

Teaching Resources on the Sustainable Management of Critical Raw Materials

Trainer's Manual for Good Use of Data

March 2020

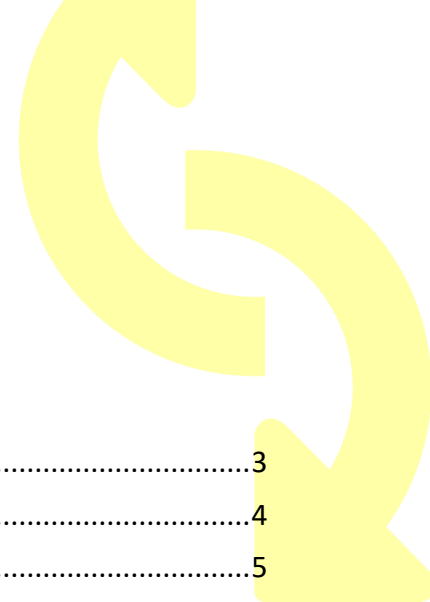


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1 Context and Introduction to Training

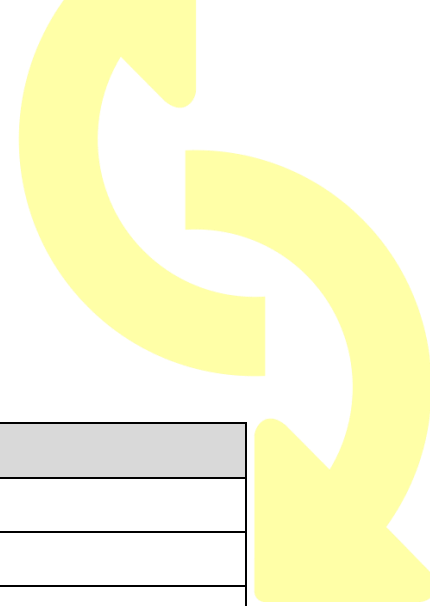
This booklet is supplementing the teaching materials and the set of further supporting booklets that have been developed to support teachers in conducting training courses related to the sustainable management of critical raw materials.

SusCritMat aims to educate people from Master's student level up, both in industry and academia about important aspects of sustainable critical raw materials. In a novel concept, it introduces courses on these complex and interdisciplinary topics in a modular structure, adaptable to a variety of different formats and accessible to both students and managers in industry. These courses will develop new skills, which will help participants to better understand the impact and role of critical raw materials in the whole value chain; enabling them to identify and mitigate risks. Understanding the bigger picture and the interconnected nature of global business and society is increasingly necessary to and valued by industry.

SusCritMat is an EU-funded project that brings together the technical and pedagogical expertise of leading educational institutions and business partners. It uses and creates teaching materials which can be combined into different course formats.

This training kit presents the key messages related with the sustainable management of critical raw materials in three major sections:

- Introduction to criticality (including criticality assessment, global resource supply chains, geopolitical factors, and economics of metals)
- Analysis of criticality (including material flows, scenario planning, and life cycle assessment)
- Solutions (including responsible sourcing, circularity indicators, circular product design, and good practice examples)



1.1 Training Materials List

The *SusCritMat project* developed the following teaching materials:

Basics
Critical Resources for Emerging Technologies
Criticality
Supply Chain Resilience
Supply Risk Factors
Circularity
Circular Economy
Characterizing the Urban Mine
Circular Business Models
Waste Management and Recycling Potential
Closing Loops on Product Level
Governance
Geopolitical Aspects
Metals & CRM Scenarios
Restricted Substances Legislation
Impact on Society and the Environment
Sustainability Assessment
Responsible Mining
Responsible Sourcing / Certification
Environmental Aspects
Sustainable Materials Usage
CRM and Sustainable Development
Tools
MFA - Material Flow Management
Good Use of Data
LCA – Life Cycle Assessment
Process Models based on LCA




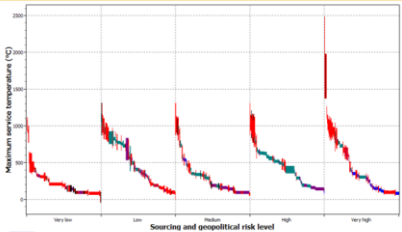
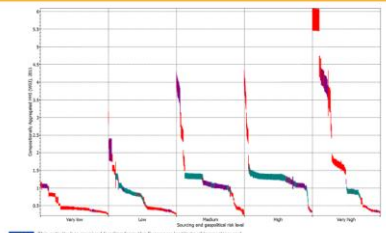
1.2 Key Messages

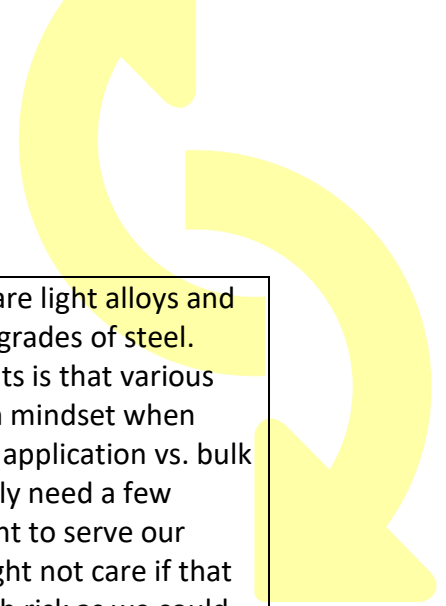
Evidently, knowing about materials is key to using them optimally. Among other things, materials data can help design products for the Circular Economy and assess criticality. The importance and availability of materials information can hardly be overstated, as they contribute to growth, increase profits and can be used to assess and avoid risks. Materials information is therefore, no exception to the rule that business processes can be improved using IT and large databases.

1.3 Learning Objectives

- Explain the importance of materials information for business decisions;
- Know about common problems relating to non-availability of materials data;
- Awareness of the advantages of materials information services such as those Granta provides
- Ability to improve certain business processes using such services

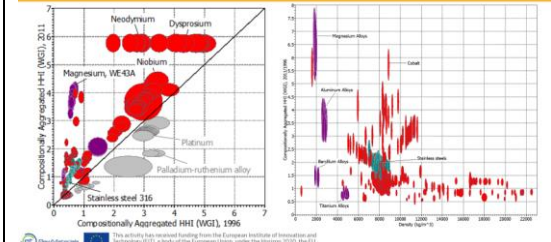
2 Slides and Notes

 <p>GOOD USE OF DATA</p> <p>DR. JAMES GODDIN, GRANTA DESIGN</p>	
<p>Material Properties vs. Risk</p> 	<p>This is a relatively simple example of what is possible by combining material property data with critical materials data in Granta CES.</p> <p>The X-axis highlights the highest sourcing and geopolitical risk level of elements contained in the ~2000 alloys contained in the MaterialUniverse database.</p> <p>The Y-axis highlights the maximum service temperature of the alloy.</p> <p>From this it is apparent that, for an operating environment above 1400 degrees, all of the available materials in this dataset will contain at least one element at very high risk of disruption due to geopolitical instability in the producing countries.</p> <p>What this graph does not account for is the quantity of the element contained in the composition.</p>
<p>Trace Element vs. Major Alloying Component</p> 	<p>The X-axis in this plot is the same as in the previous slide.</p> <p>The Y-axis is however the same metric of sourcing and geopolitical risk but calculated for the overall composition of the alloy, taking every element into account according to the relative proportion in the alloy and accounting for the sourcing and geopolitical risk of each element according to production concentration and geopolitical risk according to the World Bank Governance index.</p> <p>The red records in the top right of the plot are the 100% pure rare earth</p>


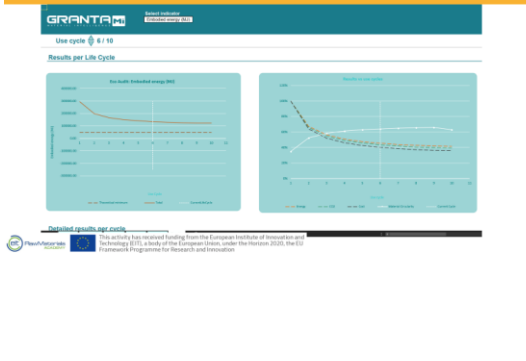
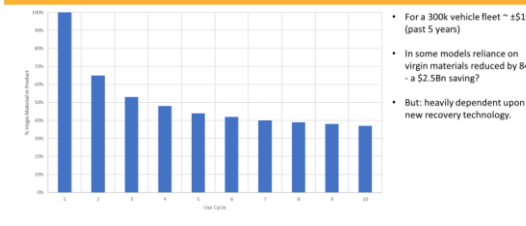


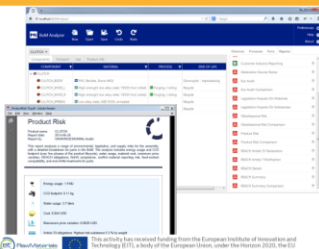

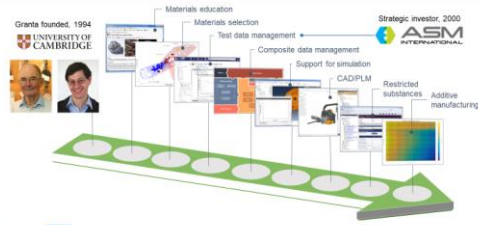
elements, The purple are light alloys and the Green are various grades of steel. What this plot highlights is that various alloys the difference in mindset when approaching specialist application vs. bulk applications – If we only need a few kilograms of an element to serve our business needs we might not care if that element has a very high risk as we could stockpile enough. If on the other hand we're using hundreds of thousands of tonnes of the material (e.g. steel in construction) we might care about alloys that contain a higher proportion of lower risk elements.

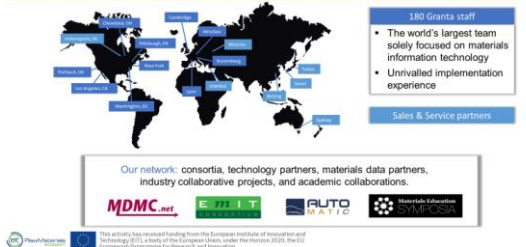



Increasing or decreasing risk?

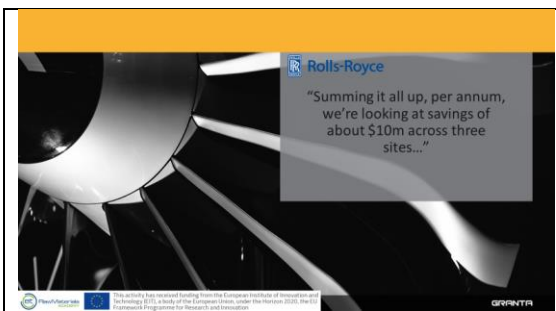
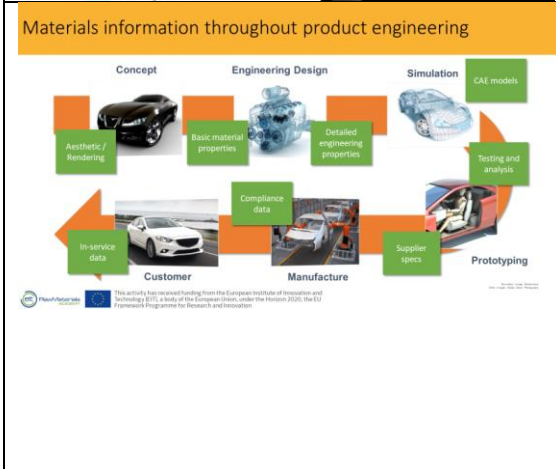


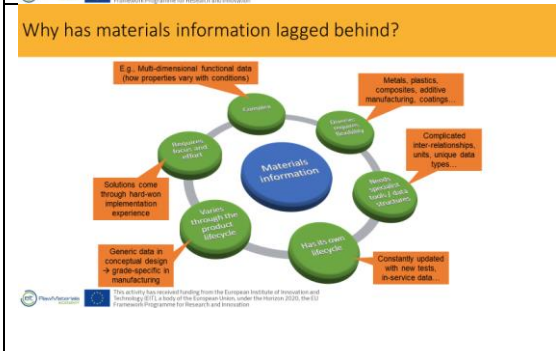


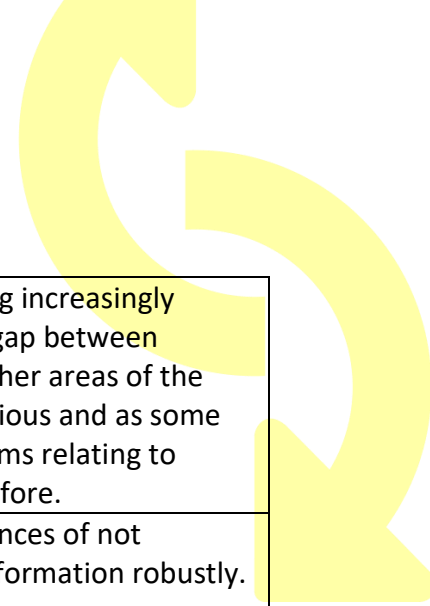
Considering the compositionally aggregated risks from the previous slide. The plot on the left looks at the risk for the material evaluated in 1996 vs the same risk evaluated in 2011 (15 years) Any material above the diagonal line has increased in risk over this period (the further from the line, the greater the increase in risk), materials below have decreased in risk. In both cases we're looking at sourcing and geopolitical risk for the whole composition. It is perhaps surprising to know that most of the metals we use have increased in risk, with the exception of the platinum groups alloys. Looking at the increase in risk over this period against Density, the plot on the right serves to highlight that many of the light alloys have been impacted during this 15 year period. Magnesium and Aluminium alloys have all increased in risk, primarily due to an increase in supply of the base elements (Mg and Al) from China during this period. What might this increase mean for applications that need light alloys (automotive and aerospace)?


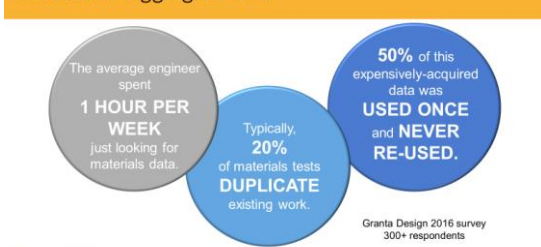
<p>How do we know how circular products are?</p>  <p>Design of new products</p> <p>Internal reporting</p> <p>Procurement</p> <p><small>The activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation</small></p>	<p>Materials data can also help us to understand how to design products for the circular economy.</p> <p>Granta Design developed a metric for quantifying material/product circularity with the Ellen MacArthur Foundation in 2013-2015, and this has been updated in 2019.</p> <p>The methodology is available freely online.</p>
<p>Multiple Life Cycle Analysis</p>  <p>GRANTA Design</p> <p>Use cycle: 6 / 10</p> <p>Results per Life Cycle</p> <p><small>The activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation</small></p>	<p>The plot on this page highlights the need to consider impacts across multiple lifecycles when dealing with circular economy products.</p> <p>Quite often the benefits of using more durable materials don't accrue until the second or third cycle of the product, something that the boundary conditions of a linear LCA might not pick up, to understand the benefits we have to expand our system boundaries to cover the multiple lifecycles of the product.</p>
<p>Reduced exposure to price volatility</p>  <ul style="list-style-type: none"> • For a 300k vehicle fleet ~ \$15m (past 5 years) • In some models reliance on virgin materials reduced by 84% - a \$2.5bn saving? • But: heavily dependent upon new recovery technology. <p><small>The activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation</small></p>	<p>Applying the circular economy to Critical Materials.</p> <p>This plot indicates the decrease in virgin material requirements for electric vehicle batteries for a 300,000 vehicle fleet. The model in this case highlighted of course a larger reduction in materials required as reuse and recycling were increased.</p> <p>Interestingly it also highlighted a reduction linked to the frequency of removing lower capacity cells from used vehicles, with a more frequent intervention rate being preferable. The model also served to highlight the potentially significant reduction in company exposure to price volatility in virgin material markets through the circular economy approach that might warrant investment is recovery technologies.</p>

<p>Product Level Reporting</p>  <ul style="list-style-type: none"> • This is one of the hands on tools tomorrow. • None of this is possible without robust materials data. • The value of robust materials data is much more than this though. <p><small>This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation</small></p>	<p>The same toolset Granta used in this analysis also allows us to assess other types of risk, particularly regulatory risks associated with substances that are being banned by REACH for example. Again this analysis depends upon a robust approach to the data needed, in this case the links between materials, substances they contain, specifications, and regulations.</p> <p>As this is a constantly evolving risk, it also requires regular updated to keep pace with new legislations and lists, and the ability to re-run assessments against these new lists to identify any changes that would require attention.</p>
<p>Granta: towards material intelligence</p> <p>Our mission is to lead materials information technology – to advance materials engineering and education, and to enable better, greener, safer products.</p>  <div style="display: flex; justify-content: space-around;"> <div> <p>Build your company's material intelligence</p> <p>Material intelligence integrated throughout R&D and the product lifecycle. Information when & where you need it. Smart decisions. Capture and re-use of resulting knowledge.</p> </div> <div> <p>Building society's material intelligence</p> <p>Help to inspire the next generation of engineers, scientists, and designers to engage with a subject that is vital to technological advances and sustainability.</p> </div> </div> <p><small>This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation</small></p>	<p>GRANTA MI is built by our company, Granta Design.</p> <p>We are the leaders in the field of materials information technology – and our mission is to maintain that lead. We started out working with materials engineering teams and in materials education, gaining a deep understanding of materials information and what is needed to use it effectively. We now apply that wherever materials information can help to optimize the design and development of products. Our vision is to continue to drive the world of materials up that ‘digitalization’ curve that we saw earlier – so that, ultimately, every piece of relevant materials information or knowledge is available when and where it is needed in a way that supports smart decisions.</p>
<p>Granta Design Materials information technology since 1994</p>  <p><small>This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation</small></p>	<p>Originally founded in 1994 with a focus on education – which is still a significant area for us as over 1000 universities worldwide use our education tools and teaching resources. Our focus on enterprise materials information management systems began</p>

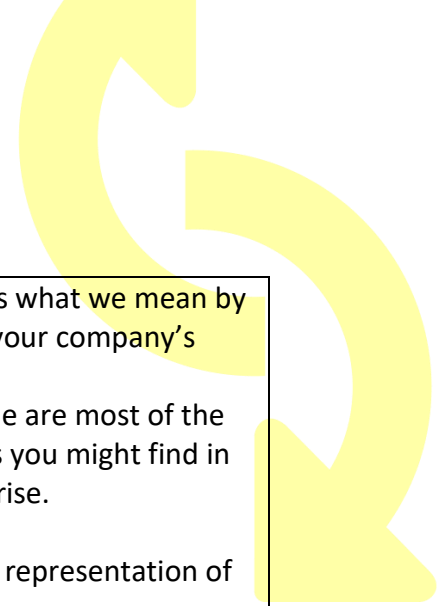
	<p>in around 2000 and we rapidly became world leaders in this unique field.</p>
<p>Software + Information + Services + Network</p> 	<p>A very important point about Granta is that we supplement our software and information with strong, global support and services for our customers, and through our unrivalled network in this field.</p> <p>There are now ~180 people at Granta making us by far the largest team solely focused on materials information technology.</p> <p>This team has unrivalled expertise – we have now completed 100s of materials data related projects with industry.</p> <p>And collaboration is in our “corporate DNA”. We organise some of the leading collaborations in the field – our consortia for industry customers (see slides in “extra slides” section for details) and our international Symposia for academics.</p>
<p>Example partners and collaborations</p> 	<p>...more on Granta’s collaboration. Here are some of the key organizations and projects with which we partner.</p>
<p>Selected customers</p> 	<p>The ultimate proof of our technology is that it is applied in industry.</p> <p>Here are some of our customers.</p>
<p>Why materials information matters Growth Profit Risk</p> 	<p>This slide highlights some of the many aspects of materials development, selection, product design and compliance that are directly dependent upon robust materials information.</p>

 <p>Rolls-Royce "Summing it all up, per annum, we're looking at savings of about \$10m across three sites..."</p>	<p>And this is why leading advanced engineering organisations are investing in materials information management technologies.</p>
<p>Materials information throughout product engineering</p>  <p>Concept Engineering Design Simulation CAE models</p> <p>Aesthetic/rendering Basic material properties Detailed engineering properties Testing and analysis</p> <p>In-service data Compliance data Supplier specs Prototyping</p> <p>Customer Manufacture</p>	<p>This slide serves to highlight that it's not just materials scientists that care about materials information, the same materials data is used through product development and capturing and centralising this knowledge has some very significant benefits. E.g. avoiding expensive duplication, design changes and supporting qualification and certification, as well as simply the time spent by engineers looking for data (which all adds up).</p>
<p>How is this valuable asset managed today?</p>  <p>Concept Engineering Design Simulation CAE models</p> <p>preferred materials test results materials specs material analysis test results certification materials specs preferred materials</p> <p>test results certification test results test results test results test results test results test results</p> <p>Customer Manufacture Prototyping</p>	<p>This slide represents the materials data landscape in many companies today – it's no wonder there is often lost data, data that only gets used once or which can no longer be understood...</p>
<p>The big picture: 'Digitalization' of business processes</p>  <p>Why? Materials Product Design Finance Human Resources</p>	<p>Other forms of digitalisation are of course further ahead, materials is a complex and varied domain however and is still catching up.</p>
<p>Why has materials information lagged behind?</p>  <p>E.g. Multi-dimensional functional data (their properties vary with conditions)</p> <p>Metals, plastics, composites, additive manufacturing, coatings</p> <p>Complicated inter-relationships, unique data types</p> <p>Hard to digitise</p> <p>Constantly updated with new tests, in-service data</p> <p>Generic data in conceptual design → grade-specific in manufacturing</p> <p>Solutions come through hard-won implementation experience</p> <p>Materials information</p>	<p>So why, exactly, has materials information lagged behind other areas in its digitalization. Essentially, because it is something of a niche area, and some of the data is highly specialised and technical. This slide breaks that down a little more – these are all reasons why organizations have "got by" with how things work today.</p>



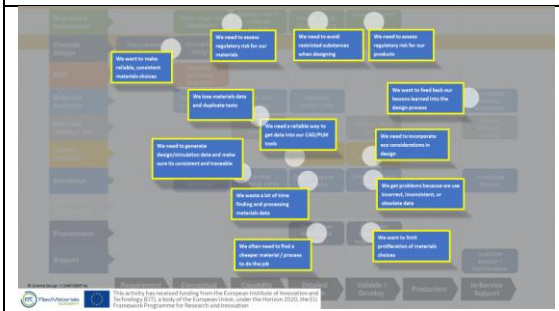
	<p>But this lag is becoming increasingly unsustainable, as the gap between materials and some other areas of the business becomes obvious and as some of the strategic problems relating to materials come to the fore.</p>																								
<p>Consequences</p> 	<p>Some of the consequences of not managing materials information robustly.</p>																								
<p>The cost of lagging behind</p> 	<p>Before we address how to meet the challenge of digitalizing materials, let's do a little more to understand why the effort will be worthwhile.</p> <p>Here are some statistics from a recent Granta survey of our contacts in major engineering enterprises.</p> <p>Something as simple as unnecessary time spent looking for data can correspond to \$100,000s of dollars across all of the engineers in an organization</p> <p>Imagine if you could reduce testing costs by 20% simply by not repeating tests – how many \$thousands or \$millions?</p> <p>And what a wasted wealth of information there is, simply because data captured for one purpose is not re-used – could we get to market faster, or get breakthrough insights if we mined that resource</p>																								
<p>An example productivity business case</p> <table border="1"> <thead> <tr> <th colspan="2">Key assumptions (based on a medium-sized enterprise company with revenues of \$2bn)</th> </tr> </thead> <tbody> <tr> <td># of materials experts</td> <td>5</td> </tr> <tr> <td># of design engineers</td> <td>100</td> </tr> <tr> <td># design iterations failed p.a. due to materials data issues</td> <td>20</td> </tr> <tr> <td>% materials engineer time on tests that are unneeded or duplicated</td> <td>20%</td> </tr> <tr> <td>% time materials engineers spend rolling-up & analyzing data</td> <td>20%</td> </tr> <tr> <td colspan="2">Business case</td> </tr> <tr> <td>(1) Cut time materials engineers spend rolling-up & analyzing data by 50%</td> <td>\$60,000</td> </tr> <tr> <td>(2) Estimate lost and duplicated tests</td> <td>-\$140,000</td> </tr> <tr> <td>(3) Reduce average weekly time searching for data from 1 hour to 15 mins per engineer</td> <td>-\$240,000</td> </tr> <tr> <td>(4) Reduce design iteration failures by 50%</td> <td>\$400,000</td> </tr> <tr> <td>Value of increased capacity available due to efficiency gains</td> <td>~\$840,000</td> </tr> </tbody> </table> <p>The Business Case for Materials Information Management. Granta Design, 2012 (page 6) http://www.grantadesign.com/papers/whitepaper.htm</p>	Key assumptions (based on a medium-sized enterprise company with revenues of \$2bn)		# of materials experts	5	# of design engineers	100	# design iterations failed p.a. due to materials data issues	20	% materials engineer time on tests that are unneeded or duplicated	20%	% time materials engineers spend rolling-up & analyzing data	20%	Business case		(1) Cut time materials engineers spend rolling-up & analyzing data by 50%	\$60,000	(2) Estimate lost and duplicated tests	-\$140,000	(3) Reduce average weekly time searching for data from 1 hour to 15 mins per engineer	-\$240,000	(4) Reduce design iteration failures by 50%	\$400,000	Value of increased capacity available due to efficiency gains	~\$840,000	<p>This is a slightly more detailed work-up of the business case for enterprise materials information management systems.</p>
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<h3>Introducing GRANTA MI</h3> <p>Features include:</p> <ul style="list-style-type: none"> • Specialist materials data structures • Tools to manage the materials data lifecycle • Full traceability • Access and change control, workflow 	<p>A core concept is the combination of in-house or proprietary materials data (from testing and analysis) with robust and well trusted commercial materials datasets to fill gaps in that knowledge and to broaden the scope of data available immediately.</p>
<h3>Our materials information library</h3> <p>Unique, comprehensive, linked</p>	<p>From the Granta perspective this is an example of some of the specialist data sets we have linked to our more general MaterialUniverse data module – the one we used for the plots at the start of this presentation.</p>
<h3>Introducing GRANTA MI</h3>	<p>These are some examples of the typical users of a commercial materials information management system and what they need the materials knowledge for.</p>
<h3>Targeted apps where they are needed</h3>	<p>Different users can access GRANTA MI via apps that are appropriate to their role and that fit within their workflow – web apps, from within a web browser, or even from within a 3rd party tool like CAD or CAE.</p> <p>The slide shows some examples. They key point is that all of these users are accessing, quickly and efficiently, a “single view of the materials truth” for their company.</p> <p>No inconsistencies, no inaccuracies – and the full history of the company’s materials activities is captured for re-use and traceable.</p>



This diagram illustrates what we mean by that idea of “building your company’s material intelligence”. Down the left hand side are most of the key functions or teams you might find in an engineering enterprise.

Across the bottom is a representation of the product lifecycle. The boxes show many of the processes where materials information is relevant. Our aim is to provide this information at all of these points, in a consistent, single system...



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Examples (www.grantadesign.com/casestudies/)

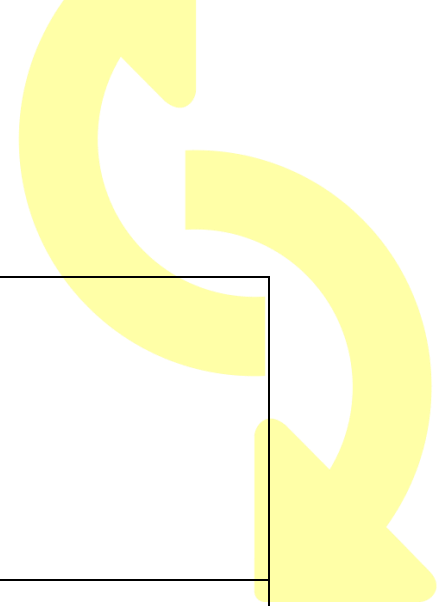
- General Motors:** delivering the right data to design
 - “Less rework, better products, no recalls, fewer warranty issues”
- Tecumseh:** materials selection
 - “Graphical selection methods helped save €2 million.”
- Honeywell:** test data management
 - “Cutting about 80% of the time... to generate a new model”
- Boeing:** restricted substance risk assessment
 - “We enable better answers in much less time”
- Rolls-Royce:** enterprise-wide benefits
 - “We’re looking at about €6.9M of savings”

The good news is that we’re making great progress. Here are some practical examples.




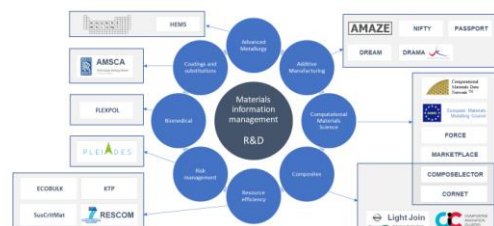
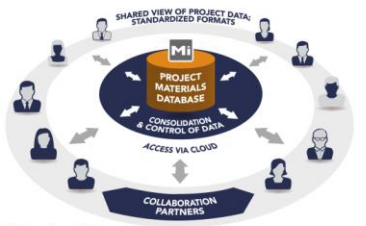
Advantages from strengthening materials intelligence

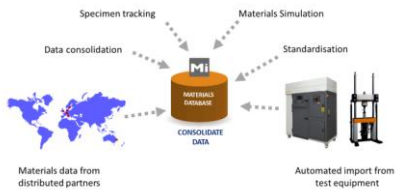


- More ROI from testing and qualification
- Smart materials choices
- Empower product engineering (CAD / PLM)
- Ensure the right simulation results
- Gain a competitive edge in composites
- Enable innovation in Additive Manufacturing
- Meet the restricted substances challenge

GRANTAM
Material Intelligence for your company
Better, faster, safer products



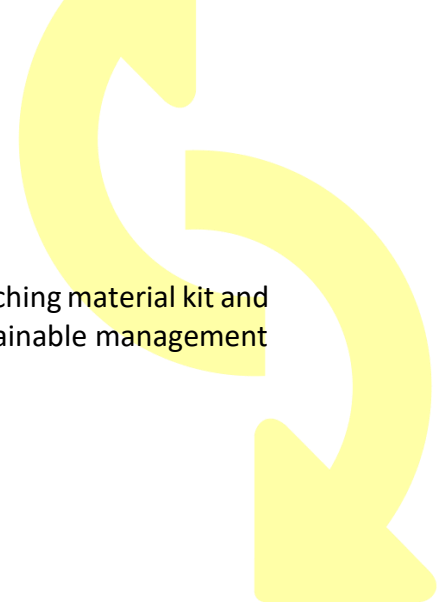
<p>More information</p> <div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <p>Watch the video "What is the value of materials data management?" www.youtube.com/user/GrantaDesign</p> </div> <div style="text-align: center;"> <p>Read the White Paper www.grantadesign.com/download/pdf/whitepaper.pdf</p> </div> </div> <p><small>This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation</small></p>	
<p>How we support our customers</p> <div style="display: flex; justify-content: space-around; text-align: center;"> <div> <p>Software</p> <p>Develop and apply material intelligence. A single 'gold source' for your corporate materials information. Targeted apps, when and where they are needed.</p> </div> <div> <p>Information</p> <p>An organized catalog of materials property data and related information. Licensed from leading providers or researched and managed by our expert team.</p> </div> <div> <p>Professional Services</p> <p>Project Managers and Materials Consultants work closely with you to establish which services you need and to project manage and deliver those services quickly, efficiently and effectively.</p> </div> <div> <p>Network</p> <p>Our consortia bring together leading engineering enterprises, to share knowledge and drive materials information technology. Granta is actively engaged in a wide range of industry collaborative projects.</p> </div> </div> <p><small>This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation</small></p>	
<p>Development in collaboration with our network</p> <div style="text-align: center;"> <p>* E.g. at regular Consortia and User Group meetings</p> </div> <p><small>This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation</small></p>	<p>A key to our success has been working collaboratively with our customers through consortia. This approach shouldn't be underestimated and there are some significant benefits, for example agreeing common data structures greatly enhances the ability to integrate with other tools without having to recreate these for each customer.</p>
<p>The Material Data Management Consortium</p> <p>MDMC.net</p> <ul style="list-style-type: none"> Collaborative project, founded in 2002 by NASA, ASM International, Granta Design Now in Phase IV <ul style="list-style-type: none"> Mission: The MDMC develops and applies materials information technology that helps to maximize the value of materials engineering for engineering enterprises Benefits for members <ul style="list-style-type: none"> Share best practice Ensure new / updated solutions meet your needs Support and networking <p><small>This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation</small></p>	<p>This is an example of Granta's oldest consortium with a focus on complex materials data.</p>
<p>EMIT Consortium</p> <p>Granta and the EMIT Consortium are working to embed eco design and compliance with environmental regulations into everyday engineering workflows</p> <div style="text-align: center;"> </div> <p><small>This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation</small></p>	<p>The EMIT consortium has been a main focus for our work on critical materials, eco design and restricted substances.</p>

<h3>AutoMATIC</h3> <ul style="list-style-type: none"> The Automotive Materials Intelligence Consortium ("AutoMATIC") To define, develop and share materials information technology related to best practices, data, and tools across the Automotive and Off-Highway Vehicle sectors in a pre-competitive environment To enable our members to implement this technology faster, and gain maximum return on investment, through collaboration, networking and shared experience  <p><small>This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation</small></p>	<p>And our automotive consortium is our most recent and deals with challenges that are specific to this industry.</p>
<h3>Granta for education</h3>  <p><small>This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation</small></p>	<p>We also collaborate extensively with the academic community, on the development of tools and education resources.</p>
<h3>Granta for education</h3>  <p><small>This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation</small></p>	<p>Our education package is used globally and the Materials Education Symposia bring together this community annually to discuss new advances in materials teaching.</p>
<h3>Granta Collaborative Projects</h3>  <p><small>This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation</small></p>	<p>Of course we also collaborate in projects at the UK and European levels, SusCritMat being one example.</p>
<h3>Collaborative Data Management</h3>  <p><small>This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation</small></p>	<p>Many of the projects listed on this page actually use our enterprise system during the project to share materials data between the partners. Being a web-based system, this increases the visibility of data during the project, enhances usability through agreeing consistent structures and meta-data and means that at the end of the project each partner can have a copy of all of the project data – not just the data they produced, as in normally the case. This significantly increases the chances of</p>

	<p>taking the project outputs to market afterwards.</p>
<p>Collaborative Data Management</p>  <p>The activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.</p>	<p>These are some of the examples of the types of data commonly managed by Granta in collaborative projects, increasingly we're shifting towards automated data import and greater levels of standardisation.</p>
<p>Example Project – Accelerated Metallurgy</p>  <p>28 partner EU project Project nearing completion</p> <p>Combines:</p> <ol style="list-style-type: none"> 1. Large scale computational exploration of new alloys (25,000+) 2. High throughput synthesis of new alloys – 1 every 20-30 seconds. 3. High throughput and distributed testing and characterisation <p>All data in a shared Granta MI database, a 'Virtual Alloy Library'</p> <ul style="list-style-type: none"> – Strong standardisation – All data linked appropriately and automatically – All data accessible by all partners – All compositions screened for risk as part of R&D <p>The activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.</p>	
<p>Example Project - HITEA</p>  <p>REACHing out for new materials</p> <ul style="list-style-type: none"> • Consortium of leading UK aerospace partners <ul style="list-style-type: none"> – Identification of substitutes to Hexavalent Chromium (REACH) • Distributed test programme <ul style="list-style-type: none"> – Shared burden, shared benefit – Strong standardisation activity – Significant high value data <p>All data collated and shared in Granta MI</p> <ul style="list-style-type: none"> – All coating systems screened against emerging legislation – Identifies candidate solutions known to be subject to risk <p>The activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.</p>	
<p>Questions / Discussion</p> <p>Thank you for your attention</p> <p>The activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.</p>	

3 Acknowledgements and Authors

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The following authors have contributed to prepare the complete teaching material kit and intend to provide an overview of major topics surrounding the sustainable management of critical raw materials:

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Besides, many others invested their time and expertise to discuss and review this teaching material.

4 Citation

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5 Disclaimer

The teaching materials within the SusCritMat project have been prepared with great care and experienced several revisions. Nevertheless, the consortium assumes no liability for the topicality, completeness and correctness of the content provided.

In case you have suggestions or other feedback how to improve the materials, we value your opinion: Please contact us via the project webpage <https://suscritmat.eu/contact/>.