W H I T E P A P E R

LEAN NPI AT OPTIMUM DESIGN ASSOCIATES: PART 2 "WHAT IS LEAN NPI AND HOW TO ACHIEVE IT"

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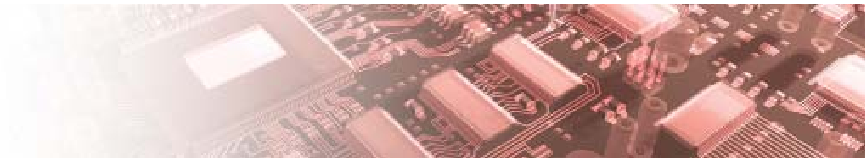


In the first part of this series, we looked at the business processes employed by Optimum Design Associates (Optimum), a PCB design and assembly service provider. Optimum's PCB design flow and the integration of Mentor Graphics PCB layout and Valor NPI tools were described.

Optimum has recognised the importance of embracing new process methodology and improvements to ensure their customers receive an unrivalled level of service. To this end, Optimum's vision is to adopt the "Lean New Product Introduction (NPI)" business process. The collaboration between Optimum and Mentor Graphics was forged to achieve the ideal combination of Mentor's software technologies and Optimum's business processes.

During this second article, Lean NPI will be defined, and Optimum's current business process will be analyzed. This will identify areas where enhancements can be made to align Optimum with the best practice Lean NPI model. In order to measure the success of the transition to Lean NPI, some performance metrics will be specified. These metrics will be referenced in future parts of the series to illustrate the results achieved by Optimum.

BEST PRACTICE STANDARD NPI PROCESS MODEL

The standard NPI process verifies that the PCB design output data is suitable for the production processes and constraints and, at the same time, provides a streamlined hand-off directly into manufacturing process preparation. Figure 1 shows the standard NPI process for PCB based products.

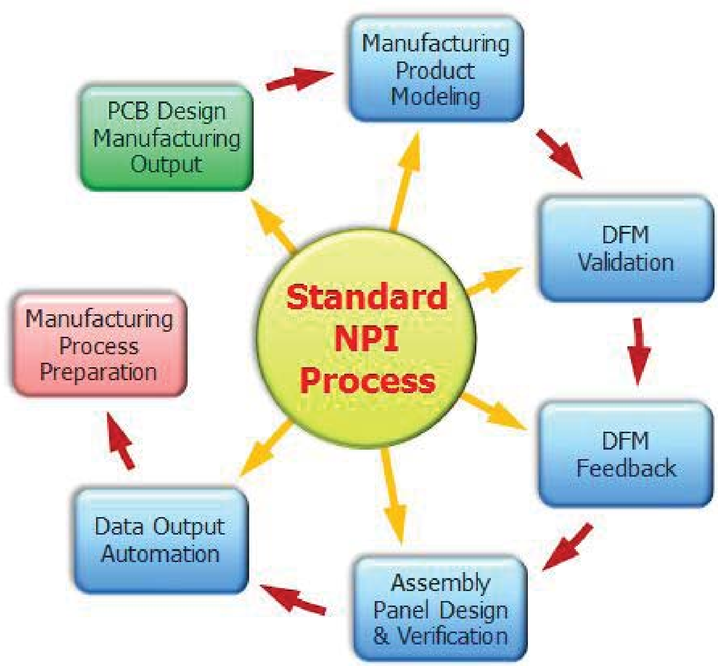
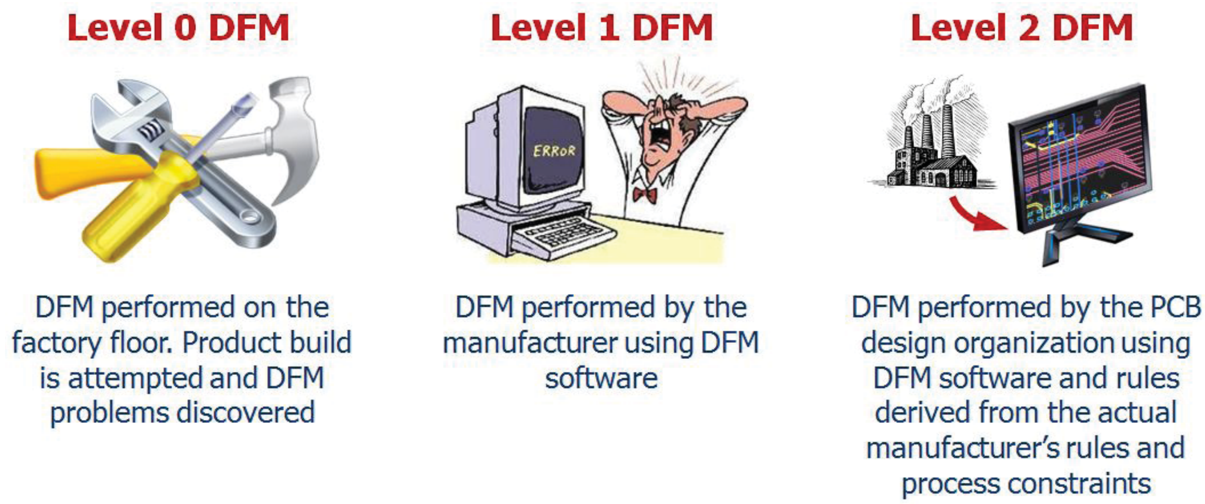


Figure 1: Standard New Product Introduction process for PCB-based products.

On completion of the PCB design, the manufacturing output is generated using an integrated data format such as ODB++. Additional intelligence and information is applied to the data to form the complete manufacturing-level product model, defining exactly what is to be fabricated and assembled with the minimum need for ancillary documentation such as drawings. Attributes are added to the data which enable a high-level of DFM to be performed automatically and repeatedly. DFM analysis is executed and feedback is provided about the design so that any DFM related problems can be fixed at source. The next step in the process is to design the assembly panel according to the assembly manufacturer's line-specifications. The assembly panel design is then DFM verified for both fabrication and assembly. The final manufacturing data can now be generated and handed-off to the fabricators and assemblers, so they can perform their manufacturing process preparation based on the same data.

WHAT IS LEAN NPI?

There are various levels of DFM that can be executed during the NPI process. Figure 2 illustrates these levels.



Level 0 DFM is performed on the factory floor where the product build is attempted and DFM problems are discovered. This method of DFM verification is very time-consuming and expensive with material wastage and production labour costs at a premium.

Level 1 DFM is performed by the manufacturer using software tools and is a reasonable method to ensure the design complies with manufacturing rules and process constraints. The downside to Level 1 DFM is that the PCB design organization is heavily reliant on complete and correct DFM feedback from the manufacturer. This feedback is used to make necessary design changes to correct DFM problems but may not include details about the design which could affect product yield or reliability.

Level 2 DFM is the ideal scenario, where DFM is executed during the design process using manufacturer derived rules and process constraints. Not only can critical DFM errors be addressed during design, but improvements can be made to increase product yield or reliability, before committing to expensive production runs.

The most efficient method of implementing DFM is to adopt concurrent DFM engineering. The PCB layout is designed in stages – placement, critical routing, final routing / planes. At each of these key milestone stages, DFM analysis is executed. It can be very difficult and time-consuming to correct DFM problems on completion of the layout. The "left-shift" of DFM analysis ensures that any DFM problems can be resolved at an early point in the design process. An example of concurrent DFM engineering is shown in Figure 3.

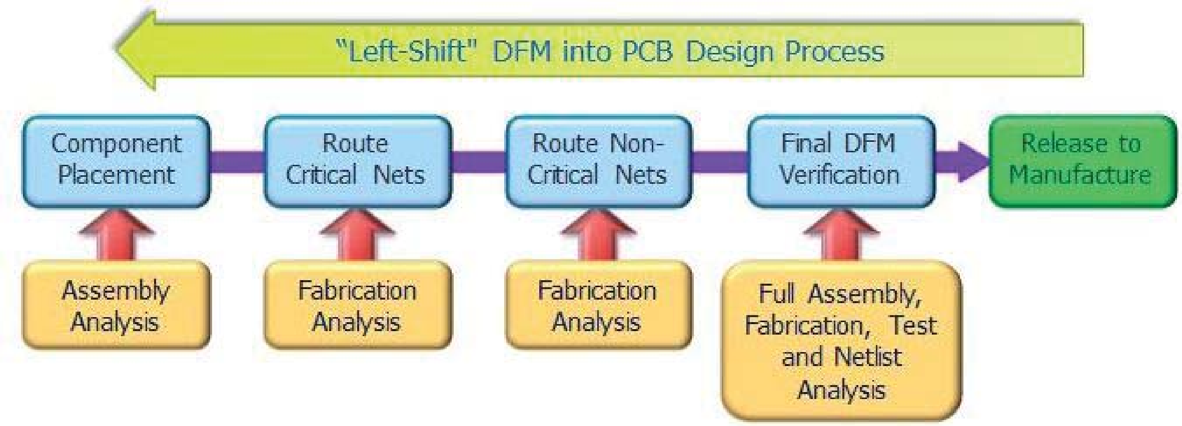


Figure 3: Concurrent engineering process, effectively "left shifting" DFM into the very beginning of the PCB design task.

Lean NPI is defined by three enhancement elements within the "Best Practice Standard NPI Process Model" seen earlier. Firstly, ODB++ data is used as the preferred format for manufacturing hand-off. Product model intelligence is contained within this ODB++ data, thus enabling high levels of automation with minimum keyboard entries. The second element is to execute concurrent DFM at key stages during PCB design development. The final element for Lean NPI is to execute DFM at Level 2. The Lean NPI definition is summarized in Figure 4.

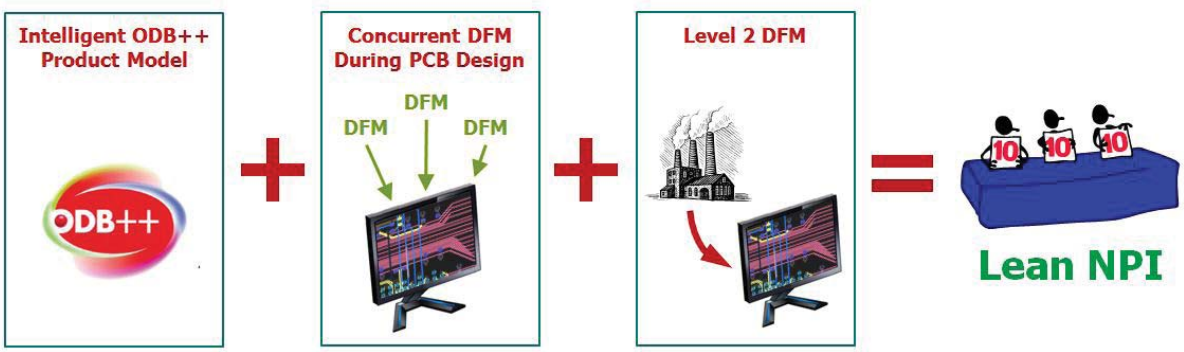


Figure 4: Lean NPI defined.

BEST PRACTICE LEAN NPI PROCESS MODEL

In order that Optimum succeeds in their goal of operating in Lean NPI mode, the "Best Practice Lean NPI Process Model" will be followed, as illustrated in Figure 5. All actions shown in green are performed using Mentor Graphics' Valor NPI and Valor Parts Library (VPL) technologies.

The PCB layout is designed in stages and concurrent Level 2 DFM analysis is executed. When the layout is complete and any DFM problems resolved, the assembly panel is designed and validated. Throughout the Lean NPI Process, ODB++ format data is used. The final ODB++ manufacturing output is generated using the standard Valor NPI Output Automation tool and released for manufacturing process preparation.

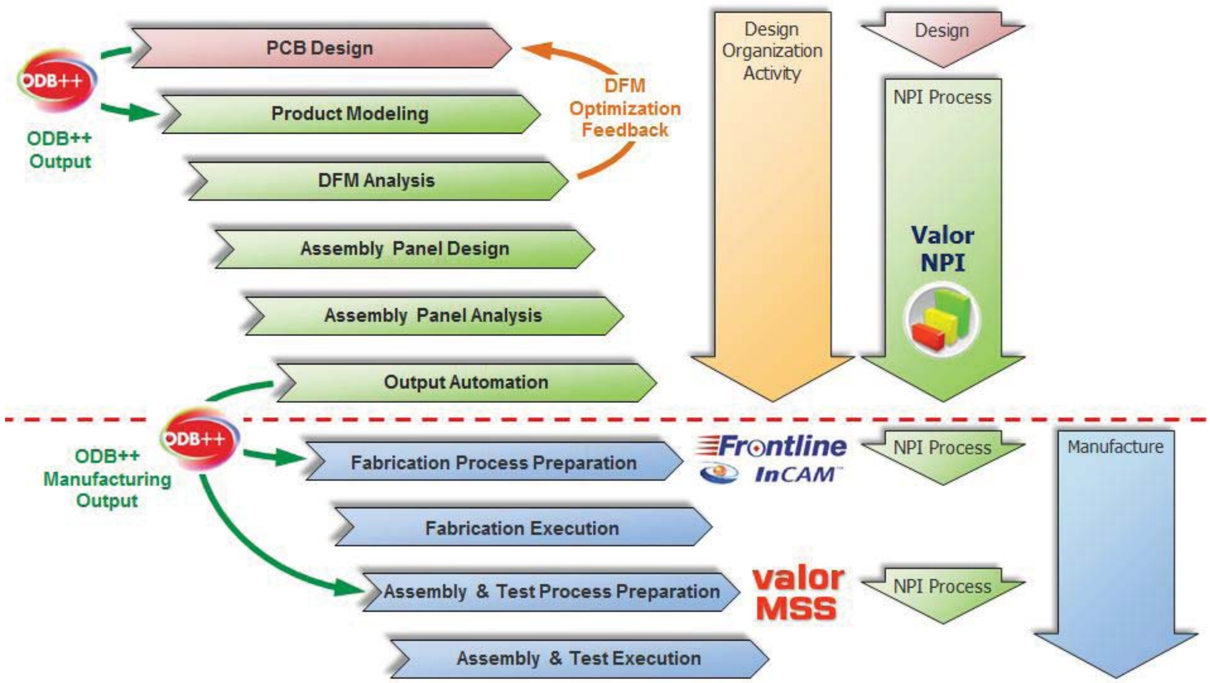


Figure 5: Best Practice model for Lean NPI.

MENTOR GRAPHICS TOOLS IN THE LEAN NPI PROCESS

As users of Mentor Graphics tools, Optimum is equipped with the complete toolkit required to successfully lay out and hand off PCB designs to manufacture, whilst following the Lean NPI process model.

Optimum uses Mentor Graphics' Expedition PCB and PADS layout tools with DFM performed using Valor NPI. The integration between Expedition PCB and Valor NPI is fully exercised to provide the feedback of DFM results. Bi-directional graphics cross-probing and the import of "DFM Hazards" are utilized to the full to efficiently correct DFM problems. Cross-probing from Valor NPI to PADS is also implemented to fix DFM problems.

For non-Mentor Graphics design flows, Optimum uses the Scorecard and Sharelist features in Valor NPI to deliver reporting functionality and provide the DFM feedback loop.

LEAN NPI PROCESS FLOW FOR OPTIMUM DESIGN ASSOCIATES

During the collaboration with Mentor Graphics, some areas of Optimum's business process have been identified where improvements can be made to achieve Lean NPI. During the first part of this series we looked at the existing design PCB Layout Process Flow followed by Optimum. By merging this with the Best Practice Lean NPI Process Model seen earlier, the resulting Lean NPI Process Flow for Optimum is shown in Figure 6. Although it may appear complex at first, many of the steps in the flow are automated using the functionality offered by Valor NPI.

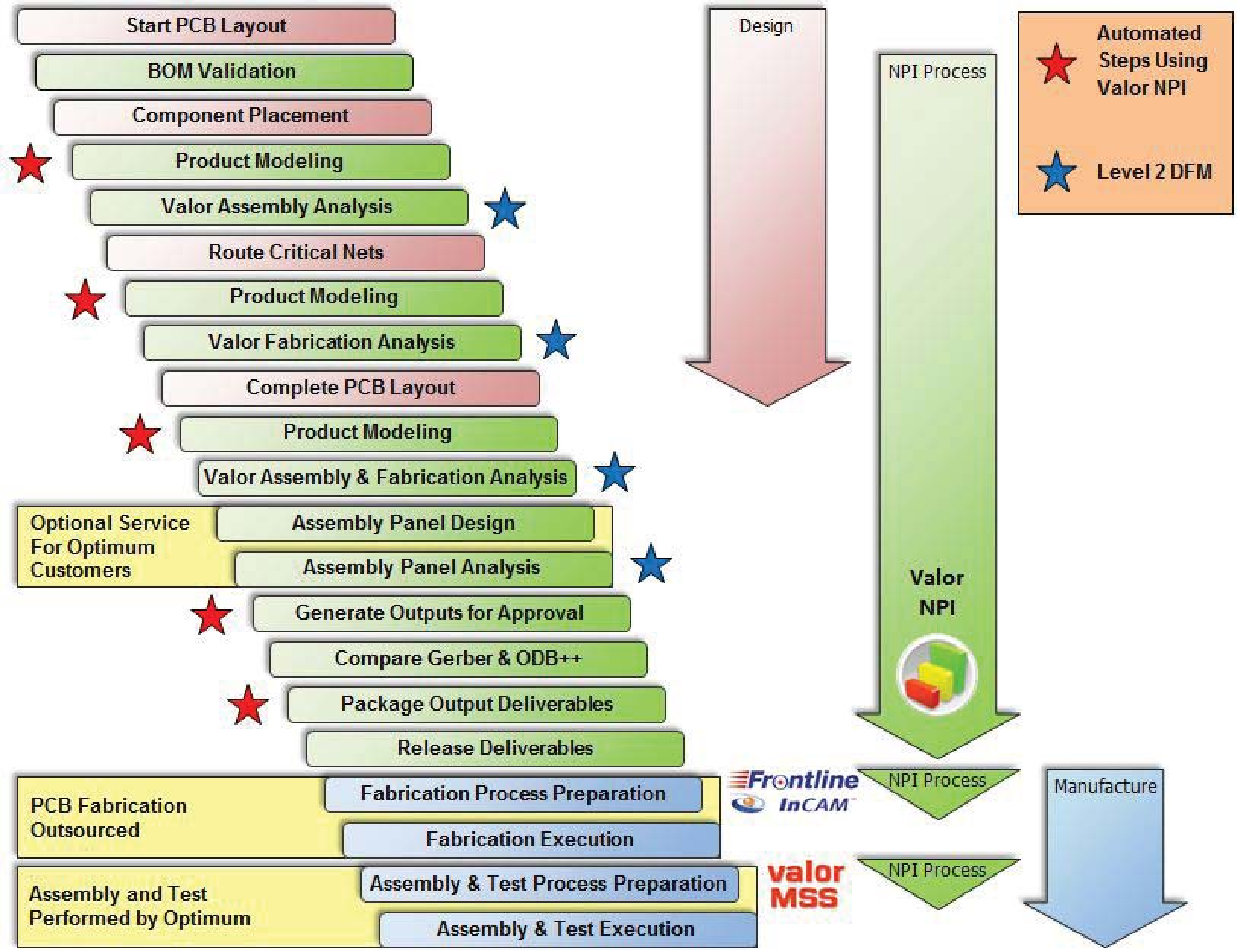


Figure 6: Lean NPI Best Practice model adapted to fit Optimum Design Associates environment.

At the beginning of the design, the BOM is validated using Valor NPI and VPL. This ensures all VPL packages are available. If new VPL packages are required, these can be generated while the component placement is performed. The completed placement is then subject to initial assembly analysis utilizing the VPL packages. If DFM problems exist, they can be fixed before continuing with any complex routing. Prior to each analysis stage, product modelling adds attributes to the ODB++ data which enables comprehensive DFM checks to be executed. Product modelling also adds intelligence and information to the ODB++ manufacturing data which defines exactly what is to be manufactured such as layer stackup, copper weights, solder mask color and component assembly instructions. This removes the need for many drawings and documents which are traditionally used to tell the manufacturer what to deliver. All product modelling activities are automated and repeatable.

Any critical routing can then be added to the design. On completion of the critical routing, an initial fabrication analysis is run. This highlights any DFM problems associated with the critical nets which need correcting before continuing with general routing. Clearly, critical routing does not want to be disturbed at a later stage due to DFM problems, as it may be very difficult to make changes whilst retaining the signal integrity.

Next, the remainder of the routing, copper areas, power and ground planes and silkscreen legend (if applicable) can be completed. A final DFM analysis is run for fabrication, assembly and test which captures any DFM problems with the completed layout.

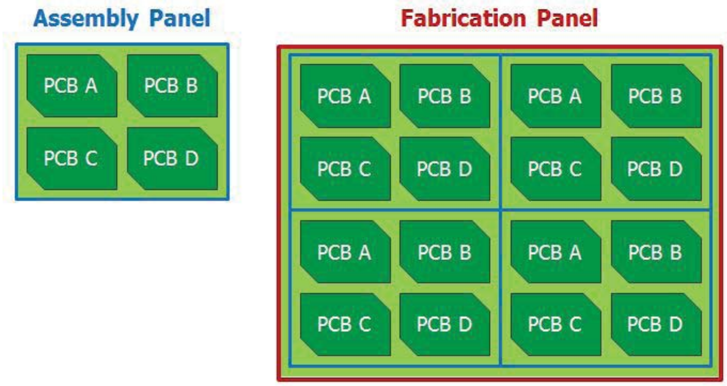


Figure 7: In actual fabrication, the assembly panel is made four-to-a-set on the fabrication panel, which is then separated into individual boards.

Once all DFM problems are investigated and corrected on the single PCB design, the assembly panel design and panel DFM analysis can be performed. This is an optional step offered by Optimum. Figure 7 illustrates the difference between the assembly panel and fabrication panel. The assembly panel is the fabricators deliverable and is used by the PCB assemblers. The assembly panel usually contains an array of single circuit boards. The fabrication panel contains an array of assembly panels and is only used to suit the fabrication processes and make best use of their raw materials.

The Valor NPI Output Automation tool is used to generate the necessary outputs for customer design approval. During the approval process, if the customer requires Gerber data as a deliverable, the Valor NPI Cam Compare tool is used to compare the Gerber output against the master ODB++ output to ensure that the Gerber data is graphically identical to the ODB++ data. Thus, the traditional Gerber data can still be used as a valid but less efficient alternative in manufacturing process preparation.

On receipt of customer design approval, the Output Automation tool is used again, this time to generate and package the final deliverable manufacturing data.

STEPS REMAINING FOR OPTIMUM TO ACHIEVE LEAN NPI

During the study of Optimum's PCB Layout Process Flow, some areas were identified where changes could be made to fully implement the Best Practice Lean NPI Process Model described earlier. Making these changes would greatly enhance the already high level of service offered by Optimum. Key areas where Optimum's business process could be modified are as follows:

1. One element of the Lean NPI definition is the use of concurrent DFM engineering during the PCB design process. Optimum's PCB design and NPI process would be enhanced by adding a DFM analysis stage when the critical routing is complete. This would ensure no DFM problems exist with the critical nets. If DFM problems do exist, they can be easily corrected and the signal integrity retained. If DFM problems are discovered with the critical nets at a later stage it may be very difficult and time-consuming to fix the problems without disturbing other routing or even the component placement, whilst retaining the signal integrity.
2. The second recommendation would be to move the customer-approval stage to after the final fabrication and assembly DFM analysis step. This will ensure that the output data used for customer review and approval not only meets the electronic design specifications but is also fully manufacturing compliant. Otherwise, changes may need to be made during the final DFM validation stage which the customer may not be aware of. This change to the process flow will also enable the customer to check and approve the ODB++ manufacturing product model - exactly what is to be manufactured.

3. The final recommendation for Optimum is to ensure that only ODB++ output data format is used throughout the flow from design to manufacturing process preparation. This will enable a more efficient data hand-off to both Optimum’s external fabrication partners and internal assembly and test lines.

HOW TO MEASURE THE SUCCESS OF ADOPTING LEAN NPI

As with any significant changes in design methods or business processes, there need to be metrics in place to measure performance improvements and show the effect of those changes on the performance of the business. Discussions with Optimum prior to the Lean NPI transition revealed aspects of the design flow and manufacturing activities which could be monitored to give meaningful statistics. These statistics would prove the effectiveness of adopting Lean NPI.

During the PCB layout process, the design is subject to assembly analysis. This highlights problems with placement as well as component footprints. By using Valor NPI and VPL, the integrity of the footprint library is checked. The number of library-related DFM problems per design can be recorded. This number will definitely reduce as Lean NPI is implemented. It is also recommended that the library itself is subject to DFM analysis. This will catch any DFM problems in the library so they can be corrected at source. This will improve assembly times and efficiency as common footprint related problems are corrected.

Using ODB++ as the only data transfer format, instead of Gerber and other file types, will make a notable difference to the manufacturing hand-off. The time taken to load, check and prepare the data will be considerably reduced, as will the possibility of error. Using ODB++, the data is loaded directly into manufacturing process preparation tools. As a result, there is a measurable time improvement in going straight from design to manufacturing process preparation.

Often there are customer call-backs from the fabrication vendors. These are either related to DFM problems or interpretation of data and design intent. In these situations the job may be put on hold until the question is resolved. If the DFM problems are captured during design and an integrated ODB++ product model is delivered to the fabrication vendor, the number of call-backs will be reduced. These can then be recorded and analysed on a regular basis.

Using Valor NPI Scorecard, a DFM report from each design can be made. The list would include, for example, the top ten common DFM problems found within designs. A report for each new design will show a reduction in these top ten DFM problems. This will occur as Optimum’s designers start to change the way they think about designing and start applying DFM concurrently during the design flow.

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