

Celestica Early Product Reviews Empower Customer Design Teams

-Highlight Opportunities for Improvement and Reduced Assembly Time-

John Allen

Celestica Corporation
Bethany, Oklahoma

Abstract

As a world leader in the delivery of electronic manufacturing services (EMS), Celestica operates a highly sophisticated, global manufacturing network with operations in Asia, Europe and the Americas. This network provides a broad range of integrated services to leading original equipment manufacturers (OEMs) in a variety of industry sectors including aerospace and defense; automotive; communications; computing; consumer; industrial and wireless devices.

Traditionally, EMS providers have been brought into the OEM design cycle at or near the prototype stage, leaving very little time for the infusion of the realities of assembly prior to production. The mitigation of assembly issues often results in reactive solutions such as complicated work procedures, custom tooling, or in severe cases, delay of product launch for a complete design spin. The Celestica early product review process, aided by the power of the Boothroyd & Dewhurst DFMA[®] software package, identifies opportunities for product simplification and assembly time reduction – enabling innovative rather than reactive solutions. This paper discusses some of the unique aspects of the EMS/OEM relationship and how Celestica has incorporated Boothroyd & Dewhurst tools to provide meaningful system assembly feedback early in the design process.

Introduction

Celestica is a world leader in electronic manufacturing services with headquarters in Toronto, Canada. Since the company's inception in 1994, Celestica's footprint has grown to include more than 40 manufacturing facilities across 19 countries. The EMS partner of over 200 OEM customers, Celestica has an annual revenue of \$8.5 billion (US). Celestica provides a wide range of services including design and engineering, manufacturing and systems integration, fulfillment and after-market services.

Globally consistent, best-in-class new product introduction (NPI) processes help to improve product manufacturability and speed the transition to volume production for improved time-to-market and time-to-profit. DFX reviews of customer products during NPI are nothing new to Celestica. For years Celestica has offered a complete line of printed circuit assembly (PCA) DFX services including reviews for fabrication, assembly and test. Customers have come to respect and value the feedback provided by these reviews. More recently, as customers outsource box build and systems assembly in addition to PCA, Celestica has added mechanical design for manufacture and assembly

(DFM/A) capabilities to its portfolio. Careful consideration of the unique aspects of the EMS/OEM relationship and their affects on the product review process has enabled Celestica to acquire and develop the tools necessary to not only participate in mechanical design reviews, but to highlight opportunities for designers to truly revolutionize their products.

Building the Service

Building of the mechanical design for manufacture and assembly review process started with the creation of a framework document to guide development efforts. The project objective was clear:

“Develop DfX processes and tools necessary for reviewing mechanical assemblies, e.g. enclosures, to improve producibility, lower cost, and improve quality in a similar manner to the DfX processes and tools for printed circuit assemblies.”

The scope of the project was set to include all aspects of mechanical assembly including final assembly, sub-assembly and mechanical fabrication with a small amount of overlap into the PCA space to cover board mechanicals. The range of products covered would include multiple industry sectors and product sizes – from cell phones to telecom switching cabinets the size of a refrigerator. As an EMS provider to more than 200 customers, each with their own service agreements, this would turn out to be no small challenge.

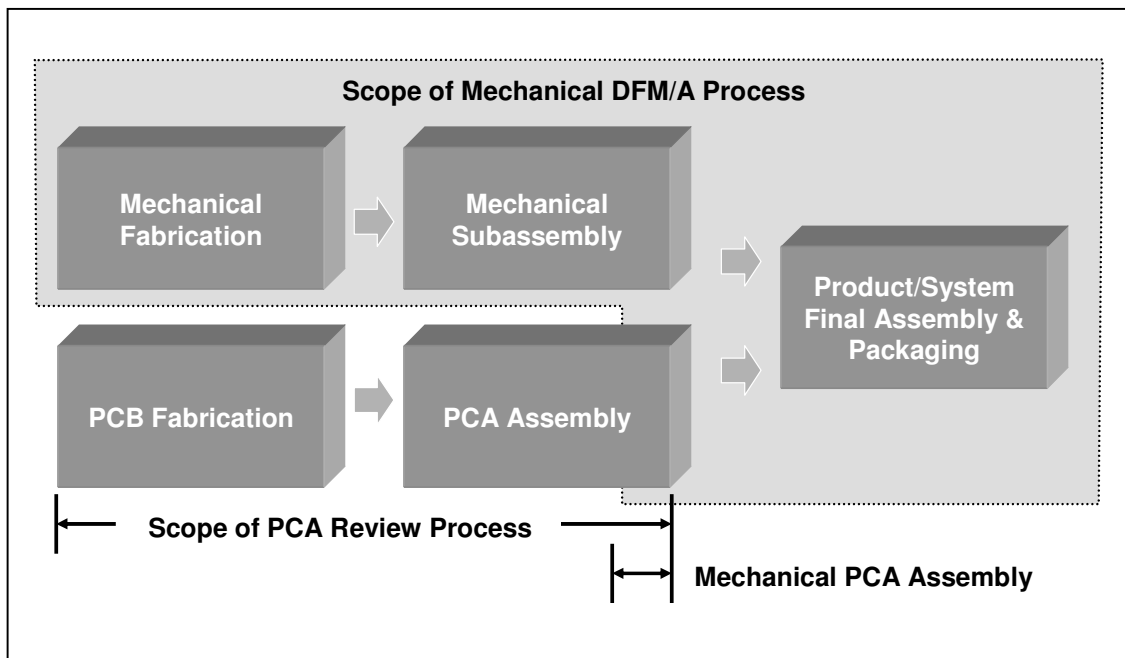


Figure 1. DFM/A Project Scope

The development and implementation of the process would follow the same approach as that of the highly successful PCA review process. Celestica would begin by providing DFA reviews at the later stages of the design cycle. Initially the reviews would focus on incremental design improvements aimed at streamlining the assembly process by minimizing assembly related difficulties. Over time, the process would be moved to an earlier stage in the design cycle and reviews would be expanded to include more in-depth analysis.

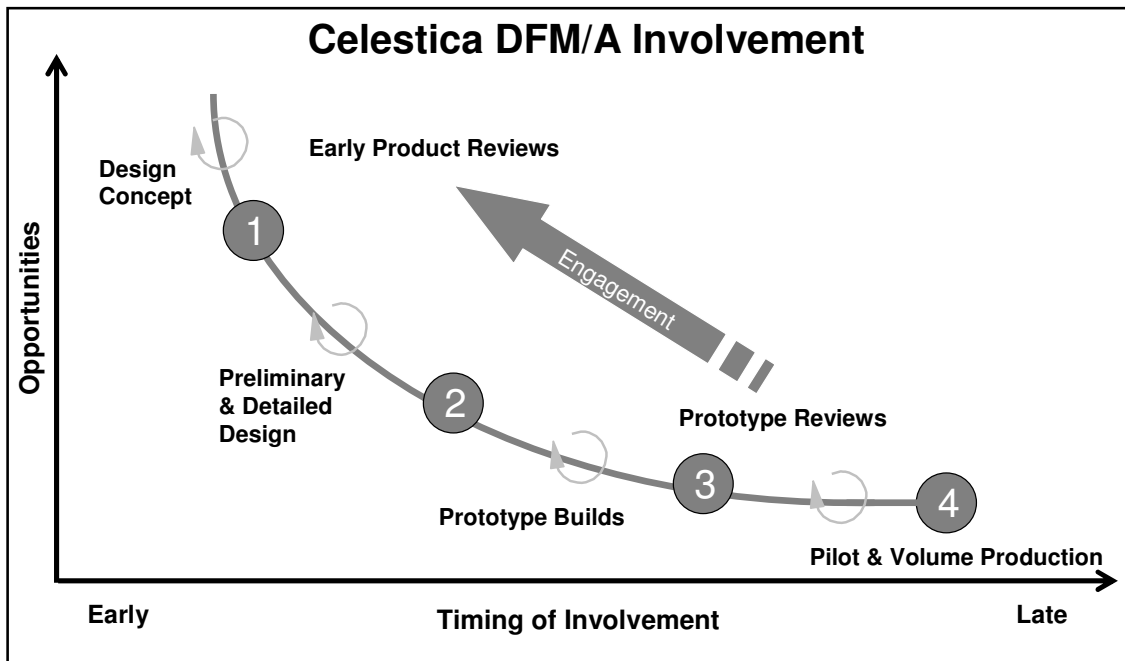


Figure 2. Celestica DFM/A Involvement

Prototype Build Reviews

The prototype build process was targeted as the starting point for the DFA service. Both internally developed and customer supplied designs would be reviewed by manufacturing engineers prior to volume production. The existing hands-on prototype build review was expanded to include fundamental aspects of design for assembly. Realizing that the review was late in the design cycle, and design decisions related to part symmetry and securing methods had already been made, the review was tailored to focus heavily on form, fit and function. Manufacturing engineers performing product reviews were provided design for assembly methodology training with an emphasis on identification of potential assembly issues. Guidelines and lessons learned documents were developed to aid in the training process. Standardized checklist and report templates were created to guide the reviewer through the review and to ensure that basic handling, assembly and mistake-proofing features were considered for each part in the assembly. Today, the process is well received by designers and, though late in the design cycle, the benefits are clear. The identification and resolution of potential assembly difficulties prior to production leads to improved producibility, lower cost and improved quality. Prototype

hands-on reviews continue today as a final pre-production review and serve as an introduction to Celestica's more advanced DFM/A capabilities.

The next step on the roadmap to developing an industry leading service offering was to move reviews to earlier in the design cycle and to expand the depth of the reviews. The opportunity for savings would be increased by the fact that more fundamental aspects of the design could be considered and design teams would have more time to act on suggestions. Conducting reviews earlier in the process would also drive the need for more advanced product review tools. Early product reviews would need to rely on virtual reviews of design data in place of the hands-on review of physical hardware used in later prototype reviews. Well aware of the success that software automation had brought to PCA reviews, the team realized the benefits of leveraging software tools to provide structure, repeatability and consistency. Focusing on the project objective to improve producibility, lower cost and improve quality, the team began to assemble a list of requirements for an early mechanical review tool including:

- Ability to draw from design data rather than physical hardware
- Identify opportunities for design optimization
- Quantified results
- Structured/Repeatable process
- Minimized review time
- Globally deployable
- Applicable for internally and customer developed designs

The Search for a Mechanical Review Tool

In an effort to save the time and expense associated with developing a mechanical review tool from scratch, the team set out to find a suitable mechanical review tool on the open market. Requirements in hand, the team analyzed the industry and began the selection process. Boothroyd & Dewhurst scored well and the decision was made to purchase the DFMA[®] tool. The software's ability to capture and quantify potential handling and insertion difficulties as well as opportunities for part count reduction set it apart from some of the other tools on the market.

Deployment for Review of Internally Developed Designs

Use of the DFMA[®] software to review internally developed designs proved to be a fairly standard deployment. Celestica designers apply the tool directly to their own work. The designers have open access to the computer aided design (CAD) data and can draw from the manufacturing engineering community as necessary to answer any questions related to potential handling or insertion difficulties. The fact that the designer runs the tool in parallel to the creation of the product fits well with the tool's "out-of-the-box" functionality. Multiple re-design options can be modeled by the designer directly within the tool and optimization can occur long before submitting the product for prototype builds. Deployment tasks centered on teaching the mechanics of the tool and

emphasizing the fundamental aspects of the methodology as part of standard design practices.

Deployment for Review of Customer Developed Designs

The deployment of the tool for use in reviewing customer designs proved more challenging. One of the first challenges turned out to be the design data package. Celestica's customers use a variety of CAD packages to document their designs. Unlike OEMs who may have standardized on a single design package, EMS companies are faced with designs completed in several different native tools. Although standard two dimensional outputs from the tools can be used, active three dimensional assembly files are more useful. Unfortunately, fully assembled three dimensional CAD files can be very large and often the tool itself requires fairly robust hardware to run efficiently. Whenever possible, Celestica converts native CAD assembly and part files into "lightweight" CAD files. A "lightweight" CAD file is a much smaller version of the original file that can be opened using off-the-shelf collaboration viewing software. Far superior to paper drawings, these viewers offer functionality such as pan, zoom, rotate and measure that greatly reduce the time necessary to complete a product review. The files can also be electronically marked-up and saved with comments during the review. Use of the Celestica product data management (PDM) team to create "lightweight" CAD files for placement in the Celestica central data repository means that DFA reviewers do not have to be fluent in all of the native CAD tools. Training for the viewing tools can be completed in a few hours versus the months necessary to become proficient in the native tools.

Customer Data Files	
Pro / Engineer	.asm, .prt, .drw
SolidWorks	.sldasm, .sldprt, .slddrw, .easm
AutoCad	.dwg, .dxf
Catia	.model, .cat, .exp
Solid Edge	.par, .asm, .psm

Figure 3. Range of Customer Data Files

Educating each customer team on the need for detailed design files early in the product life-cycle is critical to successful implementation. EMS providers, considered primarily as assembly houses, have traditionally been brought into the picture late in the design cycle. Gaining early access to detailed design files requires demonstrating to each customer the value-add that Celestica brings to the design of their products. Celestica leverages the enhanced prototype review process to demonstrate the ability to draw from the collective knowledge associated with producing products in several industry sectors (with varying volumes and levels of complexity) to improve quality, reduce cost and speed time-to-market.

The Early Product Review

The review is the heart of the process and where Celestica adds value for its customers. As outsourcing continues to grow, some OEMs are finding themselves with limited internal assembly knowledge. Celestica's manufacturing engineers work the front lines of day-to-day production and are very familiar with assembly processes, tooling and the difficulties associated with the handling and mating of parts. Their experience on the factory floor minimizes the time needed to determine the assembly sequence and maximizes the infusion of the realities of final assembly. Familiar with the entire assembly lifecycle from prototype to end-of-life, they are aware of the demands of volume production and the effects of ergonomic and design difficulties. Armed with assembly experience, advanced methodology training, the DFMA[®] software and Celestica built review tools, manufacturing engineers identify opportunities and suggested changes to improve producibility, reduce cost and improve quality.

Building the Customer Report

The customer report is the vehicle through which identified opportunities and suggestions for improvements are shared with the customer. The customer report is a living document that begins with early product reviews and is maintained throughout the design process. Celestica uses the report to share opportunities for design improvements with the customer, as well as to track customer comments and actions. As the owner of the design documentation, the customer ultimately chooses which, if any, changes are made to the product. Celestica's role is to provide the information needed for the designer to make informed decisions in a timely manner and to work with the customer to ensure as many opportunities as possible are addressed in the final design.

Though multiple re-design options can be quickly modeled and compared within the DFMA[®] tool, capturing the options on paper for transmittal to customers who may not be familiar with DFA or have access to a DFM/A tool is more difficult. Each issue must be clearly articulated, supported with comments and suggestions, and quantified with the impact to the assembly process. With the help of Boothroyd & Dewhurst, Celestica's Information Technology team was able to automate the compilation of information from the DFMA[®] database tables and exported suggestions for re-design report. Using automation, it takes a reviewer only a few minutes to create a tabular report of the opportunities in spreadsheet format once the software review is complete. The following base information is provided for each entry in the review that contains specific handling/insertion difficulties, or which does not meet the minimum part criteria:

- Part name
- Part number
- Quantity
- Identification as improvement or elimination
- Total time reduction opportunity per part (all difficulties removed)
- Itemized list of handling/insertion difficulties with potential time savings from the DFMA[®] suggestions for re-design report

As a report going back to the customer, it is important that opportunities are presented in a way that does not lead to mis-understandings around potential time savings. Each item on the pre-populated report is identified through the automation as either an improvement or elimination opportunity. Improvement opportunities represent the specific handling or insertion difficulties, while elimination opportunities represent the base time for separate operations and parts that do not meet the minimum part criteria. In the case of parts or operations with both improvement and elimination opportunities, the time savings potential is reported separately – with the sum equal to the total assembly time for the part. This allows visibility to the potential time savings associated with addressing the difficulties in the event elimination is not possible. The report is also structured such that the total opportunity in the design is reported as the sum of the elimination and improvement opportunities. This provides the ability to see the relative impact of individual opportunities on the total, and can help prioritize re-design efforts.

Starting with the pre-populated report, the reviewer must first determine how to best present the itemized issues to the customer. Though possible in many cases, the times associated with specific handling and insertion difficulties are not necessarily linearly additive. The DFMA[®] tool recognizes that certain difficulties, when present together, have a different effect than the sum of the difficulties individually. Consider the difficulties “tweezers” and “flexible” as an example. A self-stick part requiring tweezers as a standalone difficulty receives a time adder of 2.59 seconds while a similar part that is only flexible receives a 3.09 second time adder. One might assume that a part that is both flexible and requires tweezers would have a time adder of 5.68 seconds when in fact the tool assigns a 3.09 second adder to the combined part. Parts with multiple handling and insertion difficulties must be carefully reviewed to ensure that the reported time impacts add up.

Using the data supplied in the pre-populated report, the reviewer can quickly compare the total time reduction opportunity in the part to the sum of the itemized potential time savings from the DFMA[®] suggestions for re-design report. In cases where the numbers differ, the itemized opportunities can be grouped into a combined opportunity represented by the total time reduction opportunity in the part. Specific savings associated with partial solutions to combined entries can be modeled directly in the tool and fed back to the customer as a follow-up exercise if necessary. In this way, the reviewer is able to show granularity where possible, without the need to list partial solution details for the more complicated combined difficulties.

Once the report has been screened and the opportunities are grouped appropriately, the reviewer can shift their attention to adding in the details necessary for the customer to quickly understand the issue. Using the pre-populated information as a starting point, specific details are added to the description of each issue to clearly explain the opportunity at hand. The reviewer then leverages their in-depth product knowledge and experience with a broad range of products to make suggestions and/or comments on potential changes. The resulting report forms a clear, concise picture of the design opportunity – addressing both improvement and elimination opportunities. Customer

design teams are empowered with the data necessary to prioritize re-design efforts and maximize potential producibility, cost, and quality improvements.

Summary

As an EMS provider with increasing levels of mechanical assembly, Celestica has successfully added mechanical DFM/A reviews to the portfolio of DFX capabilities. Use of the Boothroyd and Dewhurst DFMA[®] software package plays a key role in the early product review process by providing structure to the review and by quantifying the time savings associated with identified opportunities. The DFMA[®] review, in combination with the Celestica-developed automated extraction of results, eliminates much of the non-value-add work and focuses the reviewer on the value-add exercise of articulating opportunities and providing suggestions for improvement. By driving the review into the early stages of the design process and focusing on design data rather than physical hardware, suggestions are provided at a time in the design cycle that enables innovative rather than reactive solutions. Customer design teams are empowered with the data needed to streamline the design to improve producibility, reduce cost and improve quality.