Lean Six Sigma Quality Transformation Toolkit (LSSQTT)*
LSSQTT Tool #2 Courseware Content
“Assessing Technological Infrastructure For Innovation”

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Lean Six Sigma Teams, Problem Solving

Lean six sigma systems thinking, through the use of data and documentation can form the basis for necessary understandings required to actually conduct team based improvements. By conducting the analysis of work areas, determining capacity, knowing product flow, layout, materials requirements, customer requirements, and other product and process specific information we can form the strong basis for determining how to re-engineer ourselves for the future. A key part of lean-focused teams and re-engineering for the future is to position new products and processes competitively. This relates directly to the issue of synchronization in information, functions, applications and how to organize information at the team level to serve ongoing and necessary day-to-day functions. But it also is about using this data and documentation to solve problems and issues which arise day to day.

We must position teams' structure and infrastructure to be able to respond to daily operations first, and problems which emerge and require solutions immediately and longer term, second. Ultimately, we must be able to transcend both of these essential levels and move into a third level of team opportunity which relates to product development and innovation. We must be able to rely on the same information we use at other levels for management and problem solving to plan and launch products in the future. This is not merely information, assuming we use it properly, it should become knowledge inherent in the organization.

We are also reminded that if we are not looking down the road to future opportunities we are probably slowly going out of business. We must not become so caught up in the necessary day-to-day operations or the essential act of solving various sizes and types of problems that we forget to give birth to new ideas and products for our future production. This is another essential reason for teams, blended out of the foundations of the functional and cross functional teams used for other reasons. Synchronization of information and functions for new product development and launch is a key part of this.

Appreciating that the team requires data and documentation seems less difficult to understand on the surface, relative to how to conduct the broader problem solving act. Synergy inherent in the relationships built around and between the data, documentation and leadership must provide technical solutions for our future. This only happens if proper design consideration is given to the overall infrastructure and organizational aspects technologically and in human resource terms.

The overall problem solution will be a function of three fundamental phases, each wrapped within the broader context of data, documentation and synchronized leadership. The phases are assessment, analysis and action, each to be pursued as the core of the concept of ongoing improvement. This provides an important relationship between assessment, analysis and action, all ongoing based on feedback within the context of problem solving. Relationships provide a useful strategy for the context of technical solutions and improvements. Product design and specifications documentation are key parts of assessment. Various tools for data analysis and documentation can be formulated as a function of the nature of the product and process. Based on a thorough survey of all persons engaged in the work areas, it is quite likely that specific areas for further analysis will become apparent.

Technical Considerations: Design. Part of process engineering for improvements in competitiveness, as well as for innovation and
applied research, is the design process. Design for product development typically involves at least four major phases. These phases are (1) identifying the problem, (2) preliminary design, (3) basic drawings, and (4) specification development. As might be guessed, problem identification occurs in the early stages of the design process. Market research would be completed, or winding down.

Information discovered during market research may indicate areas where product deficiencies lie, identifying the design problem for further development. Also during this phase, various facts must be uncovered relative to the product which is being developed. Although many of these points were touched on in the market research section earlier, it is significant to note that consumer inputs are considered very carefully during this phase. Additionally during the product problem identification phase, basic objectives must be determined. Objectives listed in this first phase commonly lend further definition to the problem focus, providing specific delineation of responsibilities for design and product development.

**Design And Product Development.** The preliminary design phase is concerned with looking at various relationships and inputs which are thought to have a potential impact on the overall product development. Designers review the competition, often obtaining and disassembling various products, enabling them to make proper judgments about how to improve their product. Rough sketching is a basic tool at this phase of product development. These "thumbnail sketches" are simple line drawings done in a three dimensional (3-D) approach for purposes of getting a reasonably good likeness of what the actual product may look like. At this stage, the designer is truly in a brain-storming mode, attempting to gain the best possible combination of appearance, serviceability, produce-ability, cost, sales appeal, and perhaps other factors.

During this phase various individuals in the organization would be contacted for input to help in gaining an appropriate group of rough sketches. People in virtually all divisions should have an opportunity for input and constructive criticism regarding the developing product, since the more input typically means additional improvements in the final product which will eventually be produced. At each stage of this phase it is critical that all sketches be saved, perhaps in a pad form, to permit the idea to evolve in a logical fashion. Also, if done this way a permanent record exists from which to work in the future. As the designer nears closure of this phase with final sketches being a logical outcome, a rendering is commonly provided for a variety of purposes. The rendering is a sketch of what the actual product should look like when completed. As such it is typically done with good line quality, shading, and in an inked format--or commonly now on a CAD work station. This rendering will then likely go to marketing, production, and other groups within the technological organization, to get a final preliminary approval prior to investing further in the product, perhaps only to drop the project at a later date if sufficient consideration is not given.

Perhaps no further investment should occur for this product if sufficient resources do not exist at this time. However, at some point during the preliminary design phase it is critical that a commitment be made for one basic design. The preliminary design which is selected is a function of inputs from all appropriate sources, providing the necessary decision for continued future development. It is quite likely that a prototype will be produced at this stage. The prototype is used to get final product feasibility inputs from individuals inside and outside the organization.

Following the preliminary design selection, working drawings are drawn up, showing all component details and relationships. The designer should be working closely with the production division to ensure that the product can actually be produced. The better the communication in this phase, the less likely that costly errors in judgment will be made. Also, the better the communication, the easier it will be to incorporate the new product design into production when the startup actually occurs. A serious cost analysis will be conducted to provide further proof that the product is feasible. It is possible at this phase, as with any phase, that the product could be shelved due to prohibitive cost estimates. Lead time must also be reduced through concurrent engineering systems. For example, while traditional prototypes would be built earlier, a few years ago, now we can model and simulate the prototype earlier in the design process, testing, evaluating and improving the product.

Specifications are developed at some point in a final phase of the design process, leading to a fully developed product. Working with one or more prototypes which were developed during the second phase, various technical groups will usually begin gathering final production data prior to actual production. The prototypes will be disassembled, time studies completed, flow charts provided, machinery acquired, personnel hired and trained, and other final preparations made. A pilot run is usually conducted at this point to gain actual data prior to full
production. Also during this final design/development phase various testing will be completed on prototypes and pilot products. The product tests may be field tests, destructive tests, or other appropriate methods for gaining final data inputs. It is quite likely at this point that changes in materials, processes, dimensions, or other relationships may occur since final specifications are often somewhat different than the original product ideas may have dictated.

The skill exercised in creating products capable of inexpensive and efficient production often means the difference between success and failure. Many otherwise excellent products fail due to production problems which should have been solved in the design process. Several general design rules should be observed when developing products. The design rules aim to help insure maximum simplicity in the overall design. This means developing the product for utmost simplicity in physical and functional terms, analyzing the materials to be used, selecting materials for suitability to the product as well as availability and cost. It is also necessary to use quality standards which are as liberal as possible without diminishing product quality. Wherever possible use pre-manufactured components and standardized parts. Components should be cross-referenced, using the same parts and materials in as many products as possible.

Focused more on production and design, as attempts are made to determine the best process, it is well to attempt to use existing processes. It is also important to note that special processes can often be built or obtained, although often at considerable cost. It should always be a goal to use existing machinery and processes in an attempt to keep capital expansion at a minimum. Wherever possible, this should not, however, be done at the expense of efficiency. If a new piece of automated equipment will get production up to speed, it should be designed in, obtained and put on line. Production steps should be eliminated at every possible occasion. Eliminate handling steps at every opportunity to help ease locating, set-up, orienting, moving, holding, transferring and so on. Plan for the large volume production since generally larger lots lower overall costs due to lower inventory, transport, training, etc.

Concurrent Design. Increasingly, there is a desire to move the product from design phases to production more efficiently. Over the past several years there has been a trend in technological organizations to perform design and production activities in a more parallel manner. This is sometimes referred to as concurrent engineering or simultaneous engineering in manufacturing and design-build in construction enterprise. This is referred to as concurrent design and production, and it is clearly related to all technologies.

Regardless of what it is called the fundamental concept remains the same. The concept is to reduce lead time between project start-up in design phases and on the tail end, when production is occurring. By sharing design information with production personnel in the early phases of design, consideration can be given to production equipment available and needed, fixturing required, new personnel requirements, vendors to be pursued, customer requirements in quality and so on. In all cases, however, formerly the design would have been complete prior to releasing information to production. But due to competitive forces worldwide, organizations must be quicker to respond to the market demand, else they miss part of the available opportunity to capture that market and develop consumers around their product base.

This also relates to downsizing and fundamental changes in organizations, due not only to competition but also to changes in the technology, primarily the computer. Now, due to computer aided design, designers can move their information virtually with a key stroke to others in various production functions such as computer numerically controlled tool path programming, inventory and quality areas, among others. As well, engineering design changes can be more carefully performed and controlled, with less impact and better quality overall. As organizations continue downsizing and reorganizing to meet technological demands of the future, only a small staff of persons will be required to perform several different functions related to concurrent design and production responsibilities, obviously contingent upon size of the organization, nature of the product and competition, and so on. This is all consistent with the overall theme of this text, that the organization should be driven by the technological functions to meet the demands of the future.

Problem Solving And Brainstorming. A key part of the systematic method for making technological improvements through process engineering and design is related to effective problem solving. While it is less effective to solve problems which enable “putting out fires” rather than affecting proper long term decision making, it is also true that problems must be solved on a regular basis in technological organizations. Eight steps can be identified for problem solving:
Identify the problem. The problem is related to objectives to be accomplished or specific problems which have arisen.

Set parameters. Why was the problem selected? What is the problem and expected results? What is not the focus of the problem?

Analyze the problem. This is analysis through organization of different parts of the problem and its sub-components, a cause and effect stage.

Preliminary ideas selection. Possible plans for remedial action and selection of best alternatives.

Decision identification. Putting the best alternative into action.

Analyze decision. Comparison between original plan (or targets) and actual results in value terms.

Prevention. This is action to prevent recurrence using standardized procedures and training.

Future planning. Analysis/impacts cause reflection for planning, approach to future issues.

Another approach to problem solving is often described as the classic "Design Process". This problem solving/decision making process commonly has six major steps consisting of problem identification, preliminary ideas, refinement, analysis, decision, and implementation. Design process is often further broken down and explained as:

Problem identification. A problem statement is determined since--if the problem is not known how can we attack it?

Preliminary ideas. Early solutions identified based on preliminary thoughts and reviews of available information, experience.

Refinement. Additional detailed study is conducted on the preliminary ideas and other available but increasing information.

Analysis. Detailed and in-depth analysis and testing is pursued through engineering analysis, field testing, prototyping.

Decision. One solution is selected and final work-ups for implementation are conducted, including final planning for full production.

Implementation. The system or device is implemented. Evaluation on-going would typically commence for feedback into the system for improvements, long-term.

This system of problem solving, design, innovation and creativity has many similarities and parallels to the previous systems and approaches presented throughout the section and chapter. As well, many of these tools are clearly related to the remaining parts of the tool and throughout the toolkit.

Brainstorming is another tool which should prove useful for addressing problems in technological organizations related to problem solving. This is an idea generating activity which is usually conducted in groups of 3-12 people (although this can vary), typically more creative and productive relative to an individual based on a synergistic affect. It may also be true that the human imagination applied to a problem with some reflection and freewheeling assists in the success of brainstorming. When brainstorming occurs it is necessary to have a leader to focus the group, and it is necessary to have someone or some method for documenting the ideas generated. We also need a relatively comfortable atmosphere and agreement on the topic or problem.

When the process is actually being conducted all members in the group should be encouraged to participate, providing only one idea per turn (to help avoid anyone dominating the process). People should be sequenced regularly to help provide ideas, and no criticism should be allowed. To assist in generating "free wheeling" and creative ideas, the following "idea spurring" questions should be asked:

Are there new ways to use the component or unit as is, or if modified? Or if not?

Can the unit/component be adapted? What else is like this, or can other ideas work?

Can we change meaning, color, motion, sound, odor, taste, form, shape?

Can we add to it? What, where to add? Can frequency, strength, size be changed?


Can we substitute? What else instead? What other plans may be helpful?

Can we rearrange layout? Other sequence? Change place?

Reverse parts? Opposites? Turn it backwards, upside down, or inside out?

Can parts be combined? How about a blend, assortment? Combine purposes, ideas?

Enhanced Design, Creativity, Five Why's

A critical part of staying competitive ties design and product development to creativity. The point in this section is to provide a systematic creativity tool for enhancing competitiveness. This is viewed particularly through a design and product development perspective. The question relates to
how best to use materials and process in innovative ways to become and remain competitive. Creativity is addressed in terms of how it can be improved to provide better products, and certainly higher levels of productivity. When addressing improvement through creativity it is important to recognize there are many different ways to solve the same problem.

Seek new solutions. It is important to try to solve problems in new ways rather than only using traditional approaches. People should learn to evaluate their ideas in objective terms without letting their ego interfere. Creative people often have problems seeking opinions about their ideas. Worse yet, once criticism is offered by others, creative people may become offensive rather than trying to take advice in a constructive fashion.

Use the team. Teamwork is an essential part of industrial design and creativity development. This is true for a variety of reasons, but fundamentally most technical problems are simply too complicated for a single individual to tackle. Teamwork for creativity is an art and a science requiring give and take in order to successfully and creatively be productive. Also, the creative individual must be able to present ideas and concepts, both verbally and graphically, in ways that will effectively communicate to all concerned. Far too many people are good draftsmen but are limited designers because they simply can not exchange ideas and information with others in an effective manner.

Know the field. In order to be creative, people must know the field. All technical options, components, processes, materials and so on must be thoroughly understood so the designer can adequately create from among all possibilities. People must take time with colleagues and even by oneself to simply try to generate ideas/solutions to technical problems. It may be important to keep a notebook handy at all times to list/design possible solutions for varieties of problems. We should not trust ourselves to remember, since the truly creative mind will be moving along into other areas and may likely forget an idea that is not documented.

Sketch it out. Closely related to this, people must keep a sketchpad handy. Some of the best ideas which have become products started out on restaurant napkins, notepads from meetings, the back of a bulletin in church, and so on, where doodling often occurs. Sketching is probably one of the single best tools the creative mind has access to, and it should be capitalized on. People must learn to do sketching efficiently and without effort, simply by practicing.

Sweat and toil. Contrary to what some people may think, true creativity does not simply happen, as if by magic. Rather, it is generally only through concentrated effort over time that most ideas are actually turned into products. Much sweat and toil are necessary to bring ideas through creative development to fruition as products. Part of this relates to confidence. People must not be afraid to develop their ideas, nor should they be intimidated by others who may not want them to be successful for petty or unprofessional reasons. Fear of failure often not only keeps us from pursuing our ideas, but also slows down the creative mind, keeping an individual from moving ahead. People must think positively about their ideas and themselves, particularly if they wish to "sell" their ideas. People cannot succumb to the mistaken notion that they cannot do something--we will only accomplish what we believe we can do.

Handle pressure. Although true creativity cannot be time-clocked in an eight to five fashion, many creative minds function better under the gun, with pressure to produce. This may be particularly true if the pressure is self imposed. If it is outside pressure (particularly from within the organization) creativity may even be hampered. An appropriate balance is necessary in the real world. While this does not mean we should be unrealistic about goals and timelines, most of us can afford to push ourselves, to improve productivity and creativity.

Get organized. Related to several points already mentioned, the creative person will probably need to organize all resources in a logical manner and place. This, along with methodical and systematic pursuit of solutions to problems, is clearly part of the key to creative functioning. Again, it is recognized that creativity cannot be mechanically produced in a machine-like fashion. But a reasonable amount of discipline surely must be a part of most creative acts. Many people create better at certain times and places. While there is no general rule to fit all individuals, creative people will generally know when and where their best work is accomplished. This could be in the shower, at church, while jogging, during meals, at sporting events, while shopping, in the shop, on the plant floor, at any time day or night. The "light bulb" of an idea may come on at any time in any environment. Creative people learn when and where they are most creative and they capitalize on this.

Get some perspective. It may be necessary to get some perspective. Sometimes we all hit low periods when we are simply less creative (or productive) than at other times. This may come and go briefly, or it may linger for days on end. However, the creative individual should recognize this for what it is and attempt to deal with it in a reasonable manner. This may mean taking some time away from...
the project to get some fresh air and start anew. Often a change in environment, people, or both, will help. Putting a project in perspective can help a creative mind be even more effective.

**Access information.** Truly creative people are not afraid to admit that they may not know all the possibilities. The reality is that we all can access more information about any given technical subject or problem. Colleagues should be consulted, friends talked to, the literature reviewed, catalogues studied, and perhaps other sources surveyed. The point is, all sources of information should be exhausted prior to expecting a truly creative and definitive solution. Closely related to this, perhaps one of the best sources which must be studied is the competition. To be most creative, it may be necessary to obtain the competition's product, and physically tear it apart to determine the strengths and weaknesses.

**Ask why five times.** And in all that we do relating to design, it is critical that we not become satisfied with the quick and easy answers. The five why's are a way of indicating that we must continually ask why? With sufficient why's, we can expect to find better answers and solutions to our technical problems. We must all become increasingly comfortable with asking why--five times. Perhaps the most important point from the above, is that creativity can be improved. Like so much about Kaizen and ongoing improvement, we must be disciplined and systematic if we wish to be creative.

## Managing Innovation, Design Phases

Innovation in product development is concerned with changing existing products, making them more competitive in the marketplace. Much overall effort in product development is actually innovation since it is generally more cost effective to change and upgrade the existing product rather than create a truly new product. True creation of new products is more related to actual research whereas innovation is the continued development of existing products. Innovation cannot be handled in a loose or uncontrolled manner. Poor management can be quite costly, detracting from overall profitability of the innovation and the organization. For example what if an innovation is not carefully and objectively evaluated before commitment or implementation to be sure it will work and save (or make) more money over time than it costs immediately. What if the innovation does not truly solve the problem that gave rise to the innovation in the first place?

Poor management can also permit people to become less than objective about an innovation. This is often the case where an individual or sub group within the organization finds a certain innovation interesting and professionally rewarding. Another example of innovation being dangerous is when people are intimidated or alienated by the technology or innovative activity. If people are not diplomatically and carefully involved in the innovative activity they will be less likely to accept the innovation. Related to the issue of diplomacy, innovation sometimes appears to be assisting in the area where it was designed to be used or applied. However it may also be true that the innovation may create disorder elsewhere within the organization for a variety of reasons. Effective communication will clearly be necessary throughout the organization during the innovation process.

The preliminary design phase is concerned with looking at various relationships and inputs which are thought to have a potential impact on the overall product development. Designers review the competition, often obtaining and disassembling various products, enabling them to make proper judgments about how to improve their product. Rough sketching is a basic tool at this phase of product development. These "thumbnail sketches" are simple line drawings done in a three dimensional (3-D) approach for purposes of getting a reasonably good likeness of what the actual product may look like. Since the design is not nearly finalized, the designer is truly in a brainstorming mode, attempting to gain the best possible combination of appearance, serviceability, produceability, cost, sales appeal, and perhaps other factors.

During this phase people in virtually all divisions should have an opportunity for input and constructive criticism regarding the developing product, since the more input typically means additional improvements in the final product. It is critical that all ideas be saved to permit the idea to evolve in a logical fashion. Also, if done this way a permanent record exists from which to work in the future. As designers near closure of this phase with final sketches being a logical outcome, a rendering is commonly provided for a variety of purposes. The rendering is a sketch of what the actual product should look like when completed. As such it is typically done with good line quality, shading, and in an inked format. This rendering will then go to marketing, production, and other groups in the organization, to get a final preliminary approval prior to investing further in the product.
It is possible, at this stage, to decide that no further investment should occur for this product if sufficient resources do not exist at this time. However, at some point during the preliminary design phase it is critical that a commitment be made for one basic design. The preliminary design which is selected is a function of inputs from all appropriate sources and provides the necessary decision for continued future development. It is quite likely that a prototype will be produced at this stage, used to gain final product feasibility inputs from individuals inside and outside the organization.

Following the preliminary design selection, working drawings are typically drawn up, showing all components and details in appropriate relationship to one another. At this point the designer should be working closely with the production division to ensure that the product can actually be produced. The better the communication which occurs in this phase, the less likely that costly errors in judgment will be made. Also, the better the communication, the easier it will be to incorporate the new product design into production when the startup actually occurs. Generally during this phase (although this must be considered at all phases) a serious cost analysis will be conducted to provide further proof that the product is feasible. At this phase the product could be shelved due to prohibitive cost estimates.

Specifications are developed at some point in a final phase of the design process, leading to a fully developed product. Working with one or more prototypes developed during the second phase, various engineering and technical groups will usually begin gathering final production data prior to actual production. The prototypes will be disassembled, time studies completed, flow charts provided, machinery acquired, personnel hired and trained, and other final preparations made. A pilot run is usually conducted at this point to gain actual data prior to full production. Also during this final design/development phase various testing will be completed on prototypes and pilot products. The product tests may be field tests, destructive tests, or other appropriate methods for gaining final data inputs. It is quite likely at this point that changes in materials, processes, dimensions, or other relationships may occur since final specifications are often somewhat different than the original product ideas may have dictated.

During design and innovation functions, and to a lesser extent, related to process and applications engineering activities, one of the critical factors is control of the overall project. It is often true that general management techniques as discussed elsewhere will be helpful in maintaining satisfactory progress on projects of this nature. But it may also be true that product development, as with research and development in general, presents some unusual management circumstances. Often personnel involved are very intelligent and creative, presenting the need for a flexible non time-clock oriented environment since truly creative activity does not follow an eight to five timeline.

Since innovation is a creative activity it is difficult to know when sub-components or sub-activities have actually been accomplished, particularly on a short-term basis. Consequently accountability is often difficult to establish/measure. Related to timelines, since innovations often change through development from original plans to actual final product it is very difficult to predict and/or stay on target with regard to budget constraints and cost control. But how can this type of activity be adequately managed--and simultaneously positively facilitated? How can an organization assure itself that it is maximizing on expenditures related to these types of creative activities--and not leading into project over-runs, and cost deficits?

One method for assisting in controlling innovation is what is termed baseline development and revision. A baseline is a reference point that provides a firm basis for moving on to another phase in product development. Failure to use baselines can result in a continual back and forth shifting from one project phase to another with potentially tremendous impact on overall progress and loss to the project. Baselines are established at key points in a products' development. The baselines are established at the conclusion of conceptual, preliminary and final design stages when prototypes are fabricated and tested, when early production models are produced and when the product is in use by consumers.

Baselines are generally defined by various documents such as specifications, drawings, test data and numerous procedural documents (i.e. flow charts, time and motion charts, layout diagrams). Regardless of what documentation is used it should be identified early in the project and upgraded over time. As the product develops, with baseline data established, personnel have a firm foundation from which to move forward through each step of the product development. Facilitating this communication as a "living document" rather than a static piece of information only, is vitally important.

Kickoff meetings and reviews can also be used advantageously to help control product development. The project/product kickoff meeting is an important initial control device including an overall
communication function. It plays an important role in orienting staff regarding the purpose and constraints of the product/project. However, perhaps more importantly a kickoff meeting also provides the setting and tone for future control actions by identifying objectives and who is responsible and accountable for various tasks and by providing an overview of control techniques that will be followed/used on the project. Kickoff meetings also help by establishing variance levels/limits which, if exceeded, will require corrective actions and appropriate reporting methods for variations and corrective actions in development. Since an understanding of controls to be used on the project is essential for their effective implementation, the kickoff meeting is a valuable method for getting staff acquainted project requirements and constraints.

Another innovation management strategy, closely related to kickoff meetings, is the design/project review. Design reviews are control strategies for assuring that the product development is on schedule and is meeting contract requirements, customer specifications, and general project technical concerns. These review meetings are used to help evaluate and guide specific subsystems/objectives within the project. More specifically the review meetings will need to be held near completion of each of the various design phases, and during various phases of full production. Key features of review sessions include independent evaluations by design, production, safety and quality personnel. Review sessions also provide comparison of design and product development. With previously established baseline data regular systematic involvement and communication can occur.

Similarly, project benchmarks are a vital part of managing the overall innovation and change strategy. Benchmarks are arbitrary points to be evaluated in the project evolution. The benchmarks are generally time or other resources dependent, meaning that the benchmarks will be set to a large extent based on the projected impact the activity going forward unchecked could have on the overall project. These will typically be a part of the larger project plan, and will often be a computer based/software applications driven type tool designed to help keep the project on task. It can also be a rather non-sophisticated listing of key events in simple chronological order, identifying the major steps of the work which are projected to be gone through, when, with necessary resource requirements, and perhaps other useful inputs--certainly to include who will be doing a given part from throughout the organization.

Identification and elimination of designs, materials and components that are not responsive to customer or other requirements, are unreliable, or use parts that have been found to be too expensive, unsafe, difficult to install or have high failure/reject rates will surface in a similar manner. Another reason the sessions are useful is to facilitate discussion to help determine if the design is really what is needed and that the product is evolving on target for subsequent phases. This includes documentation according to general project/product requirements and attempts to determine that staff, management and customer are informed regarding product design status and overall development.

Contrasted to design reviews, project review meetings are held periodically (monthly, quarterly or as needed) to help identify and/or correct any undesirable deviation from plans, present an overview of the project, or for general communication purposes to various levels of management, owners or to customers. Areas subject to project review may be:

- Major task status in terms of schedule, budget, target dates or work done.
- Summary of major accomplishments.
- Description of any significant changes from original plans or requirements (e.g. contract changes, new specifications, and so on).
- Problem areas and recommendations for correction.
- Plans/projections for the period leading up to the next review.

Regarding design or general project reviews the following should be observed in the planning for and running of the work. Plan the review a few weeks in advance, issuing a memo defining the agenda and review requirements and general meeting scope. Be sure to guide the reviewer's focus on the major aims so unnecessary comments and changes are minimized. It is important to be realistic about how much you can accomplish. Plan to accomplish a reasonable amount and stick to it. If it can't be accomplished in an hour or less you probably are trying to do too much. Send all informational packages for review a reasonable time prior to the actual meeting. Make certain it is clearly understood who will run the meeting and how information and progress will be documented. Following this a summary is sent to participants including significant dates/timelines, who will do what, and so on.

A product change request (PCR), an electronic form which serves as a communication and
documentation strategy to be used by all concerned with the product/project. The reality is that products from inception to actuality, in the market, will go through many changes. If these changes and upgrades are not carefully communicated (particularly in large organizations) to staff and others it can mean serious progress and cost setbacks. Consequently a single page form incorporating company name, subject change description, date, effect of change in man hours/cost, schedule, adjustments, justification for change, divisions/departments/affected, person initiating change, and so on, is generally used. But again, this is almost inevitably now a computer driven, electronic update type function, sometimes increasing the difficulty of facilitating the design changes properly. Safeguards must be built in to assure that the wrong persons cannot make changes in a design, causing undo harm in the process.

Prior to implementing any changes in the product, during development, several appropriate questions could be asked. PCR questions could be, will the change compromise the product's safety, reliability, availability, marketability, service life or general performance? Will the change affect the cost of the product beyond what the customer is willing to pay? Likewise will the change increase costs not directly related to the product such as greater service or maintenance costs after the product is sold? Will the change delay the product's market entrance, enabling the competition to reach the customer first? Is the risk (in changing) worth the gain in presumed desirable features? Is the technical staff in full agreement on the change? If they are not it is probably wise to re-evaluate the change since the lack of agreement may indicate a likelihood of failure with the change. Finally is the change really wanted or needed by the customer?

Change will occur in products and processes whether as new designs or innovations of old products. When changes are identified, properly documented, and communicated to all concerned, problems can still exist when actual implementation of change occurs. Even with well planned changes, several areas of concern must be accounted for:

**Anticipate problems.** After changes have been totally analyzed areas where problems may occur will be obvious. Prudent managers determine problem areas and formulate advance solutions in event a plan is needed to address problems which will likely arise.

**Use a pilot program.** Rather than making a product change in one giant step without any prior attempts, a pilot run on a small scale should prove useful in identifying weaknesses in the change before going into full scale production.

**Use gradual steps.** Often small changes rather than a single large change can be more effectively managed. This may be particularly true if the small-stepped changes are gradually phased in.

**Communicate effectively.** Good communications regarding the proposed change, how it is different from the existing plan, how it will be implemented, what various individuals' responsibility is, and expected problems, all must be carefully communicated to concerned people.

**Train people adequately.** All change details must be incorporated into existing procedures for production by way of sufficient training.

**Insist on accountability.** After change assignments are made, establish timelines, monitor results, and expect performance according to identified criteria.

**Don't oversell the change.** Be realistic about a product change. Do not raise expectations to the point that if the change fails to adequately materialize peoples' jobs are placed on the line.

**Involve everyone in the product change.** Do not have only an "in-crowd" which pits the new types against the old types. This can quickly become a damaging force in an organization. People are fearful and resistive to that which they do not fully understand, or wholly or partially uninformed about.

**Allow sufficient time.** Changes in product will are time consuming to put into action. If insufficient time is allowed, disappointment will likely be encountered. This may be costs, cost of planning time, dissatisfied customers, and so on.

### Applied Technical Research

Research is a process of critical and exhaustive investigation or experimentation to achieve the goal of discovery of new facts and their correct interpretation. It also aims at revising accepted conclusions, theories, or laws in light of newly discovered facts or the practical applications of new or revised conclusions. The principles and general rules of conducting research work are the same no matter what the area of specialization or focus. What we have learned and/or experienced in other kinds of research areas and activities can be very helpful for us to engage in the applied technical research.

What is applied technical research? Several elements of a definition are possible including invention, discovery, innovation and development:
Invention merges knowledge and experience to physically produce a previous non-existent item.

Discovery is observation and recognition of phenomena inherent in nature, unknown before.

Innovation is refining and improving what is already created and/or established.

Development evolves an invention or innovation from concept to commercialization.

Assisting in understanding applied research, there are reasons, both internal and external, for building and maintaining the research program:

- Scientific prestige, "advertising value" gained through presenting, publishing of papers.
- Interesting research may improve morale and make recruiting sharp talent easier.
- Results of some work may be bartered for information and research elsewhere.
- Pure science may give rise to practical applications.
- The ability to grow knowledge both individually and in teams.

Not only does this assist in explaining applied technical research, but also, some reasoning for efforts in this type research may be applicable and transferable from one organization to another. Specific applied technical research characteristics, oriented to process engineering, follow:

- The problem should be technical, such as process analysis, comparisons for quality, etc.
- The study will be done in a technical environment such as a laboratory or plant.
- Measurable data is collected and analyzed in a precise, objective, manner.
- It can be scientific research with laboratory experimentation involved.
- It can be a limited fact-finding study or extensive experimental research project.
- Results usually can be easily and directly applied to our organization or functions.
- The research can be viewed as technical in nature with well defined parameters.
- No identical studies are available, but similar work may be on-going or planned elsewhere.
- Problems should be within the researcher's technical knowledge and available resources.

**General research design and preparation.** Research design and preparation should include planning exact laboratory procedures step by step and having them documented. Researchers should prepare necessary data collecting and recording forms well in advance of the actual start. It is important to make sure that all needed equipment, tools and instruments are available and in good working condition. Specimen preparation procedures must be documented, determined and followed religiously. It is important to consider the method of controlling variables, general environment, data to be collected and how to measure them as issues to be resolved.

Methods of analysis and computer use must be considered, as well as method of presentation of final data and results. When reviewing technical literature it is important to make certain that all appropriate bases are touched. This will likely include technical society publications, conference proceedings, technical research papers, textbooks (Technology, Engineering and others as appropriate), manufacturer and/or suppliers' technical documents, and research and development reports, among others. The basic idea is to conduct a thorough and detailed review of literature related to the research.

Another broad area of concern is proposal writing, generally responding to a request for proposals (RFP). Proposal writing begins with scanning the grant agency's or foundation's internal guidelines, page by page, to get a "feel" for accepted funding ideas and procedures. Next sketch out with a few words the main features of the guidelines and your proposed ideas. It might be very helpful to have a colleague help review tentative responses against the guidelines and highlight the key concepts in the guideline instructions. This will assist in outlining the requirement for the preparation of the initial draft. Writing styles differ, yet the style should be informative, factual, logical and thorough. The purpose of a proposal is to convince the reviewer/agency/organization that you know and understand the problem and what to do about it.

The researcher must carefully, and in detailed ways, present an appropriate and cogent plan of attack--knowing up front the problem was truly appropriate for pursuit. The plan of attack generally includes a basic focus on problem statement, key objectives or hypotheses, methods or procedures, and all broader inputs. It is also a good technique to show how each activity will relate to the stated objectives. Review all activities to be completed and list each job or task as well as the subordinate activities. Prepare a graph of events over a calendar time line to illustrate the plan of action. Finally, develop cost estimates and prepare a budget which can be justified in relation to the problem--after all else has been
reasonably well written—the budget should be driven by other elements in the proposal. Also consider:

- A team approach is recommended, aligned with other individuals of similar interests. This is particularly true in interdisciplinary efforts. We may not use the expertise of those closest to us— we should use people inside and outside.
- Small scale is recommended to get started. It is better to make mistakes, and learn on small projects, following up with increasingly complex/significant projects. A "success story" are needed prior to going "big time".
- Applied research requires knowledge and background in math, statistics, scientific principles and computer uses as basic tools to assist in successful completion of projects.
- Documentation should be completed immediately after the final report is filed. Postponement can "cloud" the issues, and if we do not routinely document our work, we may simply not do it, losing good information.

Good research is often ongoing and always disciplined—what we learn currently will build the foundation for where we go in the future. These principles are applicable for focusing efforts toward increasing research and development output.

**Basic principles of research design.**

Strategies and approaches related to technical research are largely guided by the research question or objective of the investigation. For illustration, an analysis of yesterday's production of motors or average noise level compared to the standard is a fundamental necessity in the research process. For illustration, an analysis of yesterday's production of motors or average noise level compared to the standard is a simple experiment or comparison. Evaluation of the effects of different curing temperatures on samples of specific polymer formulation of products under identical conditions is likely a more complex experiment, requiring more sophisticated methods. Identification, through rigorous iterative processes, of determining the actual focus of the research, is a fundamental necessity in the research process. Knowing specific objectives of the problem, and the detailed procedures or methodology, is equally as important. About 50% of the research task is to determine the actual problem to study.

A thorough and ongoing analysis of related information is critical. This is often characterized as a review of related literature, and should be an ongoing part of the process. This helps keep all persons involved up to date, but as well to assure that our approaches, technologies, and so on, are up to date and on target, helping to lead to enhanced opportunities for competitiveness. This may be represented as a section or chapter in the final report—used to support preparation of the proposal—referred to earlier as the review of literature.

Regarding method of research, replication or repetition of basic experiments or study (multiple readings) does not necessarily represent true replication. This does not necessarily improve the study either. Replication provides a better estimate of error in the study. It should also help strengthen the significance of the results. Randomization is necessary to provide random samples from a population or random assignment of treatments to the experimental units, again to help make the experiment valid. Randomization is also necessary to assure the effects due to errors associated with experimental units and/or that correlation among treatments will be made as small as possible. Local control consists of applying grouping, blocking, and balancing techniques to samples or treatments. This can make experiments/tests more sensitive and their procedures more powerful and efficient.

Carrying out laboratory experiments entails several basic points. Among these are setting-up a precise laboratory work schedule. This can't be done in a haphazard manner. It is also important to consider multiple laboratory uses, other professional responsibilities, laboratory assistants' time frame, among other practices which can affect the quality of work. Follow the plan at all times since, if deviation occurs, the reliability of the results of the study will be suspect. As the study proceeds and based on results, modify the method if necessary. Be sure to record the modification in detail, and allow for alternatives in the analysis of data. Make sure all variables are tightly controlled and take precautions in collection of data, recording unexpected events.

Analyzing and presenting data for the study should be done in a logical and systematic manner. The first step in analyzing data for presentation is to organize recorded data for analysis. Wherever possible, it will probably prove helpful to utilize computer and available software to perform mathematical and/or statistical tasks. The researcher should design and use tables and graphs in good form for presentation. The data should not need to be reorganized for final presentation if the researchers have done their homework at the outset. If analyzed results and findings are organized properly, discussion and interpretation easily follow.

Summary, conclusions, and recommendations are the final part of a study to be reported. Again thoughts about this part of the study are based on the need to be methodical and systematic in our efforts. The summary should be brief but complete,
highlighting and reinforcing any key findings or relationships found to exist. Conclusions should be based solely on the findings of the study. No subjective comments or personal opinions can be presented. These may be stated as a list but it is important to make sure to check back against hypotheses, objectives or the research questions to see that they are matched and logical. It is inappropriate to present conclusions which are not aligned with the original purposes of the study. Recommendations are based on difficulties and problems to be solved for future studies and improvements which can be made. Further study possibilities which were identified in the current study may also be addressed. Research should not deviate too far from original parameters of the study.

**Developmental research.** Developmental research is frequently involved with prototype and fabrication kinds of activities. An idea is presented, drawings are completed, specifications are determined, a problem is identified, but the bottom line is that a device has to be built which will prove or disprove theories or some ideas, or simply to address a problem. In its modern day form prototype development could even be called process engineering where problems are identified in the industrial setting or elsewhere, solutions then are determined and plans are made, and a product is brought to fruition to help in the solution of that problem. This involves design, fabrication, analysis and testing/evaluation of prototype systems.

This type research is much like what many people in technological organizations have been familiar with for years. That is, solving problems on your feet with devices that have been conjured up from a variety of sources to address a specific need. This is informal prototype development and it is a crude level of research, of course fitting in under applied technical research and development. It is very appropriate to identify developmental research, for our applied technical research purposes, as prototype development, testing ideas and thinking in action--the nuts and bolts, hands-on, put-it-together and make-it-happen research and development.

**Replication research.** Replication research attempts to verify known data, information and/or behaviors. This may include engineering data, test data and information, behaviors which are thought to be true, and perhaps those areas which are known to be true. In any situation where values are known to exist under a set of circumstances, it is possible to replicate for any number of reasons, those kinds of values. Reasons for doing this kind of replication/research could include, for illustration purposes, teaching and learning environment verification from industrial circumstances. Evaluating a change in a situation where variance from standard exists and behavior and impact of the variance is not clearly understood is an example.

Examples of replication which could make excellent research and development activities in the applied technical research arena for industrial technologists would be any of the common properties and characteristics of materials. For example, tension, compression, shear, among other mechanical characteristics, and electrical conductance's, thermal conductance's, and so on all could be built into demonstration devices under the auspices of replication for educational purposes. Another interpretation of replication may be where a research activity previously conducted by one individual or group is done again by a second individual or group for comparison purposes.

**Experimental research.** Experimental research is an attempt to compare two or more behaviors to one another. It is generally true that experimental research is a rather controlled, formalized method of comparing, with or without the use of statistics, behaviors for various purposes. Experimental research may be the most sophisticated form of research available as a tool for our application. It does not have to be highly formalized nor statistical in its nature. The key to successful experimental research may be that both behaviors are gathered from a controlled set of circumstances which account for as many extraneous variables as possible and which help to provide as pure a reading on the behaviors for comparison as is possible. Knowing how one device or system in an experiment compares to another requires statistics to test appropriately.

**Process And Applications Engineering**

Process and applications engineering is viewed as an applications oriented problem solving activity within the atmosphere of a shop floor or job site production environment--regardless of industrial or technological orientation. Process and applications engineering is the identification, analysis and systematic solving of technology and human problems for improved productivity and quality in technological organizations and functions. As such, process and applications engineering is fundamental to ongoing improvement and certainly necessary for competitive interests into the future.

Improvements in technological organizations'
quality and productivity will not come from people knowledgeable only in business/management or technical aspects of technological functions or engineering. Rather it is a blend of all this through a technological perspective that will bring about the changes in production that are so necessary for American industry to remain competitive in the future. It is particularly important that the process and applications engineering view be presented within the context of the broader systems approach to technological functions. Problem solving at the work site level must be within the context of technological impacts and implications throughout the organization.

A myopic view of the product and its operations will simply not be satisfactory for competitive problem solving. Process and applications engineering must include a hands-on orientation with knowledge and experiences, as well as abilities in materials, processing and mechanical aspects of technological functions. If problems must be solved relative to materials handling, quality, cost control, safety, maintenance and ergonomics, then technological systems within production must be studied. Typical process engineering problems are:

- Analyzing quality problems in processing.
- Conducting cost analysis on a new process.
- Analyzing various materials for a redesign.
- Determining work layout and materials flow.
- New product or process development.
- Market analysis in technical developments.
- Training or evaluation related to changes.

Each of the above areas represent applications which can bring about improvements in quality and productivity, leading to overall enhanced competitiveness for the technological organization. Process and applications engineering can involve virtually any element of the technological organization, certainly not limited only to technical aspects, to help birth innovation.

Process engineering differs from traditional engineering by being more applications oriented. Traditional engineering is related more to planning and design in a theory-based circumstance. Process and applications engineering is hands-on, action oriented, problem solving which clearly uses planning and design concepts. Process and applications engineering is likely more of a short term problem solving orientation relative to traditional engineering. Traditional engineering is more mathematically and scientifically based relative to process and applications engineering.

**Market Research for Product Development.**

We must constantly seek information about the market for new and existing products. Information which is sought as a function of market research is typically identified as market size, the organization's share of the market, competitor's price, consumer perceptions, and advertising effectiveness. Desire for this information is due primarily to the shift from a production oriented economy of scarcity when people were sold products which were produced without a thorough understanding of the marketplace, to an economy controlled by the desires of the consumer.

The function of market research is to provide information which will aid in the decision-making process related to product development. Market research can be further defined as the systematic gathering, recording, and analysis of data and general consumer information. Information collected explains the market mix including facts relative to getting the right product, customer, location, price, and determining proper timing for the product. Questions asked as part of consumer market research include what are the consumer's wants and needs, and likes and dislikes? How many buyers are there in various markets? How much money do they have to spend? What brands of products do customers currently purchase? What other factors affect consumers? That is, we are listening to “voice of the customer”.

Appropriate focused product market research questions could include which of the numerous possible designs will likely be most successful? Which features and options should the product incorporate? What type of packaging and distribution system offers the most appropriate combination of aesthetics, protection, and so on? Is the product cost competitive with similar products? What types of advertising media should be used, at what cost? What characteristics should be emphasized in each market?

After basic market research questions have been addressed, various research methods are typically employed to gain additional information about the market. The three basic methods can be summarized as historical, experimental, and survey. Historical market research is primarily concerned with similar products' past market performance. Company sales receipts and other records are typically examined to aid in historical studies. Company failures, trade association records, patent records, among other sources, also must be studied.

Although past product history can be an important indication of potential product success, further studies can come through experiments with
product. Experiments typically attempt to establish cause and effect relationships which are thought to exist. Usually people are involved in some form of trial uses of the product in either a control or experimental group. The users in the experimental group are manipulated in various ways as a function of changes in the product, with the reactions of both groups being monitored and recorded. Survey research is perhaps the most common and basic approach for studying market conditions relative to products. Typical reactions to product are gathered by simply conducting questionnaires or interviews.

Before extensive effort and cost have been invested, several questions are appropriate:

○ Will costs of implementing new product be offset by profits, and over what period?
○ Can product be reduced in application scope to minimize costs, and still achieve quality?
○ Can product, with modifications, do more than one thing, increasing value?
○ If changes are involved in an existing product, will product safety be affected?
○ If the product is not practical now, could be developed later?
○ Has the market been studied? If not, is a marketing study forthcoming?
○ Do we currently have necessary to support full-scale production?
○ How similar to existing products is the proposed new product?

Although many questions arise relating to product development it is commonly accepted that products evolve out of five major phases. This includes exploration and experimentation, engineering analysis, business and marketing analysis, development and testing, and commercialization. Exploration and experimentation is an on-going search to discover potential products while engineering analysis is the initial analysis to determine which ideas are appropriate for more detailed and thorough study. Business and marketing analysis includes creative analysis which helps place the product idea into a concrete proposal of product features and a time-line for project completion. Development and testing is making the idea into a demonstrable prototype for various types of testing. This provides various field tests and lab experimentation to verify product performance. Commercialization is the actual preparation for marketing of the product following all other phases.

This also relates to a process all products go through, commonly called the product life cycle. The life cycle for a product can be defined as the way a product performs over time in the marketplace. Although it may appear that the life cycle is not related to product development, there are several ways to illustrate the relationship between product development and product life cycle. Fundamentally the relationship revolves around cost, involving issues such as how long the new or reworked product will capture the market, providing a profit for the organization? The overall cost to develop the new product and the point in dollars and units of production that breakeven will occur is also an obvious and important issue. Cost of new processes and general expansion to permit production of new product, and impact of capital expansion payback on overall breakeven for the organization, are important.

More specific to the market, the effect of a poor market response or incorrect interpretation of the projected product life cycle on overall profitability for the organization can be devastating. How long can the company carry a less than profitable product, assuming a profit will eventually be realized? What should be done with existing equipment, facilities and workers when the product begins to lose its foothold on the market? What levels of plant, equipment and personnel are necessary for meeting optimum market conditions? Can the market be influenced or created, and if yes, how is this to be done? What will the appropriate level of production be to adequately address the market demand without over building production capacity and saturating market prematurely? Can we allow demand to exceed supply and prolong a successful product, allowing the market to "pull" production rather than pushing, permitting minimum inventories to be carried.

The basic stages in most product life cycles include incubation or introduction, growth, maturity, saturation and decline. The incubation or introduction stage is where the product is introduced to the market, often with free samples and other ploys to develop the market. This stage of the life cycle is clearly costing the organization but is viewed as an investment in the future. Incubation/introduction also often provides direct user feedback to the company, sometimes causing subsequent changes in the following generations of products, improving the position of the new product in the market. During the growth stage in the life cycle the product has begun to make an impact on the market. Although consumers are becoming aware of the presence of the new product, it is only beginning to be established. The company is still investing in the market, although perhaps not as heavily as during
During maturity the product now has a clear identity with the consumer and the competition. At this point the product should begin to break even in terms of investment in development to bring the new product to fruition. Although the market response to the product still will generally remain relatively brisk, the market will begin to slow down toward leveling off. In the saturation stage the product's acceptance in the market has leveled off and if new markets cannot be developed or modifications in the product brought about to recapture some of the known market, the product will be doomed. At this point in the product life cycle it is time for stylizing. That is, through redesign and upgrading, the product will be given a "face lift", providing an increasingly competitive product. It may also be true, however, that the interest at this point is simply to stylize for purposes of keeping some portion of the market. Although it may appear quite reasonable to simply slow production and not produce so many units, thus balancing the supply and demand issue and easing the saturation in the market, it is generally not easy to simply "slow" production. The organization has probably invested heavily in plant and equipment, training, fixtures and so on. This may be particularly disconcerting if the payback on new plant and equipment has not been achieved when saturation begins to occur.

During decline the product has outlived its usefulness in the market. It is clear that the consumer prefers some more recent competitor's product at this stage. Even if stylizing could occur at this point, it would probably take substantial reinvestment in both the product and the market in order to restore profitability. Many producers will indicate that it is often wise to let the dying product meet its demise and start fresh, learning with the "losses" and regrouping to be more competitive. It should be recognized that it is often considered good business to produce a fresh identity rather than being associated with a "loser". This explains, in part, why companies periodically upgrade/change their logos and provide stylizing regularly to maintain profits.

The prudent producer will have many products (diversified) in differing stages of product life cycle. This phasing-in of new products, starting the life cycle at various times for different products, helps to sustain the overall health and financial vitality of the organization. By cycling in new products at planned intervals the systematic balancing of life cycles for various products will help carry the organization through the good times and the bad. Problems with this approach can be readily identified, however. For example, it is difficult to have new products ready to go on-line at precise times. Technologies and people needed to produce varieties of products do not always dovetail, leading to additional capital investment to have multiple products on-line simultaneously. Because cycles of product life are often very difficult to determine, it can lead to problems with a systematic, planned approach to integrating multiple products. Products not sufficiently diversified and too similar, may compete with its own product lines, resulting in negative impacts on the organization.

**Product Launch Systems For Innovation**

The "total system" is defined as the products, support and information that we, in conjunction with various delivery partners, offer to end user customers. This system sets forth the scope, work flow and deliverables for new products, support and information from program definition to product introduction. The launch system procedure applies across new product programs of all sizes and types in manufacturing and non-manufacturing industries as well. Types of new products to which these launch system procedures apply include classes I, II and III, defined as new platforms, derivatives and tailoring.

**Class I, new platform.** New platforms may include entirely new products unrelated to our existing product line. But new platforms may also frequently refer to innovation spin off's from the existing product line, typically called major derivatives. New platforms are the most substantial financial commitment and change organizationally, and are generally referred to as class I type programs.

**Class II, derivatives.** Derivatives obviously relate to existing products and technologies which are common to the core business. Existing knowledge in process and product terms would be fully utilized with common derivatives. Derivatives are also frequently referred to as major tailoring applications or programs since while substantial change must occur, it is not as significant as new platforms.

**Class III, tailoring.** Tailoring programs provide changes to existing products, to upgrade and enhance performance based on customer demands. These may also be current product support programs, to provide additional resources and organizational commitments to existing products. Class III tailoring provides the least amount of change and disruption to the organization. Launch systems apply to all new products but may be used differently:

- Cross-functional team focus on total system customer needs based on market research, customer demands and data and documentation
with customer contact and interaction throughout all dimensions of the program. Ensure the best fit of the products, support and information with the end-user customers' total business needs.

○ Prevention versus failure driven. Emphasize quality of total quality system design in all phases and functions. This includes a primary utilization of preventive systems and tools such as FMEA, QFD, OPCP, and others as fundamental building blocks and approaches.

○ PDSA cycle. Plan is focused primarily on a cross-functional program plan, frequently identified as a contract. Do would become functional and cross-functional work activities. See provides the common measures, audits and prototyping functions. Act is data based corrective actions and issues from FMEA.

○ Self-managed discipline. Cross-functional team focus on creating a product plans evidenced in a contract. Self directed team responsibility lies in managing and measuring its progress versus the plan as stated in the contract.

○ Flexibility for program needs. Cross-functional team tailors application of the program to meet the customer needs. Different cross-functional team approaches will be based on class I, II or III program types as specified by actual customer needs and demands.

○ Continuous improvement. Measures and audits provide data based improvement within and across programs, and document all. Corrective actions taken based on available data result in improvements which can be used elsewhere over time in the synchronous environment.

Several additional definitions are important to understanding launch systems.

**Charter or vision.** The charter or vision is an output of the customer led planning process and could likely be solidly based on quality function deployment or other exercises. It is a concise document written by a cross-functional management team that specifies the business goals, objectives, constraints and leadership (program sponsor, manager or leader, as appropriate) for a specific program. Supported by market and or customer research, the intent of the charter or vision document is to set clear, high-level targets for the program and create a vision of what we are striving to achieve.

**Comparative advantage.** Products, support and information advantage as judged in the marketplace by the end-user customer. Total system product quality, technology leadership (real and perceived), and timely market introduction are all key factors in establishing and maintaining a comparative advantage. By focusing on customer business needs, systemic products will consistently beat competition.

**Contract.** The contract, prepared by the program team, is a program plan to meet the business objectives of the charter. It includes "what" the team will deliver and "how" the work will get done. The contract defines the program scope, system profile, quality plan, schedule of work resource plan, measures plan, financial plan, and risk assessment. The contract is the mechanism for gaining agreement between all program stakeholders.

**Customer led planning process (CLPP).** A cross-functional process to identify and evaluate world-wide business and market opportunities and to formulate a plan which defines and integrates our technical plan, product plan, operating plan and capability improvement plan in order to provide the greatest value to our customers. This process determines the business goals and objectives for each market and creates a coordinated business plan for the company based on assessments of customers and markets, competitors, the regulatory environment, technology trends and capabilities. The CLPP is administered by planning by senior management. Participants include management from all functions.

**Management reviews.** A concise, cross-functional management meeting which charts a program, approves the contract and regularly reviews program progress and corrective action plans.

**Managed introduction.** The period of time in a program beginning with ship #1. During managed introduction, volumes are ramped up to full production levels. The program team is responsible for establishing the criteria against which the introduction is managed.

**New product planning (NPP).** NPP is systemic planning as definition, design, and development to introduce high quality new products, support and information, creating value for customers, delivering on time at target costs and volumes, while reducing time to market.

**Class I programs: New programs.** Programs called "clean sheet of paper” products, managed via a specific program team structure called a system team.

**Class I programs: Major Derivative.** Only those derivative programs designated as class I by senior management. The charter will reflect the critical market/business/product characteristics that drove this classification. Major derivative programs are managed by a system team instead of a new product introduction team (NPIT).

**Class II programs: Derivative.** This involves redesign or modification of existing products, processes or support tools/services. Derivatives are managed via a specific program NPIT team structure.

**Class II programs: Major tailoring.** This category will typically cover those tailoring programs designated as class II by management via the customer led planning process. Major tailoring
programs are managed by a NPIT instead of product change management (PCM) processes.

**Class III programs: Tailoring.** Programs or projects involving product, support or information customization for specific customer applications (e.g., changing installation related subsystems and/or parts, special performance calibrations.) Tailoring programs/projects are chartered, approved and managed as product change management (PCM).

**Class III programs: Current product support.** Programs or projects such as cost reductions, quality related improvements, source approvals and parts substitutions which are designated as class III and chartered, approved and managed via the product change management (PCM) process.

**Program definition phase.** This begins with the charter and ends with contract approval by the appropriate level of cross-functional management review. The program team focuses on getting to know the customer and the customers’ business needs through a variety of techniques including direct customer interaction. Various system and subsystem level design concepts are developed around a broad work plan for early management reviews.

**Design phase.** Focus is on designing and developing product, support and information addressing customer needs and technical requirements. The output is a high quality single stable design (for total system), including a prototype completed and no additional major changes planned.

**Development phase.** This refines a total system stable design from design phases, through continued analysis and test and releasing product for production. All business, performance, reliability, durability and production readiness issues of the total system stable design are addressed prior to the managed introduction decision. Specifics of a plan to transition responsibility from program team to "normal" production system needs to be identified prior to management review to transition properly.

**Program managed introduction.** The managed introduction phase which is focused on final transition of responsibility from the program team to the functional group and ends in full production of the total system at the final review.

**Program leader.** The program leader is the customer "champion" for the total system who oversees the entire program through all management reviews. As leader of the program team, he/she is responsible for the program budget, selection of core program team members with functional management, preparation of the contract, communication with senior management, development and implementation of reviews, elimination of barriers, program results and management processes to get there. The program leader must be skilled at driving consensus decisions while encouraging and listening to individual concerns. The leader must make timely decisions in instances when consensus can not be reached.

**Program manager.** As an assistant to the program leader, the program manager helps the program leader with his/her responsibilities listed above. Each program leader and program manager discuss and document the specific split of responsibilities appropriate for their situation. In some cases the program leader assumes all responsibilities of a program manager or vice versa. The specific functional role of the program manager is to be the team's "process architect." The program manager is a core member of the program team responsible for leading team focus on work process planning, implementation, measurement and improvement. The program manager must be skilled at application of NPP and other procedures, quality tools and process improvement methods. The program manager is responsible for evaluating the capability/skills of program team and work team members and identifying training requirements.

**Program sponsor.** As a coach, mentor and advisor to the program leader, the program sponsor provides timely resolution to barriers encountered, including ongoing communication between cross-functional senior management and program team. A sponsor stays connected to the program team by reviewing progress at each milestone major review.

**Program team and core membership.** The cross-functional team acting as the "operating committee" for the program, responsible for successful delivery of all contract elements. Core membership is consistent with all of the synchronous functions encompassing the following roles, given the scope and areas of change in each program:

- Program leader.
- Program manager.
- Functional project leaders for planning, marketing, customer engineering, and others.

These leaders and managers are responsible for integration of all technical elements of the total system. This will generally include installation, engineering, manufacturing processes, serviceability, electronic controls and reliability in product and process during all aspects of production.

Program teams and cross functions encompass other broad service entities over the life of the program including service parts and tools, parts and service training, parts and service information, warranty, service development and technical service engineering, impacting all documentation and various management information systems and finance. Program team members are responsible for results representing their functional perspectives to
include important possible milestones, such as follow.

**Preliminary design phases.** Based on various levels and types of customer demands, preliminary designs will be in place at some point as agreed to in the contract. This key deliverable must typically include an articulated effort between and among all technical entities associated with product and process upstream and downstream.

**Prototype.** This focuses on test and evaluation of the readiness of a product, support or information related component, subsystem, or support system. This will traditionally include physical prototypes but may also be computer modeling such as finite element systems and others. Documentation and data collection systems will generally be developed to a usable state of maturity when prototyping occurs. This will also likely include various pre-production and short run documentation for integrity of ability to actually perform as contracted.

**Ship #1.** The first commercial shipment of managed introduction is obviously an important milestone in the overall product launch program. This represents the date by which all production processes should be in place, and tested via earlier prototyping cycles, pre-production tests and short runs. Ship # 1 is also that actual point in the program where all systems are fully capable and ready to meet actual customer demands over the long haul.

**Stable design.** Stable design is the total system design for products, support and information that has matured to the point that the critical systems program deliverables have been demonstrated. At this point one complete program system prototype has been completed, some level of short run has been accomplished, and all parts and structure are released and accepted, and major changes are no longer planned. Major durability work begins and final machine tool/supplier commitments are made. This marks the end of the design phase.

**Ongoing production.** The ongoing production phase success and timeframe for achievement is directly linked to the earlier planning phases and functions. Elements of the earlier team will need to remain in place over the longer term based on the definition, design, development and introduction process. Checklists provided throughout this series of documents should not be substitutes for creativity. Program teams must find ways to improve the NPD process, documenting procedure changes appropriately. Enabled by management’s mutual commitment, the program team has full discretion over the program and its execution. Management reviews provide key check points for the program team managing/measuring progress versus the contract and communicate the progress to management over the course of the program. Statements of work detailing new product planning, development and introduction steps are documented as part of the charter and contract development process, cross functional team process, and product change management processes, among others.

**Special circumstances.** Special circumstances specific to each program, including deviations and/or improvements upon procedures, are highlighted in the contract by the program team. Each entity/plant function is expected to supplement documentation with local procedures as required.

**Measures of performance.** The program team is responsible for measuring and managing its performance relative to customer satisfaction, business results and process effectiveness. Performance indicators may include standard measures used across all programs supplemented by specific measures including management reviews and interim target values for measures. Actual versus target results are visited at each management review.

**Patents, USPTO**

The United States Patent and Trademark Office (USPTO) is an agency of the U.S. Department of Commerce. The role of the USPTO is to grant patents for the protection of inventions and to register trademarks. It serves the interest of inventors and businesses with respect to their inventions and corporate products, and service identifications. It also advises and assists the President of the United States, the Secretary of Commerce, the bureaus and offices of the Department of Commerce and other agencies of the government in matters involving all domestic and global aspects of “intellectual property.” Through the preservation, classification, and dissemination of patent information, the Office promotes the industrial and technological progress of the nation and strengthens the economy.

In discharging its patent related duties, the USPTO examines applications and grants patents on inventions when applicants are entitled to them; it publishes and disseminates patent information, records assignments of patents, maintains search files of U.S. and foreign patents, and maintains a search room for public use in examining issued patents and records. The Office supplies copies of patents and official records to the public. It provides training to practitioners and as to requirements of the patent statutes and regulations, and it publishes the Manual of Patent Examining Procedure to elucidate these. Similar functions are performed relating to trademarks. By protecting intellectual endeavors and encouraging technological progress, the USPTO
seeks to preserve the United States’ technological edge, which is key to our current and future competitiveness. The USPTO also disseminates patent and trademark information that promotes an understanding of intellectual property protection and facilitates the development and sharing of new technologies worldwide.

**What Is a Patent?** A patent for an invention is the grant of a property right to the inventor, issued by the United States Patent and Trademark Office. Generally, the term of a new patent is 20 years from the date on which the application for the patent was filed in the United States or, in special cases, from the date an earlier related application was filed, subject to the payment of maintenance fees. U.S. patent grants are effective only within the United States, U.S. territories, and U.S. possessions.

The right conferred by the patent grant is, in the language of the statute and of the grant itself, “the right to exclude others from making, using, offering for sale, or selling” the invention in the United States or “importing” the invention into the United States. What is granted is not the right to make, use, offer for sale, sell or import, but the right to exclude others from making, using, offering for sale, selling or importing the invention. Once a patent is issued, the patentee must enforce the patent without aid of the USPTO. There are three types of patents:

- Utility patents may be granted to anyone who invents or discovers any new and useful process, machine, article of manufacture, or composition of matter, or any new and useful improvement thereof;
- Design patents may be granted to anyone who invents a new, original, and ornamental design for an article of manufacture; and
- Plant patents may be granted to anyone who invents or discovers and asexually reproduces any distinct and new variety of plant.

The patent law specifies the general field of subject matter that can be patented and the conditions under which a patent may be obtained. In the language of the statute, any person who “invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent,” subject to the conditions and requirements of the law. The word “process” is defined by law as a process, act or method, and primarily includes industrial or technical processes. The term “machine” used in the statute needs no explanation. The term “manufacture” refers to articles that are made, and includes all manufactured articles. The term “composition of matter” relates to chemical compositions and may include mixtures of ingredients as well as new chemical compounds. These subjects taken together include practically everything that is made by man and the processes for making the products.

The patent law specifies that the subject matter must be “useful.” The term “useful” in this connection refers to the condition that the subject matter has a useful purpose and also includes operativeness, that is, a machine which will not operate to perform the intended purpose would not be called useful, and therefore would not be granted a patent. Interpretations of the statute by the courts have defined the limits of the field of subject matter that can be patented, thus it has been held that the laws of nature, physical phenomena, and abstract ideas are not patentable subject matter. A patent cannot be obtained upon a mere idea or suggestion.

In order for an invention to be patentable it must be new as defined in the patent law, which provides that an invention cannot be patented if: “(a) the invention was known or used by others in this country, or patented or described in a printed publication in this or a foreign country, before the invention thereof by the applicant for patent,” or “(b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country more than one year prior to the application for patent in the United States.”

If the invention has been described in a printed publication anywhere in the world, or if it was known or used by others in this country before the date that the applicant made his/her invention, a patent cannot be obtained. If the invention has been described in a printed publication anywhere, or has been in public use or on sale in this country more than one year before the date on which an application for patent is filed in this country, a patent cannot be obtained. In this connection it is immaterial when the invention was made, or whether the printed publication or public use was by the inventor himself/herself or by someone else. If the inventor describes the invention in a printed publication or uses the invention publicly, or places it on sale, he/she must apply for a patent before one year has gone by, otherwise any right to a patent will be lost. The inventor must file on the date of public use or disclosure, however, in order to preserve patent rights in many foreign countries.

Even if the subject matter sought to be patented is not exactly shown by the prior art, and involves one or more differences over the most nearly similar thing already known, a patent may still be refused if the differences would be obvious. The subject matter sought to be patented must be sufficiently different from what has been used or
described before that it may be said to be non-obvious to a person having ordinary skill in the area of technology related to the invention. For example, the substitution of one color for another, or changes in size, are ordinarily not patentable.

Searches, Patent, Trademark Depositories. Many inventors attempt to make their own search of the prior patents and publications before applying for a patent. This may be done in the Patent Search Room of the USPTO, and in libraries, located throughout the United States, which have been designated as Patent and Trademark Depository Libraries (PTDL’s). An inventor may make a preliminary search through the U.S. patents and publications to discover if the particular invention or one similar to it has been shown in the prior patent. An inventor may also employ patent attorneys or agents to perform the preliminary search. This search may not be as complete as that made by the USPTO during the examination of an application, but only serves, as its name indicates, a preliminary purpose. For this reason, the patent examiner may, and often does, reject claims in an application on the basis of prior patents or publications not found in the preliminary search.

These patent collections are open to public use. The collections are organized in patent number sequence. Due to variations in the scope of patent collections among the PTDLs and in their hours of service to the public, anyone contemplating the use of the patents at a particular library is advised to contact that library, in advance, about its collection, services, and hours, so as to avert possible inconvenience. For a complete list of PTDLs, refer to the USPTO Web site at www.uspto.gov/web/offices/ac/ido/ptdl/.

Who May Apply For A Patent. By law, only the inventor may apply for a patent, with certain exceptions. If a person who is not the inventor applies for a patent, the patent, if it were obtained, would be invalid. The person applying in such a case who falsely states that he/she is the inventor would also be subject to criminal penalties. If the inventor is dead, the application may be made by legal representatives, that is, the administrator or executor of the estate. If the inventor is insane, the application for patent may be made by a guardian. If an inventor refuses to apply for a patent or cannot be found, a joint inventor or, if there is no joint inventor available, a person having a proprietary interest in the invention may apply on behalf of the non-signing inventor.

If two or more persons make an invention jointly, they apply for a patent as joint inventors. A person who makes only a financial contribution is not a joint inventor and cannot be joined in the application as an inventor. It is possible to correct an innocent mistake in erroneously omitting an inventor or in erroneously naming a person as an inventor. Officers and employees of the United States Patent and Trademark Office are prohibited by law from applying for a patent or acquiring, directly or indirectly, except by inheritance or bequest, any patent or any right or interest in any patent.

A non-provisional application includes:

- A written document which comprises a specification (description and claims), and an oath or declaration;
- A drawing in those cases in which a drawing is necessary; and
- Filing, search, and examination fees.

USPTO also offers the option of provisional application, designed to provide a lower cost first patent filing to give U.S. applicants parity with foreign applicants. Claims and oath or declaration are NOT required for provisional applications as a means to establish early effective filing date on a patent to permit the terms “Patent Pending” to be applied in connection with the invention. Provisional applications may not be filed for design inventions.

Provisional applications are NOT examined on their merits. A provisional application will become abandoned by the operation of law 12 months from its filing date. The 12-month pendency for a provisional application is not counted toward the 20-year term of a patent granted on a subsequently filed non-provisional application which claims benefit of the filing date of the provisional application. The following order of arrangement should be observed in framing the application:

- Application and fee transmittal forms.
- Application Data Sheet.
- Drawings.
- Executed Oath or declaration.
- The specification as followings, in order:
  - Title of the Invention.
  - Cross Reference to related applications (if any).
  - Statement of federally sponsored R&D (if any).
  - Reference to and submission of CD ROM.
  - Background of the Invention.
  - Brief Summary of the Invention.
  - Brief description, all views of drawing (if any).
  - Detailed Description of the Invention.
  - A claim or claims.
  - Abstract of disclosure.

The title of the invention, which should be as short and specific as possible (no more than 500 characters), should appear as a heading on the first
rights of others and whatever general laws might be
patentee's own right to do so is dependent upon the
offer for sale, or sell, or import the invention, the
Since the patent does not grant the right to make, use,
offering for sale or selling or importing the invention.
The exact nature of the right conferred must
depends upon the circumstances as provided by law.

When there are drawings, there shall be a
brief description of the several views of the
drawings, and the detailed description of the
invention shall refer to the different views by
specifying the numbers of the figures, and to the
different parts by use of reference numerals. The
specification must conclude with a claim or claims
particularly pointing out and distinctly claiming the
subject matter that the applicant regards as the
invention. The portion of the application in which the
applicant sets forth the claim or claims is an
important part of the application, as it is the claims
that define the scope of the protection afforded by the
patent and which questions of infringement are
judged by the courts.

Nature of Patent and Patent Rights. The
patent is issued in the name of the United States
under the seal of the United States Patent and
Trademark Office, and is either signed by the
Director of the USPTO or is electronically written
thereon and attested by an Office official. The patent
contains a grant to the patentee, and a printed copy of
the specification and drawing is annexed to the patent
and forms a part of it. The grant confers “the right to
exclude others from making, using, offering for sale,
or selling the invention throughout the United States
or importing the invention into the United States”
and its territories and possessions for which the term
of the patent shall be generally 20 years from the date
on which the application for the patent was filed in
the United States or, if the application contains a
specific reference to an earlier filed application, from
the date of the earliest such application was filed.

The exact nature of the right conferred must be
carefully distinguished, and the key is in the
words “right to exclude” in the phrase just quoted.
The patent does not grant the right to make, use, offer
for sale or sell or import the invention but only grants
the exclusive nature of the right. Any person is
ordinarily free to make, use, offer for sale or sell or
import anything he/she pleases, and a grant from the
government is not necessary. The patent only grants
the right to exclude others from making, using,
offering for sale or selling or importing the invention.
Since the patent does not grant the right to make, use,
offer for sale, or sell, or import the invention, the
patentee’s own right to do so is dependent upon the
rights of others and whatever general laws might be
applicable. A patentee, merely because he/she has
received a patent for an invention, is not authorized
to make, use, offer for sale, or sell, or import the
invention if doing so would violate any law.

Neither may a patentee make, use, offer for
sale, or sell, or import his/her own invention if doing
so would infringe the prior rights of others. A
patentee may not violate the federal antitrust laws,
such as by resale price agreements or entering into
combination in restraints of trade, or the pure food
and drug laws, by virtue of having a patent. Ordinarily
there is nothing that prohibits a patentee from making,
using, offering for sale, or selling, or importing his/her
own invention, unless he/she thereby infringes a patent
still in force. Thus, a patent for an improvement of an
original device already patented would be subject to the
patent on the device.

The term of the patent shall be generally 20
years from the date on which the application for the
patent was filed in the United States or, if the
application contains a specific reference to an earlier
filed application, from the date of the earliest such
application was filed, and subject to the payment of
maintenance fees as provided by law. A maintenance
fee is due 3 1/2, 7 1/2 and 11 1/2 years after the
original grant for all patents issuing from the
applications filed on and after December 12, 1980.
The maintenance fee must be paid at the stipulated
times to maintain the patent in force. After the patent
has expired anyone may make, use, offer for sale, or
sell or import the invention without permission of the
patentee, provided that matter covered by other
unexpired patents is not used. The terms may be
extended for certain pharmaceuticals and for certain
circumstances as provided by law.

Assignments and Licenses. A patent is
personal property and may be sold to others or
mortgaged; it may be bequeathed by a will; and it
may pass to the heirs of a deceased patentee. Patent
law provides for the transfer or sale of a patent, or of
an application for patent, by an instrument in writing.
Such an instrument is referred to as an assignment
and may transfer the entire interest in the patent. The
assignee, when the patent is assigned to him or her,
becomes the owner of the patent and has the same
rights that the original patentee had. The statute also
provides for assignment of a part interest, that is, a
half interest, a fourth interest, etc., in a patent. There
may also be a grant that conveys the same character
of interest as an assignment but only for a
particularly specified part of the United States.

Infringement of a patent is the unauthorized
making, using, offering for sale, or selling any
patented invention within the United States or U.S.
Territories, or importing into the United States of any
patented invention during the term of the patent. If a
patent is infringed, the patentee may sue for relief in
the appropriate federal court. The patentee may ask the court for an injunction to prevent the continuation of the infringement and may also ask the court for an award of damages because of the infringement. In such an infringement suit, the defendant may raise the question of the validity of the patent, which is then decided by the court. The defendant may also aver that what is being done does not constitute infringement. Infringement is determined by language in claims of the patent and, if what the defendant is making does not fall within the language of any of the claims of the patent, there is no literal infringement.

Suits for infringement of patents follow the rules of procedure of the federal courts. If the U.S. Government infringes a patent, the patentee has a remedy for damages in the United States Court of Federal Claims. The government may use any patented invention without permission of the patentee, but the patentee is entitled to obtain compensation for the use by or for the government. The Office has no jurisdiction over questions relating to infringement of patents. In examining applications for patent, no determination is made as to whether the invention sought to be patented infringes any prior patent. An improvement invention may be patentable, but it might infringe a prior unexpired patent for the invention improved upon, if there is one.