Using Conceptual Modelers For Business Advantage

The RP market will continue to grow and the technology will continue to improve, however, advances in how this technology is applied will overshadow these technological improvements and market growth.

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Until now, rapid prototyping has been developing technologically, but in the future, it will be developed as a business tool. Like other business tools, it will have to justify itself on the basis of how much it can return to a company's bottom line relative to what it costs—just as would an engineering workstation, a new machine tool, a PDM system or an additional designer. Business managers will look at this technology and ask, "How will this RP model make money for me?"

This article explores a new means of applying the technology for business advantage, concentrating on the new generation of conceptual modelers.

Comparison of a Conceptual Modeler and a Traditional Rapid Prototyper

Basis of comparison	Conceptual Modeler*	Traditional Rapid Prototyper*
Purchase price of machine	$55,000	$500,000
Cost of making part (Note 1)	$83	$540
Cycle time (Note 2)	Same day (1 hour)	2 days (9 hours)

* Conceptual modeler used is a Z Corporation Z402.
Traditional rapid prototyper is a 3D Systems SLA 500.
Part modeled is a 75-mm diameter solid sphere.
Note 1: Price from a service bureau.
Note 2: Total turn-around time (actual build time)

Table courtesy of Santin Engineering.

Table I By the three measures listed, conceptual modelers are almost 10 times superior to traditional RP systems. By other measures, they may be inferior; however, this clear contrast suggests that conceptual modelers are a distinct tool that may be employed quite differently than traditional systems.

The Maturation of CAD

CAD is a few years older than RP, yet the way it has matured is illustrative of what is likely to lie ahead for RP. CAD began as a 2-D means of automating drafting—doing the same job that a draftsperson on a board could do, only faster and more accurately. The technology now has advanced through wireframe modeling to full 3-D solid modeling. CAD has been riding along for years on claims of making drawings faster and better; however, business managers are now asking bigger questions such as "How will it really accelerate our whole product development process?" or "Exactly how will it help us to eliminate manufacturability problems?"

Conceptual Modelers

Conceptual modelers offer abundant opportunities for making solid business improvements and have great untapped potential for cutting time-to-market. In the eyes of many, conceptual modelers are a poor person's RP system because they are more inexpensive to purchase than "real" RP systems. Their materials are cheaper, and their installation and operation are cheaper and easier; however, their parts don't provide the strength and accuracy of those made by "real" systems—and their parts can't be very large.

A company that can afford to buy a "real" system wouldn't buy a conceptual modeler. This is a limited view, which does not recognize the awesome role conceptual modelers could play in rapid product development. **Table I** shows quantitatively just how different a typical conceptual modeler is from a typical traditional RP system.

Since conceptual modelers are considerably faster and cheaper than other RP systems, and because they can be operated by anyone in an office environment, they have a potential advantage; however, few organizations are exploiting these advantages. Much of the RP community still views conceptual modelers as inferior to the traditional RP systems—in terms of the resulting parts' accuracy, surface finish, maximum size and strength.

Effectively Using Conceptual Modelers

Using conceptual modelers effectively requires a new way of looking at the real purpose of models. For example, a major American toy manufacturer has been making computer-driven models of its development concepts since the 1980s. Among other applications, it has used RP to develop doll heads. This company scans doll head shapes, creating "on the shelf" digital data files. When the designers request a model of a particular head, the model shop only has to apply a scale factor to this file to create the desired head at the required size. Although this sounds impressive, it is really only doing the same things faster.

The toy manufacturer's breakthrough didn't occur until the model shop observed that what often happens to the first head

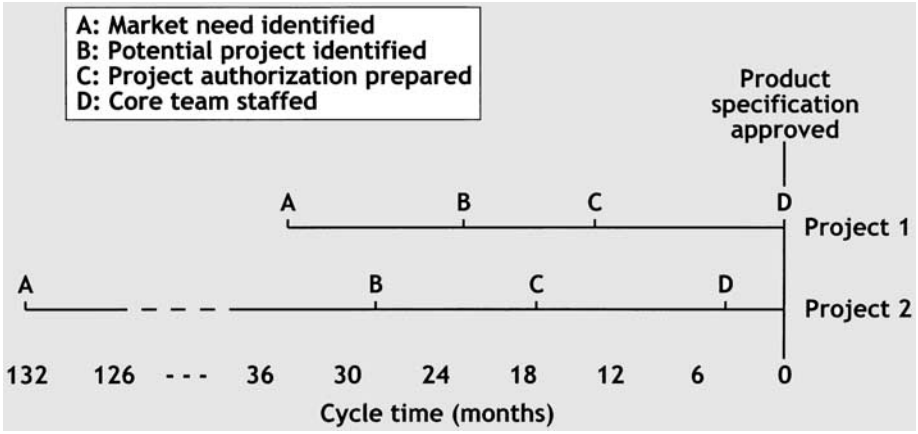
model is its return—after the development team looks at it—for another model slightly larger or smaller. So now the model shop routinely makes three models initially—one at the requested size, a smaller one and one slightly larger. This saves a lot of decision-making and model-making time—the big opportunities are not the few hours saved in making a model, but the weeks that are saved by being able to decide on the right size head without another go-around.

A second example comes from the competitive world of consumer electronics, where the highly subjective factors of look, shape and feel often get questioned at design reviews. When this happens, alternative designs must be explored, which delays the project. Designers at a well-known American electronics company identified this major waste of development time and are now overcoming it by applying conceptual models. They now identify their ultimate decision makers early, then progressively prepare them for the final design decision. The critical decision-making staff includes marketing and sales, customers, suppliers and the appropriate executives.

Now the designers initially explore dozens of options and make quick-and-dirty models using a conceptual modeler. Very early in the project, this provides 15 to 20 models. The designers show these relatively crude models to the decision makers for feedback. More importantly, the designers are building buy-in for the ultimate solution.

At this early stage, designers can incorporate customer reactions without delaying the project. They follow these first models quickly with a second round of perhaps four or five models that combine the most desirable features from the initial batch. They also circulate these models to decision makers for feedback. Now they can make the final model (or perhaps two).

At this point, the designers can almost sleep through the design review meeting, because they have set themselves up for almost certain approval of the final model. After all, everyone who will make the decision on it has personally helped to design it. How can they fail to approve "their own" design?



Figures courtesy of New Product Dynamics.

Figure 1 Great amounts of timesavings are available to companies that learn how to move decisively in the fuzzy front end of development.

A New View of an Old Process

Fortunately, newer rapid modeling technologies do provide the potential that is being exploited by the toy maker and electronics manufacturer aforementioned—enhancing communication around concepts. To take full advantage of the possibilities, however, organizations must shift their modelmaking speed toward new objectives.

Traditionally, as with CAD systems, rapid prototypes have been promoted on the basis of their direct time compression. For example, today's conceptual modelers can make a prototype in two hours that would have taken a week without rapid prototyping. This is impressive on a percentage basis, but the week saved is meager in the context of a 12-month development cycle.

Alternatively, the week saved can be extended to several weeks or months by altering the product development process. To accomplish this, first the slowest parts of the development process must be identified. Then to radically accelerate these activities, the prototype's potential must be applied. Rather than the traditional approach of searching for opportunities to apply a technology, one must first discover the major sources of waste and delay, and then apply the right tool.

Where Is the Opportunity?

Ironically, the biggest opportunity to save time is before most companies even start their clocks—the period before concept approval, which is called "the fuzzy front end" of product development *(see Chapter 3 of Reference 1)*. After concept approval, many companies have made great improvement in their time-to-market.

For example, consider that Chrysler has made progressive improvement in its post-concept development cycle time from *54* months down to nearly 20 months. However, few firms are even aware of the large amounts of time that slip away unnoticed in the fuzzy front end.

Consider the fuzzy front-end timelines for two projects from a company producing industrial valves. Although some important activities occur before this organization approves a specification, it also is true that months slip by where the project is in limbo. If one could use prototypes to crystallize options, precipitate customer feedback and provide a forum for discussion between engineering, marketing and other players, the wasted months could be recovered **(see Figure 1).**

Many companies, including Chrysler, simply choose to define the start of a development project as the time when they have approved a concept. Notice, however, that this internal milestone (concept approval) is immaterial to the marketplace and the competition, which start their clocks when the market opportunity arises. Consequently, even though a company may chose to ignore the front end, it is a completely legitimate place to save time, because it is just as valuable as any other part of the development process from a marketplace viewpoint.

Decreasing Front-End time

To discover opportunities in the fuzzy front end, one must become sensitive to where the time vanishes.

Decision-Making Delay

What holds up a decision in the design process? Later stages of the design process have well-defined decision points and relatively clear, objective data to form the basis of decision making. In earlier stages, the schedule, the process and the data are all softer. The relevant parties to the discussion

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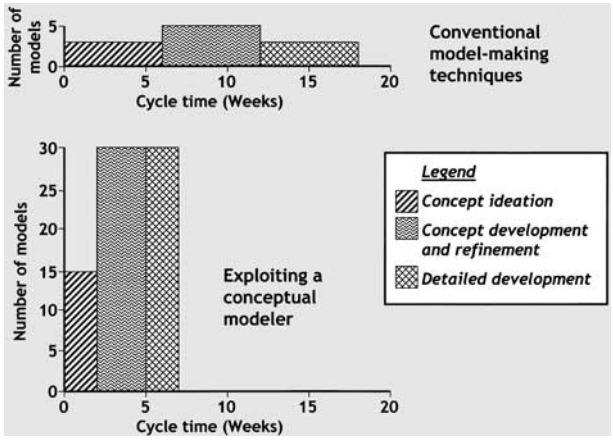

Figure 2. By exploiting a conceptual modeler for a surgical laser product, a North American firm cut cycle time in one project by 60 percent. The faster approach used almost seven times as many models, but because conceptual models are much less expensive (see Table I, page 18), the total cost of the models for the faster approach was only 60 percent of the cost of the conventionally made models.

may not have a common base of communication. It may not even be clear who the relevant parties are. There are fewer deliverable pieces of output to force a decision.

Lack of a Common Decision Making Medium

All of the relevant parties to a key decision (marketers, engineers, manufacturing staff) may not have access to the same, commonly understood information on any regular basis. Engineers have difficulty interpreting focus group results and marketers can't read engineering drawings.

Lack of Communication

A design process can wander—too many or too few possibilities may be under investigation. One company in the sensor design business on a recent project found that the different segments of the design team, which were each located in different regions, were pursuing ideas subtly incompatible with the concepts evolving at other sites. After these different branches of development grew apart for several months, the groups had a dramatic shock. Two of the three groups were forced to perform substantial redesign to be compatible with the third.

Lack of Consensus

Different parties to the design process may have different ideas where to take a product. In one recent project, several designers developed differing ideas about which way the product should go. They were left debating the relevant advantages based only on their readings of CAD drawings and 2-D renderings. The relevant arbiter of the discussion—the customer—could not be brought into the discussion because he/she couldn't effectively relate to the drawings or renderings. This left the decision process resting solely on personal opinion; the project deadlocked for weeks. Each side became more convinced that it was right, and ultimately one team member left the project.

Changes in Direction or Rework

Often a critical mistake that existed in the digital model for weeks will go unnoticed and only appear when the project approaches production. Recently one project was held up for a month when it was noticed that a late-stage change on the internal components would force a rerouting of the wiring. This problem existed in the digital data for weeks, but was only found when the project entered a late-stage modeling phase. If noticed earlier, the delay could have been avoided completely.

Sometimes the end customer will find a mistake very late in the process. On a design effort for a hand-held tool, the basic grip design was found to be extremely uncomfortable if held for several hours, which was a long but not an unusual period of use for the tool. This forced the design team into either choosing weeks of delay in product release or reaching market with a product that would only appeal to *75* percent of the potential market.

Lack of Priority or Attention

Root-cause analysis of a project in the chemical industry showed that it had lost months because certain individuals in engineering and marketing couldn't agree on defining a critical feature, so they essentially tabled the project. Management was amazed to discover that a project could be derailed so easily before it even got started.

Prototypes Accelerate and Improve Development

People React to Prototypes

In the most general sense, prototyping is so deeply ingrained in people's lives that it is hardly noticed. Documents are prototyped in rough draft and circulated for feedback; presentations are prototyped through rehearsal; and new recipes are prototyped on the family before serving them to the guests. Prototyping in its various forms is already a management tool that is used every day to create and maintain focus, to monitor and guide progress, and to communicate project status across an organization. Prototypes can be used to solicit feedback, or merely to convey information to those who need it now or will need it in the future.

Everyone has had the experience of being in an aimless meeting. Each participant has a slightly different perception of the issues and even the objective of the meeting. Then someone puts up an agenda and suggests an action plan. The plan need not be completely developed; the goal is not to give the answer, but rather to structure the discussion. Suddenly people have a prototype of future action from which to react. The holes in the action plan appear and can be addressed. Differences in opinion can be found, addressed and resolved. Improvements can be suggested. Progress can be made. Prototypes also can be valuable as a communication tool. Seeing a prototype can spur action and focus where there is otherwise little opportunity for input.

What is the relevant prototyping form for new product development? It is the one that prompts the kind of reaction that moves the project forward—that forces the specific decision that is now on the critical path. A physical prototype is the logical discussion piece and management tool for new product development.

Prototypes Create a Common Language

A 3-D model puts engineers, managers, manufacturing staff and marketers on an equal footing in evaluating a design. All of the interested parties can react to the design, as the ultimate customer will. Some companies actually involve the end customer in the process by using these tools. One medical product developer prototyped 12 different concepts of a hand-held device in one day by using a concept modeler and then convened a test panel of nurses to evaluate the design. They identified the best features from each concept and quickly created a hybrid design that captured these features.

These types of models also clarify communication. This communication can span geography, using concept modelers as a 3-D fax. Graco Children's Products—a leading manufacturer of child safety products—uses a concept modeler to communicate between the design facility in US and the production facility in China. Three-dimensional models also can communicate across disciplines. A leading automotive company

uses concept models to communicate between the engine designers and the foundry. Adidas is now using concept models to rapidly create new sole designs and then immediately broadcast these models around the world to sister facilities. It e-mails the CAD data, and the models are "printed" at the remote sites, creating a "3-D *fax"* capability.

Prototypes Crystallize Options and Force Decisions

Concept models also can be an effective project management tool—a way to provide more input to the design process. In a recent project, a sensor design company regularly produced four sets of concept models in each design iteration. It sent one copy to the marketers and a focus group of end customers several times each month. The design team stayed close to the needs of the customers, while the managers could monitor the progress of the project closely. At these meetings, the team presented options and established a consensus to pursue a given direction and reach certain goals by the next review. Regardless of technical training or access to specific hardware, each member of this design effort could access the same information at the same time in the form of the 3-D model.

Prototypes Accelerate Progress

ExpressCAD (Huntington Beach, CA)—a design services firm—went from initial concept for a skateboard wheel assembly to finished parts in just 10 days by placing itself on the regimen of a model a day. At the end of each day, a new model was delivered to the client to solicit reactions and obtain direction for the next day's activities. This is essentially scheduling creativity on a daily basis.

Prototypes Focus Attention

Design review has relied on 2-D drawings or renderings to structure the discussion. For many applications, a 3-D model can be far more effective. At this point in the design process, the final qualities of the end product need not be present in the model. Here it is only important that the model convey information more clearly than the 2-D drawing. At a recent design review for a component of an upcoming Mars lander, a concept model was used as a tool in the review process. The physical model very quickly drew attention to the problem areas of the design. For example, a certain piece would not have the thickness required to survive the impact of landing. Those involved felt that the physical model drew out the most important questions almost immediately and helped with prioritizing efforts.

Prototypes Are Used to Explore and Experiment

Many companies must wait until they have tooling before they can see their designs in 3-D. Conventional rapid prototyping involves a cost and time commitment that will typically allow for only one model prior to tooling. Concept modelers can provide many snapshot views of the product in 3-D at a fraction of the time and cost. This opportunity to see the design frequently as it evolves allows a designer to take more chances and to be more creative, as less time, effort and ego are invested in each model.

A leading Italian housewares manufacturer, Gio'Style, commands a significant premium over competitors in the same markets because it consistently delivers a superior design. To fully explore a wide range of possibilities, it uses concept modeling.

A major company in the hand-held communications market uses concept modeling to accelerate creativity. Rather than the normal practice of delaying modeling until after it establishes the major design direction, it starts by printing 10 different approaches to a design. Then the company solicits feedback on these and selects the best features of each for a new series of hybrid designs in just a few days.

Changing the Prototype Mindset

What holds us back from applying physical modeling in the radically different ways that some of the examples above suggest? There are two answers: (1) most designers have not creatively considered how they could use this new generation of fast, inexpensive models to dramatically reshape the way they design and (2) most people would rather not change familiar patterns and undertake new uncertainties.

The examples above are only starting to scratch the surface of what could be done to use conceptual modelers to our advantage *(see Reference 2 for other ideas on using rapid prototyping for business advantage)*. Following are some suggested principles that will help you to take the next steps toward modifying your design style to exploit conceptual modelers.

Each Prototype Should Be Aimed at a Specific Question That Needs Answering

When models were expensive and slow to make, one could only afford to make models that tested several ideas at once. Now we can afford to test ideas individually, then mix and match them later. Consequently, to assimilate this new behavior, explicitly plan to use each model to test only one idea or assumption.

Note that this advice "contradicts" what has been learned from Taguchi and design of experiments (DOE) techniques, which enable one to use a minimal number of models to arrive at an optimal design through quantitative analysis. In light of Taguchi/DOE, what is suggested here is "wasteful," however, in the bigger view of the value of getting a product to market quickly and the fact that much cycle time is squandered in gaining consensus between departments, conceptual models—used abundantly—are a wonderful tool to make progress quickly.

Prototypes Should Only Be Elaborate Enough to Answer This Question

In later stages of development, where models have traditionally been cost justified, the design was already refined, so a refined model seemed appropriate. When models are used early, such refinement is wasteful.

The concept of hypothesis testing also can encourage one to become comfortable with less refined prototypes. Build a model only refined enough to answer the specific question at hand. Once the answer is presented, discard this prototype and move on. This way, no money or time is wasted polishing the model.

One may notice that there is a behavioral change required here in the organization

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beyond the designer. Everyone, including the accountants, will have to become comfortable seeing a wastebasket full of models that have answered their questions. This represents progress. To help with this, consider the paperless society that computers were to bring. The truth, so far, is that paper usage is actually rising. Why? Because a high quality document can be produced more easily and at much lower cost than ever before possible, and these documents enable everyone to run their businesses more effectively.

If You Think of Multiple Alternatives, Build Multiple Prototypes in Parallel

The speed advantage of proceeding on multiple activities in parallel is common knowledge, and now one can afford to do it with models. If alternative ways to solve a design problem are developed, make models of each option first, rather than presupposing the best solution and proceeding with it. With models of the alternatives, new combinations may become apparent. It also is likely that one can eliminate downstream decision loops by presenting options early.

Commit to Decisions Progressively As Questions Are Answered

This is probably the most difficult change in habits needed, but it also is the most crucial and one that impacts other individuals—such as marketers, people in manufacturing and top management.

The principle required to make progress quickly with models is to move forward incrementally with small but sound steps. If the final decision-makers still wait until the final, "perfect" prototype appears before making any commitments, there will still be many re-decisions and rework, as well as no essential improvement in the process. This behavioral change is essential if rapid prototypes, especially conceptual prototypes, are ever to grow beyond the "cute toy" stage.

The Faster Prototypes Can Be Made, The Faster Products Can Be Developed

As just indicated, this new process is predicated on making small but sound steps quickly. Thus, the process accelerates to the extent that you can make and assess models quicker. If conceptual prototypes are still made by sending them out for processing at service bureaus and if they are still shipped to decision makers in the same way or if the decision makers still take as much time to make decisions as before, there will be no overall acceleration. Success is dependent on the ability to shorten the iterative loop.

Are We There Yet?

Is your organization operating in this new, faster mode yet? How do you know? Measure how your company formerly used conceptual models, then compare this with how your company uses them today. This will demonstrate whether your company has made substantial changes.

Figure 2 (page 22) shows before and after views of how one company changed its design process to exploit conceptual modelers. In the "before" graph, it made relatively few models. In the "after" graph, it made many times more models, but pushed its product to market in less than half the time.

References

[1]*Smith, Preston G., and Donald G. Reinertsen,* Developing Products in Half the Time: New Tools, New Rules. *John Wiley & Sons, 1998.*

[2]*http://www.NewProductDynamics.com/articles.htm*

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