Simultaneous Product Development –
Product Development @ Internet SPeeD

An ImpactXoft White Paper

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Here's a new way to set a world track record: Get all the members of your relay team to run their laps together at the same time rather than separately one by one.

The idea of changing a *relay* race into a *parallel* race might not appeal to the Olympic rules committee. But as a new approach to product development, the concept of working in parallel – or simultaneously – holds tremendous promise for many companies.

The practice of Simultaneous Product Development has arisen to address longstanding challenges in the race for market share. A list of these challenges will be familiar to anyone who has been involved in product design and development over the last decade.

- Develop products that customers want and deliver them on schedule
- Coordinate suppliers and partners
- Manage the product life cycle (design requirements planning through field service and retirement)
- Encourage product innovation and quality
- Minimize design and development cycle time and cost
- Utilize emerging technologies

Many companies have found meeting these goals to be a frustrating and difficult process. As product development becomes increasingly global, the problems seem only to intensify. Even after installing the latest ERP system and the latest collaboration portal, product development still bogs down with engineering change orders and unproductive rework. Suppliers make parts that don't fit or suddenly run out of inventory. Outsourced design teams sit on their hands while marketing revises requirements. Production dates slip and scrap costs mount while manufacturing engineers fix digital part models to adjust to material and machining capabilities.

Why have problems such as these been so persistent in product development? We believe the answer lies in the *relay* mindset that pervades industry even today. Despite all the attention paid lately to the concept of collaboration, product design and development practices still follow old habits of *seriality* formed back in the step-by-step days of paper records. Then, product development proceeded along well-worn grooves as a design was handed like a baton from one development function to the next or, in an oft-repeated phrase, was "thrown over the wall" to the next workgroup. During the nineties, the movement toward simultaneous engineering, also known as concurrent engineering, documented vast stretches of wasted time, isolated pockets of information, and huge avoidable costs associated with this serial way of working.

The pioneers of concurrent engineering made some inroads into integrating design and manufacturing functions. But that was before the Internet. The instantaneous, round-the-clock communication it enables has changed everything. Seriality is being left in the dust. Via email and web technology, product development teams scattered all over the world are making design decisions faster than ever, leaping over time zones and traditional knowledge-sharing procedures in an effort to break the stranglehold of seriality and reap the benefits of working in parallel.

This is just the beginning of the era of Simultaneous Product Development. Resourceful and ambitious companies will achieve it, and they will use it as a strategy to accomplish the business goals outlined above.

The rest of this paper explores the concept of Simultaneous Product Development and explains some of the revolutionary technologies that make it possible. Our idea is really quite straightforward. When you are working faster than ink can dry, you stop using ink and invent a tool that can keep up. In the following pages, we describe the tools we've created to usher product design and development into this new age.

Part I: Simultaneous Product Development 101

Like any other human endeavor, product design and development has a history that contains both earthquakes and evolutions. The arrival of innovative technology often has a seismic affect on industry, followed by a longer period during which companies test, implement, and master new tools. As current technologies and business practices mature, another wave of innovation is usually gathering. Tools that bring about earthquakes in product development practices are sometimes called "disruptive." But the emergence of new tools is a sign that the underlying needs of product developers have naturally evolved and must be readdressed.

COLLABORATION EVOLVES

By enabling the move from serial to parallel work processes, Simultaneous Product Development culminates three stages of collaboration that have evolved over time. From stage to stage, product development needs have grown more sophisticated. Companies continue to seek ways to sharpen their response to business demands.

Stage 1 Collaboration: Serial

In the earliest stage of collaboration, product developers communicated by means of postal mail, telephone, fax machine, and face-to-face meetings. Design documentation was paper-based, and development work proceeded step by step. Using CAD software, engineers modeled products, printed drawings for delivery to other team members, gathered comments, and then revised the CAD model for the next round of review.

Over the last decade, many organizations found it necessary to advance beyond this time-consuming method of collaboration as development cycles shrank and as customers and suppliers became more diverse.

Stage 2 Collaboration: Still Serial

In the next stage of collaboration, tools expanded to include email, Internet chat, teleconferencing, and web-based meetings. Internet communication increased as product development became globalized. Most design documentation now resided in databases, and an electronic version of the CAD product model was available for browser-based design review. Using the Web, development team members in different physical locations could meet virtually to confer on designs together and to view and mark up CAD models. Web-based design reviews helped many development teams work more efficiently.

However, once the Web-based review concludes, efficiency gains evaporate. The development process reverts to first-stage collaboration. A CAD expert again must interpret review comments and redo the product model. Many companies realize that this separate step of CAD modeling, which requires specialists to painstakingly construct the detailed geometry of products, is a bottleneck that slows product development. Until now, there has been no way to avoid it.

Stage 3 Collaboration: Simultaneous

Remember the earthquake mentioned above? That rumble is the sound of ImpactXoft integrating CAD modeling with Internet collaboration to inaugurate the era of Simultaneous Product Development. We have created technology that eliminates digital modeling as a separate, poorly connected island in product design. Our software enables every member of the development team to work as a node of a network and produce complete geometry automatically by simply adding, subtracting, or modifying product features. Every change is merged into the actual digital model rather than to a copy. And every change merges perfectly, even over low-bandwidth connections, with model alterations made by other team members.

Because ImpactXoft technology demolishes the last outpost of seriality in product development, it will finally enable collaboration in the true sense of the word. Simultaneous Product Development answers the needs of today's and tomorrow's globally dispersed development teams to work more closely and more quickly than ever.

PRODUCT MODELING EVOLVES

Product modeling tools themselves have gone through three stages of evolution, causing major shifts in the market for CAD software about every fifteen years (see Figure A). A brief look at these stages will identify some of the reasons that CAD systems have played such an indelible role in product development. It will also become clear that the age of specialized CAD modeling as a separate function in engineering – as an isolated "island of automation" – is decidedly over.

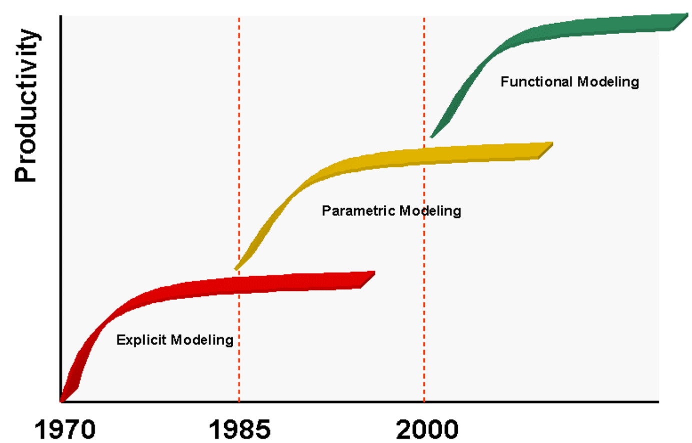

Figure A. Product modeling technology has evolved over time.

Explicit Modeling: Form

Explicit modeling is the practice of adding, subtracting, and combining lines, surfaces, and solids to create a product design. In the 1970s, the first CAD systems automated explicit modeling so that designers could *define the form* of a product electronically. The great limitation of explicit modeling is the time required to revise geometry. For example, if the shape of one part changed, the shape of the surrounding parts in the product assembly had to be accordingly reworked. Explicit modeling answered an early need for design automation, but it was only the beginning.

Parametric Modeling: Form and Fit

In the 1980s, parametric modeling was a powerful advance over explicit modeling, since it provided a way to also *define the fit* between the different elements of a product design. Now designers could not only create the shape of the product but could also determine which design elements were related such that a change in one would automatically bring about a change in the other. Design elements so related were said to be *constrained.* To speed up the process of reworking geometry as design progressed, parametric modelers recorded every step in the history of a design as it occurred. Changes were made to the variables that defined the model geometry, this *history tree* was replayed, and the model regenerated onscreen according to its new design parameters.

Parametric modeling shaved a considerable amount of time off the reworking of product geometry, but it introduced a new problem: it was hard to do. More importantly, it was hard to undo. The history-based approach to digital modeling introduced an inflexibility into product development that lasted well into the 1990s. The historical order of operations was fundamental to the proper regeneration of the model, but design changes often had unpredictable results when the history was recomputed. Selective breaking and remaking of constraints sometimes solved the problem, but designers who did not have special CAD system knowledge lost a lot of time trying to revise designs. Development team members with no CAD knowledge didn't even try.

Interestingly, some parametric systems that emerged at this time were not history-based. Called variational modelers, they allowed designers to create and revise model geometry in any order. Feature-based modeling was another advance that sped development. Modeling features are predefined packages of geometry rules for such widely used design elements as holes and fillets that can be attached to solid models and created automatically with a single command. Features now are regularly included in most modeling systems.

Functional Modeling: Form, Fit, and Function

Functional Modeling is the breakthrough technology that opens the next evolutionary stage. It advances on parametric, history-based modeling by introducing two innovations. First of all, Functional Modeling is history independent, which means that design elements added, subtracted, and modified in any sequence will always generate the same product model. There is never any need to go back and reorder the history tree for the desired modeling result. Second, Functional Modeling is based on the use of functional features. Unlike the geometric features included in traditional modelers, functional features have built-in intelligence that predefines *how design elements function* in the overall design – that is, how they relate to one another and behave in response to design changes.

Functional Modeling helps realize the long-awaited promise of letting designers work creatively and spontaneously in accordance with the way they think, not the way a modeling system requires them to think. The result is that designers raise their conceptual focus from geometry construction ("How do I build it?") to design function ("Why build it this way?"). And because Functional Modeling prevents project teams from getting bogged down in geometrical details, it is the perfect modeling approach for the era of Simultaneous Product Development.

Functional Modeling is only one of three patent-pending ImpactXoft technologies that support the practice of Simultaneous Product Development. We explain these three interlocking technologies in detail in Part III. Here they are in brief:

- ***IX Functional Modeling™***
  Enables a more logical approach to modeling focused on the ultimate functionality of the design. Takes product definition beyond the engineering realm to make it accessible to all members of the development enterprise. *Product designs are created and modified more quickly, even by nontechnical personnel formerly excluded from the process.*

- ***IX Functional Object Representation™***
  Represents model objects as small bundles of intelligent data containing the "recipe" for construction. Enables real-time collaboration on product definitions, regardless of bandwidth. *The full intelligence of part geometry travels readily over the Internet so work is shared almost instantaneously with others.*

- ***IX Design Intent Merge™***
  Intelligently translates only the required model data to be merged between global synchronous and asynchronous development sessions. Enables the fast and efficient exchange of model updates. *Multiple design modifications blend automatically into the product model that each project member sees.*

Innovation in design and manufacturing technology comes in waves, in response to changing business problems. But the fundamental business challenge remains. You need to develop products that customers want and get them to market faster and at less cost than your competitors. Interesting technologies will continue to evolve to address this need.

Part II: The Practice of Simultaneous Product Development

Simultaneous Product Development has four main characteristics that distinguish it from conventional collaborative approaches:

- It is parallel.
- It is global.
- It is synchronous and asynchronous.
- It is role specific.

It's useful to look at each one of the characteristics more closely, given the many conflicting claims about collaborative product development being made in the technology marketplace today. But first, let's take a look at what the practice of Simultaneous Product Development is not.

WHAT IT ISN'T

- It is not serial.
- It is not time-zone dependent.
- It is not model-history dependent.
- It is not bandwidth dependent.

Team communication has certainly always been vital to product development, and the rise of the Internet has encouraged many companies to investigate web-based tools as a vehicle for improving time to market. But "collaborative" does not necessarily mean "simultaneous." Most current tools for collaborative product development perpetuate the older tradition of seriality in which they are embedded. This means that they reinforce the very practices that rob companies of productivity. Project teams using these tools are still subject to the limitations of time-zone geography, history-based modeling systems that only experts can operate, and low-bandwidth connections.

For example, some packages for CAD modeling and product data management allow teams to send complete product models over the Internet. File-sharing systems such as these are useful in conveying complete CAD geometry to multiple engineers. But CAD models are huge, and they take so long to download that it makes no sense to pass them around for comment. As a result, project members work on copies and hope their changes show up in the master model. In addition, because expertise with the modeling system is required, all but experienced engineers are typically excluded from firsthand participation in design. Personnel from sales, marketing, procurement, and production have important information to contribute while products are under design, but their lack of expertise with CAD systems often shuts them out of the process. Companies often trace the source of expensive late-stage design changes to delayed feedback from a vital member of the project team.

CAD visualization tools and view-and-markup packages have arisen to address this. These web-enabled tools allow multiple users from various disciplines to interactively view and manipulate image representations quickly via a browser. The problem is that project members work with simplified pictures of the geometry from which much of the model intelligence has been stripped away. A CAD specialist must come along after they record their comments and must make all the changes directly to the product model before development can resume.

Other systems provide a virtual meeting room on the Web so that all project members can view and manipulate a complete product model and discuss design problems in real time. However, what looks simultaneous is really serial: one participant at a time controls the model while others wait to do their own work. As with view-and-markup systems, most changes to the model must then be transferred into the CAD system. One of the problems with the web-based design review is the inconvenience it causes for project members located across time zones. These systems usually force someone to be working at an unfortunate hour. Competition for Internet bandwidth can also degrade meeting performance for remote team members.

A growing number of design and manufacturing enterprises are hindered by the constraints of software that is "collaborative" in name only. They will recognize the benefits of Simultaneous Product Development and use it to their advantage.

WHAT IT IS

Very simply, Simultaneous Product Development is a method of concurrent engineering in which members of the entire global development chain work *in parallel* to create and finalize product definitions. Another term used to describe it is *parallel co-development.* The distinction between serial and parallel development may seem subtle at first, but the transformation it involves is akin to rounding a riverbend. Opportunities await product teams that enter this new world.

Simultaneous Product Development Is Global

Not so long ago, products were developed by engineers who worked elbow to elbow. Designers sat together in engineering bullpens next to an adjoining factory. But the days of physically co-located operations are numbered. Fewer and fewer companies operate under one roof. Manufacturers are increasingly decentralized, with production facilities and product development teams located all over the world.

Simultaneous Product Development replicates all the virtues of physical co-location and applies them in a global context. Distributed teams can leverage the core competencies of partners, locate facilities close to customers, and take advantage of local resources to bring innovative products to market faster and at less cost. At the same time, development unfolds like a group conversation. No participant is inadvertently left out. Even when your mechanical engineers are in Los Angeles, your electrical engineers are in Chicago, your moldmakers are in Taiwan, and your assembly operations are in Mexico, all these specialists can work just as closely together as if they were in the same room.

In many industries, OEMs are delegating more design responsibility to subcontractors throughout the supply chain and are pulling in strategic partners and customers. Mechanical engineers, electrical engineers, and industrial designers must share detailed knowledge of part geometries, clearances, tolerances, materials, and other variables. Manufacturing engineers must provide continual feedback on how evolving components can be produced and assembled. Procurement must walk hand in hand with suppliers worldwide. Marketing and sales experts must be able to influence a design before it goes off the tracks.

The information load is intense for activities throughout the product lifecycle. Without the right tools, collaboration is the Achilles heel of globally dispersed development teams.

Simultaneous Product Development Is Parallel

Figure B depicts the time and cost savings that are theoretically possible when product development proceeds in parallel rather than according to the traditional sequence. The time savings add up radically to compress the development cycle when activities run concurrently. As we discussed earlier, the ideal of concurrent product development is not new. Up till now, it's just been out of reach. The practice of Simultaneous Product Development wrestles the ideal down to earth and brings it within grasp.

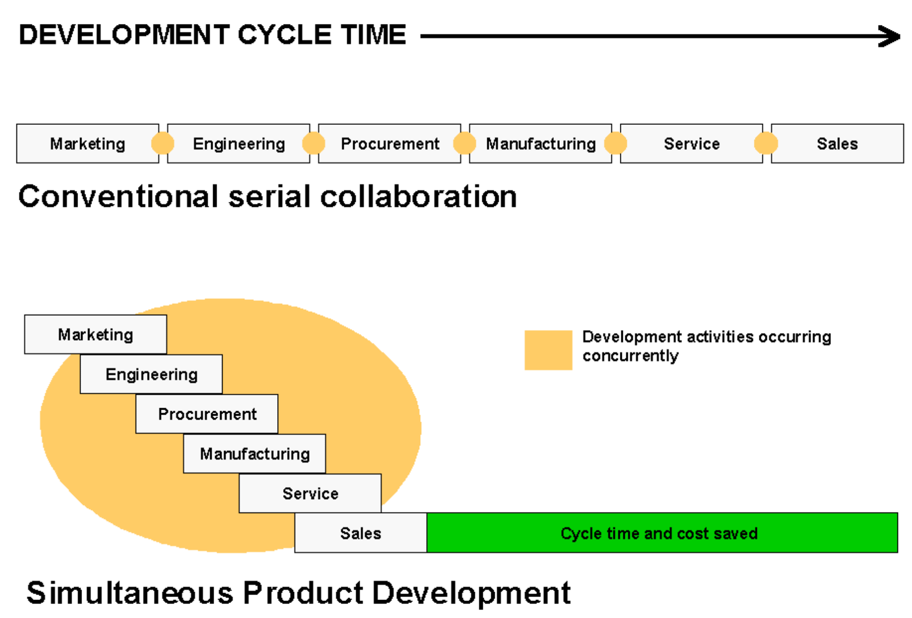

Figure B. Simultaneous Product Development reduces time to market by promoting concurrency across the entire product lifecycle.

A vital insight was required: digital product modeling had to be reinvented for design teams. Companies increasingly rely on digital models to carry the complete product definition, but few project members outside of engineering can open a CAD model and make a necessary change. CAD modeling has sometimes been a troublesome adventure even for engineers.

Simultaneous Product Development is based on the premise that specialists from every area – design, manufacturing, procurement, quality control, service and maintenance, sales and marketing, and so on – should be able to contribute directly during product design. In this way, product definition can proceed as quickly and efficiently as though all these experts were together in the same room, discussing issues, making recommendations, and resolving problems. These experts are not just shown the design in a visualization tool and asked to record opinions or notations that someone else must later interpret and insert in a master model. They actually interact with the geometry and remodel the product themselves.

The modeling software should be easy to use, so that product experts who have no experience with digital modeling – and who as a result have traditionally been excluded from vital modeling decisions – can work concurrently with modeling specialists. The authoring tool should simplify the design process and reduce the emphasis on geometry creation, so even CAD novices can easily revise the original model. Designers and other professionals familiar with modeling software can work with part geometry much faster than is possible in a conventional CAD system.

Simultaneous Product Development Is Synchronous and Asynchronous

The terms *synchronous* and *asynchronous* describe two different modes of development used by globally dispersed product teams.

- In synchronous development, project members log on together at the same time to a scheduled design session.
- In asynchronous development, project members work offline at different times and log on whenever they are ready to post their contributions.

As we explain below, *synchronous* and *asynchronous* mean different things depending on whether the tools that implement collaboration are serial or simultaneous. Using serial tools for synchronous development– view and markup software, virtual meetings, and so on – severely limits the productivity of teams. Everyone might be logged onto a meeting site at the same time, but the synchronism stops there. Participants must wait their turn to work directly on the product model or must pass along to others comments that are later incorporated into the model.

In contrast, Simultaneous Product Development allows project members logged onto a design session *at the same time* to all work directly on the product model *at the same time.* This is the true definition of *synchronous.* It means *simultaneous.* They can all do their own work on the same model at the same time without interfering with one another. In synchronous mode, project members work on their respective models at their own pace and then broadcast and merge their additions and changes. The models of other project members are automatically reconciled with their own. Only ImpactXoft technology makes this possible.

Project members who choose the asynchronous mode of Simultaneous Product Development are especially free from the limitations of serial tools. Asynchronous collaboration is often the mode of choice when the development enterprise spans time zones. But problems arise when people work offline at their own locations and then try to compile ideas. An expensive and time-consuming layer of administrative control is usually required to enforce the order in which project members can make changes and to later reconcile inconsistent design suggestions. ImpactXoft technology erases the need for this step-by-step control and thereby transforms asynchronous collaboration into true parallel co-development.

Here's how it works. A mechanical engineer in the New York broadcasts her updated product model over the server on a Tuesday evening. Nine hours later, when the industrial designer in India logs onto the project, he receives her updates and merges them into his own design, simply by clicking on her update package sitting in the inbox. Without missing a beat, he continues to develop the product and then broadcasts his updates to the project team. A few hours later, when the marketing director in France logs on, he easily merges the engineer's and the designer's changes to check the developing product against customer requirements. He then broadcasts his own updates. On Wednesday morning, when the engineer logs on again from her location in the United States, she merges the designer's and the marketing director's updates to examine the model for new structural issues that may have arisen.

Meanwhile, other team members located elsewhere in the world are receiving and broadcasting updates to the product model just as easily. They can receive notes or documentation from other project members, as well as review a list of all the model updates that have occurred since they last logged on. They can perform modeling operations while offline and then log on whenever they are ready to share their contributions. This type of asynchronous development, the truest manifestation of "around the clock" product design, has never been so simultaneous.

Simultaneous Product Development Is Role Specific

The members of any product team contribute specialized knowledge according to their expertise and role in the project. But the members of Simultaneous Product Development teams are able to contribute *in parallel* because they all have the opportunity to perform hands-on modeling. Production specialists make ongoing updates regarding assembly and fabrication on the factory floor. Industrial designers correct the aesthetics of a product model as it evolves. Sales and marketing personnel revise digital designs to match market demand and the voice of the customer. Quality experts adjust models to comply with company and industry standards. Procurement specialists access geometry to check if outsourced parts will fit.

Project members see whatever model components are pertinent to their specific role in development. They focus on their individual development tasks and then merge their contributions with those of others, as appropriate.

For example, because an industrial designer focuses on external shape, his view of a product model will differ from that of a mechanical engineer, who is concerned with structural integrity. The designer must send shape changes to the engineer, but the engineer need not send structural revisions back to the designer because they don't affect external aesthetics. The model the designer works with might be a solid that is not split or shelled. On the other hand, the engineer would see the very same model with the split, shell, and ribs displayed. In the same way, the project coordinator could configure her settings to automatically view all updates to the model that are posted to the server. She might want to see the contributions of the designer, the engineer, and all other project members. Her model would show all the merged data.

As you can probably imagine by now, Simultaneous Product Development enables global teams to run quickly through "what-if" scenarios. Together, project members can generate ideas that never occur to specialists working in isolation. They can speedily air concerns about requirements, manufacturing, testing, service, and so on. With ImpactXoft technology, getting deep multidisciplinary input during the early stages of product modeling is finally an attainable goal.

Part III: The Tools of Simultaneous Product Development

For companies that wish to achieve Simultaneous Product Development, ImpactXoft provides practical tools that are easy to implement.

- A design authoring tool that is robust and intuitive so even CAD nonspecialists can work directly with solid models
- A means of representing model geometry so project members can use the Internet to share complex product design changes instantaneously, even over low bandwidth
- A method of merging design changes so contributions from all remote project participants blend together smoothly

Below we describe this trio of underlying technologies for Simultaneous Product Development and the capabilities of our IX SPeeD Suite of software.

UNDERLYING TECHNOLOGIES

Three proprietary ImpactXoft technologies serve as the foundation for Simultaneous Product Development: Functional Modeling, Functional Object Representation, and Design Intent Merge. These enabling technologies operate in the background of IX SPeeD software, automating tasks as project teams focus on creating, modifying, and sharing product definitions.

IX Functional Modeling™

Functional Modeling is an approach to design authoring that shifts the emphasis of product modeling away from the time-consuming construction of geometry. At the heart of Functional Modeling are *functional features* that encapsulate rules governing how design elements, such as ribs and pockets, should behave to meet industry-specific design and manufacturing expectations. Functional features have built-in intelligence that preserves the function of design elements, and they automatically generate and adapt model geometry as the design unfolds.

Why the focus on function? The function of any design element – a rib, a fillet, a pocket – is expressed by the way the element behaves within the context of the overall product model. Thus, for example, the function of a rib is to add strength to a shelled body, the function of a fillet is to round a sharp edge, and the function of a pocket is to add a container to a body. ImpactXoft has invented a way to embed into each design element the rules of behavior that designers expect so that each element serves its function properly. (For an illustration of how Functional Modeling works, see Example One.)

Example One: The Way It Works

How Functional Modeling Simplifies Design

Figure 1. Here is a thin walled enclosure that an engineer might use to start a design for a computer housing.

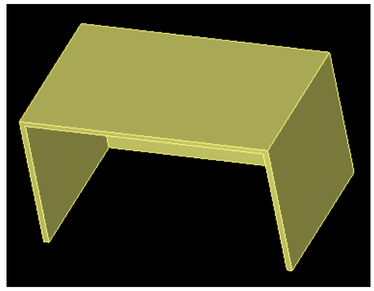
Figure 1

Figure 2. (a) Let's say the engineer adds a pocket to the enclosure to install a control panel. This design step is completed by simply selecting a feature called Pocket and indicating the size and location of the pocket. Functional Modeling applies rules to preserve the behaviors the engineer expects of a pocket. (b) For example, IX Design automatically creates a pocket that has lateral walls, a bottom wall, and predefined fillets to maintain a constant thickness and to ensure manufacturability.

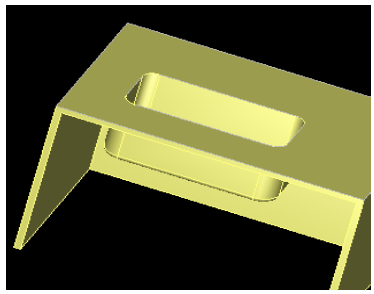
Figure 2a

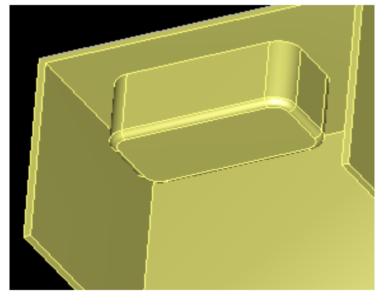
Figure 2b

Figure 3. With Functional Modeling, even complex topology changes are easily managed. Here the pocket is dragged outward so that it grows beyond its initial dimension. As you can see, the pocket retains walls even when it protrudes from the enclosure. In other modeling systems, a pocket dragged to an edge might turn into an open-sided slot or might even fail the model. Traditional modeling systems can not automatically adjust to such a radical change in a parameter because they are based on the geometry of design features rather than on the behavior of design features.

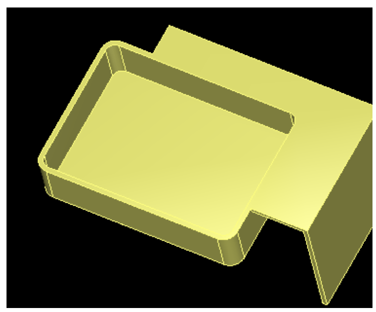
Figure 3

Figure 4. (a) Here the engineer adds ribs to the enclosure. The ribs, like the pocket, are design objects with established rules governing their relationships with other objects. (b) The underside of the enclosure shows that the added ribs conform perfectly to the shape of the pocket and uniformly fit within the available space of the enclosure.

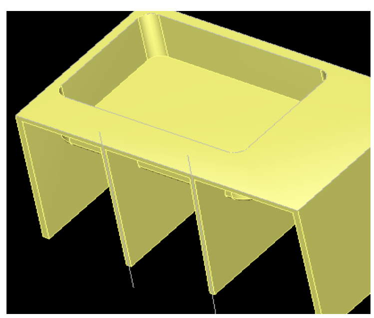
Figure 4a

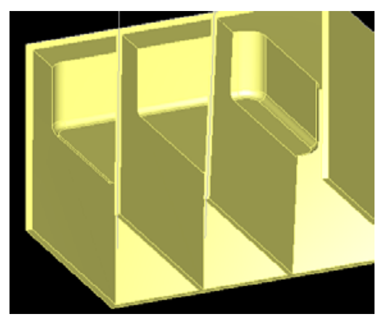
Figure 4b

Figure 5. (a) Here the engineer decides to change the volume body of the enclosure. In this example, the addition of a simple box shows the power of Functional Modeling to preserve design intent by keeping the volume of the pocket intact. (b) Furthermore, the shell parameters and the ribs extend to the new volume body of the enclosure accordingly, without requiring any modeling operations from the engineer.

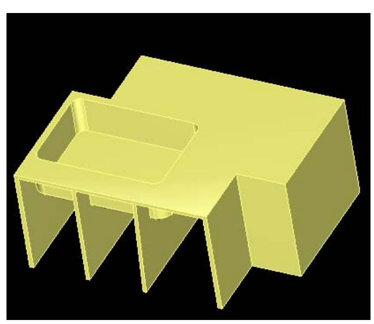
Figure 5a


Figure 5b

Product development teams will find Functional Modeling a refreshing change, because traditional modeling approaches consistently produce models that behave in ways designers do not expect and did not intend. Parametric, history-based modeling systems are particularly weak at preserving original design intent through multiple modeling revisions. Because these systems regenerate the product model by replaying the construction history, modeling often requires a deep understanding of the tricks of the history tree. Even to create a model, designers must first think in terms of the detailed constraints, relationships, and steps necessary to manifest part geometry.

ImpactXoft recognizes that designers and other project members, especially CAD nonspecialists, should be thinking about how to fulfill product requirements, not how to operate their software. So Functional Modeling is *history independent.* Design elements can be introduced in any order, and the model will always observe design intent. Functional Modeling is also associative, which means that a change to one element automatically updates all related elements.

Functional features include fillet, chamfer, cutout, boss, rib, and shell, as well as those not found in other modeling systems, such as divide, grill, pull, push, and split. Designers can also create their own functional features to embed specialized in-house modeling rules and intelligence.

IX Functional Object Representation™

Functional Object Representation is a technology that represents objects in the product model as small bundles of intelligent data containing the “recipe” for construction. This approach provides a solution to the problem of sharing large CAD models over the Internet. For expediency, many design collaboration packages strip important details from CAD models so that project members share only a simplified faceted model. Even faceted models travel slowly over variable Internet bandwidths, however, and design changes still must be reconciled later with the original model.

Using ImpactXoft technology, project members send one another only the instructions needed to create the digital model. This instructional “recipe” conveys intelligence on the full model (with all its features and functionality), including any changes that have been made to the model, in a small bundle of data. The reduction in file size is dramatic. Elaborate revisions to a digital model may amount to a bundle of perhaps 10 kilobytes. Consequently, design changes can be very quickly transmitted over standard dial-up Internet connections as low as 9.6 kbps. With the capacity to communicate efficiently even over low bandwidths, no project member need be excluded from timely decision making.

IX Design Intent Merge™

Design Intent Merge is a technology for receiving the bundles of model data created by Functional Object Representation and intelligently blending design modifications into the model stored on each participant’s workstation. Project members can exchange multiple design revisions in quick succession while the system automatically merges all the updates. As a result, in synchronous or asynchronous mode, globally dispersed development teams can communicate efficiently and stay focused on design productivity. (For an illustration of how ImpactXoft technology enables concurrent product development, see Example Two.)

Example Two: The Way It Works

How IX SPeeD Enables Concurrent Product Development over the Internet

Figure 1. (a) Using IX Design software, the offsite industrial designer starts modeling a computer mouse for her customer. (b) The designer joins the development team. Current members show four engineers, a marketing manager, and a site administrator. Testing and procurement experts will also join. The designer logs on, sends the basic shape of the mouse plus the splitting surface to the mechanical engineer, and continues to work.

Figure 2. The mechanical engineer shells and splits the mouse body and begins to determine internal components such as ribs that will hold the circuit board and the ball and its supports.

Figure 3. Meanwhile, the designer experiments with the top face of the mouse. She decides where she wants to place the buttons and sends just the button profiles to the engineer. The remainder of the face will follow when she is satisfied with the shape.

Figure 4. (a) The engineer accepts the button profiles. Thanks to ImpactXoft technology, they merge automatically into his view of the mouse as he works. (b) A few minutes later, the completed top face of the mouse arrives in his inbox from the designer. It, too, merges flawlessly and updates his engineered buttons accordingly. (c) A closeup of the engineer's inbox shows the extremely small file size of each design change he has received. The button profiles are only 22 KB.

Figure 5. (a) The marketing manager joins the design session remotely and requests more curvature to the mouse. Shown here is the designer's view with the revised shape and placement for the mouse wheel. (b) A closeup of the chat window along the bottom of the screen. The designer and the marketing manager discuss the change in realtime.

Figure 6. (a) The engineer merges the final changes he receives, including the new shape and the wheel depression. All his own contributions to the internal components instantly update with no reworking required. (b) Rather than showing an exploded view, the designer's final view of the model displays according to her role in the project.

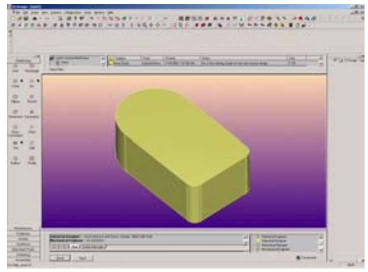

Figure 1a

Figure 1b

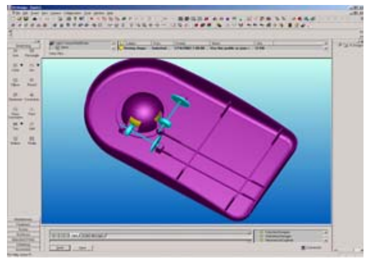

Figure 2

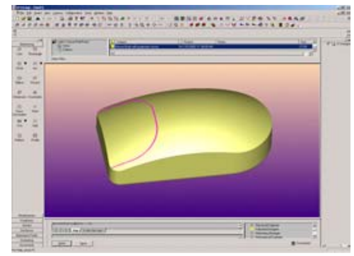

Figure 3

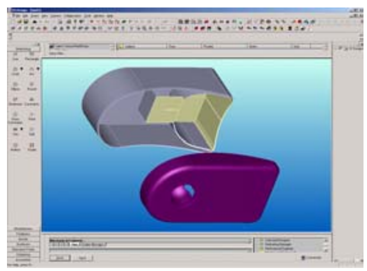

Figure 4a

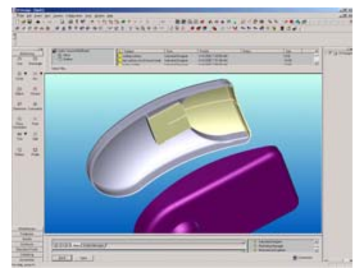

Figure 4b

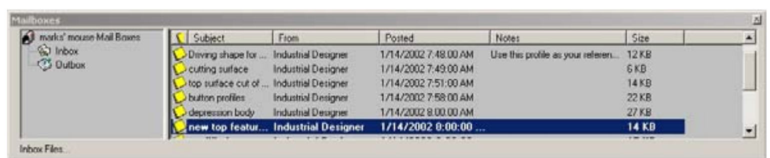

Figure 4c

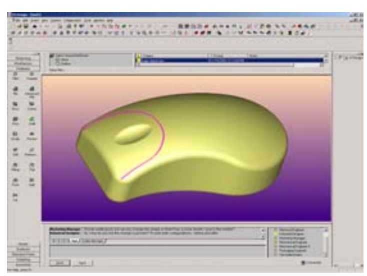

Figure 5a

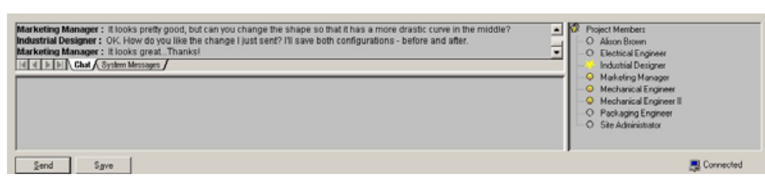

Figure 5b

Figure 6a

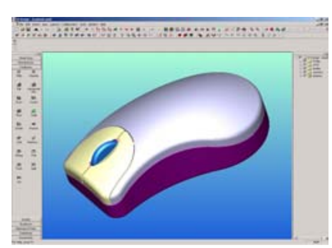

Figure 6b

IX SPEED SUITE

Product development teams use IX SPeeD software to work concurrently in an Internet or intranet environment.

- In synchronous mode, project members log on to a design session and work together in real time to create a digital product model. Modeling operations merge immediately with the respective models of participating team members.

- In asynchronous mode, project members work separately on assigned design tasks and then send changes to other team members, who have the option of selectively or automatically accepting modifications whenever they join the project.

- For role-specific use, the software displays different versions of the same model to project managers, industrial designers, mechanical engineers, procurement specialists, molding manufacturers, and so on.

The IX SPeeD Suite consists of IX Design – digital modeling software reinvented for the age of the Internet – and server software that supports global parallel co-development.

Some major capabilities of IX SPeeD Suite:

- ***Functional Features***
  A set of modeling features with predefined functions and behaviors that govern the way design elements interact and that automatically generate geometry
- ***Sketcher, Wireframes, Surfacing***
  Design tools that project teams use to build and manipulate complex models for product components and assemblies
- ***Detailing***
  Tools that produce accurate documentation associated with product models
- ***Organizer and Navigator***
  Management tools that project teams use to organize model elements and access information vital to the product definition
- ***Automatic Sharing and Merging***
  Tools that update the product model instantly for all project members
- ***Selective Sharing and Merging***
  Tools that project members use to share updates selectively, as appropriate
- ***Global Chat, Bulletin Board, and Notification Mailbox***
  Tools that project members use to communicate while online together and to view all past and recent design updates
- ***Project Management***
  Comprehensive management options for assigning privileges to project participants according to incumbent business infrastructures and processes
- ***Open Architecture***
  Opportunity for complete customization using the COM-based IX Application Development Framework
- ***Interoperability***
  Compatibility with other modeling systems via tools for importing and exporting digital models in formats such as SAT (ACIS), IGES, STEP, VDA-FS and Parasolid
- ***Encryption***
  Projects can be set up with zero, 40-, or 128-bit encryption.

Part IV: More Earthquakes and Evolutions

Functional Modeling and its related technologies do not represent the last earthquake in product design and development. Indeed, if market patterns continue, these tools will serve as a foundation for building emerging technologies starting in the 2015 timeframe. Future tools may take advantage of rule-based operations to generate entire product models automatically, based on design goals and constraints established by the user. Such "design synthesis" systems are a distinct possibility if artificial intelligence and sophisticated inference engines continue to advance. These and other technologies will give product developers tools that we can barely imagine today.