Design Environment ROI:
How Design Teams On A Budget Can Build A Best In Class Design Environment

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Abstract

Design workflow is the core to your design team's competitive advantage; it's the conduit by which you turn your team's expertise and ideas into manufacturable products. And yet, all engineering teams face the challenge of maximizing their productivity within limited financial resources. How can the less-capitalized teams develop a design workflow that competes with the highly-capitalized teams? Simple: open tools.

In this session, we present business examples from both market research and from direct experience with customers and supply chain partners. From these examples, we quantify the impact of some of the key elements of a design flow based on currently available open tools:

- SDK availability
- User Interface throughput
- All free tools are the same (or are they?)
- Blurring steps in the design phase
- Moving DFM upstream for designers

And also report on areas where open distribution tools may NOT be the right choice:

- High performance signal design
- High end design

Introduction

From small, start-up firms to large, established organizations, the common denominator among design teams is budget. Some teams may be better funded than others and, thus, possibly possess greater freedom to experiment with various design options to discover a groundbreaking solution. Nonetheless, few design teams are isolated from trends emerging in the engineering environment: increasing responsibilities to manage outsourcing, growing expectations for more and/or better results despite fewer resources, and changing models for software pricing and distribution.

As design teams face increasing pressures to perform in a business environment in which the perception of effective and valuable software tools is in a state of flux, it behooves them to take a closer look at tools incorporated into the design workflow. To remain competitive, teams must be able to demonstrate that tools at their disposal provide an added value to their processes and the organization as a whole. In the past, adopting comprehensive software packages may have required a significant investment, but they at least provided a competitive advantage over less capitalized players. Today, however, with the preponderance of free and open tools, such investments no longer ensure relative outperformance and may, in fact, prove to be detrimental

in terms of creating inflated break-even points or consuming profits that, potentially, could have been dedicated to additional research and development efforts.

Discussion of Methodology

The methodology for this paper involved collecting industry research, conducting interviews, and holding discussions with PCB designers. To a limited degree, our methodology also entailed first-hand experience from the perspective of the PCB manufacturing floor.

Tools Evaluated

- Advanced Circuits PCB Artist
- Cadence Design Systems Allegro
- Cadence Design Systems OrCad
- CadSoft EAGLE
- Engineering Express
- Mentor Graphics PADS
- Mentor Graphics Expedition
- Sunstone Circuits PCB123

Data

In this section, we will present the case studies and research sources compiled to create this paper's conclusions.

Factors Influencing ROI Trends

Studies about software pricing trends indicate a movement toward viewing new technology and tools with an eye toward the return on investment (ROI). According to a Software Pricing Trends report compiled by PricewaterhouseCoopers, a new breed of customer has emerged "that judges software by its ability to contribute value to the organization – measuring where, when, how much, and how well software is used." [1]

Several years ago, investing in software provided a competitive advantage – enhancing product cycles to make them faster, better and cheaper. Oftentimes, the software was a proprietary feature and indicated deep pockets to support such an investment in business and the future of business. Those days are no more. Today, software is part of the mainstream costs of doing business. However, as corporate balance sheets are constantly scrutinized, each expenditure must be able to justify itself and IT departments and engineering groups must be able to account for their purchases like never before. PricewaterhouseCoopers notes that a number of factors are prompting customers to re-evaluate the value of software they buy, including "constrained budgets, executive demand for more demonstrable ROI, a growing focus on business-process oriented management, and a concomitant rise in the use of externally provisioned software services."

At the same time, corporations are revisiting their perceptions of effective software tools and evaluating whether their impressions are lagging behind the reality of the marketplace. In figure 1, below, from PriceWaterhouseCoopers report, "Software Pricing Trends: How Vendors Can Capitalize on the Shift to New Revenue Models", we can see begin to visualize the impact of this

shift in perception. The current state of software pricing, the report argues, is built upon qualitative competitive advantages offered by proprietary software, resulting in a high market value and a spectrum of enterprise development cost choices. At the point of implementing these high market value software packages, however, organizations typically find that only a few applications within the suite are utilized, leaving tools – and thus investments – on the table. The "more is better" mentality is costly and increasingly viewed as outdated. Corporations are deciding whether to trust new methods of software distribution and selection to help achieve their overarching goals.

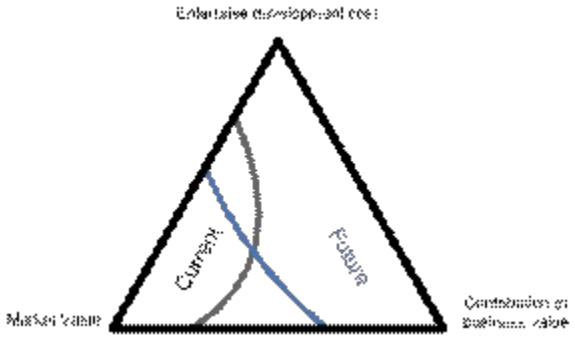

Figure 1: Open Software Value Shift

As alluded to already, the trend is for design teams to shift their selection processes, giving higher priority to business value over market value. This change in customer evaluation behavior will be driven by a number of factors (detailed below) and will place increasing pressure on traditional software developers to change how they do business.

Decline in Software Prices

With IT budgets tightening up, software vendors have been forced to explore new options in delivering their tools to customers. According to the PricewaterhouseCoopers report, software prices have taken a downturn in recent years and are expected to continue this trend in the foreseeable future. Executives are questioning the value of the software they buy, and as a value is increasingly assigned to software, organizations are eliminating the functionality they do not use but have been paying for. Instead, they are focusing their dollars on tools that provide measurable, meaningful value. One avenue open to executives is outsourcing software as a service, allowing organizations to pay periodically or on demand for the services they use, rather than front exorbitant licensing costs. As certain software vendors adopt this approach, others who do not are being forced to lower their prices to attract and retain subscribers.

Decline in PCB Sales

According to IPC, overall sales of rigid PC manufacturing decreased $6.4B per year between 2000 and 2005. In addition,. US production lost more than half of its 2000 sales by 2005, dropping from 25% of $38.8B – or $11.3B overall – to just 11% of $32.4B, or $3.5B overall. General consensus is that this is a trend driven primarily by economics; overseas production cost savings can be compelling for long lead time, high volume products. The impact on the US PCB manufacturing industry has been easy to recognize: between 2001 and 2006, the number of North American PCB manufacturing facilities dropped from 750+ to 449.

Increase in PCB Design Starts
IPC also reports an overall increase in the number of rigid PCB design starts. This statistic illustrates the ongoing trend toward building PCBs into new product areas, and into innovative applications. More design starts will lead to an increase in prototype-specific production.

SDK Availability
The SDK provides a method to add the functionality required without waiting for the software developer to add the necessary components. Users can access the database in a controlled and maintained way, and can write their own plug-ins to extend design tool functionality. In addition, developers can use the SK to build plug-ins and add-ons to distribute to other users – either for free or for a fee – enhancing a base tool in a powerful and widely needed way.

The increasing availability of software development kits (SDKs) is also affecting how software purchases are perceived. With the option of using free tools to design and create applications, engineers and IT purchasing departments are finding little cause to invest additional funds into licensed products. While free tools may have been perceived as lower quality in the past, today's tools are encroaching upon entrenched, licensed products.

Consumers Drive Demand for No/Low-Cost Tools
Increasingly, customers see traditional software sales models as business overhead. If there is an equivalent tool on the open market, customers are beginning to show a preference for it, especially in instances of high cost specialized tools. For instance, Microsoft Office continues to dominate, despite the free availability of Google Office or OpenOffice for equivalent toolsets. Although costs do add up, the $400 per user investment in Microsoft Office requires little effort to recoup. If a company is seeking specialization along the lines of a full suite of PCB tools from a first-tier developer, however, then a $40,000 per user investment can become prohibitive, as few small or emerging companies can absorb such costs. Table 1, below, shows an example of the cost rollups for equipping a design team with PCB design tool, assuming a typical per-engineer cost of $10,000 per license. As companies move their usage models further tot the right on this table, the savings become significant.

Seats	100% SW License	50-50 License/Usage	25-75 License/Usage	100% Usage Model
2	$20,000	$10,000	$10,000	$0
5	$50,000	$30,000	$20,000	$0
10	$100,000	$50,000	$30,000	$0
15	$150,000	$80,000	$40,000	$0

Table 1: Equipping a Design Team, Example Cost Roll-Ups

By demanding new methods of pricing and delivery from tool vendors, customers are driving down software prices and building value into their processes by containing the costs of their tools and paying for the functionality and applications required. In addition, the greater availability of free or low-cost tools can help level the playing field shared by the smaller, start up organizations on one side, and the better-funded, well established companies on the other.

With lower expenses to recoup, companies – new or old, large or small – have greater freedom to experiment with design and discover the optimal configurations for their products.

The Impact of the User Interface on Productivity

In addition to cost considerations, a company may decide to use free tools or open tools based on ease of use and adoption among the workforce. Introducing applications into the work flow that are intuitive can soften the learning curve and allow companies to achieve improved productivity at a faster rate. Applications that integrate short cuts and quick key commands quickly build 'power' users who are able to move through the data at a fast pace and produce at a greater rate. By iteratively reducing the Tools with an optimal user interface should have a quantifiable impact on the ROI.

Blurring the Steps in the Design Phase

Another consideration when selecting tools to incorporate into your work flow is the ability to provide a holistic impact on the workflow process. In the PCB industry, traditional design-for-manufacturing (DfM) systems separate the design team, manufacturing supply chain, and test and component suppliers. Typically, a team designs a complete circuit board and then submits the design to manufacturing). Once manufacturing receives the details, it can determine whether or not the board can be produced according to the rules of that particular fabricator. If not, the design must be reworked, usually resulting in cost overruns and delays.

Although DfM tools and design rule check for PCBs were available by the late 1980s, a culmination of ever increasing design complexities, shorter design cycles, and increased levels of outsourcing for design and manufacture have illuminated the shortcomings of this outdated method.

Current trends in PCB design flows, and IC design flows as well, are to find new ways to bring manufacturing related information upstream, through the information barrier that exists between design and manufacturing. The more information that designers can receive about how their design decisions will affect manufacturing, the more designers can to avoid design pitfalls and even maximize potential yields.

To this end, multiple IC design tool developers have been innovating new data flows intended to improve designer access to manufacturability information. Notable examples of this work can be found in the Cadence tool suite, as well as the Zuken and Mentor Graphics tool suites. Note that these software firms also continue to follow a pay-per-license, vertical integration business model – a strategy that can exclude design teams who do not have sufficient resources to pay for the entire design flow.

Moving DfM Upstream for Designers

By bringing all PCB stakeholders together in one design and manufacturing ecosystem to make meaningful design flow connections, organizations have an opportunity to improve ROI. Sunstone Circuits is pursuing a collaborative approach, working with PCB software developers to create DRC/DfM rules decks that accurately and completely implement the PCB fabrication design rules. Once completed, tested and certified, the rules are made freely available from the

company's website for downloading into CAD systems, allowing customers to design directly for a specific manufacturer. With a certified rule deck driving the CAD tool's routing constraints, engineers can check the manufacturability of the design at any point and fix errors as they occur, rather than at the end of the process. Such integration also allows for more experimentation and a reduced time to market.

Case Study- Industry Trends

SketchUp vs. AutoCAD

In the 3D modeling world of professional architects and engineers, Google's SketchUp tool is making a concerted run at the long dominant position of AuoCAD. SketchUp is a 3D tool designed to be intuitive and flexible to use. Originally developed by @Last Software, SketchUp was made available as a free download under Google's ownership, allowing its integration into Google Earth and other tools that provide SDK-type functionality. This integration allows users to extend the functionality of the tool. As a result, a whole group of hobbyists now use SketchUp for personal projects rather than 'borrowing' or illegally using AutoCAD or similar fee-based tools.

SketchUp's appeal lies not only with individual users: increasingly, businesses are adopting the technology to bypass more expensive 3D modeling tools. A PCB manufacturer recently commissioned a manufacturing engineering consulting firm to propose a new manufacturing line. The firm's engineering proposal was submitted using SketchUp. Not long ago, the same design files would have been produced in AutoCAD. With free software providing all of the necessary functionality, however, the engineering firm rationalized that there was no need to pay for the same capabilities. As more users arrive at the same conclusion, AutoCAD will likely cede its market share to SketchUp over time.

Results

In this section, we present some scenarios that roll up the different factors on ROI.

When To Choose Open Tools

In Figure 2; we present the traditional product adoption curve. In the arena of PCB design tools, this curve is active on two levels:

- PCB board fabrication technology
- Adoption of Software Distribution models

In PCB design and technology, open PCB Tools will tend to get most adoption from the early majority and late majority users. As a general rule, no-cost tools are not targeting the 15% of the market building product using state-of-the-art PCB technology. The priorities for free-distribution tools align more closely with the large portion of the user community working back

from the leading edge. And for these users, many of the high-end features in the big-tier traditional software packages are of little value at best.

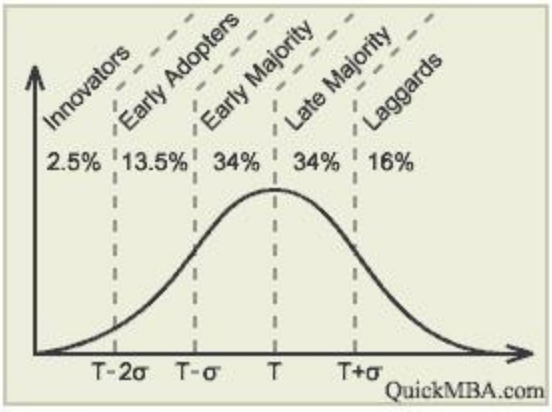

Figure 2: The Product Adoption Curve

This is not to say that free-distribution tools are poorly suited to large organizations. Rather, and regardless of organizational size, open tools tend to work well for design teams that operate with an amount of autonomy. Many free-distribution tools are tailored for use by an individual engineer, or small team – change control and version control functionality, for example, is usually not overly sophisticated – meaning that extremely complex, multi-site or multi-variation designs might be better served long-term by the corporate environment's vertically integrated tool.

Corporate design flows, however, can sometimes cause inadvertent issues for self-contained designs or designs requiring a low level of collaboration. During our research, we encountered users who started their use of free-distribution PCB tools because of a breakdown in the corporate design flow. In one case, the designer was given a project schedule with sufficient time for development work and a reasonable amount of room for project success. Unfortunately, when this designer contacted the corporate design team to arrange board design, he was informed that the corporate team faced a six week backlog in projects. If this designer waited for the corporate team to complete his project, he would miss his project development window. In this designer's case, using an alternate path – free-distribution tools in his case – though ultimately successful, was initially not his preferred solution.

The adoption of free-distribution design tools has also been driven by the needs and resources of the individual user. Based on the number of trends presented in this paper, including the strong wave of acceptance for open source and free-distribution tools throughout corporate environments, we submit the following observations:

- Free-distribution design tool adoption was driven by Innovators comprised mainly of individuals: hobbyists, students and very small entrepreneurial teams.
- Through word-of-mouth, and personal experience, free-distribution design tools increasingly found use among early adopters in non-critical corporate projects, often implementing test fixtures, support hardware, or non-product equipment.

- Further experience with the tool brought a wave of product-oriented prototyping and a shift from innovator/early adopter to early majority users, prompting a dramatic increase in the user base for free-distribution tools industry-wide. During this shift in the user community, free distribution users also shifted into corporate design teams. Free distribution tools now found themselves coexisting with the vertically integrated tools already installed in the corporate design flow.

Our interviews with users indicate that they tend to choose free-distribution PCB tools when one or more of the following conditions occur in their design:

- uses rigid PCB, 10 layers or less
- requires the collaboration of 5 or less individuals
- does not rely heavily upon a hierarchy of modular sub-designs

When NOT TO Choose Free-Distribution Tools

As compelling as the free-for-distribution tools model can be for many users, there are situations where open tools are not a suitable choice. Customer discussions point to these situations as key decision points for tools purchases:

- Reliance upon pre-existing data libraries
- Impedance calculation is high priority
- Design is timing-critical
- Very High layer counts
- Need for parametric back-annotation is critical to design success

High Performance Signal Design

Impedance control is just a part of the overall issue for high-end design. In general, 'complex, high-speed' designs are where the traditional high end CAD/EDA vendors have developed their core competencies.[1] High speed memories (DRAMs, DIMMS, etc.) require tight controls on overall trace lengths, in addition to impedance matching. In other words, simple length matching is not sufficient.

Instead, for high end designers, controlling the relative lengths of different classes of signals is a critical part of the design process. An example might mean managing the constrained relationship between control signals and instance data traces. There are also trace separation constraints which control the maximum amount of crosstalk that a signal is allowed to inject into a neighboring trace. High-speed differential serial busses also have their own trace length and separation requirements.

Big, complex designs often have the conflicting requirements of 1) maximizing the number of routes per layer and 2) minimizing crosstalk. These designs also usually have a special set of

[1] Customer interviews

routing rules in areas near or under ICs[2]. Large BGA devices in particular present challenges along these lines.

CAD/EDA vendors such as Cadence, Mentor Graphics, etc, often allow for input of these constraints to the design database, thereby assisting the CAD designer, via interactive feedback, in the hand 0routing process. The common consensus among high-speed engineers we spoke to is that auto routing solutions and highly-constrained high-speed circuitry regions still do converge on suitable routing solutions. Most high-speed design-critical routing is still accomplished by expert hand routing and extensive tool-aided constraint feedback.

Simulation Required

Based on the review of free distribution tools available at this writing, simulation is not generally an option in the PCB open tools design flow. Digital simulation requirements can be a critical decision point for high speed, complex designs. In PCB design flows in which impedance, timing constraints, and complex bus logic are factors, designers often require access to a simulation environment integrated with the CAD database. The engineers we interviewed commonly indicated that back-annotating a PCB layout into a signal integrity simulation not only saved design time but improved the accuracy of the simulation, resulting in components being moved or re-routed to improve performance and yield targets.

The introduction of user-accessible Software Development Kits (SDKs), such as the SDK included in Sunstone Circuits' PCB123 tool, means that interfacing design tools to third-party simulation environments are now possible.

You NEED Integration, But Your Team Doesn't DO Integration

Process integration can greatly extend the reach of a free distribution tool. Your team may not have the resources or expertise to write plug-ins. Utilizing a community of plug-in developers can be a great resource for such teams. Until recently, this sort of team generally would pay the cost to purchase traditional distribution CAD tools, and bear the cost of up-front licensing and ongoing maintenance support. Free for distribution tools generally did not provide the support and extensibility required. PCB123 and Sunstone have changed this equation by opening up the tool environment to plug-in developers. Design teams needing process integration can now make one of a number of choices to match their available resources:

- Traditional CAD Software – strong vertical integration, weak connection to manufacturing
- Free Distribution Software – varying levels of vertical integration, stronger connecton to manufacturing
- Free Software Plus Off-the-Shelf Plug-Ins – customizable utilities, adding functionality as needed
- Free Software Plus Contract Integration work – customized design flow via contract programmers using the SDK.

[2] For some designs, trace breakout regions often violate the standard rules.

Final Conclusion/Summary

Sunstone Circuits has developed an Return On Investment calculator, available for access/download from our website at: http://www.sunstone.com. Interested parties can use this tool as one more point in their ROI analysis for design tools.

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[1] PricewaterhouseCoopers. “Software Pricing Trends: how Vendors Can Capitalize on the Shift to New Revenue Models”. 2007.