Managing Innovation

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Abstract

Although a simple concept in an academic sense, management of innovation is a complex activity for technology managers. Innovation is multifaceted and technology and business managers are poorly educated and unaware of the numerous perspectives they need to deal with. Technology and business managers are also not adequately trained in the tools that support innovation in a global environment.

Innovation is an ad hoc activity in far too many organizations. Successful management of innovation requires in depth understanding of organizations' cultures, the outlooks and expectations of various functional areas, and a process that couples technological creativity to stakeholder needs and expectations at the front-end and to engineering and manufacturing capabilities and limitations at the backend.

Introduction

Innovation is a centrally important aspect of today's business environment. Although strategy, execution, and capitalization remain cornerstones of businesses, innovation is becoming an equally important cornerstone in many sectors. The entire internet economy is based on innovation in business models, which are themselves becoming as important as products as defining features of many businesses. For example, e-Bay has revolutionized the auction business model through innovations involving use of the internet. Innovation in business processes is also a common strategy for gaining competitive advantage. For example, many companies such as GE and the start-up SupplierMarket.com are using internet-based innovations to revolutionize the procurement process and supplier chain management processes. Innovation in product design has also grown greatly in importance. A common strategy for success in productoriented companies is to introduce superior products more quickly, allowing customization to better satisfy the demands of specific customers. Often these superior products are also less expensive. At its extreme, this strategy, which is called mass customization, allows each customer to customize an item to their tastes.[1]

Other chapters of this book have looked at the ways in which innovation is used in successful strategies to gain differentiation, competitive advantage, and the associated higher margins. This chapter looks at the management of innovation. It offers business leaders and managers important knowledge, techniques, and tools to improve their management of innovation. The techniques and tools are demonstrated with real examples of their use. Although the discussion and examples are centered on managing product innovation, the techniques and tools are also readily usable for managing business model innovation. These tools and techniques are equally pertinent to large and small companies and to OEM corporate managers, design service providers, and consultants.

Understanding Innovation

Innovation can occur in all activities and functions, including business models, strategies, processes, and product design as was discussed in the introduction.[2] Innovation is often looked upon as a purely creative activity that cannot be precisely understood and described let alone managed. It is no wonder that there is a diversity of outlooks of what constitutes innovation in many organizations. Some view innovation as an act, which is incorrect. In the context of business models, strategies, and processes, innovation is often through of as the creation of ideas, which is also incorrect. In the context of product design, innovation is often confused with invention. Innovation involves “introducing into use” in most contemporary definitions. The generation of ideas and inventions are

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[1] James H. Gilmore, Joseph B. Pine, “The Four Faces of Mass Customization,” Harvard Business Review, 75(1), Jan/Feb., 1997.

[2] Joan Magretta, “Why Business Models Matter,” Harvard Business Review, May, 2002.

not innovation because by themselves they may or may not lead to a business result. Thus, innovation needs to be treated as a process and not as an act if innovation is to be managed properly. This is the central theme of this chapter, which introduces the concepts of the innovation process.

Recognizing innovation as a process is critical to addressing many of the complaints about the lack of creativity and innovation in organizations today.[3] Most businesses have an adequate supply of creative people, but they lack the processes to harness this creativity. Companies do many things that unknowingly inhibit innovation because too much focus is placed solely on the act of creating ideas or concepts, and not enough emphasis is placed on thinking them through and instituting actions that bring them to reality. It is wrong to divorce the creation of ideas from accountability for working them through to being discarded or acted upon. Fewer ideas which are followed through to their logical completion are far more valuable that numerous ideas that receive virtually no follow-up. Follow through on ideas is natural in organizations that link accountability with the creation of ideas.

The nature of the problem with not linking accountability with the creation of ideas is well exemplified by the common misuse of ideation and brainstorming. Ideation and brainstorming are often treated as autonomous acts, rather than as part of a broader, well-defined process with a specific objectives and an endpoint. There is no definition of ownership, no clear expectations, and no definition of accountability for follow through until the ideas are discarded or implemented. This situation has numerous consequences that have a substantial impact. Ideas that do not have ownership and follow-up pose a severe problem to managers whose work lives are already overburdened. These managers view the ideas as a problem that adds to their workload. The ideas do not go anywhere, which leads employees to be skeptical of management's desire and ability to innovate. This culture of skepticism becomes ingrained and inhibits innovation.

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[3] Theodore Levitt, "Creativity Is Not Enough," HBR, August, 2002, pp. 137 to 144 (from HBR 1963)

Smaller companies are often viewed as more innovative than larger ones. This situation does not exist because smaller companies have more innovative employees. In fact, larger companies probably have an equal proportion of innovative employees so they have more in absolute numbers. Larger companies also have more resources to support innovation. They should be more successful at innovation. Rather, smaller companies appear to be more innovative because they lack the conformity mechanisms found in larger companies that inhibit innovation. In small companies, the founder or a group of closely-nit leaders maintain the culture through direct contact with all of the staff. These leaders can effect innovation if they take ownership of the idea. This becomes impractical as organizations grow beyond the size in which direction from a single individual or closely-nit group of leaders to the staff is practical. Part of the growth process for organizations is the necessary definition and institutionalization of beliefs, principles, and approaches, but this is in conflict with the requirements to have an innovative organization. Innovation requires change. Failure to treat innovation as a process that involves ownership by people with sufficient authority dooms ideation and brainstorming to be dead-end activities.

Understanding Innovation as a Process

The specifics of innovation processes will necessarily differ from situation to situation and company to company. Nonetheless, a framework that contains all of the functions that are common to all innovation processes can be defined as follows:

- Deep and specific understanding of customers' needs and business strategies.
- Clearly stated objectives with a specific outcome.
- Definition of each participant along with their accountability and roles.
- A logical set of activities with a timeline.
- Procedures and associated tools.
- Training.
- Ownership and leadership.

- Reporting.

For example in product development, understanding innovation as a process starts with a recognition that the innovation process involves customers and possibly their customers as well as the innovator's employees and vendors. It is important to understand and define the role of each participant in the process. It is also important to recognize that a consequence of this situation is that managing innovation will cross organizational and geographical boundaries. An effective innovation process must take integrating different cultures and geographical locations into account. This means that virtual organization management techniques and internet-based communications techniques and technologies will be important components of managing the innovation process a shown in Figure 1. The innovation process for product design also involves integrated product design, engineering, process design, and rapid prototyping. This situation challenges technical managers in ways that they are not used to and for which they are not prepared.

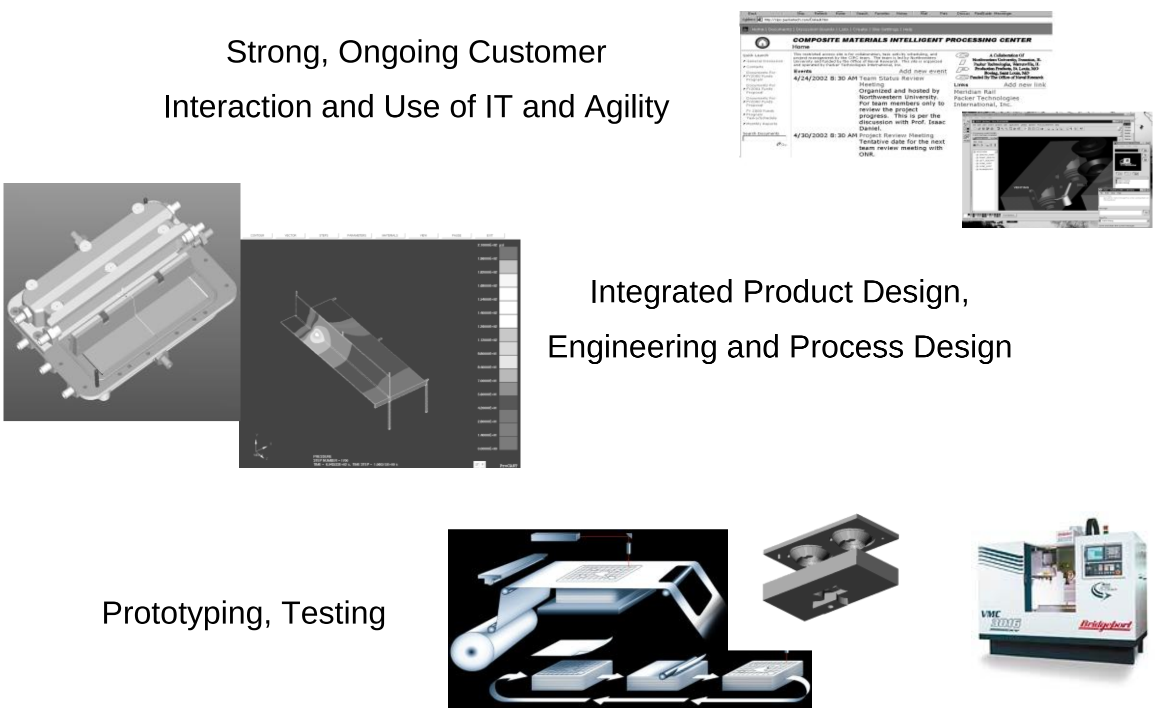

Figure 1: Components of Innovation in Product Design

The Role of Customers

Innovations in product designs are driven by cost-reduction and customization. This is easy to understand. Computer technologies in the form of design tools and marketing/sales vehicles are leveling the playing field. These technologies allow modestly capitalized start-ups to challenge and sometimes displace large, well capitalized, long-standing players in a product category. Computer design tools and marketing/sales vehicles commoditize product sectors, making value-added status hard if not impossible to achieve based on performance superiority or customer access. This is forcing companies to continuously cut costs and to differentiate themselves more and more by transforming a better understanding of customers' needs and desires into a steady stream of customized products and by using their knowledge to provide superior customer service.[4]

This environment has forced a change in the role of innovation in companies. Innovation used to drive product development, whereas in today's environment product development is driving innovation. Although it has always been important to manage innovation, it becomes far more important to do so when innovation is being driven rather than acting as the driver. Today's business leaders and managers are adjusting to this paradigm shift, and their success may make or break their companies.[5]

Customers need to be an integral part of developing innovative products. The traditional iterative process of producing prototypes, market testing, and revising the design is too lengthy. Customers need to be an ongoing, integral part of the design team, participating in decisions about functionality, form, performance, and cost. Innovation in product design also requires a much better understanding of customers' needs, opportunities, and limitations. This is especially challenging because customers frequently have not

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[4] Nicola D'Amico, "A Measure of Success," Business, November, 2001.

[5] W. Chan Kim and Renee Mauborgne, "Knowing a Winning Business Idea When You See One," Harvard Business Review, Sept.-Oct., 2000.

thought through their product strategy to the extent that ensures successful acceptance by the marketplace.[6]

It is very infrequent that the design of innovative products fails for technical reasons. Designs usually perform to the degree that was expected. What is far more common is for the customers' expectations to not be met. This can be because the customer's expectations were not appreciated by the design team, or because the customer did not completely or properly think through what they needed. Design failures for these reasons are all too common and often occur because the role of the customer is not properly defined. Although, the customer needs to define what functions, performance, and cost are needed, the nature of the interaction between the designer and the customer is often one in which there is far more of the customer's focus on how the requirements will be met than on defining the requirements correctly.

Defining the requirements should be the role of the customer. Deciding how to best meet the requirements should be the role of the designers and engineers. Commingling these roles usually leads to very poor definition of functions, performance, and cost. It also sometimes leads to exclusion of valuable design features such as certain materials and processes. The result is that the prototype meets the performance that was expected, but it does not satisfy the requirements for the product to be successful in the marketplace. Revisions and additional prototypes are needed. There is not only a substantial impact on cost and especially the development time, but the ability to customize products for specific market segments is severely hampered.

The Role of Internal Staff

Dealing with innovation often exceeds the experience and training of the staff, yet many organizations provide no training and do not make the demands and roles of the

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[6] Anthony W. Ulwick, "Turn Customer Input Into Innovation," Harvard Business Review, January, 2002.

innovation process a continuous topic of discussion. Innovation's increasing importance is forcing more interaction between scientists and engineers and non-scientists and non-engineers. These groups have very different training, thought processes, and terminology. Organizations need to provide on-going support in risk taking, accountability, and team building for scientists and engineers.[7] How many companies provide basic business and project management training to entry level scientists and engineers? The answer is that it is not the norm, but it should be. Non-scientist and non-engineers also need training in scientific and engineering methodology. Although science and engineering are challenging to learn to a degree sufficient to practice them, understanding their issues and approaches can be readily learned by non-scientist and non-engineers. How many non-scientists and non-engineering technology managers in your organization have undertaken any training to understand science and engineering methodology and management? How many companies offer this type of training?

Scientists and engineers are often different from non-scientists and non-engineers. They have endured a very challenging technical education and are most often very intelligent, but they may not be very effective in getting things done, which is a critical requirement of innovation. Scientists and engineers also tend to want to understand why specific demands are being placed on them. Questioning, challenging, and recreating/validating is the core of their education. It's natural for scientists and engineers to question what they are told. It's natural for them to rework the issue. They have been trained that this leads to advancement that it is good. This is part of the internalization process for scientists and engineers, but it infuriates non-scientists and non-engineers. They may view this behavior as uncooperative and non-trusting.

Scientists and engineers also differ from each other in important respects.[8] Scientists are usually more creative and less detail-oriented. Science education is strong on developing

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[7] John K. Borchardt, "Risk Management in Product Development," Today's Chemist at Work, April, 1999.

[8] Simon Ramo, The *Management of Innovative Technological Corporations*, Chapter 7, Wiley and Sons, New York, 1980.

analytical skills and theoretical understanding. Engineering education is strong on developing experience in applying practical knowledge.

Scientist and engineers are not trained in team building. They think of innovation as an individual activity, and as an event rather than a process conducted by a team. In fact, their training is geared toward individual accomplishment, especially for scientists and engineers with advanced degrees. Scientists and engineers are trained as if their careers will be in an academic-type environment, one in which technical considerations are paramount. They have little if any training in understanding consumer expectations, corporate organizational structure, organizational management, project management, risk taking, entrepreneurship, and understanding basic financial reports.

Scientists and engineers also are trained to be certain of facts before making a decision. Although this may be highly desirable, it is not practical in making business decisions. This orientation inhibits risk-taking, which is essential to innovation. This area will always pose a significant challenge. The reality is that a detail-oriented, anti-risk taking orientation is necessary at many times, but may be hard for non-scientists and non-engineers to understand. To better appreciate this, consider what qualities are important in the scientist who developed the metal alloy and the engineer who designed the structure of the plane or bridge you are sitting on.

Scientists and engineers also generally have no training in project management. They have had to develop their organizing abilities on their own. The results may be limited and unusual. They may find it difficult to breakdown a complex activity into a simple set of tasks with an appreciation of their sequencing and interaction. This lack of basic project management skills can be extremely frustrating to non-scientists and non-engineers. Don’t scientist and engineers get it? The answer may well be no. They have not had the training and experience that non-scientists and engineers have had.

The interface between technology and business needs far more attention in organizations. People who can bridge this divide are rare and should be sought and retained with great appreciation. Every innovation team involving technology needs to have bridging this gap as a defined role for an individual and this needs to be viewed as a critical role on the team. The process of innovation is about people working together in a seamless way, practicing common approaches, analytical processes, and decision making skills.

The Role of Vendors

Vendors play a central role in the product development process and must be viewed as important members of the team. There are several drivers that have increased the importance of vendors. One is that as companies define their core competencies they tend to outsource functions that fall outside of their core. Another factor is the increasing variety and sophistication of prototyping and manufacturing technologies. It is increasingly impractical for companies to invest in and support all of the functions that create cutting-edge products.

Having to cross organizational boundaries to form product design teams poses additional demands that scientists and engineers have not been trained to address. Organizations differ in their cultures, their approaches to risk and decision making, and their procedures to name a few areas that are important parts of innovation. There are also the logistics issues. The people who have to work together are not co-located and usually do not share the same resource management systems.

This situation is best addressed through virtual enterprise techniques. The virtual enterprise turns the design team into a fully functioning enterprise that comes together, performs the design task, and disbands for redeployment to the next project.

A Process Map for Managing Innovation

Since innovation is a process, managing it is similar to managing other processes. In addition to defining objectives, roles, and accountability, a flowchart of the activities should be developed and followed. The flowchart captures the best practices in the activities from throughout the organization, allowing all to benefit from them. It also provides a framework for training new employees and for gaining consistency.

Any process for managing innovation needs to capture all of the essential activities to turn an idea or concept into a result. Whether managing business model innovation, strategy innovation, process innovation, or product design innovation, these activities in general include:

- Establishment of the true functional and performance requirements,
- Development of a plan of action, including the assignment of tasks and responsibilities,
- Execution of the set of actions,
- Monitoring and periodic reporting and reviews,
- Testing and validation of the results.
- On-going collaboration.

Figure 1 above showed the components of the innovation process for product design. The components are collaboration tools; integrated product design and engineering; and rapid prototyping and testing. Coupled with clearly defined objectives, a timeline, and the definition of the roles and accountability of people, the entire innovation process is well described in a manner that can be taught, monitored, and managed.

The establishment of such a process will be described for product development as an example. Although specific to product development, this example shows the steps, approaches, techniques, and some of the tools that are pertinent to all innovation processes.

The innovation process map for product design is shown in Figure 2. This process captures and defines all of the activities that are critical to innovation in product design. It starts with establishment of requirements, progresses to integrated design and engineering activities, ending with prototyping, testing, and validation. It captures the flow and interrelationship of the activities that form the innovation in the product design process. This is an actual innovation process used by a startup product design venture. This innovation process consistently removed 5% to 40% from the cost of near net shape plastic and cast metal products and shortened the design time by 20% to 50%. For example, metal castings for large complex components were routinely designed in 50% of the time traditionally achieved and 25% to 40% cost reduction was routinely achieved.

<u>Requirements Finalization</u> – This beginning step of the process might also be called the external or customer kickoff meeting. The process as shown assumes that there has been substantial prior consideration of the project. Prior discussions would normally include market assessments of benefits and price, one or more product concept meetings, ideation and brainstorming leading to preliminary design concepts, preliminary consideration of materials and manufacturing processes, preliminary consideration of prototyping methods and validation testing, and a proposal with a work breakdown structure, schedule, and cost estimate. In many ways, the requirements finalization meeting needs to be a reconsideration of all of this prior activity.

A design guide is a tool that is handy for coordinating the product development process. The design guide initially contains the customer's requirements, goals, and expectations, which should be clearly defined as part of the requirements finalization process. All members of the team will have a copy of the guide, which will be updated to include all

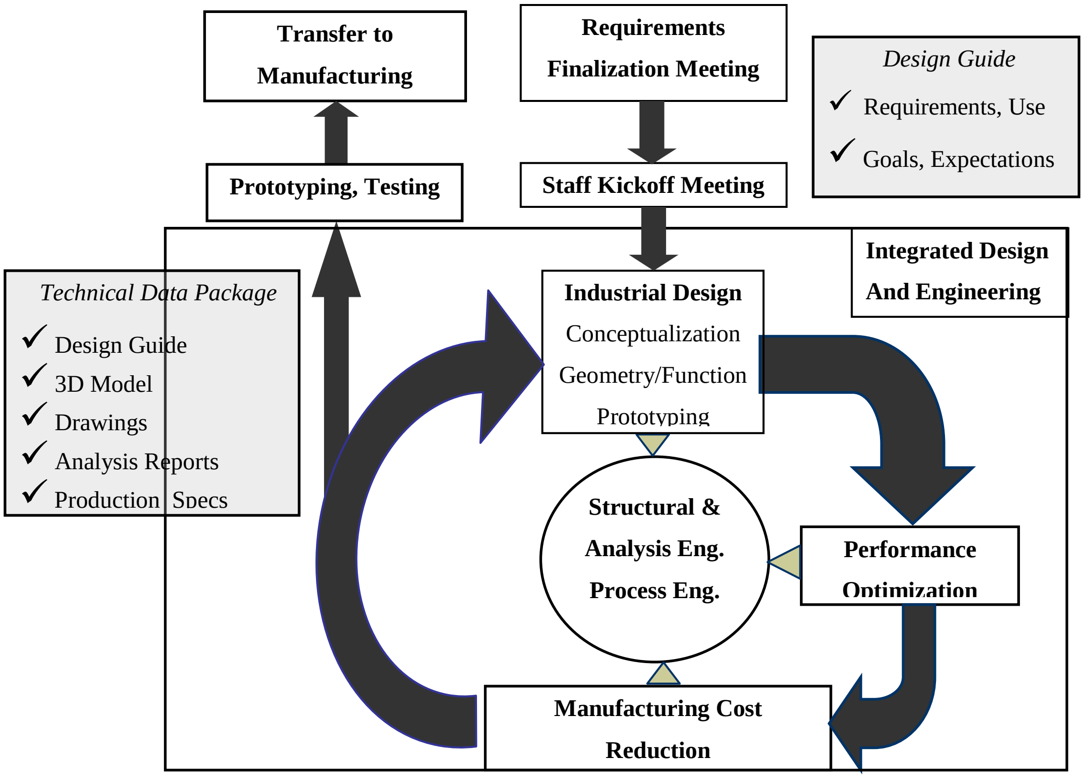


Figure 2: An Innovation Process for Product Design

design decisions and revisions, the conceptual or functional design, the descriptions of the components or modules that makeup the product, and the interface requirements for the modules to be brought together. These items will be further described as the remainder of the design process is described. The logistics of maintaining the guide, such as version control, will be further discussed in the section on internet-based collaboration.

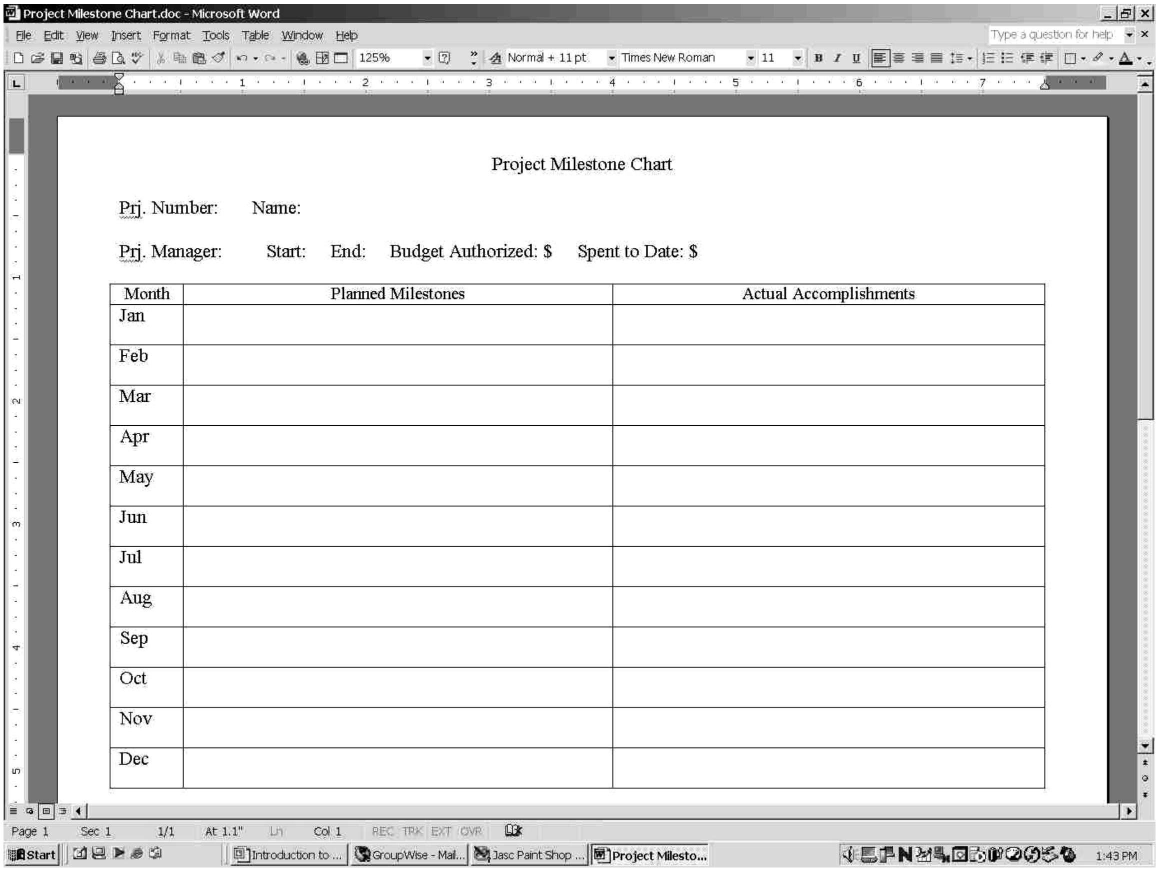
<u>Staff kickoff Meeting</u> – Managing the timeliness and quality of project work is essential for survival in today's competitive product development environment. The outcome of the design effort determines if customers come back and establishes a reputation in the marketplace. The goal has to be 100% customer satisfaction in today's environment. Managing the timeliness and quality of design project work requires recognition of the importance of these issues by engineers and their dedication to the daily use of the

procedures and tool that are provided. This is a make or break issue for companies and the outcome is totally within their control.

The staff kickoff meeting is important so that every member of the team understands the customer's expectations, their role, the role of the other members, and the work plan. The design team leader should prepare a milestone chart and a work plan prior to the staff kickoff meeting.

The milestone chart is an important tool. Milestone charts contain a very succinct itemization of milestones (completion of critical path activities, deliverables, etc.) by month. Project leaders enter the planned milestones at the outset of the project. These are not changed without agreement by senior management. The actual accomplishments are entered at the end of each month. This information is used by senior management to monitor overall progress on satisfying the customer's expectations and the deliverables on each project. Project milestone charts are a much better tool than work plans for senior managers to monitor a portfolio of design projects. It is difficult to assess the information in work plans without detailed knowledge of the project. Planning the milestone chart also helps the project leaders and the project staff to appreciate the customer's expectations and the timing of critical activities.

Every project at its outset needs to have a work plan with a sufficient level of detail to manage it properly. Project work plans are for the project leader and staff to understand and coordinate their work assignment. Project work plans are sometimes overlooked by design team leaders in the mistaken belief that the Gantt chart in the proposal is an adequate schedule. This is seldom the case. Proposal schedules are intended for the customer to understand the sequence and timing of the logical steps to design the product. The level of detail that is appropriate for this purpose is usually not sufficient for leading the project. Also, the proposal schedule does not contain staff assignments and other information that is needed to manage the project.



Project Milestone Chart

Prj. Number: Name:

Prj. Manager: Start: End: Budget Authorized: $ Spent to Date: $

Month	Planned Milestones	Actual Accomplishments
Jan		
Feb		
Mar		
Apr		
May		
Jun		
Jul		
Aug		
Sep		
Oct		
Nov		
Dec		

Figure 3: Design Project Milestone Chart

<u>Industrial Design and Engineering (Design, Engineering, Analysis, Optimization, Manufacturing Cost Reduction)</u> – These are a set of partially concurrent and partially iterative activities that are the guts of the design project. The design process has been revolutionized by the use of analysis and simulation tools, Figure 4. First, a three dimensional (3-D) solid model is developed. Then, a mesh is defined in preparation for finite element analysis. Finite element analysis allows important properties of the part to be calculated and assessed, for example stress levels and thermal properties. Other aspects of performance may also be calculated, Figure 5.

A recent innovation in the design process is the inclusion of process design. Often called design for manufacturing, integrated process and product design ensures that the design can be manufactured. It also allows the cost of manufacture to be minimized and the design to fully benefit from the capabilities of the process.

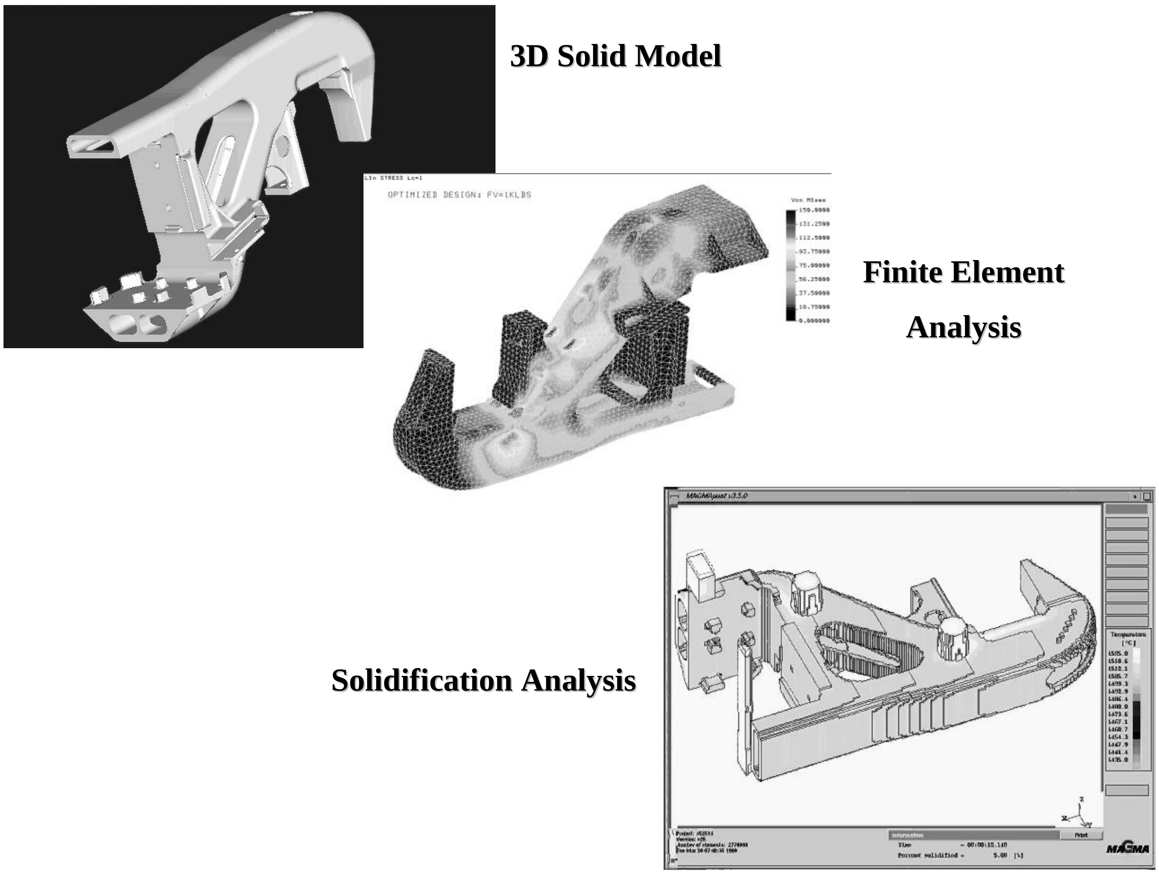


Figure 4: Integrated Product and Process Design for a Metal Casting

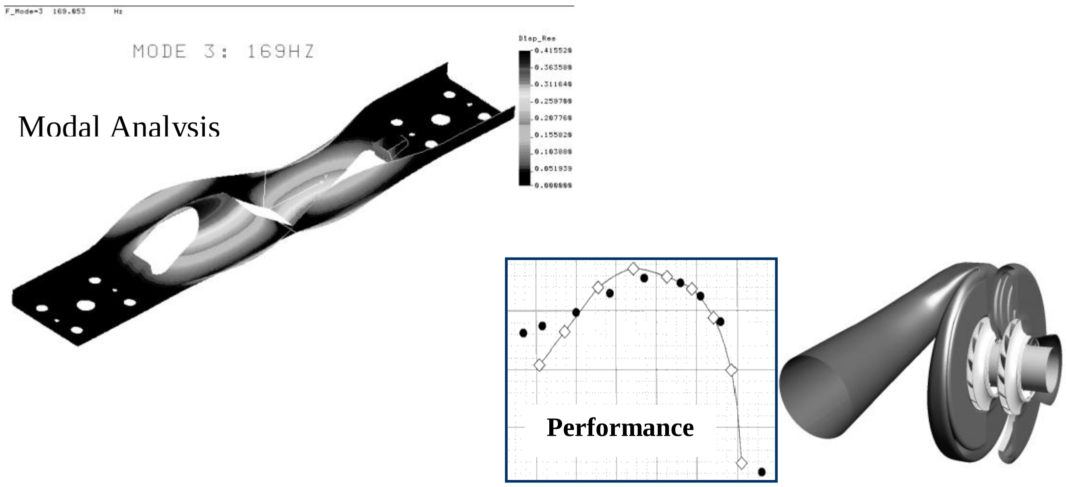


Figure 5: Performance Analysis

Prototyping and Testing – The purpose of analysis and simulation is to minimize the need for prototyping. Nonetheless, the design needs to be validated through prototyping and testing. Ideally, the use of analysis and simulation will result in the first design performing properly without need for adjustment or modification.

Selection of a prototyping technique is very important. Sometimes the actual manufacturing process will need to be used as is often the case with advanced processes such as metal casting and composites fabrication. In other cases, injection molding for example, a process that is different than the actual manufacturing process can be used. This is advantageous especially when one of the rapid prototyping processes can be used. Rapid prototyping allows a part to be made directly from a solid model. An example of a rapid prototyping process is the laminated object manufacturing (LOM) process described in one of the case studies presented below.

Transfer to Manufacturing – The final step in the design process is the transfer of the design to manufacturing. This involves make-buy decisions and the qualification and selection of vendors. Part of this activity occurs early in the design process, during the design for manufacturing phase. Part of the activity occurs at the end of the design process.

Sometimes the design team will make this transfer, but often a customer has hired an independent design firm and the customer will make the transfer. There are important advantages for the transfer to be made by the design team.

Coordinating and Managing the Design Process -- The design process shown in Figure 2 appears to be a relatively straightforward and linear process. This is not the case. There is much activity that underlies each of the steps in the process. This is shown in Figure 6. It may be valuable to flow chart the activities that compose each of the steps of the innovation process.

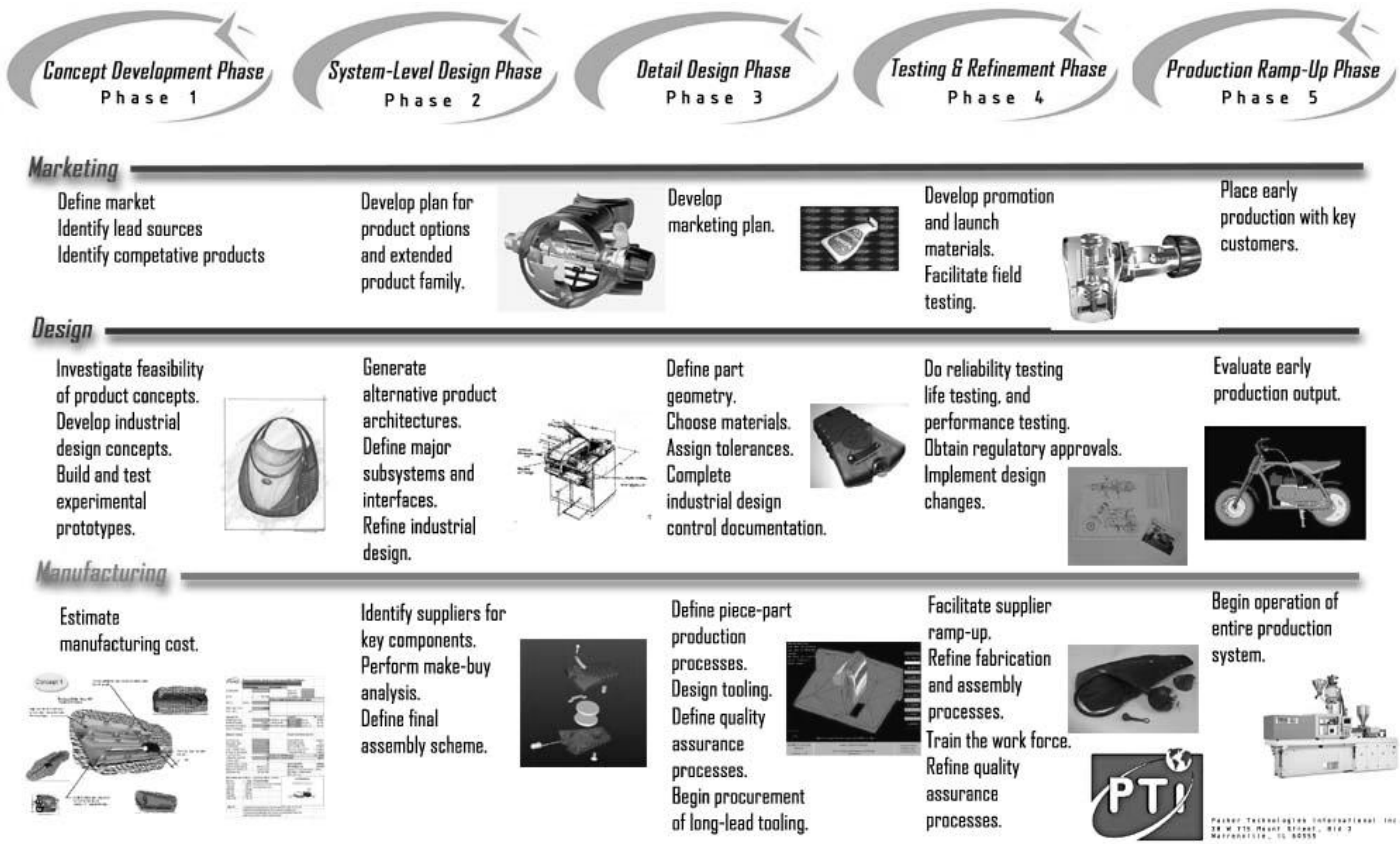


Figure 6: Functional Interaction in the Design and Engineering Phases

On-going collaboration is an essential part of the design process. This collaboration spans organizations and different geographical locations. There are many logistics and project coordination issues. One example is ensuring that every team member has the current version of the design manual, which might be revised on a daily or more frequent basis by various members of the team. Internet-based collaboration and coordination address many of these issues. Nonetheless, internet-based collaboration is still unused or new to many organizations. This section covers both the techniques and tools. Although the technology and tools will change, the procedures will endure.

Internet-base collaboration offers a host of functions that are useful for managing organizationally and geographically dispersed teams. These functions are:

- Password protected web sites.
- Contact information.
- Events list.
- Task lists.
- Document libraries with document version control.
- On-line collaboration with whiteboards and program sharing.

Internet-based collaboration software allows geographically dispersed teams to share documents with assurance that they are using the current version. It also provides a way to schedule and monitor the status of tasks, schedule meeting, and have access to current contact information. The team can also hold virtual meetings, sharing presentations and engineering documents.

Internet-based collaboration software also contains tool that allow design teams to employ new techniques in the design process. For example, threaded discussion groups are common on the internet, being used for interest groups such as photographers to share information. Threaded discussion groups can be used in an innovative way in the design process to reach consensus on functions, features, and design options. Another feature, document discussion, can be used in an innovative manner to edit reports.

Several different software packages that are useful in the design process exist. These packages offer similar core features as described above. Some offer additional specialized functions such as supplier chain management and on-line quote solicitation. Most packages are offered as a service with a monthly subscription fee. At least one is offered to be installed on a user's server and operated by the user.

Setup of these software packages is generally straightforward, but may require experience with setting-up and administering a server. Some of the packages are accessed through commonly-used internet browsers. These packages offer simplicity of setup and use. Other packages require that a client program be installed on the user's computer. These packages can require special setup of firewalls that may not be acceptable to some organizations.

Case Study

Figure 7 shows the homepage of a password protected collaboration website. This site is for a Composites Intelligent Processing Center that is funded by the Office of Naval Research, managed by Northwestern University (Evanston, IL), and co-managed by Packer Technologies International (Naperville, Illinois), which also is the design member of the team. The team also includes Boeing, St. Louis, which is the customer, Production Products (St. Louis), which is a composites fabricator, and a Navy laboratory, which is the customer's customer.

The Center's mission and operation are an innovative approach to addressing the limiting problems that are actually faced by RTM manufacturers such as Boeing and Production Products. The manufacturers define the problems. Solutions are devised by Northwestern, Packer, and several Navy labs in collaboration with the manufacturers. Evaluations and demonstrations of the solutions are performed in actual manufacturing environments by the manufacturers.

This innovative approach overcomes a number of problems that are encountered in developing and deploying new technology. The approach makes sure that the people who experience the problems every day are the ones that define them. Technical people who are not on the manufacturing line each day tend to define the problems more on perceived technology gaps than on actual experience. Also, development of technical solutions can produce results that are not easy to use for manufacturers. Technology will not be used if it is not easy to use, or if it requires discarding the recently started corporate initiative, or discarding the large capital investment that has not been recovered. Demonstrations of technical solutions that are done outside of the manufacturing environment do not really validate the results because they generally use more capable people, equipment, and facilities than exist in the manufacturing environment.

Although the approach to the Composites Intelligent Processing Center addresses many problems that impede the development and use of new technology, the approach posed new problems related to organizing and coordinating a team that came from different corporate cultures and geographical locations. Utilization of virtual enterprise formation and operation techniques and internet-based collaboration were the answer to these barriers.

The website shown in Figure 7 was created with Microsoft's Share Point Team Services by Packer Technologies International (PTI). Hundreds of websites can run on a single server. PTI operates dedicated websites for a number of its customers. Share Point Team Services also allows sub-webs, so each team member in a multi-member program such as the Composites Intelligent Processing Center could have its own password protected sub-web. This is a very flexible arrangement for structuring a collaboration website.

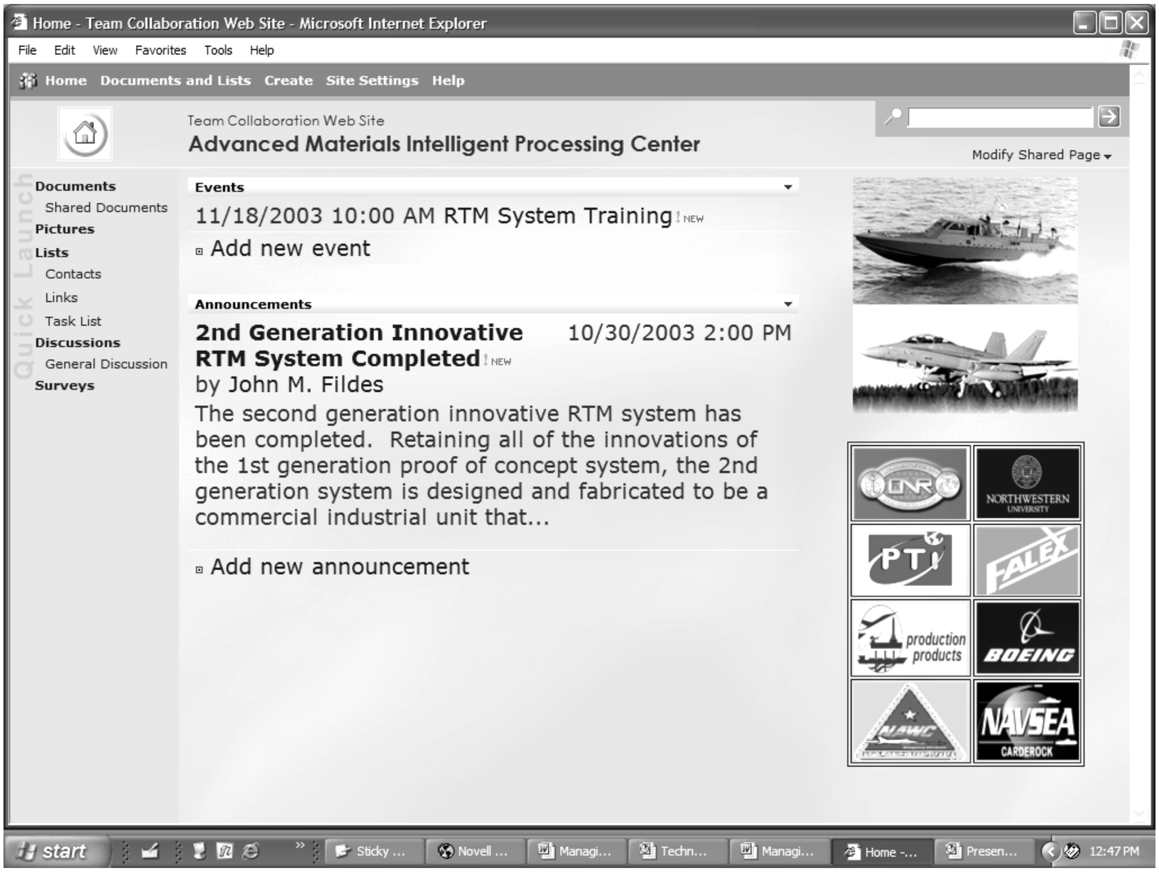


Figure 7: Design Collaboration Web Site

The website is accessed through commonly used internet browsers so there is little training needed for users. The homepage offers easy access to all of the site's areas and functions. An event list is used as a reminder for meeting and reports. An announcements list allows the members to disseminate information of interest to the team. A contact list makes it easy to find phone numbers and e-mail addresses for all of the team members. The links list allows easy access to each member's own website.

Figure 8 shows a document library. This library contains technical reports, presentations, engineering drawings, results of analyses, monthly status reports, and each organization's proposal. Having all documents available in one place is a tremendous asset for the team and for management of the program. For example, PTI has a library that holds all of the project milestone charts, allowing the project leaders and senior management easy access to the current version.

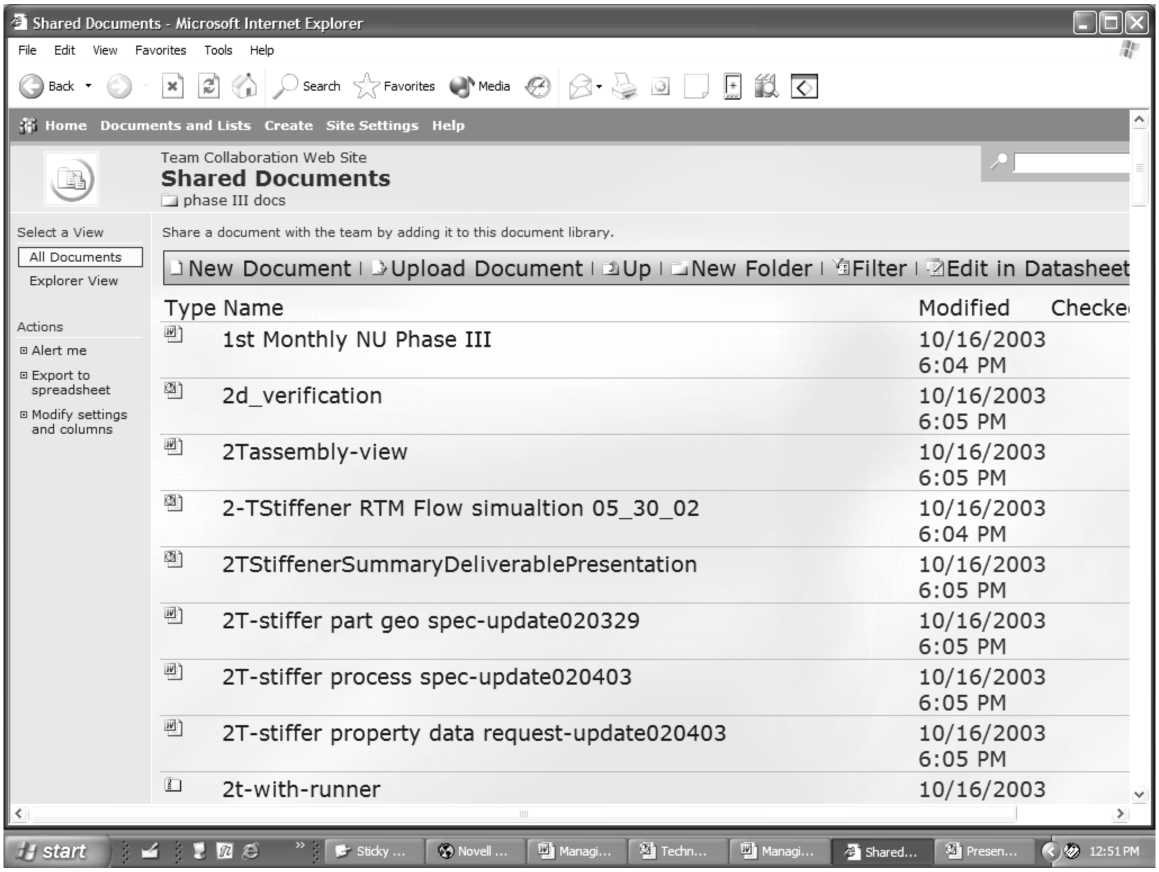


Figure 8: On-Line Document Library

The view of the document library can be easily modified. Multiple views can be defined to suite different needs. Documents in this library have been organized by the type of document and the program task to which they apply. The library can be searched and documents can be filtered and sorted so that it is easy to find documents. The name of the creator, the date of creation, the name of the last user to modify a document, and the date of the last modification is automatically tracked by the system. Each user can specify if and when they will be notified by e-mail of changes in the library.[9]

[9] Notification based on changes to specific documents is not currently supported by Share Point Team Services, but would be a valuable feature.

What can be done with a document depends on the type of document.

Figure 9 shows an on-line task schedule. It features and uses are similar to that described for document libraries. Each user checks the task schedule for the work assigned to them and they update the % completion. This gives the customer a much better ability to monitor the status of the project.

Figure 9: On-Line Task Schedule

Figure 10 shows a typical form that is used to enter content. Other forms are used for defining views of documents and lists. Share Point Team Services creates what is called a forms-based web site. The user configures the site and enters content by interacting with a database that drives the site. This greatly simplifies the user's job in configuring and using the site.

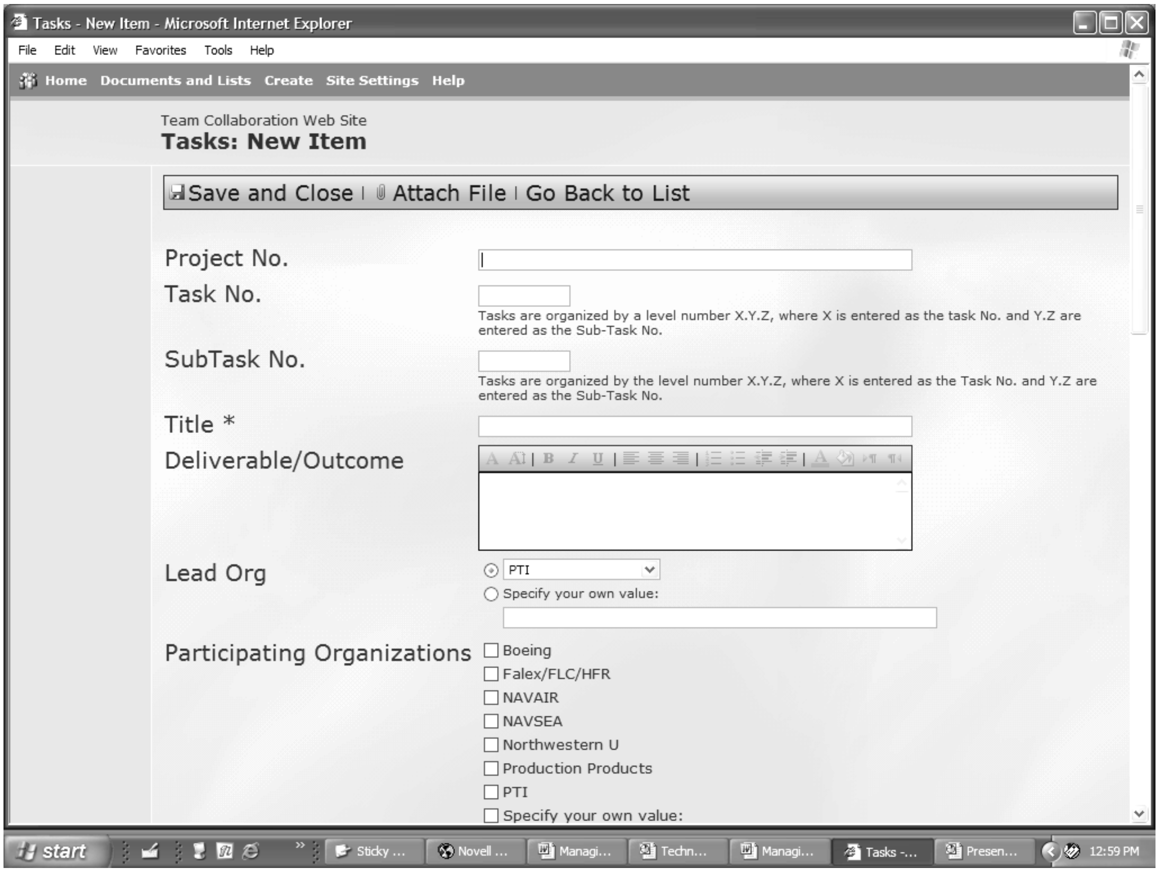


Figure 10: Forms-Based Site Management

Use of a collaboration web site offers an opportunity to employ new project coordination and management procedures, and this requires some thought and experimentation. For example in the Composites Intelligent Processing Center program, internet-based meetings are held using Microsoft Netmeeting.

Another advancement is that integrated (across team members) presentations are now possible and are used. A presentation template is placed in the document library prior to the meeting. The template contains the tasks with their objectives and lead organizations and a place to summarize the work completed in the reporting period. Each organization enters the work they completed and adds additional slides to provide backup material. Each organization always sees the full and current version of the presentation. The team used to have each organization give their presentation, leading to much duplication of background material such as objectives. The team's interactivity was also not well portrayed by these individual presentations. Now, a single integrated presentation cuts out the duplication and leads to a far more efficient meeting. The portrayal of the team's interactivity has become the central theme of the presentation.

During the Netmeeting session, one team member runs the presentation. The presenting member takes control of the presentation when it is time for their material. The interaction of the team during the on-line presentation is every bit as good as when they were in the same room. The team held quarterly review meetings at a single location for the first two years of the program. Usually, at least two participants of each organization attended. The total attendance was typically more than a dozen people. With the on-line collaboration system, the team now holds on-line meeting on a monthly basis and the meetings are more efficient. This has led to better program management and closer interaction of the team.

Netmeeting is also used for on-line engineering collaboration. 3-D views of the design can be shown by running any CAD system that runs under the Windows operating system. ProEngineer and SolidWorks are used in the Composites Intelligent Processing Center program. During the session, any participant can take control of the program as if they were actually running it. PTI routinely uses this approach to hold design development, design review, and design acceptance meetings with many of its customers. This not only saves money, it cuts time from the design process because much dead time occurs in projects waiting for meeting so the next activity can start.

Figure 11 shows the redesign and conversion from a fabrication to a casting for an I stiffener made by the resin transfer molding (RTM) process. RTM is an advanced composites process that is used in the aerospace and automotive industries to make light weight parts with great strength. RTM is an automated process in which a dry fiber perform, usually graphite or glass, is placed in a closed mold and resin, usually an epoxy, is injected under pressure at an elevated temperature. Design of the part, tool, and process is technically demanding.

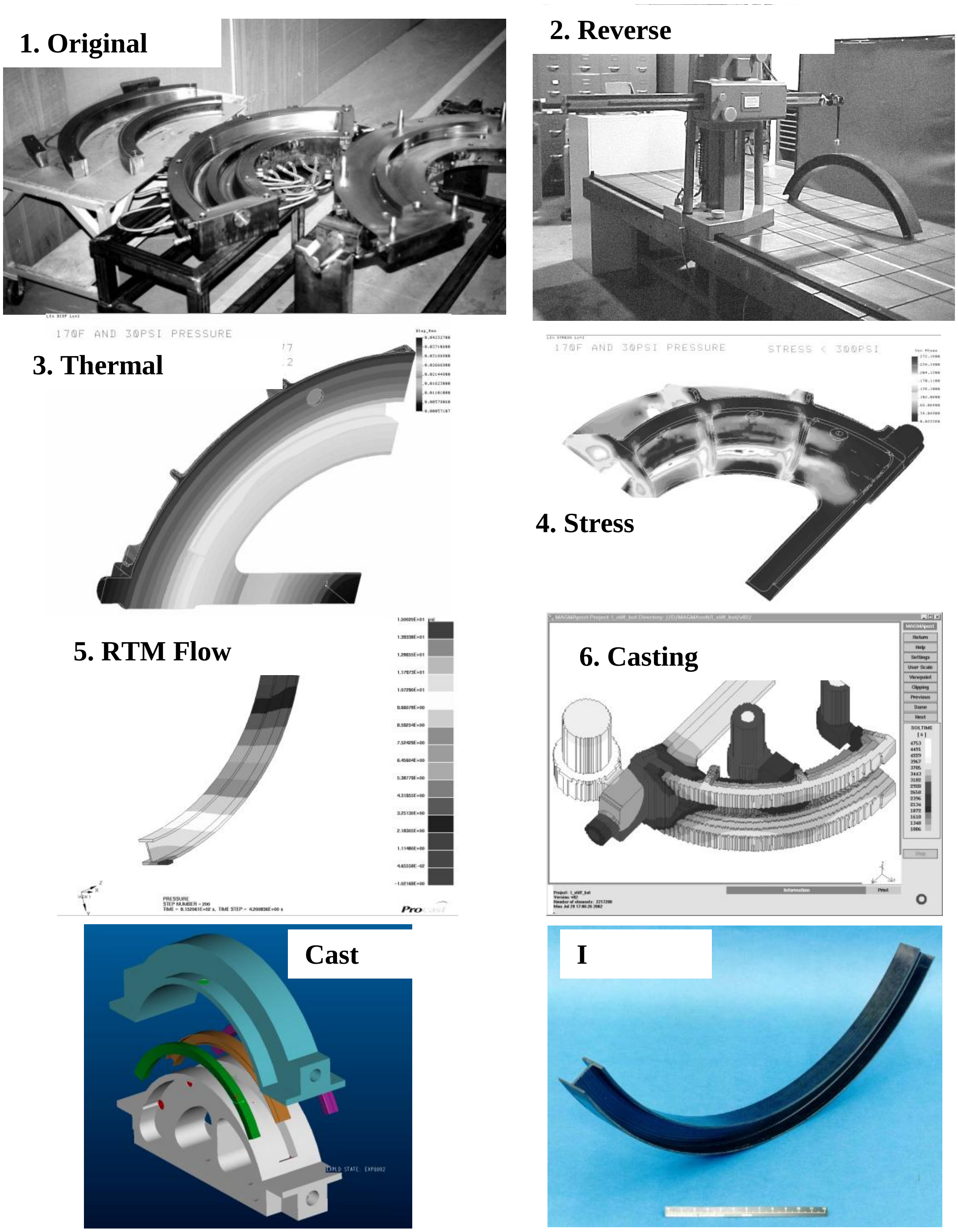


Figure 11: RTM I Stiffener Tool Designed With Innovative Process Described Herein

The tool shown in Figure 11 was originally fabricated by machining, which led to a complex, heavy, difficult to handle, and difficult to use tool. Pinching of the preform during closing of the tool, which is impossible to detect until the entire production cycle is complete, occurred in about 40% of the runs. The preform is over $10,000 and the resin is also costly, so a 40% scrap rate has a tremendous cost impact.

The tool was redesigned as a casting. Castings have been problematic as tools because of porosity. Extensive use of flow modeling, temperature distribution, and solidification of the casting process overcame this problem. Use of a casting reduced the mass and complexity of the tool. Additionally, heating channels can easily be included. Other innovations in the design overcame the problem with pinching of the preform. Design of the RTM process was an integral part of the tool design process, Figure 12. Flow modeling of the resin in the anistropic perform was used to improve the location of the gates and vents to achieve a shorter and more consistent infiltration of the resin. Integrated tool and process design also improve control of dimensional tolerances.

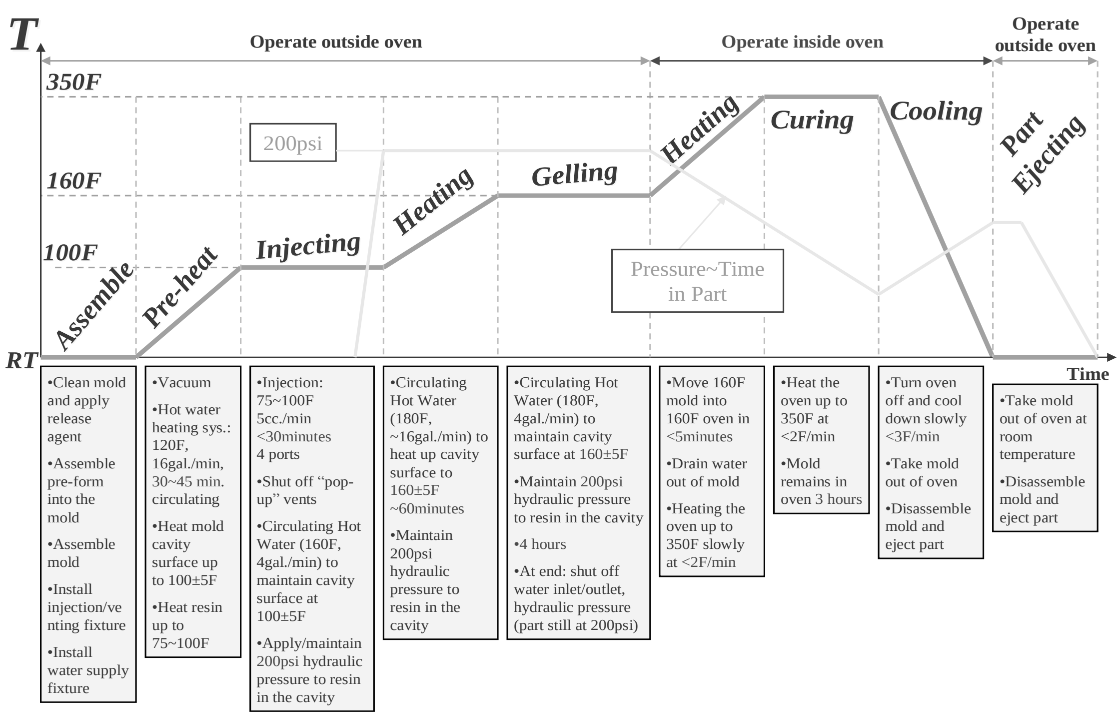


Figure 12: Integrated RTM Process Design for I Stiffener

Figure 13 shows the process to design and validate an innovative vibration mount. This was a very challenging design problem with demands for geometry, dimensions, and the resonate frequency of the structure. This structure could probably have not been designed with conventional techniques.

The conventional design of RTM parts uses little process simulation. Also, the production mold has to be made produce even a prototype. The investment in the production mold is so great that there is great pressure to “tweak” the mold to make it work rather than scrapping it. The design issues in the vibration mount were so demanding coupled with the lack of accurate analytic models required an original design and two substantial revisions to achieve the desired result. This would not have been possible with conventional design techniques.

The design challenges were overcome through the creation of an innovative rapid prototyping process for the RTM mold and the extensive use of flow modeling and internet-based design collaboration. The rapid prototyping process allowed an RTM mold to be made from a solid model. Internet-based design collaboration allowed revision of the design in a matter of hours. Flow modeling ensured that the mold would perform as desired. The combined result was that a redesign was performed and a prototype mold was delivered in less than one week. The molds produced the parts as expected, allowing the bulk of the time and focus to be on testing and understanding the physics of how to achieve the desired resonate frequency within the geometry and dimensional targets.

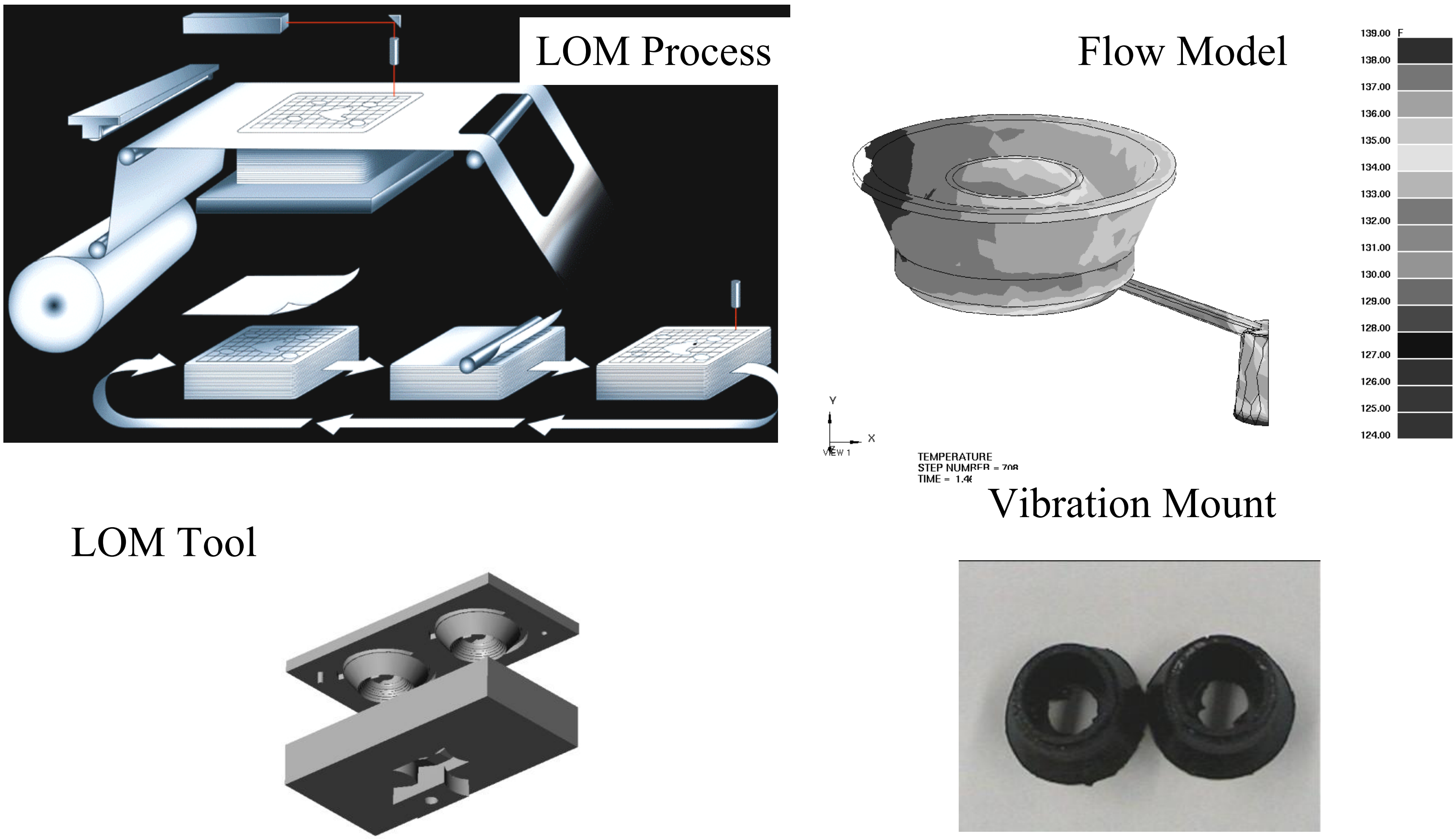


Figure 13: Innovative LOM RTM Prototype Mold

Summary

Innovation needs to be distinguished from creativity and invention. Innovation is a process in which a central feature is transferring an idea into action. This is true for all areas in which innovation can be manifested, be it business models, strategies, or product designs. Innovation needs to be treated as a process to be effective. This does not stifle creativity; rather it aids it by allowing ideas to become reality, avoiding the skepticism that results from not acting on creative input.

Establishing a process for innovation requires that the roles of people be clearly defined, which requires an understanding of the outlooks of various groups of people who must work together as a team. The objective and expectations must also be clearly defined. A process map is also required. The map outlines the logical set of steps that must be performed to bring about a concrete result. This approach bring consistency and allows every team to use the best practices in each situation.

Working in this environment and managing it pose demands that most scientists and engineers and many business people have not been trained to meet. Companies need to provide this training in areas such as understanding organizational structures, working with differing company cultures, virtual enterprise techniques to establish business functions that transcend internal systems and tools, and internet-based collaboration techniques that bridge geographical separation. These approaches and tools are not widely used, but they have been very successful in enough situations to conclude that they are an essential ingredient of be competitive in the future.