AMR Research

AUGUST 2003

AMR Research Report

Improving Innovation and Cash Flow in High-Tech Manufacturing

by AMR Research Staff

The pace of change in fundamental technologies from microelectronics to networking and software demands an increasingly integrated and powerful product development and lifecycle management process. Most large high-tech manufacturers see a tight connection between their ability to innovate and their competitiveness. Efforts to improve innovation must overhaul information systems that have grown up as highly fragmented, complex collections of tools and data. In order to do this, many may discover a path to transformed product innovation infrastructure with lower systems costs and better cash flow. The challenge is to adopt a new approach to buying and managing innovation infrastructure.

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The Bottom Line: Cost-neutral transformation of product development and lifecycle management is possible for many high-tech manufacturers, but new thinking about how to procure, implement, and manage the systems is needed, starting with a shift away from buying multiple packaged applications and instead looking at the environment holistically for immediate infrastructure savings, near-term operating improvement, and long-term strategic impact.

The innovation challenge

The pace and complexity of product innovation is increasing, as are as the costs of innovation infrastructure. However, the R&D effectiveness is decreasing. How will high-tech companies meet this challenge without adding new cost burdens?

At the Stanford Supply Chain Forum in 2002, Motorola delivered a presentation about its strategic plan for overhauling the supply chain in response to competitive pressures—most notably, from Nokia in the cell phone business. Despite a huge intellectual property portfolio (1,196 patents issued in 2000) and a historically strong competitive position, Motorola had been ground down to 17% market share and was in "recapture mode," trying to get back into the game.

The plan for rebuilding market share in Personal Communications Services (PCS) was based on the following five points:

- Cost
- Compelling products and signature experience
- Applications and solutions
- Technology and innovation
- Operator partnering

Winning on all five of these fronts demands a lot more than supply chain reengineering. It depends on getting product design and engineering decisions right from the beginning. It also includes merging fuzzy feedback from consumers with systems engineering across embedded software, mechanical design, component selection, and manufacturing process planning. The innovation challenge in this case, as in so many others in the High-Tech industry, boils down to doing more complex product development, faster, with the same or fewer resources.

The conspiracy of several fundamental forces has pushed product innovation to the top of the agenda in terms of strategic competition in High-Tech. Moore's Law means that all products depending on microprocessors must renew themselves completely every few months. The globalization of manufacturing means that companies must build leadership in their unique core competencies—chip design, fabrication, software, assembly, sales, service—while relying on outsiders for the rest. Network effects of the Internet reward products that can handle standards and penalize those relying on proprietary technologies for system performance. New product development—especially for Fortune 100-class high-tech companies—must address these issues.

The National Electronics Manufacturing Initiative (NEMI), a non-profit industry association comprising component makers, systems OEMs and Electronic Manufacturing Service (EMS) businesses has published a roadmap for its members concerned with managing product lifecycle information. They characterize the business environment in High-Tech around a number of key challenges that define the innovation challenge (see Appendix B for the full text):

- **Commoditization of electronics—**"The time frame is shrinking in which a company can recoup any advantage from its new Intellectual Property (IP) advantage."
- **Globalization of outsourcing—**"The global outsourcing has continued at a very rapid rate. Asia and most notably China have become key providers of contract work. Eastern Europe is another area where this practice is spreading."
- **Evolution of innovative business models—**"The business climate has spawned the growth of entirely new classes of supply chain partners, such as components supply hubs, and is changing the relationships between component suppliers, distributors, EMS providers, and OEMs."
- **Emergence of the Outsource Design Manufacturer (ODM)—**"ODMs present themselves to OEMs as a turnkey design and manufacturing solution. The ODM owns the product design, development, and manufacturing, but then uses the marketing and distribution channels of its OEM customer."
- **Rapid construction and decommissioning of plants—**"The time required for a company to ramp up a manufacturing facility as well as to decommission a facility is shrinking. The most competitive businesses have achieved a ramp-up time of 12 weeks to bring a new contractor facility up to production."
- **Distributed liability / Vendor-Managed Inventory (VMI)—**"OEMs and EMS providers are increasingly less willing to accept ownership of materials and components until they are actually consumed or delivered."

- **Management of product End of Life (EOL): channel redirection, product obsolescence—**"Commensurate with shrinking IP advantage time frames and shorter product lifecycles come accelerated product obsolescence. Companies are developing skills in 'channel redirection' to effectively manage their older products."
- **Market standards-based solutions—**"The adoption of and promotion of standards can now actually be a major competitive factor."
- **Web Services gaining momentum—**"Web Services maturation will foster the growth of additional business process management capabilities and create an avenue for 'womb to tomb' process tracking. By example, Web Services will enable the device and platform independence needed to support design collaboration."

These forces combine with rapid change in the structure of the industry because of acquisitions to place a huge premium on the need to get a handle on innovation processes and, by extension, the innovation infrastructure of engineering, R&D, product development, launch, and retirement.

The value of transforming innovation infrastructure

If 80% of supply chain costs are determined in the conceptual phase of product definition, then better execution here should have a huge business impact. This widely cited principle makes sense for anyone with an understanding of engineering, manufacturing, and the supply chain. Unfortunately, the transformation needed to achieve these financial gains is a multiyear exercise, spanning many functional groups as well as separate budgets. If companies could wave a magic wand and realize suddenly the full effects of such a transformation, AMR Research believes that the incremental contribution to bottom-line cash flow would run well into the hundreds of millions.

Tables 1 to 3 break out where, in terms of cost savings, revenue enhancement potential, and capital efficiency, and high-tech manufacturers stand to benefit from overhauling the innovation infrastructure. Some of these benefits are relatively near-term and straightforward, while others (often the larger, more strategic impacts) demand much more of a leap of faith to accept as part of a business case.

Table 1: Cost savings potential

Operating Expense Reductions	Savings Potential	Timing	As-Is Cost (per $1M Revenue)	Fully Realized Potential Per $1M of Revenue*
Engineering Labor	Engineering labor hours are estimated to be as little as 30% efficient. By reducing meeting, travel, document search, error correction, and other non-value-added time sinks, engineering efficiency will double to 60%.	2004	$60K	$30K
Engineering IT Support Costs	Dedicated IT attached to engineering functions could be reduced with better integration and fewer total systems to support; better application management.	2003	$6K	$1K
Document Handling Costs (printing, shipping)	By sharing electronic documents via compression and electronic distribution or Web-hosted checkin and checkout printing, packaging and shipping could be reduced by more than half.	2003	$0.5K	$0.2K
Returns and Warranty Expenses	Outsourced tasks should be focused on low value and critical, but not core, tasks where local expertise is not providing competitive advantage. A balance of onsite and offsite resources helps core tools support remains local.	2005	$20K	$5K
Tooling Expenses	Increased design reuse will reduce tooling costs by using more existing parts and reducing EMS setup errata.	2004	$20K	$5K
Assembly Labor Expenses	Better design for manufacturability through integration of CAD, BOM, and CAPE systems will reduce labor hours in manufacturing (mostly EMS).	2005	$100K	$5K
Scrap and Rework	Better links between engineering and manufacturing reduces bad lot production by improving communication of engineering change.	2005	$20K	$3K
Excess and Obsolete Inventory	Better part specification and more accurate component data in coordination with suppliers, plus faster design to manufacturing cycle times reduce E&O. Best-in-class E&O is Dell at 0.005% of revenue.	2005	$25K	$5K
Purchased Standard Parts Expenses	Increased design reuse, platform reuse, and part count reduction will allow lower cost sourcing by reducing variability of demand to suppliers, purchasing leverage, and purchasing process costs.	2004	$500K	$20K
Prototyping Costs	Increased use of virtual prototypes will reduce physical prototype expenses by more than half.	2004	$25K	$5K
Documentation Expenses	Better access to electronic product data will reduce costs of document creation for work instructions, marketing literature, and regulatory compliance.	2003	$3K	$2K
Total			**$779,500**	**$81,200**

Source: AMR Research, 2003

* Assume 2010 end of horizon

Table 2: Revenue enhancement potential

Operating Expense Reductions	Savings Potential	Timing	As-Is Cost	Fully Realized Potential Per $1M of Revenue
Shorten Time to Volume, Capture Price Premiums	Faster resolution of engineering changes required during early production ramp-up; earlier identification of potential component shortages; quicker to full yield production runs allows OEMs to fully meet demand (less or no backlog) while prices are higher.	2005		$50K
Shorten Time to Market, Capture Standards	Better engineering coordination across mechanical, electronic, and software engineering allows time to initial general release to be reduced. For most high-tech manufacturers, this can mean defining standards and capturing lasting pricing power.	2006		$50K
Service/Software Post-Sale Revenue	Installed equipment has an increasingly large post-sale service opportunity, largely captured as software maintenance fees but also as field service and spare parts sales. Maintenance of comprehensive unit-level product information enables this business.	2008		$40K
Total New Operating Margin Per Unit				**$220,700**

Source: AMR Research, 2003

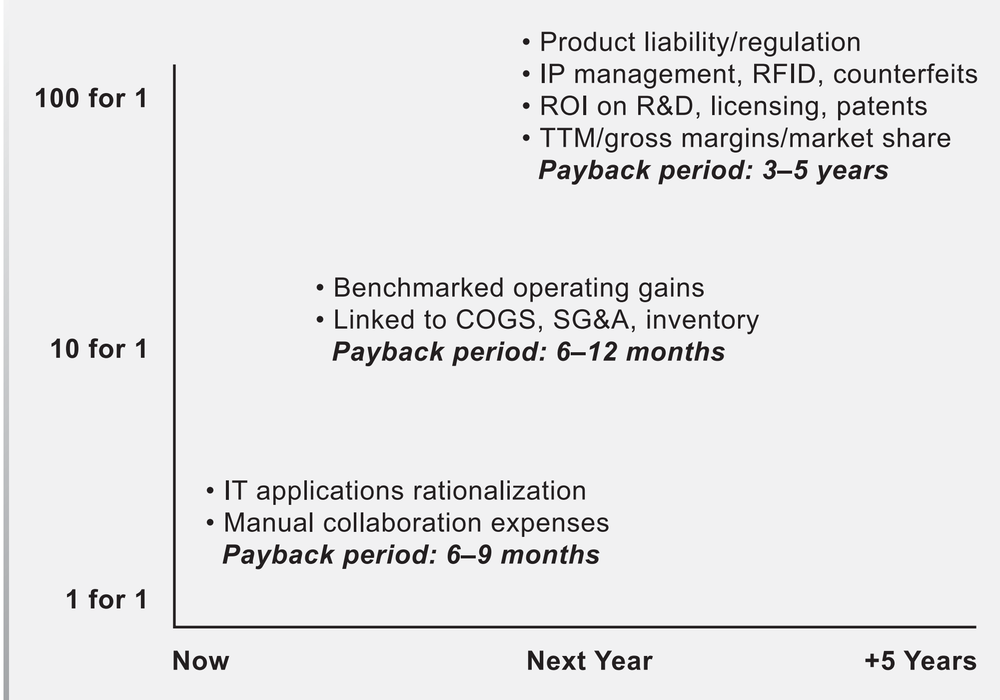
Table 3: Capital efficiency improvement potential

Capital Efficiency Improvements	Savings Potential	Timing	As-Is Cost	Fully Realized Potential Per $1M of Revenue
Inventory	Design for postponement made possible with better design linkages to cost estimation and maximum part, tool, and software reuse could reduce total material inventory levels by 20%.	2005		$2,000
ROA on Intangibles	By quickly merging product platforms and technology, intangibles on the balance sheet can generate strategic benefit as new revenue or better margins—assume 20% better performance.	2005		$2,000
Finished Goods Inventory	By extending product platform reuse, postponement strategies will allow higher rates of manufacture-to-order, which will reduce finished unit inventories.	2005		$50
Total New Capital Margin per Unit				**$4,050**

Source: AMR Research, 2003

The challenge from a transformation standpoint is to make a concerted effort to identify and capture these benefits wherever possible through the use of better tools and processes in the innovation infrastructure without relying on the big bang multiyear systems implementation approach.

Figure 1: PLM payback schedule—three levels of impact



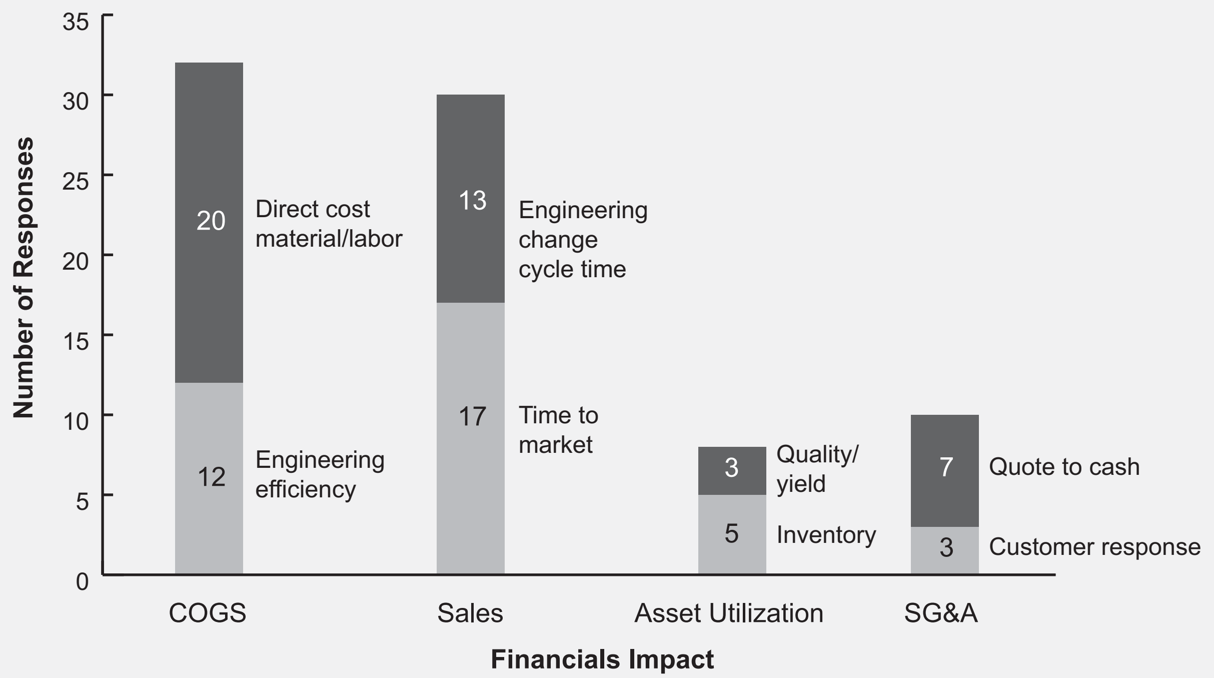
Source: AMR Research, 2003

AMR Research has conducted field research across 120 companies in various industries, targeting the innovation challenge to find the payback is best understood and managed according to the following framework (see Figure 1):

- **Infrastructure savings—**This accrues immediately after go-live. Most users' as-is Product Lifecycle Management (PLM) environment spans many, often dozens of, separate systems. Much of the interaction between these systems is manual, with redundant data entry and hard copy via courier very common forms of integration. Coupling this with a general freeze in new IT spending leaves PLM with a simple first gate—any new spending should replace existing spending, delivering lower Total Cost of Ownership (TCO) for PLM infrastructure within six to nine months.
- **Improvement in established operating metrics—**This accrues 6 to 12 months after go-live. Our research finds a number of widely used and generally well-benchmarked operating metrics applied to PLM initiatives (see Figure 2). Any organization intent on performance improvement in areas associated with product development, launch, and retirement should be able to identify several such metrics and tie PLM projects and owners explicitly to them.

- **Strategic competitiveness impacts**—This accrues three to five years after go-live. PLM's impact on a company's strategic position can be very compelling. 10% of PLM initiatives we reviewed were begun with little or no formal financial ROI analysis, relying strictly on the strength of strategic arguments. While this has worked to get some moving, long-term projects have a tendency to lose their way (and momentum) unless some benchmarks can be pointed to along the way as indicators of improvement.

Figure 2: High-tech operating metrics targeted in PLM business cases



Source: AMR Research, 2003

The first level of payback—infrastructure savings—includes examples of both IT infrastructure and engineering services, or administrative infrastructure (see Table 4). The credibility of any effort to transform the innovation infrastructure should be strengthened significantly by successfully identifying and delivering on hard savings such as these. While the ROI is likely to be small—one dollar of spend on new technology should save a dollar of existing spending—its self-funding nature opens the door to pursue more meaningful operating improvements.

Table 4: Infrastructure savings

Type of Cost	Infrastructure Impact	Business	Application
IT Infrastructure Costs	Reduced total number of systems required for product data: "Significant reduction in TCO for PLM."	Semiconductors	MatrixOne
	Saved $1.1M in first 6 months with system decommissioning and document handling savings.	Semiconductor Equipment	Eigner
	Eliminated many legacy systems.	Testing Instrumentation	MatrixOne
	Outsourced tasks should be focused on low-value and critical, but not core, tasks where local expertise is not providing competitive advantage. A balance of onsite and offsite resources helps core tools support remains local.	Telephone Equipment	MatrixOne
	Eliminated manual parts database maintenance expense.	Computers Servers	i2 Technologies SRM
Other Infrastructure Costs	Saved $30K in first three months with document printing and shipping.	Electronic Manufacturing Services	Alventive for Design Collaboration
	Direct savings in print room expenses.	Electromechanical Machinery	Eigner
	90% improvement in cost and time of document delivery.	Semiconductors	PTC Windchill
	Eliminated 4 of 7 ECO coordinator positions at $70K each annually.	Electronics	Agile
	Eliminated card catalog and administrative costs to maintain.	Storage Devices	Agile
	Affected print room, courier, and network charges.	Electrical Gear	Centric Innovation Center

Source: AMR Research, 2003

The next level of payback involves going after improvements to operations that are one of the following:

- **Internal**—Improve internal engineering, design, and development processes
- **Supplier-facing**—Reduce direct materials or other operations expenses
- **Customer-facing**—Increase speed and effectiveness of customer interaction

These operating improvements can be readily traced back to financial statements, and although not all are equally “hard” in terms of immediate cash impact, the business value can at least be compared on a standard scale—namely, the income statement or balance sheet.

Examples here include well-benchmarked process improvements that should be the outcome of any well-conceived initiative to promote business improvement. The common thread is that each can be clearly identified in terms of before and after performance, with some linkage to business profitability.

These characteristics allow large-scale transformations to be broken down into discrete projects, with clear accountability. Project management is thus easier, and investment can be tracked more closely to results. Roughly speaking, such business impacts should deliver a 10 to 1 payback on project investment.

Table 5: Case examples of internal, supplier-facing, and customer-facing impact of PLM—High-Tech

Internal	**Business**	**PLM Application**
ECO cycle time reduced by 50%; ECO administration expense reduced by 60%	Personal Computers	Agile
Cut box assembly time from 3 hours to 2 hours, 15 minutes; ECO cycle time improved 40%	Storage	PTC Windchill
TTM reduced by 5%; design errors and development costs reduced by 5%	Semiconductors	MatrixOne
90% faster FDA document generation cycle time	Medical Devices	Agile
Overall engineering administrative activity improved 80% (ECO, search, vault, etc.)	Storage	Agile
Supplier-Facing	**Business**	**PLM Application**
Reuse improved from less than 2% to 59%; total savings of approximately $500M over 3 years on direct materials	Personal Computers	CATIA, i2/Aspect, Cadence, Homegrown PDM
By allowing suppliers access to CAD files, lead time in developing tooling reduced by 80%	Semiconductor Equipment	Eigner
Material cost reductions approximately 2% to 3%	Electronic Manufacturing Services	Agile
Customer-Facing	**Business**	**PLM Application**
Order-to-manufacture cycle time reduced from 4 weeks to 1 day; errors essentially eliminated	Wireless Transmission	Agile
Order errors reduced by 50%	Elevators	SAP PLM
RFQ response time reduced from 2 weeks to 24 hours	Electronic Manufacturing Services	Agile
Order volume increased 40%; order errors decreased 75%	Semiconductors	PTC Windchill
Almost 100% of customer order errors eliminated; cut down purchasing order cycle time by 30 minutes per transaction; 100% elimination of sending out-of-date product records to customers	Electromechanical Machinery	Eigner
Customer RFQ cycle time reduced 75%	Electronic Manufacturing Services	Alventive for Design Collaboration

Source: AMR Research, 2003

For payback at the highest level—strategic competitiveness impacts—few users are evolved enough to provide meaningful examples. One way of considering the value is by reference back to the Motorola strategy discussed above. It is fair to say that given an ideal transformation of its overall capacity for product innovation, Motorola will be in a position to compete effectively in the cell phone market as it expands into new geographies like China and Southeast Asia. Without such a transformation, critical things like time-to-market, software/hardware design integration, and overall materials costs would pose serious problems.

One large high-tech manufacturer that has undertaken this transformation is **IBM**. In 1993, IBM lost $8B. The complexity of its innovation infrastructure was extraordinary at the time, with 5,000 separate hardware products all managed in disconnected silos of process and information technology. Lost development expense on products that never made it to market was 25% of the total, and time to market at the high end was 70 months. Part reuse across products was less than 2%. The organization stepped up to a multiyear transformation effort known internally as Integrated Product Development, which aimed to tap the cost and time savings opportunities available early in the design process.

The following results seven years later should be compelling to any business leader:

- Abandoned project expense dropped from 25% to 1%
- Time to market down from the 70-month high to 18 months on average
- Part reuse rising from 2% to 59%
- A 2000 profit of $8.4B for IBM

The cost of transforming innovation infrastructure

AMR Research has argued that PLM is not a monolithic application and that parts can be purchased at reasonable prices. This is true, but the critical consideration is whether such point applications are layered on top of an already overly complex systems infrastructure or instead part of a strategic roadmap to improve innovation overall. Table 6 includes price and cost range estimates for several common elements of the innovation infrastructure.

Table 6: PLM investment range

PLM costs	High	Average	Low
Core PDM, per user seat license* (net)	$6K	$3K	$0.5K
Implementation costs (multiple of SW)	2X	1X	0.5X
Maintenance costs (per year, percentage of license)	22%	18%	12%
Additional costs	**High**	**Average**	**Low**
Database licenses	$200K	$125K	$50K
Internal allocations (multiple of SW)	3X	2X	1X
Specialty Applications (per deal)	**High**	**Average**	**Low**
Product portfolio management	$1,500K	$500K	$50K
Implementation costs (multiple of SW)	2X	1X	0.5X
Component supplier management	$2,000K	$500K	$100K
Implementation costs (multiple of SW)	4X	3X	0.5X
Configurators	$3,000K	$600K	$120K
Implementation costs (multiple of SW)	4X	2X	1X

*Deployments may be supplier-facing, customer-facing, or internally oriented.

Source: AMR Research, 2003

A word of warning about pilots or point application: The Product Data Management (PDM) foundation is a strategic decision, defining what product information means to the organization, all the way from marketing catalogs to Computer Numerical Control (CNC) machine programs. Some mature implementations face their biggest challenges of rationalizing PDM systems that were put in place as independent efforts. The challenge is to avoid proliferating a new generation of applications and databases, which create future integration burdens. For additional information about PDM foundations, see the *AMR Research Report* "I've Got PDM: Now What?," January 2003.

For almost all high-tech manufacturers, the starting point for transforming innovation infrastructure is not a clean slate. Dozens of systems and millions of dollars of existing spending are in place today. For most large companies ($1B+), especially where acquisitions are major part of recent company history, the number of separate systems supporting innovation from R&D through engineering is often difficult to even definitively nail down. AMR Research estimates that, on average, high-tech manufacturers have between five and eight major PLM systems per billion dollars in revenue. Examples of companies with 100 or more separate (and usually disconnected) systems are not uncommon. More than half of these systems are typically custom-built, homegrown legacy systems.

Given this existing infrastructure complexity, the key to successful transformation for larger high-tech manufacturers is a roadmap that aims for application rationalization and overall simplification. Point applications, which if installed in a small company ($100M) to replace e-mail or file drawers, may in larger organizations add to total cost of ownership by introducing integration burdens and maintenance expense while also increasing risks of system failure. Larger organizations can keep the cost of transformation down and drive toward lower ongoing expenses by looking at innovation infrastructure as an opportunity to remove complexity, and with it, cost and risk.

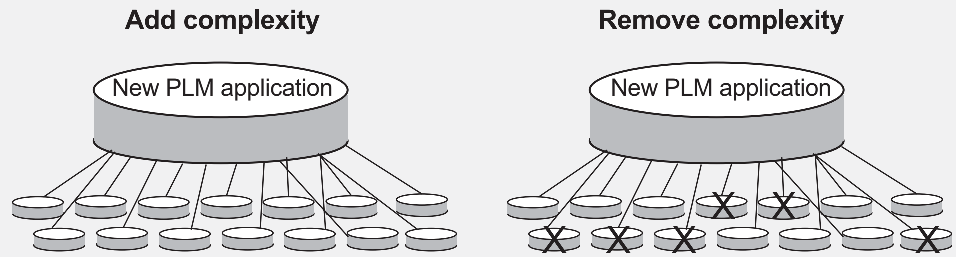
Table 7: Complex disparate infrastructures are currently supporting the innovation process

Legacy Product Development Systems Across Industries	Automotive	A&D	High-Tech
Contract Management		◆	
Earned Value Management		◆	
Program Management	◆	◆	
Portfolio Management			◆
Project	◆	◆	◆
Parts Database	◆	◆	◆
Military Specifications		◆	
Material Specification	◆	◆	◆
Configuration Management	◆	◆	
Requirements Management	◆	◆	◆
Drawing File Server	◆	◆	◆
Bill of Materials (BOM)	◆	◆	◆
Mechanical Computer Aided Design (MCAD)	◆	◆	◆
Electrical CAD (ECAD)	◆	◆	◆
Computer-Aided Engineering (CAE)	◆	◆	◆
Government Procurement		◆	
Spreadsheets	◆	◆	◆
Adobe Documents	◆	◆	◆
Software Development	◆	◆	◆
Typical number of disparate systems in a $1B company	**10 to 15**	**20 to 30**	**5 to 8**

Source: AMR Research, 2003

Common Issues:
Custom homegrown supported by internal IT specialists
Stand-alone applications requiring point-to-point integration
Manual transfer of data between systems
Minimal Internet access
Limited ability for electronic collaboration with external partners

Figure 3: Reducing complexity in innovation infrastructure



	Add complexity	Remove complexity
Project costs	• Software license • N point-point integrations • Process, data definition • Training	• Software license • N-X point-point integrations • X data conversion/transfer • Process, data definition • Training
Comp cost index	**100**	**90**
Ongoing costs	• New app maintenance • N existing apps maintenance • N point-point integration maintenance • HW/infrastructure	• New app maintenance • N-X existing apps maintenance • N-X point-point integration maintenance • Reduced HW/infrastructure
Comp cost index	**100**	**80**

Source: AMR Research, 2003

What is your cost containment strategy for innovation infrastructure over the next five years?

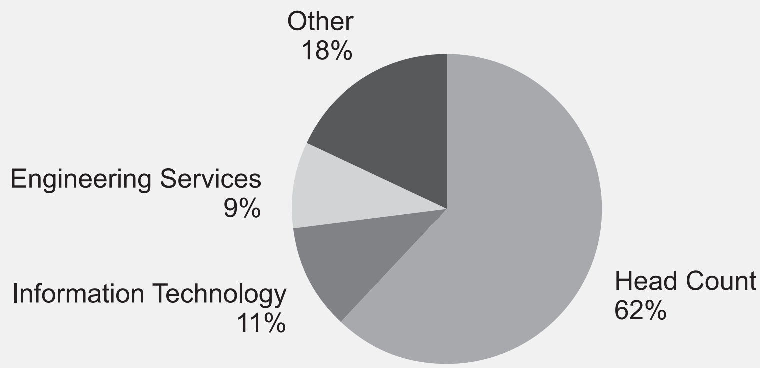
If IT budgets can't grow much more and R&D spending is expected to be more efficient, then some sort of cost containment strategy is needed. Several issues unique to the innovation infrastructure demand special attention when coming up with a strong cost containment approach to enable transformation.

- **Higher degree of system complexity**—The drivers of system complexity include the fact that engineering, R&D, and product design are technically sophisticated user groups that are often willing and able to buy their own tools, independent of corporate IT. The resulting proliferation of Computer-Aided Design (CAD) tools, parts databases, and engineering process controls makes for massive heterogeneity in application programming languages, databases, hardware, and networking protocols. This makes integration difficult and system upkeep expensive.

- **More expensive downtime**—The high cost of engineering and other product development human resources implies a greater burden on the organization when systems go down. The ratio of support personnel to users in engineering environments is often as high as 1 to 10. Making matters worse is the interdependency of tasks in a typical product development environment. Problems in any phase of engineering may become huge overall program slippages as successor tasks wait and delays accumulate.
- **Wider partnering adds to communication costs**—As discussed in the NEMI roadmap (see Appendix B), increasing outsourcing of manufacturing and design stands to increase infrastructure costs as new partners are added and more product information is exchanged.

To get more out of overall corporate investment in product innovation tools, people and processes supporting R&D, engineering, and product development should be looked at together. AMR Research estimates that total innovation spending in the High-Tech industry breaks down as shown in Figure 4.

Figure 4: Allocation of the project development budget—High-Tech



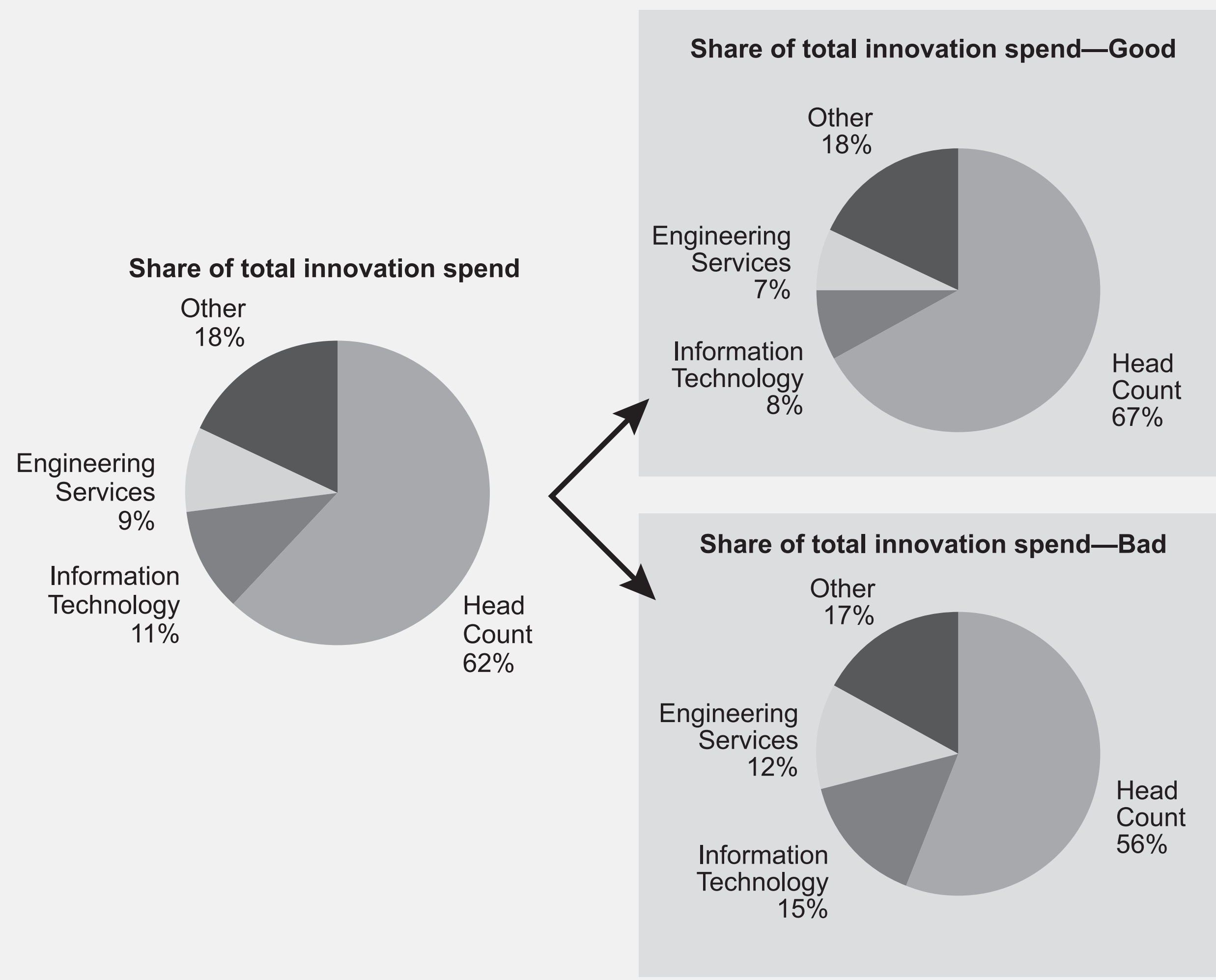
Source: AMR Research, 2003

For every dollar spent on product innovation, only 62 cents goes to the highly trained (and paid) designers that come up with new chips, boxes, software, and other high-tech product innovations. This 62% also does not take account of true engineering effectiveness, which is often estimated to be a slow as 30%, with the balance of most engineers' time being spent on administrative tasks or searching for information. In fact, one of the most common measures cited in business cases for deploying new PLM applications is engineering efficiency.

Fully 20% is spent on tools that support these people—either their IT tools or the supporting administrative personnel who hold jobs like engineering change coordinator or document room administrator. Given the level of complexity in this infrastructure today and considering the pace of increasing interaction demands introduced by additional partners, plus more software/hardware interfaces in end use products, the challenge is to spend more on brainpower and less on enablers.

Returning to the Motorola example cited above, cost containment is about how a huge IP portfolio and tremendous collective brainpower can be channeled directly toward the competitive goal. Large high-tech manufacturers need to ask how they will manage the innovation infrastructure to avoid adding costs in IT and engineering services, which might be better directed at true R&D. The opportunity may be to move toward a better balance of innovation spending rather than getting mired in increasingly expensive support functions.

Figure 5: Increase spending on brains rather than support



Source: AMR Research, 2003

Cost-neutral ways are needed for creating an innovative product development infrastructure

In a recent survey by AMR Research of more than 100 manufacturing companies, 65% reported that their product development IT budgets will be flat or increase slightly, and only 12% reported that their budgets will increase by more than 5%. Within Automotive, only 6% reported that their budgets would increase by more than 5%. With this level of budget growth, users interested in transforming their product development organizations in order to maintain competitive advantage will have to find creative ways to be cost-neutral.

Because of budget constraints, users are not able to spend huge budget increases on hiring new IT employees to effect a product development transformation. Rather, they must find projects that allow them to cut operational costs while investing in process and technology improvements. However, finding resources with the necessary skills while maintaining the status quo is difficult, if not impossible, for most users. For many companies, effectively leveraging the efficiencies of scale and skill and the cost advantages of offshore resources that can be delivered by outsourced services providers is an efficient way to overcome their staffing hurdle.

Developing internal support for using outsourced services while transforming product development IT requires the following:

- **Defining core processes that should not be outsourced and non-core processes that can be outsourced**—Not everything done in product development is a core process, and successful companies can identify potential areas for cost savings based on a realistic assessment of their competitive advantages.
- **Developing a realistic financial analysis of the costs and benefits involved**—The cost analysis must include not only implementation costs, but also the ongoing maintenance and operations costs. AMR Research finds that most people ignore the ongoing maintenance and operational costs in their analysis, grossly underestimating their actual costs. The benefit analysis must capture the potential cost savings for IT and product development that results from the transformation.
- **Addressing user attitudes about the risks associated with changing product development tools and the way that IT supports product developments**—Issues that must be addressed include the perceived risks, such as loss of control, reduced service levels, and increased costs resulting from using outsourced resources.

Develop the business case for outsourcing existing, non-core pieces of product development IT support

When surveyed by AMR Research, most users responded that they needed to see at least a 30% cost savings from an outsourcer to compensate for the perceived risk of outsourcing a core competency. Since most users within product development organizations are skeptical that a large IT outsourcing arrangement can deliver 30% savings, many quickly dismiss outsourcing IT support for product development. However, we believe that by selectively outsourcing—rather than outsourcing everything—a business case can be constructed that leads to a positive return.

Rather than attempting to outsource all of IT for product development, selective outsourcing can be shown to provide specific skills that are preventing new strategic projects from being started. For example, targeted elements of the product development environment that have been successfully outsourced include the following:

- **Data conversion—**The outsourcer redraws files from one format to another using offshore labor.
- **PDM help desk support—**The outsourcer provides help desk support for stable PDM applications.
- **Hardware preparation and setup—**The outsourcer manages the complexity of multiple suppliers and delivers a standardized configured platform to the user.
- **Legacy PDM application management—**The outsourcer maintains custom code for the few remaining groups required to use it.

In all four examples, the IT groups doing this outsourcing saved money because of better efficiencies provided by the outsourcing partner and, in the case of the data conversion example, because of lower cost offshore resources.

Essential to pursuing this strategy is the ability to segment product development activities into multiple categories:

- Core processes that are critical to the company's product development and provide competitive advantage—Examples may include software engineering (many of the users that we investigated are quickly increasing the portion of R&D dedicated to software), form factor design, or specialty technologies like optics or precision measurement.
- Critical processes for product development that provide no competitive advantage—An example of this may be managing the Engineering Change Order (ECO) process or ensuring proper process data collection for regulatory compliance. Such processes in High-Tech are especially vital as short product lifecycles allow OEMs to redesign their supply chains frequently with new EMS partnering arrangements or third-party integrated circuit designs that alter overall production requirements.
- Commodity processes that provide little value, such as managing access to a repository of legacy engineering drawings

Focus on outsourcing support for the critical and commodity processes. For critical but non-core processes, partners able to provide physical support like manufacturing or board design must also be assessed in terms of their ability to manage product information flows smoothly with the OEM. For pure commodity processes, lowest cost and proven expertise are likely to be found together, since scale economies favor outsourcing providers that can offer the lowest bid. Developing relationships with outsourcing partners for such processes allows organizations to refine internal processes that are core, while taking advantage of market-ready skills at lower costs for non-core processes.

Pragmatic approaches to managing costs are available

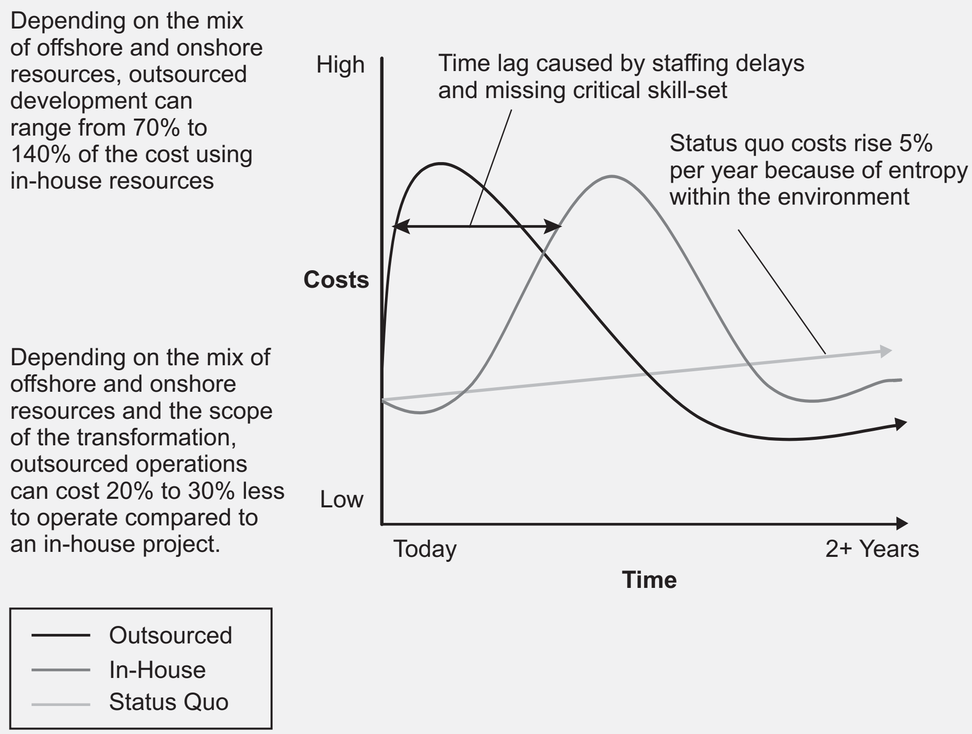
When developing a strategy for transforming IT support for product development, it is necessary to compare in-house costs with potential outsourcing costs. However, simple cost comparisons are not enough. Users must also factor in the risk associated with delayed and poor implementations. Users must also consider the benefits to be achieved by higher quality and better maintained solutions that consolidate and integrate applications (see Table 8). Figure 6 compares the cash flow associated with maintaining the status quo, transforming with in-house resources and with outsourced resources.

Table 8: Cost and benefit considerations for transforming product development IT

Decision Criteria	Factors to Consider
In-house labor costs versus outsourced labor costs	Outsource labor costs are now undergoing a dramatic transformation as companies offer more offshore capabilities. Most large service companies now offer blended service offerings comprising a mix of local and offshore resources. Since offshore resources can be as low as 30% of onsite resources, substantially lower labor costs can be achieved through outsourcing. The skills provided by offshore labor are primarily for development and maintenance of custom code using standard tools (e.g., Java, C++, .Net) and development practices. Offshore labor has significantly fewer skills in project management and packaged application support. The actual labor rate savings provided by a mix of local and offshore resources will depend heavily on the mix project management, custom applications, and packaged applications. AMR Research has seen projects using blended outsourced resources cost in a range of 70% to 130% of estimated costs using in-house resources. However, outsourced projects done without offshore labor can cost 140% as much as similar projects done with in-house labor. For PLM-related projects, offshore savings will be most significant for application development and data conversions and less significant for ongoing application operations and maintenance.
Startup costs and project delays	When doing the transformation with existing in-house resources supplemented with permanent new hires, users must factor in the cost of project delays caused by delays in freeing up critical resources from current assignments or in hiring critical resources and project delays caused by in-house resources not having the necessary skills to quickly solve critical problems. For example, a user implementation of a new PLM system was about to miss its go-live date because the in-house staff no longer had the expertise to complete the integration with a legacy IMS. An outsourcing partner was brought in that could provide IMS expertise within 24 hours.
Operational benefits from well-integrated systems	In a study of the benefits of application integration, AMR Research found that companies with well-integrated application platforms spent 11% less on application maintenance and operations than companies with multiple non-integrated applications. Creating an integrated environment for product development applications involves integration with non-product development-specific applications such as the ERP, procurement, and supply chain planning applications. It is highly unlikely that the IT staff within product development will have the necessary expertise; a more efficient way to succeed with an integration strategy is to leverage skills of a services partner.
Operational benefits from consolidated systems	In a study of the benefits of application consolidation, AMR Research found that companies that have consolidated their applications down to a limited number save between 20% and 25% on operations. However, an effective consolidation strategy depends on an effective team with the ability to manage both the technical and organizational challenges necessary to reduce the number of little used customized applications. The most effective examples of consolidation projects used outsourced resources for about 25% of the project teams and focused the resources on the following: • Change management and facilitation for guiding team to best practices • Specialized technical knowledge (new products from vendor) • One-time tasks that could be done offshore (data conversion programs)
Operational benefits from well-maintained systems	Software vendors report that users running properly configured applications and systems running the appropriate latest service packages report significantly fewer defects than users running poorly maintained systems. One vendor reports that 80% of defects found and reported by users are duplicates of known defects that a user would not have experienced had it been running the latest appropriate service packages. Because they have multiple clients running similar applications and technologies, outsourced service providers can leverage maintenance expertise across multiple users—that is, they know the proper service packages and configurations because they install them at multiple sites.

Source: AMR Research, 2003

Figure 6: Cash flow comparisons for product development IT strategies



Source: AMR Research, 2003

When developing a specific plan for transforming your product development organization's technical infrastructure, you need to quantify the following items:

- How many product development applications does your company currently operate, and what is the average number of users per application?
- Who supports the applications, and how many of the support people are hard-to-replace experts?
- What are the maintenance requirements (scheduled and unscheduled) for your product development applications?
- Are the support service levels and problem resolution times for the applications acceptable?
- What is the service-level performance of these systems?
- What is the percentage of custom applications compared to packaged applications, and how stable is the integration between systems?
- What does all of this cost both in terms of hard costs and opportunity costs?

Alternatives exist when selecting an outsourcing partner to assist with the transformation. When you are selecting an outsourcing partner, consider the following:

- **Specific application expertise—**Outsourcing saves you money when the outsourcing partner has access to skills that can enable it to more efficiently perform the outsourced tasks. You should not pay for nonexistent expertise.
- **Integration expertise—**Successful integration is a key component for reducing operating costs and achieving better product design efficiencies.
- **Operations expertise—**Look for specific abilities to manage complex environments with well-structured Service-Level Agreements (SLAs).
- **Global labor delivery process—**You want access to lower cost offshore resources, but you don't want the management burden of directly managing these resources. Look for a provider that can offer a blend of onshore and offshore resources.

User attitudes are a critical barrier for transforming product development IT

When asked about interest in outsourcing aspects of IT support for product development, 70% of high-tech IT and engineering managers expressed no interest in PLM application maintenance or hosting, and 59% expressed no interest in PLM application infrastructure maintenance or hosting. Digging deeper into these attitudes and comparing them to Automotive and A&D manufacturers that generally have more experience with outsourcing the innovation infrastructure, however, reveals some ambivalence.

Table 9: Interest in outsourced services

Outsourcing Type	No Interest in Outsourcing	Somewhat Interested	Very Interested	Already Outsourcing This Activity
PLM application development	67%	19%	11%	4%
PLM application maintenance or hosting	70%	22%	14%	4%
PLM application break/fix support	56%	30%	11%	4%
PLM infrastructure managed services (hardware, app servers, etc.)	59%	22%	11%	7%
PLM infrastructure break/fix support	65%	19%	12%	4%
Other application maintenance or hosting	50%	31%	8%	12%
Other application break/fix support	54%	23%	8%	15%
Help desk	52%	22%	11%	15%
Product design work	69%	15%	4%	12%

Source: AMR Research, 2003

Where high-tech manufacturers do show a combination of interest and relatively low levels of existing outsourcing is in the PLM applications and infrastructure. In PLM application development, PLM application break/fix support, and PLM infrastructure break/fix support, the percentage claiming to be very interested in outsourcing is 11% to 12%, while the same functions are currently outsourced in only 4% of user situations. The implication of these figures coupled with detailed interview findings suggests that high-tech manufacturers do see some value in targeted domain expertise specific to PLM applications, which were primarily challenging to IT and engineering resources internally because of their lack of integration skills. When developing your transformational strategy, look for areas for which a high interest but low outsourcing penetration exists as a starting point.

The relatively high level of response from high-tech manufacturers that claimed no interest in PLM application development outsourcing—67% versus 6% among automotive companies and 46% among A&D companies—appears to reflect the prevailing habit of turning to outsource services providers to fill in narrowly defined skill gaps. One senior engineering IT executive had a typical response: “We look to outsiders for gap filling. The internal IT organization steps up to support any approved projects. It can decide how much to use outsiders.” Users also want to shape the development direction for the packaged applications vendors supplying their software. One noted, “We need some of our skin in the game" with our applications suppliers. Another said, "Outsourcing buffers us from our apps providers." This may seem a benefit when considered in light of application rationalization, but there seems to be meaningful distinction between older or lesser applications from small, nonstrategic vendors and the more critical relationship sought with leading application vendors that can serve as a foundation layer or product information backbone.

When asked what benefits from outsourcing were important, high-tech user responses highlighted integration challenges. Expertise in PLM deployment, cited as extremely important by 37% of respondents, was tied with expertise in application-to-application integration as the most frequently cited extremely important benefit. The contrast with Automotive and A&D illustrates the much higher level of concern in High-Tech with integration: Both Automotive (47%) and A&D (43%) saw more benefit in PLM deployment expertise than in integration (Automotive 35%, A&D 39%). Also, where integration emerges as the most important benefit for High-Tech, it is substantially less important to Automotive and A&D than many other items.

Table 10: Value of outsourcing

Outsourcing Benefit	Not at All Important	Somewhat Important	Extremely Important
Expertise in PLM deployment	30%	33%	37%
Expertise in PLM application upgrades	26%	41%	33%
Expertise in application-to-application integration	22%	48%	30%
Resources for day-to-day operations and application management	26%	48%	26%
Reduce cost of PLM software deployment	19%	48%	33%
Reduce cost of PLM software upgrades	26%	41%	33%
Reduce cost for day-to-day operations and management	33%	30%	37%
Reduce integration cost	26%	52%	22%
Expertise to respond to change requests from the product design group	22%	48%	30%
Resources to react to changes in demand for IT	30%	44%	26%
Expertise in the most current technologies	19%	63%	19%
Ability to leverage relationships with application vendors	26%	59%	15%
Reduce assets on books	52%	50%	19%

Source: AMR Research, 2003

Table 11: Attributes of outsourcing partner

Outsourcing Partner Selection Criteria	Not at All Important	Somewhat Important	Extremely Important
Demonstrated expertise	15%	22%	63%
Price relative to in-house cost of providing the service	15%	26%	59%
Financial stability of outsourcing partner	15%	30%	56%
Price relative to other potential outsourcing partners	11%	44%	44%
Partner's ability to provide training, change management, and project management	22%	52%	26%
Potential partner's relationship with application vendors	22%	44%	33%
Previous relationship with outsourcing partner	15%	52%	33%

Source: AMR Research, 2003

Among the most interesting observations to emerge from the survey data are the relatively weak importance scores attached to cost savings. Detailed interviews, at all levels and across functions in High-Tech, almost automatically start with the comment, as offered by one IT executive, "It's all about cost." The conversation, however, gradually moves toward the idea that certain critical skills are lacking in-house and that outsiders are attractive for their ability to deliver those skills. It is clear that users in High-Tech need to address costs first and foremost, but that they recognize the strategic importance of this technology environment and will, in the end, gravitate to demonstrated skills with PLM applications in the field.

Successful transformation requires the support of executive management, product development staff, and the IT staff. While outsourcing is not appropriate for all user environments, those standing to benefit will need first to answer legitimate questions. Ensuring support depends on developing a transformation plan that realistically addresses their concerns. The reasons that most users give for not wanting to outsource their product development IT support and strategies for addressing these concerns are in Table 12.

Table 12: Common concerns with outsourcing IT support for product development

User Concerns	Strategies for Addressing Concerns
Cost savings do not materialize (users have seen too many outsourcing deals for which promised savings never materialize)	When developing cost / benefit model be sure to include both deployment and ongoing operational costs as well as cost savings achieved with IT operations and savings achieved within product development. Consider outside help for benchmarking current costs.
Outsourcing support for core competencies is a poor strategy (90% of the companies surveyed feel that product development is either a core competency or that they have a capable product development organization and can't risk damaging produce development)	Although product development may be a core competency, not every activity within product development is core to the company. Users need to clearly identify core activities, critical but not core, and low-value activities within product development and focus initial outsourcing efforts on the low-value and critical but not core activities.
Loss of control and response latency (Having to negotiate for extra support rather than telling an employee down the hall to go do it—despite comprehensive SLAs, resolving problems will take too long)	Ensure that SLAs are carefully prepared and define escalation paths and criteria for managing non-standard service requests. Also ensure that outsourced resources are balanced between higher cost on-site resources to address control and latency issues and lower-cost offsite (or offshore) to address cost concerns. Finally, benchmark response times for current in-house procedures to ensure that outsourced service levels equal or exceed.
Loss of expertise (Loose access to tool experts that assisted engineers with design techniques if the tool support was outsourced)	Ensure that outsourced tasks are focused on low value and critical but not core tasks where local expertise is not providing competitive advantage. Also balance onsite and offsite resources so that core tools support remains local.
Encroaching bureaucracy (Managing change via an SLA would result in an overly bureaucratic organization)	Develop a partnership relationship with the outsourcing partner and develop a shared risk and reward structure around business objectives. Nothing cuts through bureaucracy like rewarding someone for exceptional service. Invest in the necessary training to ensure that line management has the necessary relationship management skills to successfully manage an outsourcing relationship.

Source: AMR Research, 2003

Closing Comments

A structured approach to cost-neutral transformation of innovation infrastructure is essential for future growth

With the passing of the late 1990's boom, established high-tech manufacturers have had a chance to slow down and look at the state of their innovation infrastructure. What most see is a highly complex, expensive collection of systems and processes that aren't well integrated. When growth returns, companies that can get to market fast with profitable and compelling products will win market share and create huge shareholder value. Among the largest companies, many see that their product innovation potential will be severely impeded unless they can transform the overall infrastructure that gets it done. Despite this imperative, tight IT budgets will require most to deliver such transformation without adding new capital spending. The answer for some is a cost-neutral transformation that replaces the old with the new and takes advantage of third-party expertise. Users looking to develop a strategy to do this need to consider three essential elements:

- **Strategic goals—**What company-specific, CEO-level mission is driving your competitive position? What is core? What is critical but not competitively core? What is commodity? Use these questions to look for outside resources that can do a better job.
- **Cost containment—**What infrastructure savings are possible based on tapping global scale and low-cost resources? What integration competence is needed to leverage existing systems? What distinctive skills or organizational will are needed to rationalize applications, systems, and people?
- **Risk mitigation—**What mechanical approaches to controlling buyer risk, including SLAs, process benchmarking, and financing terms, are available to avoid funding transformation as a big bang implementation? How can these be incorporated into a project plan that protects ongoing operations of engineering, R&D, and product development?

APPENDICES

Appendix A: Research methodology

The findings in this Report are based on surveys conducted by AMR Research of more than 100 IT and engineering managers from companies within the Aerospace and Defense, Automotive, and High-Tech verticals. Information gathered from the surveys was supplemented with in-depth interviews of more than 50 product development, IT, and financial control managers.

Appendix B: 2002 NEMI Roadmap, Product Lifecycle Information Management (excerpt, pp. 7–12)

III. Situation Analysis

The current business climate reflects an industry quickening its pace of production and innovation. Electronics have assumed more of a commodity nature, globalization of outsourcing has continued at a rapid pace, production sites are constructed and decommissioned in shorter time frames, and OEMs are outsourcing a broader scope of production processes—and in some cases, the entire design and production process.

Information exchange infrastructure has also matured. Standards for data exchange have been developed and are being implemented. RosettaNet's Partner Interface Processes (PIPs) and IPC's Product Data Exchange (PDX) and Computer-Aided Manufacturing using XML (CAMX) are examples of standards that have been developed and adopted by some of the larger OEMs and EMSs over the past two years. These standards are also being rapidly embraced in Asia. The value of IT is more universally understood and is thus better supported within manufacturing operations. Web services are emerging, and new business models continue to evolve. Each of these factors is helping to shape the current business climate.

Commoditization of electronics

Electronics end products transition quickly from a unique, branded, and costly status to a commonly available product that competes on price, availability, and terms. Although companies compete to release unique and innovative offerings, the time frame is shrinking in which a company can recoup any advantage from its new IP advantage. The supply chain is evolving to support the rapid commoditization of IP.

Globalization of outsourcing

Outsourcing is the business practice of one company using another company or companies to design, build, and service (or any combination of these) part of or even a complete product. The advantages of doing business this way are numerous. Outsourcing can lead to quicker inventory turns, higher manufacturing efficiency, reduced time to market, proximity to global markets, and adherence to local content regulations. The resources and expertise of the contracted company can be hired and leveraged by the contracting company at greatly reduced costs.

The global outsourcing has continued at a very rapid rate. Asia and most notably China have become key providers of contract work. Eastern Europe is another area where this practice is spreading, although it is hindered by the lack of infrastructure east of the Ural Mountains. India is a key provider of outsourced services, and is turned to more often for software products than manufacturing because of more developed infrastructure in that area.

Some geographies that had previously experienced a high degree of success in providing outsourcing services have flattened or softened. This is true for North America, Central America, South America, and, to a lesser extent, parts of Asia. Some countries that had provided outsourcing services now seek them for themselves. For example, some companies in Taiwan have resorted to outsourcing their manufacturing to growth areas such as China.

Outsourcing is including a greater breadth of production processes such as warranty and repair, call center activities, reverse logistics, management process of returns, and field replaceable units.

With these advantages come disadvantages. Large companies moving into a region change the economy. Their very presence creates a new and higher economy, eventually making it a less competitive outsourcing geography.

Evolution of innovative business models

The business climate has spawned the growth of entirely new classes of supply chain partners, such as components supply hubs, and is changing the relationships between component suppliers, distributors, EMSs, and OEMs. While EMS profit margins have always been slim for manufacturing services, they have been known to make extremely generous margins on their component purchases. OEMs, which themselves have lost much of the leverage that they once enjoyed with component suppliers, are pressuring EMSs to make their component margins transparent. When successful in doing so, an OEM and EMS negotiate openly on margins, removing much of the business risk for the EMS.

Emergence of the ODM

Referred to at times as Outsource Design Manufacturers and at other times Original Design Manufacturers, ODMs are a relatively new player in the Electronics industry and are primarily located in low-cost geographies. ODMs present themselves to OEMs as a turnkey design and manufacturing solution. The ODM owns the product design, development, and manufacturing, but then uses the marketing and distribution channels of their OEM customer. Large North American OEMs have entered into partnerships with ODMs because it makes business sense in the current domestic economy. By sending the higher cost portions of the design and manufacturing processes to a geographically favored ODM, it allows the domestic company to remain competitive and to survive.

ODMs tend to be young companies without complex internal IT architectures and legacy systems to integrate. They are consequently more nimble as they have fewer business process encumbrances. They enter the market as the outsourced low-cost designer and manufacturer. They offer a menu of configurable items that shed the cost of design and the high-cost infrastructure associated with it. ODMs are also becoming service providers by offering warranty entitlement servicing (call centers). This is yet another slice of the available market's pie and is also made possible because of their lower cost geographic location and associated lower labor costs.

EMS versus ODM: Relative advantages and disadvantages

Traditionally, EMSs have many advantages. They tend to have large-scale manufacturing capabilities with a worldwide footprint, enabling them to drive down the cost of doing business while being close to their customers' end markets. They offer services ranging from prototype to New Product Introduction (NPI) through High-Volume Manufacturing (HVM). Many also offer design, warranty, repair, and EOL services, thus providing a fully managed product lifecycle solution.

EMSs have several disadvantages that hinder them in the current business climate. Prominent EMSs have experienced a large part of their growth through acquisition. This has left EMS firms with multiple sites running multiple systems, some of which are Commercial Off the Shelf (COTS) applications but many of which are homegrown. For them, internal integration is as complicated as supply chain integration. The complexity of their internal IT infrastructure makes adoption of standards by their customers more imperative, but at the same time, adapting their complex web of systems to communicate through a new standard is more burdensome than for their low-cost ODM competitors.

Historically, EMSs first entered the market to provide assembly services with consigned parts. They've had to manage their customer relationships carefully to expand the services that they provide into design, box-build, logistics, and aftermarket support in order to hold onto their business segment. ODMs, on the other hand, began their partnerships with OEMs on completely different terms.

ODMs have many advantages inherent to their structure. They are typically in low-cost geographies, are small (but growing), flexible, and quick to adopt new standards and technologies. ODMs typically brand products under their own name, and while these branded products are not necessarily unique, they are competitive on price, are readily available, and are feature-centric. On the negative side, since ODMs provide full product lifecycle management and own the IP of products they provide, they pose a threat to their customer base that EMSs do not. They also do not currently have the geographic footprint or address the breadth of product types that EMSs are capable of supporting.

Rapid construction and decommissioning of plants

The time required for a company to ramp up a manufacturing facility as well as to decommission a facility is shrinking. The most competitive businesses have achieved a ramp-up time of 12 weeks to bring a new contractor facility up to production. This capability is made possible by relatively affordable production equipment, a large and available labor pool, government incentives, and available infrastructure on the contractor side.

Distributed liability /VMI

OEMs and EMSs are increasingly less willing to accept ownership of materials and components until they are actually consumed or delivered. Tracking of inventory and consumption is more complex as traditional procurement and accounts payable practices are becoming obsolete. The practice of consigning components is rapidly being replaced with point of consumption inventory management. Material hubs are being implemented to support this new model of delayed ownership. Co-location of the VMI hub on the manufacturers' premises demands real-time IT solutions that are replacing older batch mode EDI processes with real-time standards.

Management of product EOL: channel redirection, product obsolescence

Commensurate with shrinking IP advantage time frames and shorter product lifecycles comes accelerated product obsolescence. Obsolescence is defined as: 1) A decrease in the value of an asset brought about by the development of new and more economical methods, processes, or machinery; 2) The loss of usefulness or worth of a product or facility as a result of the appearance of better or more economical products, methods, or facilities.

Companies are developing skills in "channel redirection" to effectively manage their older products. Channel redirection consists of "planning, organizing, monitoring and redirecting obsolescent product to alternate channels or customers in order to maximize its economic value and minimize write-off potential" (George W. Brown, Intel Corporation).

Market standards-based solutions

The adoption of and promotion of standards can now actually be a major competitive factor. The last two years have brought significant progress in the development of much needed standards for information exchange among supply chain partners. NEMI initiated a suite of standards, many of which are now available from IPC as formal standards and have been integrated into vendor products. Among these standards are the PDX suite of standards that provide a well-defined way to exchange Bills of Materials (BOMs), engineering changes, and as-built product genealogy. NEMI and IPC also worked together on the release of the CAMX standards (IPC 2540 series) that enable shop-floor integration.

Since PDX was dual-tracked through both the IPC and RosettaNet, companies are now able to implement the same standard exchange mechanisms in either format. NEMI collaborated with RosettaNet on the release of a collection of manufacturing PIPs, in Clusters 2 and 7, which replicate the PDX data content.

Products implementing the standards listed above are now deployed in a number of production environments and, in some cases, support multiparty design and manufacturing transactions.

Web services gaining momentum

Web services promise to provide the enterprise with code reusability (decreasing the total cost of ownership). While attracting a lot of attention and investment, the technology is still evolving in areas such as security/privacy, messaging/routing, quality-of-service/reliability, transaction processing, and interoperability.

As Web services mature (2005/6) and are supported by robust registries and repositories, enterprises will move away from message exchange infrastructures and toward a "shared vault" paradigm, which incorporates structured and unstructured data, transactions, and information. Although Web services maturity will not obviate existing, it will require yet another paradigm shift. Many in the industry will leverage matured trading exchanges and outsource providers to eliminate the cost and overhead of internal IT resources needed to expose full registries and repositories to value chain partners.

Web services maturation will foster the growth of additional business process management capabilities and create an avenue for "womb to tomb" process tracking. By example, Web services will enable device and platform independence needed to support design collaboration.

NOTES

NOTES

AMR Research is a strategic advisory firm that provides business and technology executives with the critical analysis and practical advice needed to manage resources, mitigate risk, and increase business value. The company's industry-specific research initiatives focus on key trends, issues, and developments in Enterprise Management, Customer Relationship Management, Supply Chain Management, and other strategic business applications and enabling technologies that drive the market. AMR Research, founded in 1986, is headquartered in Boston with an office in Irvine and European headquarters in London. More information is available at www.amrresearch.com.

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AMR-R-16141

Acronym List

Acronym	Definition
BOM	Bill of Materials
CAD	Computer-Aided Design
CAE	Computer-Aided Engineering
CAPE	Computer-Aided Process Engineering
CNC	Computer Numerical Control
COGS	Cost of Goods Sold
COTS	Commercial Off the Shelf
E&O	Excess and Obsolete
ECO	Engineering Change Order
IMS	Inventory Management System
IP	Intellectual Property
IT	Information Technology
EMS	Electronic Manufacturing Service
EOL	End of Life
HVM	High-Volume Manufacturing
NEMI	National Electronics Manufacturing Initiative
NPI	New Product Introduction
ODM	Outsource Design Manufacturer
OEM	Original Equipment Manufacturer
PCS	Personal Communications Services
PDM	Product Data Management
PLM	Product Lifecycle Management
R&D	Research and Development
RFID	Radio Frequency Identification
ROI	Return on Investment
SG&A	Sales, General, and Administrative
SLA	Service-Level Agreement
TCO	Total Cost of Ownership
VMI	Vendor-Managed Inventory
XML	Extensible Markup Language