

Semiconductor Product Lifecycle Management

Industry Adoption, Benefits
and The Road Ahead

Kalypso White Paper by Bill Poston & Joe Dury



Executive Summary

Escalating design costs, growing product complexity, shrinking average sales prices, and the relentless pace of innovation are creating intense pressures on companies in the semiconductor industry. With the industry's daunting design challenges, accelerated lifecycles, and complex supply chains, it is no wonder that product launch dates, development budgets, and quality targets are frequently missed.

To help understand the industry challenges and possible solutions, Kalypso examined the product innovation, design and launch processes of more than 25 leading global semiconductor companies. Kalypso research and analysis revealed that:

- There is an opportunity for significant improvements in new product development and lifecycle management processes. Semiconductor executives are not content with the status quo.
- Semiconductor companies have been slow to adopt Product Lifecycle Management (PLM) as a solution. Key adoption barriers were cited including: 1) low awareness of PLM solution sets, 2) limited understanding of PLM's value proposition, and 3) lack of a "standard" semiconductor PLM model.
- While no single, standard model is available, there are PLM solutions targeted at semiconductor companies. A comprehensive PLM offering would include strategic, design, data management, software development, and supply chain capabilities.
- PLM is providing an advantage to early adopters. It helps provide a single version of the truth for product information, enabling better process discipline and more efficient execution.
- Early adopters of PLM are seeing: improved time to market and ramp to volume; reduced design costs and more re-use; better chip quality, design, and manufacturability; more efficient collaboration, control, and communication of product design, development, and engineering change order information; and other strategic benefits.

Semiconductor companies must focus on improving product development to optimize innovation, design, and engineering processes with PLM strategies and solutions. More and more semiconductor firms are finding that a PLM system utilized for its collaborative design records enables better product capability, improved quality and reliability, lower product costs and faster time to market. To be successful, semiconductor companies need to avoid the "big bang" approach of ERP systems and to start small, think big, and build incrementally.

Semiconductor Industry Is Evolving Rapidly, Product Development Processes Are Not

Escalating design costs, growing product complexity, shrinking average sales prices, and the relentless pace of innovation are creating intense pressures on companies in the semiconductor industry. Competition is as fierce as ever, and the stakes are rising as companies move from one process node to the next while continuing to explore alternative technologies.

Circuit densities are 10 times what they were just three years ago. These densities put increasing pressure on ensuring a robust integrated circuit (IC) design process. This, coupled with the integration of digital circuitry with analog ICs continues to put increasing complexity on the IC design process and as a recent *EETimes* article states, "Analog circuitry on a digital chip is the 'secret sauce' that can make a proprietary semiconductor uniquely qualified for high-volume applications—and that's where the money is."¹

Chip densities for both digital and memory ICs have continued to evolve with the device geometries going from 90nm to 65nm and currently moving to 45nm. These device dimensions are now approaching the lattice and atomic limits of silicon itself. Both, new process and design methodologies, used selectively on 90nm and 65nm designs, are now required for 45nm technology for consistent results in both in development and manufacturing.² The cost of a design error, especially one late in the development cycle, could be catastrophic.

Today, a design flaw undetected until tape-out could mean scrapping a 90-nanometer mask set worth more than \$1 million. At 65-nanometer, mask set costs could rise to nearly \$2 million. According to a recent report, a 65nm mask set can cost 1.8 times that of a 90nm mask set, while a 45nm mask set can cost 2.2 times that of a 65nm version. Thus the development costs for a new chip or chipset can easily cost in excess of tens of millions of dollars if first pass silicon success is not certain.³

With the industry's daunting design challenges, accelerated lifecycles, and complex supply chains, it is no wonder that product launch dates, development budgets, and product targets are frequently missed. Semiconductor companies are operating at the bleeding edge of innovation and delivering breakthrough technologies, but their product development processes and execution need serious attention.

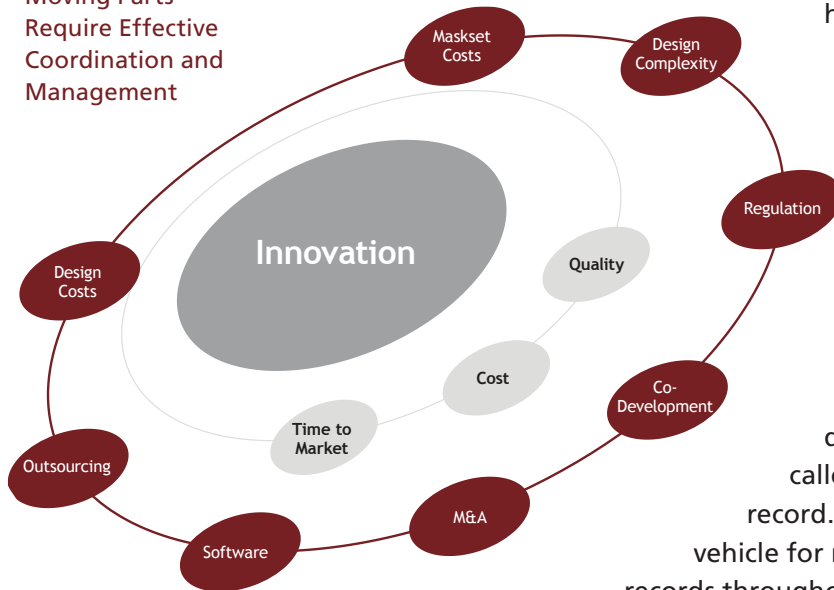
1 Johnson, R. Colin. "Analog Design Expertise is Rare, Valuable" *EETimes*, 2008

2 For results at 45nm technology node, devices are scaled to less than 100 silicon atoms along the MOS gate/channel length and sometimes less than 1000-2000 dopant atoms in the active area, and less than 5 or 6 atomic layers for the insulating oxide.

3 The Information Network (New Tripoli, Penn)

As shown in Figure 1, semiconductor companies need to think about how to proactively manage the moving parts of the New Product Development (NPD) process to become more strategic, effective, and ultimately more innovative.

Figure 1:
New Product Development: Moving Parts Require Effective Coordination and Management



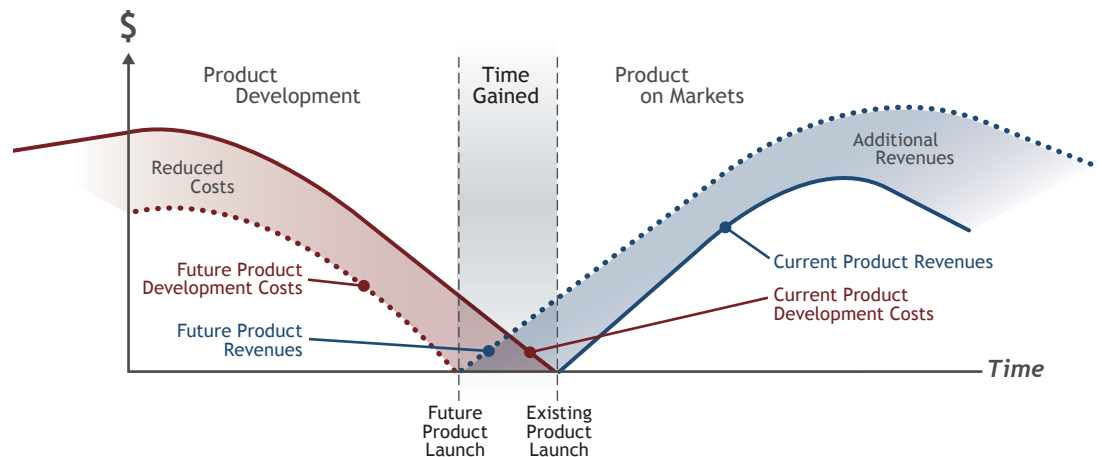
Fortunately, these moving parts can be managed with greater process discipline and efficiency using Product Lifecycle Management (PLM) solutions. PLM can help semiconductor companies

manage critical product information with distributed global teams, across the extended supply chain, and throughout the entire product lifecycle.

A critical differentiator in IC development process is the product information created during development, oftentimes called product data or the product record. PLM systems are an excellent vehicle for maintaining and retrieving these records throughout the entire product/project lifecycle including such items as engineering project decisions, the specification hierarchy, the validation and verification information and the CAD records (electrical, mechanical, and software).

When used appropriately, PLM software can greatly enhance an enterprise's bottom line by delivering a potential 5 to 10 percent revenue uplift as well as considerable savings and productivity improvements in product development activities, as shown in Figure 2. Firms that utilize enterprise PLM systems for collaborative design and leverage common data through the product lifecycle can experience marked improvements in product capability, time to market capability, better product quality and reliability, and lower product cost.

Figure 2: Summary of PLM Benefits



As the semiconductor industry continues to evolve and the competition intensifies, semiconductor companies will need strong execution to meet aggressive time cycles for new product introduction. The rewards will go to companies that can not only innovate, but also effectively execute in a collaborative development environment.

To become truly competitive and prosper in this fast-paced, “high-stakes” environment, semiconductor companies should embrace PLM. Not just the technology – but the strategic thinking and business processes that enable a comprehensive solution.

Semiconductor Companies Are Seeking Profitable Growth, Missing Targets

According to industry benchmarks, manufacturers of all sizes are focusing their product strategies on new revenue opportunities in combination with cost control to achieve profitable growth.⁴ Semiconductor companies exemplify this focus, but place an even higher strategic importance on the value of time to market and ramp to yield.

For many semiconductor companies, achieving profitable growth in a more complex product development and design environment is a significant challenge. Kalypso research shows that semiconductor companies of all sizes have not been meeting their product development targets in 2006.⁵ This includes semiconductor companies with annual sales ranging from \$100 million to more than \$5 billion.

Consider these semiconductor industry findings:⁶

- Only 45% of new product launches meet their original launch date
- More than 60% of all semiconductor designs require at least one re-spin
- Only 59% of semiconductor designs make it into production
- Over 40% of development projects exceed the planned budget
- Less than 60% of semiconductor projects hit their product cost targets
- 83% of issues identified during validation are design-related

In addition, according to a 2006 survey conducted by the Fabless Semiconductor Association, companies are most concerned about the challenges of higher mask costs, greater design complexity, intellectual

“Getting quality chip designs out the door takes super-human effort.”

**Director of Engineering,
Global Semiconductor Company**

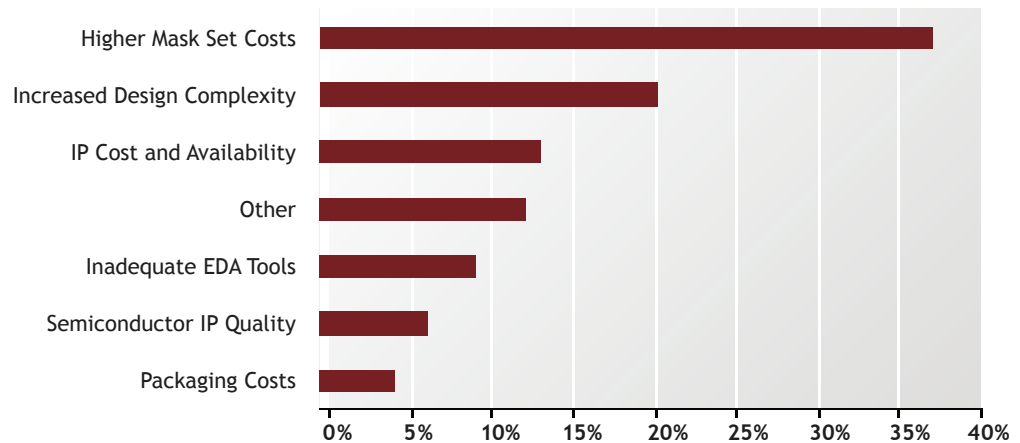
4 Brown, Jim. “PLM Battles Global Design Complexity.” *Managing Automation*, 2006.

5 Kalypso Semiconductor Analysis, 2006.

6 Ibid.

property costs and availability, and inadequate EDA tools. Figure 3 below shows the top responses of approximately 150 survey respondents who were asked “What is your biggest challenge to overcome as you look to move from one process node to the next?”

Figure 3 : Top Business Challenges for Semiconductor ⁷



“Quality takes a back seat and it shows up in operations.”

Director of Quality, Fortune 500 Semiconductor Company

Opportunities for Improvement

There are clearly opportunities for improvement, and Kalypso analysis indicates that executives are not content with the status quo.⁸

More pointed comments made by executives regarding semiconductor NPD and lifecycle management processes follow:

- “Speed is the company mantra. Quality takes a back seat and it shows up in operations.”
- “Changing product design requirements during development is like remodeling a car as you are driving down the highway at 90 miles per hour.”
- “With rising mask costs, we can’t afford extra spins and our success rate to first silicon is 0%.”
- “We have to collaborate inside and outside of the firewall...with intellectual property providers, foundries, suppliers, and other key parties.”
- “Getting quality chip designs out the door takes super-human effort.”

⁷ Fabless Semiconductor Association, Industry Survey Results, 2006.

⁸ Kalypso Semiconductor Analysis, 2006.

- “We are working on chips that have little to no market potential and this is a waste of time and effort. Resources could be utilized elsewhere.”
- “I lose sleep over the security of our intellectual property. FTP-ing files can’t be the best solution.”
- “We need to collaborate on a lot of details and changes that are critical to the product. There has got to be something better than email and Excel to keep in synch.”
- “We have so many systems. It is hard to keep track of what information goes where.”
- “We often have to ask the foundry for the latest versions of our designs.”
- “Design and IP re-use is limited due to lack of product family definition and portfolio management processes.”

In addition to the comments above, interviewees emphasized the need to reduce costs related to development processes, prototypes, and product introduction. Executives also cited the need for better, more meaningful NPD metrics related to cost, quality, test, and assembly.

The interviewees shared that they did not necessarily have the right processes, tools, or enablers in place to tackle these problems. Lastly, while many of them were able to speak to the challenges cited above, in general, most interviewees were unaware of solutions available to them.

PLM for the Semiconductor Industry

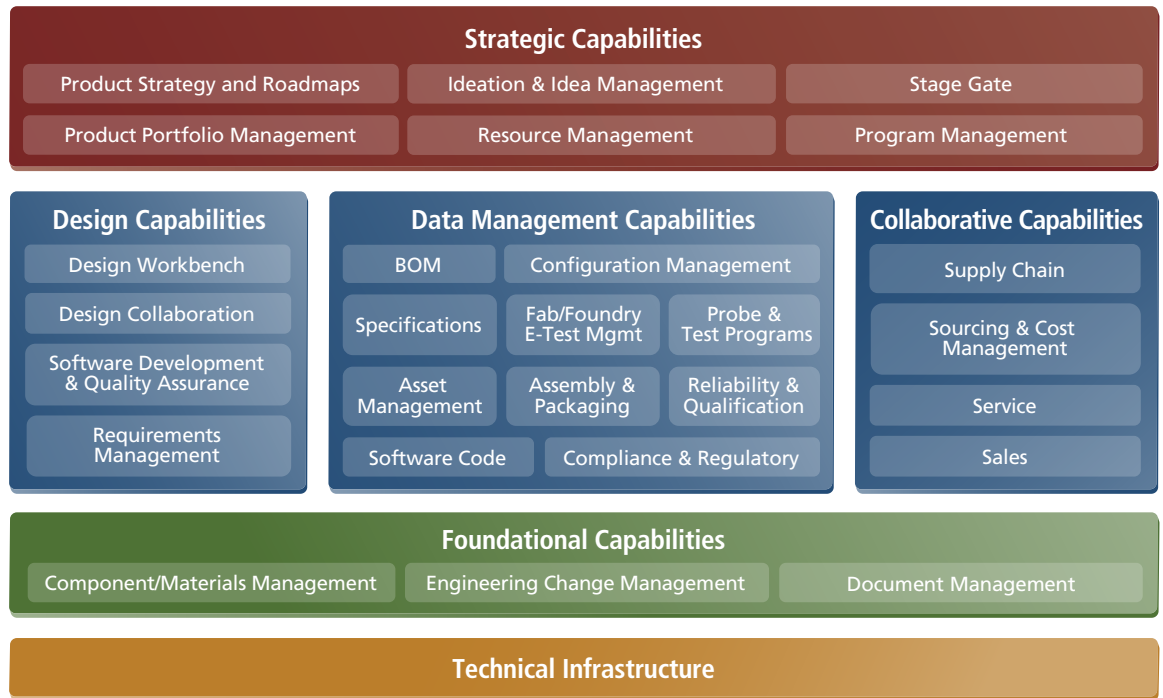
Part of the challenge to greater industry adoption of PLM to date has been the lack of a standard packaged software offering for semiconductor. While it is difficult to claim that a single, standard model is available, PLM software suppliers have made great strides in recent months with solutions targeted to specifically address the challenges faced by companies in the semiconductor value chain.

The components of a comprehensive offering include the functionality and technical infrastructure to support strategic, design, data management, software development, and supply chain processes. The components of a comprehensive PLM solution for semiconductor are shown in more detail in Figure 4 on the next page.

Strategic Capabilities enable program management for product development processes and launch programs, as well as product portfolio management. More advanced solutions enable product and technology roadmapping, and support for idea management and ideation processes.

Design Capabilities of a PLM solution start with basic customer needs definition and extend to the decomposition of specific product requirements.

Figure 4: Components of a Comprehensive PLM Solution for Semiconductor



The design capabilities will allow a user to link customer requirements in the system to features and design teams, providing a record of the linkages and changes throughout the development process. The design collaboration enables geographically dispersed, cross-functional teams to work together in digital form across EDA/CAD platforms. IP management enables both re-use and protection of purchased and invented technology.

Leveraging PLM capabilities to manage IP also enables a design manager or engineer to quickly gain access to existing IP that may be re-used in a design. While this reusable IP may originate from various cross-functional organizations or groups, PLM facilitates access to the correct version of IP and builds the relationships and linkages to enable the reusable IP owners to support the design. This can drastically reduce time to market and design timelines as well as improve the quality of the IP/design.

Data Management Capabilities are often seen as the foundation for an effective PLM system. This functionality can be used to logically link all information related to a product and manage change to that information over time. This provides a single version of the truth across the global value chain of customers, employees, partners, and suppliers. It includes requirements, technical specifications, design definitions, production schedules, test reports, sourcing plans, and quality inspections that are tied to critical processes and tasks.

In reference to the **Software Capabilities**, source code management is an integral, but often omitted, component of a comprehensive PLM solution.

Many companies find that integrating bug tracking and issue management in their PLM solution offers them a much more powerful way to resolve design issues identified during testing or in production.

Additionally, software is becoming a significant factor in a solution for most semiconductor companies. PLM is a vehicle for bridging the two disciplines of IC and software, which is critical given the financial impact of not having commonality, intersection points and gates/constraints of how to control changes or requirements in the IC part of the design that impacts the software, and vice versa. Today, many of the IC bugs or issues can be corrected via the software stack.

“Our success rate to first silicon is 0%.”

Process Architect, Global Semiconductor Company

Last, integral to the development process and an important part of a comprehensive solution are the **Supply Chain Capabilities**. PLM, particularly as it relates to the semiconductor industry, should almost always be considered a multi-enterprise system. Outsourcing foundry operations and test and assembly functions means that design shops need not only a secure way of collaborating on new product launches, but also an efficient way to communicate timely changes to existing product specifications.

Given the varied facets of each component in a comprehensive PLM solution, these components are almost never implemented all at once. Rather, most companies find that the best approach to a PLM implementation is to define a strategy based on a commercially available platform, and create a roadmap that integrates additional new capabilities over time.

Slow PLM Adoption In Semiconductor

To date, adoption of PLM has been slow in the semiconductor industry. Other discrete industries such as Aerospace & Defense, Automotive, and High-Tech Equipment have embraced PLM solutions at a much faster rate. Why?

One reason for the slow adoption can be attributed to the inherently cross-functional nature of PLM, which can lead to confusion regarding where and how it fits within the organization. Executives were consistent in their comments that “it is not always clear who should ideally champion the PLM effort.” In addition, throughout Kalypso interviews, semiconductor executives indicated that their understanding of PLM decreases when they consider the implications on the supply chain.⁹

⁹ Kalypso Semiconductor Analysis, 2006.

According to Kalypso interviews, barriers to adoption in the semiconductor industry include:¹⁰

- Low awareness of PLM
- Limited understanding of PLM's value proposition and place in the organization
- Sponsorship and internal resources; lack of a strong champion
- PLM process/system improvements that lag dynamic industry shifts
- Lack of a "standard" semiconductor PLM model
- Historical bias towards home-grown, custom solutions
- Low user acceptance of previous enterprise PLM solutions

Additionally, there is a lot of apprehension associated with switching over from an ad hoc, in-house solution to a PLM solution. Some expressed the fear in running the risk of delaying a project because the switch meant there were escapes in bugs or delayed schedules. Others will use PLM from a design packaging gate onwards, but struggle with using it from the inception of design through to manufacturing. Lastly, there are those companies that use PLM for small designs, but get cold feet when it comes to a major design with a complexity and magnitude has never been executed with the system.

In order to create value, PLM requires a sound process, user acceptance, and corporate adoption. This, of course, requires change to business processes and ways of working across functions and design partners. This change does not come easy.

Transforming to PLM: A Strategy Prior to PLM Implementation

To ensure that PLM creates the most value and delivers the most significant return on investment, semiconductor companies must take a strategic approach to PLM and move from a systems installation mindset to a transformational program approach. The leading semiconductor companies that have adopted this "vision-driven" approach to PLM are significantly outperforming those that view the programs more tactically, and are gaining significant top- and bottom-line benefits as a result .

Leading companies employing a strategic PLM program reported seeing increased business benefits in the following areas:

- 100% of best-in-class companies improved hitting their launch dates
- 84% of best-in-class companies experienced an increase in hitting revenue targets
- 89% of best-in-class companies achieved better product cost targets

¹⁰ Ibid.

- 95% of best-in-class companies improved ability to meet development budgets
- 98% of best-in-class companies increased the ability to hit quality targets

“Think big, start small,
move fast and build
incrementally.”

The proof is in these numbers: putting a strategy in place before launching a PLM implementation program is clearly beneficial. When PLM is implemented not just as a technology but as a strategy to guide people, processes, and change, it enables companies to work more effectively, better meet their customers’ needs, and reduce time to market and time to profit.

Being strategic does not mean attempting to “eat the elephant” in one effort or driving PLM as the best new IT tool to be mandated for the enterprise. The most successful companies have defined a transformation vision and are taking an incremental approach to implementing PLM.

Implementing PLM: Start Small, Think Big, Build Incrementally

Developing a strategic PLM program is a multi-step process that is best addressed by starting small, thinking big, and building incrementally. Kalypso recommends a PLM implementation program that includes the following steps:

- Assess and gather PLM requirements from engineering, sourcing, supply chain operations, and program management
- Define an integrated PLM strategy based on strategic imperatives that includes people, process, and technology
- Educate and align the organization on PLM vision
- Develop a PLM business case
- Select a suitable PLM platform solution that supports current and future business requirements
- Scope and plan a PLM program roadmap and implementation approach
- Execute work of implementation plan

An example of a properly scoped and executed PLM implementation program is a leading global semiconductor manufacturer. This company embarked on a major initiative across three business units to replace legacy systems and define and implement a strategy for PLM to improve time to market, engineering productivity, and design data quality.

This manufacturer launched a “start small, think big, and build incrementally” phased implementation approach which delivered pieces of PLM in “bite-sized” chunks to phase in implementation of the solution. This incremental approach also included an overall change management implementation plan involving communications, organizational change management, and training.

During the implementation, the company realized incremental business value, which created a healthy competitive environment with business units vying to be next in line on the implementation schedule. In turn, this created a “pull” for the PLM system, avoiding the change management problems that occur when new initiatives are “pushed” upon traditionally independent business units. This factor, along with the realization of business value, added to the momentum of marching towards their ultimate PLM strategic vision.

Figure 5: Summary of PLM Benefits



Reaping the Benefits of PLM

Companies with a strategic PLM program in place are realizing the anticipated benefits from operational effectiveness that are helping them pull ahead of the pack and deliver better products to the market faster. Today, after taking an incremental yet comprehensive approach to all of the dimensions of PLM, the semiconductor manufacturer highlighted in the previous section is realizing the benefits of a successful implementation, which include:

- Centralizing product data by providing access to a single version of the truth – the Product Data Record (PDR)
- Synchronizing product content information
- Improving data integrity (accuracy and timeliness)
- Enabling cross-functional collaboration
- Decreasing time and cost for data input and maintenance
- Identifying opportunities for product design and technology re-use
- Reducing the amount of data negotiations during the new product introduction phase
- Standardizing product data workflows

With a strategic PLM program in place, companies are seeing time to market and time to profit being condensed by 5 to 30 percent. This means more revenues due to improved market penetration, but also frees up R&D capacity to work on other new product development projects and improve innovation throughput.

Additionally, PLM enables the ability to commercialize and launch products globally and concurrently, instead of sequentially by regions, improving the success rate of new product introductions. With concurrent development activities and global tracking of progress and status, companies can analyze timeliness data, understand causes of delay, and develop mitigation plans.

As seen in Figure 5 on the opposite page, companies with a PLM program realize improvements in financial performance, time reduction, product quality, and business metrics. These improvements include:

Reduction in their product development costs by 10% to 40%

- Increase in the productivity of its design/development engineering teams by 20% to 30%
- Raised reuse of existing knowledge assets (Intellectual Property) by 10% to 35%

Improved methods for support to their development teams

- **Compliance:** traceability across entire lifecycle of a product, ingredient, process or idea (from concept to commercially-available product)
- **IT:** rationalized infrastructure to R&D requirements

Semiconductor Companies Can Improve Processes with PLM

Despite slow adoption, many benefits of PLM are available to semiconductor companies today. Today's PLM solutions can enable semiconductor companies to efficiently manage all of the information about innovative chip designs and development processes, from initial concept through end-of-life.

Providing a single, collaborative record of truth, a PLM solution ties together all product-related data across the global value chain of customers, employees, partners, and suppliers.

As shown in Figure 6 on the following page, an integrated semiconductor PLM solution may include feature requirements, design definitions, hardware and software specifications, cost data, production schedules, customer communications, sourcing plans, and tests and reports.

Integrated PLM ties together product information related to critical processes and tasks through the development lifecycle, and provides visibility into potential problem areas that can be addressed early in the development process.

Key benefits that can be realized with semiconductor PLM include:

- Improved time to market and time to volume
- Reduced costs, including design re-use
- Better chip quality, design, and manufacturability
- More efficient process for managing customer needs and technical requirements
- Better collaboration, control, and communication of product design, development, and engineering change order information across internal and external teams
- Input from multiple parties early in the product development process to enhance designs and prevent rework

Figure 6: PLM Provides a Single Collaborative Record of Truth



Today, these benefits are being realized by the early adopters of PLM. Early adoption will provide a first-mover with a competitive advantage as the value of the PLM system grows with refinements over time. Better execution on product development and lifecycle management processes is the goal.

This will be critically important for semiconductor companies with accelerated cycle times, intense competition, and eroding pricing power. Leaders should focus on improving product development to facilitate better innovation, design, and engineering processes with PLM strategies and solutions.

We suggest developing a long-term PLM strategy and initial roadmap centered on solving a single, high-impact business problem, and using this as the foundation on which to build a comprehensive solution. Semiconductor companies should think big, start small, move fast, and build incrementally.

About This Study

Between January and October 2006, Kalypso examined the product innovation, design, and development processes of more than 25 leading global semiconductor companies. The research sample included semiconductor companies with annual sales ranging from \$100 million to more than \$5 billion.

Since this original study, Kalypso interviewed semiconductor clients and contacts to update these findings to understand their current problems.

Kalypso conducted in-depth interviews focusing on the industry-specific challenges of NPDP. Research focused on the business issues, challenges, opportunities, and barriers to greater adoption of PLM technology in the semiconductor industry.

Profile of Interviewees

Job Title

The research sample included respondents with the following job titles: Senior Management (78%), Director or Manager (20%), and Other (2%).

Job Function

The research sample included respondents from the following functional areas of responsibility: Engineering (52%), Foundry (30%), Design (13%), Packaging (3%), Logistics/Supply Chain (2%).

About Kalypso

Kalypso is a consulting firm serving the world's most innovative companies. The firm helps clients to deliver on the promise of innovation. Service offerings encompass all aspects of innovation including product strategy, development, introduction, commercialization, lifecycle management, and PLM systems selection and implementation. In addition to the firm's deep industry, technology, operational, and training expertise, Kalypso provides a flexible, collaborative approach to deliver unparalleled client satisfaction.

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