

Is the 4th Industrial Revolution in the EU industry a chance for the RM sector ?

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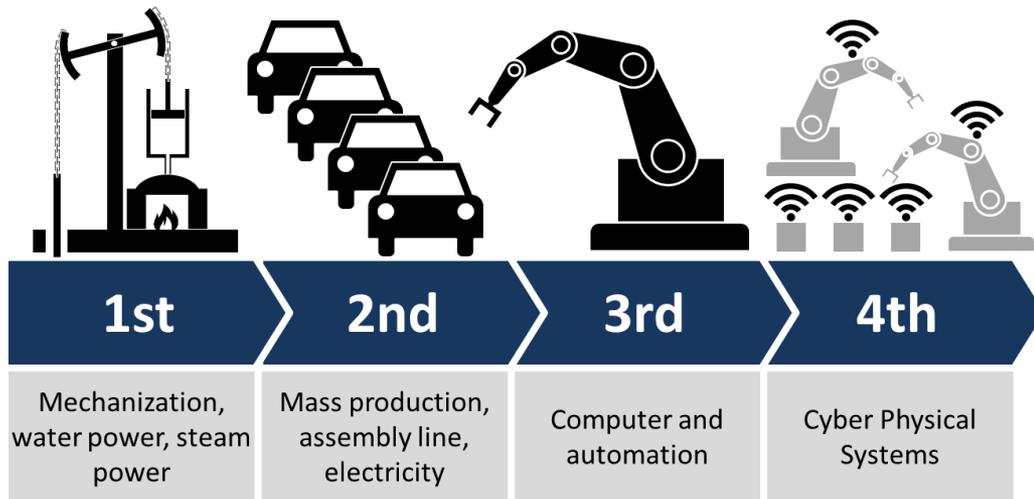


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Content of the presentation.

1. The fourth Industrial Revolution in Europe.
2. Digital Europe – an important step towards implementation of Industrial Revolution in Europe
3. Is EU ready for digitisation ?
4. Raw material sector – past and ongoing activities to achieve “mine in real time” (digital mine).
5. Is digitisation a way to solve current challenges in Raw Materials sector (mining and RM recycling)?
6. Conclusions and proposals for the VERAM consortium.

The Four Industrial Revolutions.



end of XVIII c. beginning of XX c. 70-ties. of XX c. announced in

Picture by; "Christoph Roser at All About Lean.com"

2011, Germany as Industry 4.0 program, or **the fourth industrial revolution**,



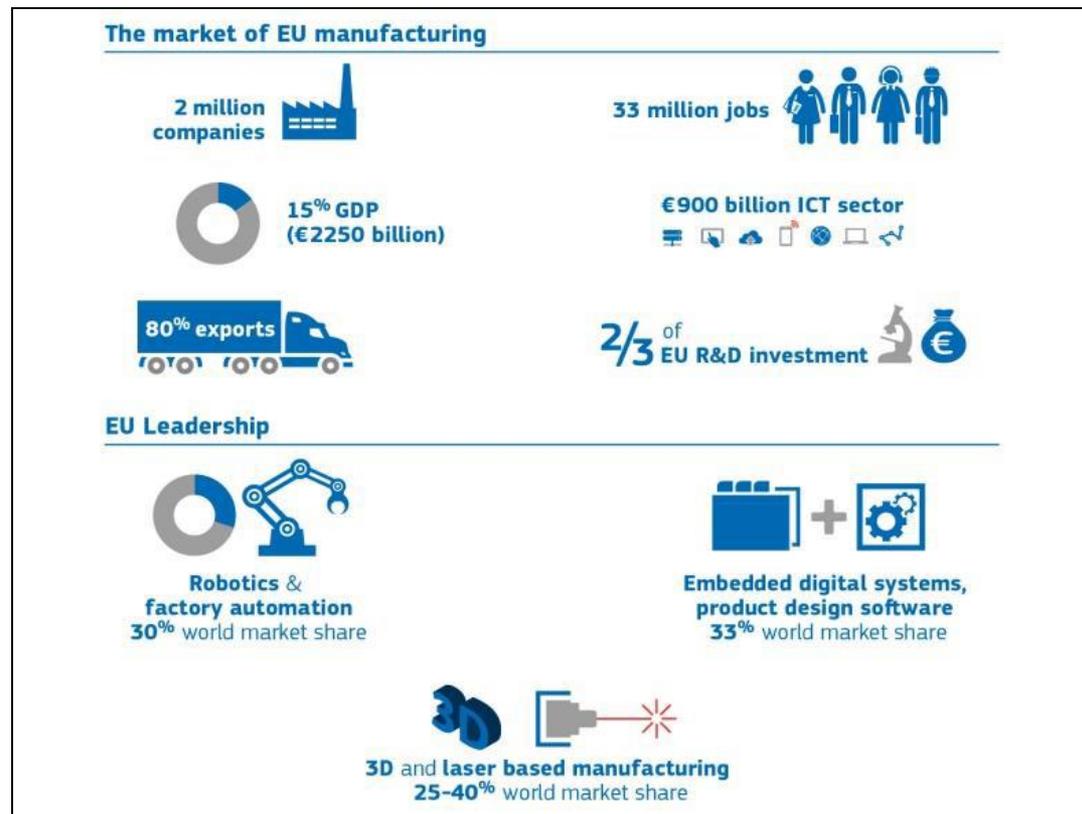
The term "Fourth Industrial Revolution" refers to technologies and concepts of value chain organization. It consists of the intelligent networking of product development and production, logistics and customers.

Concept of Industry 4.0 regards it as a series of ***disruptive innovations in production and leaps in industrial processes*** resulting in significantly higher productivity.

The manufacturing sector - one of the pillars of the European economy.

European industry is strong in digital sectors: electronics for automotive, security and energy markets, telecom equipment, business software, laser and sensor technologies. EU also hosts world-class research and technology institutes.

The manufacturing sector in the European Union accounts for **2 mln companies, 33 mln jobs and 60% of productivity growth**. We stand on the brink of a new industrial revolution, driven by new-generation information technologies such as the **Internet of Things (IoT), cloud computing, big data and data analytics, robotics and 3D printing**. They open new horizons for industry to become more adventurous, more efficient, to improve processes and to develop innovative products and services.

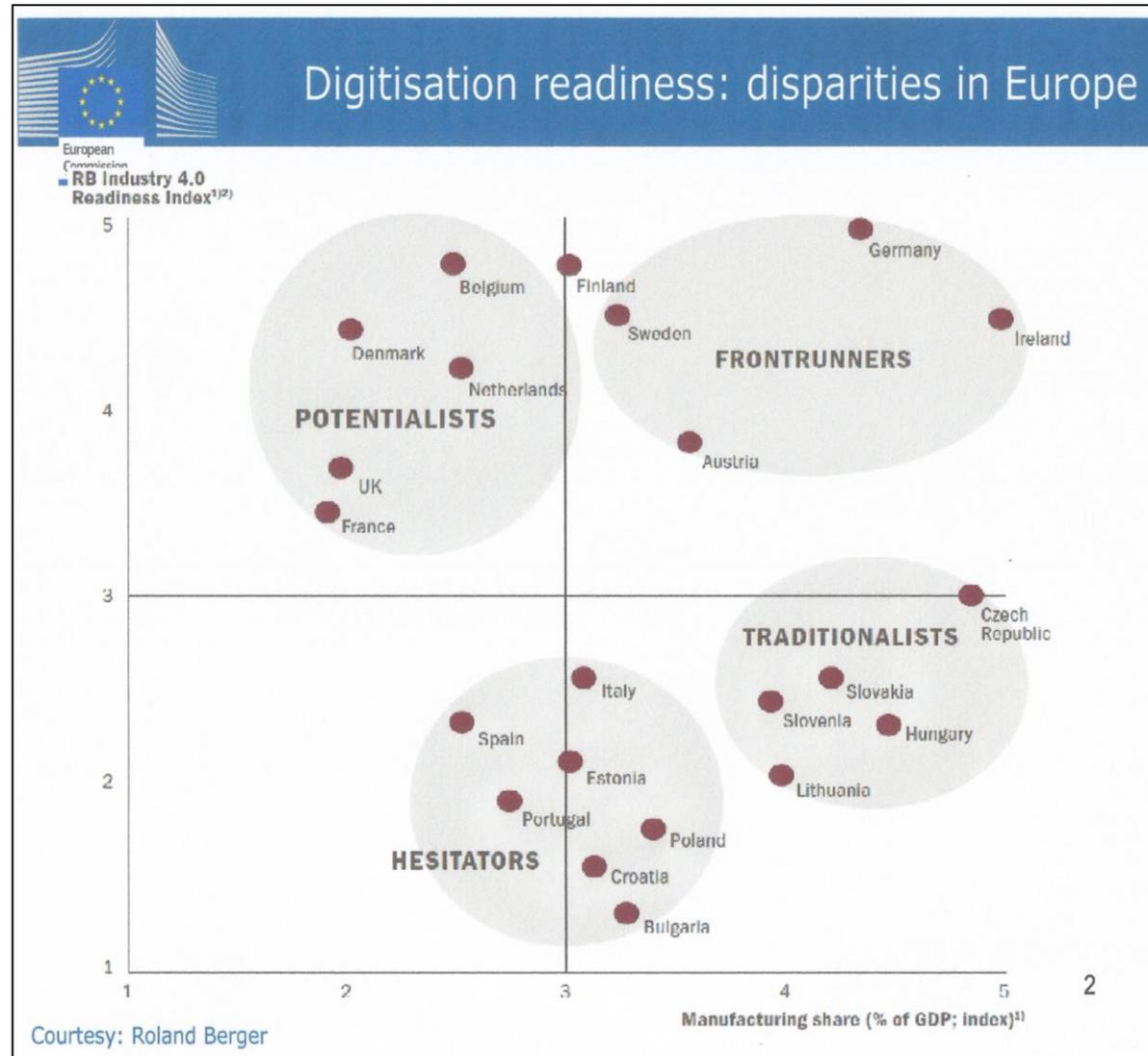


Disparities in digitisation level in Europe.

1. **High-tech sectors face severe competition from other parts of the world** and many traditional sectors and small and medium enterprises (SMEs) are lagging behind. There are also large disparities in digitization between EU MS and regions.

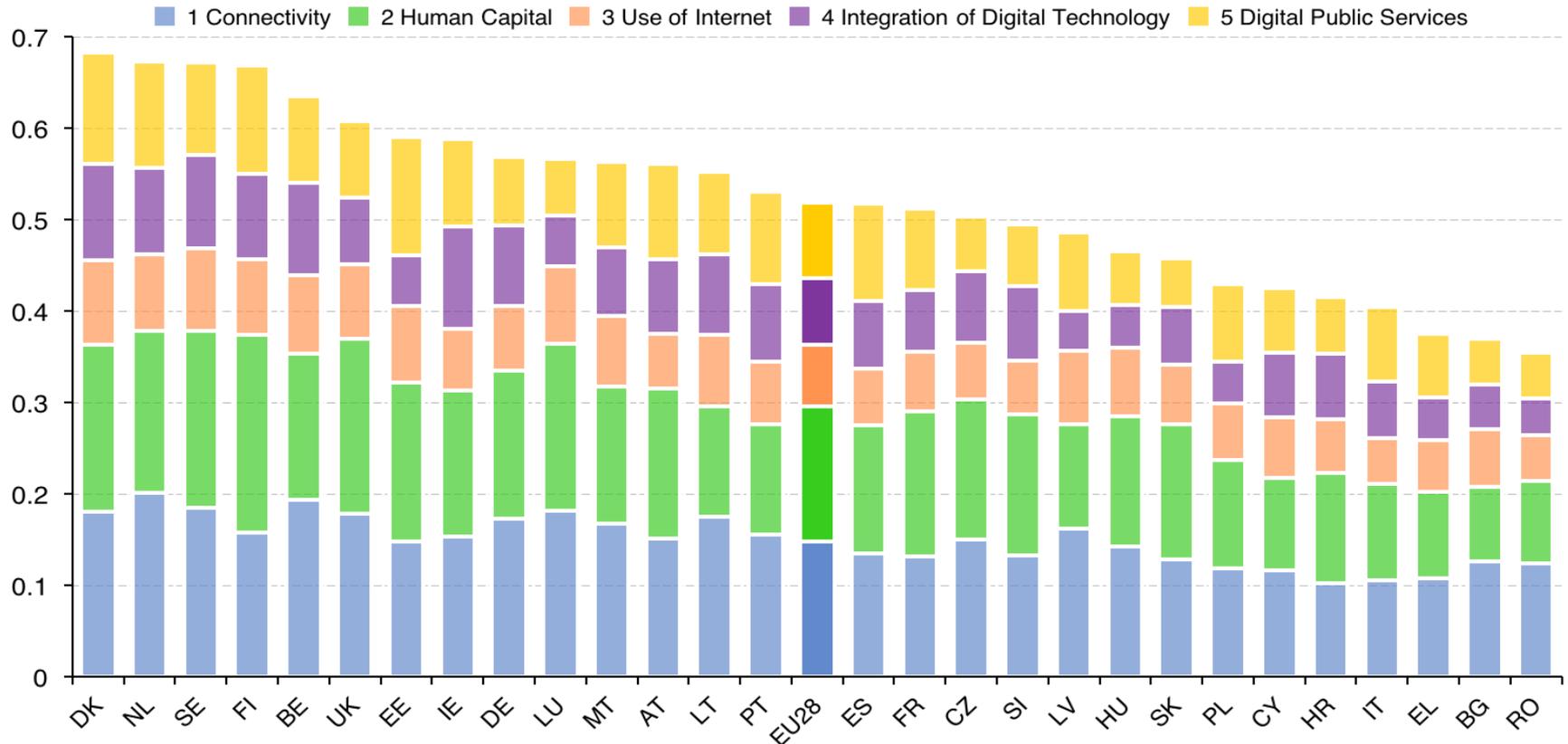
2. **About 40% of EU workers have an insufficient level of digital skills.** Source: EUROSTAT, digital skills of the labour force 2015

3. It is expected that rapidly growing demand will lead to more than **800 000 unfilled vacancies in ICT sector by 2020.**

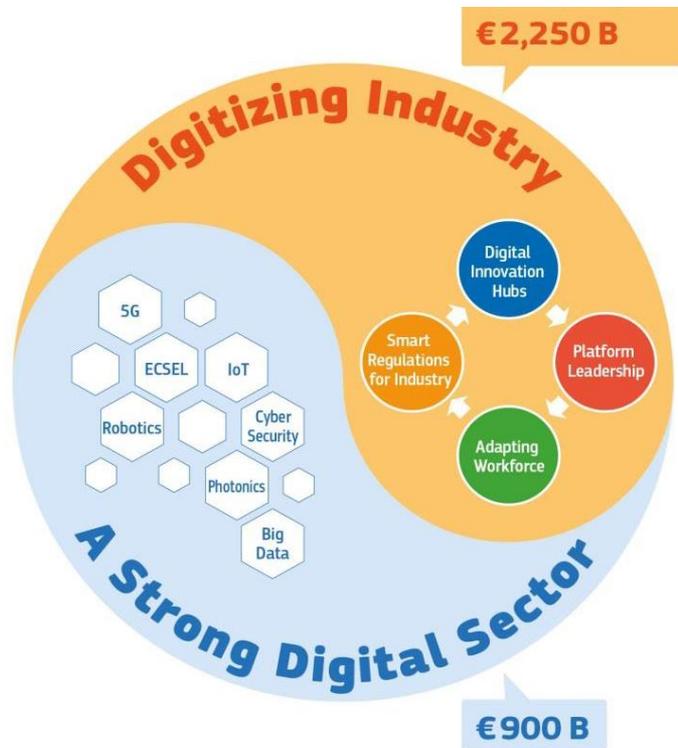


Source: Industry 4.0; Study for ITRE Committee;2016

DESI - Digital Economy and Society Index in EU.



Top countries in Europe are also leading at a global stage (I-DESI). The top three of best performing European countries are also leading the DESI index: **Sweden, Denmark and Finland**. They are closely followed by S.Korea, Iceland and the United States. **United States are the undisputable world leader with regards to the adoption of Digital Technologies by business**, but nine out of the first ten countries on this dimension are European countries.

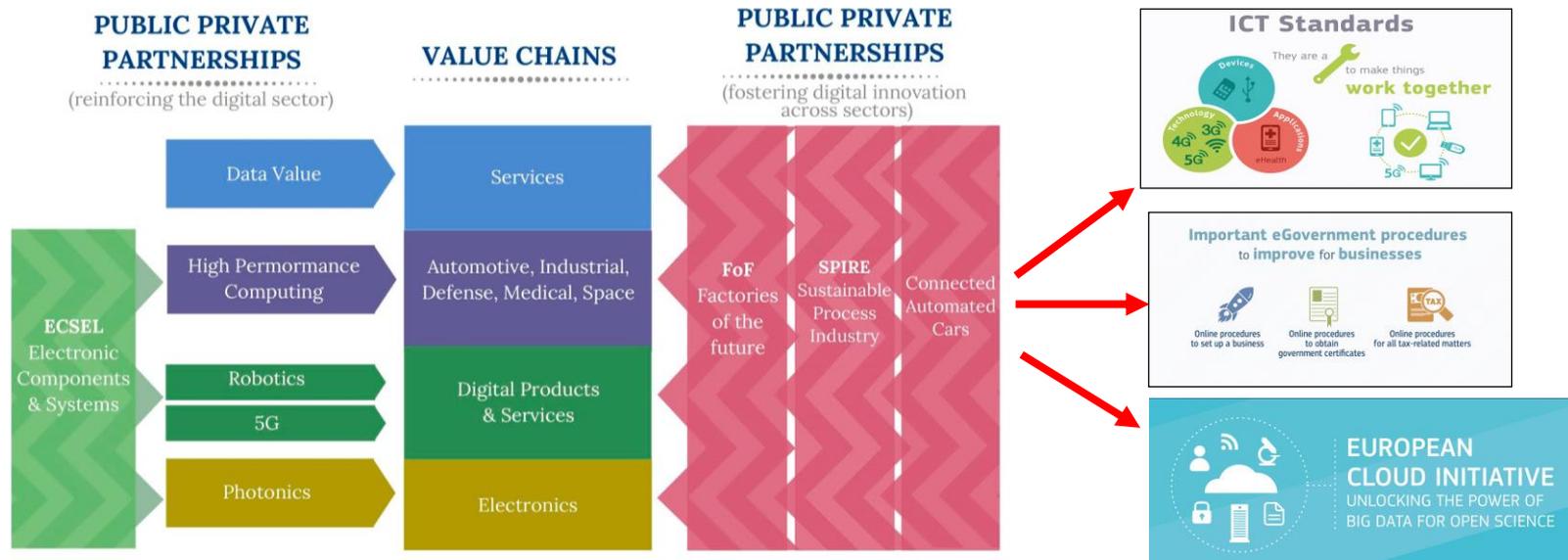


Digitisation of industry would create an **additional €110 billion of revenue** for industry per year in Europe over the next five years (2015-2020), according to studies by PwC and Boston Consulting Group.

Four planned actions to start 4th Industrial Revolution in EU.

1. **Develop digital innovation hubs:** Digital research and competence centres spread across Europe will lead the way and provide the necessary support to businesses. On-going EU-level initiatives will facilitate the networking and collaboration "glue".
2. **Leadership in platforms for digital industry:** availability of state-of-the-art open and interoperable platforms which any business can use to make its products, processes and services ready for the digital age.
3. **Closing the digital skills gap:** There is a clear need to promote digital skills at all levels, for re-skilling, and for lifelong learning across Europe and its regions.
4. **Framework conditions for smart industry:** We need to identify regulatory gaps and unintended barriers to the digital transformation of our industry.

Ongoing EU initiatives in innovation to speed up digitisation.



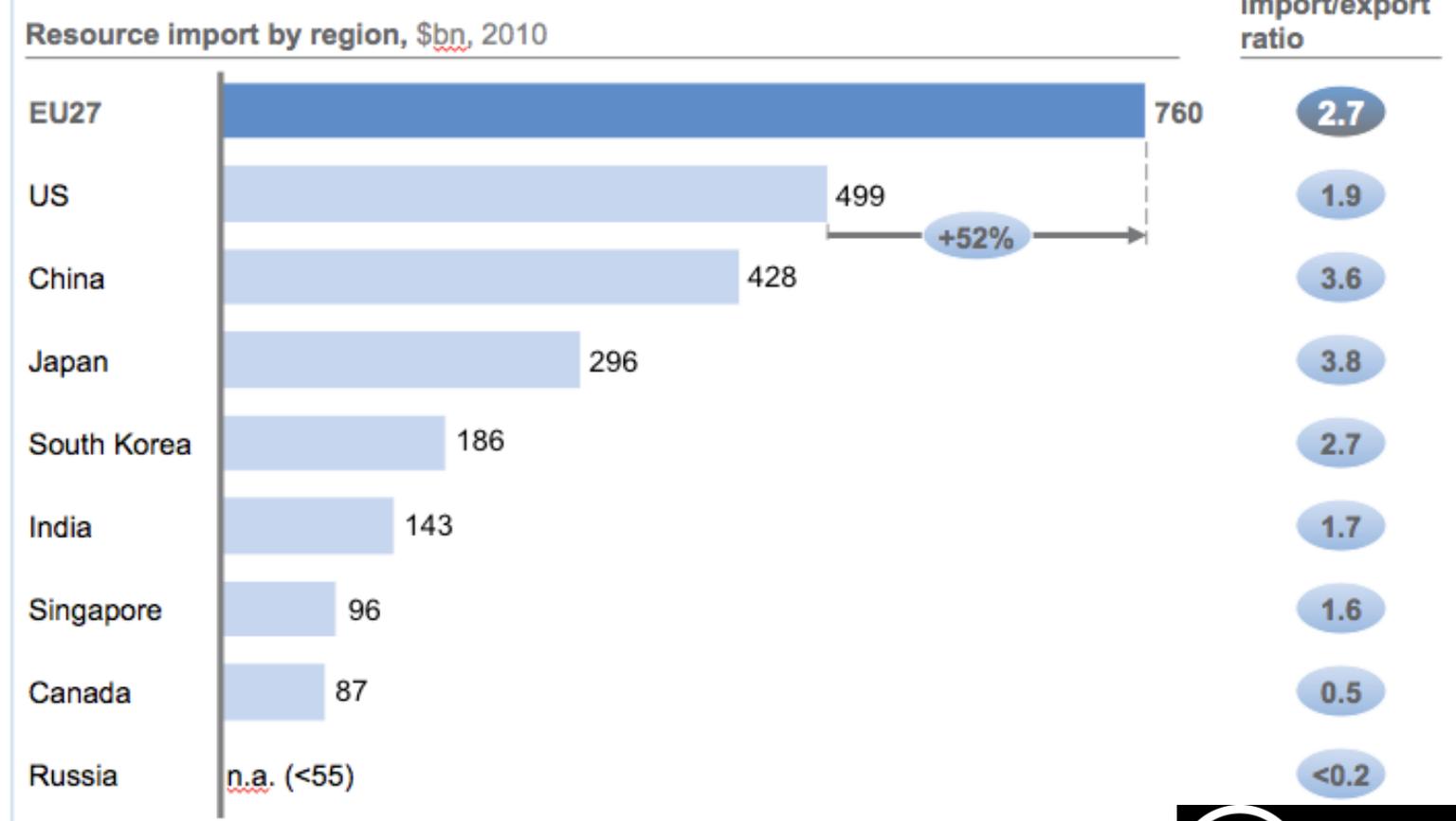
- 1. Photonics:** one of the key enabling technologies for our future prosperity and an essential element of many sectors, from energy and health, to everyday products like DVD players and mobile phones;
- 2. High Performance Computing** plays a pivotal role in stimulating Europe's economic growth and advancing European science;
- 3. Robotics;** a key driver of industrial competitiveness and essential to address key societal challenges in areas such as demographic change, health and well-being, food production, transport and security;
- 4. Future internet** aims to advance Europe's competitiveness in Future Internet technologies and to support the emergence of Future Internet-enhanced applications of public and social relevance;
- 5. 5G** stimulates the development of network internet infrastructure to ensure advanced ICT services for all sectors and users;
- 6. ECSEL;** a tripartite PPP in the area of electronic components and embedded software. It is supported with 1.2 bln € from the EU in Horizon 2020, 1.2 bln € from member states and from industry;
- 7. Factories of the Future** aims at helping EU manufacturing enterprises, in particular SMEs, to adapt to global competitive pressures by developing the necessary key enabling technologies across a broad range of sectors. It will help European industry to meet increasing global consumer demand for greener, more customised and higher quality products through the necessary transition to a demand-driven industry with less waste and a better use of resources.

Digitisation and future (intelligent) mining.

1. One of the biggest challenges the mining industry faces today is the **ability to manage the complete value chain as one operation.**
2. **The value chain** starts from mining, goes through ore transportation (vertical or horizontal), through processing operations and finally, to the shipping of **final mine product to the market** for further value add.
3. Better management of the complete value chain will help companies understand where **operational effectiveness, workforce safety, environmental compliance and energy efficiency can individually increase productivity and extract more** value from existing assets. However, in order for this to happen equipment needs to operate reliably and predictably.
4. **Ensuring worker safety** is going to be another challenge going forward. As an industry, we're trying to **remove people from dangerous situations** by leveraging greater mechanization and automation.
5. Removing people from dangerous or uncomfortable places will also allow the industry **to attract a stronger, more educated workforce.**

Europe is the world's largest net importer of resources.

Europe is uniquely placed to benefit from the impending resource revolution, since Europe is the world's largest net importer of resources



SOURCE: Resources Futures, a Chatham House Report, 2012; World bank



Ten technologies with the power to transform mining (2014).

In red colour - technologies which need development using disruptive ICT technologies.

- 1. Robotics**
- 2. Internet of Things**
- 3. Advanced airborne gravity gradiometer technology for mineral exploration**
- 4. 3D imaging technologies**
- 5. Automated drilling**
- 6. Efficient shaft and tunnel boring system**
- 7. Autonomous haulage**
- 8. Plasma technology for increasing precious metal yields**
- 9. Copper-eating bacteria**
- 10. Remote operating and monitoring centres.**

Robotics.

1. The application of robotic technology, although very limited in current mining operations around the world, **has far reaching potential for the mining industry.**
2. Robotic devices powered by artificial intelligence **can perform a range of tasks including drilling, blasting, loading, hauling, bolting mine roofs as well as ore sampling and rescuing trapped miners.**
3. **The use of robots in rescue operations** also represents a promising technology. demonstrated the potential of using robots in areas where humans can't even enter.

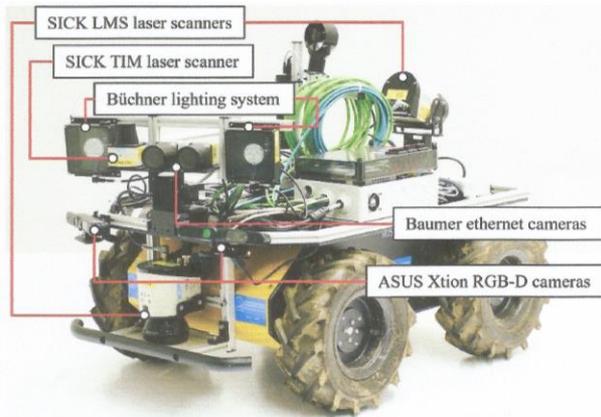


Fig.1 Robot „Aleksander”, equipped with cameras and several sensors for mapping, exploring environmental conditions at research and educational mine “Reiche Zeche”, Freiberg, Germany.

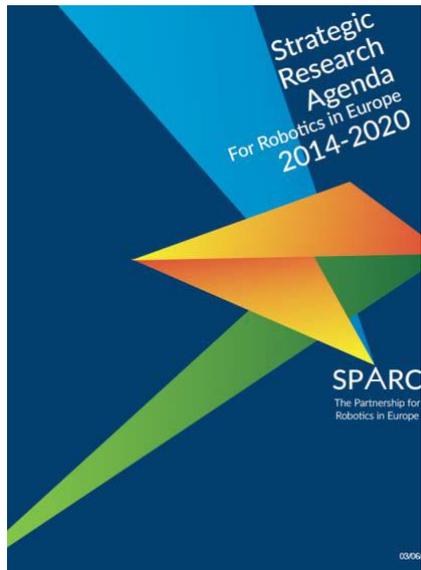


Fig.2. Hand held Raman spectrometer for mineralogical analysis onto UAV instrument (drone) during sight tests at Rosebery Mine, Australia.

Where to start robotics research & innovation in mining?

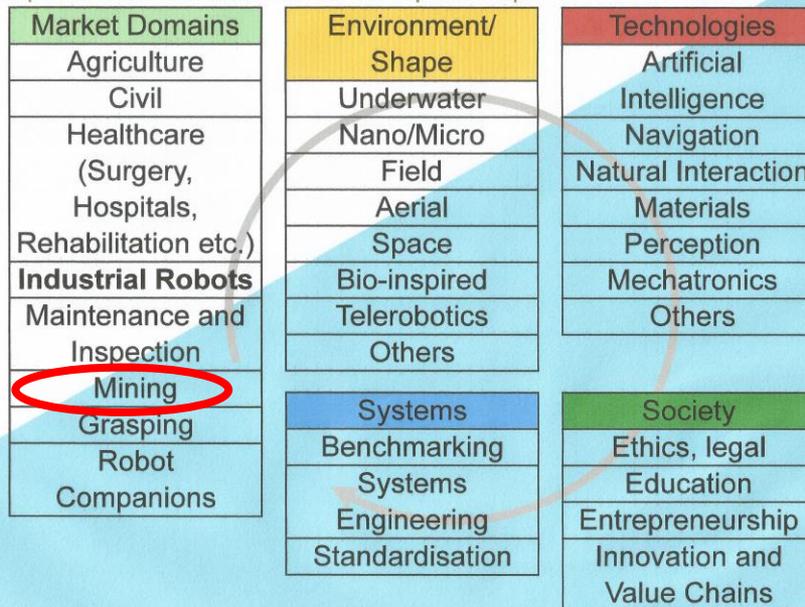
The European Commission funds over 100 collaborative projects on advanced research into robots which aim to understand the world around them through sensing, perception, understanding, reasoning and action.

SRA; vision, aims



Topic Groups of euRobotics AISBL

Example of Communication between Topic Groups



Brussels 21 Jan 2015

INNOVATION IN DIGITAL MANUFACTURING

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MAR = Multi-Annual Roadmap updated every year

2014-2020

Robotics2020
Roadmap
for Robotics in Europe

Produced by euRobotics AISBL
First Draft (v1) 13/03/2014

IoT in mine – one of the most important challenges XXI for RM sector in XXIst century.

1. IoT represents the next step towards digitisation where all objects and people can be interconnected through communication networks, in and across private, public and industrial spaces, and report about their status and/or about the status of the surrounding environment.

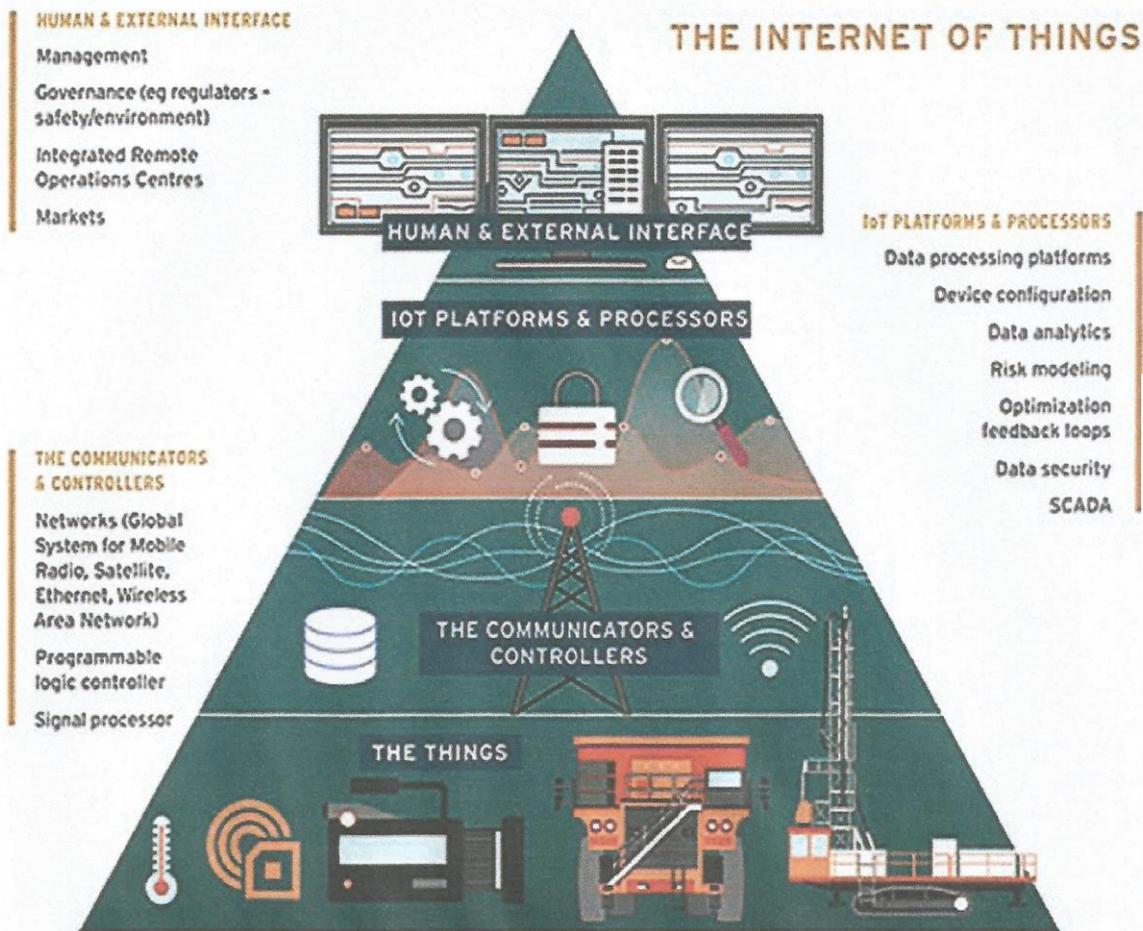


Fig 1. The Internet of Things (IoT) stack in mining company.

2. The IoT is based on various disciplines and technologies like sensors, embedded systems, various communications technologies.

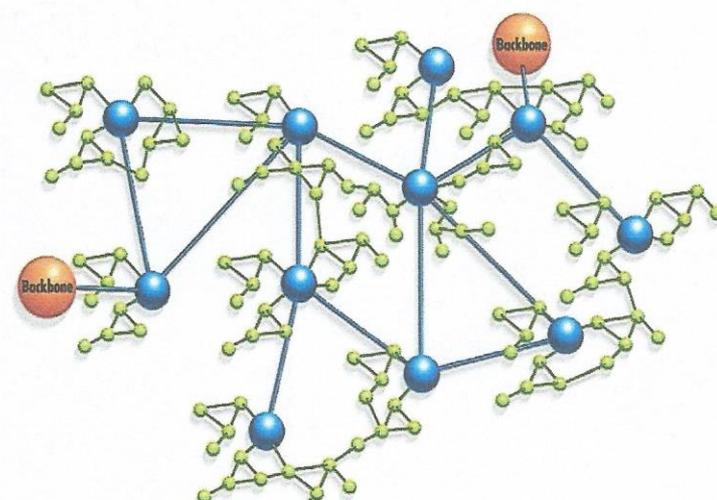


Fig 2. The Internet of Things devices form a mesh network.

Reliable sensors - important step towards Real-Time Mining (H2020 project) and Continuous Process Management in Mineral Extraction.

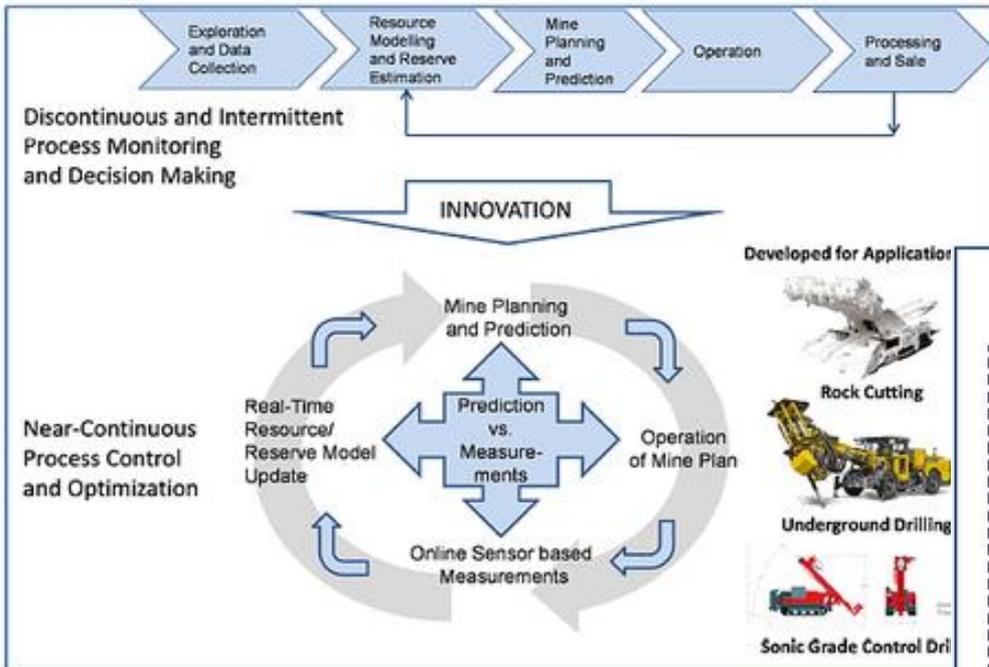


Fig 1. Moving from discontinuous process to a real-time continuous closed loop process.

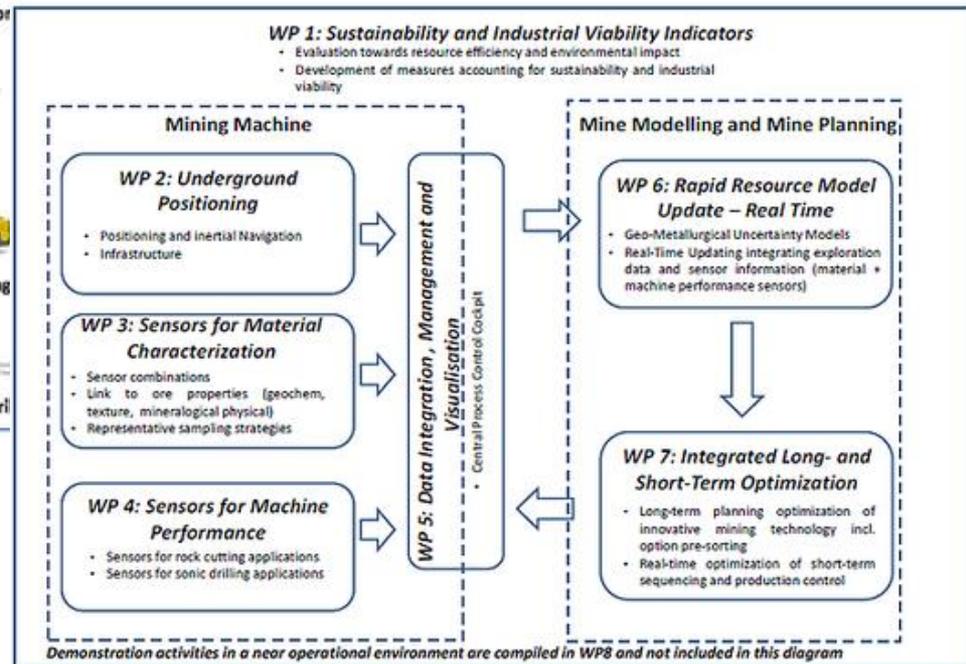


Fig 2. Flow chart and building blocks of real time mining.

source: „Real-Time Mining – Moving Towards Continuous Process Management in Mineral Resources Extraction. J Benndorf, M W N Buxton, K Nienhaus, L Rattmann and others; Ilrd International Future Mining Conference; 4-6 November 2015, Sydney, Australia

Big Data.

Flexible interaction and synergistic collaboration between humans and machines for fully autonomous and continuous operations requires adaptation from many fields, including robotics, automation, communication, human factor, pattern recognition, mine design, Sensor systems which can detect, track, classify and ensure data visualisation.

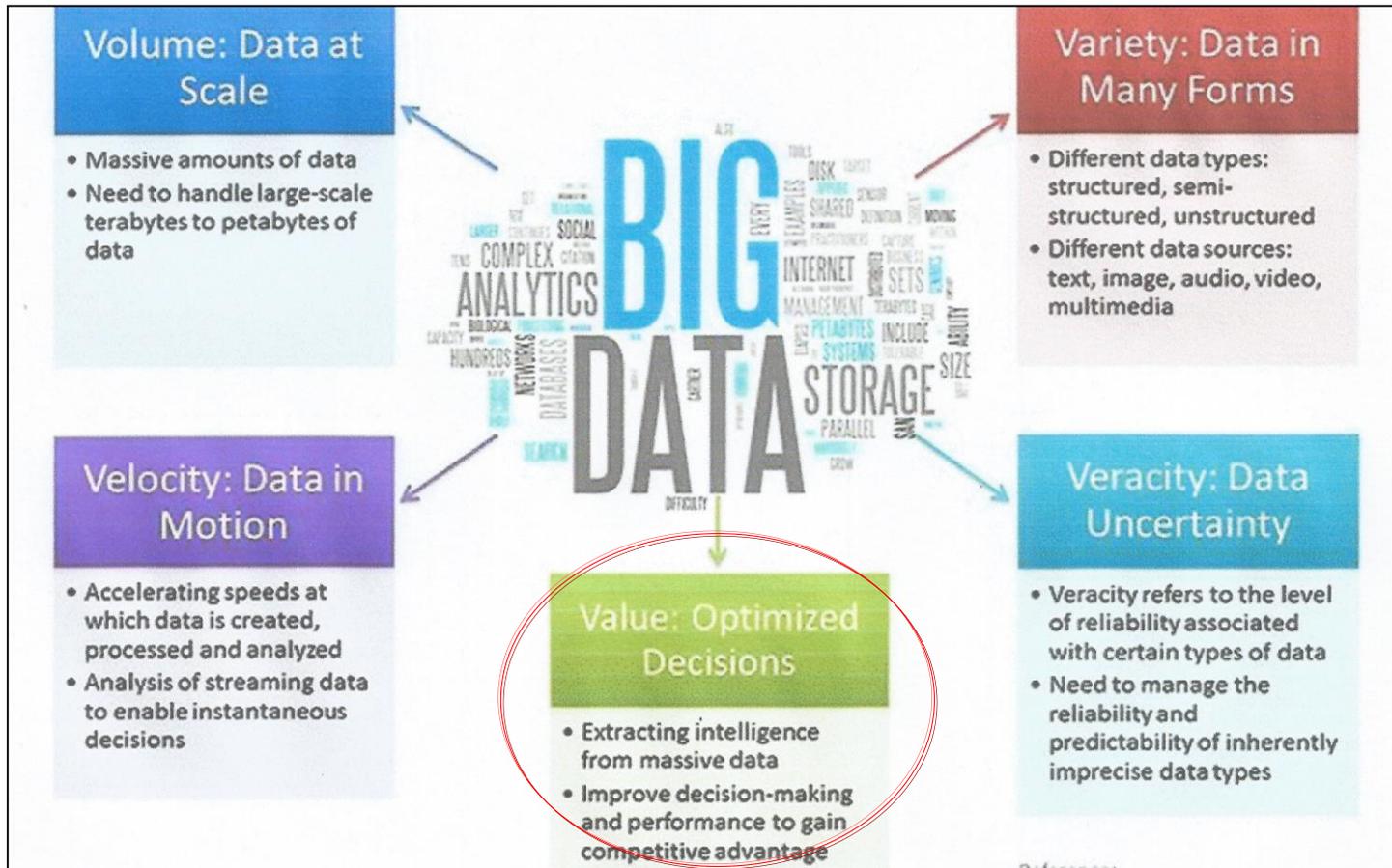


Fig 1. Principle of 5„V“; after Butler (2012) and Demczenko (2013).

(Volume) (Velocity);(Variety); (Veracity) → (Value)

source: „Synergistic Collaboration of Humans and Automated Systems“; J Ruiz-del Solar, E Widzyk-Capehart, P Vallejos, R Asenjo; Illrd International Future Mining Conference; 4-6 November 2015, Sydney, Australia

IoT, automation and robotics alone will not solve all the problems facing mining in XXI century !

A. The mining sector traditionally has been spending much less than other sectors on innovation. Main barriers to invest in innovation in mining sector:

1. Technological uncertainty,
2. Skills deficit
3. Lack of innovation culture
4. Lack of budget - in 2016 the mining sector has traditionally spent significantly less than other sectors on innovation, many innovation programs have been put on hold.

B. Many current innovation initiatives in mining sector are focused **on operating a bit faster or more efficiently rather than being disruptive.**

C. That approach provides short-term benefits but does not enable mining companies to make the **step-change needed for future sector growth.**

Top 10 business risks facing mining and metals in 2016/2017 report by E&Y.

1. Cash optimization
2. Capital access
- 3. Productivity**
4. Social license to operate
5. Transparency(resource nationalism)
6. Switch to growth
7. Access to energy
8. Joint ventures
- 9. Cybersecurity**
- 10. Innovation**

Past „Intelligent Mine’ activities in Europe.

INTELLIGENT MINE TECHNOLOGY PROGRAM 1992 - 1997

The real time control of resources and production

Machine automation

Automation of production and production maintenance

IMPLEMENTATION
1997

PERSONNEL

TECHNOLOGY

DATA UTILIZATION

INTELLIGENT MINE ~2000



SMIFU project: future vision as an inspiration for new solutions in future technological operations in mining (2009-2012).

- One control room;
- Zero entry mine;
- Mine – attractive and safe place to work;
- Continuous mining;
- Pre-concentration;
- On line monitoring of mining and mineral processing operations.



BOLIDEN

KGHM
POLSKA MIEDŹ S.A.

metso

Atlas Copco

ABB

SANDVIK



Outotec

LULEÅ
TEKNISKA
UNIVERSITET

AGH

source: Intelligent Mine Implementation
HUT, Prof. Pekka Särkkä; 2006

I2Mine – FP7 UE funded project (2011-2015).

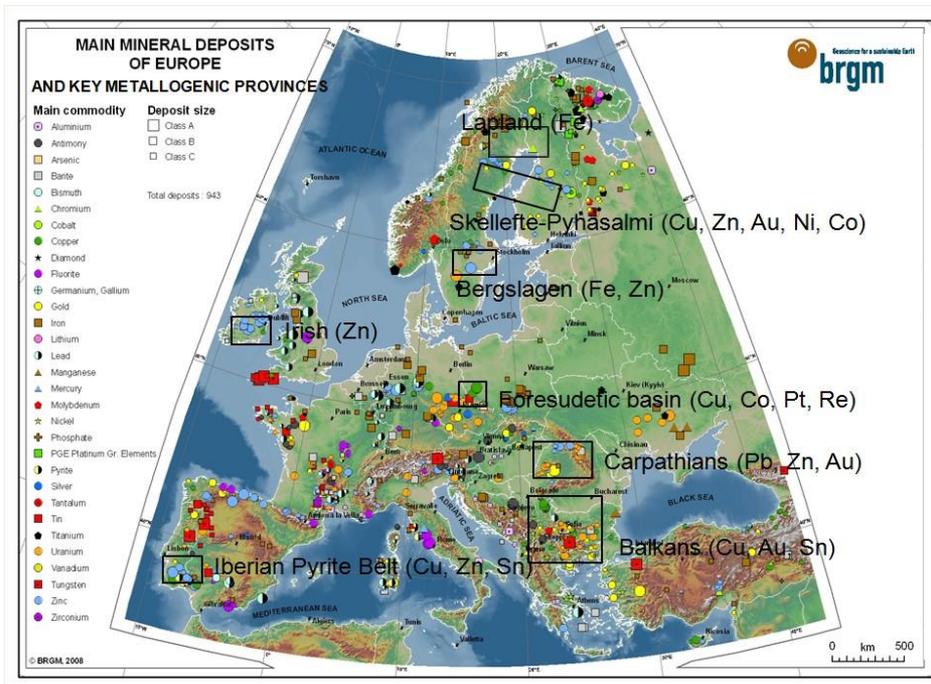
Innovative solutions for safe extraction of deep laying mineral deposits in Europe



I2Mine was the biggest EU RTD project in extractive sector which was funded by FP7 grant.

I2Mine project was to develop some innovative projects to execute the vision of **Intelligent Mine**.

Europe – still two pillars of safe supply in raw materials.



source: UNEP/EU Working document, Project Ref: LIFE08 ENV/UK/000208, March 2011

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Na	Mg											Al	Si	P	S	Cl	Ar
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K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
55	56	*	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Cs	Ba		Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
87	88	**	104	105	106	107	108	109	110	111	112	113	114	115	116	(117)	118
Fr	Ra		Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Uub	Uut	Uuq	Uup	Uuh	(Uus)	Uuo

* Lanthanides	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
** Actinides	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr



1. Mining is a key approach to tap Europe's unexploited minerals at a depth of 500–1500 metres, including critical raw materials, with estimated value of about €100 billion. Europe also hosts several **world class mining equipment providers**.

2. **Recycling is another key way for reducing European demand** for RM.

At present (2012) each EU citizen generates at about 17 kg of WEEE/year. It is assumed that in the year 2020 this amount will increase til 24 kg/person.

The EU 2012 WEEE flows.

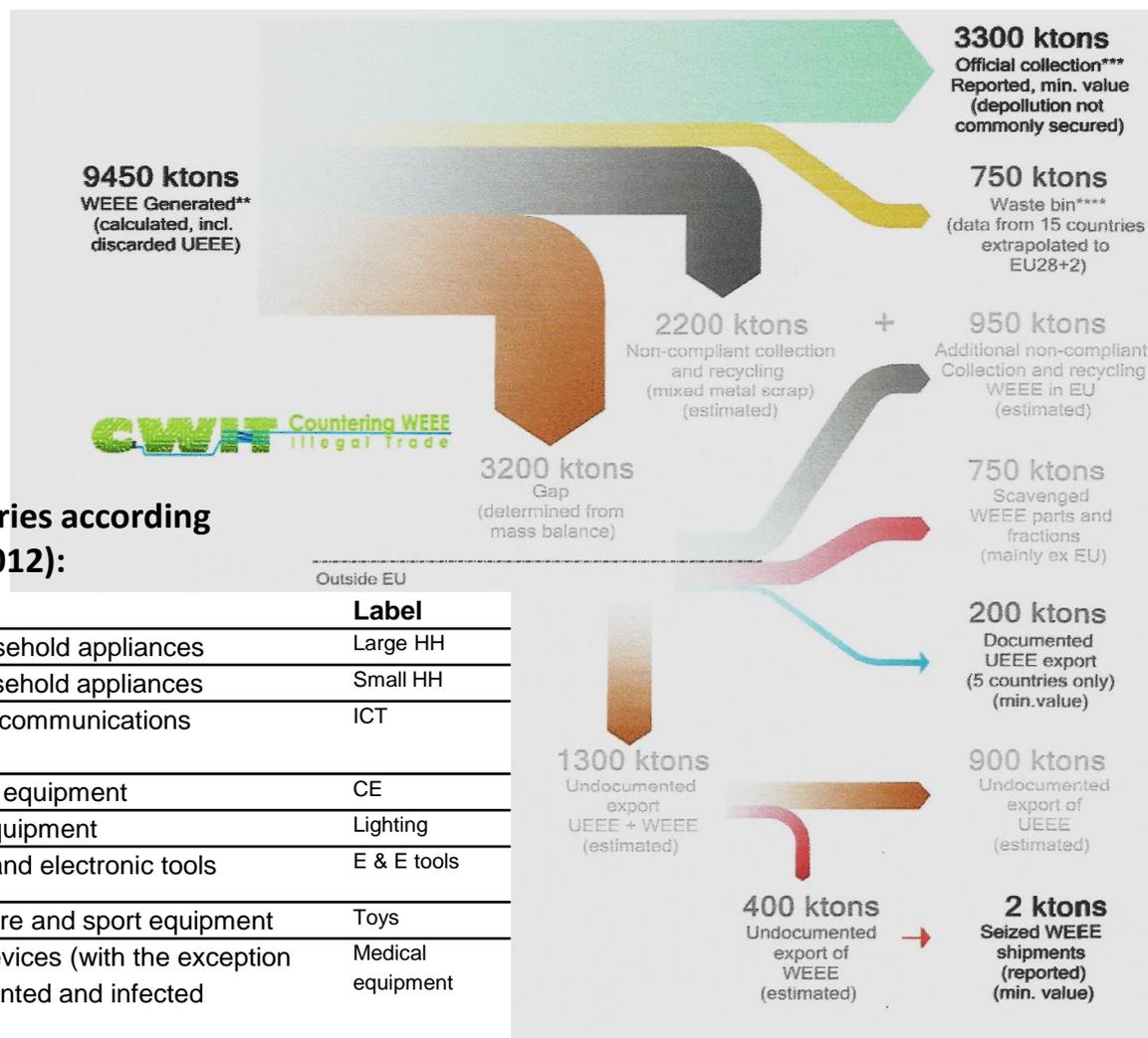


Table 1. WEEE (e-waste) categories according to the EU directive on WEEE (2012):

N	Category	Label
1	Large household appliances	Large HH
2	Small household appliances	Small HH
3	IT and telecommunications equipment	ICT
4	Consumer equipment	CE
5	Lighting equipment	Lighting
6	Electrical and electronic tools	E & E tools
7	Toys, leisure and sport equipment	Toys
8	Medical devices (with the exception of all implanted and infected products)	Medical equipment
9	Monitoring and control instruments	M & C
1	Automatic dispensers	Dispensers
0		

Main flaws in EU WEEE recycling.

Poor collection



Deviation of collected materials \Rightarrow dubious exports \Rightarrow backyard treatment



Digitising (IoT) creates many opportunities for Circular Economy.

IoT can facilitate the transition to new business models in the circular economy where all actors of the value chains are closely interconnected and use collaborative platforms to share data on resource flows, and end-users are empowered in their consumption patterns.

Resource constraints

- 3 bn new consumers are driving **resource demand**
- **Exhaustion** of easy-to-access reserves
- Need for **imports** from volatile regions stretches supply and increases volatility



Investment & economy

- Long-term investment opportunities
- Resilience to external shocks
- Unemployment challenges



The new consumer

- Emerging bias of **access over ownership**
- **Car-sharing** services are an example—membership is spiking



Enabling technology

- New technologies improve **product tracking** and separation
- Better **supply chain management** makes reverse logistics feasible



Source: *The Guardian*: Seattle Public Utilities (Seattle.gov); Frost & Sullivan, "Sustainable and Innovative Personal Transport Solutions—Strategic Analysis of Car sharing Market in Europe"

Intelligent Assets – Unlocking the Circular Economy Potential.

Performance models. A business agreement in which the customer pays for the use, or the performance of a product rather than the product itself. The rationale is that there is **no inherent benefit in owning the product.**

On the contrary, **ownership can entail additional costs (upfront investment), risk (unpredicted repair, maintenance or obsolescence) and end-of-use treatment costs.**

Performance models go under several names with different specifics, e.g. service contracts or “servitization”, leasing or asset centralization.

The emergence of IoT has also led to the popular notion of “**anything-as-a-service**”. The term “performance model” is used to encompass all these varieties in this report.

The overall objective of the Digitising European Industry (DEI initiative) an opportunity for RM sector.

Any industry in Europe, big or small, wherever situated and in **any sector can fully benefit from digital innovations to upgrade its products, improve its processes** and adapt its business models to the digital change.

This requires not only a dynamic digital sector in Europe but also the **full integration of digital innovations across all sectors of the economy.**

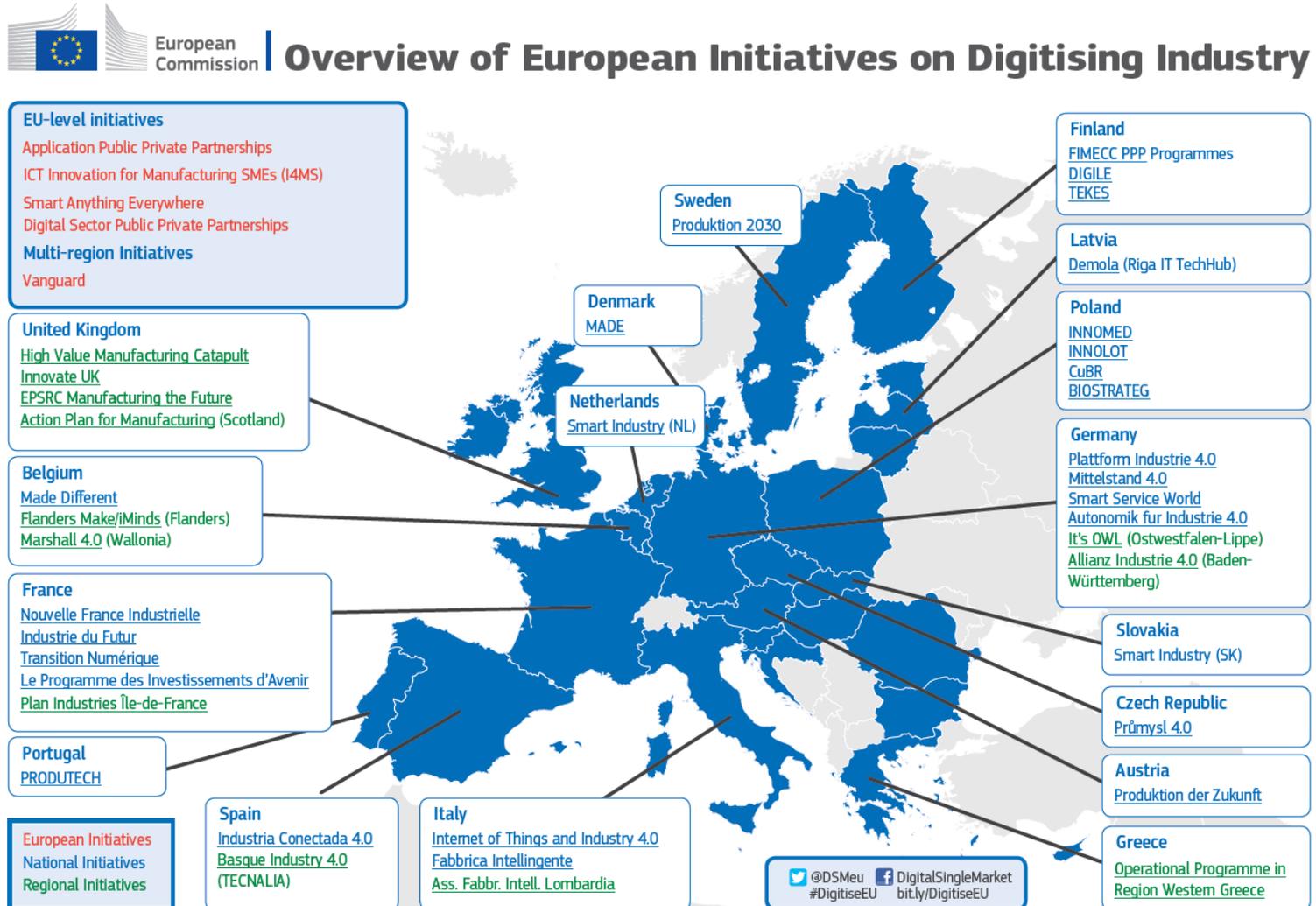
The DEI initiative is based on an ambitious **collective effort** involving public and private stakeholders across Europe at regional, national and EU level.



All photos; courtesy of prof. dr hab. inż. Krzysztof Krauze, AGH, Cracow

1. A step in digitizing RM sector - entering into European initiatives.

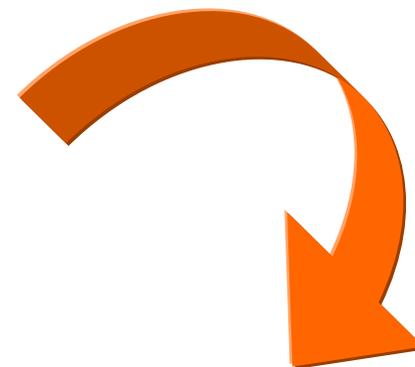
More than 30 national and regional initiatives for digitising industry have been launched across Europe in recent years. With value chains increasingly distributed across Europe, the further digitisation of industry brings challenges that can only be resolved through a collective EU-wide effort.



2. A step in digitizing RM sector - establishing suitable competence centre.

Competence centre which will do services for digital transformation of RM sector:

- Supporting experimentation and testing with new ICT technologies;
- Supporting broad collaborative network involving original equipment manufacturers and leaders in ICT, automation and robotics;
- Showcasing technologies in pilot factories;
- Offering training courses;
- Brokering between users and ICT sector;
- Keeping track of global developments



In cooperation with digital innovation hubs focused on innovation services:

- Mentoring services
- Start-up support
- Access to finance for growth
- Advice on access to new markets
- Advice on IPR and legal issues
- Access to "living labs" to validate new products or services
- Awareness raising and scouting on digital needs



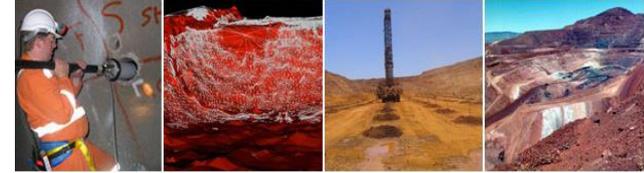
More than 50 competence centres currently participate in I4MS in the 220 experiments. It enables access to technology and expertise to 210 SMEs from 22 Member States and countries associated to the Research and Innovation framework programme Horizon 2020.

Source: An Action Plan for Digitising European Industry (draft); 23 December 2015; DG CONNECT, European Commission Components and Systems

3. A step in digitizing RM sector in EU - broader international cooperation.

Australia has three main centres for mining automation:

- CRC Mining (University of Queensland)
- CSIRO / Queensland Centre for Advanced Technologies (QCAT)
- Rio Tinto Centre for Mine Automation (RTCMA) and (The Australian Centre for Field Robotics (ACFR) at the University of Sydney)



How far advanced is Australia in terms of technology, automation in particular?

Our vision of a fully-automated remotely controlled mine is deliverable but will take years, substantial R&D investment and a broad collaborative network involving original equipment manufacturers and leaders in automation. **The creation of a fully-automated mine could not be achieved by any mining company working in isolation.** Rio Tinto's approach is to seek out the most capable groups in the world to work with.

John McGagh; Rio Tinto's Head of Innovation



Laurentian University

Centre for Excellence in Mining Innovations (CEMI);
Mining Automation Laboratory (LUMAL)

University of British Columbia

Mine Automation and Environmental Simulation Laboratory (MAESL)

Queens University

The Robert M. Buchan Department of Mining

**LatAm IT, Communication,
Automation in Mining
25-26 May 2016; conference in
Santiago; Chile**

Who could make the DEI program for RM sector ready?

in cooperation with:

- a national and regional initiative for digitising industry in EU (DEI) close to or focused on RM;
- EXCEL PPP;
- euRobotics/SPARC PPP;
- Factories of Future PPP;
- SPIRE PPP;
- Connected Automated Cars PPP.

Who ?

- ETP SMR + FTP / VERAM partners
- EIT KIC on RM
- EIP on RM
- ERAMIN + WoodWisdom-Net
- ?



Vision and roadmap for European raw materials

www.veram2050.eu

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