# Destroying Boundaries:
## Integration and Collaboration in the Automotive Value Chain

**Office for the Study of Automotive Transportation**
Bruce M. Belzowski
Michael S. Flynn
Maitreya Kathleen Sims

**Oracle Corporation**
Paul Hebeler
John P. McGlynn

# Destroying Boundaries:
## Integration and Collaboration in the Automotive Value Chain

**Office for the Study of Automotive Transportation**
Bruce M. Belzowski
Michael S. Flynn
Maitreya Kathleen Sims

ORACLE®
**Oracle Corporation**
Paul Hebeler
John P. McGlynn

**July 2003**

Office for the Study of Automotive Transportation (OSAT)
University of Michigan Transportation Research Institute (UMTRI)

UMTRI 2003-17

## Acknowledgements

- The members of the OSAT and Oracle teams would like to thank the many automotive executives who took the time to participate in our advisory board, interviews, or survey. We are especially grateful for the time and insight they volunteered in support of our efforts.
- We would also like to thank the Original Equipment Suppliers Association (OESA) for its collaboration in this project. In particular, we would like to thank Neil DeKoker, Margaret Baxter, Noelle Schiffer, and Michelle Maki of OESA. Their support throughout the project has been invaluable.
- We would also like to thank the following individuals for their important contributions to our efforts: Richard Senter from Central Michigan University; Jeffrey Davis from Oakland University; Morgan Edwards, retired from Ford Motor Company; M. Lee Burge, Jan Eveswell, Mark Ostroth, Michael Ordonez, and Amy Grude of OSAT; Shekinah Errington and Monica Milla of UMTRI; and John Kelliher, Shobhan Porter, Lloyd Lyons, Tom Demrick, Sujith Abraham, Deborah Lilienthal, Leann Myers, and Rick Sidey from Oracle.

# Table of Contents

Executive Summary . . . . . 5

Introduction . . . . . 8

Research Results

1. Industry Evolution: Significant Disconnects Looming . . . . . 11
2. Integration and Collaboration: A Holistic Approach . . . . . 15
3. Executive Decision-making: Job 1 for Survival . . . . . 22
4. Product Design and Development: New Roles, New Partners . . . . . 28
5. Supply Chain Management: Great Risks, Great Opportunities . . . . . 36

Summary and Recommendations . . . . . 45

Bibliography . . . . . 46

# Executive Summary

Automotive suppliers today face major challenges in supporting their customers including: Organizing their resources to support them on a global basis; delivering innovation, quality, and value with increasing speed; and operating profitably in the face of continuous competitive pressures to reduce costs. Suppliers to survive and prosper must integrate their internal processes (combining or unifying their internal business processes across functions, activities, and units) and effectively collaborate with both their customers and their suppliers (coordinating their business processes with external customers and suppliers).

The University of Michigan's Office for the Study of Automotive Transportation (OAST), and Oracle Corporation, with the cooperation of the Original Equipment Suppliers Association (OESA), collaborated on this important topic to identify:

- the general *value* of these efforts, and their specific value to certain company activities;
- the *progress* different types of suppliers are making in developing these efforts;
- actual *examples of* integration and collaboration efforts in executive decision-making (EDM), product design and development (PDD), and supply chain management (SCM);
- current *barriers and facilitators* to successful implementation of these efforts; and
- a *vision* of the future, more fully integrated and collaborative value chain.

The results of this study are drawn from a set of eight preliminary interviews, followed by a survey of over 100 high-ranking supplier executives, including nine of the Top 10 and 14 of the Top 20 suppliers, with about 60 percent of the supplier executives in the survey vice presidents or above. The study concluded with 12 interviews with executives from major suppliers.

The major findings are categorized into five sections:

## 1. Industry Evolution: Significant Disconnects Looming

Suppliers report that over the next five years there will be a continuing shift in responsibility and power from the OEMs to the supply base, especially system integrators, for major activities such as PDD and SCM, as well as lifecycle and warranty costs.

Suppliers expect major changes in the structure of the supply base over the next five years, accentuating changes that have occurred since the mid-1990s. Fifty percent of the Tier 1 suppliers in our sample report they will remain Tier 1 suppliers, while 30 percent expect to become system integrators and 20 percent expect to become Tier N suppliers. We find important differences between current system integrators and these emerging system integrators (ESIs) as well as between current Tier N suppliers and these enhanced Tier N suppliers (ETNs). ESIs tend to lag current system integrators in a number of Key Performance Indicators (KPIs) as well as in their progress in integration and collaboration. ETNs generally have more of a cost reduction and PDD focus compared to current Tier N suppliers. They also consider their customer collaboration efforts as more of a combination of value added activity and cost reduction rather than purely a value added activity.

## 2. Integration and Collaboration: A Holistic Approach

Our results strongly support the hypothesis that companies must develop and execute internal integration and external collaboration strategies to meet the critical survival challenges they face over the next five years. Suppliers view only cost reduction as being more valuable to their future survival than internal integration and external collaboration among a set of ten efforts.

However, the data on specific efforts show a clear pattern:

- Integration efforts across the activities are well ahead of collaboration with both customers and suppliers.
- Integration is seen as more important to recent specific performance improvements than is either form of collaboration.

We consider the need to distinguish primary and secondary links for various industry activities. Primary links are those that strongly bind adjacent tiers in an activity, while secondary links characterize less intensely involved tiers. Suppliers tend to focus their collaborative efforts on the primary links at the expense of appropriate and competitively beneficial attention to the secondary links.

- In PDD, they report collaboration with customers (the primary link) is further advanced and *more* important than is collaboration with suppliers (the secondary link).
- In SCM, they think their external collaboration with customers (the secondary link) is *less* important than collaboration with suppliers (the primary link).
- In EDM, they report external collaboration with customers (the primary link) is *more* important than is collaboration with suppliers (the secondary link).

Suppliers report barriers and facilitators to integration and collaboration across four different categories: organizational patterns, human resource or personnel practices, business processes, and information technology. Balancing change efforts across all four categories increases the likelihood of implementing change successfully.

## 3. Executive Decision-Making: Job 1 for Survival

Suppliers report they are about half way to their goal in internally integrating their EDM business processes, but only about a quarter of the way in external EDM collaboration with their customers and suppliers. They also tend to believe their internal EDM integration efforts play a more important role in their companies' performance improvement than do their external EDM collaboration efforts. They do report that collaboration with customers plays a more important role than does supplier collaboration.

The industry's information challenges of the past few decades represent three waves or sets of challenges. The first wave was and is simply collecting or acquiring information. The second wave involves organizing the information so that it can be stored and retrieved. The third wave involves the deployment and use of the information.

In terms of Wave One, we see business information acquisition rated the least critical survival challenge. In terms of Wave Two, suppliers in this study generally consider their information to be timely, accurate, analyzable, relevant, and electronically available. However, they report that information is fragmented across the organization. This significantly hampers an executive's ability to make major decisions based on good, current information. Companies spending more on information technology tend to have more accessible and less fragmented information. In terms of Wave Three, supplier executives emphasize traditional financial metrics (such as gross margin and revenue growth) over operational metrics (such as reductions in engineering change notices or RFQ success rate) in evaluating internal program efforts.

## 4. Product Design and Development: New Roles, New Partners

Suppliers estimate they are about halfway to their goals for internally integrating and externally collaborating with their customers in PDD. But external collaboration with suppliers is developing substantially more slowly; suppliers feel they are about one quarter of the way to this goal.

This progress is reflected in suppliers' reporting that internal integration efforts have been "very" important as sources for their improved PDD performance over the past two years, while customer collaboration is "moderately" to "very" important, and supplier collaboration is of just "moderate" importance to PDD improvement. This reinforces our conclusion that suppliers need to consider more activity with the secondary link of supplier collaboration in PDD for future success.

Suppliers "often" electronically communicate drawings, engineering change notices, and quality specifications, while they communicate product data, project plans, and target cost and financial information less frequently—"sometimes" in scale terms.

## 5. Supply Chain Management: Great Risks, Great Opportunities

SCM is currently the least developed internal integration effort by quite a wide margin. Suppliers report they are about one quarter of the way toward achieving their goal. They are also only about a quarter of the way to their external collaboration with customers and suppliers goals. Suppliers recognize this lack of progress and are currently focusing many of their integration and collaboration efforts on SCM.

Suppliers report that internal integration efforts have been "very important" in achieving improvement in their SCM performance over the past two years. They report that collaboration with customers is "moderately important" to their improvement, and that collaboration with suppliers is "very important." Similarly to PDD, these results reinforce our conclusion that suppliers need to tap into the secondary link (in this instance, customer collaboration) in SCM to succeed in the future.

Suppliers all too often fail to implement the lessons they learn as suppliers when acting as customers. Thus they report that their integration and customer collaboration efforts are driven by the need to add value and reduce cost. However, their own external supplier collaboration efforts are driven more by the need to reduce cost. As OEMs' cost and value strategies undercut suppliers' long-term competitiveness, so will similar suppliers' strategies undercut their own suppliers.

Advanced shipping notices and shipping schedules are electronically communicated "very often," forecasts "often," inventory information and part bill of materials (BOM) "sometimes," and process data and supplier capacity constraints "once in a while."

Our survey also suggests that warranty information is one of the least often electronically communicated types of information between suppliers and customers. Warranty responsibility faces other challenges as well. For example, suppliers report the current systems for analyzing the source of parts' failures are inaccurate and unclear. They also express concern about the quality of dealer data and comment that the current system lacks visibility and standard dealer coding.

## Conclusion

This study provides suppliers the opportunity to benchmark their progress in internal integration and external collaboration. As the supplier industry continues to evolve, suppliers' competitive success will depend on their ability to function smoothly and effectively with all parts of the value chain. Integrating processes internally and collaborating with both customers and suppliers in the value chain concurrently is not an easy task, but one that suppliers must confront and master. Managing the increased responsibility for PDD and SCM throughout the supply chain demands that suppliers have these processes in place. Without these processes, supported by effective EDM, suppliers will find their companies gradually replaced by suppliers that can manage the internal and external relationships demanded of today's—and tomorrow's—automotive value chain.

# Introduction

To survive and prosper in the coming decade, all automotive suppliers—particularly system integrators and large Tier 1 suppliers—must overcome several major challenges.[1] They must:

- Organize their resources to support global manufacturers (OEMs) and system integrators
- Deliver innovation, quality, and value to their customers with increased speed
- Operate profitably in the face of continuous competitive cost-reduction pressures

Suppliers can effectively meet these challenges only if they integrate their internal business processes and collaborate with both their customers and suppliers. These conclusions flow from analyses of research performed by the University of Michigan's Office for the Study of Automotive Transportation (OSAT)[2] and Oracle Corporation, with the cooperation of the Original Equipment Supplier Association (OESA).

We chose integration and collaboration as the unifying principle for this research because of our previous research on the effects of information technology and e-business on system integrators.[3] During the e-business boom of the late 1990s, auto industry analysts viewed integration and collaboration as two of the most promising areas where e-business would play an important role. In this view of e-business, the Internet-based software would enable integration of real-time communication of information—both internally and between business partners.

As shown in figure 1, integration would connect a company's human resource, financial, research and development, product development, supply chain management, manufacturing, and distribution systems to allow for a free flow of information throughout the company. Collaboration would connect suppliers to the product development system to support the development of new products utilizing suppliers' ideas and innovation. It would also connect suppliers to the supply chain management process, smoothly processing bids for participation in new programs and delivering components and systems flawlessly to plants throughout the world. The results of all this activity would be monitored and measured, calculated and combined, and would appear on a near real time basis to the executives' desktops, allowing them not only to

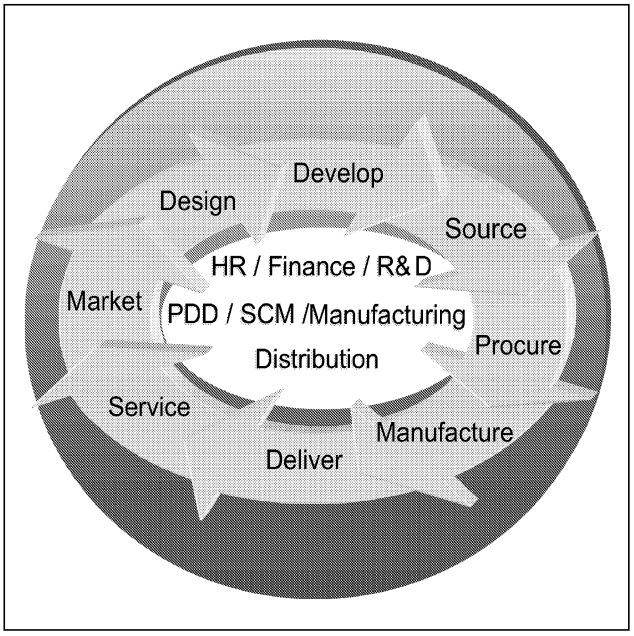


**Figure 1. The automotive enterprise design, production, and sales cycle offers numerous opportunities for integration and collaboration activities.**

1 We define a system integrator as a module/system supplier direct to assembly and Tier 1 as a material, part, or component supplier, also direct to assembly. We define Tier N suppliers as those that supply material, parts, or components to system integrators or Tier 1 suppliers.

2 OSAT, a research unit of the University of Michigan Transportation Research Institute, has performed research, analysis, and communication activities focused on the automotive industry for nearly 25 years.

3 Flynn, M.S.; Belzowski, B.M.; Booms, C. 1998. *Beyond Y2K: Information Technology and the Automotive System Integrator.* Ann Arbor, The University of Michigan Transportation Research Institute, Baan, and Hewlett-Packard Company.

Heidingsfelder, M.; Benecchi, A.; Dergis, M.; Rasche, J.; Flynn, M.S.; Senter, R. Jr.; Belzowski, B.M. 2001. *Automotive System Integrators: Spiders or Flies In the e-Business Web?* Ann Arbor, The University of Michigan Transportation Research Institute, Roland Berger-Strategy Consultants.

understand and monitor company activity, but also to make better decisions about the future of the company. However, this comprehensive vision of integration and collaboration has been slow in materializing.

One reason for the slow progress toward this vision is that integration and collaboration involve more than just the licensing of e-business technologies. For example:

- Organizational changes must align the business practices with the vision.
- Personnel changes must support the organizational changes.
- Business process changes must occur in companies' basic processes such as PDD and SCM.
- Information technology (IT) changes must support the goals of the company by enabling the company not only to "infomate" its current processes, but also to envision completely new ways of doing things.

Over the past five years, OEMs and suppliers have taken the e-business opportunity, in the form of integration and collaboration, to heart and many have re-organized their companies to take advantage of these new ways of conducting business. We feel now is an appropriate time to measure the value of integration and collaboration to suppliers, their importance to performance improvement, the pace of industry change in both arenas, and the barriers and facilitators to internal integration and external collaboration with customers and suppliers.

The results of this study are drawn from a set of interviews with eight Advisory Board members, a survey of over 100 high-ranking supplier executives, including nine of the Top 10 and 14 of the Top 20 suppliers[4], and 12 subsequent interviews with executives from major suppliers. Nearly 60 percent of the sup-plier executives in the survey are vice presidents or above.

## *Major Industry Challenges*

Throughout this report we refer to three major industry challenges. First, our investigation into the current and future status of the survey sample of suppliers' role in the industry led to a revealing finding about the potential structure of the supplier industry. We look at the role of system integrators, the large, system or module suppliers; the Tier 1 suppliers, a wide range of suppliers selling directly to the OEMs; and the Tier N companies that are a part of the supply chain of the system integrators and Tier 1 suppliers. In particular, we look at the changes taking place in the Tier 1 supply base, where a significant percentage of Tier 1 suppliers expect to become system integrators in the next five years, while another set of Tier 1 suppliers expect to become Tier N suppliers.

Second, this report also analyzes the value of internal integration and external collaboration with customers and suppliers across three major activities: Executive Decision-Making (EDM), Product Design and Development (PDD), and Supply Chain Management (SCM). We examined a total of nine activities and chose to focus on PDD and SCM because of each activity's importance in the changing manufacturer-supplier relationship; we selected EDM because we see it as a potential differentiator among companies in the near future.

In figure 2 we see the varying importance of external collaboration with customers on improvements across these areas.

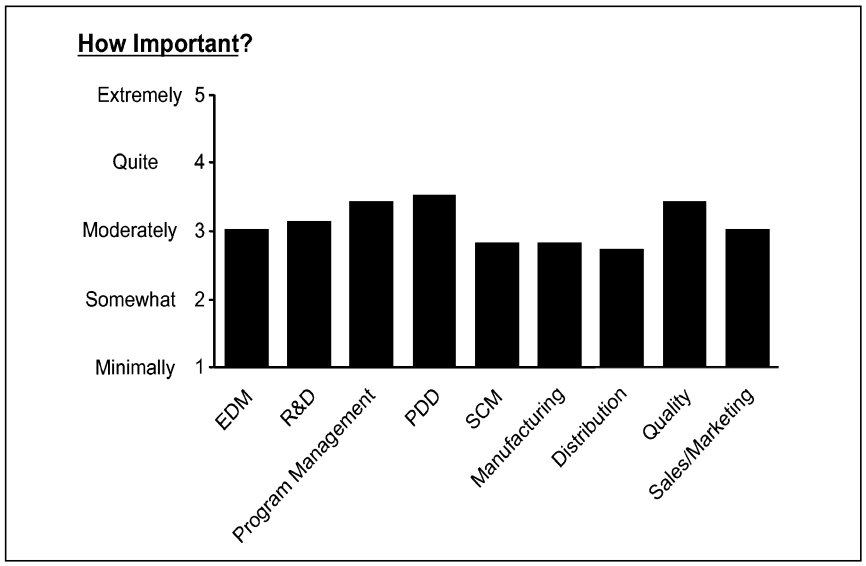


**Figure 2. The importance of external collaboration with customers differs across activities.**

4 A total of 104 executives participated in the survey for a response rate of 13 percent.

This analysis illustrates one of the main themes of this study: the primary and secondary links between suppliers and their customers. Primary links are those that in some sense naturally bind adjacent tiers in an activity, while secondary links characterize less intensely involved tiers. In this case, PDD is the primary link to the manufacturer while SCM is a secondary link. These results lead us to consider a holistic approach to integration and collaboration in PDD, SCM, and EDM.

Third, in EDM we see a different challenge based on sequential waves of information consisting of first collecting and acquiring information, next, organizing the information, and finally, deploying and using information. In particular we look at differences among characteristics of information based on how timely, accurate, analyzable, relevant, electronic, and accessible it is. We also look at the type and value of metrics used by executives to measure the progress of their company efforts.

To present these results, we organized the report into five major sections:

1. **Industry Evolution:**
   Significant Disconnects Looming
2. **Integration and Collaboration:**
   A Holistic Approach
3. **Executive Decision-Making:**
   Job 1 for Survival
4. **Product Design and Development:**
   New Roles, New Partners
5. **Supply Chain Management:**
   Great Risks, Great Opportunities

# Research Results

## 1. Industry Evolution: Significant Disconnects Looming

*Changing supplier roles offer both challenges and opportunities for superior supply chain collaboration.*

Over the past ten years, the supplier industry has undergone significant change including consolidation. This has resulted in an impressive number of global system integrators capable of delivering innovative and complex systems and high value components. These companies are complex, averaging over 62 plants worldwide. Also, the average number of recent acquisitions (2.3), joint ventures (1.8), and divestitures (0.9) are all quite large. Supplier size and role in the industry are clearly related if we look at system integrators and Tier N suppliers. However, one particular sector of the supplier industry, the Tier 1 suppliers, varies considerably in size. Figure 3 shows that total automotive revenue for Tier 1 suppliers ranges from less than $250 million to over $1 billion.

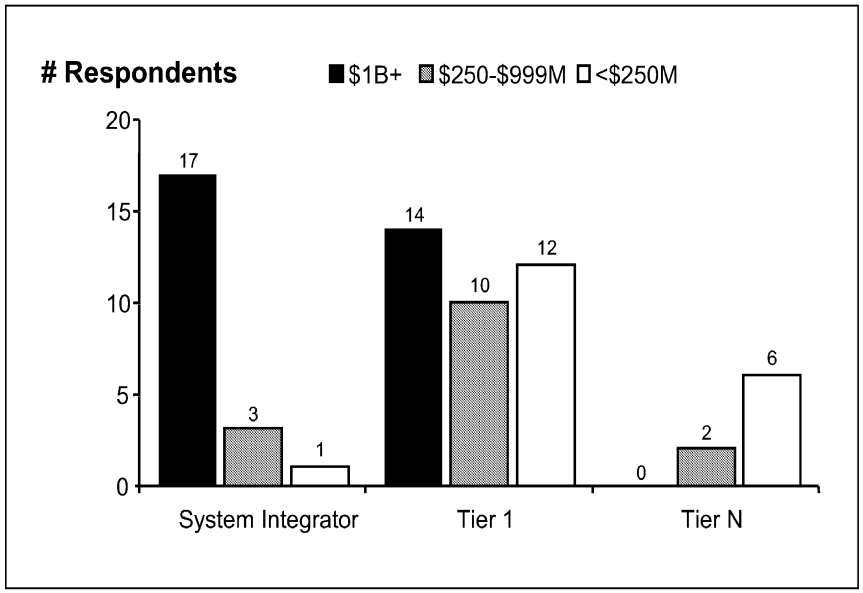


**Figure 3. Tier 1 suppliers vary considerably by automotive revenue.**

Tier 1 participants in our survey made up the majority of suppliers in our sample (about 58 percent). However, as figure 4 illustrates, by 2007 there will be a substantial change in this group as 30 percent of these suppliers expect to become system integrators

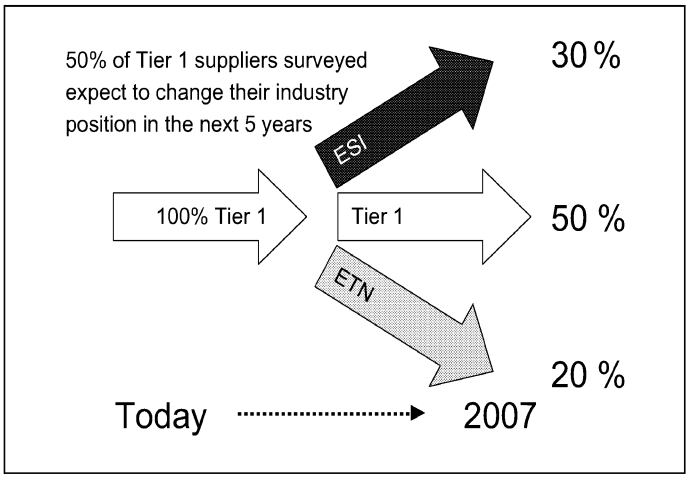


**Figure 4. Many Tier 1 suppliers expect to change their industry position by 2007.**

(ESIs or emerging system integrators), while 50 percent expect to remain Tier 1 suppliers, and 20 percent expect to be considered Tier N suppliers (ETNs or enhanced Tier N suppliers).

Figure 5 shows that these results are similar to ones generated from OSATs research in the mid-90s[5] that forecast the rise of system integrators and the reduction of Tier 1 suppliers.

Since then the number of system integrators has indeed grown. This analysis also suggests an increase of system integrators will occur over the next five years, as well as a significant increase in Tier N suppliers. Two questions arise from this potential structure: How many more system

5 Flynn, M.S.; Belzowski, B.M.; Bluestein, B.; Ger, M.;, Tuerks, M; Waraniak, J. 1996. The 21st Century Supply Chain, The Changing Roles, Responsibilities, and Relationships in the Automotive Industry. Ann Arbor, The University of Michigan Transportation Research Institute and A.T. Kearney, Inc.

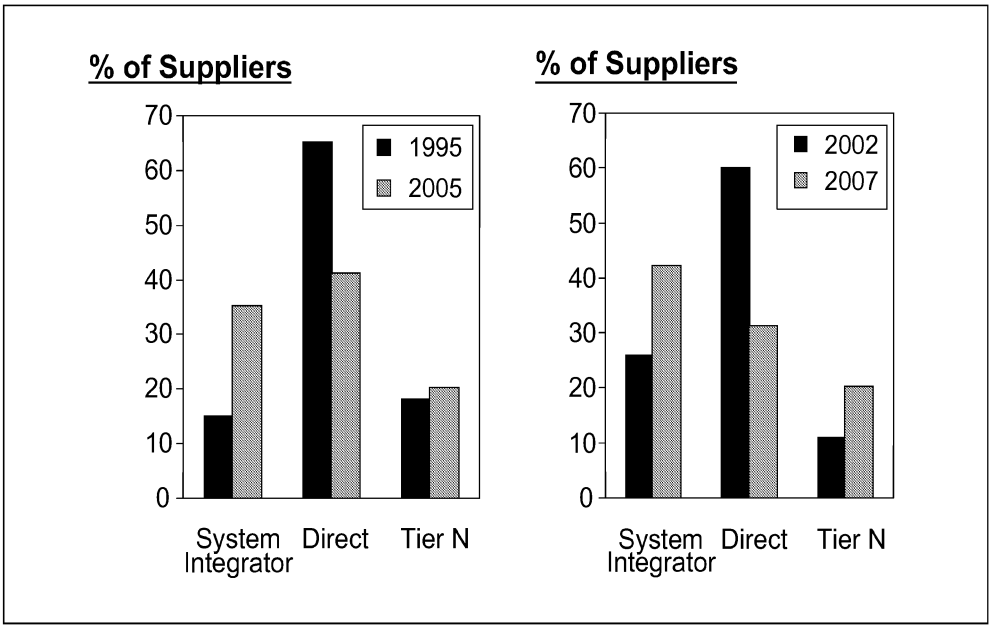


**Figure 5. The migration of Tier 1 suppliers continues.**

integrators will the industry require or tolerate, and will the supplier industry be able to leverage a possibly more capable Tier N supply base? More system integrators focused on systems not yet clearly defined could provide more innovation or reduce competition, while a more capable Tier N supply base could also improve innovation yet strain the collaborative abilities of the system integrators or major Tier 1 suppliers.

Supplier consolidation will continue tentatively, primarily due to the lack of clarity by OEMs about the requirements for system integrators, as well as uncertainty about which systems they will choose to develop internally. Each OEM has developed its own supplier strategy (including divisional differences within some companies), and suppliers have adapted to survive. But survival is not enough. For companies, especially large public companies, to succeed, they must be profitable.

## *Emerging System Integrators (ESIs)*

ESIs plan on shifting up the tier system to higher value-added work, and they have substantially different ideas of the competitive challenges they face than do current system integrators. Our data cannot tell us whether the ESIs have distorted views, or whether the current system integrators' views are already dated. But the differences should be instructive to both groups, and illustrate an important arena in which existing disconnects may have serious implications for the industry.

In contrast to current system integrators, ESIs view innovation capability as less critical to their survival, and internal integration as less valuable in meeting their competitive challenges as they move into the system integrator role. In view of the shifting locus of PDD and research and development in the industry, we suspect they may be underestimating the importance of innovation capability.

ESIs are generally further behind in their integration and collaboration activities than are the system integrators, their future competitors. Indeed, of 27 such activities, they lag current system integrators on 14, although not in PDD or SCM. Moreover, they view collaboration with customers as less important in their improvement efforts in SCM. If we look at changes in performance over the past two years, as in figure 6, they show less improvement on four of eight critical dimensions: cost reduction, market share, on-time delivery, and profit margin.[6]

It may be that shifting up the value-add chain might improve some of these performances. For example, system integrators enjoyed a sales increase of about five percent from 2000 to 2001, while ESIs experienced a loss of some six percent. But it might also be that ESIs will enter a tier level where the competitive bar and performance standards are simply higher than they anticipate or can meet.

6 All comparisons presented in this report are reliable at the 10 percent level ($p<.1$); many, of course, are much more reliable ($p<.05$ or less).

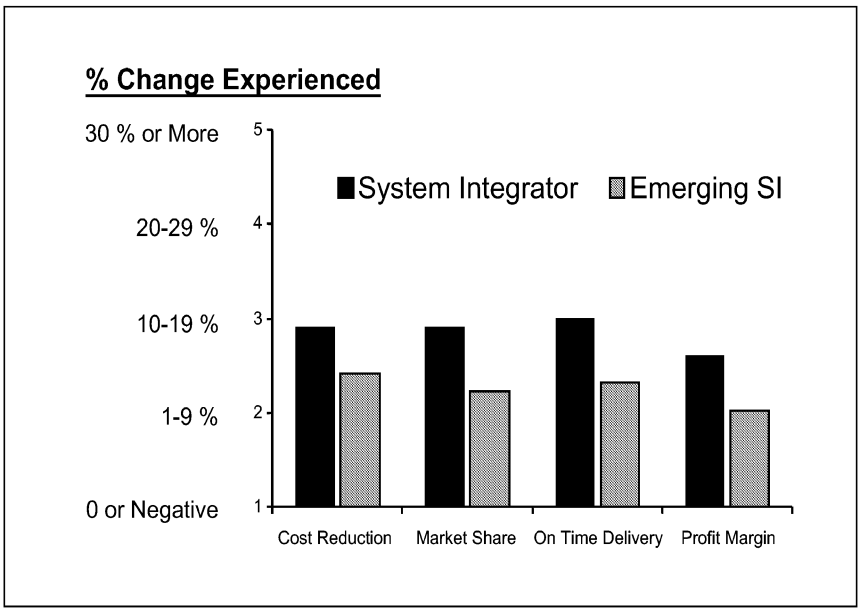


**Figure 6. ESIs report less improvement than system integrators on four critical dimensions.**

The ETN suppliers bring with them Tier 1 supplier processes rooted in OEM systems. They also report much of the current OEM thinking on cost reduction and responsibility as well as the Tier 1 supplier frustration with OEM mandates. The current Tier N supply base is generally characterized as focused on manufacturing support to Tier 1 suppliers, and our interviewees view them as having extreme technology barriers and limited financial resources and systems. As one interviewee noted, "They adapt to change, but they have no systems."

### *Enhanced Tier Ns (ETNs)*

The other path some 20 percent of our Tier 1 suppliers expect to take is becoming a Tier N supplier or enhanced Tier N (ETN). Currently there is a wide variety of capabilities within the Tier N supply base. Some of these suppliers are former Tier 1 suppliers who have moved down the supply chain because they decided not to become system integrators or because their component did not have enough value to the OEMs to rate continuing as a Tier 1 supplier. Many Tier N suppliers are focused solely on manufacturing excellence within a small range of components.[7] The ETN suppliers are similar to the former Tier 1 suppliers. They differ significantly from other Tier N suppliers in a number of areas. They

- expect system integrators and Tier 1 suppliers to gain more responsibility for total lifecycle product cost
- consider efforts in reducing costs and cycle time more valuable to their future survival
- report that internal integration is more important to their PDD improvement
- expect to be further along in their collaboration with their suppliers in 24 months
- consider collaboration with customers efforts driven more by the need to both add value and reduce cost rather than to only add value
- report that customer mandates are a barrier instead of a facilitator to collaboration

> They (Tier N suppliers) adapt to change, but they have no systems.
>
> – OSAT Interviewee

The combination of former Tier 1 suppliers already in the Tier N supply base plus the ETN suppliers offers system integrators and major Tier 1 suppliers the experience and knowledge to collaborate fully in the their processes, including EDM, PDD, and SCM. They offer system integrators opportunities to develop extremely capable and innovative supply chains. They also have the potential to set a new standard for Tier N suppliers in terms of collaboration with their customers. Already, some major Tier 1 suppliers are making the most of what they call their "key" suppliers. One interviewee reports, "When we target key suppliers, they co-locate with us. We do technology sharing with them. Sometimes they bring experience from other industries and from other auto companies. They sometimes show us different systems and ways of doing things."

7 In our sample, about 60 percent of Tier N supplier automotive revenue comes from supplying system integrators and Tier 1 suppliers. About 30 percent of revenue comes from supplying OEMs and about 10 percent comes from supplying the aftermarket.

> When we target key suppliers, they co-locate with us. We share technology with them. Sometimes they bring experience from other industries and from other auto companies. They sometimes show us different systems and ways of doing things.
>
> – OSAT Interviewee

Another option for the development of ETN suppliers may be through consolidation of the supply base. Like the OEMs, system integrators and major Tier 1 suppliers would rather work with fewer, more capable suppliers. The pressure on margins that eventually works its way down the supply chain may force Tier N suppliers to merge with or acquire other suppliers. They may need to do this in order to expand both their engineering expertise and the financial resources to support their growing role in the industry. ETN suppliers could possibly merge with current Tier N suppliers to support either their engineering or manufacturing activity.

### *Power and Responsibility in the Value Chain*

The assignment of power and responsibility for lifecycle cost across the automotive value chain also centers on system integrators. As shown in figure 7, the supplier executives in our survey report that system integrators will gain the most responsibility for total lifecycle product cost.[8]

It is puzzling that system integrators are predicted to gain some power in the value chain while OEMs are not expected to lose any. This apparent contradiction has three possible explanations.

First, it might reveal an important disconnect in the industry's thinking about its restructuring. It would not be surprising if many suppliers might not understand the effects of the changes that are taking place in the industry. But the suppliers in our survey are primarily the top suppliers in the industry, and it would be surprising for them not to understand the re-distribution of responsibility and power in the value chain.

Second, this result is in contrast to our recent research that suggested that OEMs would probably lose power, but may try to re-capture any power they had relinquished in the recent past by using e-business technologies.[9]

Third, it may just mean that the total amount of power or control in the system is increasing. After all, while the Japanese OEMs are often thought to have more control over their supply base than the Big 3, it is also clear that they are much more dependent on that base. In this view, the system itself has more power. We tend toward this third interpretation of an

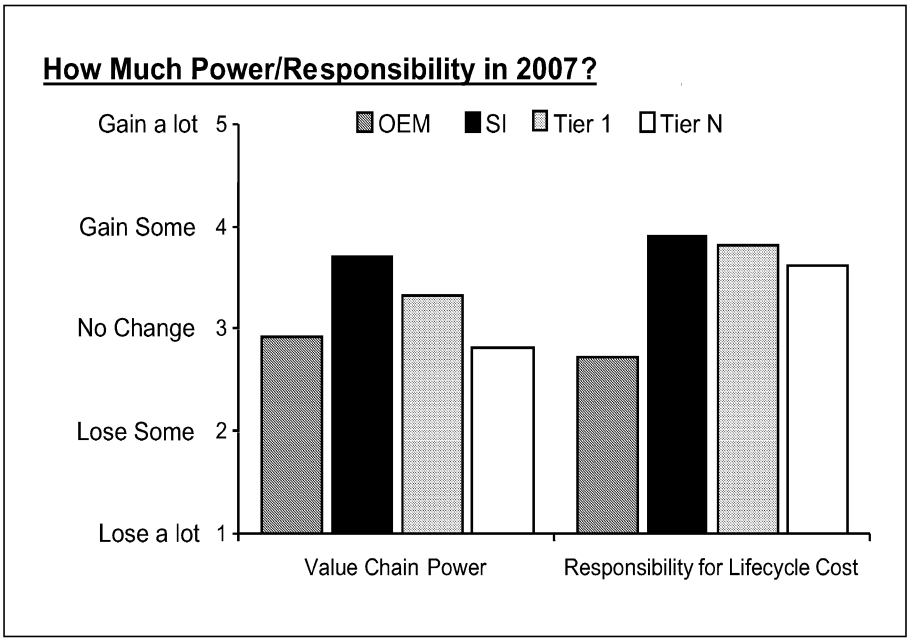


**Figure 7. System integrators will gain power and responsibility in the value chain**

8 Likert scaling is a convenient method for attitude measurement that allows easy respondent participation and administrator scoring. Our survey utilizes five point scales to allow respondents to choose a neutral position, thereby decreasing measurement error.

9 Heidingsfelder, M.; Benecchi, A.; Dergis, M.; Rasche, J.; Flynn, M.S.; Senter, R. Jr.; Belzowski, B.M. 2001. *Automotive System Integrators: Spiders or Flies In the e-Business Web?* Ann Arbor, The University of Michigan Transportation Research Institute, Roland Berger-Strategy Consultants.

industry in which suppliers are gaining, but OEMs are not necessarily losing power and responsibility.

### *Industry Challenges*

North American suppliers today face a variety of challenges that would test the management ability of most businesses. In figure 8, they report the 11 business challenges we asked about as at least "moderately critical" to their company's survival over the next 5 years.

Profitability, operational performance, innovation capability, customer satisfaction ratings, and PDD capability are considered the most critical challenges. They form an interesting set of key performance indicators and functional expertise. Two areas with lower ratings, SCM capabilities and business information acquisition, are interesting because they represent two potential areas for differentiation. Business information acquisition should provide executives information that can help them make better strategic decisions, while companies with better SCM capabilities should be more able to leverage their supply chain.

## 2. Integration and Collaboration: A Holistic Approach

*Disconnected subsystems—islands of excellence—constrain global suppliers from achieving across the board, world class performance levels.*

Some companies in the industry have recognized that the complexity of the vehicle itself, their own organizations, the industry's design and production activities, and the network of participating companies requires performance optimization at the system level across all these systems. Sub-system optimization poses a major challenge to company and industry performance. As OEMs have outsourced major vehicle systems and activities, competitive success increasingly relies on how well the entire value chain performs, including the allocation as well as the execution of activities.

Our results strongly support the hypothesis that companies must develop and execute internal integration and external collaboration strategies to meet the critical survival challenges they face over the next

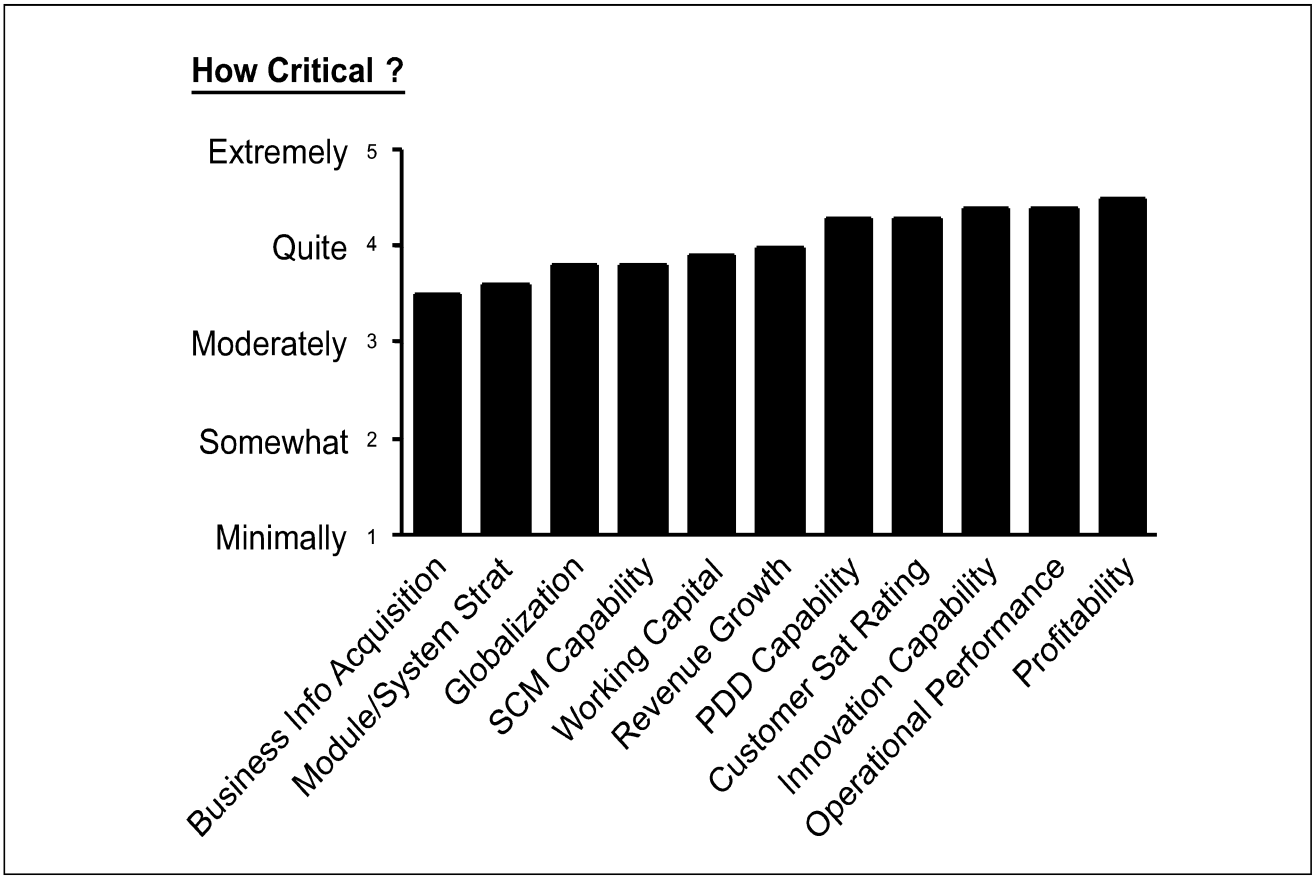


**Figure 8. Suppliers find many challenges critical to company survival.**

five years.[10] Indeed, figure 9 shows that suppliers view only cost reduction as more valuable among a set of ten efforts. Indeed, they consider integration and collaboration equivalent to quality improvements and cycle-time reduction in meeting the challenges their companies face.

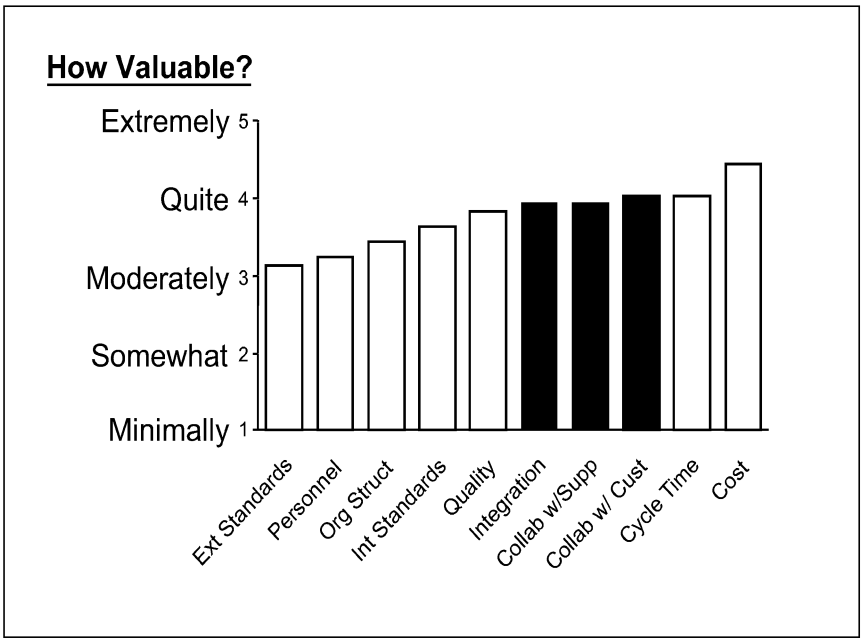


**Figure 9. Integration and collaboration are valuable in meeting company challenges.**

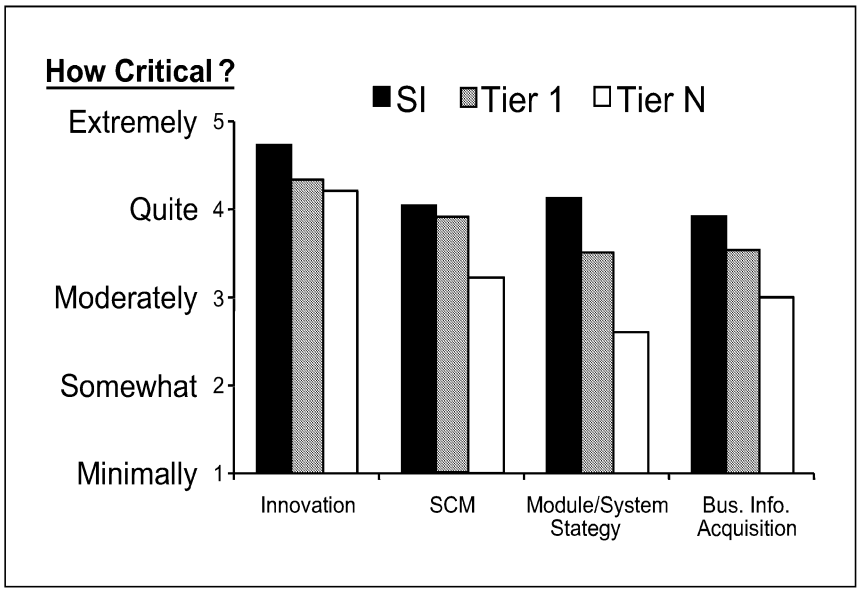


**Figure 10. System integrators view some challenges as more critical to their survival.**

### *Internal Integration*

Suppliers in general view internal integration as "quite valuable" in meeting competitive challenges. However, system integrators generally view improvement in their internal integration as more valuable in meeting their challenges than do Tier 1 or Tier N suppliers. Might the emphasis on integration simply reflect the system integrators' greater size and complexity? Our data fail to support this. Of course, some Tier 1 suppliers are also quite large and very complex. A more compelling possibility emerged in our interviews with some system integrator executives. They report a focus on internal integration to "get their own house in order" because of the large number of mergers, acquisitions, and joint ventures their companies had undertaken over the past five years. They also express some need to integrate their internal processes on a global basis to support their OEM customers and to leverage their capabilities rather than duplicate them.

As shown in figure 10, the three tiers significantly differ in how critical they feel four challenges are to their survival over the next five years: Innovation capability, supply chain management capability, module/system strategy, and business information acquisition. In each case, system integrators see these as more critical challenges. These differences probably reflect the different roles that are emerging in the industry

10 Again, internal integration is defined as a company combining or unifying its internal business processes across functions, activities, and units. External collaboration is defined as a company coordinating its own business processes with its external customers and suppliers.

> "Getting our own house in order will make it easier for information to be available to those who need to see it. If we can't do this internally, then we are just creating more chaos, faster."
>
> – OSAT Interviewee

and the heightened responsibilities of system integrators. Internal integration is required to meet these challenges effectively. However, in some cases, the differences may be larger than is healthy. For example, business information acquisition perhaps should be higher across all three tiers.

Supplier executives consider internal integration very important to a wide range of their actual performance improvements over the past two years. This result holds across eight of the nine activities we investigated, including EDM, PDD, and SCM, the three this report targets.[11] Supplier executives also report that their companies are roughly halfway to their goals of internally integrating most of these activities, although they are only slightly more than a quarter of the way to their SCM goals.

We think there may also be a control issue here. System integrators are new to their roles and may be reluctant to exercise the control over other suppliers needed for collaboration, especially before they are internally performing well. This perhaps reflects an acute sensibility about what many see as the industry's past negative experiences with the exercise of top-down control.

### *Collaboration with Customers*

In general, suppliers also view collaboration with their customers as "quite valuable" in meeting their competitive challenges. However, they report that collaboration with customers is only "moderately important" to their performance improvement in most of their specific activities, the only exceptions being PDD and Quality, where it is "very important."

Suppliers are close to halfway to reaching their goals for collaborating with external customers in a number of areas:

- Quality
- Program management
- Product design and development
- Manufacturing operations
- Distribution
- Sales and marketing

Three activities are moving more slowly, falling closer to one quarter of the way to their goals:

- Executive decision-making
- Supply chain management
- Research and development

### *External Collaboration with Suppliers*

Suppliers also view collaboration with their own suppliers as "quite valuable" in general in meeting their competitive challenges. However, while they report that collaboration with suppliers falls between "moderately" and "very important" to their performance improvement in SCM and quality, it is only "somewhat" to "moderately" important in their other seven efforts.[12]

---

11 In addition to EDM, PDD, and SCM, we asked about R&D, program management, warehousing and distribution, manufacturing operations, quality assurance, and sales and marketing. Results for these other activities will be reported separately.

12 The importance scale includes the following scale points: minimally important, somewhat important, moderately important, very important, and extremely important.

Suppliers report they are about halfway to their collaboration goals with their suppliers in the areas of distribution and quality. But they are only about a quarter of the way to their supplier collaboration goals in:

- Executive decision-making
- Research and development
- Program management
- Product design and development
- Supply chain management
- Manufacturing operations
- Sales and marketing

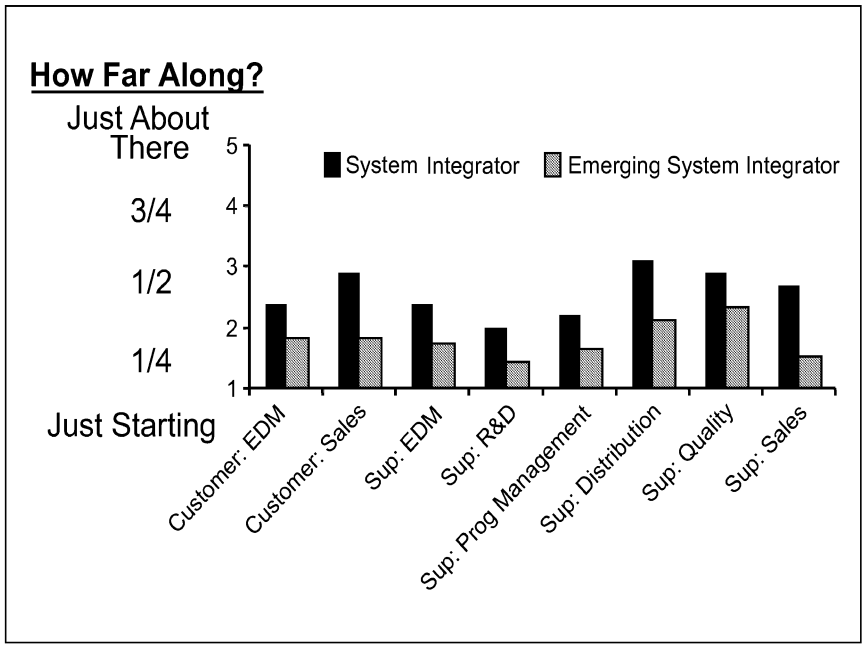


**Figure 11. Emerging system integrators (ESIs) face numerous collaboration challenges compared to their future competitors, system integrators.**

An interesting pattern emerges in our data that clearly shows that the emphasis on collaboration with suppliers will differentiate across the tiers in the next few years. For seven of the nine activities, there are significant differences among the tiers in how close suppliers think they will be to their goals in 24 months. For three of these activities, the higher the tier, the closer to their goal they believe they will be. For four of the activities, including PDD, system integrators and Tier 1 suppliers believe they will be further along than do Tier N suppliers.

There are also important differences between current system integrators and emerging system integrators (ESIs) in the pace of these changes. In general, current system integrators are further ahead in integration and collaboration than emerging system integrators. As displayed in figure 11, ESIs face major efforts to perform integration and collaboration activities at the level of current system integrators, their future competitors.

Few interviews revealed well-developed processes for collaborating with suppliers. But as Tier N suppliers gain more responsibility for warranty and total product lifecycle cost, as suppliers expect will occur, the need for Tier N suppliers to have more collaborative relationships with their customers becomes as important to them as is the system integrators' collaborative relationship with their OEM customers. And that can only happen if system integrators and Tier 1 suppliers develop ways to collaborate with their own supply base, the Tier N suppliers.

### *Primary and Secondary Links: A Holistic Approach*

At the most general level, our data suggest that integration and both forms of collaboration are quite important to suppliers meeting their competitive challenges. However, the data on specific efforts show a clear pattern:

- Integration efforts across the activities are generally ahead of customer collaboration and well ahead of supplier collaboration.
- Integration is seen as more important to recent performance improvements in specific activities than is either form of collaboration.

As we consider the value chain for automotive production, we can distinguish primary and secondary links for various industry activities. Primary links are those that in some sense naturally bind adjacent tiers in an activity, while secondary links characterize less intensely involved tiers. Suppliers tend to focus their collaborative efforts on the primary links, perhaps at the expense of appropriate and beneficial attention to the secondary links.

- In PDD, they report collaboration with customers (the primary link) is further advanced and *more* important than is collaboration with suppliers (the secondary link).
- In SCM, they think their external collaboration with customers (the secondary link) is *less* important than collaboration with suppliers (the primary link). There are no differences in how far along they are between customer and supplier collaboration in SCM.
- In EDM, they report internal integration (the primary link) is further advanced and *more* important than either form of collaboration (the secondary links).

If one truly sees the industry as a complex chain of activities, then these results may raise some concern. As figure 12 shows, suppliers may be missing or underutilizing the benefits of collaborating with their customers on SCM, with their suppliers on PDD, and with both groups on EDM.

By focusing too exclusively on primary links suppliers may create value chains that contain elements that perform excellently, but whose overall execution is held back by poorly performing, more slowly developing areas. Activity chains perform at the level of the weakest link, whether we focus on EDM, PDD, or SCM. So supply chains with the best performing weak link will generally win, and that requires paying attention to secondary as well as primary links.

To be sure, as OEMs struggle with the transfer of complex systems and requirements to system integrators, system integrators must themselves be careful not to pass the burden of too many demands and activities on to other tiers. Part of improving weaker links is ensuring that they have the capability to handle the burden. Without that, system integrators may find they have just shifted or even created a weak link that will undermine the performance of the entire chain. This is of particular concern with Tier N suppliers because of the wide range of capabilities currently in that area of the supply base. In the future, as our previous discussion of enhanced Tier N suppliers noted, the capabilities of the Tier N supply base may improve as current Tier 1 suppliers become Tier N suppliers.

Suppliers themselves can be faulted for dealing with their own suppliers in ways that they resist being treated by their customers. One of the major issues confronting the industry is the manner in which some OEMs are demanding cost reductions from their

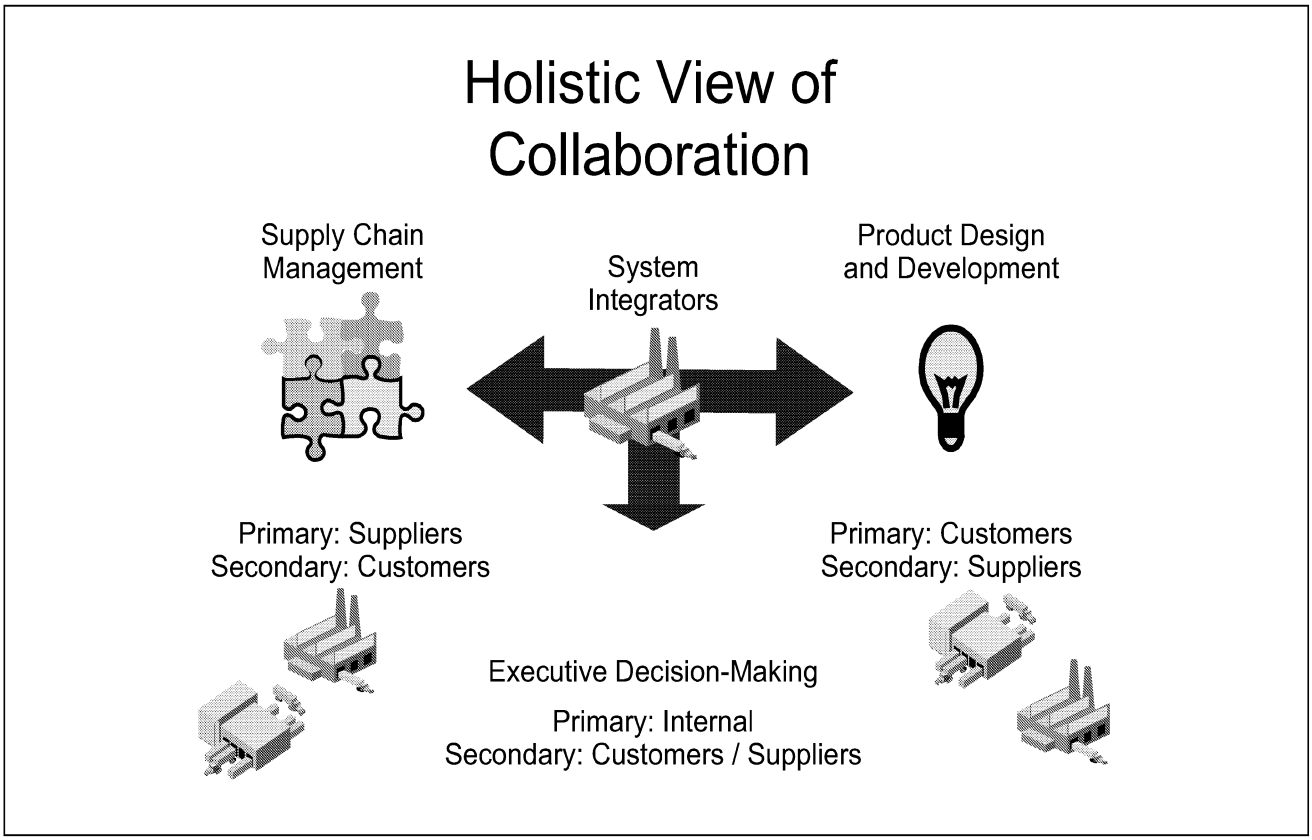


**Figure 12. Suppliers focus too often on primary links in collaboration at the expense of secondary links.**

suppliers. Yet suppliers report, as shown in figure 13, their own efforts to collaborate with their suppliers are more cost than value driven, even though they report their efforts at internal integration and collaboration with customers are equally driven by cost reduction and adding value. Beyond the irony of this situation, this approach has downside risks that are as great for value chain performance when pursued by suppliers as when pursued by OEMs.

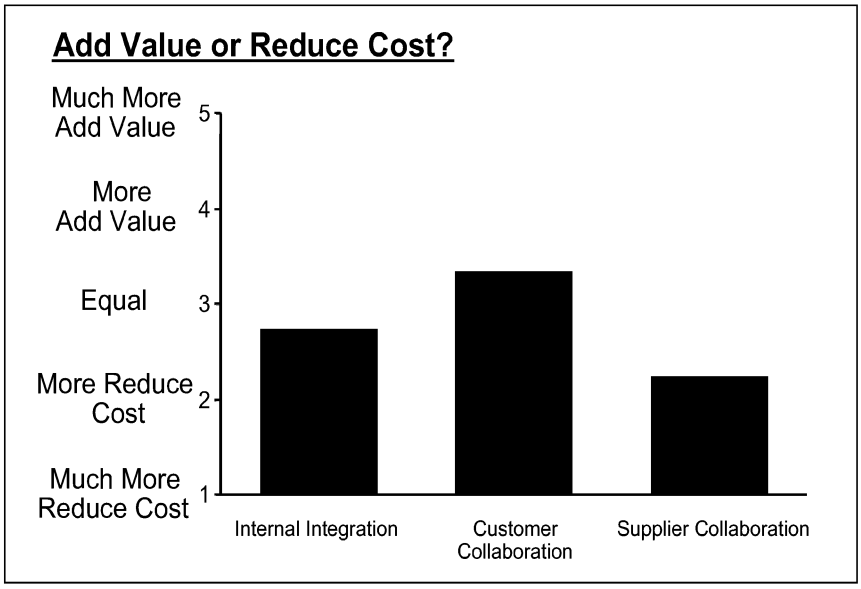


**Figure 13. Suppliers see supplier collaboration driven more by cost than by value.**

Finally, system integrators must be careful that they function as the key link in the supply chain, rather than the point of disconnect, where efficiency, quality, and value markedly deteriorate. The evolution of the supply chain over the past ten years has created a class of Tier N suppliers who previously supplied the OEMs. Given their experience with the OEMs, many of them are able to collaborate fully in the system integrator's processes, including EDM, PDD, and SCM. Collaborating with these suppliers promises the system integrator a stronger and more effective supply chain partner, and avoids the system integrator ultimately overburdening itself by taking on more and more specific tasks and responsibilities. That path leads inevitably to decline as many OEMs have learned.

Just as OEMs have recognized that collaboration with their suppliers is critical to their competitive survival and success, system integrators that can effectively collaborate with their suppliers may create the next critical competitive advantage.

So how can companies begin to better coordinate their internal integration and external collaboration efforts? The problems and challenges of internal integration and external collaboration have plagued the industry for years, from the internal functional silos to the walls separating companies themselves. These boundaries are necessary for many reasons, but can be major barriers to a value chain's ability to deliver a quality product at a reasonable price while providing all the participants reasonable profit for their contributions.

### *Balancing Change Efforts*

Companies face numerous barriers to improving their internal integration and external collaboration efforts, and thus achieving competitive success. They enjoy an equally large number of facilitators, and a wide range of choices in how to proceed. The areas or domains in which they often encounter barriers and where they can develop successful approaches are essentially the same. Figure 14 shows that they include organizational patterns, human resource or personnel practices, business processes, and information technology.

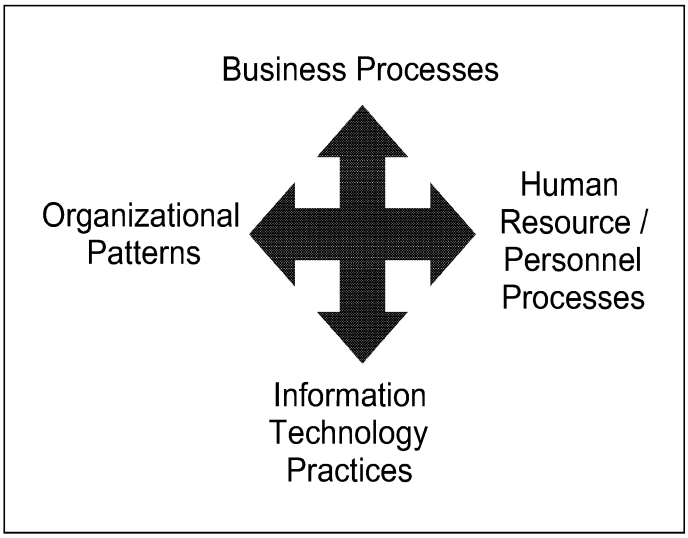


**Figure 14. Change efforts need a balanced approach to succeed.**

Making boundaries within companies and between customers and suppliers more permeable, by integrating internally and collaborating externally, confers a competitive advantage to the suppliers that can master this difficult challenge. In our survey, suppliers reported on a variety of methods across all four domains, totaling 25, for enabling internal integration and external collaboration. We highlight the most important within each domain for integration and for each form of collaboration. We look specifically at barriers and facilitators to EDM, PDD, and SCM in their respective sections.

### *Internal integration*

- Organizationally, suppliers report that their company's continuous improvement initiatives and corporate technology strategy facilitate internal integration. The higher the supplier's tier, the more corporate technology strategy facilitates integration. This is most likely because system integrator companies are much more complex organizations, and they need strong technology processes and strategies to manage the complexity.
- The business processes that most facilitate integration are EDM and PDD practices. However, EDM is less a facilitator for system integrators than it is for Tier 1s and Tier Ns. It is difficult to say whether this is because system integrators are further along in integration or because EDM is more challenging for system integrators.
- Two personnel practices—reliance on executive champions for initiatives and strategically hiring new personnel—offer a combination of high-level and "new-blood" backing for integration efforts. Strategic hiring is considered less useful to Tier 1 suppliers than to either system integrators or Tier N suppliers.
- In the information technology domain, the use of Web-based enabling software and the development of portals are the most effective support for integration efforts. Common internal IT metrics and standards are also considered facilitators of integration.

### *Collaboration with customers*

- Organizationally, suppliers report that the company's continuous improvement initiatives and co-location with customers facilitate customer collaboration.
- The supplier's own PDD practices are the business process that most facilitates customer collaboration.
- The same two personnel practices that facilitate integration efforts—reliance on executive champions for initiatives and strategically hiring new personnel—boost customer collaboration efforts as well.
- In the information technology domain, the use of Web-based enabling software and the development of portals are again the most effective, supporting customer collaboration as well as integration efforts. Both of these are especially useful for system integrators.

### *Collaboration with suppliers*

- Organizationally, suppliers report that the company's continuous improvement initiative is really the only facilitator of supplier collaboration.
- The business processes that most facilitate supplier collaboration are the supplier's own SCM, PDD, and EDM practices.
- The same two personnel practices—reliance on executive champions for initiatives and strategically hiring new personnel—that facilitate integration and customer collaboration efforts also boost supplier collaboration efforts.
- In the information technology domain, the use of Web-based enabling software and the development of portals are again the most effective, supporting supplier as well as customer collaboration and integration efforts. Portal development is again especially useful for system integrators.

Six of these approaches are useful facilitators of integration and both forms of collaboration: continuous improvement initiatives, PDD, reliance on executive champions, strategically hiring new personnel, portal development, and Web-based enabling software.

Effectively using these facilitators is not easy. Tying internal integration and external collaboration to a company's continuous improvement initiatives requires careful process planning and constant monitoring. If an executive champion supports these efforts, it will help with funding, promotion, and follow-through, but finding a committed champion can be difficult. Strategic hiring is more easily planned than accomplished, since it not only requires a careful needs analysis, but is subject to the vagaries of the labor market.[13]

Using Web-based software to enable these efforts affords companies the opportunity to scale to different types of companies across the tiers and globally if necessary. It can also facilitate learning via knowledge bases. Technology can also "depersonalize" transactions in ways that can neutralize reactions to human control that might otherwise present barriers to implementing the changes necessary for internal integration and external collaboration. In this sense, technology can readily permeate boundaries within and between companies and allows integration and collaboration the opportunity to provide the competitive advantage companies seek.

But technology does not come without costs. Though suppliers report information technology as a key enabler of integration and collaboration, they also report that the cost of implementation and ownership represent barriers to these processes. Companies continually weigh the advantages and disadvantages of enabling processes through information technology. Understanding and measuring the value information technology brings to these processes may determine the success of companies' integration and collaboration efforts.

It is critical to note that these approaches cross the traditional triad of process, people, and technology, including both organizational and business processes. Moreover, each of these is a high-ranking approach overall. It is essential that suppliers recognize that this strongly suggests there is no silver-bullet approach or one type of approach that alone is likely to sufficiently facilitate internal integration and external collaboration, which are critical to meeting the survival challenges of the next five years.

## 3. Executive Decision-Making: Job 1 for Survival

*Executive Decision Making (EDM) must leverage collaboration and integration efforts to collect, analyze, and provide key operational and financial information to all relevant decision-makers*

No activity has more effect on the success of a company and its supply chain than the decisions of its executives. In many ways, a company's survival depends on its executives making the "right" decisions. EDM becomes more challenging as suppliers become larger and more complex and activities and expertise becomes more divided across the differentiated OEM/supplier tier structure of the industry. Decisions will be based upon information gathered from disparate sources across the industry, and the consequences of those decisions will more immediately and seriously affect all the companies in a given value chain.

EDM is a relatively new formal business process in the automotive value chain, especially when systematically associated with external collaboration with customers and suppliers. EDM is often regarded as built into a company's "internal processes," rather than a process in its own right that requires both internal integration and external collaboration for effective execution. Both internal integration and external collaboration with customers and suppliers do in fact play a crucial role in EDM because the speed and quality of information and its retrieval often determine decision-making effectiveness. In short, effective EDM is the foundation for a successful supply chain.

[13] In mid-2003, this may be less constraining than in the future.

As noted earlier, suppliers currently believe business information acquisition is "quite critical," but they feel business information acquisition is the least critical business challenge among the nine rated business challenges. System integrators, in particular, view business information acquisition as significantly more critical to their companies' survival over the next five years than do Tier 1 and Tier N suppliers. This result may preview the deployment of EDM throughout the value chain as the more capable suppliers recognize its importance and leverage effective EDM as a source of competitive advantage.

### *Pace of Change*

Based on our interviews, suppliers think of EDM as more of an internal process. These results are also reflected in our survey as shown in figure 15, where suppliers report they are about half way to their goal of internally integrating their EDM business processes, but only about a quarter of the way in external EDM collaboration with their customers and suppliers. Suppliers indicate that they expect this gap to remain about the same over the next two years, in spite of progress toward the goal in both instances.

Today's system integrators indicate they are significantly further along in externally collaborating with their customers and suppliers in EDM than are ESIs. This is an example of an activity that ESIs may need to improve if they expect to compete effectively.

Interestingly, non-IT executives believe their companies are further along in internally integrating and externally collaborating with their suppliers in EDM than do IT executives. Perhaps IT executives are more aware of information technology's value and have a keener sense of their own company's information capabilities. IT executives may also be more aware of the available flexible networked software, and feel that the company can achieve much more than its current level.

### *Sources of Improvement*

We sought to identify the value of internal integration and external collaboration for company performance improvement. In general, companies report they have experienced some improvement in their executive decision-making activity over the past two years. Overall, suppliers tend to believe their internal integration efforts play a more important role in their companies' EDM performance improvement than do their external collaboration efforts. They do report that collaboration with customers plays a more important role than does supplier collaboration. This focus on internal integration is also reflected in interviewees mentioning more EDM integration than collaboration initiatives.

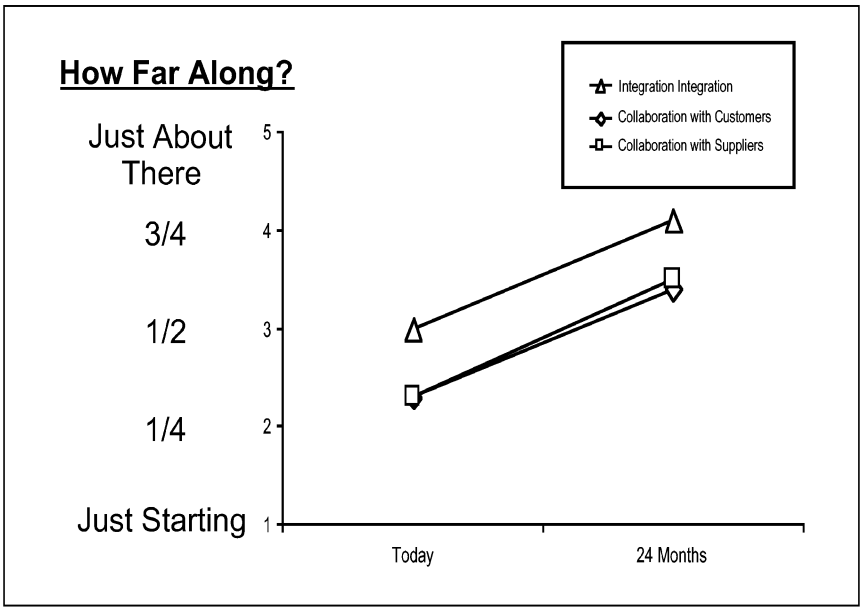


**Figure 15. EDM is considered an internal integration activity more than an external collaboration activity.**

The comparative importance of EDM integration efforts, as well as collaboration with customers over suppliers, is consistent with our finding that the focus of specific efforts is placed on primary rather than secondary links. The inward focus of EDM improvement efforts is hardly surprising since companies have long recognized the value of internal information flow and the many barriers it faces. Suppliers may play a secondary role in EDM improvement because suppliers may see EDM collaboration as a tool that leverages their relationships with

customers. This makes sense because some of the main operational metrics used by suppliers are based on their performance with their customers. Still, many of the operational metrics on delivery and quality are heavily affected by the supply base. Collaborating with both customers and suppliers in EDM should offer suppliers a better route to improving their performance on metrics crucial to their business success.

## *Information Waves*

We can consider the industry's information challenges of the past few decades as representing three waves or sets of challenges. The first wave was and is simply collecting or acquiring information, and the associated challenges are ones of speed and adaptation to the global nature of the industry. The second wave involves organizing the information so that it can be stored and retrieved. This involves challenges of consolidation and the development of standards. The third wave involves the deployment and use of information, and the challenges here are ensuring that the right information is accessible to the right people at the right time. Process improvement is built into the information waves as companies try to collect better and more timely information thus continually improving each process in each wave.

### *Wave one*

As noted earlier, business information acquisition compared to other business challenges is rated the least critical challenge, though system integrators consider it more critical than do Tier 1 and Tier N suppliers. We think this wave represents the basic decision by companies to invest in the processes needed for EDM. Most information technology (IT) systems in place today have capabilities to automate and record transactional events such as material receipts or shipment activities. As a result, massive amounts of transactional data have been collected and stored. However, the users who recorded these transactions often had little to do with analyzing the data in aggregate, which leads to wave two consolidation and standards challenges.

### *Wave two*

Organizing and analyzing information is problematic, especially for companies that have grown through mergers and acquisitions and are challenged to "see the big picture." Our research yields two interesting insights on wave two challenges. First, suppliers report that establishing common internal standards within a company is indeed "quite valuable" in meeting their challenges, while establishing common external standards within the industry is "moderately valuable." This belief is consistent with the emphasis on internal integration over external collaboration. But it raises serious concerns that companies might become well integrated internally, yet continue to have difficulty communicating with each other. It is also perhaps a bit surprising, in light of the many calls for industry wide standards from the supplier community over the past few years.

Second, suppliers in this study generally consider the information they utilize to be timely, accurate, analyzable, relevant, and available electronically. However, they report that information is fragmented across the organization-significantly hampering an executive's ability to make major decisions based on good, current information. One supplier executive stated, "We have lots of data, but we don't have information when you need it. It's hard to consolidate data on a timely basis into real time metrics."

### *Wave three*

Even if a company can collect and analyze information, third wave challenges loom large for the industry. An important challenge in effectively deploying information is making sure that the right information goes to the right people at the right time. Suppliers today have a plethora of metrics at their

> "We have lots of data, but we don't have information when you need it. It's hard to consolidate data on a timely basis into real time metrics."
>
> – OSAT Interviewee

disposal to help executives measure the performance and success of their companies' various improvement efforts. Company performance metrics drive what information is important and to whom. But the challenge is to select metrics that best measure improvement for each of the different activities, to access the information provided by the metrics, and to make decisions based on the right metrics. Equally important is a capability to change metrics as overarching business strategies are changed over the long term.

Supplier executives in this study appear to rely on traditional financial metrics (such as gross margin and revenue growth) over operational metrics (such as reductions in engineering change notices or RFQ success rate) in evaluating internal program efforts. It may be that supplier executives themselves are evaluated more in terms of financial than operational metrics, but some interviewees suggested that companies do this because financial performance metrics are profit-driven and readily available, while operational performance metrics are process-driven and more difficult to obtain. In any case, some operational metrics may, in fact, drive financial metrics and can offer more frequent and more targeted information. And although they are more difficult to collect, they allow early identification, analysis, and resolution of problems before they become reflected in the financial metrics.

Suppliers may in fact be using too many metrics, leading to possible conflicting departmental goals and slow—even inappropriate—decisions. It is more difficult to align company goals to a large number of metrics. Interestingly, the lower its tier, the fewer metrics a company uses. System integrators use eight metrics "always," and thirteen metrics "very often." Tier 1 suppliers use two metrics "always," and eighteen metrics "very often." Tier N suppliers use one metric "always," and thirteen metrics "very often." The metric used most often, across all tiers, is operating costs versus budget.

However, choosing appropriate metrics can be difficult, especially when different metrics correspond to different processes. And standardization can be inflexible, both analytically and structurally. A more flexible approach would allow one business system to support multiple metrics. Ultimately, a common business system with common business processes and a common data model can provide a unified standard set of financial and operational metrics. This may provide the best platform for a leaner, more agile company positioned to leverage its more effective EDM. But it will require some difficult decisions as to the appropriate use of these metrics across the company and its efforts, including rules for who uses which metrics for what purposes.

### *Executive Decision-Making Integration and Collaboration Efforts*

Our interviews revealed some of the specific efforts executives are pursuing to integrate internal business processes that provide information to support executive decision-making. Of the 20 interviewees, all but one indicated they were pursuing internal integration efforts. The effort most frequently reported is the implementation of IT applications. Most respondents remarked on a specific process the application was meant to improve. The next most frequently mentioned efforts are analyses of financial and operational metrics. One interviewee spoke about his company's "Operating System" that links metrics to goals and performance improvement, "This is a system that uses standard tools and metrics to drill down into the business all the way to the plant level. It even incorporates information from customer meetings. The key is that this information is available to everyone, and we use it for goal setting and performance improvement. This system fertilizes the change

"This is a system that uses standard tools and metrics to drill down into the business all the way to the plant level. It even incorporates information from customer meetings. The key is that this information is available to everyone, and we use it for goal setting and performance improvement. This system fertilizes the change process."

– OSAT Interviewee

process." Respondents rarely mentioned the specific financial metrics they addressed, but some identified operational metrics such as customer satisfaction, quality (PPM), and schedule performance.

Many executives indicated that their companies are implementing programs or technologies to enhance the performance attributes of information exchange, such as accessibility, consolidation, and timeliness. These examples are an indication that companies are taking steps to improve the information attributes that survey respondents feel are barriers to effective EDM.

Of the 20 interviewees, 16 indicated they are pursuing collaboration efforts to support EDM. The most commonly mentioned external collaboration efforts in EDM are operational metric analyses. Only one company mentioned it is pursuing financial metric analysis efforts with its customers or suppliers, even though our survey suggests financial metrics are more often used than operational ones.

Beyond customer and supplier collaboration to support EDM, suppliers may also be able to use Web-based software to collaborate with peer suppliers or third party suppliers of consumer information or market trend sources. These collaborations offer future avenues of support for EDM.

### *Barriers and Facilitators to Integration and Collaboration in Executive Decision-Making*

We used multiple measures to evaluate the barriers and facilitators to EDM. In our survey we find, as Figure 16 shows, that although suppliers generally consider information within the company to be timely, accurate, analyzable, relevant, and available electronically, it is fragmented and difficult to access. Despite the capability to receive information electronically, executives and their companies are often burdened by disparate systems—whether electronic or organizational—that limit their access to information. Enterprise Resource Planning (ERP) programs offer one solution to gathering and reporting information. But one interviewee from a decentralized company talked about the challenge of disparate systems, "If the whole company was on one ERP system, it would be nirvana."

> "If the whole company was on one ERP system, it would be nirvana."
>
> – OSAT Interviewee

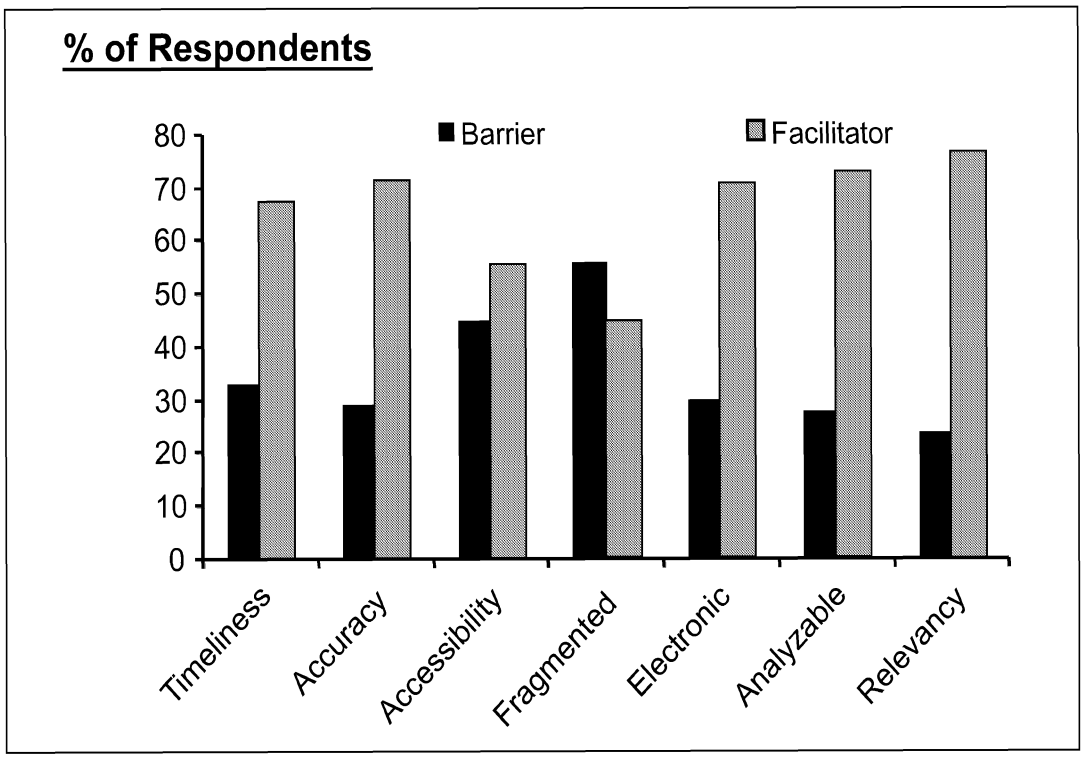


**Figure 16. Information challenges include accessibility and fragmentation.**

Our survey analysis reveals that Tier N suppliers consider the accessibility of information within their companies as more of a barrier than do either system integrators or Tier 1 suppliers. This may be a bit of a surprise since Tier N suppliers are smaller and less complex. But as our earlier discussion noted, these suppliers respond to orders but lack the systems that make information easily accessible within the company. This finding has important implications for their ability to play their role in the value chain. As major suppliers begin to include their key suppliers into their EDM, PDD, and SCM processes, Tier N suppliers will need to have accessible information throughout their companies.

The amount companies invest in IT seems to decrease the extent to which they experience accessibility and fragmentation barriers to information. Figure 17 shows that suppliers that invest more than 1.5 percent of their annual revenue on IT report their information is more accessible and less fragmented. Companies investing proportionately more in IT may be beginning to reap the benefits in these critical, technology-sensitive information attributes.

Interviewees also reported what barriers their companies face to integrate their internal business processes in support of EDM, as well as to collaborate with their customers and suppliers in this activity. Cost is the most mentioned barrier to integrate internal business processes in support of EDM. This is not surprising given the weak economy and related tightening of corporate purse strings. An information attribute—timeliness—is the next most frequently mentioned barrier. Interviewees mentioned other information attributes as barriers, including accessibility and fragmentation, each noted as significant barriers by suppliers in our survey. One interviewee brought up the point that their measurements surface problems but offer few solutions, "Our systems are good at measurements. These measures give us some insight where the improvement opportunities lie, but they don't provide sufficient amount of detail to solve the problem."

> "Our systems are good at measurements. These measures give us some insight into where the improvementopportunities lie, but they don't provide sufficient amount of detail to solve the problem."
>
> – OSAT Interviewee

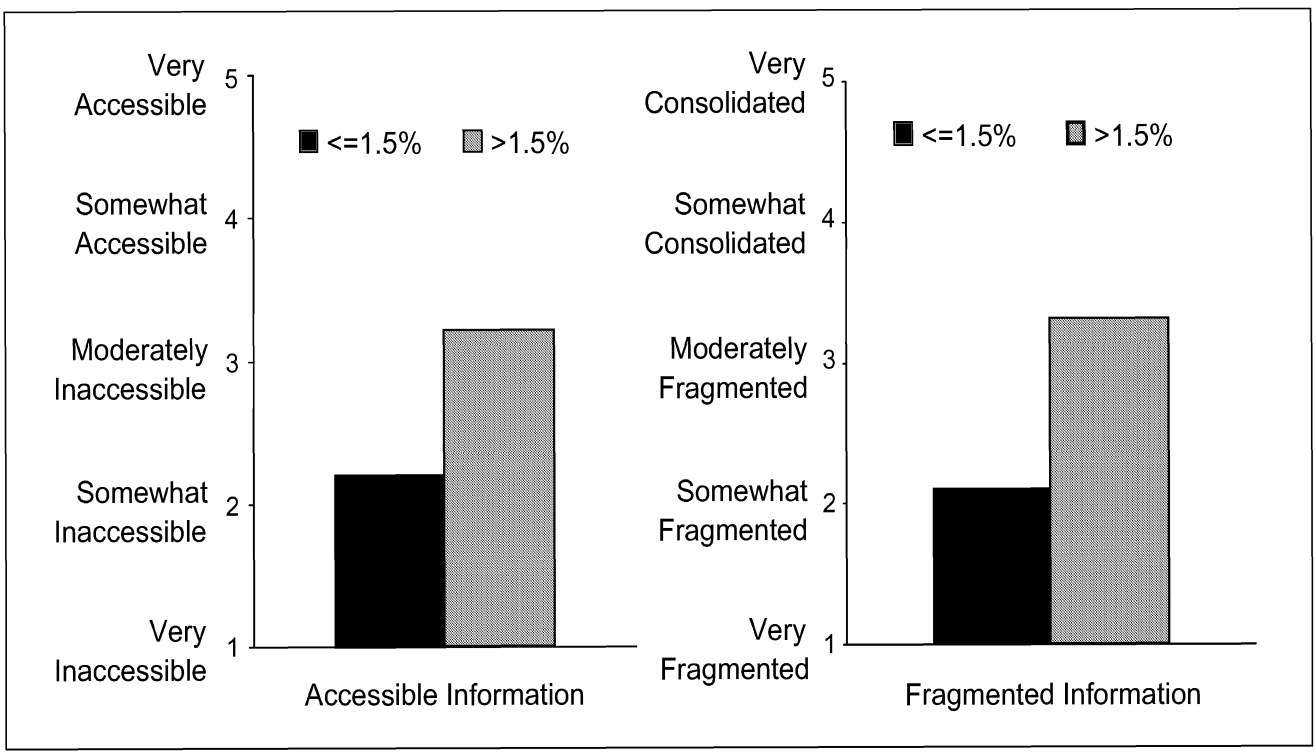


**Figure 17. Companies that spend more on IT have more accessible and less fragmented information.**

Interviewees indicated that a standard infrastructure is one of the most important facilitators to internal integration of EDM. Interviewees also see accessibility as the information attribute that most facilitates the integration of business processes to support EDM. These two facilitators are related in that a standard infrastructure could easily be one of the keys to making information more accessible.

Barriers to collaboration varied widely, ranging from concerns about information attributes like accessibility, visibility, and confidentiality, to more general concerns about solution costs and understanding EDM technology. Facilitators also varied widely, from acquiring relevant information to implementing standard systems. One respondent remarked that increasing supplier responsibility, particularly in warranty, would drive suppliers to master external collaboration. This response is reinforced by similar material from other interviewees discussing why transferring warranty responsibility is a looming problem.

Though executives have been making decisions for as long as their companies have existed, EDM, as a formal business process, is relatively new in the automotive value chain, especially when associated with collaboration with customers and suppliers. EDM is often regarded as built into a company's "internal processes," rather than a process in its own right that spans both internal integration and external collaboration. EDM does, in fact, play a crucial role in both internal integration and external collaboration with customers and suppliers, where the quality of information and speed of information retrieval often determine decision-making effectiveness. In short, effective EDM is the foundation of an efficient, capable business, and collaborative EDM is a necessary attribute for a successful supply chain.

### *Future State of Executive Decision Making*

Suppliers of the future will learn to develop their executive decision-making capabilities so that boardroom strategies are tied to operational execution. Supplier executives especially need to show consistent performance to their global customers and suppliers across their far flung operations. These suppliers of the future will have information that is rapidly gathered and accessible, allowing speed to become a differentiator of success.

Future EDM processes will evolve and be supported by near real time information that is accessible to the right people at the right time. EDM will become adaptable so suppliers can respond to new challenges with fact-based decisions. It will be rooted in meaningful metrics that can change as fast as the company itself adapts its strategies. Systematic EDM will avoid complex information infrastructures that "lock in" behavior, and rely instead on consistent company wide standards. Focusing on a smaller number of key operational metrics will ensure everyone in the company is aligned. Simplification and flexibility will be the rule. Companies will avoid using more and more data collection "layers," lessening the cost of moving data across multiple systems.

Once these changes occur, suppliers will find it easier to incorporate customer and supplier information into their EDM. For example, decisions about sourcing can be based on visible supply chain capacities. Decisions on product portfolios can be based on knowing the needs of a customer's customer.

## 4. Product Design and Development: New Roles, New Partners

*System integrators realize that innovation through PDD provides competitive differentiation, but many system integrators have not yet launched major collaborative initiatives with their supply base.*

The transfer of more product design and development (PDD) activities to the supply base is a key part of the industry's realignment of responsibility, and is rooted in two OEM interests: The desire to draw on supply base expertise and the wish to reduce internal costs.[14] For suppliers, especially system integrators, this transfer of responsibility brings with it major opportunities to increase their share of the industry's value-add activities. Indeed, as shown in figure 18,

[14] In our survey, we also asked about R&D and Program Management, arguably part of PDD, and found the three activities highly correlated. So, for the sake of clarity we decided to focus our discussion only on PDD.

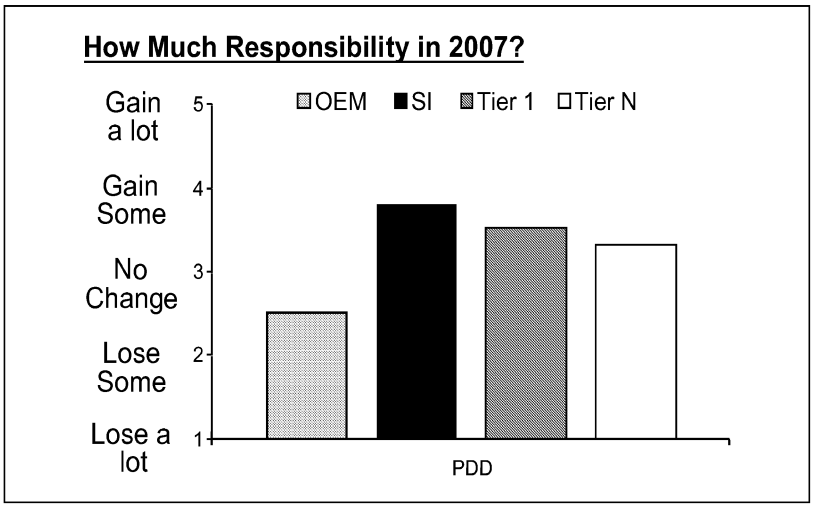


**Figure 18. The transfer of responsibility for PDD to the supply chain will continue.**

suppliers in our survey report that OEMs will lose, while all tiers of suppliers will gain responsibility in PDD over the next five years. And it is the system integrators that will gain the most.

Recent surveys report that some OEMs and suppliers are reducing the amount of design and engineering responsibilities they outsource and have even taken some work back in-house that they had previously outsourced.[15] OSAT reported on some of the issues surrounding this transfer of responsibility, including supplier capability and OEM ability to evaluate, in a recent report on engine system development.[16] Despite this trend, competent, innovative suppliers will find opportunities to add value and lower cost in the PDD process.

Suppliers see product development capability as a "quite critical" competitive challenge going forward. Profitability, operational performance, innovation capability, and PDD rank in the most critical group of challenges they face. In keeping with the changing allocation of PDD responsibility, all tiers of suppliers view PDD as a "quite critical" challenge. However, how critically they view the related challenge of developing a module/system strategy is strongly affected by their tier: System integrators see this as much more critical than do Tier 1s, and Tier 1s in turn see it as much more critical than do Tier Ns.

### *Pace of Change*

Suppliers estimate they are halfway to their goals for internally integrating PDD. Companies that invest more in IT (greater than 1.5 percent of revenue) report that they are substantially closer to their target than those that invest less. This may be because IT supports more rapid implementation or because IT permits the development of more effective goals. But the development of Web-based software, discussed earlier, may support this accelerated progress.

Suppliers report they are nearly half way to their goals in customer collaboration for PDD as well. Interestingly, Tier 1s see themselves as closer to their targets than do the system integrators. Whether this reflects different goals or actual differences in implementation is difficult to say. The interviews suggest that there are still challenges in this arena, as the OEMs have not fully specified their expectations, nor established the systems necessary to support the transfer of PDD responsibility to the supply base. It may well be that this is more of a problem for the more complex—and newer—modules and systems that the system integrators supply.

As figure 19 shows, external collaboration with suppliers is developing substantially more slowly; suppliers feel they are about one quarter of the way to their goal. As noted earlier, leveraging the supply chain holistically offers suppliers a potential advantage because of the expertise of their supply base. We think this is particularly true in PDD because of the many former Tier 1 suppliers already within the Tier N ranks, and also because of the many Tier 1 suppliers today that expect to become Tier N suppliers over the next five years.

---

15 Murphy, Tom, "24th Annual Engineering Survey," *Ward's AutoWorld, March*, 2002, pp.37.

"IP's Come Back In-house," *Automotive Industries*, May, 2003, pp. 6.

Mayne, Eric, "Ford Now Covets Seating, Climate Control," *Ward's Automotive Reports*, April 7, 2003, pp.1.

16 Belzowski, B.; Flynn, M.S. 2002. *Engine System Development: Change, Challenges*, and Value. Ann Arbor, The University of Michigan Transportation

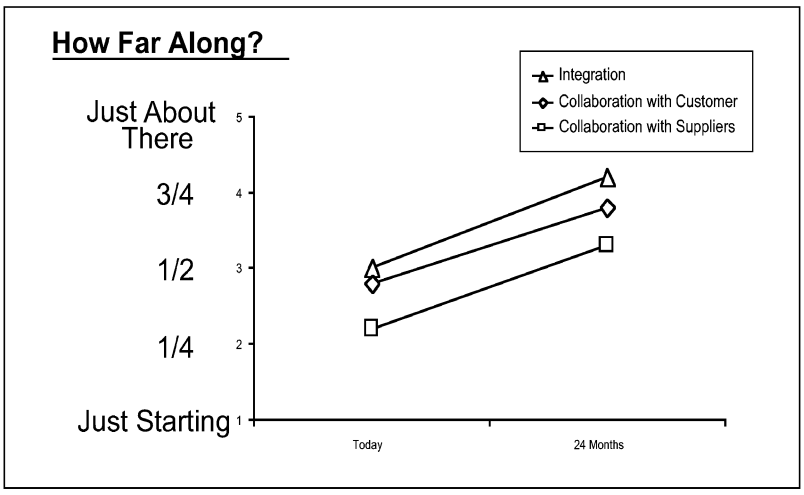


**Figure 19. External collaboration with suppliers in PDD is developing slowly.**

### *Sources of Improvement*

Suppliers report they have made, on average, some improvement in their PDD performance over the past two years, although system integrators report more improvement than do Tier 1 and Tier N suppliers. It is important to understand the influence of integration and collaboration efforts to this PDD improvement.

The focus on PDD efforts in the past was largely on internal integration, involving attempts to improve communication and coordination across internal functional units such as manufacturing, marketing, and engineering. This is still a major focus, and these suppliers do report that internal integration efforts have been very important as sources for their improved PDD performance over the past two years. The interviews reveal they are working on simultaneous and concurrent engineering on a global basis, and are also developing internal standards to support this global engineering initiative. As one interviewee noted, "In concurrent engineering, better ideas change the process worldwide simultaneously."

> In concurrent engineering, better ideas change the process worldwide simultaneously.
>
> – OSAT Interviewee

However, there is a somewhat newer wrinkle to these PDD efforts, and that is the focus on customer collaboration. Indeed, these suppliers report that customer collaboration is "moderately" to "very important" to their PDD improvement. Across all nine activities we explored, PDD, along with Quality, have the highest ratings for the contribution of customer collaboration to improved performance. This is probably due to the OEMs' focus on ensuring that their suppliers understand their requirements. But the process is moving slowly as one interviewee reports, "One barrier is having to move at the customer's speed. I don't see us developing more capability than they can handle. OEMs move slowly."

On the other hand, external collaboration with suppliers is of moderate importance to PDD improvement, and the interviews suggest that there are only

> One barrier is having to move at the customer's speed. I don't see us developing more capability than they can handle. OEMs move slowly.
>
> – OSAT Interviewee

limited initiatives under way here. However, we expect the next generation of PDD efforts will involve a more intense focus on system integrators collaborating with their own suppliers in PDD. This is based on the same twin rationales that have sparked the transfer of PDD to system integrators: the higher expertise and lower costs often found in the supply base. Collaborating with suppliers in PDD may be the next major source of competitive advantage for system integrators, much as it has been an important advantage for early-implementing OEMs.

As noted earlier in our discussion, there are some important potential sources of supplier PDD expertise for system integrators to draw upon: the current Tier N suppliers who worked directly with OEMs in the

*continued on page 32*

## Engineering Change Notices and Customer Collaboration

The engineering change notice (ECN) is one of the industry's most costly practices. As one supplier noted, "Today, the problem is that ECNs are not well coordinated, in fact, they can conflict with one another. Engineering change control is not synchronized, and there is lots of re-work." Suppliers in our survey report that ECNs are "often" communicated electronically with customers, and they expect the frequency of communication to increase. There are substantial tier effects concerning ECNs. System integrators report communicating electronically more often with their customers about ECNs, both today and in the future, than do Tier 1 and Tier N suppliers.

Suppliers have long been ambivalent about ECNs and their effect on customer collaboration. Suppliers generally do not like ECNs because they tend to occur late in a program, giving suppliers less time to test and validate the effects of the changes on their component or system, which, in turn, can affect quality ratings. As more responsibility for PDD is transferred to the supply base, we expect the number of ECNs to decrease. But if OEMs continue "shadow" engineering and force suppliers to make late changes in a program, this situation may become a bone of contention in terms of warranty responsibility (See Warranty Responsibility and Customer Collaboration discussion on page 37).

On the other hand, some suppliers rely on ECNs to negotiate the final cost of a program. Most contracts allow for increased costs due to ECNs, and some suppliers bid low on a program knowing the final cost will increase because of them. Suppliers also use ECNs for leverage in warranty negotiations. Late changes to a program that are not adequately tested and validated become justification for warranty cost sharing. Finally, suppliers find managing ECNs well creates a good working relationship with their customers which can lead to future business.

Given the importance of ECNs to the cost structure of a program, it is surprising that tracking the number of ECNs is one of the metrics used least often by supplier executives to track improvement efforts. Considering the potential cost ramifications of ECNs, we expect this metric will increase in importance in the near future.

past and have a reservoir of such experience and relevant knowledge to offer, and the enhanced Tier N suppliers who will come from the ranks of current Tier 1 suppliers. These suppliers offer system integrators opportunities to develop extremely capable and innovative supply chains.

### *e-Product Design and Development*

Our research explored the patterns of electronic communication in the PDD process, assessing how often a variety of PDD-related communications occur between suppliers and their customers. In effect, these communications reflect activity levels across different types of collaborative efforts with customers. We queried the suppliers in regard to drawings, engineering change notices (see discussion on page 31), product data, project plans/work breakdown structures, quality specs (PPAP), and target cost and financial information.

Suppliers "often" electronically communicate drawings, engineering change notices, and quality specifications, while they communicate product data, project plans, and target cost and financial information less frequently—"sometimes," in terms of the scale. This second set of PDD items may demand less frequent communication. Suppliers do indicate that they expect the frequency of electronic communication for each of these items to increase over the next 24 months. They expect the greatest increase to take place in quality specification (PPAP data), product data, project plans/work breakdown structures, and target cost and financial information.

There are substantial tier effects on these electronic communication patterns. System integrators report more frequent information flows with their customers in drawings, engineering change notices, and target cost and financial information. We cannot tell if this increase in communication between system integrators and their customers is initiated by the system integrators or by their customers, but it probably occurs because of the importance and complexity of the systems they engineer.

### *Product Design and Development Efforts*

The importance of PDD to supplier success is also seen in the current integration and collaboration initiatives of suppliers. We collected information on current efforts from both our survey and interviews. As shown in figure 20, our survey of suppliers shows their companies currently initiating a variety of

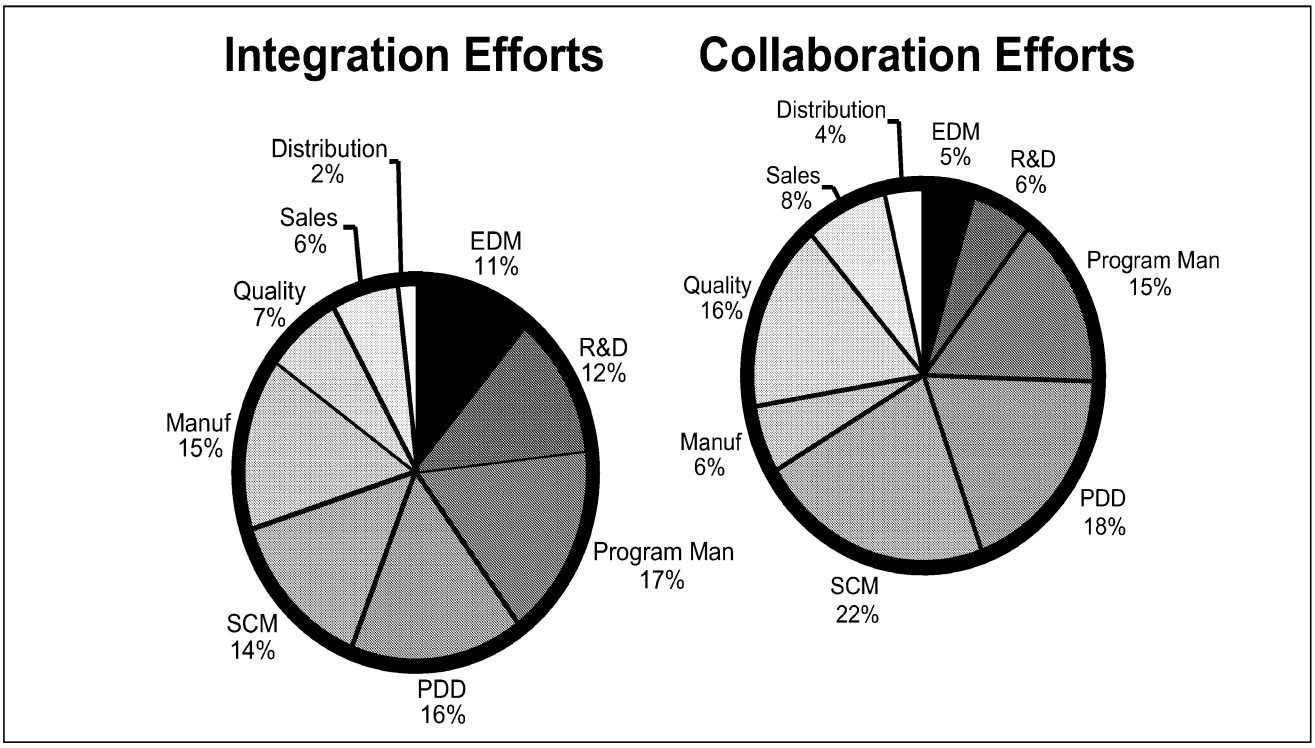


**Figure 20. PDD is the second most-reported integration and collaboration initiative.**

integration and collaboration efforts with PDD initiatives representing the second most-often reported integration and collaboration initiative.

We also asked interviewees about their company's integration and collaboration efforts. Suppliers report that they are about half way to their product design and development integration goals, and the efforts they report show they are focusing on areas that prepare them for becoming global competitors. They most often report efforts in the areas of adopting internal global standards for engineering and sourcing, as well as common global vocabulary and metrics. They are also essentially re-designing their organizations by implementing both global product development teams and cross functional teams for simultaneous design and engineering. To a lesser extent, they are instituting virtual design and engineering processes, and integrated, Web-based CAD and CAE. These issues have been discussed for the past decade as areas suppliers will need to develop if they are to evolve into system integrators, but it is clear from our supplier responses that these issues are only now gaining serious attention and momentum within their organizations.

Although suppliers in our survey report they are further along in their collaboration with their customers than with their suppliers in PDD, our interviewees reported a number of initiatives to collaborate with their suppliers as well as ones involving their customers.[17] Suppliers report collaboration with customers taking place through co-location of engineers on customer product platform teams and work on system contracts. They also report collaborative links developed through portals and common software used for PDD.

Our supplier interviewees highlighted the leadership of OEMs in collaborating with them. A number of suppliers noted that they are waiting for OEMs to take the lead in collaborating. On the other hand, supplier interviewees report they are building Web-based tools to collaborate with both customers and suppliers in activities like EDI and engineering releases.

In terms of specific supplier to supplier collaboration in PDD, interviewees report some co-located cross-functional teams, and collaboration through links such as portals, common software, or computer-aided design (CAD). But other suppliers report that though they may be exchanging drawings with their suppliers, they are not truly merging business processes. These efforts reveal that some companies are taking advantage of their supply base's expertise, but they still seem in the quite early stages of actually merging business processes between PDD organizations.

## *Barriers and Facilitators to Integration and Collaboration in PDD*

### *PDD integration*

Interviewees report that the majority of barriers to internal integration of PDD are *organizational* in nature: global variation/complexity in products and services, conflicting goals, the organizational mindset/culture, and the need for a quick return on investments.

The rest of the reported barriers are distributed equally across process, people, and technology. *Process* barriers center on the need for standards and the challenge of changing work behavior. *People* barriers include the lack of skills needed to implement major change and the need to overcome pockets of resistance. *Technology* barriers consist of the problems of having multiple and legacy systems, the cost of the systems, the technology gap between what people want and what is available, and, in a few cases, even Internet connectivity.

Facilitators of PDD integration are fairly evenly distributed across the organizational, process, people, and technology categories. No one type of *organizational* facilitator stands out: A cost improvement culture and a global structure and organization are two of the most often mentioned facilitators. Interestingly, for some companies, being global was considered a barrier. Perhaps it is also critical for global companies to have a continuous improvement culture, a major source of integration. Among *process* facilitators, interviewees consider developing standards and common processes and, to a lesser extent, Six Sigma programs and an in-place change management process as key. Having skilled people in place, proper training, and support from top executives are

[17] This may reflect our choice of interviewees. We deliberately chose companies we had reason to believe are more advanced in integration and collaboration efforts.

reported to be the top *people* related facilitators. The most often reported *technology* facilitator is the need for common software to integrate PDD processes.

### *PDD collaboration*

The barriers to collaborating with customers and suppliers in PDD are many and complex. When talking specifically about collaborating with their customers, suppliers focus on two main barrier areas: organizational and technological. The most often reported *organizational* barrier concerns supplier confidence in their customers' protection of the suppliers' intellectual property. This barrier reflects customers bidding out a supplier's design, but also the complex issue of some customers also being competitors. One of the more interesting challenges reported by suppliers concerned the OEMs' definition of "common." One interviewee said, "OEMs aren't as common as they think they are. We have examples of parts differing between the same vehicle and same OEM in different locations, yet the global price for the part is based on a standard that says things aren't different. The OEMs say they don't care. They know the parts are different, but the business is awarded as if the parts are the same globally. This is the internal conflict. Uncommon becomes common."

OEMs aren't as common as they think they are. We have examples of parts differing between the same vehicle and same OEM in different locations, yet the global price for the part is based on a standard that says things aren't different. The OEMs say they don't care. They know the parts are different, but the business is awarded as if the parts are the same globally. This is the internal conflict. Uncommon becomes common.

– OSAT Interviewee

The *technological* barrier most often reported is the challenge of dealing with the multiple legacy systems of OEMs and the multiplicity of CAD/CAE systems. One supplier is hopeful that Covisint will aid the industry in this area: "I saw a glimmer of hope in Covisint. If the OEMs said they would use the same collaborative tools through Covisint, that would help a lot, but they haven't done that. They see collaboration as a competitive differentiator. It may be a pipe dream to think that we will ever collaborate through Covisint."

I saw a glimmer of hope in Covisint. If the OEMs said they would use the same collaborative tools through Covisint, that would help a lot, but they haven't done that. They see collaboration as a competitive differentiator. It may be a pipe dream to think that we will ever collaborate through Covisint.

– OSAT Interviewee

Collaborating with suppliers in PDD is also a multi-faceted challenge. On the *organizational* level, there is the problem of the extreme differences among Tier N suppliers in terms of their process capability and their resources for financial investments. Still, some of these challenges mirror the Tier 1 supplier challenges in dealing with their OEM customers. Some find their processes being shared among competitors, but they also understand that their relationships have been very cost- and black box-driven, creating a build-to-print-at-low-cost philosophy that does not easily lend itself to collaboration.

Interviewees also note that Tier N suppliers have many customers and that only if they are the main customer can they influence system decisions. The variability of Tier N suppliers in terms of capability and resources is shown by their lack of processes that system integrators can access. As one interviewee reported, "They adapt to change, but they have no systems." *Technology* is seen as one of the major barriers to supplier collaboration in PDD. Some Tier

N suppliers have only a fax machine while others have only one computer on site. One interviewee described the plight of many Tier N suppliers, "There are extreme technology barriers with many of our suppliers. They are not on the leading edge of IT and making change is all about what the ROI is in better collaboration. It's more of a survival mode for suppliers. There are a handful of companies today who have that capability." Many system integrators and Tier 1 suppliers have gone off shore to recruit Tier N suppliers, and they find many of the same technology and process challenges apply there as well.

There are extreme technology barriers with many of our suppliers. They are not on the leading edge of IT and making change is all about what the ROI is in better collaboration. It's more of a survival mode for suppliers. There are a handful of companies today who have that capability.

– OSAT Interviewee

Interviewees describe similar facilitators for externally collaborating with their customers and suppliers. They consider long-term relationships and co-location as the two main *organizational* facilitators, although collaborating with customers demands a more global view of co-location. One supplier sees real advantages in having its suppliers co-located, "When we target key suppliers, they are co-located with us. We do technology sharing with them. Sometimes they bring experience from other industries and from other auto companies. They sometimes show us different systems and ways of doing things." Suppliers also see standards and common processes as important *process* facilitators to collaborating with customers. A statement of work that clearly defines the roles and responsibilities can avoid shadow engineering by customers and promote effective collaboration and cost reduction. Having knowledgeable *people* with good communication skills and the power to make binding decisions as project leaders is a facilitator, particularly in regard to customer collaboration.

When we target key suppliers, they are co-located with us. We do technology sharing with them. Sometimes they bring experience from other industries and from other auto companies. They sometimes show us different systems and ways of doing things.

– OSAT Interviewee

Interviewees list a number of *technology* enablers for collaborating with both customers and suppliers. These include central repositories, private networks, and virtual collaboration tools, as well as the Internet. Interviewees view these as leading to more common processes.

### *Future State of Product Design and Development*

In the future, suppliers will develop and expand their PDD competencies, providing value to their customers. The demands on their expertise will increase, and their responsibility will also grow. Internal effectiveness and customer collaboration will be key, but a major competitive differentiator may well be how effectively suppliers can collaborate with their own suppliers.

Suppliers will require strong and reliable customer partnerships, and become more profitable by adding more value, eliminating waste, lowering transaction costs, and restraining duplicative efforts. We expect these challenges to be influenced by the supplier's tier position, and system integrators, with primarily OEMs as customers, probably facing the greatest challenges.

Much of the benefit of improved PDD will come through associated improvements in SCM, to which we now turn.

## 5. Supply Chain Management: Great Risks, Great Opportunities

*Suppliers consider SCM the major focus area for driving out costs, but collaboration needs to extend beyond traditional partners.*

Again, the nature of the automotive industry calls for competitive activities and decisions to be optimized at the system level. The only way to accomplish this is for each tier of the industry to carefully manage its own suppliers. That requires supply chain management (SCM), a set of activities addressing the performance of the supply base that go far beyond the traditional market-test and purchase decision. Companies must manage collaborative efforts with suppliers much as they are learning to manage collaborative efforts with customers. The traditional barriers between companies must be made more permeable so that the value chain can compete effectively.

But the industry has recognized that SCM is difficult. It is not easy to maximize the efficiency of the chain across so many dimensions. The supply chain must provide world-class quality, innovation, and delivery, as well as service customers around the globe, all while pressured by demands for cost reductions and intense competition.

Suppliers report that their supply chain management capabilities will be "quite critical" to their survival over the next five years. Nevertheless, SCM ranks below a number of other challenges, such as profitability, operational performance, innovation capability, customer satisfaction ratings, and PDD capability. Still, suppliers report some improvement in their SCM performance over the last two years similar to improvements in almost all the other eight activities we measured. There are also tier effects here, as system integrators and Tier 1 suppliers see SCM as more critical to their survival than do Tier N suppliers.

As figure 21 shows, suppliers expect that they will have more responsibility for SCM over the next five years, while OEMs will have a little less responsibility. System integrators will experience the largest increase. It merits mention that this pattern applies to all of the areas we asked about: PDD, SCM, total life-cycle product cost, and warranty cost. These results affirm the emerging importance of system integrators in the industry, both as performers of activities, and as critical links in the industry's value chain.

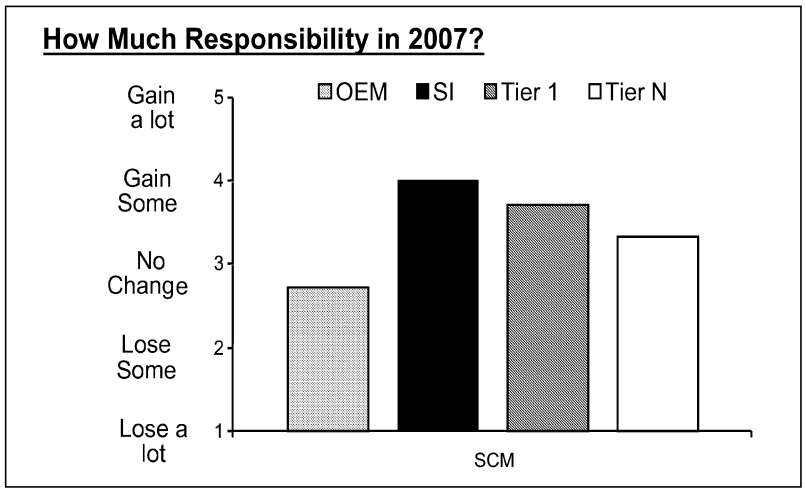


**Figure 21. System integrators and Tier 1 suppliers will gain more responsibility for SCM.**

### *Pace of Change*

SCM is currently the least developed internal integration effort by quite a wide margin. Suppliers report they are about one quarter of the way toward their goal, although they expect their integration efforts to be nearly three quarters of the way complete in two years. A similar trend applies to their external collaboration with customers and suppliers. External collaboration with suppliers is an area where suppliers expect more progress in SCM over the next two years.

### *Functional differences*

IT executives think their companies will make more progress in SCM integration and supplier collaboration over the next two years than do general management executives. This is an intriguing difference. If there is an IT component to these efforts, which there almost always is, then IT personnel may have a better and more accurate understanding of what the outcomes will be. But general management

*continued on page 38*

## Warranty Responsibility and Customer Collaboration

Our survey indicates a major shift in warranty responsibility is under way across the entire supply base. Specifically, as shown in figure 22, we found that suppliers believe OEMs will "lose some" responsibility for warranty cost by 2007 and that suppliers, especially system integrators, will "gain some" responsibility by 2007. The changes in warranty responsibility are the largest among a list that includes expected shifts in product design and development, supply chain management, and total lifecycle product cost.

Our survey also suggests that warranty information is one of the least often electronically communicated types of information between suppliers and customers. Suppliers report warranty information is "sometimes" communicated electronically with their customers today, but they expect to "often" communicate warranty information electronically in 24 months.[18] This is the largest increase in communication frequency among the 14 types of electronic information exchanges we assessed. System integrators indicate they "sometimes" communicate electronic warranty information today while Tier 1s and Tier Ns indicate they communicate this information "once in a while." This difference across tiers may reflect differences in the pattern of responsibility transfer across tiers to date.

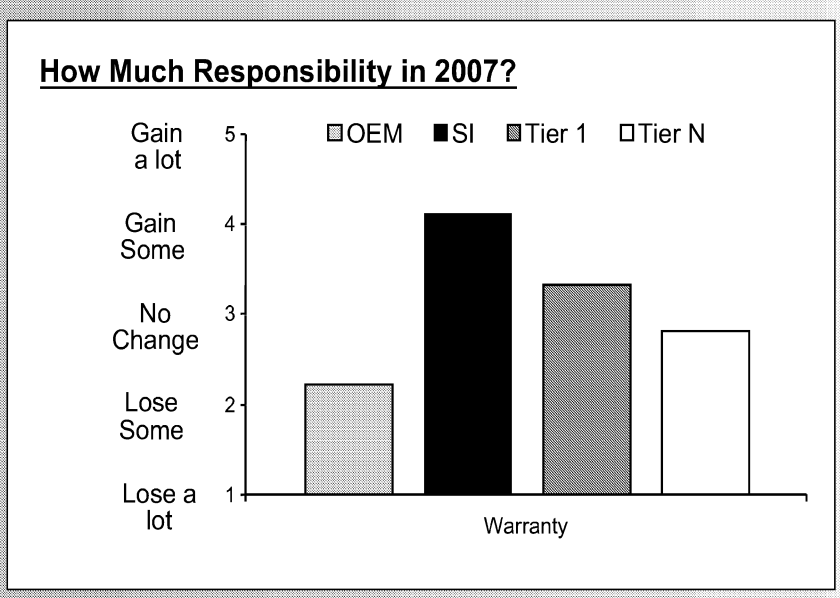


**Figure 22. Suppliers expect a major shift in responsibility for warranty to system integrators.**

These findings prompted us to ask interviewees directly whether they believed the lack of warranty communication was a problem and whether they expected to see more transfer and use of warranty information. The response was essentially unanimous:

Suppliers feel the current systems for analyzing the source of parts' failures are inaccurate and unclear. Interviewees also expressed concern about the quality of dealer data and commented that the current system lacks visibility and standard dealer coding.

Given the trend to transfer responsibility throughout the supply chain and the possible extension of warranty beyond seven years, suppliers have become increasingly concerned about tracking warranty information. Not only are suppliers concerned about identifying an IT solution to mediocre warranty communication, but they also want a process solution, so liability responsibility can be clearly demarcated. This will require patient negotiation with customers—a task more easily contemplated or dictated than undertaken and completed.

18 The scale points used for this question include: rarely, once in a while, sometimes, often, and continually.

may better understand how the complexity of the efforts and resistance to change may slow the progress of these initiatives. This is a case where the different views may indicate useful boundaries for the prediction.

### *IT investment*

Companies that invest more (greater than 1.5 percent of revenue) on IT report they are closer to their goal of internally integrating their SCM processes than are companies that spend less on IT. Today there is a strong IT component to most SCM efforts, so IT may be provide an edge in internally integrating such efforts. Again, it may be the development of Web-based software (noted in the introductory facilitators and barriers discussion) that supports this accelerated development.

## *Sources of Improvement*

Suppliers report that they have made "some improvement" in their SCM performance over the past two years, and that internal integration efforts have been "very important" in achieving that improvement. They report that collaboration with customers is "moderately important" to their improvement, and that collaboration with suppliers is "very important."

Again, there are some tier effects. System integrators report that collaboration with customers is considerably more important to their SCM improvement than do Tier 1 suppliers. We suspect this is good for system integrators, if only because they are paying more attention to the secondary link, and we think that is important. Smooth performance across the chain requires paying attention to secondary as well as primary links. Part of the primary link with suppliers focuses on scheduling. As one supplier noted, "We're driving to level schedule our facilities rather than whipsawing our suppliers with changing schedules, but it depends on how lean our facilities are to react to our customers. We need to have the right tool to do that work with suppliers."

Suppliers consider their integration and supplier collaboration efforts to be more important for SCM performance improvement than are their customer

We're driving to level schedule our facilities rather than whipsawing our suppliers with changing schedules, but it depends on how lean our facilities are to react to our customers. We need to have the right tool to do that work with suppliers.

– OSAT Interviewee

collaboration efforts. Moreover, companies that report "great improvement" in SCM report their integration and supplier collaboration efforts are significantly more important to that improvement than do those companies that report only "some improvement." Companies reporting "great improvement" also expect to make more progress to their SCM goals in two years, both in integrating their internal processes and in both forms of external collaboration.

Suppliers report they are trying to keep the OEMs at arms length when it comes to supplier selection. A few interviewees report instances of OEMs trying to pressure suppliers to give work to Tier N suppliers that the system integrator or Tier 1 supplier had already decided to de-source. OEMs may have a larger pool of suppliers to draw on, but forcing specific relationships upon suppliers can compromise their daunting task of building supply chains capable of supporting global OEMs.

Suppliers report the continuing emphasis on cost reduction over adding value is a challenge when dealing with the purchasing function at some OEMs. Purchasing agents reward structures all too often compensate them based on the cost taken out of the part, focusing the agent's efforts on reducing cost rather than on adding value. Sometimes this can result in perverse outcomes. One supplier reported a collaborative experiment among three Tier 1 suppliers. Working together, they were able to design a system that combined their individual parts and reduced cost and added value. Yet the OEM rejected the design because the cost of one part was not reduced, and the relevant purchasing executive refused to approve the new system. If the purchasing system were

flexible enough to reward reducing cost by introducing a previously undefined system, the supplier and the OEM would have benefited. Again, system or vehicle optimization is key.

Unfortunately, suppliers all too often fail to implement the lessons they learn as a supplier when acting as a customer. Thus they report, as shown in figure 13 earlier in the report, that their current integration and customer collaboration efforts are driven by the need to add value and reduce cost. However, their external supplier collaboration efforts are driven more by the need to reduce cost. As OEMs' cost and value strategies undercut their long-term competitiveness, so will similar suppliers' strategies with their suppliers.

Supplier consolidation could play an important role in the future development of SCM. Like the OEMs, system integrators and major Tier 1 suppliers would rather work with fewer, more capable suppliers. The pressure on margins that eventually works its way down the supply chain may force many Tier N suppliers to merge with or acquire other suppliers to expand both their engineering expertise and their financial resources to support their growing role in the industry. How that consolidation should occur is an open question. Should Tier N suppliers consolidate around the same activity to increase scale economies or should they combine to share a larger part of value-add activities such as PDD? As noted in the Industry Evolution section, there is also a potential source of future expertise from the Tier 1 suppliers (enhanced Tier N suppliers) who expect to function as Tier N suppliers within the next five years.

**Intellectual Property Protection and Customer Collaboration**

Some of our interviewees report that collaboration with OEM customers in SCM (including purchasing) has sometimes led to their proprietary designs being "shopped" to other suppliers. These companies feel that keeping their intellectual property rights is important to avoid or at least delay their products becoming commodities. When OEMs violate a supplier's intellectual property rights, they may threaten the supplier's survival. A number of suppliers report that they are selective in what they share with certain customers, based on the OEM's past failure to protect the supplier's intellectual property.

### *e-Supply Chain Management*

Our research explored the patterns of electronic communication in the SCM process, assessing how often a variety of SCM-related communications occur between the suppliers and their customers. In effect, these communications reflect levels of collaboration with customers in a range of activities. These communications include advanced shipping notices, forecasts, inventory information, part BOM (bill of materials), process data, shipping schedules, and supplier capacity constraints.

Advanced shipping notices and shipping schedules are communicated "very often," forecasts "often," inventory information, process data, and part BOMs "sometimes;" and process data and supplier capacity constraints "once in a while". While one might think that all of these SCM exchanges do not demand continual communication, suppliers do indicate they expect the frequency of electronic communication for each item to increase substantially over the next 24 months. They expect significant increases in the frequency of electronic communication of inventory information, process data, supplier capacity constraints, forecasts, and part BOM.

It is interesting that Tier N suppliers report receiving less frequent electronic communication from their customers (typically system integrators and Tier 1 suppliers) than system integrators and Tier 1 suppliers receive from their customers (the OEMs). This may partially reflect the system integrators' and Tier 1 suppliers' inability or unwillingness to send this information, and it could also result from the Tier N suppliers' inability to receive it. There is no question that certain infrastructure and standardization issues continue to challenge e-SCM.

Some of these exchanges can also be useful metrics used in executive decision-making (EDM). In particular, forecasts, inventory information, and supplier capacity constraints seem appropriate inputs for EDM. They can offer supplier executives insight into the mechanics of their relationships with customers, as well as some detailed information about SCM processes and activities.

## *Supply Chain Management Efforts*

The importance of SCM to supplier success is also seen in the current integration and collaboration initiatives of suppliers. We received information on current efforts from both our survey and interviews. The importance of SCM to supplier success is quite clear in their survey responses about their current integration and collaboration initiatives. As shown in figure 20 on page 32, SCM initiatives represent one of the most often named current integration initiatives; however, SCM is the most often named collaborative initiative. This result represents the importance suppliers give to overcoming the challenges of SCM, as well as the opportunity this effort offers the organization.

### *SCM integration efforts*

Interviewees shared quite a bit of information about their company's integration and collaboration efforts. Suppliers report that integrating SCM is the least developed activity in their companies, though they also report many initiatives in progress. The higher level activity may be because suppliers think they are behind in development of SCM. Interviewees' comments about their current SCM integration efforts reveal the difficulty of the SCM challenge. They note a number of efforts to develop SCM globally, such as building global SCM capability, developing global sourcing, even managing the company's spend on a global basis. Similar to PDD, SCM demands setting up processes that flow equally well up and down the supply chain, touching both their suppliers and their customers. Costs abound in these types of activities, and it may be in the system integrator's best interest to reduce the number of its own suppliers by encouraging the consolidation of the Tier N supply base, similar to what the OEMs pursued in the case of Tier 1 suppliers beginning some ten years ago.

Our supplier interviewees mentioned specific SCM business processes such as globally standardizing processes and part numbers. One company is mapping the supply chain for its products, tracing material flows from its own supplier's supplier to its customer's customer. This map includes planning, sourcing, manufacturing, delivery, and warranty-return as well as the more traditional logistics.

The Enterprise Resource Planning (ERP) system is by far the most often reported information technology enabler in the integration of SCM. Some supplier interviewees are just now deploying ERP, while some are trying to standardize on a few systems globally. This need to standardize reflects the fact that so many different systems have already proliferated throughout the numerous plants and divisions characteristic of system integrators and large Tier 1 suppliers. A number of very competent plant level ERP vendors exist in the industry today, but larger suppliers may need to gravitate to systems that can scale to meet their future global needs.

### *SCM collaboration efforts*

Collaboration with customers in SCM tends to be based on electronic communication, primarily EDI, which comes in a number of forms. Our interviewees report that Web-EDI, particularly EDI-XML, offers the industry a standard that could significantly lower supplier costs and better connect the total supply chain. For collaboration with their customers, suppliers see the basic EDI transaction as mature, but currently more of a batch rather than a real-time system. It provides a one-way push of information from OEMs to their suppliers. In contrast, Web-EDI supports a two-way flow of information that can be used to track the history of transactions and offers visibility across the entire supply chain. Suppliers report using this electronic medium for diversity reporting, inventory visibility, sequencing, packaging, logistics, materials compliance, and component end of life issues.

Because the OEMs generally specify which systems will be used, suppliers report they must be care-

ful not to take on too many new initiatives or to duplicate their efforts. This is an area where some suppliers report groups like the Automotive Industry Action Group (AIAG) or perhaps Covisint can play a useful role in setting some process standards that aid the entire industry.

Although our survey respondents reported that their collaboration with their suppliers is very important to their improvement in SCM, our supplier interviewees tended to describe their collaborative efforts with phrases like "moving toward." As noted in the PDD discussion, suppliers feel they must wait for the OEMs to define what forms of collaboration will take place with the OEMs. Suppliers, on the other hand, are free to decide how they will collaborate with their suppliers. Yet they seem as slow as the OEMs in setting up the necessary systems for SCM collaboration. They do see the potential for collaboration, as well as for some specific tools, like Web-EDI. Suppliers also do not seem to be waiting for the OEMs to develop a unitary system across the value chain. As one supplier noted, "The Web investment between OEM and Tier 1s is already there, but not between Tier 1 and Tier N. That's the key opportunity." They simply have not yet made the investment in systems to connect with their supply base.

> The Web investment between OEM and Tier 1s is already there, but not between Tier 1 and Tier N. That's the key opportunity.
>
> – OSAT Interviewee

For the suppliers who are collaborating with their suppliers, the tendency is to focus first on their key high volume suppliers. These suppliers may sometimes be large materials suppliers who have the systems and personnel to work in a collaborative manner. But many other Tier N suppliers are neither as large nor as capable. As one interviewee observed, "Sometimes suppliers are so small it's hard to understand who is capable." One supplier reports beginning to include their suppliers in the release cycle including BOM (bill of materials) and engineering change notices (ECNs)

> Sometimes suppliers are so small it's hard to understand who is capable.
>
> – OSAT Interviewee

Another supplier described an electronic bar code process that is intended to move the supply base toward a paperless process. This Tier 1 supplier has initiated a program where all parts are bar coded, and all documents including the contract and automatic shipping notices (ASNs) are available electronically. This company encourages its suppliers' participation by offering a pay-on-receipt process that is linked directly to the bar coding. Thus when a component arrives at the Tier 1 supplier, the bar code is scanned, and if the electronic contract, ASN, and bar code scan are all in place, the Tier N supplier is paid immediately. This process is designed to be paperless and offers both parties advantages: The Tier 1 supplier and the Tier N suppliers have a real-time view of their inventory and can use a form of vendor managed inventory (VMI), while the Tier N supplier is paid much faster.

## *Barriers and Facilitators to Integration and Collaboration in SCM*

### *SCM integration*

The barriers to internal integration of SCM are primarily organizationally and process-oriented. The *organizational* barriers center on problems of change management at both the plant and personnel levels. People respond to incentives, so these must change in order to generate the desired change in behavior. There are also problematic organizational structures, especially in how purchasing relates to other functions. The *process* barriers include failure to take a holistic view of sourcing, such as failing to use a total cost model and failing to re-design processes effectively, for example, optimizing a single process element rather than the entire process or failing to

establish common processes in all areas. The challenge of legacy systems and processes are other important process barriers.

The facilitators of internal integration of SCM, like its barriers, are primarily organizational and process related. In the *organizational* arena, executives report that it is important to have strong leaders driving initiatives. They also report that a global company demands internal information that moves quickly. Our interviews yielded two illustrations of how structure can influence SCM performance. One is an example of one of the strengths of centralized structures: The respondent reports that combining various divisions produces "uniform global common company measures that focus on total costs." The other suggests a strength of decentralized structures: Each of the divisions acts as an individual entity, allowing information to travel faster. One system integrator also notes that the pressure of becoming an effective module supplier speeds up information transfer across the organization.

Respondents report that common and standardized business processes that connect the company are important *process*-related facilitators. One interviewee reports, "Our goal is for different functions externally and internally to have the same agenda. If we change IT, it needs to go to all the IT people who are touched by the process. We have a knowledge/learning checklist that helps us make sure we're connecting with everyone."

Our goal is for different functions externally and internally to have the same agenda. If we change IT, it needs to go to all the IT people who are touched by the process. We have a knowledge/learning checklist that helps us make sure we're connecting with everyone.

– OSAT Interviewee

Process also plays a role in SCM metrics: "We're working on metrics that cut across organizations: common metrics that show how a process will impact the unit and the company."

We're working on metrics that cut across organizations: common metrics that show how a process will impact the unit and the company.

– OSAT Interviewee

### *SCM collaboration*

Some of the reported barriers to SCM external collaboration apply to both customers and suppliers. This is the case with many *process* barriers involving the lack of standards for the bill of materials (BOM), engineering change notices (ECNs), and workflow. One supplier reports that improved workflow, "will help solve the timing and coordination conflict. We could save 30 percent of the time consumed in the program."

(Improved workflow)…will help solve the timing and coordination conflict. We could save 30 percent of the time consumed in the program.

– OSAT Interviewee

But some important *organizational* issues also confront companies, including reduced funding for business process redesign and a very interesting catch-22 situation in the use of technology to support business process redesign. An interviewee explains, "Functional organizations and divisions have unachievable financial targets without changes to business processes that technology can enable. But when the technology investment has to be made, the financial hurdle rates (ROI) for the business process

change are difficult to achieve." The *technology* challenges include the need for SCM visibility to include images as well as information and the challenges of effectively handling the sheer volume of data and accompanying security issues.

> Functional organizations and divisions have unachievable financial targets without changes to business processes that technology can enable. But when the technology investment has to be made, the financial hurdle rates (ROI) for the business process change are difficult to achieve.
>
> – OSAT Interviewee

In terms of barriers related directly to SCM collaboration with customers, suppliers report four main areas of concern. First, given the number and instability of OEM programs, suppliers are wary of taking on too many different initiatives. Second, the costs of making changes in supply chain systems are large, and suppliers feel they do not have access to sufficient capital to implement changes. For example, one supplier notes, "Suppliers are spending 1 percent of sales on software, not 3 percent like the OEMs." Third, the way credit is assigned for cost savings is often capricious, with multiple programs taking credit for the same cost savings. Finally, suppliers report the need for more consistent and timely communication of program changes from their customers.

> Suppliers are spending 1 percent of sales on software, not 3 percent like the OEMs.
>
> – OSAT Interviewee

The capability of Tier N suppliers to meet the demands of SCM collaboration is probably the major barrier to that collaboration. Some system integrators and major Tier 1 suppliers are uncertain of their supply chain's ability to support OEM initiatives. For some of their suppliers, system integrators have to reformat information into spreadsheets their Tier N suppliers can access, and there is always a cost issue for Tier N suppliers, especially in the area of instituting new business processes. Moreover, the lack of a transparent IT infrastructure is very apparent at this level of the supply chain. Finally, some system integrators and major Tier 1 suppliers worry that technology transfer and development of their suppliers could create a future competitor from the more capable Tier N suppliers.

The general facilitators that apply to both customer and supplier SCM collaboration center on developing industry standards for processes like the bill of materials (BOM), engineering change notices (ECNs), and workflow. They include developing central repositories that support a fully exploded BOM and tools to allow true SCM collaboration. The facilitators for customer SCM collaboration include large volume contracts that force each party to value more highly the need for collaboration, and better communication of plans, changes, and areas for improvement. This type of collaboration will eventually lead to better warranty resolution. Better collaboration with suppliers will occur, according to interviewees, through level scheduling that permits smaller batches and lower buffer inventories, electronic payment processes that speed up payment, more uniform processes for evaluating suppliers, and supplier follow-up people to facilitate the collaboration.

### *Future State of Supply Chain Management*

Suppliers in the future will have holistic views of their supply chains that provide visibility from customer to lower tier suppliers. These suppliers will deliver the right product to the right place at the right time at the lowest cost, achieving a level of excellence that is rewarded with new business opportunities. Collaboration with customers will have moved beyond receiving a just-in-time (JIT) schedule to one that engages many supplier SCM activities, such as identifying new sources of materials, involvement in lean practices, and Six Sigma projects.

Suppliers of the future will have integrated internal systems that will provide efficiency and visibility. Suppliers will be more capable of responding to events such as an unplanned production disruption without today's cost-adding expedited fire drills. In the future, suppliers will be able to react earlier, faster, and with more options.

As result, the supply chain becomes holistic. It avoids optimization for a single specific measure, which can create unintended upstream or downstream conflicts and costs. With the supply chain working from timely and visible information for both demand and supply sides, real waste and cost can be removed. A supply chain such as this can be a more efficient "pull" mode of operation because proper inventory and safety stocks are in place, ensuring the optimal satisfaction of actual demand.

# Summary and Recommendations

## Summary

Automotive suppliers, especially system integrators, face extraordinary pressures as the industry transitions to a "higher responsibility" business model that includes enhanced supplier roles in product design and development (PDD), supply chain management (SCM), and expanded consequences of executive decision-making (EDM). The combined requirements of global reach, continuous innovation and quality improvement, and increased speed, all within the context of operational profitability and constant cost-reduction pressures, make this transition extremely challenging.

In order to manage this transition, suppliers must be able to optimize the integration of their internal processes and their collaboration processes with customers and suppliers. There has always been a certain level of integration and collaboration throughout the industry, but today's e-business practices offer opportunities to combine, streamline, and unify these processes. Supplier companies are implementing these practices, and this report establishes a benchmark for suppliers to measure their own progress, and for OEMs to assess industry-level progress.

The pressure of the transition to the "increased supplier responsibility" business model is encouraging some Tier 1 suppliers to take on the challenge of becoming system or module suppliers (emerging system integrators or ESIs), while other Tier 1 suppliers see a better business case for becoming Tier N suppliers (enhanced Tier N suppliers or ETNs). ESIs will face serious integration and collaboration challenges as they enter the system integrator sphere, while ETNs may offer the industry more capability than is typical of the Tier N supply base.

Supplier companies tend to be further along in their integration efforts than their collaboration practices, but the increased responsibility model demands more of a balance between these two practices. Activities such as PDD and SCM are highly collaborative, so increased responsibility in these activities translates to more collaboration with business partners.

Balance also plays an important role in how suppliers currently view their collaboration with their customers and suppliers. They consider their collaboration with their customers as more important in PDD and collaboration with their suppliers as more important in SCM. Yet PDD is limited by and must build on the collaboration and skill resources of the supply chain and some very capable Tier N suppliers offer system integrators collaborative PDD opportunities. So too, the OEMs offer them collaborative SCM experience. A more holistic, total supply chain view of collaboration by suppliers may yield competitive advantages.

All of these opportunities also present challenges to companies that hope to take advantage of them. Balance is key here as well, with companies utilizing facilitators and overcoming barriers across organizational patterns, human resource or personnel practices, business processes, and information technology for successful implementation.

Specific activities present challenges across the whole industry. In EDM, companies are struggling with internal information that is fragmented across the organization—significantly hampering executives' ability to make major decisions. Companies in the survey that spend more on information technology tend to have information that is more accessible and less fragmented. Reducing the number of engineering change notices in PDD may reduce costs while simultaneously creating a need for a new price and warranty negotiating process. In SCM, suppliers are failing to implement the lessons they learn as a supplier when acting as a customer. As OEMs' cost and value strategies undercut their long-term competitiveness, so will similar suppliers' strategies with their own suppliers.

As the supplier industry continues to evolve, suppliers' competitive success will depend on their ability to function smoothly and effectively with all parts of the value chain. The numerous opportunities for cost savings and process improvement throughout the industry from improved integration and collaboration processes have their own cost issues. But managing the increased responsibility for PDD and SCM throughout the supply chain demands that suppliers have these processes in place. EDM processes must also be in place to give managers the tools needed to guide their companies through these complicated challenges. Without these integration and collaboration processes, suppliers will find their companies gradually replaced by suppliers who can manage the increased effectiveness, efficiency, and speed demands of today's—and tomorrow's—automotive value chain.

## Recommendations

The following recommendations address some ways to jumpstart your collaboration and integration change programs:

1. Internal integration within and across business unit organizations is easier when executive strategies, personnel practices, business processes, and information technology are aligned.

2. Expand business processes to include collaboration with both customers and suppliers across PDD and SCM. Balance collaborative efforts with suppliers and customers.

3. Avoid operational "islands of excellence" that cannot scale and be leveraged. These too often suboptimize, and the incremental improvements they offer can become sources of conflict and lower the holistic value chain effectiveness. Avoiding these "islands" provides global suppliers consistency across geographic regions.

4. Integration of business operations, especially ones that are Web-enabled, can enhance the scaling capability of those lean internal resources. This creates new opportunities so that key skills are more easily mobilized.

5. Move from managing with global financial metrics to more targeted operational ones, enabling faster root cause analysis and quicker resolutions of exceptions. Suppliers must be able to collect, aggre gate, and analyze data so that it enables fact-based decisions. Over time, improved operational metrics will lead to improved financial metrics.

6. Rely on fewer, but more meaningful, operational metrics. Stay flexible to change metrics consistent with changes in business strategies. Achieving better company visibility on key metrics will assist organizational alignment.

7. A supplier's PDD processes, through better customer collaboration, enable a better balance of cost and quality. The avoidance of shadow engineering reduces cost and time, and lessens commodity pricing by customers.

8. System integrators' collaboration with suppliers in PDD efforts will yield payoffs like those enjoyed by the OEMs from similar efforts. Suppliers can contribute significantly to reducing part or module cost and increasing its value.

9. Achieve reliable performance across the value chain by creating new collaborative business processes, company culture, and organizational relationships.

# Bibliography


Belzowski, B.; Flynn, M.S. 2002. *Engine System Development: Change, Challenges, and Value*. Ann Arbor, MI, Office for the Study of Automotive Transportation, The University of Michigan Transportation Research Institute and Eaton Corporation.

Flynn, M.S.; Belzowski, B.M.; Bluestein, B.; Ger, M.; Tuerks, M; Waraniak, J. 1996. *The 21st Century Supply Chain, The Changing Roles, Responsibilities, and Relationships in the Automotive Industry*. Ann Arbor, MI, Office for the Study of Automotive Transportation, The University of Michigan Transportation Research Institute and A.T. Kearney, Inc.

Flynn, M.S.; Belzowski, B.M.; Booms, C. 1998. *Beyond Y2K: Information Technology and the Automotive System Integrator*. Ann Arbor, MI, Office for the Study of Automotive Transportation, The University of Michigan Transportation Research Institute, Baan, and Hewlett-Packard Company.

Heidingsfelder, M.; Benecchi, A.; Dergis, M.; Rasche, J.; Flynn, M.S.; Senter, R. Jr.; Belzowski, B.M. 2001. *Automotive System Integrators: Spiders or Flies in the e-Business Web*. Troy, MI, Office for the Study of Automotive Transportation, The University of Michigan Transportation Research Institute and Roland Berger-Strategy Consultants.

"IP's Come Back In-house," *Automotive Industries*, May, 2003, 6.

Mayne, Eric, "Ford Now Covets Seating, Climate Control," *Ward's Automotive Reports*, 7 April 2003, 1.

Murphy, Tom. "24th Annual Engineering Survey," *Ward's AutoWorld*, March, 2002, 37.

**July 2003**
UMTRI 2003-17

**Office for the Study of Automotive Transportation (OSAT)**
University of Michigan Transportation Research Institute (UMTRI)

2901 Baxter Road
Ann Arbor, Michigan 48109-2150

Phone: (734) 764-5592
Fax: (734) 615-4003

E-mail: bbl@umich.edu
www.osat.umtri.umich.edu

**Oracle Corporation**

Automotive Industry Practice
3290 W. Big Beaver Rd., Suite 300
Troy, MI 48084

Phone: (248) 614-5116

E-mail: john.p.mcglynn@oracle.com
www.oracle.com