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The New Product Development Process for Manufacturers

A Proven Approach Based upon Industry Best Practices

Abstract

Specific processes in New Product Development (NPD) have proven themselves to be cost, time and results effective. This process is here explored and detailed so that the reader can enjoy the fruits of the approach. The process is the result of honing over twenty years of NPD experience so only the best practices are presented.

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Objective:

The objective of this document is to outline the process for the development of new product.

Background:

It is recognized that many existing New Product Development (NPD) processes lack structure and are not as effective as they should and could be. Attempts have been made in the past to add structure, but they have often simply encumbered the process to the point of ineffectuality. Certain aspects, however, of best practices from manufacturing industries are tremendously effective. Our attempt is to here distill those effective practices into a streamlined, focused process.

Process Structure:

The development process kicks off after a requirement is recognized from the synergistic cooperation of product strategy and a customer or market demand. This product requirement becomes the subject of conceptualization. This very early part of the development is left very flexible, so that good ideas may be spawned and bad ideas rejected. In some instances this approach is referred to as the 'Fuzzy Front End', (FFE). The output of the FFE may be a proposal that will initiate a development program. The conceptual efforts are here included in the first phase, development, for the purpose of structure.

The process is based upon a phase-gate approach. This means that there are a series of developmental phases that are separated by a decision gate. These phases are represented as:

Development
Engineering
Production Implementation
Commercialization

The gates occur between each of these developmental phases. The gates are intended to act as control mechanisms for the purpose of ensuring that we are working on appropriate products. The deciding body that will determine whether a program moves forward or not includes management representatives.

There are a series of deliverables that are required at the completion of each phase. These are of importance because they define the activities within the phase as well as provide a basis for metrics of the process and the team.

Depending upon the type of product that is under development, the entry point into the developmental phases may differ. If, for example, the new product is simply an extension of an existing family, there may not be a need for a development phase, such that the ideas generated from the FFE can be directed to the engineering phase.

The personnel that will develop new product are incorporated into a New Product Development Team. Again, depending upon the sophistication and complexity of the development program, various team members will be required. It is important that the team be consistent through the development phases and that the team be empowered to conduct whatever business is required. This empowerment is obviously tempered by the gating function of the management council, and is subject to imposed timeframes and budgets.

The Team

The most important asset that will be applied to the new product development program is the employees that make up the development team. Without skilled and motivated team members no forward progress is obtainable. The team requires innovative, creative team members that are results-oriented.

The team will have the full power that each of the phases provides. The team will also be responsible and accountable for it's activities and performance. Once the team has been named, it is imperative that the whole enterprise recognizes the team and it's authority. The managers of the enterprise need to be aware of the fact that the team will occasionally require their assistance, and they should be prepared to assist.

In some instances, the team members will share responsibilities. It is not uncommon that the Program Manager is the same person as the Sales Engineer, or the Design Engineer the same as the Research & Development Engineer. Other combinations can be imagined, and where they make sense, should be encouraged. Additionally, the names or titles shown here may not correspond to the names and titles within a specific organization. They are intended to define a role, not necessarily be precise titles.

The team members that are essential in the general case are considered below:

Program Manager: This person is the delegated leader of the team. The Program Manager is one who has been appointed to that position by the business manager. In this sense, the Program Manager is the business representative, as the business will be the organization that enjoys profitable sales at the end of the development program. The Program Manager may in fact be the business manager. The Program Manager may be one of the other members of the team that has been designated by the business manager to fulfill the role of Program Manager.

> **Qualifications:** The Program Manager should be an individual who is familiar with the NPD process, and understands the sets of deliverables. This person should be knowledgeable in the area of project management.
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> **Responsibilities:** The Program Manager is responsible for communication from the team to the business manager. The Program Manager is responsible for the facilitation of the NPD effort. The Program Manager is also responsible for acting as the voice of the customer. Since the Program Manager is the business delegate, it is imperative that the Program Manager continuously represents the welfare of the customer. The Program Manager will also be responsible for communication within the team, as well as representing the team to other bodies. The Program Manager is also responsible for communicating to managers and others in authority if any team member is not performing to expectation.

Sales Engineer: The sales engineer is the representative from the Sales and Marketing Group, or equivalent.

> **Qualifications:** The Sales Engineer must be familiar with the industry, the market and the customer. This should include experience with the application of similar product
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> **Responsibilities:** The Sales Engineer must report to and include the Sales Manager, or equivalent, in the decision making of the team. The Sales Engineer is responsible for interface with the customer, and for gathering as much data as possible on the use and

performance of the new product. Where appropriate the Sales Engineer will facilitate direct communication between the customer and the other members of the team.

Design Engineer: The Design Engineer is the representative to the team from the Design Engineering Group, or equivalent.

Qualifications: The Design Engineer should be versant in design engineering. This includes experience in designing from concept through production and the ability to perform cursory analyses and experiments as required by the program.

Responsibilities: First and foremost in the responsibility set for the Design Engineer team member is to report to and include the Design Engineering Manager, or equivalent, in the decision making of the team. The Design Engineer is responsible for the creation of drawings and engineering documents. Also, where required, the Design Engineer is responsible for the maintenance and administration of the electronic models for the purposes of analysis, fixture design, modification, etc.

Process Engineer: The Process Engineer is the representative to the team from the Manufacturing or Production Group, or equivalent.

Qualifications: The Process Engineer will need to be experienced in the manufacture of product. This includes development of new processes, the adaptation of existing processes and the control and understanding of each of the processes.

Responsibilities: It is incumbent upon the Process Engineer to report to and include the Manufacturing Manager, or equivalent in the decision making of the team. The Process Engineer is responsible for the design of the process, and the implementation of that process. In some instances this will be the development of a previously unknown process, so experimentation will also be required. Costs analyses and the development of the Process Control Plan will be the responsibility of the Process Engineer.

Quality Engineer: The Quality Engineer is the representative to the team from the Quality Group, or equivalent.

Qualifications: The Quality Engineer will be experienced in the NPD process. This includes development of process and quality plans, the design and implementation of gaging, etc.

Responsibilities: The Quality Engineer is responsible to report to and include the Quality Manager, or equivalent in the decision making of the team. The Quality Engineer is responsible for the development of the various quality plans and processes. The Quality Engineer will facilitate the Design and Process Failure Mode Effects Analyses (DFMEA, PFMEA).

Research & Development Engineer: The Research & Development Engineer is the representative to the team from the Research & Development Group, or equivalent.

Qualifications: The Research & Development Engineer will need to be experienced in the NPD process. The Research & Development Engineer needs to be familiar and versant with several enabling tools, such as Design of Experiment (DOE), Finite Element Analysis (FEA), etc.

Responsibilities: It is incumbent upon the Research & Development Engineer to report to and include the Director of Research & Development, or equivalent in the decision

making of the team. The Research & Development Engineer is responsible for assisting in the design of both the product and the process. The Research & Development Engineer is also responsible for collecting and managing the technologies developed through the NPD process.

Purchasing Agent: The Purchasing Agent is the representative to the team from the Purchasing Group, or equivalent.

Qualifications: The Purchasing Agent should be experienced in materials procurement, supplier and supply chain management, and in the NPD process.

Responsibilities: It is the responsibility of the Purchasing Agent to report to and include the Purchasing Manager, or equivalent in the decision making of the team. It is further the responsibility of the Purchasing Agent to design the supply chain, and to involve as effectively as possible our supplier base as integral members of the development effort.

Ad-Hoc Team Members: Additional or Ad-Hoc members may be added to the team as required. These team members may bring a special set of skills, or a special perspective. The Ad-Hoc members will not necessarily be a team member for the entire duration of the program. Ad hoc team members may include customers or suppliers.

The Phases and Deliverables

The following is a brief description of each of the development phases along with a listing of the deliverables from each phase, along with a description of each of the activities leading to that deliverable.

Development Phase

The Development phase is the first formal phase of the NPD process. It is intended to illuminate and demonstrate the potential of the product at hand. In the old R&D model, the Development phase includes the Concept Development, Feasibility Study and Prototype Development phases. It has been witnessed that these phases tended to operate simultaneously, so their consolidation is obvious.

The deliverables follow:

Customer Input: Customer input is a requirement, and can act as the start point for the Development Phase. All of the subsequent deliverables will hinge upon the customer input. In the case of a specific OEM development, the customer input is self-evident. In the case of a catalog type of product, the customer input can be developed through interviews and information exchanges with a representative set of customers that provide a cross section of the market.
Responsibility: Sales Engineer

Product Concepts: Based upon the intercept of the customer input and the business product strategy, a number of product proposals should be made. These can be as simple as sketches, with sufficient explanation of the concept. It has been demonstrated that the quantity of ideas that are generated is directly related to the success of the product. Each of the team members should be encouraged to participate in this exercise. This deliverable will encompass much of the FFE. The concepts should be shared, and then catalogued into a library of ideas. If patent protection is sought, these concepts will be key in establishing priority dates. Only one product concept should emerge as the vehicle for further development.
Responsibility: Team

Product Objective: The product objective should be a recitation of the intention of the product. It should include a physical description of the product, an overview of the specifications, comments towards the expected market and/or industry, and the anticipated selling price and cost structure. The product objective should also describe the number of sizes and permutations in the case of a catalog family. Developing a strong product objective is key to communicating to the team and to the steering committees the development intention.
Responsibility: Team

Market Analysis: The market analysis is critical to defining the requirements of the product, the cost structure, the specifications, etc. The market analysis should be considered a required deliverable. In the development phase the market analysis may not be complete or fully accurate, but should be sufficient for the steering committee to make a judgement towards the continuation or cancellation of the program.
Responsibility: Sales Engineer

Cost Analysis: Sometimes referred to as a Financial Model, the cost analysis is equally key as the market analysis and should be considered a required deliverable. The cost analysis should project the intended manufacturing process, the supply chain, estimates of the required capital, etc. The costs analysis may not be complete or completely accurate in the development phase, but should be sufficiently compelling for the steering committee to continue the program.
Responsibility: Process, Purchasing

Specifications: The product specifications are required to design the product. These specifications should include capacities, ratings, limits, etc. In the case of an OEM special, it is especially critical to procure the specifications from the customer to avoid substantial and possibly irrecoverable mistakes later. In this case, the specifications should be considered a required deliverable.
Responsibility: Team

Technical Bulletins: Technical bulletins are essential communications vehicles to further test the market and refine the market analysis. Technical bulletins may be developed with or in the absence of prototypes.
Responsibility: Sales Engineer, R&D

Drawings: The drawings developed during the development phase should be to prototype only. Ideally, the drawing is representative of an electronic model, that can be used to create other sizes and variations, as well as to serve as the basis of FEA, the creation of tools and fixtures, etc. In the interests of velocity in the case of a family of products, one size and permutation only should be drawn.
Responsibility: Design, Process, R&D

Prototypes: Whenever possible and cost effective, prototypes should be built at the earliest possible time in the overall NPD process. Prototypes are effective tools both internally and externally, and are the single most effective way to procure customer feedback. Prototypes will also serve to compel the steering committee to advance the program.
Responsibility: R&D, Process

Technical Feasibility: Technical feasibility is achieved through either the testing of prototypes to product specifications or through an analysis from product of similar nature. In some instances similitude may be the only cost effective avenue to demonstrate technical feasibility. Technical feasibility should be considered a required deliverable.
Responsibility: R&D, Design, Process

Patent Application: When the product is of a unique nature and it warrants protection from a patent, an application should be made. A current recommendation is to either apply provisionally, or in the case of a utility patent to designate the U.S. as the recording authority and the EPO as the searching authority. Provisional patents are substantially less expensive than a utility.
Responsibility: R&D

Business Plan: Based upon the product specifications and the suitability to customer input, a cursory business plan should be constructed. At this early stage the data included will be estimates. The plan should include projected sales price, costs, volumes, and ramp-up estimates. This is a required deliverable.
Responsibility: Program manager

Program Planning: Program planning is a required deliverable from the development phase. At this point of the program, enough should be known to project and estimate the amount of effort and timing for the remaining phases of development. This should be a team activity such that everyone should be responsible for planning his or her work.
Responsibility: Team

Engineering Phase

In the engineering phase, the product design, process and supply chain should be designed simultaneously, or as simultaneously as possible. This is partly to avoid design commitments that cannot be tolerated in the process, and to realize the lowest possible cost as a development criterion. As this is the second phase some of the deliverables from the development phase may need to be reconsidered and updated, such as the product objective and the specifications. These modifications should be made at the end of the engineering phase, and should be based upon the findings of the engineering phase.

The deliverables follow:

Market Analysis: The market analysis of the engineering phase should be substantially more complete and accurate than that from the development phase. Upon successful completion of the engineering phase, commitments will be made to tooling, etc., so accuracy is a must. Volumes, market segments, penetration times, etc. should be estimated at this time. This is again a required deliverable.
Responsibility: Sales Engineer

Cost Analysis: The cost analysis of the engineering phase should likewise be substantially more accurate and complete than that from the development phase. Process and work flow, cycle times, scrap rates, etc. should be considered.
Responsibility: Process, Purchasing

Customer Feedback: By the end of the engineering phase, customers should have responded to the technical bulletins, market queries, prototypes or all of these. It is the critical time to ascertain the market viability of the product. In the case of an OEM special, this is especially critical before the commitment to tooling.
Responsibility: Sales Engineer, R&D, Quality

Design Failure Mode Effects Analysis: The DFMEA needs to be conducted during the engineering phase and should be completed before commitment to a final design. It is important to capture as much experience as possible, and to put significant weight into the voice of the customer.
Responsibility: Quality, Design, Sales Engineer, R&D

Process Failure Mode Effects Analysis: The PFMEA is also conducted in the engineering phase, in keeping with the intent to design the product, process and supply chain simultaneously. The results of the PFMEA can influence the cost analysis.
Responsibility: Quality, Process, Purchasing

Drawings: The drawings developed during the engineering phase should be to limited production only. In the case that the electronic model was created well in the development phase, analyses to verify design specifications may be conducted. Materials specifications should all be completed at this point. Additionally during the engineering phase the fixtures, jigs, gages, packaging, etc should be designed. Integration of the product design platform with the tooling design platform will pay dividends in accuracy and velocity.
Responsibility: Design, Process, R&D, Quality

Prototypes: As in the development phase, prototypes are the best method with which to procure and solicit customer feedback. In the engineering phase these may in fact be ‘pre-production units’ that are very close to the final process. In keeping with the philosophy of ‘Stream of Product’, the number of prototypes produced during the engineering phase can be substantially

larger than that produced in the development phase. The design and process of the prototypes produced during the engineering phase should be closer to the production intent.
Responsibility: Process, Design, R&D, Purchasing

Beta Site Tests: In the case that prototypes were produced expeditiously, real application testing may be conducted. This is important on two major fronts. First, from a marketing perspective, we will have real experience with the product before the commercialization phase. Second, from an engineering perspective, defects and flaws have an opportunity to show themselves before commitment to tooling, etc.
Responsibility: Sales Engineer, Quality, R&D

Design of Experiment: During the next phase, production implementation, the product will be subjected to validation tests. It is imperative that the experiments, tests, rigs, etc. be designed during the engineering phase to avoid conflicts in timing and expectation in the next phase. Again, integration of the design platforms will aid the accuracy and velocity of this undertaking. It is important to integrate the DOE with the outputs from the DFMEA and PFMEA, so that attributes with high risk values can be studied and determined during the actual tests.
Responsibility: Design, R&D, Quality, Process

Market Literature and Sales Aids: The design of the marketing aids should be completed during the engineering phase to speed the procurement of same during the production implementation phase.
Responsibility: Sales Engineer

Feasibility Study: The feasibility study is an integral part of the Quality System, and should be conducted towards the end of the engineering phase, when much is known about the design, process and supply chain. This study will identify capital requirements to aid in the development of capital requests.
Responsibility: Quality, Design, R&D, Process, Purchasing

Process Control Plan: The Process Control Plan is the output of the design of process. The Process Control Plan will outline the steps that are taken to ensure that the product is manufactured reliably, robustly and with lowest cost. Although the development of the Process Control Plan is the domain of the Process Engineer, the other members of the team should have an active role in the review process.
Responsibility: Process

Business Plan: The business plan constructed in the development phase will need to be updated. Much more accurate estimates should be available at the conclusion of the engineering phase. This required deliverable should receive adequate attention to compel the gating committee to proceed with the product development program.
Responsibility: Program manager

Capital Requests: Completed CRs are the last deliverable of the engineering phase. These result from the total engineering exercise and should be the last hurdle before production implementation. The execution of the CRs by the steering committee is the official commitment to progression to the next phase.
Responsibility: Team

Production Implementation Phase

Upon successful traverse of the engineering phase gate, the program enters the production implementation phase. This phase, as its name implies, will result in the development of the processes and procedures that will produce the product to its production intent. This is the phase that will expend most of the capital that has been allocated to the program.

The deliverables follow.

Product Produced to Production Process: This term is self-explanatory, and replaces and updates the prototypes and pre-production samples alluded to in the development and engineering phases. These are the products that will be subjected to validation testing, and delivery to customers.
Responsibility: Process, Design, Quality, Purchasing, R&D

Market Analysis: This will be the final market analysis before penetration into the market. As such, it is expected that the market analysis of the production implementation phase is very accurate and very complete. Beta sites, and actual customer accounts should be considered in this market analysis.
Responsibility: Sales Engineer

Cost Analysis: The real costs of manufacturing the product should be understood during this phase, and should be captured in this cost analysis. This will be the working cost analysis as the program enters the market place.
Responsibility: Process

Beta Site Test Results: Hopefully by the conclusion of the production implementation phase, results from beta site tests conducted with pre-production units from the engineering phase will be forthcoming. This will help to bolster the marketing plans as well as to verify and validate the product design.
Responsibility: Sales Engineer, R&D

Customer Feedback: Along with the results from beta site tests, there should be a large of body of customer opinion and feedback. This information is critical, as it will help the steering committee determine whether or not to launch the product.
Responsibility: Sales Engineer

Market Literature: The promotional literature along with final technical bulletins and product specifications must be completed before the program can traverse to the market launch. As these items were designed in the engineering phase, it should be a task of ordering the printing, publication, etc.
Responsibility: Sales Engineer

Material Master: The material master is the control center for the product information. This is the tie in for finance, purchasing, PIC, etc. Of especial importance is that the material master serves as the print revision control center, so design data is controlled.
Responsibility: Design, Process, R&D, Quality, Purchasing

Bills of Materials: The bills of materials are required in order to configure the product. If a configuration tool is utilized, it will influence the generation of the bills, and should be created now.
Responsibility: Design, Process

Routings: The routings determine the workflow in order to produce the product. Attention to routing detail can help lead to the lowest possible manufactured cost.

Responsibility: Process, Purchasing

Op Sheets: The op sheets specify to the manufacturing associates how the product is to be built. The manufacturing specifications are included in the op sheets. The op sheets may contain specialized technical procedures.
Responsibility: Process

Quality Procedures: Quality procedures are put into place to ensure conformity of the process and the product by a regular method of operation and inspection. The quality procedures should stem from the quality plan.
Responsibility: Quality, Design, Process, R&D

Fixtures, Gages, Tools, Test Rigs, etc.: These items were designed in the last phase. In the production implementation phase, these items will be purchased, constructed, etc. In addition, they will be debugged and addressed in the quality procedures, the routings, the op sheets, etc.
Responsibility: Quality, Process, R&D, Purchasing

Validation Tests: The final control for the release of a product design to production level prints is the successful completion of the validation tests. These tests should have been designed along with the fixtures and rigs in the last phase, so that part of this exercise will be the purchase and/or construction of the rigs. In the case of an OEM special, the customer may perform this validation. It is imperative to follow up with the customer and procure a letter of validation or equivalent.
Responsibility: Process, R&D

Production Part Approval Process (PPAP): The PPAP is analogous to validation tests in that it is a requirement, primarily in automotive business before proceeding to production level prints and operation.
Responsibility: Quality, Process, R&D

Drawings: The product drawings may be traversed to production level upon the successful completion of the validation tests or PPAPs. Class A indicates that the design is production ready, such that full volumes may be processed through the enterprise.
Responsibility: Quality, Design, Process, R&D

Business Plan: The business plan should now be of sufficient accuracy that it will serve as the game plan for the release, sale and expansion of the product. Endorsement by the business manager is especially important at this junction.
Responsibility: Program manager

Commercialization Phase

The commercialization phase represents the culmination of all of the effort put forth in the preceding phases. It is not, however, the end of the program, as the true character of the product will now be tested and illuminated. Many of the deliverables from the earlier phases will need to be updated and modified as the product finds its place in the market. This includes the market analysis and the cost analysis, as well as possibly the product objective.

The deliverables follow.

Profitable Sales: While this may be very obvious, it still requires attention to verify that all of the cost and market analyses have been accurate. In some cases a program may already be in place to improve the profitability, through cost reductions, product enhancements, etc.
Responsibility: Team

Growth: One measure of the success and an indicator of the ongoing success of a given product are the increase in demand and sales. In the case of an OEM special, there may be only one fixed channel for the product, thus limiting its growth. In the same case, however, growth may be achieved through the expansion of the product to become a catalog type product.
Responsibility: Team

Customer Feedback: The product is now being produced to production process and is being delivered through production channels. The feedback from the customer should be evaluated to improve both the product and delivery.
Responsibility: Sales Engineer

Cost Analysis: As with the earlier phases of development, the cost analysis is key in determining the success of the product. The cost analysis of the commercialization phase may be used to enhance the accuracy of subsequent cost analyses of product still in development.
Responsibility: Process, Purchasing

Market Analysis: As with the cost analysis, the market analysis may now be tuned according to actual sales and demands. This analysis may also be used to improve the accuracy of products still in development.
Responsibility: Sales Engineer

Business Plan: The business plan as constructed in the production implementation phase should be reviewed for accuracy. The plan will now begin generating a history of the product, as well as a means with which to compare performance vs. expectation.
Responsibility: Program manager

Enhancement Plan: No product as produced the first time is perfect. An enhancement plan may be developed to address unanticipated problems with the design or process. The enhancement plan may lead to a new, new product development program.
Responsibility: Team

The Gates:
The following is a brief description of the gates that control the movement from one phase to the next. These comments may be used to assist the members of the steering committees in terms of acceptance criteria. They may additionally be made the basis for the measurement of the process, the team, etc.

Kickoff:
Previously unmentioned, this is the 'gate' that starts the development program, occurring before the development phase. The interaction between the market/customer demands and the product strategy will tender several requirements. Based upon the perceived value in addressing these requirements, the new product development program may be started. A brief proposal and description can be tendered to the gating committee, which if accepted will initiate the development phase.

Gate to Engineering Phase:
Allowing the program to traverse from the development phase to the engineering phase is based upon the quality and quantity of the deliverables. The product objective should be reviewed to acquaint the gating committee with the product at hand. In particular, the cost analysis and market analysis should be reviewed. These are still preliminary analyses, but should at least indicate potential success of the product. Further the technical feasibility should be evaluated from the standpoint of viability. Finally the program planning should be reviewed, as an indicator of the amount of resources and effort that will be required to realize the product.

Gate to Production Implementation:
The entry into the production implementation phase indicates a commitment from the gating committee to the allocation of monies for the tooling, fixtures, etc, required to produce the product. This will be through the examination and execution of the CRs. The deliverables to be analyzed before this commitment are the market analysis, the cost analysis, customer feedback, and the FMEAs. Based upon the quality of these deliverables, the net value of the product should be quantified, providing a means with which to allow progression to the production implementation phase.

Gate to Commercialization Phase:
The traverse to the commercialization phase should be based upon the successful completion of the production implementation phase. In most cases, unless something completely unanticipated occurs during the production implementation phase, the product should be ready for release. Especial attention should be given to the cost and market analyses, along with customer feedback, completed beta site tests and the results of the validation or PPAP tests.