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New Product Introduction Process Integration

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Introduction

The world market is changing for the OEM, CEM, and electronic manufacturers. This changing market dictates that as a global industry more focus is placed on reducing the time to market for "New Product Introduction". The current process has many redundant steps and requirements that greatly vary from one OEM or CEM to another. The transfer of the data and information required to build the design are ineffective. Often the fabricators receive designs with erroneous or incomplete information, resulting in even more delays in introducing the product to the marketplace. This is further compounded because prototype PCBs are frequently built at one facility and then transferred to another manufacturer or split between manufactures for production. The problems that are found at the prototype stage are not fixed before it is transferred to production, and the new production facility must once again deal with the same issues as the prototype manufacturer.

As the intricacy of the NPI process and the complexity of design requirements increase, the need for software tools grows dramatically. A fully integrated process from predesign analysis, where the designer is determining the initial characteristics of the design, through to the final product reaching the customer is essential, given today's environment. This paper describes a process that builds value into each step of the NPI job flow and retains the information for use throughout the entire process. Quality checks must be performed throughout the NPI process, and the design integrity must always be maintained even when transferring the design from one manufacturer to another. With the global placement of designs for prototyping and production, consistency in the design's performance, regardless of where it is manufactured, and a historical record of the design's life cycle are necessary so that the product's performance is never compromised or derogated.

New Product Introduction (NPI) Process Issues

Typical NPI Process Is Not Integrated or Automated

Rather, the process could be best defined as a series of individual functional steps that may be unique to an organization within a company or unique to a company. In many cases, each step is autonomous to the other and the communication is limited. The variation is tremendous between companies, and even within a company, different organizations may have their own way of doing things. One of the most significant and complex NPI process issues is the inefficiency and redundancy of the NPI process as it functions today. To fully understand the inefficiency and redundancy, the entire NPI process must be analyzed from the conceptual design through to the actual release of the design to the board manufacture. Figure 1 illustrates a generic NPI process flow from conceptual design until release to purchasing. This process is only an illustration, and in actuality, it will vary significantly between companies and even organizations within a company.

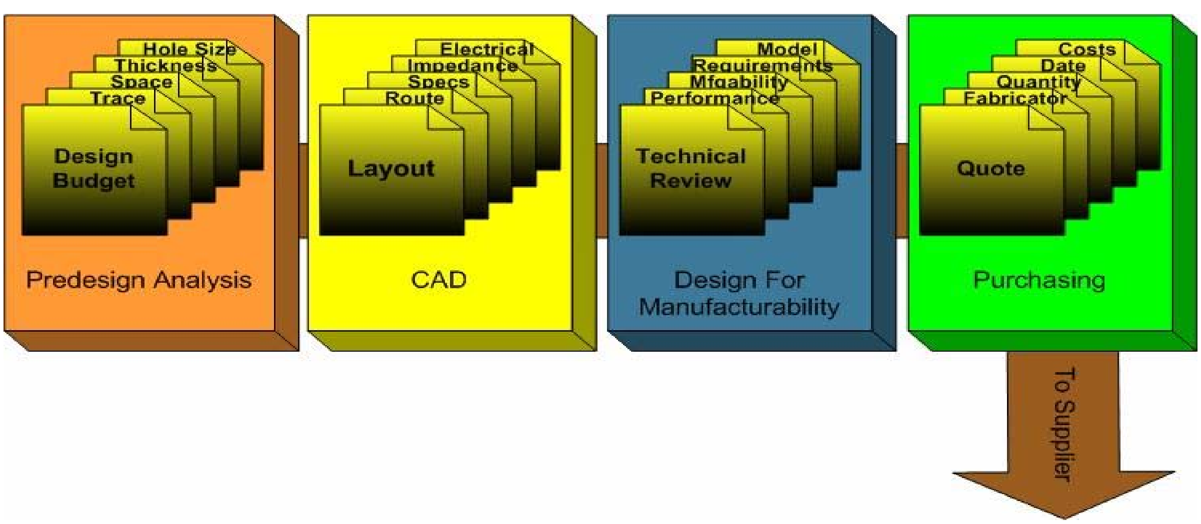

Figure 1 – NPI Design Process

As shown in Figure 1, the first step in the example process is to determine the preliminary requirements for the design. What are the fundamental design requirements? What is the expected functionality of the design? What are the basic attributes of the design? These are all questions that have to be answered before the design can be finalized.

Once the preliminary design requirements are developed, the next step would be to compare the requirements to existing design budgets or standards. This is standard design criteria that have been set up within a company or organization as guidelines with known manufacturability and performance results. This step could best be illustrated by taking the conceptual design requirements and comparing them to known design budget results. For example, a standard eight-layer board typically has certain minimum and maximum features associated with it. These standards could be related to the following:

- Layer circuit density
- Trace width
- Trace-to-trace spacing
- Pad-to-trace spacing
- Overall thickness
- Pad size
- Finish hole size
- Hole count

All of these design attributes are generally known, and they are based on known market capabilities. Movement to either the high or low side of these features may require increasing the layer count or facilitate decreasing the layer count. Changes to the design budget must be validated before the design is sent to layout so that the design is optimized. For example, if the circuits are too dense and the spacing is inadequate, this may drive the layer count up. Conversely, if the design requirements provide more than adequate spacing or the circuit density is low, the layer count may be decreased.

As shown in Figure 1, the next step in the design process may be to complete the actual CAD layout of the design. This is where the fundamental requirements and the design budget are put to the test and the layout on the CAD system is completed. The final product coming from the CAD station will more than likely be a modified version of the design budget. This step is where the rubber hits the road and the final design requirements are established. The layer structure, hole count, hole size, line width, spacing, copper density, et cetera are all determined in the CAD layout.

Design for manufacturability (DFM) review would typically follow the CAD layout. The digital data would be analyzed against known manufacturability requirements to assess the design’s manufacturability. Analyzing the data using design rule checks or a complete technical review of the design would all be a part of this step. Deficiencies that materialize would be sent back for correction so that the design would be optimized for manufacturability before it is released to purchasing. Once the optimized design is completed, the digital data, along with generic specification and design requirements, would be sent to purchasing to order the needed circuit boards.

When a fabricator wins the quote and receives the order, the first step is for the product engineer to review the digital data and all of the design requirements, including drawings and specifications. Figure 2 illustrates the process the printed circuit board fabricator goes through to introduce the design into the manufacturing facility. The total job requirements have to be understood and established before manufacturability of the design can be assessed. A mistake here could mean that the design will be shipped flawed with the wrong soldermask, the wrong finish, the wrong lay-up, et cetera. Once the product engineer understands the design requirements, a design for manufacturability review may be completed before the design is sent to CAM. CAM will input the design, flash drawn pads, snap pads to the drills, convert drawn planes to polygons, delete non-functional pads, and then run design rule checks. These steps are necessary so that the digital data can be thoroughly analyzed for manufacturability.

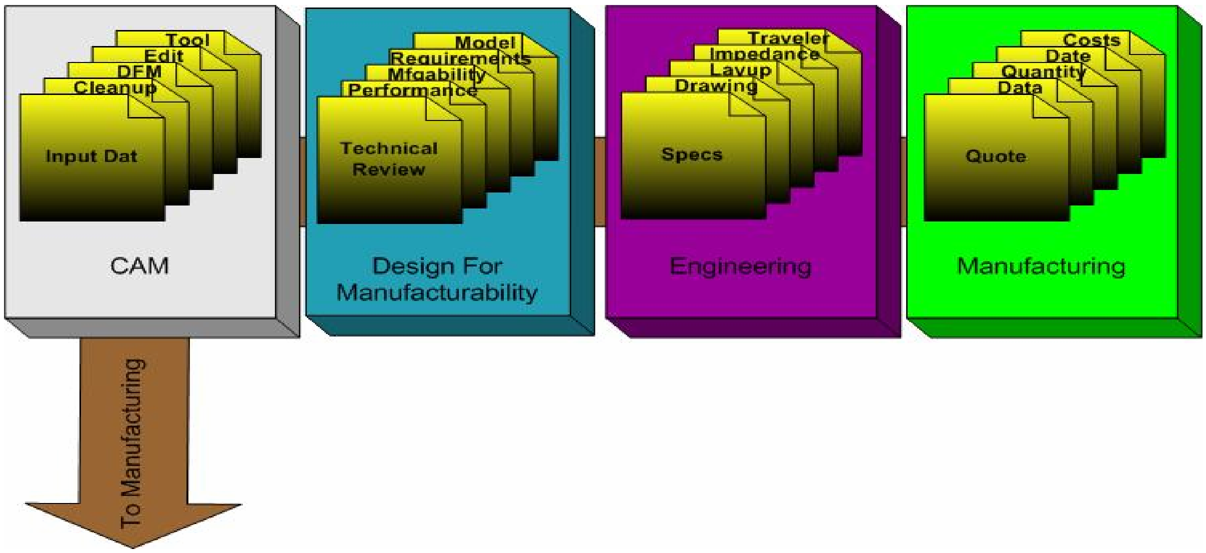

Figure 2 – Fabricator NPI Process

After the design is cleaned up and prepared, the fabricator will typically run a design rule check to determine if the design meets manufacturability requirements. Normally this check would be run on all of the layers, and key attributes such as line width, spacing, clearances, and copper density are verified. If the design requirements are below minimums, then the CAM engineer will optimize the areas of concern so that the design meets the manufacturability requirements. Moving on through the process flow of getting the design to manufacturing, the fabricator will lay out the panel for manufacturing, add other tool enhancements to the design, such as etch compensation grow, stretch factors, and tooling features, and provide the tooled design to manufacturing.

When the individual steps described here are reviewed, each one is necessary and contributes to the overall quality of the final product, but when reviewed in context of the total process, there are many redundancies and inefficiencies. Figure 3 shows many overlapping functions that could be eliminated if the process was structured properly and an efficient process flow was implemented. In essence, each step as described is autonomous, and some parts of it are recreated in each subsequent step. **This becomes particularly apparent when the design is transferred to the manufacturer or if the design is transferred from one manufacturer to another.** If the process was integrated from the preliminary design phase, several steps could have been eliminated, and critical design analysis and requirements could have been transferred in an intelligent format to subsequent steps. In all cases, the NPI process must be reviewed in its totality to determine how efficient or how redundant the process is. An OEM/design organization can have a very efficient NPI process only to have it made inefficient by the fabricator or visa versa.

Figure 3 – NPI Process (Predesign To Manufacturing)

Transfer of Specifications and Requirements Is Manual and Error Prone

New designs contain numerous geometrical and non-geometrical requirements, as illustrated in Figure 4. Non-geometrical customer specifications and design requirements are typically in print or electronic text format that cannot be intelligently used and analyzed by software driven tools. In this format, generally all the user can do is print and copy the documents for visual interpretation. The biggest causes of error for the fabricator's front end is lack of understanding the total design requirements or errors in transferring the requirements. The engineer can be set up for failure by the transmission of unclear or incomplete design requirements from one step in the NPI process to the next. The copper weight requirements, soldermask requirements, layup tolerances, hole size tolerances, and missing or unclear dimensional tolerances are examples of the incomplete non-geometrical attributes the engineer often sees. Typically, these items are noted by the engineer and the design is placed on hold while clarification is obtained from the design owner. In a worst case scenario, the engineer may not find the questionable condition and the design could be built and shipped to the incorrect requirement. If, for example, the drawing and specifications requirements were collected in an intelligent format, the product engineer at the manufacturer would not have to go back and reconstruct all of the information the design owner originally developed. The engineer would be able to review one screen and know the total requirements for the design. This information could then be used to drive the CAM process and the actual processes in manufacturing.

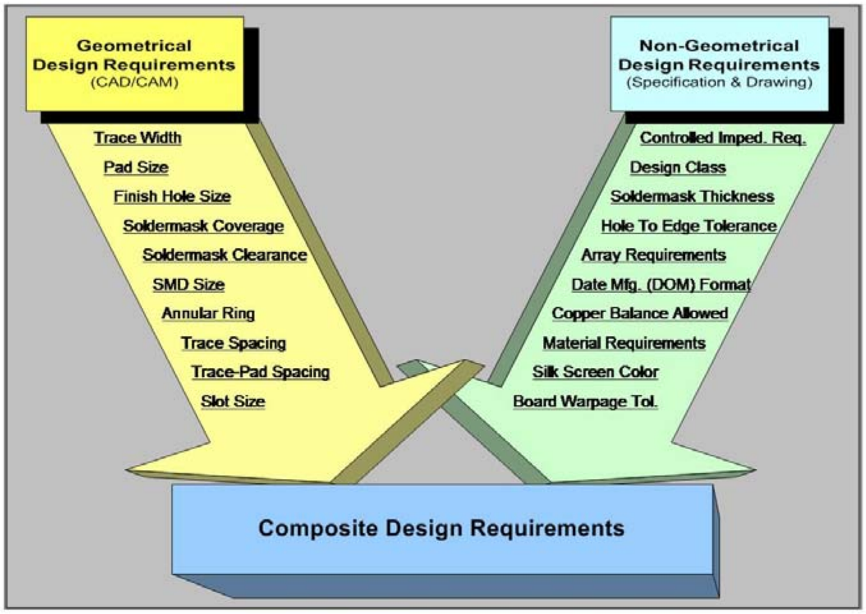

Figure 4 - Geometrical and Non-Geometrical Attributes

Design for Manufacturability Analysis (DFM) Is Inadequate

DFM analysis of the design's geometrical data is not being fully utilized by the industry, and DFM analysis of the design's non-geometrical data is not even considered in the vast majority of the cases. The first item to consider is the definition of geometrical and non-geometrical data. Figure 4 provides an illustration of the types of design attributes that fall into each category. From definition standpoint, geometrical attributes are related to the digital data and it can be analyzed through any of the available CAM tools that are on the market. Non-geometrical attributes are typically related to design requirements as provided through the generic specifications, customer drawings, project specifications, and customer specifications.

Both geometrical and non-geometrical attributes of a design are critical to establishing the total or composite design requirements. Without completely understanding and knowing all of these requirements, the design cannot be optimized for manufacturability. In addition, to complete a full DFM analysis of the design, the composite requirements must be analyzed in their totality, that is as they relate to each other and interact with each other. Table 1 illustrates the relationship of copper weight (non-geometrical) to trace width and spacing (geometrical).

Table 1 – Geometrical and Non-Geometrical Attributes Relationship

Process Drivers	Design Attribute Requirements	Manufacturing Capabilities	Manufacturing Capabilities	Etch Process Method A	Etch Process Method B
Copper Weight	1 oz	1 oz	1/2 oz	1 oz	1/2 oz
Trace Width	5 mil (.0127cm)	5 mil	4 mil (.0102cm)	5 mil (.0127cm)	4 mil (.0102cm)
Trace-To-Trace Space	4 mil (.0102cm)	5 mil	4 mil (.0102cm)	5 mil (.0127cm)	4 mil (.0102cm)
Trace-To-Pad Space	4 mil (.0102cm)	5 mil	4 mil (.0102cm)	5 mil (.0127cm)	4 mil (.0102cm)
Note:				Design is unmanufacturable on 1 oz material.	Design meets all requirements using ½ oz material

This simple illustration shows that with "Etch Process A", the design is unmanufacturable because the process capability using 1 oz material is restricted to 5 mils (.0127cm) for the trace-to-trace spacing, trace-to-pad spacing, and trace width; whereas using ½ oz material "Etch Process Method B" has the capability of manufacturing the product. A cursory review of the manufacturing capabilities would indicate the design is manufacturable with 1 oz material, but when all of the related design attributes are analyzed, the design is not manufacturable. These types of issues frequently come up and usually result in delayed shipment, low yield, or scrapped product.

This type of analysis is also lost when a design is transferred from one manufacturer to another. Capabilities will vary significantly between manufacturers. Another manufacturer may be capable of building the design using 1 oz material, but this would not be known unless the composite design requirements are analyzed to the manufacturer's capabilities. This further supports the need for DFM analysis to be performed on the composite design requirements to the manufacturer's capability. Analysis performed to multiple manufacturers' capabilities would result in determining the manufacturer that has the processes that are most capable of building the design with the highest expected yield.

Design for manufacturability analysis of geometrical requirements before the design is released to manufacturing has progressed to a degree over the past several years. Software tools are available in the CAD and CAM environment that do an excellent job in analyzing these attributes. However, there is still not a discipline within the industry to implement these tools and use them to their fullest capabilities.

Often it is thought that the only requirements for a design are contained in the digital data that is transferred to the supplier for manufacturing. This is supported by the fact that in today's market, many CAD and CAM systems exist that provide the capability of transferring digital data in several different formats, and various software programs are available to analyze the design data for manufacturability. There are also major initiatives within the industry to improve the digital data and build intelligence into the data format. While most design owners do not strictly adhere to a policy of completing design for manufacturability analysis before sending a design to the supplier, for the most part, tools and capability exist on transferring and analyzing geometrical/digital data. However, a quick look at the non-geometrical requirements discloses that very little is being done in that area. For example, drawing requirements, customer specifications, project specifications, et cetera are typically provided in an unintelligent format, and visual and cognitive interpretation of the requirements is necessary. Also, as shown in Table 1, there are many instances where overlapping requirements must be considered. The failure to perform total design for manufacturability analysis on the total design requirements often results in designs that are low yielding or in some cases that are unmanufacturable.

Software tools are not currently being utilized to analyze the non-geometrical design requirements. A designer may review the requirements at a high level, and the product engineer at the fabricator may do the same, but as a general rule, this analysis is superficial. At best, this analysis is cognitive only, and a full evaluation of the composite geometrical and non-geometrical requirements is not completed.

Incomplete Design Data Packages and Data Errors

One of the major issues associated with the introduction of a new design into manufacturing is incomplete data packages or data errors that are not found at the design levels. Drawings sent with measurements missing or key information left out is one of the most frequent reasons for a design being placed on hold. Data errors and issues that are not properly noted are also key contributors to this issue. Providing inadequate or no annotations on items, such as the acceptability of hanging traces or other unique design requirements, usually results in delays. It is imperative that clear annotations be provided along with the design data and the non-geometrical design requirements.

Design History Is Fragmented and Not Available

A quick look back at the example NPI process shows how fragmented the process is. Each step in the NPI process has a history of events or actions that took place within that step. This history, if retained, currently resides within the specific step where it was created. The information is not readily available to be transferred to the next step for reference or for use. In many cases, the history resides in the minds of the people involved and it was never documented. Several levels of communication are required to track the changes of a design through its design phase and throughout its life cycle. Figure 5 illustrates the design history and the independent relationship as a design moves through the NPI process. The consistency of this function also varies greatly between companies and organizations, but clearly a focus in this area would deliver benefits over the life cycle of the product.

Two key issues are apparent when the design history is isolated. The first is the tracking of the changes made to a design through the development stages of the design, and the second is the tracking of the changes made at fabrication. The design owner does not have the tools required to assemble this information in a readily accessible format so that design changes can be tracked, controlled, and be accessible for reference whenever the need arises. Currently to assemble these changes, several companies and organizations would have to be contacted to retrieve the historical data that was maintained within each step of the NPI process. In most cases, this approach is inconceivable and practically impossible.

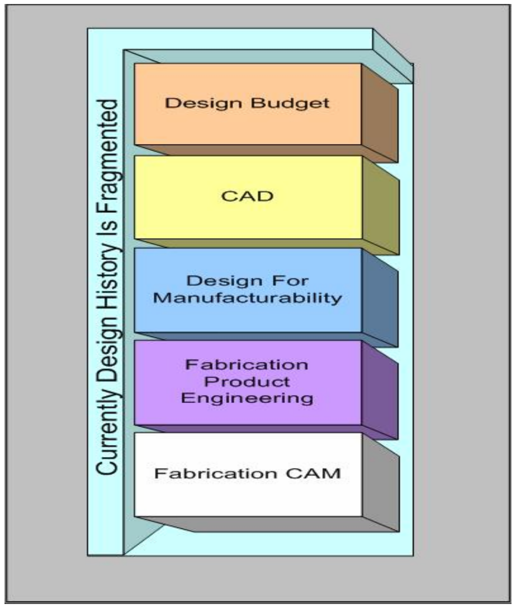

Figure 5 – Fragmented Design History

Inadequate Tools for Maintaining Design Integrity

The changing requirements forced by today's global market and the increasing complexity of the designs being developed, design integrity and consistency are becoming major industry concerns. This is especially true for the high speed designs or HDI designs where slight differences in manufacturing stack-ups and design edits can impact the overall performance of the product. Today, for the most part, fabricators will edit designs for manufacturability and yield improvements to meet the needs of their manufacturing processes. If the design is being built by more than one fabricator or if it is transferred from one fabricator to another, then the OEM is receiving product that superficially may look the same, but there are subtle differences because of the changes made by the fabricator for manufacturability and yield.

For example, if a design requires a 0.004" (.0102cm) core to achieve the controlled impedance and capacitance requirements and it also requires a given line width to meet the electrical requirements, then these requirements must be maintained to meet the intent of the design. If the fabricator does not stock a 0.004" (.0102cm) core and decides to use a 0.005" (.0127cm) core, which is well within core thickness tolerances, then the fabricator will have to adjust the line width to achieve the desired impedance. Similarly, if a fabricator moves selected traces slightly to center them for yield improvement and another one does not, it could cause degradation in signal performance and cross talk between the circuits. Five years ago, when controlled impedance tolerances were +/- 20% or simply designed into the product with no measurement verification required, this may not have been a problem. However, today +/- 5% is normal and changes such as this could create a problem in the overall performance of the design. Complexities such as these establish the need for better tools that will enable the design owner to provide clear specifications and requirements, so that in all cases, the product will be manufactured to the original intent.

Inadequate Tools for Moving Product in the Global Market

Today a design may be developed internally to a company and the prototypes built in North America. Tomorrow, that same design may be moved from North America to Asia. Another design from the same company may be outsourced to a contract designer for development and the prototypes and production may both be done in North America. In today's global market, this is true for the printed circuit board, the assembly, and the system.

Every time a job is moved in the global market, the engineers must reassemble and interpret the design requirements. The CAM operator must complete design rule checks and edit the design for manufacturability. Unclear requirements are identified and the job is placed on hold until clarification from the design owner is received. Additional geometrical and non-geometrical changes are made to the design by manufacturing. Variations from the design intent are evident. Subtle difference in design performance may occur due to the changes in the composite design requirements. These are all characteristics that occur every time a design is moved in the global market. While some of these variations may have minimal impact on the design performance, some may be catastrophic and affect the overall project.

Limited Resources to Manage More Designs

In almost all cases, a company is constantly under pressure to do more with less. Elimination of less critical steps in the NPI process may be done to reduce costs. Each design owner may be assigned additional designs to develop or to maintain through the life cycle. The constant change the industry is going through dictates that each engineer become more efficient and productive. Unfortunately, in many cases, the efficiency and productivity has not improved, but the work load has increased significantly. To compensate for this, critical steps in the NPI process are brushed over or eliminated out of necessity.

The Case for Integration of the NPI Process

A quick review of the NPI issues discussed above is provided in Table 2. All of these issues, when considered collectively, point toward the integration of the NPI process across different organizations within a company and integration of the process across multiple companies as the primary solution. This integration not only has to provide flexibility between companies and organizations, it also has to offer the flexibility that is required within the global marketplace. The tools used within the industry today, such as CAD, CAM, DFM, and other engineering tools must be anchored to this integration so that the most robust design possible is designed and built at the lowest costs possible and with the shortest time to market that is possible. These tools must also be supplemented with additional tools that enable the design owner to have complete knowledge and control of those designs.

The design owner must have total knowledge of the design and its composite history from the conceptual design stage and throughout the design's life cycle. It is also imperative that the design owner completes design for manufacturability analysis of all geometrical and non-geometrical attributes that compose the total design requirements. The design owner must control the design so that its integrity is maintained regardless of the design's movement within the global market. While it may seem to be an insurmountable task to integrate the NPI process, it is very feasible to accomplish this task if the discipline and the proper tools are used throughout the process.

Table 2 – NPI Process Issues Summary

1. Typical NPI Process Is Not Integrated or Automated
2. Transfer of Specifications and Requirements Is Manual and Error Prone
3. Design for Manufacturability Analysis Is Inadequate
4. Incomplete Design Data Packages and Data Errors
5. Design History Is Fragmented and Not Available
6. Inadequate Tools for Maintaining Design Integrity
7. Inadequate Tools for Moving Product in the Global Market
8. Limited Resources to Manage More Designs

New Product Introduction Structure

Integral to addressing the issues surrounding the introduction of new product to the marketplace is the structure around which the process is integrated. The framework to the integration must be comprehensive and flexible to meet the needs of the dynamic environment the electronics industry is faced with today. This structure must first be implemented before the integration of the various CAD, CAM, and engineering tools can begin. The flow of the NPI process within a company and the transfer of the design to the company's suppliers must first be established. Then the detailed flow within the suppliers' organizations has to be understood and concurrently mapped out so that the total process is understood.

Once the basic foundation and structure are known, then the process of integrating existing CAD, CAM and engineering tools to the structure begins. The process flow must be built in such a manner that each step in the process adds value to the design. Pertinent data must be retained in an intelligently usable format throughout the process so that subsequent steps in the process flow use the data seamlessly without having to recreate the data that was previously generated. Intelligent rule sets can be applied at successive steps in the process flow to derive the needed requirements. Figure 6 illustrates how a streamlined NPI process flow that eliminates redundant steps can be created. The database tables illustrate the structure that both drives the intelligence in the process flow and retains the design requirements so that they can be accessed and utilized throughout the entire NPI process. The interactive interface and core software structure provide the key intelligence that drives the entire process and the design for manufacturability analysis for the composite design requirements. A structure such as this provides the flexibility that is needed in the global market.

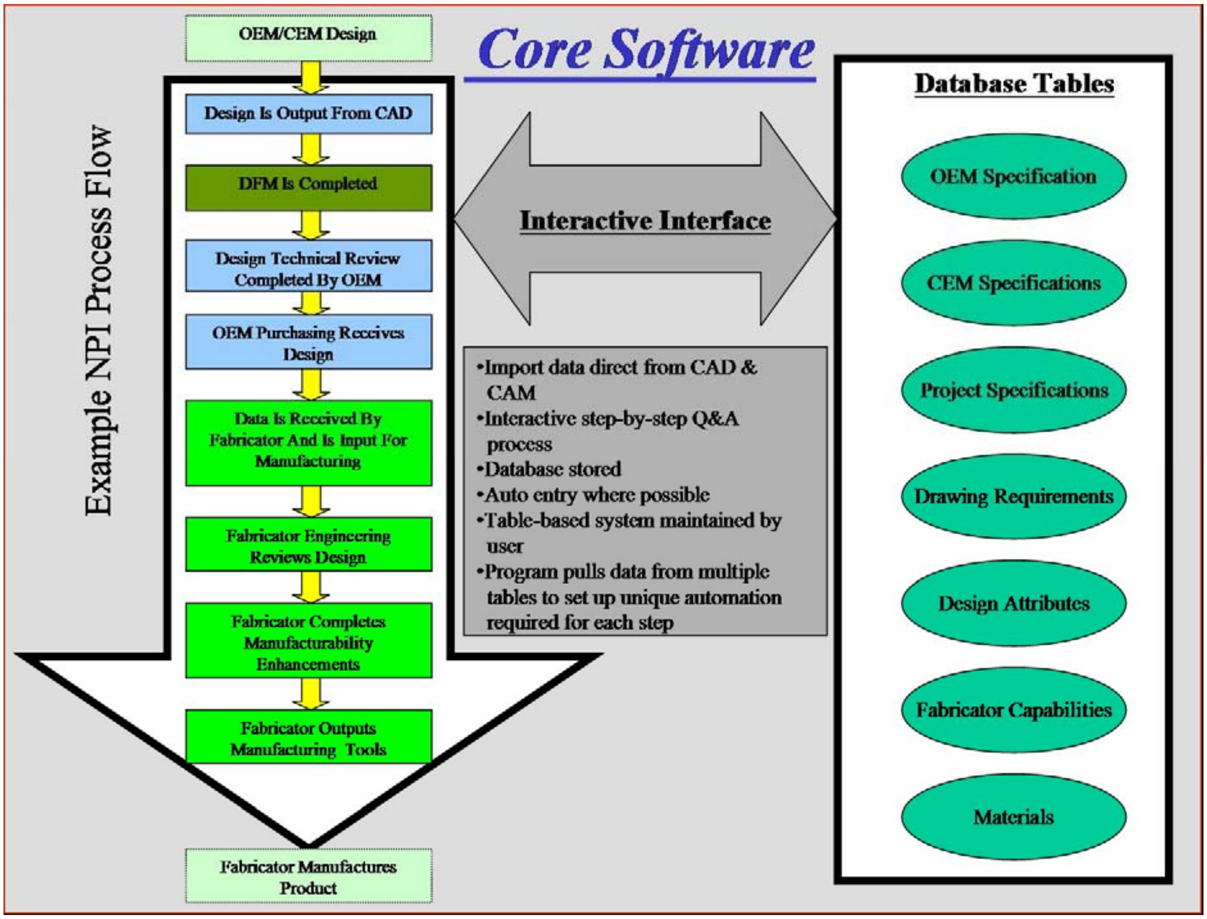

Figure 6 - NPI Process Structure

Total Design Requirements

The structure of the NPI process should provide the mechanism for establishing the total or composite geometrical and non-geometrical requirements for the design as illustrated in Figure 4. A closer look at the requirements would show that often the requirements may be based on conflicting values, and so an order of precedence has to be established. The pertinent design data that is collected through the NPI process structure provides the design attributes that must be analyzed to establish the total design requirements. From the default specifications through the release of the purchase order, design requirements are being established. Sorting through each level of these requirements ultimately establishes the final design requirements. Figure 7 illustrates this complex issue of interpreting the design attributes and establishing the final design requirements. The only effective way to complete this process is by analyzing the many facets of the design requirements for both geometrical and non-geometrical attributes. This approach allows for establishing default requirements for every design within an organization or company. More specific design specifications such as OEM, contract manufacturers, project requirements, and design specific requirements may in fact take precedence over lower level specifications and, in many cases, it is very difficult to establish the end product requirements. A hierarchal structure that takes all of these different requirements into consideration based on each specification's priority for a specific design is a necessity in determining the design's composite requirements. Without this approach, manual review of each applicable specification or requirement is necessary before the composite design requirements can be established.

Once the composite design requirements are established, they can be analyzed through software designed to perform such functions, and the data can be transferred to other organizations and again be analyzed with software designed for that specific task. This methodology provides the alternative solution to the fragmented NPI process and is the mechanism for integrating the NPI process across multiple organizations and companies. It provides each organization or company with the autonomy and the flexibility that is needed for the process to be effective.

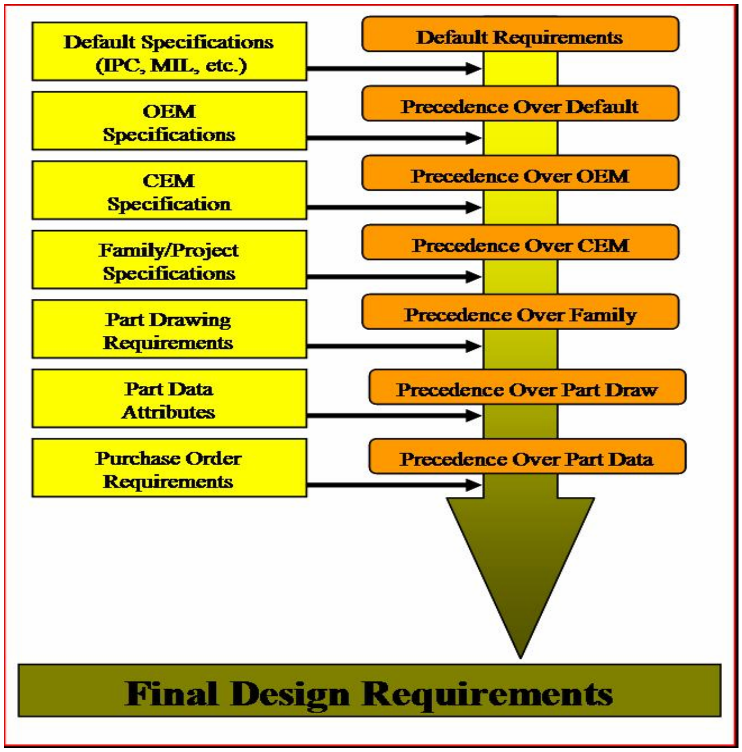

Figure 7 - Specification Hierarchy

Design for Manufacturability Analysis

Design for manufacturability analysis should not be viewed as an option, but it should be viewed as a necessity by the design owner. A complete DFM performed on the composite design requirements at the design level gives the design owner more control and it minimizes the potential for a design being placed on hold for questions or for a design being built incorrectly. The NPI process should have built-in capability and automation to perform a complete analysis for the composite design requirements with minimum effort and maximum result. Geometrical and non-geometrical design requirements should be analyzed using software that considers the relational complexity illustrated in Table 1. In order for the manufacturability to be accurately assessed, it is necessary to first establish the final design requirements as identified in Figure 7, and then to match these requirements to the actual manufacturing capabilities. The result of this type of analysis identifies the manufacturer that is capable of building the specific design based on its attributes. This type of analysis also shows where design deficiencies exist and the changes that are required to make the design more manufacturable.

To be effective, design for manufacturability analysis must start at the conceptual design stage and be carried throughout the entire design process. This analysis should be performed using software that is integral to the structure and that is specifically designed to analyze the composite design requirements. Since it is integral to the structure, it will provide the media for maintaining the design history and provide the design owner with full control and ownership.

Composite Design History

Integrating the entire NPI process into a formal structure provides the ability to retain a history of the design throughout its life cycle. Maintaining all levels of historical data, that is predesign, design budget, CAD layout, fabrication changes, and the movement of the design within the global market, facilitates troubleshooting any problems that may arise with the design. In addition, it also facilitates movement of the design within the global marketplace. No longer will the historical record be fragmented and unique to each step in the NPI process. With a bi-vertical record of all changes introduced to a design, each step in the NPI or life cycle process will have the benefit of knowing what changes transpired before the design moved to the step at hand. For example, if the design is moved from Fabricator A to Fabricator B, the design owner and the new fabricator will have a first-hand knowledge of the changes made by Fabricator A. Additionally, Fabricator B will have the history of how the design was built at Fabricator A, which will eliminate the potential for the design to be built incorrectly. The design owner will then have the first-hand knowledge of changes between fabricators and the potential impact on the design integrity. Figure 8 illustrates how the history for each step is transferred into the NPI structure and is available for reference through the vertical process.

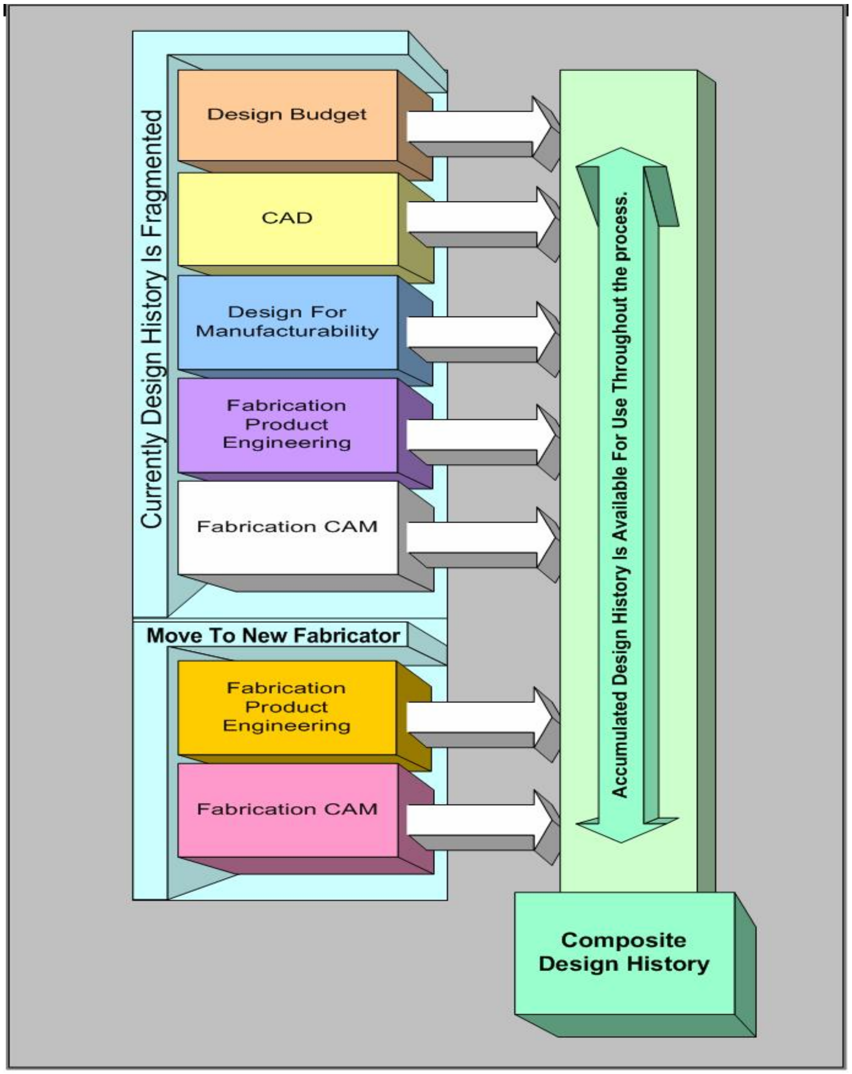

Figure 8 - Composite Design History

Design Integrity

One of the key reasons for integrating the new product introduction process is to maintain the design intent or design integrity. By placing the design owner in the driver's seat, final authority over any changes that are made to the design throughout its life cycle are controlled by a single source. The design owner must be in control especially with the impact of the global market. Subtle changes in the design as described previously may have a tremendous impact on the product's performance in the field. Understanding these differences and the impact is often very difficult to determine. For that reason, changes to any given design must be controlled by the design owner and the changes between different manufacturers must be minimized, especially on complex designs.

Figure 8 shows how the design owner can be in control of the design throughout its life cycle. However, before this can occur, the structure must be in place along with the proper integration and automation. The ability for establishing the composite design requirements and maintaining the composite design history must also be integral to the process before it will be successful.

The Global Market

Also integral to the global market is the ability to move designs seamlessly from one manufacturer to another. The integrated NPI process provides the structure to move the design without having to repeat and duplicate all of the engineering and CAM steps that are involved. Figure 9 also shows this. The composite history and composite design requirements can be transferred to other manufacturers or facilities in their entirety. It also provides the capability to verify the manufacturers' capabilities as they relate to a specific design prior to actual movement of the design.

The global market is more than just moving a design from one manufacturer to another. The global market also encompasses the capability of a company to cross engineer designs or cross tool designs. The integrated NPI process provides tools that facilitate better utilization of the resources within a company by allowing cross utilization of designers or engineers in different organizations. This approach also facilitates the outsourcing of these functions when the load dictates. The total process becomes more efficient and allows for load leveling during peak periods.

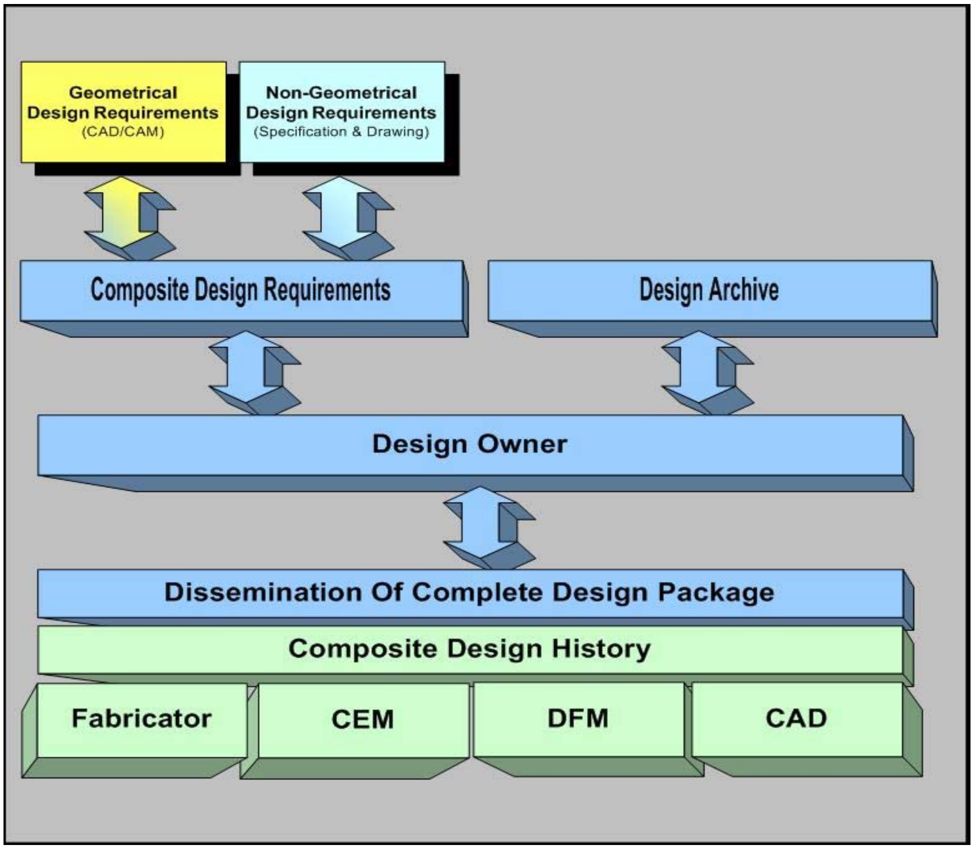

Figure 9 - Design Integrity

Summary

The new product introduction process as it exists today is usually a series of autonomous steps that may cross several organizations within a company or several different companies. Because of the autonomy and the intricacies of each step, the process is very inefficient, redundant, manual, and error prone. If the NPI process at most companies is measured from the conceptual design analysis through to the final product reaching the marketplace, many weeks would be required to get a new product to market. A tremendous opportunity exists to streamline this process and make it more efficient, while at the same time creating a more robust product that can easily be moved within the global marketplace.

Establishing a defined and structured NPI process flow provides a common source of information for the design during its introduction to the marketplace as well as throughout the design's life cycle. Integration of the engineering tools to this structure offers tangible benefits in the quality of the design being released and accurate modeling of the design as it is being developed. This in turn decreases the number of revisions required on any given design and increases the design's manufacturability.

The composite design requirements and the composite design history obtained through such a structure provides the necessary tools to easily move the product in the global marketplace. This approach puts the design owner in control of any changes that may transpire through the design phase or movement of the product within the marketplace. With the design owner controlling the changes, the original design intent can be maintained.

Tools are available within the industry that facilitate the integration of the new product introduction process. It is a matter of developing an NPI process flow and structuring it so that predesign analysis tools, layup modeling tools, process modeling tools, and DFM relational analysis tools can be integrated logically to the process. Value should be added to the product through each process step and the pertinent data retained for use in the process wherever it is needed.

As shown in Table 3, significant improvements in productivity, cycle time, quality, and capacity can be obtained through integrating and streamlining the new product introduction process.

Table 3 - NPI Process Improvement Statistics*

Description	Expected NPI Process Results
Productivity	30% to 50% measured improvement in productivity
Cycle Time	50% to 70% reduction in overall cycle time
Quality	20% to 75% measured improvement in overall quality
Capacity	20% to 100% increase with same number of employees

* Note: Statistics are based on actual results obtained through reengineering of multiple NPI processes