WINNING THE PCB TRIFECTA VIA "CORRECT BY CONSTRUCTION" DESIGN PRINCIPLES

Best-in-Class companies are increasingly running design rule/DFM checks and simulation early in the design process, when the cost to fix design flaws is low. "Correct by Construction" design methodology is the practice of performing testing and simulation in parallel to development activities. As Best-in-Class printed circuit board (PCB) developers integrate realtime, Correct by Construction methodology into PCB design, they are reaping three massive optimization benefits by reducing cycle time and costs, and improving product quality while achieving real-time product feedback.

DFM (design for manufacturability) refers to the designer's practice of optimizing a PCB layout to prevent board defects from occurring during fabrication.

PCB Design Pressures and Challenges

For PCB developers, today's engineering environment is filled with external business pressures (Figure 1).

Figure 1: External Business Pressures of PCB Design



Design schedules are shortening, and firms are experiencing increased pressure to meet tight delivery deadlines. Product complexity is increasing as customers demand differentiated, feature-rich products. Often, design errors and problems are found late in the design process or even after release, necessitating costly engineering change orders (ECOs). Best-in-Class firms feel these pressures acutely. They are 24% more likely to differentiate their products via performance and capabilities and twice as likely to differentiate based on faster time-to-market.

Along with these business challenges come formidable internal development challenges (Figure 2).



Figure 2: Internal Challenges of PCB Design

Operational efficiency is a major internal challenge: even with rising product complexity, PCB designers still need to achieve higher production yields. The demands of complexity and multidisciplinary design trigger frequent design changes. As always, management and validation of constraints for performance and manufacturability is an issue. All these internal challenges exist in an environment characterized by inefficient collaboration across the design team and other teams such as manufacturing/production or electronics manufacturing services (EMS) providers.

In the face of an engineering environment filled with both external business pressures and internal development challenges, there must be a better way of doing things.

Enter "Correct by Construction" Methodology

Correct by Construction methodology is the practice of introducing massive improvement into the PCB design process by moving manufacturing and performance validation via design rule / DFM checks and simulation into the PCB design system and integrating it with other design activities (Figure 3).

Figure 3: Correct by Construction Decreases Cost of Change and Increases Ability to Affect Functionality



Source: Aberdeen, March 2018

Think of Correct by Construction as moving manufacturability and performance analysis (DFM checks, integrated constraint management, design rule checks, electrical checks, simulation, etc.) from a postprocess step run at the end of the design or by the manufacturer into an integrated solution within the PCB design system. Correct by Construction is a **major advance** in the design of PCBs, allowing users to ultimately eliminate many of the iterations used for manufacturability and performance analysis today, thus making the overall flow more efficient.

Instead of waiting until a PCB design is completed to perform manufacturing and performance validation, Correct by Construction integrates this as an "in-line" part of the PCB design process. The result of in-line manufacturing and performance validation is improved new product development and introduction (NPDI) — better cycle time/faster time-to-market, reduced costs, and improved product quality.

By identifying and correcting issues during development, the cost to fix design flaws is low. This improvement results from integrating many design check/DFM check activities into early design, yielding real-time feedback that is critical to avoid costly redesign-rework that occurs late in the product development cycle.

As Best-in-Class PCB developers integrate a real-time Correct by Construction methodology into PCB design, they are reaping major benefits by producing a design that is right the first time (i.e., "correct-byconstruction") and by avoiding costly ECOs issued after the product has gone into manufacturing.

Best-in-Class Metrics for PCB Development

Aberdeen selected five strategic metrics to define Best-in-Class companies. Together, these metrics strongly suggest an effective PCB development environment that incorporates Correct by Construction methodology to meet product targets and beat product development cycle times of All Others (Table 1).

Table 1: Who Are the Best-in-Class?

Best-in-Class Metric	Best-in- Class	Industry Average	Laggard
Product Cost Targets Met	85%	67%	38%
Product Launch Dates Met	86%	66%	35%
Product Quality Targets Met at Release Date	90%	73%	39%
Product Revenue Targets Met	81%	66%	45%
Length of Development Cycle (2 Years)	+3%	+18%	+18%

% of Products Meeting Target = 122, Source: Aberdeen, March 2018

The Aberdeen maturity class framework is comprised of three groups of survey respondents. This data is used to determine overall company performance. Classified by their selfreported performance across several key metrics, each respondent falls into one of three categories:

- Best-in-Class: Top 20% of respondents based on performance
- Industry Average: Middle 50% of respondents based on performance
- Laggard: Bottom 30% of respondents based on performance

Sometimes we refer to a fourth category, All Others, which is Industry Average. and Laggard combined. The Best-in-Class perform much better compared to Laggards across cycle time, cost, and quality metrics:

- Cycle Time: 2.5x better performance on meeting product launch date targets (6x better on holding the line on length of development cycles over the past two years).
- **Cost:** 2.2x better performance on meeting product cost targets.
- Quality: 2.3x better performance on meeting product quality targets at release date.

Strong Organizational Maturity for the Best-in-Class

To effectively respond to pressures and challenges, Best-in-Class firms embrace Correct by Construction best practices at higher rates than All Others. Not only are they conducting these activities earlier, but they are integrating these activities into the design process to eliminate the typical waterfall development process that forces them to retrace their steps, slowing down time-to-market (Figure 4).



Figure 4: Best-in-Class Actions to Support PCB Design

% of Respondents n = 122, Source: Aberdeen, March 2018

The Best-in-Class shift to Correct by Construction starts with a commitment to improving individual design productivity through tool and process efficiency, and they are twice as likely to do so as All Others. This implies that Best-in-Class firms don't just *run* their manufacturability and performance analysis during design, they embed their design requirements in their tool so they are checking against design rules in real time as they

design. Further, they cement their advantage by implementing common design tools and best practices across the company.

Best-in-Class organizations continue their commitment to Correct by Construction through their implementation of Design for Excellence (DFx) strategies that optimize for manufacturability, performance, and cost at multiple stages of the design cycle (see sidebar).

The Best-in-Class are moving many manufacturing and performance validation activities into the design stage to reap the full benefits of a Correct by Construction design methodology (Figure 5).

DFx (or design for excellence, or design for x), are terms and expansions used interchangeably where "x" is a variable which can have one of many possible values, including manufacturing, fabrication, test, power, cost, or reliability.



Figure 5: Best-in-Class Actions to Support Correct by Construction PCB Design

n = 122, Source: Aberdeen, March 2018

The value of Correct by Construction methodology comes not from moving one of these activities earlier in the design cycle, but from moving all activities **and** being able to do them in real time. To maximize the benefits of Correct by Construction, leaders are adopting a holistic approach to bring manufacturability and performance analysis (DFM checks, integrated constraint management, design rule checks, electrical checks, simulation, etc.) into the design phase to achieve Best-in-Class results. The evidence shows this is happening at Best-in-Class firms, which are:

- 2.75 times more likely than All Others to pursue centralized constraint management
- 35% more likely than All Others to implement DFM during the design cycle
- 27% more likely than All Others to perform power integrity analysis
- 26% more likely than All Others to perform signal integrity analysis

Results: Best-in-Class Meet Targets

Correct by Construction results in better results across the board (Figure 6).



Figure 6: Best-in-Class Meet Product Targets with Correct by Construction Design Methodology

The Best-in-Class perform much better compared to All Others across cycle time, cost, and quality metrics:

- Cycle Time: 54% better performance on meeting product launch date targets.
- **Cost:** 49% better performance on meeting product cost targets.

[%] of products meeting target = 122, Source: Aberdeen, March 2018

Quality: 48% better performance on meeting product quality targets at release date.

Aberdeen research also shows firms integrating simulation into design decreased engineering change orders after release to manufacturing by 21%, built 27% fewer physical prototypes, and decreased their length of development time by 29%.

Conclusions and Recommendations

Increasingly, analysis is becoming an important part of the design process, not a post-process step. Correct by Construction methodology elevates in-design analysis for PCB to a new level to deliver shorter cycle times, lower costs, and higher quality.

Many people are familiar with the adage: *"Cost. Time. Quality. Pick two!"* However, Aberdeen research shows that Best-in-Class firms who incorporate a Correct by Construction methodology perform better in all three areas. To maximize the benefits of Correct by Construction, Industry Leaders are adopting a holistic approach to bring manufacturability and performance analysis (DFM checks, integrated constraint management, design rule checks, electrical checks, simulation, etc.) into the design phase.

Given these benefits, why wait until your PCB design is done to find out if you have problems? It makes more sense to run analysis during design so you can solve issues early in the process, and completely avoid design re-spins after product release. Not only do the Best-in-Class improve cycle time, cost, and quality, but their entire PCB design process, as measured against the cost of the final product, is 32% more efficient.

Technology must have operational meaning, purpose, and application for you to make an investment. Correct by Construction methodology meets these criteria, producing a better PCB development system that ensures you stay one step (or more) ahead of the competition. Driven by pressures and challenges, Industry Leading designers are adopting Correct by Construction methodology to perform manufacturability and performance analysis in-line to avoid costly rework and ECOs later. In short, the benefits of Correct by Construction methodology are real.

Related Research

Embrace Your Passion for Design: PCB Tools for the Joy of Engineering; February 2017

Making Complex Wire Assemblies Simple with Integrated Harness Design Software; February 2017

Design for Manufacturing in Aerospace and Defense; September 2016

PCB Data Management: How Industry Leaders are Managing their Data; August 2015

About Aberdeen Group

Since 1988, Aberdeen Group has published research that helps businesses worldwide to improve their performance. Our analysts derive fact-based, vendor-neutral insights from a proprietary analytical framework, which identifies Best-in-Class organizations from primary research conducted with industry practitioners. The resulting research content is used by hundreds of thousands of business professionals to drive smarter decision-making and improve business strategies. Aberdeen Group is headquartered in Waltham, Massachusetts, USA.

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