Clear vision of the future

In spite of digital design and digital manufacturing implementations, designers and production planners do not have any visibility across each other's changes if they are working in separate environments.

To avoid costly downstream rework, digital product and production data must be managed together using a common framework (data model)

DS PPR data model allows for unlimited configured relationships between the PPR objects

Managing change across virtual design and manufacturing

Before the advent of concurrent engineering, it was common practice for engineers to 'throw designs over the wall' between disciplines,departments and suppliers, with a final toss to production planners who often determined the products couldn't be manufactured. The designs were either sent back for rework or the production issues reconciled through trial-and-error testing on physical prototypes, wasting time and money. This cycle was repeated endlessly, but most manufacturers shared the problem, so the playing field was somewhat level. However, over the last decade, technological advances have driven an avalanche of change, opening up geographically diverse markets to each other and the world, heating the competition to the boiling point.

Today, change is the norm in manufacturing environments. Input from customers, marketing, and financial and competitive reports flows in daily, influencing product development decisions from concept through maintenance. At the same time, pricing wars, customer segmentation, and shrinking market windows are placing enormous pressures on manufacturers to streamline global operations, collaborate across suppliers and systems, and do it all faster, better, and cheaperleveraging digital tools and technologies. To keep pace, most large development organisations have implemented digital design, simulation and manufacturing solutions to streamline lifecycle processes and reduce the need for physical prototypes. Some performdigital manufacturing planning and simulation entirely in 3D, creatinga 'virtual factory' environment before releasing designs to production. This paradigm shift is placing more real-time data and analysis toolsinto the hands of global development teams, improving decision-making and often doubling or tripling productivity within a few months of implementation.

Working in the 'landscape' of change

As concurrent engineering increases and production cycles shrink,development teams and the systems that support them must manage a stream of real-time design changes – each requiring routing andreconciliation. However, global organisations work inside a maze of disparate systems and data formats, creating obstacles to understanding change within the context of lifecycle processes and resources as the product matures. As a result, designers and planners don't have visibility into how changes could impact design decisions and downstream manufacturing processes and resources, and vice versa.

In this super-heated environment, change scenarios are becoming increasingly diverse and unpredictable. Sometimes planners must ask the designers to make manufacturing-specific changes that don't affect the design (form, fit and function) itself. For example, a design may pass with flying colors, but may be rejected because it is difficult toassemble or disassemble on the shop floor, given the available time and resources. This rework not only extends time-to-revenue cycles, it wastes time that could be spent developing innovative new products and cost-saving designs.

In the early design stages, the impact of a design change could be minimal because few process plans have been defined and no resourcescommitted. However, further downstream, even a 'simple' change (from the designer's point of view) could cause the entire production process to be reworked or scrapped, incurring unforeseen costs and business risk. So, in spite of enhanced tools and technology, the 'Rule of 10' still applies: the cost of correcting a hundred-dollar mistake in the design phase could increase exponentially across prototyping,setup, and production phases to one million dollars after the product has reached the market.

Gaining visibility and control of change processes

To significantly reduce development time and costs, concurrent work and change iterations between design and manufacturing need to be evaluated and managed in relationship to each other, in near real time. As virtual product development becomes mainstream, how do we close 'change management' gaps between disciplines and provide 360 degree visibility into change impacts across the product lifecycle? Is it possible to introduce controls and data structures that work across these diverse processes without hindering work in-progress?

With more digital product and production data being created and captured, there must be a methodology for organising this information so the development of the virtual product (design) and the virtual factory (planning) can be concurrent and transparent across the product lifecycle. What is needed is a common data model or framework that links digital design, process and production requirements and provides a lifecycle view of the complete product definition. As a critical enabler of a successful product lifecycle management (PLM) strategy, this unified framework should:

- Introduce production rules into design processes from the conceptual phase of development.
- Give manufacturing planners early access to in-work designs toallow for concurrent design–manufacturing planning and ongoing manufacturing input into design decisions.
- Provide a robust yet flexible configuration management system that allows changes to be effective for design only, manufacturing only, or both.
- Provide a change management system that enables bi-directional communication between design and manufacturing planning to request, incorporate, consume, and reconcile changes.
- Enable design change impact analysis on related manufacturingprocesses and resources.
- Provide the above capabilities in a collaborative 3D environment to establish virtual product and virtual factory definitions that evolvetogether throughout the product lifecycle.

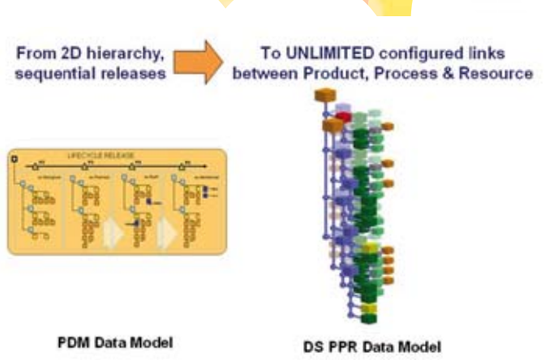
To fulfill the above requirements, Dassault Systèmes (DS) has implemented a breakthrough approach to managing lifecycle data and change impacts in the form of a product, process, and resource (PPR) data model (See figure 1). In a traditional PDM system, the PPR data is usually authored in multiple CAD/CAM applications and copied to aPDM system upon release to manufacturing planning. The product structure must undergo a series of non-trivial restructurings throughout its lifecycle to generate the multiple 'views' of product data needed tosupport specific production and maintenance activities. In such a system, it is virtually impossible to gain a comprehensive view of change impacts across design and manufacturing processes.

In strong contrast to the traditional PDM data model, DS PPR datamodel includes unlimited relationships between the PPR objects, whichare recorded according to specific configurations. Why PPR? Simply put, PPR comprises the three functional and material areas impacted by any change in the product definition. The relationships between andamong the three must be maintained in real time across disciplines, data sources, and suppliers to provide decision support for concurrent lifecycle processes and 'guided exploration' of design alternatives and innovation.

Configuring Relationships to Manage Change Impacts

The logic behind the DS PPR data model is simple yet powerful in itsreach. Each part is linked with at least one manufacturing

DS PPR data model provides the visibility of change impact from one class of object to any other



process and one resource. Therefore, any of the relationships between the PPR objects can be exploited at any time to enable the earliest possible evolution or change. Since such relationships are explicitly defined and managed within the database, one is able to directly see the impact of changes from one class of object to any other (eg, If a part is changed for product number 50-100, which manufacturing plans are affected?). Having this PPR knowledge early on is essential to avoiding serious time and cost overruns during planning and production.

As discussed, the parts, part-process, and process-resource links can be configured according to design change only, manufacturing change only, or both. This robust yet flexible management capability lets a designer make a distinction when recording a design change that does not affect its 'related' manufacturing plans (eg the new design does not affect its assembly relationships) with a design change that does (eg shape or supplier change). It also allows a manufacturing planner to record a change that affects manufacturing instructions but does not impact design (for instance, changing the work instructions to improve the efficiency of the assembly process).

This unique DS PPR data model is designed to maximise knowledge reuse across work instructions by including the notion of configurable control flow and precedence relationships between processes. These relationships can also be configuration-controlled and change-managed like the rest of the DS PPR data model content. Thus, a simple plan re-sequencing may affect how the parts are being assembled for a specific configuration, but would not affect the design itself. This type of change would still be managed and tracked using the same consistent methodology.

This system also lets a production planner directly influence design through the change request process, reducing downstream errors, timeand costs. Before a new design is released, a review and sign-off froma manufacturing planner must be obtained. Having this closed loop from manufacturing planner to the designer improves decision making and prevents designs from being 'thrown over the wall' unless proven to be manufacturable in the first place.

The integrated DS PPR data model also enables advanced change management methodologies. For example, to accomplish a specific change (e.g. change a part and revise the work instructions for the new part), many interconnected changes are required. By grouping these smaller changes together, the entire collection of changes can inherit the same resulting configuration characteristics. This grouping enables both designers and planners to continue working in their own environment as efficiently as possible while still managing change. Furthermore, both disciplines can now validate the impact of the change request before the actual implementation.

DS provides all of the above capabilities as a set of out-of-the box integrated applications that spans engineering and manufacturing. When used in conjunction with DELMIA Manufacturing Change Management (MCM), ENOVIA LCA Change Management (LCM)provides a common framework to ensure that changes in design and manufacturing are defined, managed, and tracked through a singlemechanism across the product lifecycle.

Managing change to improve business agility

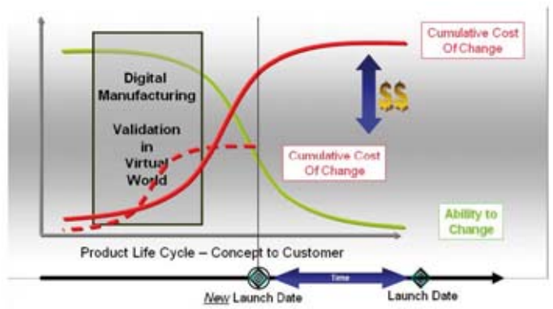
The Product, Process, and Resource data model provides the foundation for a unified product lifecycle management (PLM)environment. The integration of the virtual product and virtual factory

Resolving all design mistakes in the virtual world significantly reduces the cumulative cost of change and time-to-market.

facilitates intense collaboration between design and manufacturing planning, letting them evaluate designs and make changes quickly and accurately in the virtual development phases when the cost of change is low. This results in optimised designs that mature rapidly with faster production ramp-up and

The 'rule of 10': a $100 mistake in the design phase could cost $1 million to fix after the product reaches the market

overall time-to-value cycles – a clear competitive advantage (See figure below).

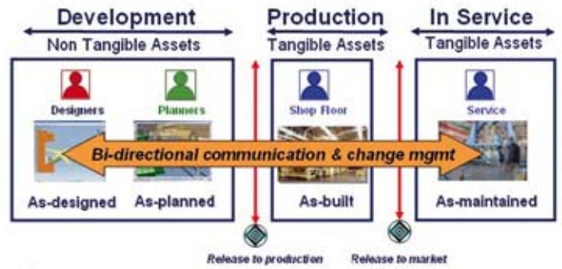


However, in today's environments, design and production changes rarely follow the manufacturer's timetable; they occur due to globalmarket pressures, new customer requirements, changes in manufacturing facilities or equipment, or regulatory issues, causing a disruptive ripple effect. For example, when a change is required for a part that is already in production, the accuracy of the manufacturingbill of materials could be affected depending on where (ie application) the 'as-built' condition is stored.

In addition to systems-level challenges, critical human and plant resources are impacted by post-production changes. For instance, field sales personnel may request a color change to make the new product more competitive; maintenance may request a change to make it easier to repair; while shop floor staff might ask the manufacturing planner to shift work from one control station to another to improve production flow.

The rich relationships between DS PPR objects provide a robust and consistent way to control and reconcile these changes, from manufacturing planning and consumption, all the way to the shop floor. This might involve traditional EBOM-MBOM comparisons, BOM-process plan consumption analysis, interrogations of the data authored in both engineering and manufacturing domains, as well as reconcilinginformation that feeds or comes in from other enterprise application systems such as Supplier Relationship Management (SRM),Manufacturing Execution System (MES), and Enterprise ResourcePlanning (ERP). Because the DS PPR data model records and reconciles information that both feeds and comes from other enterprise application systems, changes can be executed efficiently and accuratelywithout disrupting daily operations, providing a 360 degree view of the change cycle and improving business agility.

Finally, to ensure rapid and seamless communication, the DS PPR-based change management application is available as easy-to-use, web-based applications so that enterprise stakeholders from marketing tomaintenance can directly participate in the change process anytime,anywhere (See figure below).



Management coverage

The ability to quickly and strategically respond to change is critical tosurvival in the 21st century marketplace. To create a global business model that is responsive to customers and competitive threats, manufacturers must 'build in' operational agility. Failing to track andmanage change can forever bury key processes and real production costs deep inside a maze of application silos. ENOVIA LCA Change Management unifies people and processes far beyond traditional design and production planning functions, providing the path to a truly 'live' product and factory development environment where constant change offers opportunity, not chaos.

ENOVIA covers change management processes across the product lifecycle and across the extended enterprise.

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