WHITE PAPER

The Business Case for Material Intelligence

The impact of materials information on productivity, innovation, cost and risk in the engineering enterprise.

If your organization makes or designs products, it uses materials. Information about these materials is vital, often with multi-million-dollar impact. In other areas of product engineering, digital transformation is already highly embedded, i.e. technologies such as CAE, CAD and CAM, which are now "must haves" for every manufacturing enterprise. Software technology to manage and effectively apply materials information had lagged behind – but this is changing, rapidly.

In this document, we explore why this is, with materials information management increasingly establishing itself as a core engineering technology. This is because manufacturers, who have always understood the importance of making good materials decisions, are now recognizing the value of digital transformation to support those decisions. It is also because industry trends such as the digital twin, digital thread and Materials 4.0 are highlighting the need for this change. We outline significant industry trends and the associated challenges, both in the context of the wider product lifecycle, relevant to every manufacturer, and for specialist materials R&D and materials engineering organizations.

Stephen Warde, Arthur Fairfull

Delivering effective materials information management requires a systematic approach, supported by the right software. This must not only manage the diverse data sets required to define a material in an engineering business, but enable those data to be linked, shared, controlled and applied in a way that builds the material intelligence of the organization.

This is the goal of materials information management systems such as Ansys GRANTA MI™. Here we briefly discuss the use of such solutions and the business benefits they deliver across sectors including aerospace and defense, automotive, medical devices, and industrial and electrical equipment. We itemize sources of return on investment including faster time-to-market, reduced costs, lower business risks and product innovation that can drive market share and customer satisfaction.

We conclude with a checklist of issues you may want to consider in managing the materials information in your own business – whether you are considering this as a senior executive or as a manager of a technical function within the business.

/ Why materials information matters

Development organizations making a product consider three fundamentals: its shape, the materials from which it is made, and how it will be manufactured. In deciding on these factors, they aim to optimize a fourth factor: product function.

In today's engineering enterprises, software technology helps with each of these issues. Collectively, these enterprises make multi-billion-dollar investments [1] in computer-aided design (CAD) for shape, computer-aided manufacturing (CAM) to control manufacturing processes and computer-aided engineering (CAE) to optimize function. But investment in specialist information technology for materials had lagged behind.

Is this because materials decisions and the information required to make them, are relatively unimportant? Table 1 shows that this is not the case – materials information is central to critical product development questions, with significant commercial impact.

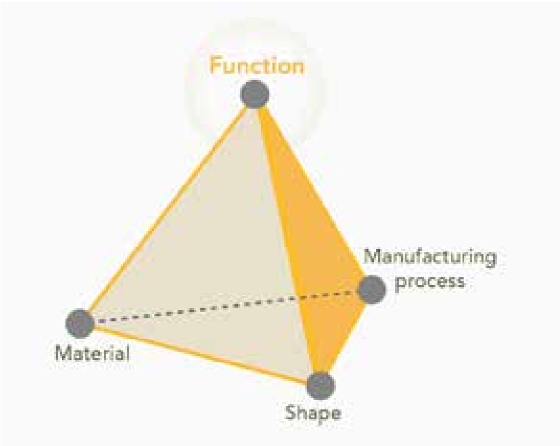


Figure 1. In product design we manipulate shape, process and material to create a desirable product with optimal function.

Question	Materials information requirements	Commercial impact
How to lightweight?	Structural and physical properties and cost and impact of alternative materials approaches (e.g., composites)	Competitive advantage
Can I increase the lifetime of a product in the field?	Latest test data and analysis of material performance in-product	Profitability
How do I avoid global manufacturing problems?	Properties of equivalent grades available in different geographical regions	Avoid disruption and cost
Could I deploy Additive Manufacturing?	Complete history of AM builds and testing to support qualification of new parts	Competitive advantage
Can we cut the number of warranty issues?	Consistent information across different departments and disciplines	Profitability and reputation
Are we exposed to restricted substance risk?	What regulations might impact this material?	Legal liability and reputation
Could I make this at lower cost? Or lower eco impact?	Engineering, environmental, and cost properties to enable evaluation of alternatives	Profitability, competitive advantage

Table 1. Examples of why materials information matters.

In this document, we explore the need for a systematic approach to materials information management, the challenges that enterprises have often struggled with in deploying effective strategies in this area and the trends that mean this is changing. We begin by looking at these issues from two perspectives: materials information technology required to support the product lifecycle across the enterprise (which applies to every manufacturing business) and the more focused requirements to support materials engineering and materials R&D (which applies to many, but not all, enterprises).

/ Enterprise-wide challenges and trends: Data complexity

Every manufacturing business uses materials information throughout its product design and development process, and beyond. As a material becomes attached to a product at the conceptual design stage, and the material and product evolve through their lifecycles, three things happen to complicate the management and use of information about that material.

1. Multiple data sets are attached to the material.

Engineers often focus on technical properties such as strength, toughness, or thermal response. To assemble and manage this data for a material is a difficult challenge requiring, for example, complex multi-dimensional mathematical models to describe properties for use in simulation. But, for a manufacturing enterprise to fully describe a material, also requires data on many other factors, such as aesthetics, regulatory compliance, cost, environmental properties, suppliers, alternative grades, and application history (Figure 2). This data is typically generated in many different places, and managed (if it is managed at all) in varied systems.

- Testing
- Characterization
- Statistical analysis
- Approved properties
- Certification
- Environmental impact

- Engineering properties
- Design allowable data
- CAE models
- Purchasing specs
- Aesthetics / rendering
- Preferred materials
- Restricted substances
- Environmental data

- Supplier specs
- Batch testing
- SPC data
- Comparison with specs
- Process improvement
- Equivalent grades
- Compliance information
- Process improvement

- Live in-service data
- Failure reports
- In-service testing
- Empirical knowledge
- Materials substitutions
- Aging data
- Recycling and disposal

Figure 2. Examples of material information across the product lifecycle

2. The definition of the material evolves.

For example, a conceptual designer may specify “a light, strong, durable plastic.” A generic type of plastic, such as ABS, is identified during embodiment design. Finally, a specific manufacturer’s grade of that plastic is chosen.

3. Materials property data have their own lifecycles.

Information on individual properties can develop over time, particularly for long-lived applications where the material is pushing performance envelopes, such as an airplane or power plant. This change is independent of the lifecycles of the products in which the material is used, but these two lifecycles need to be connected.

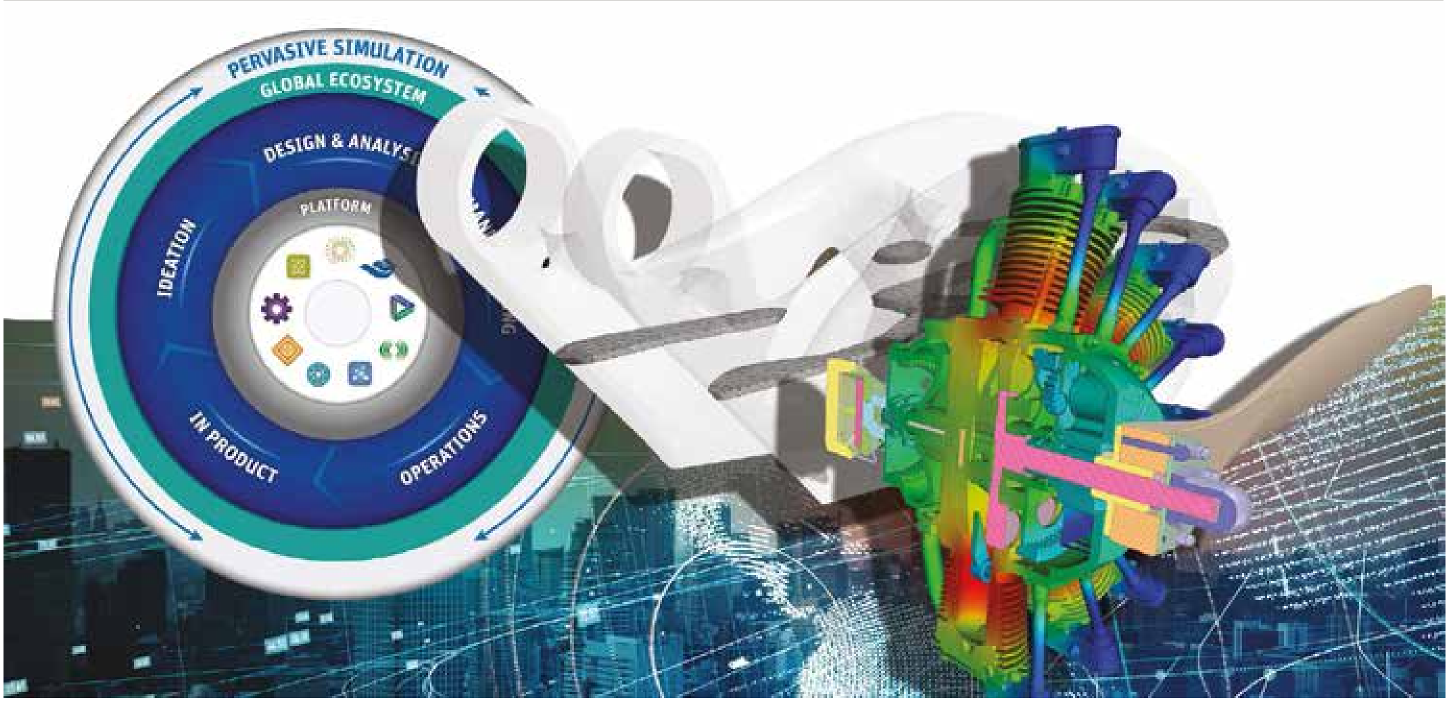
Adding further complexity, many manufacturing enterprises describe materials not in terms that a university engineering student would recognize, but as a material or process specification. These typically comprise a series of documents specifying characteristics such: as acceptable ranges of mechanical properties, processing steps, or surface treatments, as well as the type or types of material covered. A specification is usually met by many different purchasable materials.

/ Enterprise-wide challenges and trends: Business process challenges

Designers, engineers, or managers have requirements in applying materials information within their everyday workflows that may appear straightforward. They want to make the right material and product decisions based on reliable data and they want to be able to get that data quickly and reliably. But the context outlined above presents some real challenges in achieving this goal:

- How to get the right data, when and where it is needed. For example, how does a CAD or CAE user who is not a materials expert find the right input data for calculations without wasting substantial time or introducing risk of error?
- Enterprise-wide consistency. As materials definitions evolve and data is pulled from multiple sources, how can the organization ensure that a simulation analyst validating a material for a safety-critical application and a purchasing agent who later has to acquire a grade of that material are talking about the same material?
- Integration into business processes and systems. Managing materials information requires specialist tools, but these systems must not themselves become isolated ‘siloes’ of information. In particular, materials information must be managed in the context of the company’s Product Lifecycle Management (PLM) solutions.
- Minimizing business risk. Delivering the right materials data to the right place to drive innovation would be a win for any business. But how can this be done in a way that does not expose the business to competitive risks if access to valuable IP is not controlled? Or how can we avoid new risks relating to the materials themselves, such as introducing restricted substance compliance problems into a product due to missing materials risk information?

To be meaningful, both the digital twin and digital thread must fully represent the materials in your products.



/ Enterprise-wide challenges and trends: Key industry trends

These drivers should motivate a more systematic approach to materials information. If they do not, then some of the key trends in industry will soon change this. One is the move toward digital twins [2] – the concept that every physical asset has a complete digital representation throughout its lifecycle to support design and decision-making.

Similarly, organizations are considering the digital thread [3]: the capture and flow of data to ensure that everything to do with an asset can be traced throughout its lifecycle across traditional functional siloes. Initiatives in these areas are attracting multi-million-dollar investments, but organizations are still working out how to turn aspiration into reality. In a recent Accenture survey [4], 97% of aerospace & defense executives said they aim to use digital twins, but only 7% had fully integrated digital threads that impacted their strategy.

To be meaningful, both the digital twin and digital thread must fully represent the materials in your products and this, in turn, demands effective materials information management.

/ Materials R&D and Materials Engineering

Materials R&D and materials engineering cover a broad spectrum of activities, from "pure" R&D, exploring the development of wholly new materials systems, to program-driven materials characterization, testing, and analysis (Figure 3). There is particular emphasis on this work in sectors such as: aerospace and defense, characterizing and qualifying materials for high performance, safety-critical applications; energy and nuclear, monitoring and extending the life of materials in service; and medical devices, balancing functional, biocompatibility, and regulatory requirements. And, of course, the core business of materials producers is developing new polymers, metals and composites. If your organization does not have a materials R&D function, you may want to skip to the next section.

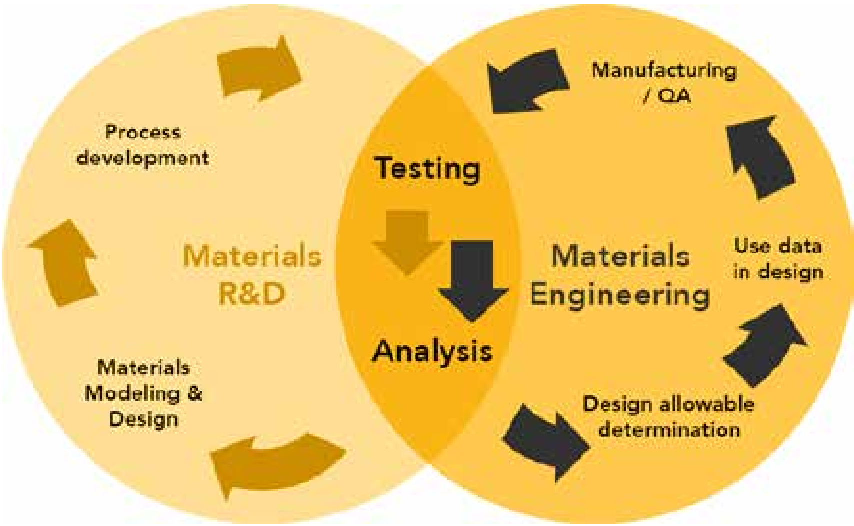


Figure 3.

Testing (whether in-house or by outsourced test houses) can generate huge quantities of data (e.g., qualifying a single composite for use on a new airliner can require tens of thousands of individual tests). This data must be analyzed, often in tandem with simulation methods, to drive insight. The ultimate target is typically to generate robust property values and process specifications that can be deployed for use in design. In the case of aerospace, this means generating statistically validated "design allowable" values.

Aerojet Rocketdyne	Fokker Aerostructures	Lawrence Livermore NL	Rolls-Royce
Airbus Helicopters	GE – Aviation	Lockheed Martin	SAFRAN
ASM International	GKN Aerospace	Los Alamos National Lab	Sandia National Labs
AWE	Honeywell Aerospace	NASA	Sulzer
Boeing	IHI Corporation	Northrop Grumman	United Technologies Corp
Embraer	Kansas City Plant	Raytheon	US Army Research Labs

Table 2. Members of the Material Data Management Consortium (MDMC) at date of publication

The Material Data Management Consortium [5] (Table 2) is an industry collaboration that has analyzed this workflow to identify best practice materials information management. Requirements include:

- A systematic approach to capture and link all of the data produced, from test through to design, enabling comprehensive and repeatable analysis that can generate vital insight.
- Management of the complex and specialist nature of much of this data, with its particular conventions, units, measurement techniques, and terminology. Multi-dimensional functional data or models are required to describe many properties: for example, the stress/strain properties of an alloy are captured as a mathematical model describing its likely behavior at different temperatures and loading conditions.

- The need to manage the materials data lifecycle, noted in the previous section.
- A focus on productivity: A Granta survey [6] established that 20% of materials tests are repeated unnecessarily, while engineers averaged 30 minutes daily just searching for data.
- Capturing knowledge (i.e., not just data but its full context and associated notes) for re-use, securing vital IP for use beyond the silos in which it is generated, and when key staff retire.
- The importance of traceability – these organizations want to be able to trace every design decision right back to the analysis that drove it, and the test results underlying that analysis.

Materials information technology is increasingly a prerequisite for effective materials R&D.

These are demanding requirements. A key reason why many organizations have yet to adopt a systematic materials information management approach is that they are hard to fulfil with generic data management solutions, such as PLM for example, because it is difficult to configure the data models of such systems to support complex property data.

The good news is that adoption of best practice materials information management has expanded dramatically over the past decade, with MDMC members as notable pioneers. Materials information technology is increasingly a prerequisite for effective materials R&D, and this is being further reinforced by some key current trends, detailed in Table 3.

What all these trends have in common is that they require organizations to bring together the physical and digital worlds. They can be viewed as the impact on the materials domain of Industry 4.0 – the so-called fourth industrial revolution, in which digital technology and physical products are becoming inseparable. We describe these trends as “Materials 4.0,” and any enterprise that depends upon materials performance needs to consider their implications.

Trend	What is it?	Implications
Additive Manufacturing	Innovative manufacturing methods enabling creation of parts based on a 3D digital model, usually building them layer-by-layer. Has transformative potential due to its to ability to deliver shapes and weight / performance combinations that could not previously be manufactured, and to create parts on-demand.	• AM projects generate large quantities of materials, machine, test, process, and other data. • Analysis and simulation using this data is essential to optimize property process relationships and bring products to market. • Traceability and context for data are critical, as AM performance
Composites and nantoechnology	The ability to preferentially align reinforcing components (most commonly fibers) within materials, and thus to give optimum performance with lighter weights. Incorporation of carbon nanotubes is the latest technology, providing enhanced conduction properties.	• Collation and processing of test data into “design allowables,” particularly to account for statistical variation in properties. • Collation of scientific databases on nanotube performance supporting modeling (see below) and test/simulation correlation.
ICME / Multiscale modeling	Integrated Computational Materials Engineering [7]. Use material and process simulation techniques at different length and time scales in combination with one another, and with experimental calibration and validation, to generate insight into material performance and design new materials systems.	• Must handle large quantities of complex output data from simulation runs and testing. • Combine this disparate data and enable easy comparison analysis. • Support (automated) workflows in which output of one method becomes input to the next.
Machine learning / artificial intelligence (AI) for materials	Computational methods for analyzing and applying data based on inferring patterns within the data itself. Applications to materials data could include error-detection, gap-filling, and property prediction, and cleaning ‘noisy’ data.	• Machine learning needs input data. • In particular, well-pedigreed training data sets are important to success. • AI can automate data processing and application if used as part of a systematic approach [8].

Table 3. Key Materials 4.0 trends and their trends for materials information technology

/ Typical response and business motivation

The challenges in digitalizing materials information are reflected in the experience of the real engineering enterprises with which we interact. Compared to other key business processes, such as those relating to people or finance (even to other aspects of product design and development), materials have lagged behind in their degree of digitalization, as illustrated in Figure 4. But the good news is that it is catching up, and enterprise-wide projects to manage materials information are now commonplace. These projects avoid materials information existing as a disconnected "island" and are changing the historic approach in which materials data tended to reside in Excel spreadsheets, fileshares, or document stores, with no connections made between the many different data sets that make up the full description of one material.

Figure 4. The Materials sector has lagged behind, but is catching up.

A fundamental motivation for this change is the cost associated with uncontrolled data management. This begins with apparently simple productivity issues, which are well-documented and by no means unique to the materials domain. An Arthur D. Little report [9] states, "Up to 80% of the work done in an engineering department is identical or very similar to work done previously." The analyst firm IDC estimated [10] that an enterprise employing one thousand knowledge workers wasted nearly $2.5m per year simply due to an inability to locate and retrieve information. Table 4 highlights how these, and other more domain-specific issues, might impact a business that fails to manage materials information effectively.

Other factors are also contributing to a more compelling need for systematic materials information management:

- Digital transformation trends are increasing digital twin and digital thread.
- The quantities and importance of materials information are growing, in some cases exponentially.
- Digitalization strategies in companies have proven themselves in more tractable areas, and organizations are looking to apply the same logic to the next set of critical business problems.

Example issue	Impact	Typical cost / risk
Inconsistent materials definitions in different parts of the business	Failed design iteration: extra design cycle needed	$ millions
20% of materials tests are unnecessary duplications of previous work	Wasted time and effort	$ hundreds of thousands
Productivity: time spent searching for or correcting data	Delay and cost in materials engineering	$ hundreds of thousands
Adding a material with a restricted substance risk to a product design	Disruption to product supply or product recall	Legal penalties or reputational damage
Proliferation of different materials and suppliers	Missed opportunities for purchasing efficiencies	$ millions
Incorrect or inconsistent data used in simulation	Wrong simulation results	Reduce ROI on simulation investment
Wrong material grade used in manufacturing	Quality or warranty issues	Multimillion $ and potential liabilities

Table 4. Typical costs and risks due to uncontrolled materials information

/ The alternative: systematic approach to achieving material intelligence

The most effective response is to implement a specialist system for managing materials information. Ideally, this should extend to as many of the processes and data sets relating to the company's materials as possible, creating a single "gold source" for all relevant information that can be accessed whenever and wherever it is needed throughout the enterprise. The concept of such a system is illustrated in Figure 5 [11].

Whatever technology is selected, it is important to meet the following criteria:

- Information technology alone is not enough. It needs to be accompanied by a systematic approach to capturing, curating, and sharing materials information, with the right processes and people in place to ensure that this happens. Using a system provider with strong implementation experience is a good approach.
- Any system must have at its heart database tools and data structures that can handle the complexity of materials data, while retaining flexibility so that it can be adapted to the information environment of any given enterprise.
- It is vital that the system has strong integration capabilities with other business and product development software and systems: notably CAD, CAE, and PLM. This integration must work across the multiple solutions from different vendors in use at most engineering enterprises.
- Control is important. Change management and version control tools must manage data as it evolves, and access control must ensure that users see role-appropriate data that they are authorized to see.

The aim is to develop "material intelligence": a rich resource of data, information and experience that can help to drive business success.

The goal is not merely to handle data more efficiently or to use it more consistently, although these are important benefits of the system. A materials information management system connects data across the enterprise, enabling more informed analysis. It supports tools to perform this analysis, generating useful information from data. And, as that information, available in its full context, is applied to make decisions, it captures the resulting experience so that it can be re-used in the future. The aim is to develop "material intelligence" – a rich resource of data, information and experience that can help to drive business success. The next section provides some examples of this success.

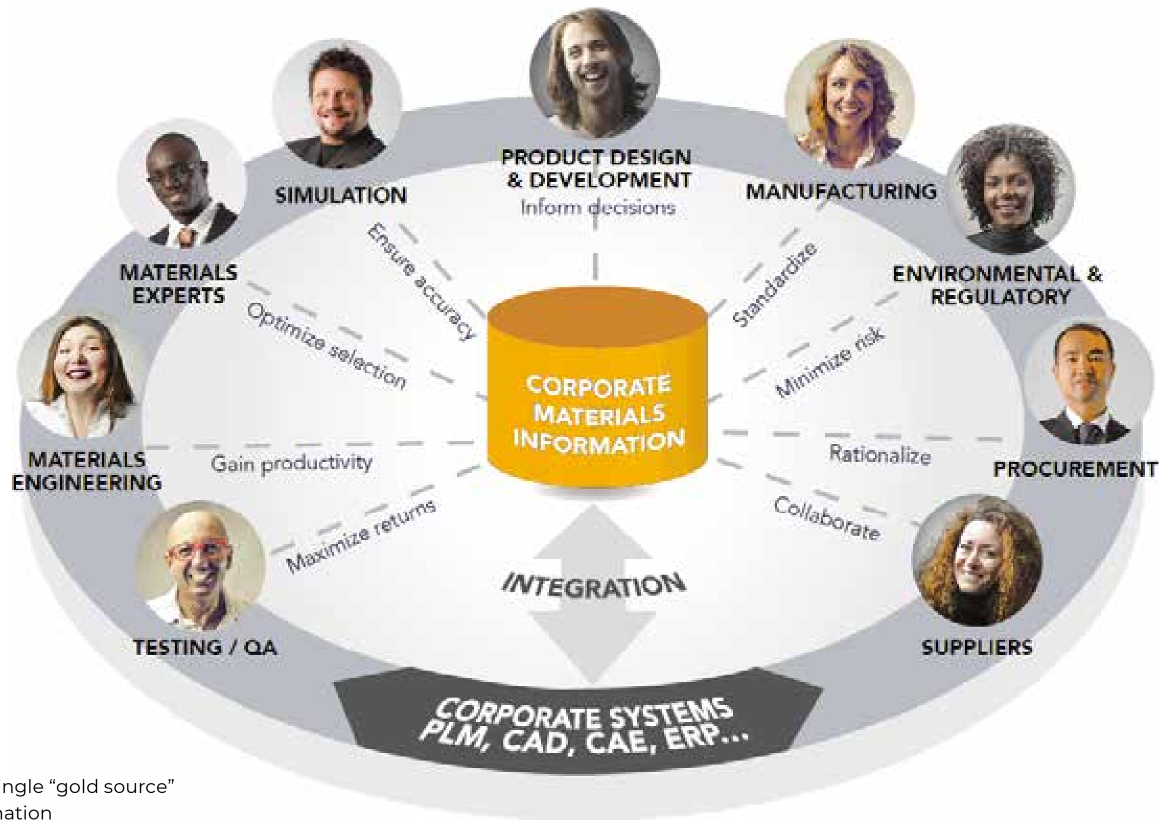


Figure 5. Enterprises need a single "gold source" for corporate materials information

/ Case studies: Materials engineering in the aero engine sector

Chief of Materials Design Services, David Cross, and Project Lead, Amandeep Mhay, from Rolls-Royce discuss the company's project to manage materials information in a systematic way using the GRANTA MI system in a video that can be viewed on the Ansys website. [12]

This is one example in a sector where materials information management has been widely adopted. What does a typical project look like? Key challenges are large quantities of legacy data scattered across disparate sources, and the need to manage complex workflows to capture, analyze and use new data generated by testing, QA and research. Tests are duplicated – a Granta survey found 40% of all generated test data was not re-used after initial analysis, although in many cases it may have had applications in other projects. When every data point costs thousands of dollars, this represents a large expense.

Another key issue is traceability – the objective of ensuring that the pedigree of every material and the data behind every decision is easily available. Having fast, reliable access to all relevant materials information is also important for engineers who need accurate and statistically valid property data as they seek to push materials to their limits in a highly regulated, safety critical environment.

Typical annual savings from an enterprise project are $10 million.

Systematic materials information management programs in the sector focus on building a "single source of the materials truth" – capturing and linking test data, the statistical roll-up and analysis of that data, and the resulting design allowable property values. This design data is published in a controlled way, often to thousands of engineers. Organizations have quoted annual savings in excess of $10 million by ensuring that data is consistent, accurate, and accessible by the authorized people who need it. Costs are avoided, errors are reduced and more value is extracted from legacy data.

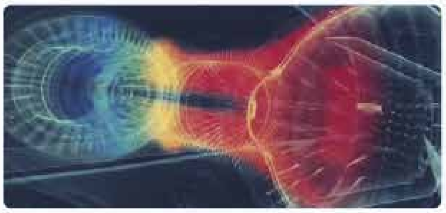


Figure 6. Watch a video summary of the Rolls-Royce story at ansys.com/materials/rr

/ Case studies: Additive manufacturing at EWI

At a web seminar [13] hosted by IEEE Globalspec, Alex Kitt, Product Manager at EWI, described the organization's use of GRANTA MI to facilitate best practices in managing and using Additive Manufacturing (AM) data. Challenges included:

- Making best use of many sources of linked data (e.g., from powder characterization, builds, and mechanical testing).
- The need to share pedigreed data with a range of customers and partners.
- The range of project/program types and goals.

Given the complexity of the data involved, these are tough requirements to meet. But collaboration cannot proceed unless project members can reliably share data and know that they have a complete and accurate picture of project results and analyses.

"The pedigree of AM data is becoming more important," explained Alex Kitt. "We needed to progress from our past state, where most of our data outputs were Excel sheets, to a mature data handling world." To meet these challenges, EWI implemented a materials information management system. Key to success was use of a best practice Additive Manufacturing 'Schema' [14] (Figure 7) – the database structure which helps to identify which data to capture, and how.

The system has been deployed on its first project – an 'America Makes' program studying the mechanical performance debit in L-PBF processes with thin walls with narrow flow channels. The aim of the program is to understand the cost/benefit of HIPP treatment and finishing. These are questions where a response must be very data-driven and consider the full pedigree of mechanical testing data that is the end-result of the experimental work.

Data that might otherwise have been lost was retained so that it could be fully utilized later.

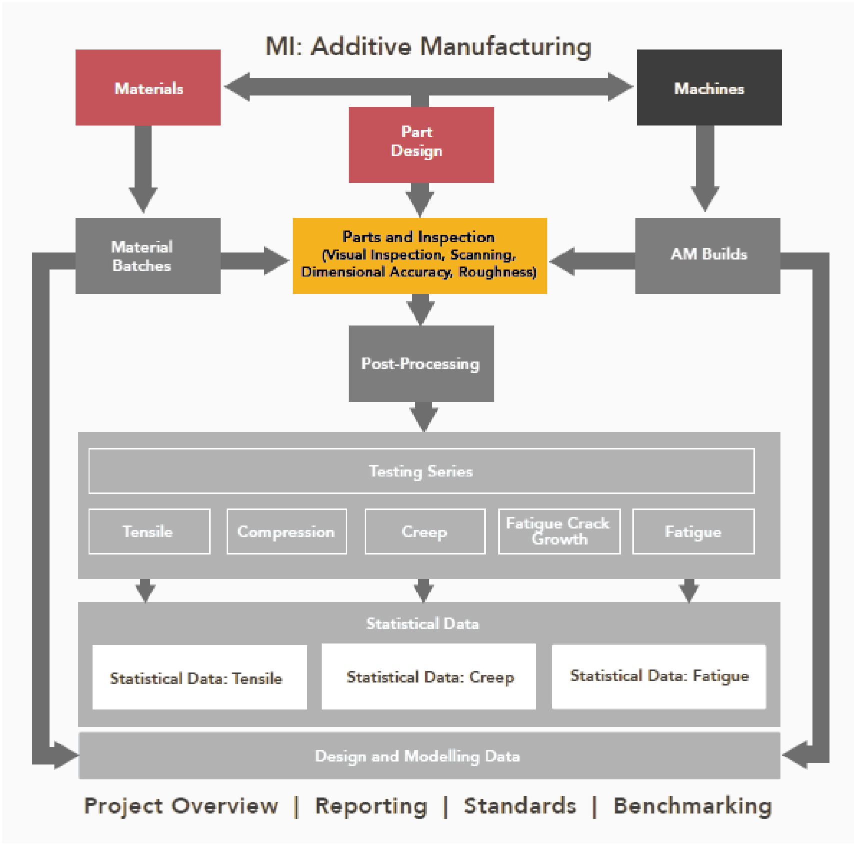


Figure 7: A key element in successful data management for AM is the right schema: the data structures that ensure capture and traceability of data with their its inter-relationships.

/ Case studies: Support for simulation

Simulation is an increasingly standard component of the product development process. But good simulation is not possible without good data and, in particular, good materials data. Engineering organizations need to find this data or to derive it from test data. This derivation can be complex, requiring analysis of large volumes of test data in order to provide a strong statistical basis for properties across the full range of relevant conditions, followed by manipulation of the results to generate the parameters and coefficients that populate the materials cards recognized by CAE software.

The project delivered a return on investment by taking out a lot of inefficient work activities in the product engineering community.

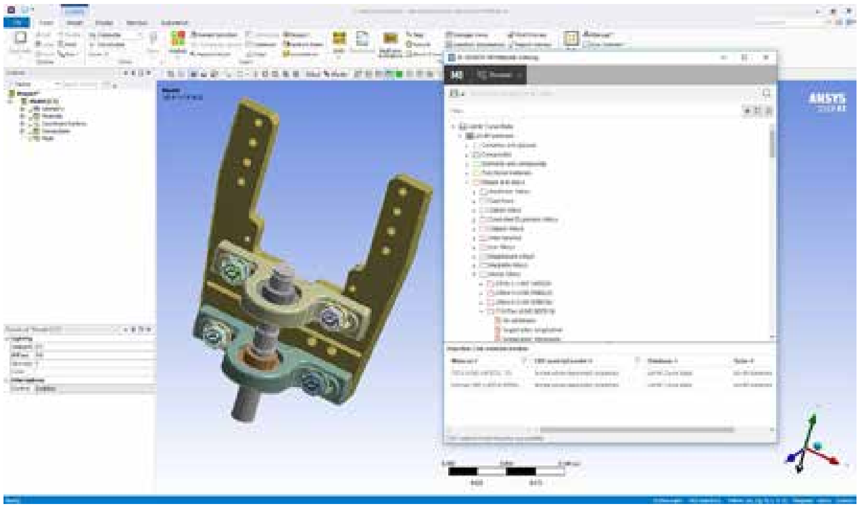


Figure 8. One key to effective materials data support for simulation is providing easy access to the data from within the simulation environment, as illustrated here.

We need tools to make this process efficient and avoid error. It is important to perform these tasks in a systematic, managed way, so that we can avoid the need to repeat analyses, and so that simulation inputs can be easily traced to their source. Once the best possible simulation data is available, it will not be used unless it is made available to the simulation analysts that need it in a manner that ensures they can access it quickly and easily.

This need has been recognized by organizations in varied sectors – in one webinar [15] an electronic and electrical component maker discussed how it deployed a materials information management system to support a community of 1,400+ engineers with data, including input data for computer aided engineering (CAE). The results have been greater integrity in capturing and storing data, and in presenting that data to internal customers. The project delivered a return on investment by taking out a lot of inefficient work activities in the product engineering community.

Similar motivations were in play at major Automotive OEM PSA Peugeot Citroën, which discussed its implementation of materials information management to support simulation in a 2016 press release issued by Granta Design [16].

/ Case studies: Avoiding regulatory risk

Regulatory risks are a major concern for today's manufacturers. A prominent source of such risk are restricted substance regulations, such as the European Union's REACH regulation [17] or the US TCSA [18]. The presence of impacted substances in your products or associated processes can result in production interruptions as materials become obsolete; higher costs; or, in the worst cases, product withdrawals, legal liabilities and reputational damage.

For the first time, all the vital linkages between data were recorded in one place.

Forward-looking organizations want to avoid this risk and are concluding that, since such risks are usually introduced to products through materials and process decisions, the best route to achieve this lies through effective materials information management. In one example, a major aerospace OEM looked for a way to connect and analyze its data on materials, specifications, regulations, and parts – something described as a "a laborious and costly process when you consider the mountains of data."

The solution was to build a centralized hub of materials knowledge, allowing restricted substance information to be fully integrated with other materials information. For the first time, this provided all the linkages in one place. An example of the benefits was provided when an analysis undertaken prior to implementing the system was repeated using the new system. The first attempt occupied 11 people over 14 hours and found two specifications that used an at-risk chemical. With the new system, one person took 20 minutes to find six impacted specifications – a substantial productivity saving but, more importantly, a more comprehensive assessment that will remove risk from the development process.

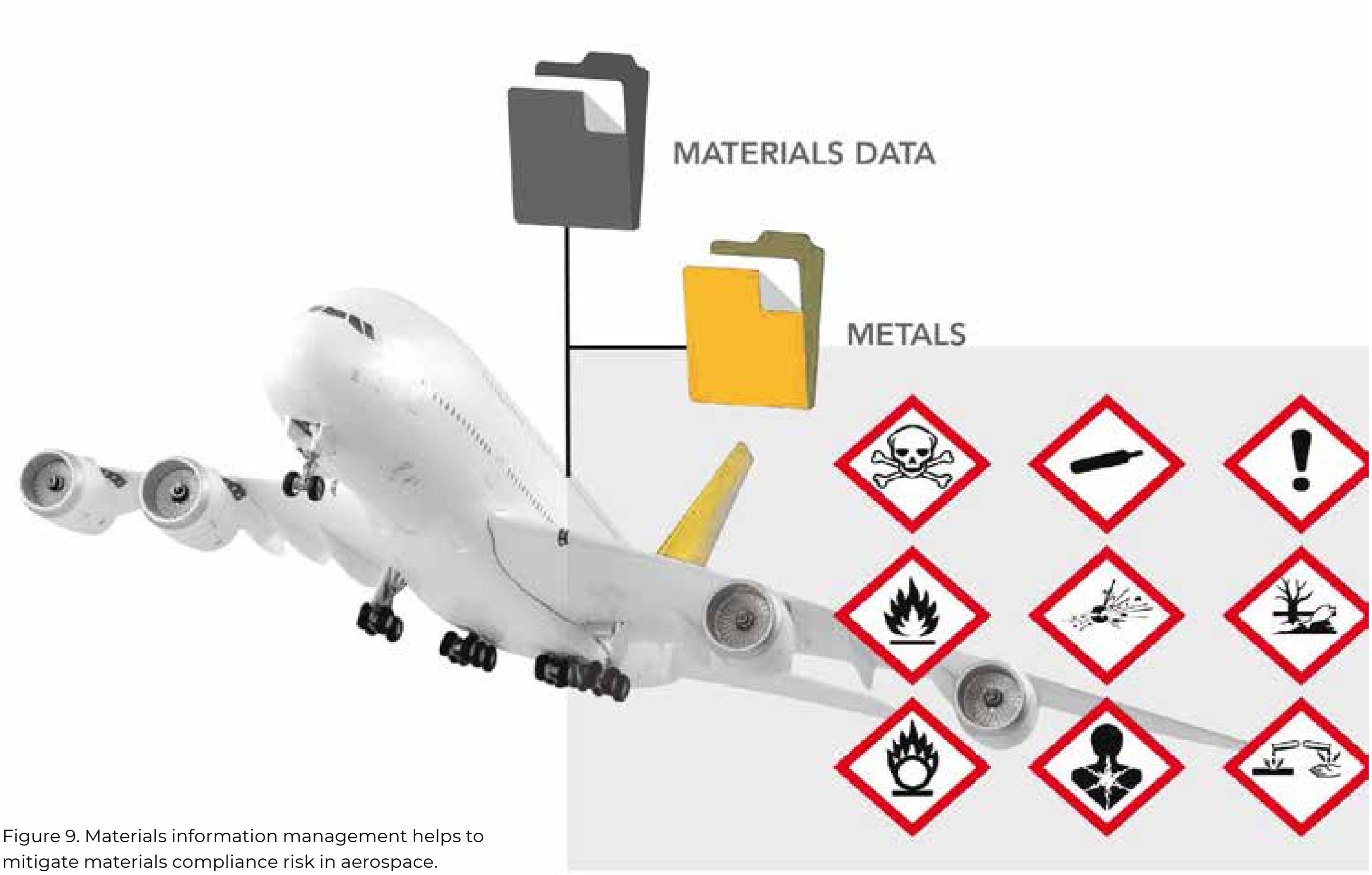


Figure 9. Materials information management helps to mitigate materials compliance risk in aerospace.

/ Case studies: Enterprise-wide consistency and efficiency

Finally, two examples demonstrate the business benefits of creating a single 'gold source' of company materials information that can be accessed across theenterprise.

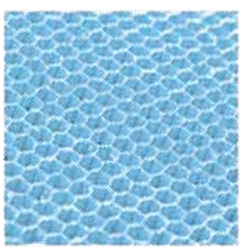
A major automotive OEM aimed to address the situation in which a "material" means a different thing to different people. The team had to develop a harmonized definition, or "materials call-out." They analyzed how materials touch processes from design concept, through materials selection and sourcing, to production and beyond. Many different tools were used to handle materials information through this process — over a dozen in the case of plastics. These tools often did not talk to one another. The data structures used also made it hard to share materials data across product lines and geographical regions. They designed a system based around just two tools—a materials information management system which "authors" data into the second key tool, their PLM system. Within PLM, this data can be consumed by a diverse audience ranging from engineers to purchasing staff to lawyers. The motivation is consistency – ensuring, for example, that a CAE person and a welding engineer use the same version of the steel, leading to less rework, better products, no product recalls and fewer warranty issues.

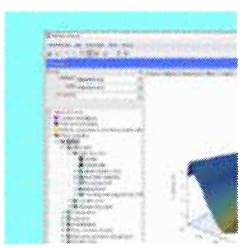
An engineer saved around $200k and 22-26 weeks of testing.

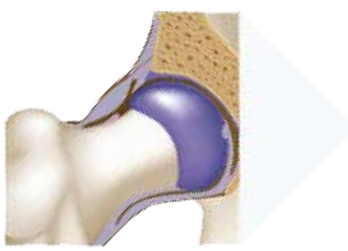
A medical device manufacturer decided to centralize its materials information in a searchable database. The key to success was to regard the project not just as an IT solution, but as a combination of the technical element and the customer interface. Making a system that was easy to navigate and query through a web interface led, in one example, to an engineer being able to access a material analysis completed a decade earlier that saved around $200k and the 22–26 weeks it would have taken to test the affected component to meet standards.

Another use case is when doctors need to check whether a device used in a medical procedure contains latex to avoid severe allergic reactions. The company can now respond within a few minutes of that request to say the product doesn't have latex and the doctors can proceed.

Using the same version of the steel leads to less rework, better products, no product recalls and fewer warranty issues.







/ Checklist: your next steps toward "material intelligence"

Do you need to review your materials information management strategy?

Here are some questions to consider:

Your focus	Ask yourself...	Next steps
Corporate digital transformation	• Are materials a significant cost? • Are materials critical to product success? • Do you have a strategy to manage and use IP for materials, as you do in other areas?	Ensure materials are part of your IT strategy. Brief your team to identify solutions that handle specialist materials requirements but integrate with wider IT infrastructure.
Engineering productivity	• Does your organization own significant amounts of materials data? • Do accuracy, traceability, or consistency in design or simulation matter? • Do you know what materials information best practice is for peer organizations?	An audit of your materials information environment is a good start. For example, Ansys can conduct a standard Material Intelligence Survey.
Corporate PLM and similar strategic initiatives	• Do you have an active PLM or similar project? How are you handling materials? • How do you connect and manage all the different materials datasets across your organization? • What compliance or quality risks might be associated with your materials data?	Ensure materials data is considered in your business process and PLM strategy. Read our separate white paper: "Material Intelligence for CAD, PLM, and Industry 4.0."
Materials engineering, testing, qualification	• Are you paying for thousands of materials tests each year? Do you ever duplicate these? • Are you making efficient, effective use of all the materials data you possibly could? • Are the results of your work used effectively by your organization?	Find out what peer organizations are doing, e.g., MDMC members. "Off-the-shelf" software solutions are now well-established to meet these challenges.
Additive manufacturing	• Are you aiming to optimize / qualify new AM processes? • Do you know what data to capture? • Are you trying to better understand property / process relationships?	A first step is to understand what data you might need to capture. The Ansys AM Data Schema document might help. Contact us for a copy.
Simulation	• Where do your analysts get materials data? • Are you confident that they are using consistent, accurate, traceable data? • Is time wasted looking for or correcting data?	Ensure your analysts are using one, consistent data source. If determining models via in-house analysis, audit how that data is deployed and whether it is traceable to its source.
Materials decision-making or assignment	• Are you confident that everyone in your development process is defining materials consistently? What are the risks if they don't? • Do you ever waste time finding or correcting materials information or assignments?	Map your process to understand where materials are assigned. If definitions come from more than one source, could these be consolidated? Can you eliminate any manual transcription of data?
Restricted substances	• Are you subject to legislation like REACH? • How do you avoid introducing risk from your supply chain or development decisions? • What costs or delays are possible if a restricted substance issue arises?	Consider an information system to manage these risks for materials, substances, and specifications. How will it support reporting and analysis when you have incomplete declarations from suppliers?

/ Summary - return on investment

Table 6 summarizes the returns from materials information technology discussed in this paper.

Of course, these returns are only examples. The ROI that any given enterprise can expect will depend on which of the issues described (or the many other issues that materials information can impact) are relevant, and the specifics of the company or project impacted – its size, the materials types used, the nature of products, and so on. We saw in the aero engine example how the combination of some of the materials engineering, innovation, and enterprise-wide efficiency items can sum to multi-million dollar benefits. The scale of those benefits will be larger for a larger enterprise implementing an enterprise project, and smaller (though still significant) for a group-scale project tackling just one of the issues listed.

We invite you to use the ideas outlined in this paper to consider the potential returns for materials information technology in your organization.

	Example sources of return	Typical benefit
Engineering productivity	Eliminate 40% of tests that repeated previous work	$2m in annual costs avoided
	Effective transfer of knowledge to new Tech Center increases R&D team efficiency by 1%	$2m in annual productivity
Innovation	AM product gets to market 3 months sooner	$5m product revenue
	AM product gets to market 3 months sooner	$1m annual production costs
Simulation	Use approved data every time – avoid need to repeat a design iteration owing to inaccurate simulation	$1m direct costs and costs due to project delay
	1,000+ engineers save 20 mins per week currently spent looking for data	$1m in time saved
Regulatory risk – restricted substances	Accurate understanding of supplier declarations avoids 1 month delay on key customer project	$3m revenue
	Spot that a key material will become obsolete under a proposed regulatory update	$10m cost avoided in delay and redesign
Enterprise-wide consistency and efficiency	Consistent naming avoids one quality problem per year due to procurement of wrong material	$2m annual cost savings
	Save 0.1% of materials costs by using fewer different materials across multiple products	$5m annual cost savings
	Ensure traceability of all design decisions, enabling fast response to materials issues	Protect tens of $millions in brand value

Table 6. Typical return on investment from best practice materials information technology.

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