CIMdata

Leveraging Product Development Knowledge

"The Role of Product Data in Creating Innovation"

A CIMdata White Paper

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"The Role of Product Data in Creating Innovation"

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If yours is a manufacturing company, then for every person who uses a CAD and other technical solutions to create and analyze product designs there are many others who need to consume all kinds of product definition information—specifications, CAD models, drawings, analysis results, to assembly/disassembly animations, to support their work—that is, they would if they had a way see it, interact with it, and reuse it. Because they lack the multitude of tools used to create product data, they often laboriously recreate information in a form they need, wasting valuable time and resources and squandering work already done. Or they work from less informative drawings, misunderstanding the design more often because the information they can access is incomplete and difficult to interpret. Visual data solutions have evolved to provide access to all product design information in a way that is easily accessible, streamlining the work of many people and producing incredible benefits for the organization and allowing companies to exploit visual data in workflows beyond viewing and mockup.

Your product information is a valuable asset and should be available in a common way to all participants in your value chain regardless of the tools they have at their disposal, providing unparalleled communication among all who work to create your products and services. The challenge is to support a lifecycle information communication solution based on business needs and those of your product lifecycle processes, not just support for discreet, individual uses of data in particular departments. You need to do this to support the transformation of your product lifecycle processes by leveraging the data that forms your enterprise's knowledge base throughout all of your product development organization.

The Visual Product Data Opportunity:

The chart in Figure 1 shows the average number of employees in manufacturing companies that can see data generated in CAD solutions on a regular basis—albeit, generally only that generated in the CAD system they use. It is important to note that many companies use a multitude of CAD systems, including multiple mechanical and electrical CAD systems. The chart presents an average view of the situation; your company may have many more non-CAD users than portrayed here. This points to a basic issue in many enterprises—*the inability of people to leverage product development knowledge.*

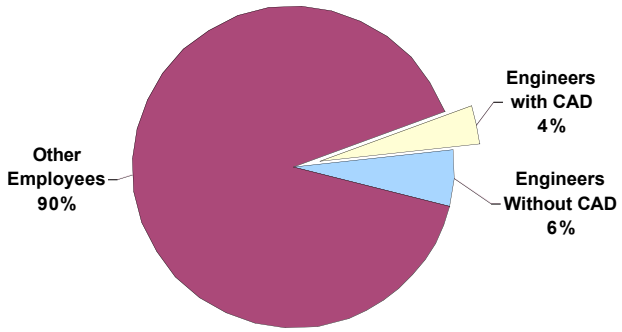

Figure 1—On Average, 96% of Employees in US Manufacturing Companies Don't Have Access to CAD Data

(Source: US Bureau of Labor Statistics)

This can best be accomplished by having a common visual data format that is lightweight, interoperable, precise, managed in PLM, and universally accessible through a number of tools that promote data reuse—viewers, digital mockup,

collaboration, CAD, CAE, digital manufacturing, technical publication, and many others.

A key enabler of Product Lifecycle Management (PLM) solutions is access to all kinds of product development information within the collaboration context of and throughout the discrete stages of the product lifecycle. However, just making information available and easily found provides only part of the value that data access through PLM offers. The greatest benefits of PLM accrue when the broadest, most complete set of product information can be used and reused by all types of people in the enterprise, including product designers, engineers, manufacturing engineers, managers, marketers, maintenance personnel, sales, purchasing, and many others, from the time the information is first created until the product is retired from the market.

Leveraging the value of information is not only an issue of allowing people to find what they need. It also entails communicating that information in a manner that a multitude of people can make use of it and derive value from it while performing their tasks using the tools at hand throughout the product lifecycle. Because people use product information in vastly different ways, this need to communicate information applies to all types of data—textual, 2D drawings and photographs, 3D designs, 3D analyses input and results, dynamic data (e.g., flow simulation, motion studies, ergonomic evaluations), product structures, product manufacturing information (PMI), work instructions, and many other elements of product data and their attributes. While 2D data, i.e., documents and drawings, is usually readily available and may help convey certain types of information, it is poorly suited to helping people understand the highly content rich 3D data that defines and describes products in manufacturing companies today. One of the most glaring examples of this is the heavy reliance product developers place on using 2D drawings to define complex products. The third and fourth dimensions (i.e., time-based assembly motions) of real products are typically ignored in this context because the 2D drawing and text paradigms just don't support the representation of three-dimensional and time-based information at all well and certainly not in an intuitively obvious manner.

Clearly, we need better ways to communicate and leverage product and process definition information.

This is particularly important because data communication is the key to successful collaboration processes. Likewise, collaboration is a primary enabler of innovation; one of the major initiatives pursued by progressive organizations today. A recent survey by Boston Consulting Group shows that 90 percent of manufacturing executives state that "*...generating organic growth through innovation is essential for success.*"

To innovate you must be able to collaborate. *"Superior [financial] results, in most cases, seem to be a function of the quality of an organization's innovation process—the bets it makes and how it pursues them—rather than the magnitude of its innovation spending. Collaboration is key. The link between spending and performance tends to be strongest in those areas most under the control of the R&D silo, such as product design, and weakest in those areas where cross-functional collaboration is most difficult, such as commercialization."*[1] To collaborate, people must be able to find information easily, very easily, but they also must be able to see, evaluate, and reuse that information in an environment that meets their needs. While you can use many different solutions and formats for working with and collaborating on product definition information, this leads to a number of issues, some not unlike those

[1] Jaruzelski, Barry, Kevin Dehoff, and Rakesh Bordia, "Money Isn't Everything" A study of the Booz Allen Hamilton Global Innovation 1000, strategy+business, December 2005, http://www.strategy-business.com/resiliencereport/resilience/rr00027.

encountered when using multiple CAD solutions. Among these, in the competitive vendor landscape, many different software tools with their own data formats have been developed to view, collaborate on, and work with product data, leading to a proliferation of data formats and increased maintenance, training, and IT support costs. The proliferation of data formats results in multiple versions of data having to be maintained and carefully synchronized so that when the original (e.g., CAD) data is changed, all derived data is updated to match. This leads to a much higher potential for some data to become inconsistent and out of synch with the original product design data. When data is being used to do work within the product lifecycle processes, many problems can arise from the use of outdated information, including but not limited to propagating and compounding errors and faulty decision-making. People also have to learn how to use multiple solutions, raising training costs and complicating their work environments. Finally, confusion and frustration can arise when data in an incorrect format is sent to someone who does not have a solution with which they can both see and work with the data. All of these factors lead to increased costs and the high probability of increasing the number of errors throughout the product lifecycle. The solution is to limit the number of tools and data formats used to utilize product data.

When choosing a solution that will allow one consistent mechanism for viewing, analyzing, repurposing, and publishing all types of product design information within collaborative and interoperable product lifecycle processes, technical and business issues have to be considered within the context of how an extended enterprise needs to use product data, who needs to use that data, and how that data will be created, maintained, and managed. The technical and business issues are linked to the types of usage that need to be supported within a business environment. In any case some of the key issues to consider are described below. Companies must understand the requirements placed on the tools and data at each stage of their lifecycle. Then the ability of a single data standard and associated tool set to meet those requirements can be evaluated.

Usage Scenarios

Using product information to support product lifecycle processes to best advantage requires that companies develop a strategy that embraces the complete product lifecycle, all kinds of data, and all types of people. To fully understand the requirements, two aspects of the use of visual data in the product lifecycle are important: the collaboration contexts that occur within every stage of the product lifecycle (both within the company and throughout its supply chain) and the interaction of each product lifecycle stage with the next.

Many organizations consider using product information visualization solutions as a point solution applied to only one or a few processes within product development, however, this minimizes value because it does not take advantage of the potential of leveraging high-value data in other areas. Many opportunities to reuse product information exist. Some examples follow.

Innovation is driven by collaboration, through both serial activities and real-time meetings that occur throughout the product development organization and with the supply chain. Over the last decade tools have been developed that allow real-time, on-line meetings to occur with the participants being thousands of miles apart. To realize the increase in productivity that these types of real time collaboration sessions can bring and for them to be effective tools in the product lifecycle a lightweight viewable data format is critical and brings very high levels of benefit to organizations. Collaborating only on native CAD data limits the number of people who can actively participate in decision processes because everyone has to have access to the same CAD tool and know how to use it. Another major problem is that native CAD files tend to be quite large, on the order of hundreds of

megabytes or gigabytes of data, and thus can not be easily transmitted unless the organization has very high bandwidth connections among its locations and with suppliers and partners.

Offline or asynchronous collaboration is another area where visual data can be used. In this collaboration mode an intermediary system, either a database, workflow manager or PDM system manages the interaction among the collaboration participants who all work on their part of the product at different times. The key issue in this collaboration context is data interoperability because each participant is likely to employ a different set of tools to do their work and they must be able to share data seamlessly and without losing information due to data translations. Interoperability of data among processes fosters data reuse as well as supporting decision making. The more data is reused, the more value is derived from it. Employing a universal visual data format and associated viewing tools supports data interoperability and reuse.

Document based collaboration using visual data is the third collaboration context. It supports work with suppliers and customers by allowing data to be published into common document formats such as MS Word and Adobe PDF. These formats support very wide distribution of both 2D and 3D information. This collaboration context provides universally accessible information that can be viewed and worked with using readily accessible and familiar tools.

An example of document based collaboration is the use of design data in both printed and electronically published materials such as brochures, presentations, proposals, quotations, etc., to support marketing and sales. These often need to be repurposed into MS Word, PowerPoint, PDF, web pages, and other "document" formats from which they can be viewed, evaluated, and manipulated. Often, engineers or designers are asked to use their CAD tools to create these special views or pictures of product data. This disrupts the product design process and uses high-priced resources wastefully. Today, using appropriate formats and solutions, 3D visual data and other product definition information can be repurposed in many ways by people who are not trained CAD users. 3D data can be published in electronic formats, such as PDF, so that readers can interact dynamically with the 3D data (rotating, zooming, sectioning, and performing other 3D operations on it), improving their understanding of the data and increasing the value of the data.

When supported by accessible data and appropriate viewing solutions, these three collaboration contexts can be used in a number of product lifecycle activities as described below.

During the product design process, engineers may need to be able to use product information from many different sources (e.g., multiple CAD solutions) to perform design in context and mockup studies. They also need to be able to share their designs with suppliers in a way that does not compromise intellectual property. To support this, viewing tools can provide the ability to create geometric envelopes of complex parts and assemblies that reveal essential interfaces while hiding internal geometry.

In most organizations, change approval and design approval processes require a multitude of different types of people to review, evaluate, and approve what is going on. Most of these people, especially managers, costing analysts, marketing, and other personnel typically do not have access to product design information beyond drawings and text, so they miss out on being able to take advantage of high-value engineering information to make informed decisions. Even when they do have access to a broad set of product data, they can't see it without using multiple tools. These factors increase the chance for errors and cause delays in the decision making process. A strong viewing solution will provide access to many types of product information through simple to use tools.

During manufacturing, service and maintenance, delays and problems caused by miscommunication are extremely costly. These processes can be accomplished much more quickly and with fewer errors when they are supported by 3D information such as animated assembly, disassembly, and repair instructions. Today, documents that are used in these processes are likely to contain embedded design models, animations, cross sections, and exploded views. Without a solution that can view and manipulate 3D data, these have to be produced by engineers and designers running expensive CAD tools.

There are many other areas in which solutions to view and work with product data can be and are used to great advantage. As an example, the chart in Figure 2 shows where visual data is used, as compared to CAD data usage, in automotive processes. This illustrates the breadth of the impact that can derive from making product information ubiquitously available and viewable throughout the product lifecycle.

Things to Consider

How product information is to be used in your organization will drive the decision of adopting a particular data format and a data viewing solution set that can leverage that data. It is important to realize that there may not be one absolutely "correct" data format choice; but the "best" choice will allow a multitude of types of data to be used by the largest community of workers to support the collaboration contexts and lifecycle requirements while allowing the process participants to use their tools of choice. There are considerations, both technical and business, that should be taken into account to help understand what is required from the data format as well as the tools that create and allow access to it.

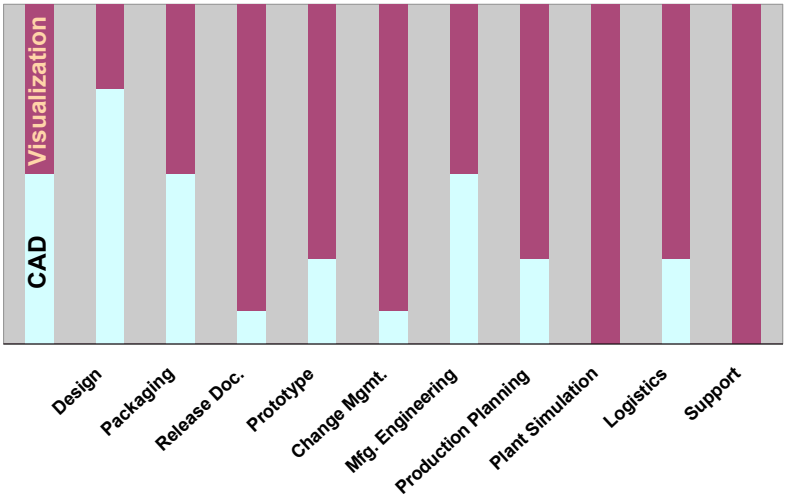

Figure 2—Proportion of Visualization Usage vs. CAD Usage in Automotive Processes
Source: Odette International, 2004

Technical Issues

Many different capabilities are needed to some degree to support various uses of information. As you consider data formats and applications that create and work with those formats, you need to understand and evaluate a number of technical issues based on the usage scenarios required to support your business requirements. These include:

- Breadth of data types supported
- Ability of the solution to work in your managed data environment
    - CAD and other data source integrations
    - Support for assemblies as well as parts
    - Lightness of data representation
    - Data accuracy
    - Others

The breadth and depth of data that can be accessed (e.g., documents, CAD, CAE and FEM, PMI, PDM, ECAD, and other types of attributes and data) determines how well the visual data format can be used to support a broad range of users and usage scenarios. The more

complete and rich the data is, the more different types of people can take advantage of it in their work areas and the more value it brings to the organization. Product and program reviews and change approval processes require access to many types of data that are authored in a large number of different tools. These processes are highly streamlined when people have a single, rich data format in which to examine all of the information they need to consider in making and documenting a valid decision.

The data must be available in a managed environment so that users can predetermine what parts and types of data are accessible, helping protect proprietary information by limiting what others can see. Digital rights management (DRM) capabilities provide further protection of intellectual property. For instance, with DRM, data owners can specify how a recipient can use data, for instance, not allowing the data to be printed, exploded, or measured. DRM also provides methods to limit the lifespan of data, causing it to become inaccessible or to self-destruct after a preset date.

As stated above, a primary issue is how people are allowed to see and interact with data that comes in many different varieties from text to CAD models. However, people can't see what they can't find, so a prerequisite to efficiently re-using information throughout product lifecycle processes is that people have convenient access to whatever information they need and that they are assured that they are using correct, consistent, up-to-date sets of information. Data management solutions provide essential capabilities to assure that information, including viewable data, is stored and organized for easy retrieval and that interrelationships among data are maintained. Just having the ability to look at and work with data does not ensure that people will find what they really need—*the viewable data has to be organized and managed effectively!*

In collaboration, especially within supply chains, a major issue is that not all companies or departments are likely to use the same CAD tool. To allow all people to collaborate effectively, data viewers must be able to import and assemble parts that were created in multiple CAD tools. Likewise, the primary product data authoring tools (e.g., CAD) should be able to import and work with data from the data viewing tools. Transferring data from CAD and other authoring tools into a common viewable format is key to improving the usefulness, reuse, and hence the value of product definition data. For MCAD, this includes not only geometry, but also attributes and other information. A complete data-rich solution may include ECAD data, text, photos, analysis results, etc.

Since most product definitions are assemblies of many parts, the assembly or product structure relationships and configurations of the parts of the assembly must be available for users to navigate, so they are able to understand the structure of the overall design. When the data is to be used to perform DMU studies, this structure may need to be augmented with information that describes how parts move with respect to the parts with which they are connected. DMU also helps people evaluate design assemblies that are comprised of components created in more than one CAD system—as long as the data can be accessed in a common format.

Lightweight data formats can significantly reduce the size of viewable data files. Smaller files can be transmitted more quickly through lower bandwidth communication systems (see Figure 3 below). However, lightweight (or compressed) data formats usually loose some fidelity, becoming less accurate or less meaningful. The process of compressing and then decompressing the data may also be time-consuming, creating a trade-off between file size and data loading times. The level of compression is impacted by a number of factors that include the geometry used for the viewable

data, the amount of data loss that is acceptable (which can vary greatly depending on how the viewable data is to be used), and the desired fidelity of the compressed data to the original data (that is, the data accuracy retained). However, some use cases, such as on-line, web-based sales catalogs, can be best served with low fidelity data at high compression ratios.

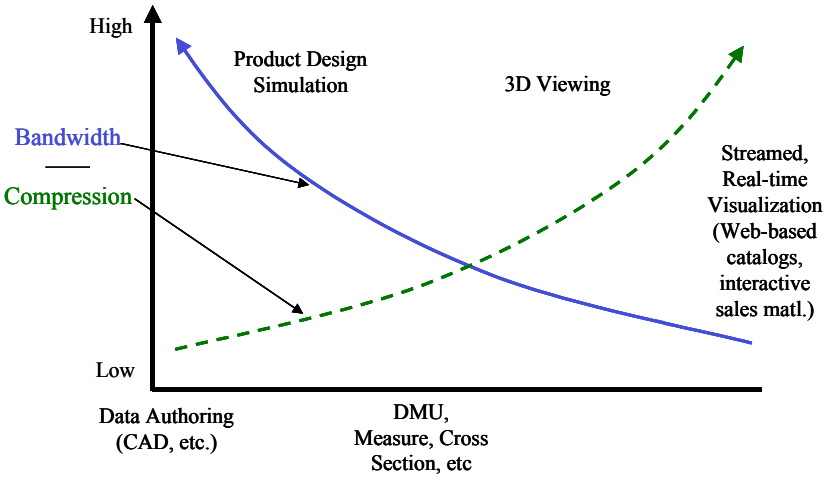

Figure 3—Effects of Data Compression and Communication Bandwidth

Measurable accuracy is desirable in some cases. For some uses, such as shipping or packaging studies, low accuracy of measurements (say to the nearest millimeter) can be tolerated. For other use cases, such as using the viewable data for design reviews, the accuracy may need to be equal to that found in CAD models. Some viewable formats are based on triangular tessellation of the surfaces of CAD designs. When this is done, the chordal deviation (or sagitta) of the planar triangles when compared to the original surface determines measurable accuracy. The smaller the triangles used, the closer they approximate the original geometry, but the larger the viewable data becomes. Accuracy that is good enough for one user may not be sufficient for other users so it is important that the viewable data files can be generated at user-specified fidelity. Boundary representations (B-reps) with precise surface definitions may also be embedded in the viewable data file, providing measurable accuracy equivalent to that in a CAD model. But this increases the size of the file.

Importing viewable data into CAD is an emerging capability that allows designers to use geometric data developed in many other systems to support their design processes.

Data streaming is a set of techniques that enhances the users' experiences by building up a viewable display of data over time. Traditionally, applications have needed to retrieve an entire data file before the user or the application could begin to see, access, or work with the data contained therein. This slows down work and can frustrate users. Streaming applications partially alleviate this issue by enabling access to the data before the entire file is downloaded. Starting with a rough, incomplete view, streaming refines the quality of the view until it is either completely detailed or the user moves their point of view. In order to maximize its effectiveness, a streaming application determines what the user is viewing and sends data in an order that is specific to the user's viewpoint. Some viewing formats can store multiple sets of data at various resolutions to facilitate streaming the data to the user from the lowest resolution of data to the highest.

A number of other capabilities are desirable and beneficial in viewing solutions. These include:

- Interference, clearance, and contact detection
- Cross section generation
- Exploded view generation
- Assembly and disassembly animation
- 2D and 3D markup and annotation
- Mechanism simulation
- Measuring in 3D
- And many others

Business Issues

In addition to the technical issues that determine how well a particular visual data format and viewer solution work, are the business issues, marketing, and delivery programs of the supplier. *When you select a visual data format you are also selecting a business partner—the solution's provider and their network of partners!* You will be relying on the solution to support your primary product lifecycle and support activities. So, you need to be certain that the solution and its provider and partner network are stable and that the solution will continue to be enhanced and maintained to support all of the types of information you need and the ways your enterprise needs to access and work with that information well into the future. These business criteria determine its viability as part of a long-term strategy for viewing, sharing, and collaborating on data throughout the product lifecycle processes.

You should evaluate issues such as:

- Who drives the development of the data format and the tools used to work with the data—the company or an industrial advisory board? If there is an advisory board, is it dominated by one industry? Can you become a member? If not, how can you influence the future of the solution? If there is not an advisory board, how can you influence the solution?
- What are the strengths and weaknesses of the solution strategy; including future directions, data types supported, industry processes supported, cost of support, frequency of updates, level of innovation?
- How many companies use both the data format and the solutions to work with the data? Which industries are the users in? In what processes is the solution used effectively? Does the supplier understand your business area?
- How much of the data schema and APIs are publicly documented and available. Is access to the API restricted or costly? How restrictive is its license? Is the API accessible from your IT development environments? Is the data format definition open and extensible?

Ultimately, how the visualization solution fits in your PLM strategy will determine how viable it will be in helping solve your business needs. Remember, you can't collaborate on information if you can't find it! Having rapid and organized access to all data in a consistent viewable format encourages people to take advantage of product definition information. The acceptance and usefulness of visualization solutions will depend on the ability of the visual data and the tools to support all types of workers throughout your product lifecycle and across all collaboration contexts. Its usefulness will also increase if it is integrated with your entire PLM environment, from CAD to PDM to digital manufacturing, and others.

One key business issue for all technology decisions is cost. Low cost or even free applications have become available in the past few years that allow basic consumption and manipulation of visual data. Free viewers tend to expand adoption of a visualization technology, which can drive its acceptance and long-term viability. The capabilities of most free viewers are fairly basic; for instance, they generally provide the user with the ability to rotate parts or assemblies, but lack precise measurement, cross sectioning, and assembly structure management commonly found in purchased viewers. While free viewers may not have all of the capabilities an organization needs to support its business processes, they can be used quite satisfactorily under certain circumstances, such as when data needs to be published to people in the supply chain who do not have the wherewithal to buy special viewing solutions and for people who are basic consumers of information or for reviewers, for whom the ability to peruse product data may be sufficient. The key issue when evaluating a low cost or free solution is its ubiquity. If you already have an application that allows access to the data, then it will be much

easier to leverage that existing application than deploying a new tool, even if it is free.

Summary and Conclusions

Of course there are many other issues that need to be considered, but the important thing is that you understand why your organization (including your extended enterprise of suppliers and customers) needs to be able to view and interrogate 3D and other product definition data and what benefits you expect to receive from this capability.

You need to develop a process for visual data sharing and use in collaboration as well as other product definition processes—both for internal users and with your partners. Base this on a life-cycle story built around business needs and those of your product lifecycle process, not just support for discreet, individual events in particular departments—look for ways to transform your product lifecycle processes. As much as practical, adopt a consistent, common format, not separate formats for different users or different data types.

Don't forget PDM, you have to be able to manage the data and assure that people can find what they need easily. As well, PDM will help guarantee that people are always working with the most up-to-date and consistent data, avoiding costly errors.

Many cost reduction opportunities are evident from the use of a unified visual data format and solution strategy.

However, the keys to much larger top-line business transforming benefits derive from how well your strategy supports ubiquitous data reuse throughout your organization, leveraging your intellectual assets to support product innovation.

About CIMdata

CIMdata, a leading independent worldwide firm, provides strategic consulting to maximize an enterprise's ability to design and deliver innovative products and services through the application of PLM. CIMdata works with both indus-trial organizations and suppliers of technologies and serv-ices seeking competitive advantage in the global economy by providing world-class knowledge, expertise, and best-practice methods on PLM solutions.

CIMdata helps industrial organizations establish effective PLM strategies, identify requirements, and select PLM technologies, optimize their operational structure and proc-esses to implement solutions, and deploy these solutions.

For PLM solution suppliers, CIMdata helps define business and market strategies, delivers worldwide market informa-tion and analyses, provides education and support for inter-nal sales and marketing teams, as well as overall support at all stages of business and product programs to make them optimally effective in their markets.

CIMdata provides world-class knowledge, expertise, and best-practice methods on PLM solutions. These solutions incorporate both business processes and a wide-ranging set of PLM enabling technologies.

In addition to consulting, CIMdata conducts research, pro-vides PLM-focused subscription services, and pro-duces several commercial publications. The company also pro-vides industry education through international conferences in North America, Europe, and the Pacific region.

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