WMF GENESIS,
USE SMARTER, LESS AND LONGER,
CRITICAL MATERIALS
WORLD MATERIALS CONNECT

2019

Facing A World Challenge

3 megatrends: booming of the middle class, urbanization, electrification of power trains

- Passenger aircrafts: 34 000 by 2036, 40% replacement and 60% growth
- Electric vehicles: 54% of new car sales in 2040
- Smartphones: 1,9 billion units in 2018, 10 fold the number of 2009

Resources of our planet under incredible pressure with temporary or long term bottlenecks

Difficult situations on waste management and landfill disposal

ONE PLANET NOT TWO !

Promoting A Global Answer

Why	**Decouple economic growth and materials consumption while creating value for our industries**
What	**Change mindsets and behaviors in order to use materials smarter, less and longer**
Who	**Industry Leaders** (MNCs, SMEs and Start Ups) **Political leaders** (International organizations, Nations and Big Cities) **Key Opinion Leaders** (Academia, NGOs, Experts and Media).
How	**Speak with facts and figures** **Use collective intelligence to design actionable recommendations** **Use networking to speed up implementation**

The World Materials Forum

Done

4 editions since 2015 and 1000 participants from 30 countries:

- 60 CEOS & 280 Comex of MNCs
- 130 CEOs of Start-ups
- 170 Public Institutions
- 260 Academia & experts

The outcome

- Since 2015: the WMF Criticality Assessment – a yearly survey on critical materials future supply/demand
- Since 2016: the WMF “Smarter, Less and Longer” toolkit
- Since 2017: the WMF Start Up Challenge
- Since 2018: the WMF Monthly Newsletter
- Already in 2019: World Materials Connect
- Throughout: numerous field projects in materials science, supply chain and digital technologies

Scientific Keynotes Speeches

2015: Prof. Ludwik Leibler (ESPCI Paris)
Vitrimer: a high potential new material in between plastics and glass

2016: Prof. Stuart Parkin (Max Planck Halle)
Spintronic and Cognitive Computing Technologies for Materials Efficiency

2017: Prof. Reinhold Dauskardt (Stanford)
Multifunctional hybrid materials for using materials smarter, less and longer

2018: Prof. Éric Fullerton (UC San Diego)
Materials Challenges and Opportunities linked to Big Data

2019: Prof. Hideo Ohno (Tohoku University)
Subject TBC


FORUM


WORLD MATERIALS FORUM | NANCY | 29 & 30 JUNE
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The « Smarter, Less and Longer » toolkit

% of innovative materials Product performance on weight % overall product usage EBITDA on raw materials weight	**Use Smarter**
Product lifetime Resale price	**Use Longer**
Buy-to-use % of recycled materials into new products % End-of-life recycling Energy consumption	**Use Less**

Smarter, Less and Longer in Aeronautics

SMARTER

AIRBUS Design: only 0,8% A350 flights suffer technical delays above 15mns only one year after aircraft launch thanks to adding operability & reparability on top of weight into aircraft design objectives

AIRBUS - HEXCEL: **20% improvement of mechanical performance** to weight thanks to switching from Titanium to Hexcel thermoset composite material on some A350 fuselage door frame

LESS

AIRBUS - GKN: **54% weight saving** on A 320 pylon bracket thanks to additive manufacturing

AIRBUS - CONSTELLIUM: 75% raw material volume (Aluminium Lithium) is collected after downstream processing and reinjected within the upstream casting process thanks to close loop recycling

LONGER

AIRBUS – SUEZ - SAFRAN: JV in order to reuse 500 to 1500 parts (from servo valve to engine) per decommissioned aircraft

SOLVAY: **20% increase in aircraft tire lifetime** thanks to new generation of silica

Smarter, Less and Longer in Automotive

SMARTER

PSA Design: **20% unused functionalities** on existing models and their suppression for new models
thanks to IoT and Data Analytics

UBER-LYFT: **40% car usage rate at car sharing providers vs 6% with car private ownership**

LESS

IMERYS: **10% weight reduction** for automotive interior trim thanks to its talcs for plastics

PSA: **40% improvement of mechanical performance** to weight thanks to use of High Strength Steel on 208

ARKEMA – DURISOTTI: **30% weight reduction** for light truck floor thanks to Elium thermoplastic composite

I PULSE – RENAULT/NISSAN: **10% weight reduction** per vehicle thanks to new forming technology based on huge magnetic fields

Getting The Big Picture On Critical Materials

Idea = Target the right priorities for industrial companies to choose which materials/countries they want to buy from/invest in & for political entities to select the materials/countries in which to prioritize their actions/regulations

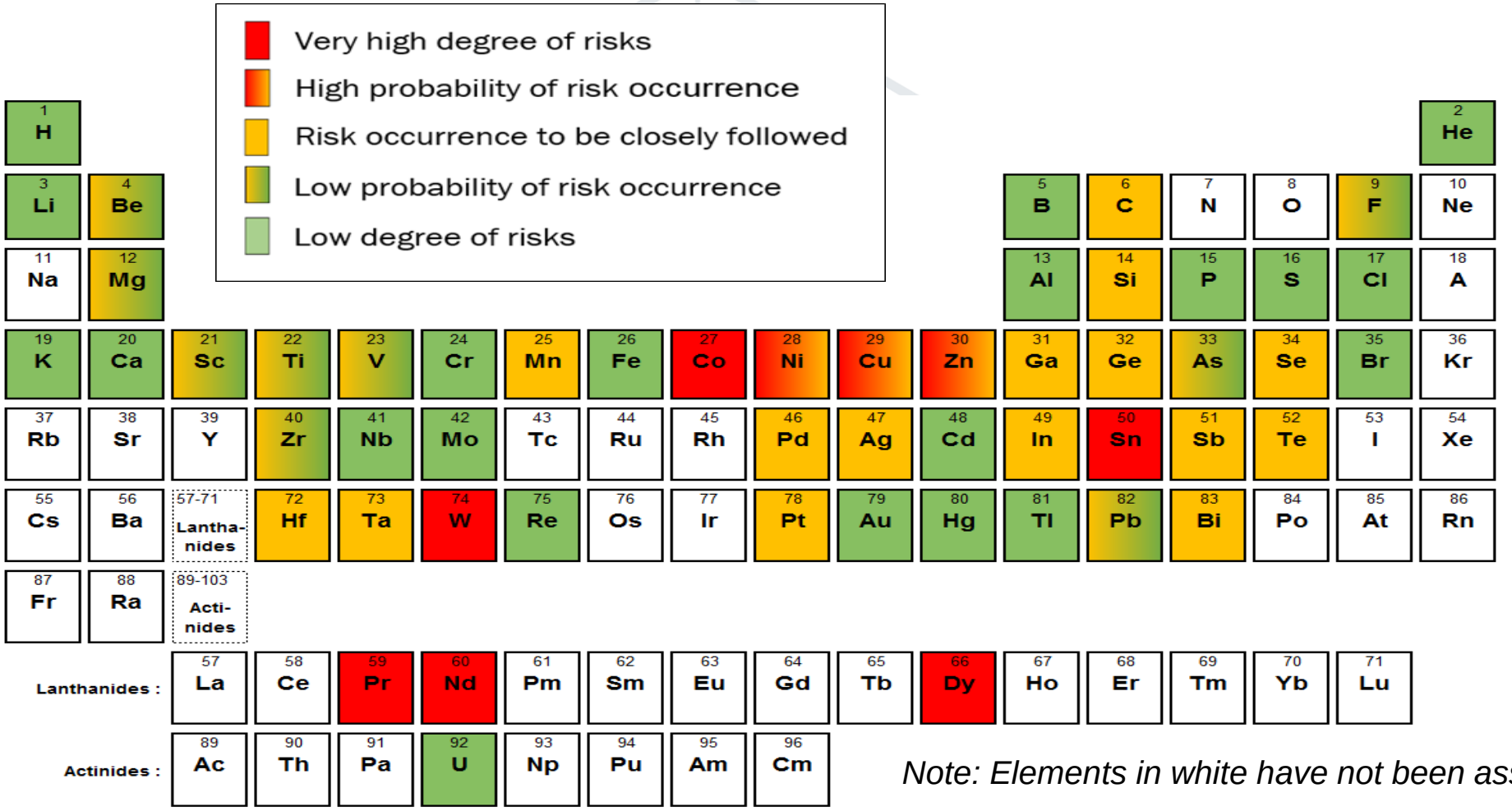
Thorough yet simple decision making tool based on 6 components impacting the balance supply/demand:

- Years of known USGS reserves
- Uncertainty of supply
- Political exposure
- Qualitative assessment of recycling
- Uncertainty of demand
- Vulnerability on core applications

Opportunity to identify and track progress on solutions

- New mines/capacities
- Substitution by less citical materials
- Scrap reduction throughout the supply chain for existing products
- Design of new and lower weight products
- Collecting, sorting and recycling schemes

WMF Criticality assessment by BRGM, CRU & McKinsey



Note: Elements in white have not been assessed yet

Top critical = cobalt

Very high risk

- 70 years of reserves will decline to 25 years in 10 years time if no new reserves are identified
- **Supply deficit in 2027 is forecasted to be greater than 30%**
- **At least 60% of mine supply comes from the Democratic Republic of Congo**
- High recycling rate is needed and we are not there yet
- **More than 60% of demand growth comes from electrification of car power trains**
- No real alternative yet in battery applications

Solutions progress

New mid size mines are being developed in Australia and Canada

BASF – DOE project to develop cathodes without cobalt

SAMSUNG Project to recycle smartphones and recover cobalt

EV bodies lightweighting and EV batteries energy efficiency projects altogether

The trio of « really » rare earth: Pr, Nd and Dy

The status

- Only 3 of 16 rare earth are « red »: Pr, Nd and Dy
- At least 90% of mine supply comes from China
- Less than 1% recycling (Solvay stopped in 2016)
- Europe and US have stopped most of their mining and refining capacities

Solutions progress

Developing capacities in Australia (Lynas, MountWeld), restarting Mountain Pass in the US

Samsung has planned a 1, 4 billion $ R&D budget to find alternatives to rare earth on the 2013-2022 period

Tesla induction motors or swith reluctance engines used in mining do not require the use of rare earth

Start ups such as Ajelis (France) or Momentum Technologies (Texas) develop lower cost recycling technologies

Fraunhofer demonstrated minus 80% in new permanent magnets + recycle/reuse permanet magnets at 96% capacity

Why WMF needs Start Ups?

- **The idea:** Identify breakthrough ideas that meet a triple win
  - fiiting the needs of consumers
  - ensuring profitability of industries
  - using materials Smarter, Less and Longer.

- **The 1st step: a yearly Start Ups Challenge since 2017, with a jury combining :**
  - WMF Steering Committee and MNCs (CGG, FPT, Rio Tinto, Total)
  - Key scientists : Berkeley, Mines Paris Tech, Stanford, UC San Diego, Special Chem

- **The 2nd step: World Materials Connect as from January 2019 :**
  - create a community of Materials start uppers
  - get them privileged access to WMF partners in order to speed up, communicate and celebrate on successes in **using materials Smarter, Less and Longer**.

Start up Challenge

- **Eligibility criteria**
  - number of permanent staff below 50
  - confirmed economic viability
  - demonstrated breakthrough - whether technical or organizational - in one of the topics selected by the WMF Edition
- **International jury**
  - 12 members / International (5 countries) / CEO & Academics
- **12 Nominees** free booth at Hôtel de Ville de Nancy during WMF 2019 / Transportation / Accomodation
  - Shooting of a professional one minute pitch video presenting the nominee's company (shown during WMF 2019)
- **2 Awards**
  - Grand Prix: 50 000 €
  - Coup de Cœur: 20 000 €

Deadline to apply: 28 February 2019

https://worldmaterialsforum.com

The 6 Start Up Challenge awards in 2017/2018 (3 US, 1 Canada, 1 France, 1 Portugal)

CITRINE (California), GRAND PRIX 2017: AI for 2-5x acceleration of the materials development process

CUBERG (California), GRAND PRIX 2018: Non flammable liquid electrolyte for very safe metal/lithium batteries.

SEPION (California), Coup de Cœur 2017: Longer lasting ion lithium batteries thanks to membrane coating

POLYSTYVERT (Canada), Coup de Cœur 2018: Recycled PS with the properties of virgin materials

KEEY (France), Participants Award 2017: Silica containing Construction Waste used as insulation aerogels

SMALLMATEK (Portugal), EIT Award 2018 : Higher metal corrosion resistance with lower use of encapsulated nano corrosion chromium free inhibitors into coatings


WORLD MATERIALS FORUM
NANCY | 27, 28 & 29 JUNE 2018


MATERIALS

World Materials Connect

Idea = connecting Materials Start Ups with WMF MNC Partners

A global network of Start Ups , with, at this stage : 10 France, 15 (Rest of Europe : Austria, Belgium, Finland, Italy, Netherlands), 15 California, 15 Rest of North America (Canada, Colorado, Louisiana, Massachusetts, NY, Texas, Utah), 5 Israel

A combination of : Materials Science (25 of which 6 in Composites), New Processes (16 of which 5 for 3D Printing), Recycling and Energy Valorization (12), Big Data and AI (7)

Mallinda: Vitrimer based composites

High output of car parts thanks to less than 1 minute cycle time & full recyclability such as glass.

Less than one minute cycle time using similar industrial compression molding techniques versus
Similar quality part in thermoset via compression forming prepreg**: 20-120 minutes**
Similar quality part in thermoset via high pressure resin transfer molding: **5-7 minutes**
Lower quality part in thermoset via bulk molding compound: 1-3 minutes
Lower quality part in thermoplastics via compression forming: 2-10 minutes
Lower quality part in thermoplastics via injection molding: less than 1 minute

All scrap is both reusable (since the resin is cured and stable) and recyclable (vs recycling of thermoset by pyrolysis costly at 300°C min). Typical scrap rates run ~30% so the savings are significant.

For autonomous cars at maximum 50mph speed**, up to 500 kg could be removed from the average automobile by replacing metal structures** such as: door inners, body panels, chassis, roofs, pillars, and suspension components with our stampable composites. As an example, replacing the steel door inners of a 5 door hatchback car would reduce the total weight of those parts from ~140 kg to ~40kg, a weight reduction of >70%.

Mallinda: Case Study Door Inner for Audi

A3 5 Door Weight*

	Weight per Door	Estimated Weight of Inner
Front Door	54 kg	27 kg
Rear Door	40 kg	20 kg
Hatch	82 kg	40 kg
	Total 5 Door Inner Weight	136 kg

Steel Cost per kg: $3.06

Total Est. Steel Cost: $416.67

Mallinda Weight Efficiency

	Estimated Weight of Inner	Mallinda Weight
Front Door	27 kg	8 kg
Rear Door	20 kg	6 kg
Hatch	40 kg	12 kg
	Total 5 Door Inner Weight	40 kg

Carbon Fiber Composite Cost per kg: $19.80

Total Est. Composite Cost: $808.31

Weight savings = 95 kg

Cost per kg Saved = $4.12

*Rocky Mountain Institute, “Kickstarting the Widespread Adoption of Automotive Carbon Fiber Composites, 2013

THANK YOU
FOR YOUR ATTENTION