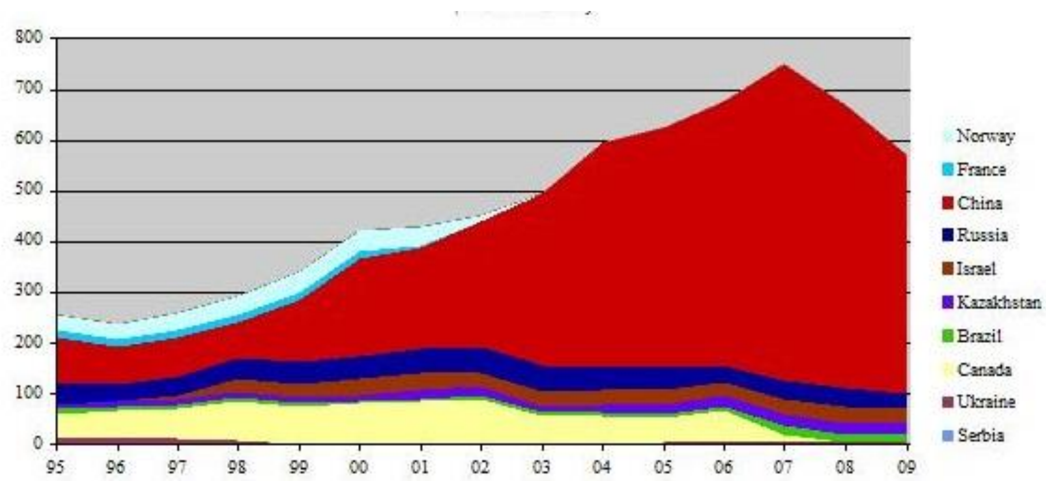
Low level substitution → **High level substitution**

Driving forces →	← Restraining forces
• Advantage of low density • Aluminium has good crash performance • High strength steel needs critical raw materials like Nb	• Steel is getting stronger • Steel is low cost • New design necessary

Remarks: Reduced weight of body is used to put in new gadgets: electric motors containing CRM.

Landscape: Magnesium

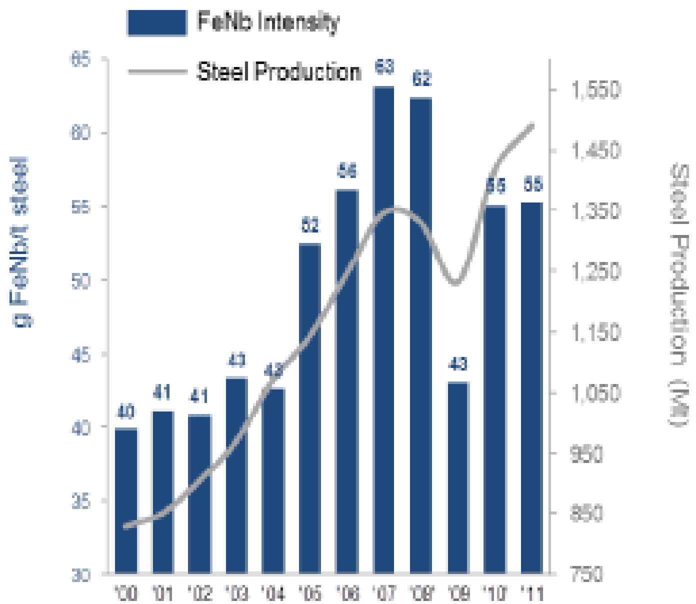


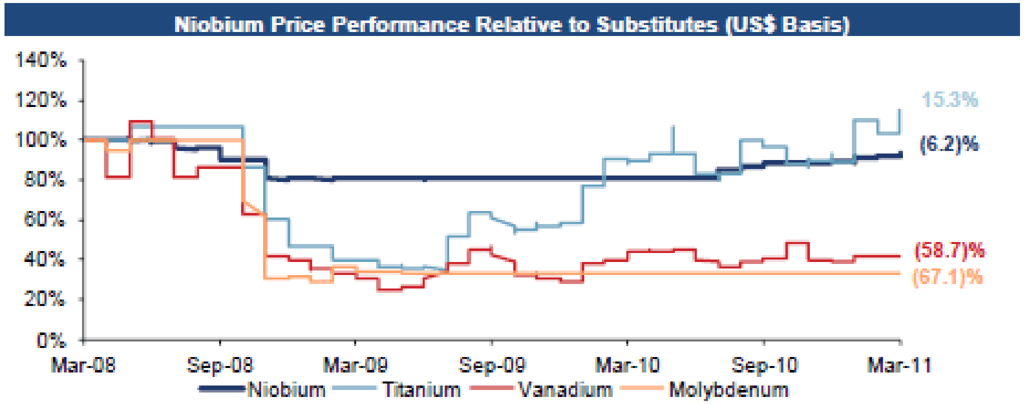


- Environmental, low cost, production is being faced out due to unfair competition (now also in China)
- Mg production could be renewed in a much more efficient and environment friendly way so that the standard production procedure will be too costly
- Other important factors may compensate this fact, new magnesium production processes, new developments of alloys

Landscape: Niobium in steel

World Niobium Usage Intensity And Consumption Forecast





Source: IAMGOLD

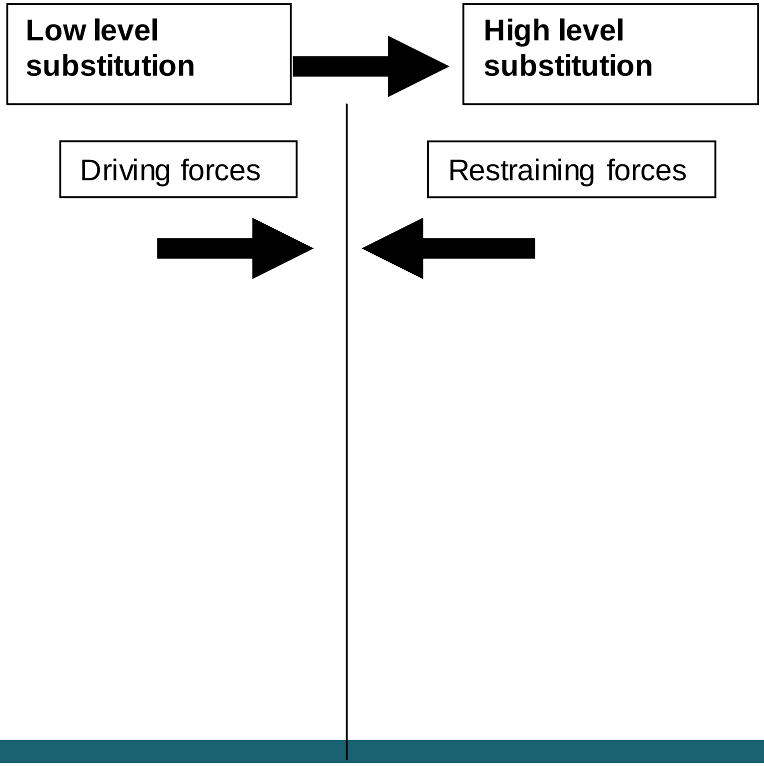
- The EU countries could take on responsibility to identify and develop new sources and production processes for Niobium.
- The challenge in material research compared to economical price volatility is the speed of the process. Material development is slow process, when substitute is ready, the prices can be on acceptable level again.
- Nb is also important metal in nuclear power industry.
- Niobium is a relatively expensive alloying element in steel. An increase in the price of niobium will make the steel significantly more expensive, which will result in a search for substitutes for Nb in Steel. I do not know about the biomedical sector.

“Development on regime level”

policies, market trends influencing CRM demand

Impact of landscape developments on the specific applications and for Europe

- Is there a specific pressure for change (substitution) in Europe?
- Are there specific challenges and barriers for substitution of critical materials in a particular subgroup of applications?



Impact of landscape developments on the specific applications and for Europe

Driving force:

1. Toxicity
2. Cost effects (Profitable solution, volatile prices, Small amounts high cost %)
3. Availability supply risk
4. Environmental aspects/awareness, brand image
5. Legislation (Ban of substance)
6. Better performance in application

Restraining forces:

1. Loss of performance
2. Investment in research (too long, too costly, uncertain ROI)
3. Technological lock in (Existing economical lifetime in infrastructure, Expensive equipment investments)
4. Companies awareness of risk
5. Diverse interest between different stakeholders (Industry, research, EU, …)
6. Lack of data, information, gap in research
7. Lack of human resources (educated personnel, researchers and engineers educated in subject)
8. Qualification and regulation of new material (certificates)
9. Highly integrated, complex supply and reverse supply chains

Policy interventions

- Which are relevant policy initiatives in the EU and on a national level?
- Do these policies respond to the needs of companies?
- <u>What policy initiatives should there be?</u>

1. Harmonised legislation (National, EU and on imported goods)
2. Certification of products (minimum level)
3. Education, research industry driven (industrial involvement is a prerequisite for EU funding support, (triangle, regulation policy, Market pull, Technological push)
4. Export legislation (monitoring of exports of waste, scrap…)

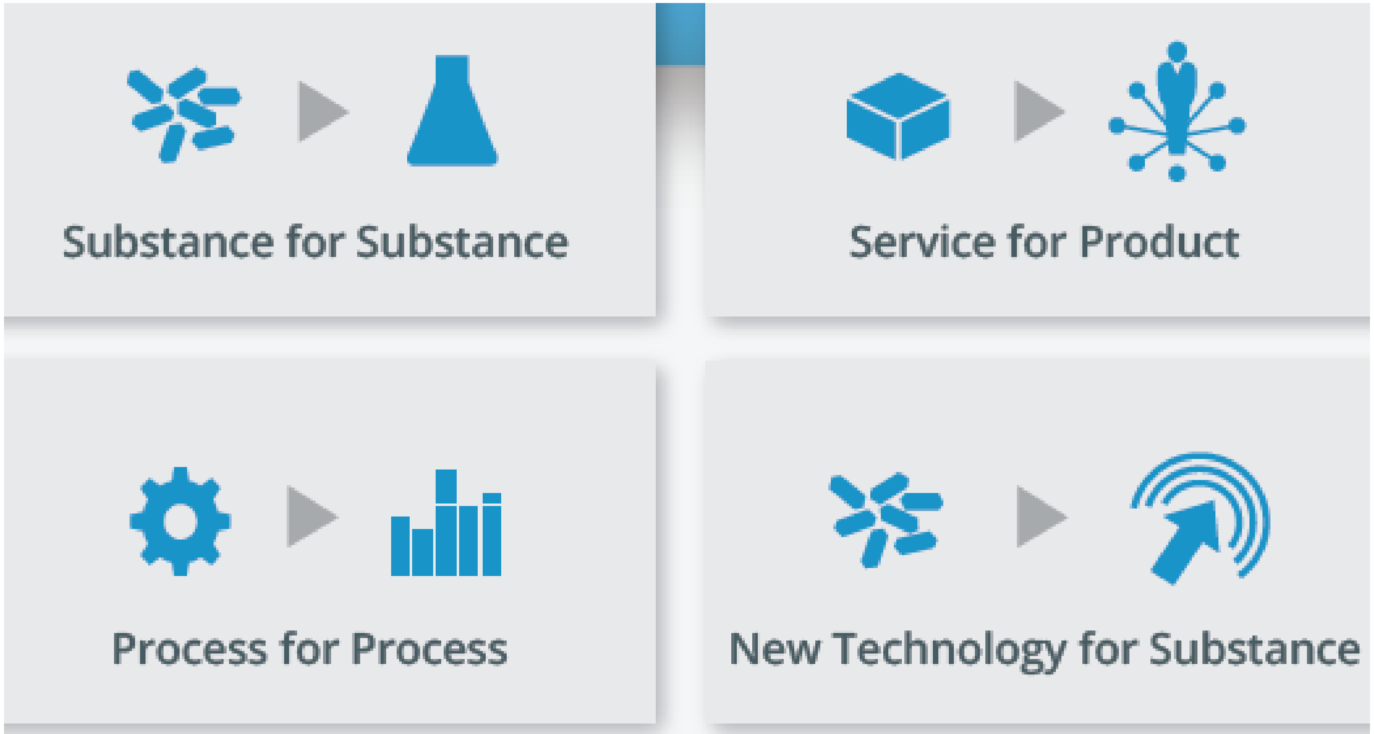
Market initiatives

- Question to be answered: What do we know about company strategies in the field of material substitution?

1. Circular economy (Leasing to encourage efficient recycling components, material) (Service for product)
2. Market and consumer studies to understand behaviour
3. Considering supply risk during design development of substitutes
4. Revisiting abandoned alloy systems
5. Sharing risk, pooling knowledge

Relevant research activities

Questions to be answered: Which are the most relevant research activities going on in Europe? Can gaps in research be observed?



Relevant research activities

<u>Substance-substance</u>

- Reduction of heavy REE
- Substitution of W, CO Tu in hard metals
- Co in maraging steel
- Replace Nb in steel
- Replace chemical alloying element by micro structure
- Replace REM in Mg by abundant elements
- Replace W in High T steels
- Development of steels as substitute of nickel based alloys in High temperature application
- Development of new alloys through new combinations of conventional alloying elements
- Diamonds for tungsten carbide
- GA, AS substitution with GaN to lower costs and environmental impact on electronic devices
- Graphene – bi dimensional materials
- Projct Samulet (UK rolls Royce, Granta design)
- Ir replacement by Heusler alloys
- Multiscale material design: process-structure-properties-performance
- Materials based on available elements
- UK/TSB project: REACH Hexchrome substitution-Knowledge risk sharing at low TRL
- Accelerated Metallurgy: High throughput materials science
- Integrated Computational Materials Engineering: ICME

Relevant research activities

<u>Technology-substance:</u>

- Magneto-caloretic alloys for refrigeration
- Near net shape technologies/additive manufacturing projects:
  - reduced production waste
  - more complex in design
  - new materials combination possible

<u>Service for Product</u>

- Leasing models/circular economy

Relevant research activities

Process-process:

- Out-of-autoclave composite curing process
- Development of casting process to reduces porosity of components and so compete with high performance alloys based on critical elements.
- Improved TBC (Thermal barrier coating) application to ease bulk requirements in turbine blades
- Carbothermic reduction of Al avoiding fluorspar use
- Electrolytic Titanium production avoiding Mg use.
- Use of natural gas in production of iron substituting coke
- Use of natural gas in production of FeMn, FeSi and silicon alloys substituting coke
- Low cost solar silicon through metallurgical processes instead of Siemens process
- Magnesium production through more efficient processes than the Pidgeon process (e.g. Bolzano or Mintek process)
- Self propagating high temperature processes

Niches of innovation – research initiatives, new consumption patterns, early signals of change

Your vision for 2030

- What are your expectations about alloy design and application for 2030?
- How are these new alloys going to be produced in 2030?

2030 is too short term for the materials industry. Possible developments:

- Intermetallics: New era of development of complex intermetallics
- Additive manufacturing can results in a new class of materials
- Knowledge based design of alloys. There is a need for more kinetic and thermodynamic data for systems with many components.
- New materials for the next generation of nuclear reactors.

- **Advice**: Europe (EU and national states) should concentrate on education of enough good engineers. The engineering education should have interaction with industry.