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MI

The Business Case for **Material Intelligence**

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

Stephen Warde, Arthur Fairfull

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Executive Summary

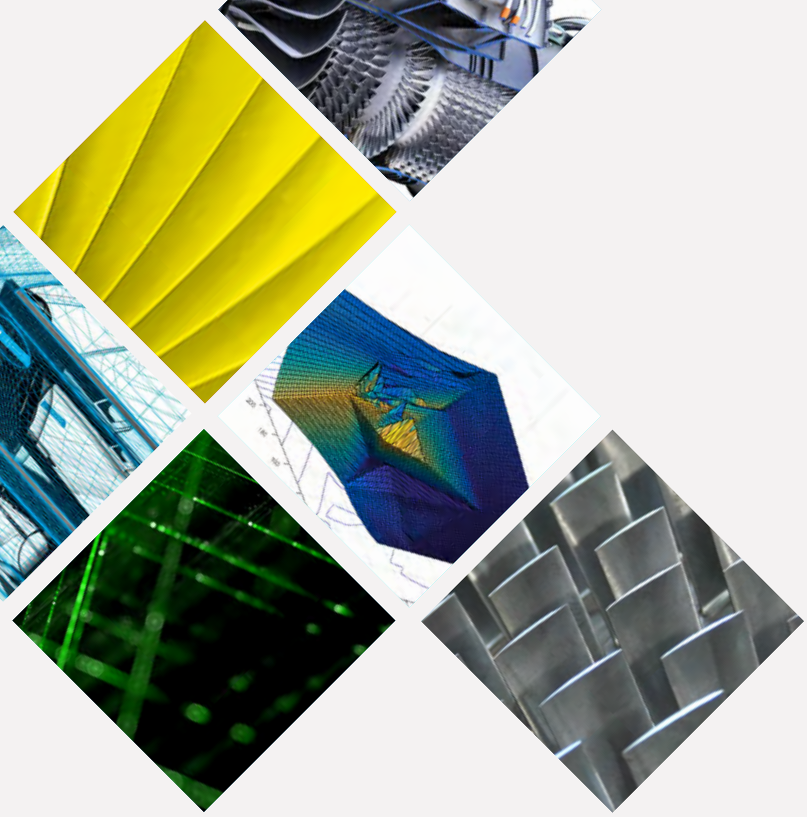
If your organization makes or designs products, it uses **materials**. **Information** about these materials is vital, often with multi-million dollar impact. In other areas of product engineering, **digital transformation** is already highly embedded, for example, via technologies such as CAE, CAD, 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 white paper, 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.

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 the **GRANTA MI**™ software, and we outline a series of case studies of the use of GRANTA MI and the business benefits that it delivers 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 manager of a technical function within the business.



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1. 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.

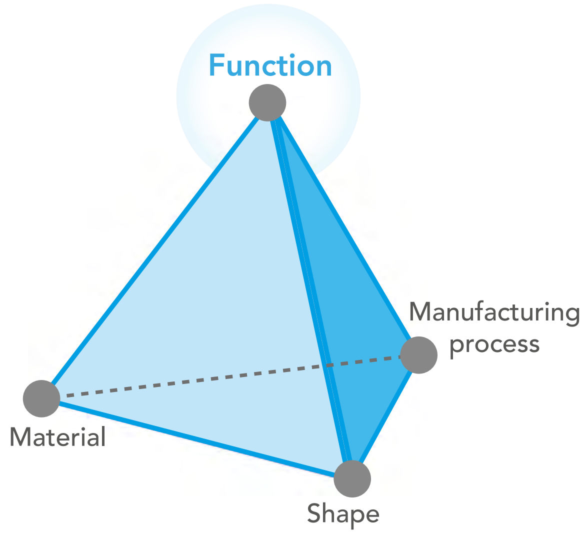


Figure 1. *In product design we manipulate shape, process, and material to create a desirable product with optimal function.*

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

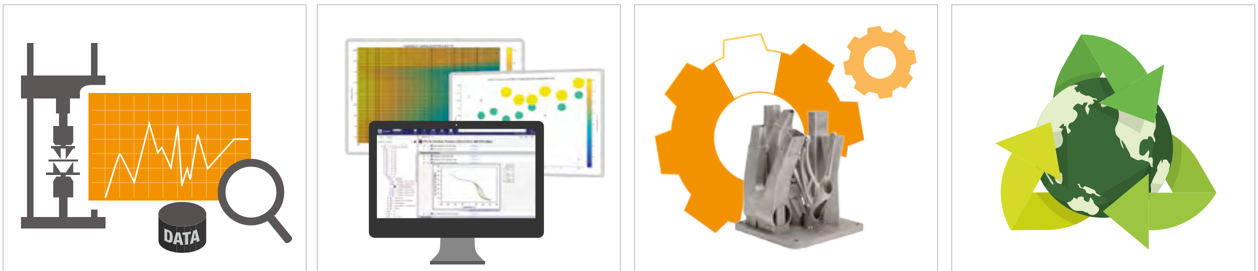
Table 1. *Examples of why materials information matters.*

In this white paper, 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).

2. Enterprise-wide challenges and trends

2.1 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 then the material and product evolve through their lifecycles, three things happen to complicate the management and use of information about that material.



RESEARCH	DESIGN & SIMULATION	PRODUCTION	IN-SERVICE & END-OF-LIFE
Materials R&D	Decision support data	Materials Q&A	Materials Performance
• Testing	• Engineering properties	• Supplier specs	• Live in-service data
• Characterization	• Design allowable data	• Batch testing	• Failure reports
• Statistical analysis	• CAE models	• SPC data	• In-service testing
• Approved properties	• Purchasing specs	• Comparison with specs	• Empirical knowledge
• Certification	• Aesthetics / rendering	• Process improvement	• Materials substitutions
• Environmental impact	• Preferred materials	• Equivalent grades	• Aging data
	• Restricted substances	• Compliance information	• Recycling and disposal
	• Environmental data	• Process improvement	

Figure 2. *Examples of materials information across the product lifecycle*

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: e.g., 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.

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 materials 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.

2.2 Business process challenges

Designers, engineers, or managers have requirements in applying materials information within their everyday workflows that may appear straightforward. They just 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 create new risks relating to the materials themselves, such as introducing restricted substance compliance problems into a product due to missing materials risk information?

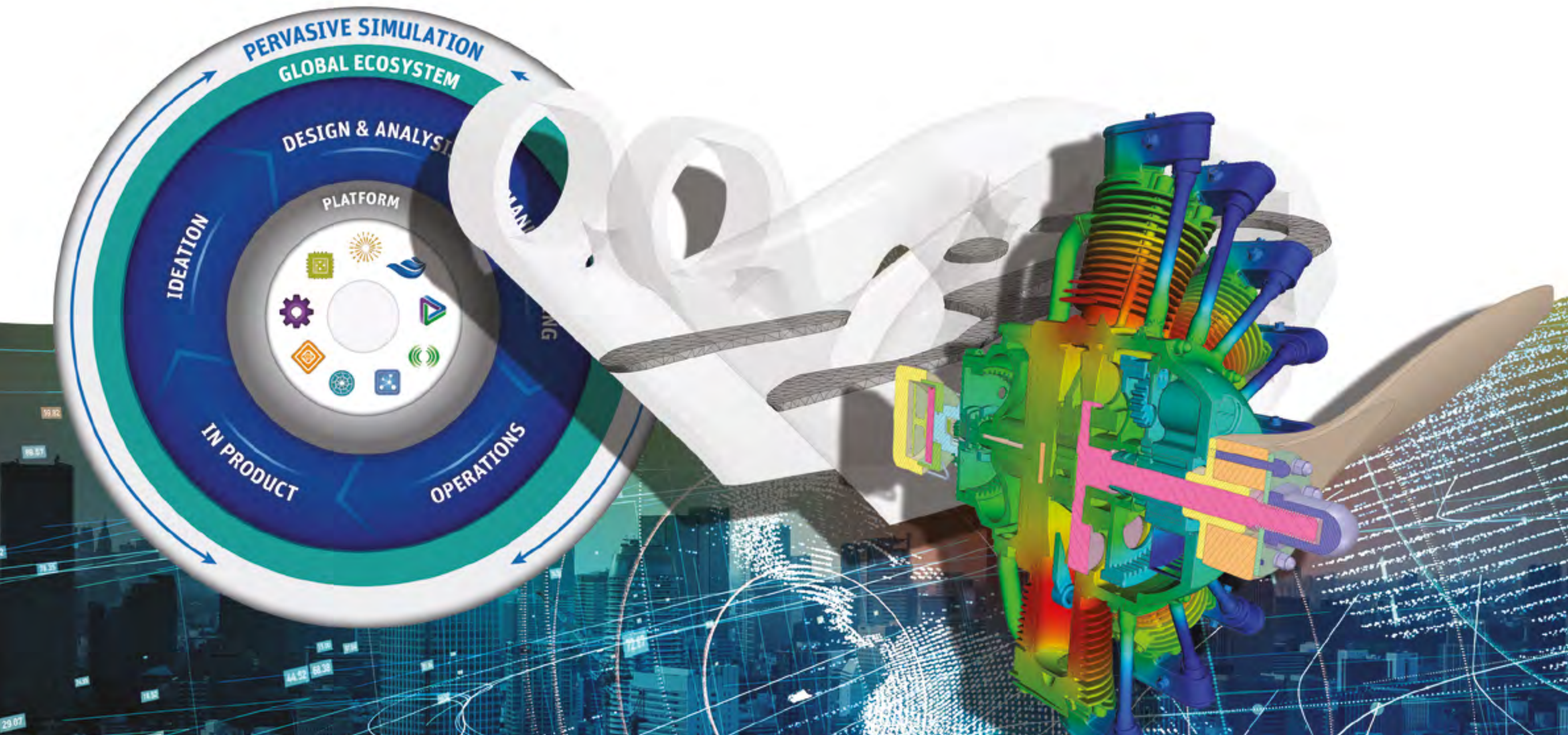
> To be meaningful, both the Digital Twin and Digital Thread must fully represent the materials in your products

2.3 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 towards **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.



3. Materials R&D and Materials Engineering

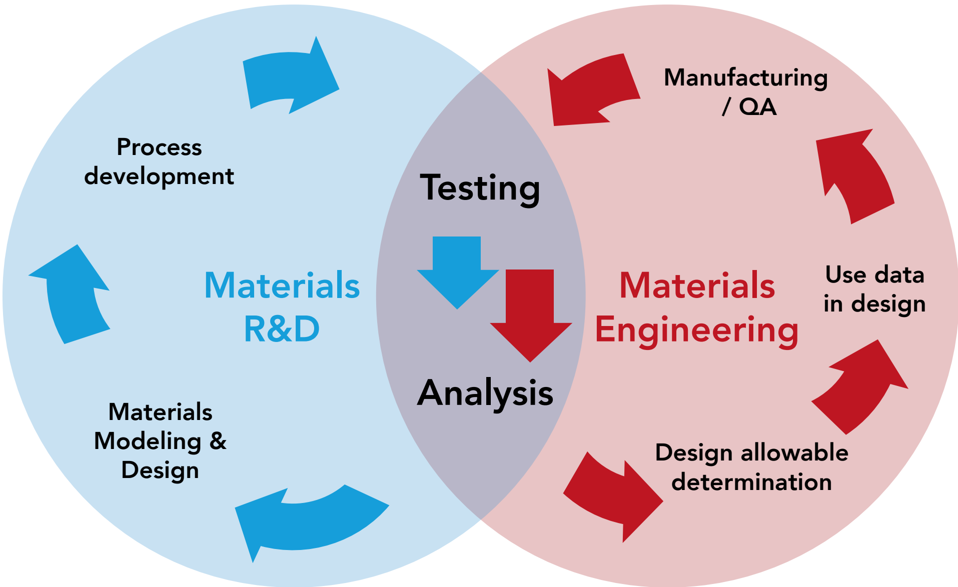


Figure 3

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 highly 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.

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.

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.

- The system must manage 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,

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*

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 organization want to be able to trace every design decision right back to the analysis that drove it, and the test results underlying that analysis.

These are demanding requirements, and 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 pre-requisite for effective Materials R&D, and this is being further reinforced by some key current trends, detailed in Table 3.

> Materials information technology is increasingly a pre-requisite for effective Materials R&D

What all of 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. At ANSYS Granta, 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 is highly process and application-specific
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*

4. 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 had lagged behind in its 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.

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.

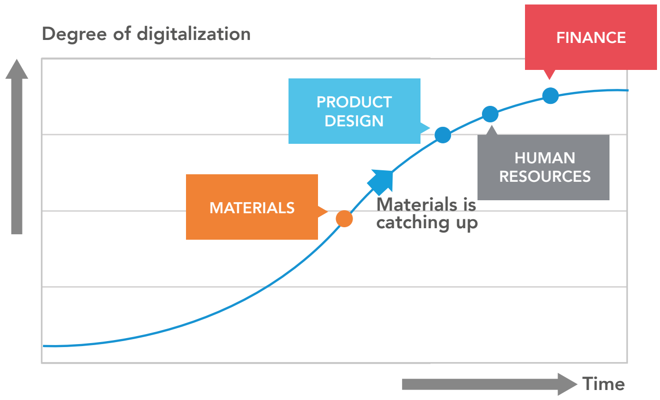


Figure 4. *Materials has lagged behind, but is catching up*

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

- Digital transformation trends such as 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	Miss 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	Multi-million $s and potential liabilities

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

5. A systematic approach with GRANTA MI

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 leading such system is the GRANTA MI software [11], illustrated in Figure 5.

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 real engineering enterprises.

> GRANTA MI delivers 'material intelligence' – a rich resource of data, information, and experience that can help to drive business success

- **Control** is important: change management and version control tools to manage data as it evolves, and access control to ensure that users see role-appropriate data that they are authorized to see.

The goal is not merely to handle data more efficiently or to use it more consistently, although these are important benefits of the system. GRANTA MI 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 future. The aim with GRANTA MI 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.

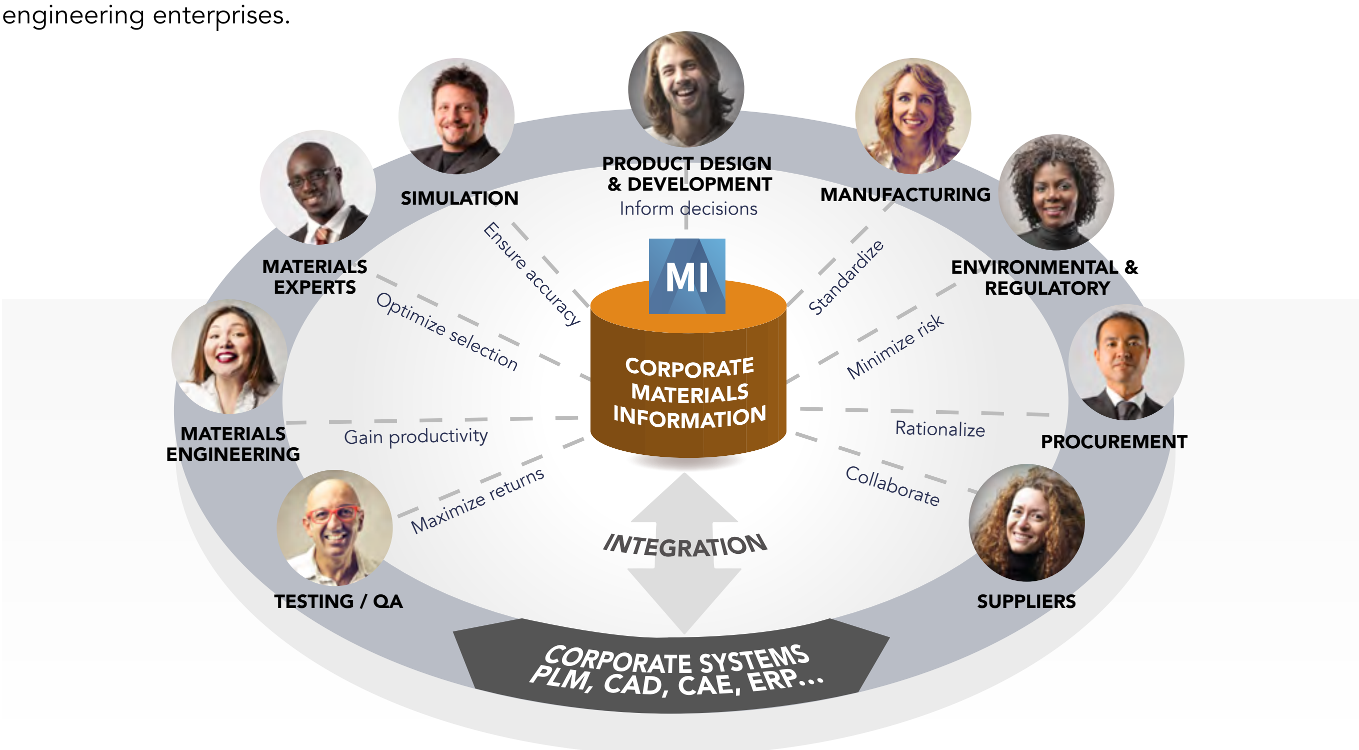


Figure 5. *GRANTA MI creates a single 'gold source' for corporate materials information*

6. Case studies

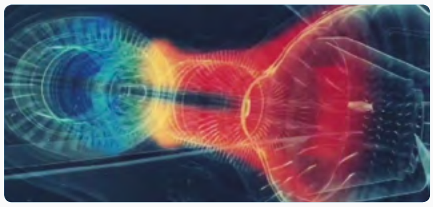
6.1 Materials Engineering – Rolls-Royce

Leading aerospace engine manufacturer Rolls-Royce has certified £6.9m of annual savings due to the materials information project supported by GRANTA MI. [12]

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.

Rolls-Royce responded with a systematic program that has now been running for more than 10 years. GRANTA MI provides a 'single source of truth' for verified materials information to over 2,000 engineers.

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



Rolls-Royce faced challenges including large quantities of legacy data scattered across disparate sources, and the management of complex workflows to capture, analyze, and use new data generated by testing, QA, and research. Without a systematic approach, tests were duplicated and 40% of all generated test data was not re-used after initial analysis, although in many cases it may have had applications on other projects. As project leader Amandeep Mhay points out, when "every data point costs thousands of pounds", this represents a large expense.

Another key issue was traceability – the objective of ensuring that the pedigree of every material and the data behind every engineering decision was easily available. Having fast, reliable access to all relevant materials information is also important for Rolls-Royce

> Rolls-Royce has certified £6.9m of annual savings due to the materials information project

It maximizes the value of that data by ensuring that it is consistent, accurate, and accessible by the authorized people who need it, when they need it. Costs are avoided, errors are reduced, more value is extracted from legacy data, version-controlled data becomes fully traceable, and Rolls-Royce engineers have fast access to reliable inputs for design and simulation.

6.2 Innovation with Additive Manufacturing – AMAZE Project

Additive Manufacturing (AM) initiatives are proliferating within and between manufacturing organizations, seeking to realize the full potential of this exciting technology. Key to success is understanding the subtle ways in which factors including feedstock properties, build parameters, machine variability, operating conditions, and part geometry combine to influence the properties and reliability of the final AM parts. Development teams must organize, combine, and analyze large amounts of data from materials suppliers, the build process, materials testing, and simulation – often in parallel with learning which data they need to focus on, and why.

One project that addressed these challenges was AMAZE [13] (Additive Manufacturing Aiming Towards Zero Waste & Efficient Production of HighTech Metal Products). This major international collaborative project, funded by the European Union Framework 7 program, involved partners such as Airbus Defense and Space, Avio, BAE Systems, Bombardier, Concept Laser, Cranfield University, the Manufacturing Technology Centre, Norsk Titanium, Renishaw, and Volvo. It aimed to cut the cost of producing high- tech metal products and to almost eliminate waste from the process.

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

The project recognized the need to address the data management challenge, and so deployed the GRANTA MI software. This enabled partners to pool materials data and to create a single go-to source of knowledge on materials, processes, and properties for process refinement and coordination. The database captured project data from materials procurement, manufacturing, inspection and testing. Data that might otherwise have been lost was retained so that it could be fully-utilized later, supporting valuable insights and saving time. Experience gained in this demanding project informed the development of data structures (a so-called 'schema') to identify, link, and store the key types of information required in AM projects (Figure 7). This schema has been further developed and is now commercially available as a GRANTA MI component for use by any AM project. [14]

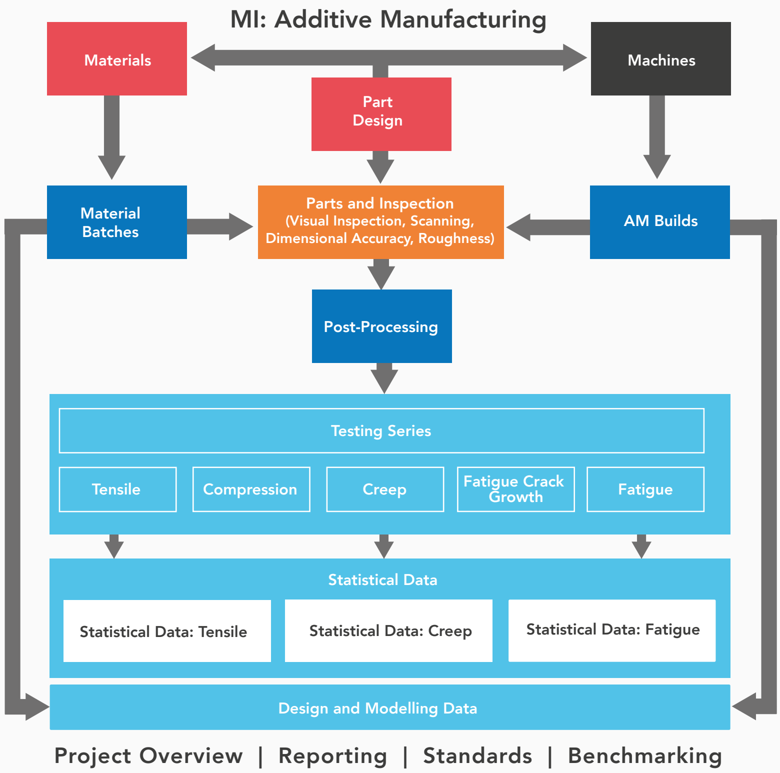


Figure 7: *Outline sketch of the GRANTA MI Additive Manufacturing schema, which provides the data structures needed to capture and use valuable AM project data.*

6.3 Support for Simulation – Molex and PSA Peugeot Citroën

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.

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 such as electronic and electrical component maker Molex, who use GRANTA MI 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 the internal customers at Molex. Director of Material and Process Technology, Brett Rickett, explains: "taking out a lot of inefficient work activities in the product engineering community was a great way to be able to show Return on Investment" [15].

> "Taking out a lot of inefficient work activities in the product engineering community was a great way to be able to show Return on Investment"
> *Molex*

Similar motivations were in play at major Automotive OEM PSA Peugeot Citroën, where Materials Chief Expert Louis David described the reasons for using GRANTA MI: "Granta was able to meet our short term needs, especially for the data required for modeling… and an open approach that can support future extension of the project." [16]

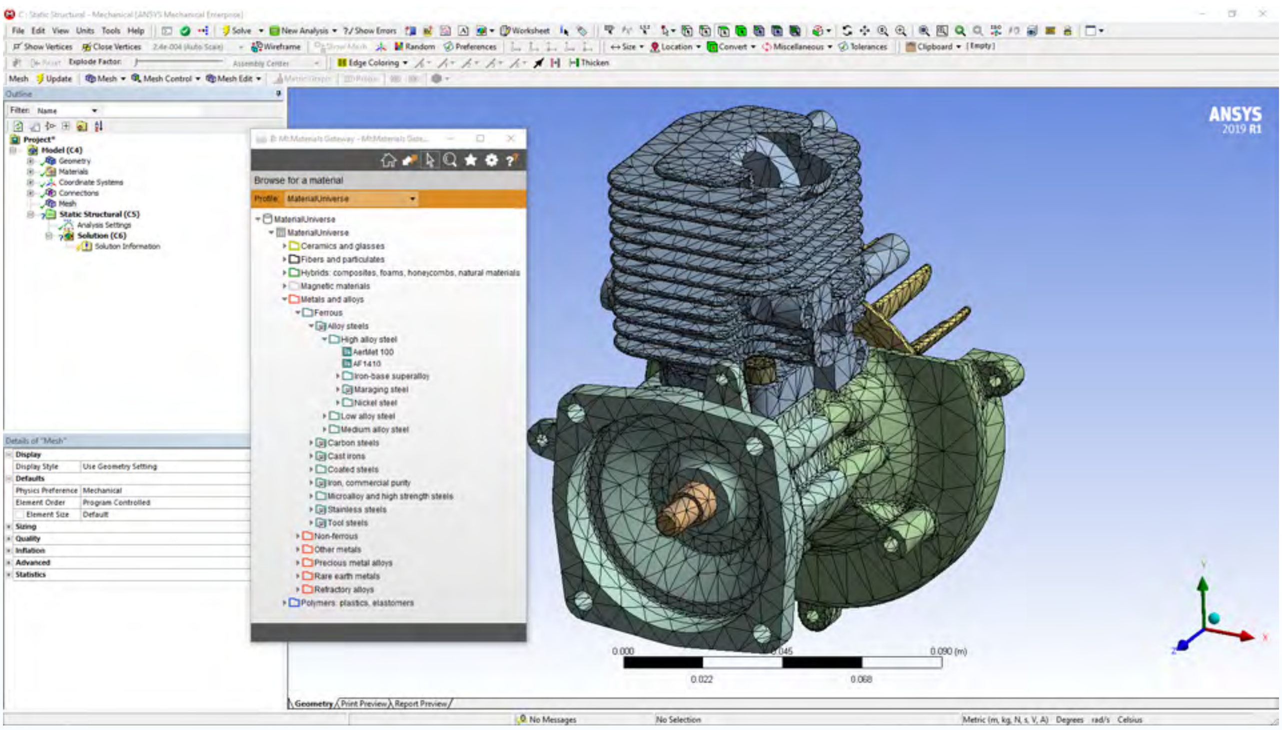


Figure 8. *a robust mechanism to deliver materials data for simulation is via the MI:Materials Gateway app, which enables direct access to the corporate materials database from within CAE software (in this case, ANSYS Mechanical).*

6.4 Avoiding regulatory risk – Boeing

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.

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. One example is Boeing, which looked for a way to connect and analyze its data on materials, specifications, regulations, and parts – something Boeing's Peter Mezey describes as a "a laborious and costly process when you consider the mountains of data". [19]

> "For the first time we have the linkage all in one place"
> *Boeing*

Boeing adopted the GRANTA MI software to provide a centralized hub of materials knowledge, allowing restricted substance information to be fully integrated with other materials information. "For the first time we have the linkage all in one place," adds Mezey. He shares a story in which an analysis undertaken prior to implementing GRANTA MI 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 GRANTA MI, 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. *Boeing use GRANTA MI to determine materials compliance, suitability, and sustainability*

6.5 Enterprise-wide consistency and efficiency – GM and Ethicon Surgical Care

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

At General Motors, the aim was to address the situation in which a 'material' means a different thing to different people. The GM team had to develop a harmonized definition, which they name a '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—GRANTA MI, which manages materials information and 'authors' it into the second key tool, their Teamcenter® PLM system. Within Teamcenter, this data can be consumed by a diverse audience from engineers, to purchasing staff, to lawyers. Global Process Lead for Materials Lifecycle Management, Denise Massa, cites an example [15] where a CAE person and a welding engineer could be working on the same material but using different descriptions: "We want them to all be using the same version of the steel, so we have less rework, better products, no product recalls, and fewer warranty issues."

> "We want them to all be using the same version of the steel, so we have less rework, better products, no product recalls, and fewer warranty issues."
> *GM*

Ethicon Surgical Care decided to centralize its materials information in a system built on GRANTA MI. Staff spent months collating data and ANSYS Granta helped them to create a searchable database. Principal Material Engineer, Jackie Anim says: [20] "The Granta solution was not just an IT solution. It was a combination of the technical element and the customer interface. We wanted to feel like the solution belongs to us. We wanted it to be searchable – all you do is type something in, hit 'search' and the result has to pop up. That's what we wanted and Granta did just that." She describes an example in which being able to access a material analysis completed a decade earlier by an Ethicon engineer 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, avoiding severe allergic reactions. "We're able, within a few minutes of that request, to say the product doesn't have latex and they can proceed."

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

CHECKLIST: your next steps towards **'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, Granta 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 1000s 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 Granta 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

The table 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 Rolls-Royce 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. ANSYS Granta has considerable experience in analyzing the materials information situation within enterprises and identifying areas where materials information technology could provide a return. We are happy to work with you to perform such an analysis. Contact us (details at grantadesign.com/contact).

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

Area	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
	Identify a more efficient material or process option	$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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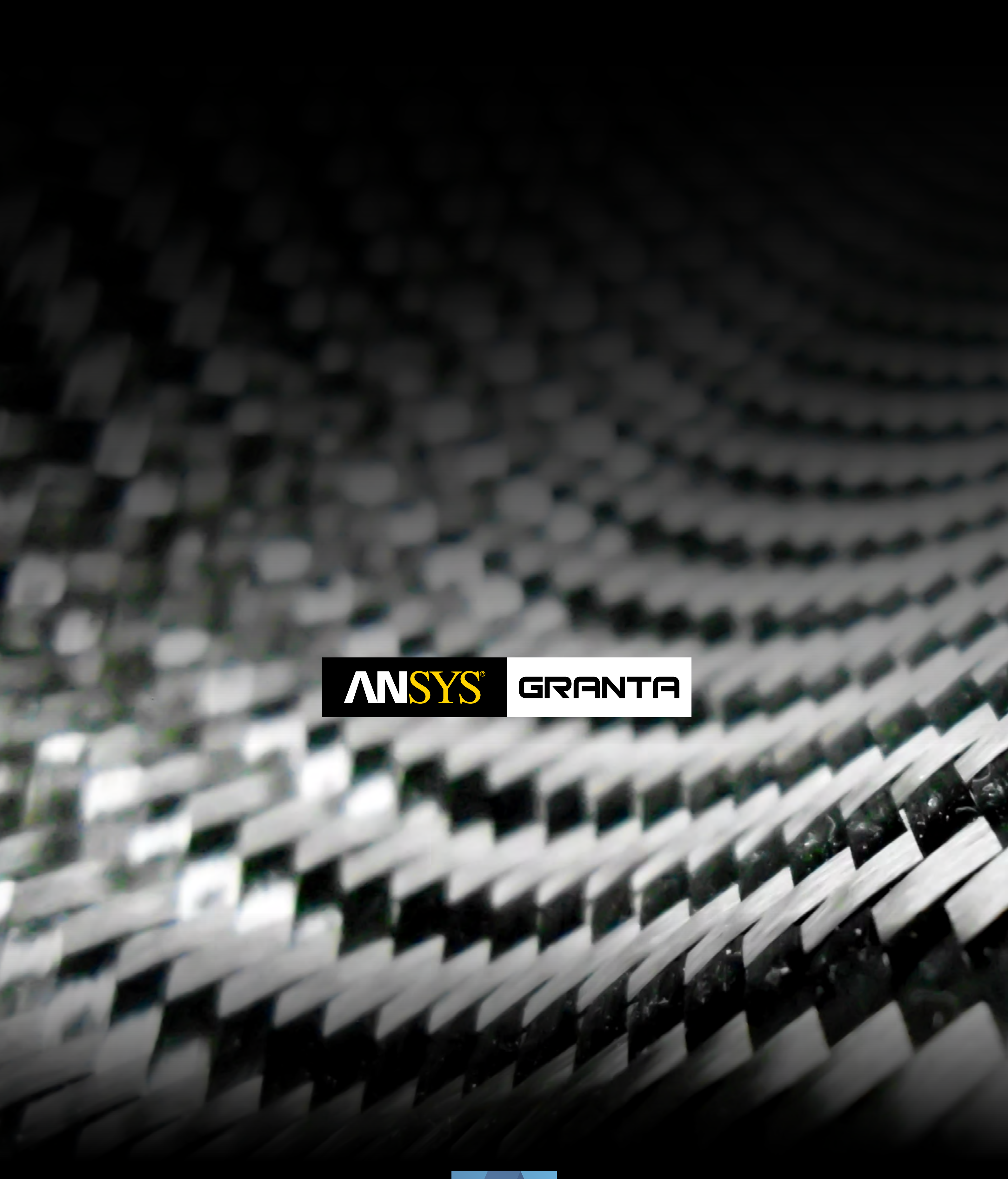

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