Chapter 2
Technology Integration State, Issues, Benefits, and Obstacles

Abstract As a program/project manager, you have understood where your company stands at a global market environment in terms of competitive business strategy, operational business capability, and technology integration needs. After visiting several manufacturing plants and interviewing related people, you found urgent needs of technology integration for improving operational integrity and performance. Unanimously, operational people were really concerned about operational disruption, a primary reason for deteriorating productivity and quality, and they asked your help for resolving this problem. You also found that this problem is closely related to supply, assembly, and delivery processes of automotive manufacturing along inbound and outbound logistics network. Next you may want to dig into for what technologies are available for addressing this operational problem and know their current state, issues, benefits, obstacles, regulations, and others. You recognized that operational disruptions occur because of the lack of visibility among business processes and assets. You noticed that RFID and interoperability technology could resolve most of the operational disruptions. These two technologies received so much industry attentions in the past decade, are still being under further development and validation, and will be expected to bring in a great potential. Other technologies might help address this disruption issue, but because of space limitation, we cannot cover all those technologies. This chapter only focuses on the *interoperability technology* within supply chain management domain. It is legitimate to consider the operational disruptions in the supply chain domain, because the supply chain network includes much more disruptive factors to be resolved than any other business domains. Investigating the interoperability technology is valuable because of its significance and prevalence in the future. Although some variations exist by technology, the interoperability technology would *share the current state, issues, benefits, and obstacles with other new technologies by and large*. Later chapters will discuss more about the RFID in detail.

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Fig. 2.1 Current state of supply chain interoperability

2.1 Current State of Supply Chain Interoperability

The Institute of Electrical and Electronics Engineers (IEEE) (Institute of Electrical and Electronics Engineers 1990) defines interoperability as "the ability of two or more systems or components to exchange information and to use the information that has been exchanged." Interoperability is a futuristic technology that will expect to provide companies with an enormously improved business environment. This section describes the current state of supply chain interoperability. Refer to Fig. 2.1.

2.1.1 No Communication Standard for Product Life Cycle Management

A supply chain consists of several internal and external members. To achieve supply chain profitability, all the supply chain members should work together

Fig. 2.2 Product life cycle

using close and effective information sharing. However, no standard communications exist among the members because of heterogeneity of systems or components. Furthermore, when we extend the scope of business communications beyond the supply chain management, we face much more serious issues. If we classify the product life cycle into three big components, we may end up with (1) design and engineering, (2) supply chain management (including manufacturing), and (3) sales, service, and warranty as shown in Fig. 2.2. The global economy requires that for the entire product life cycle, companies communicate effectively with business partners accommodating all these three components. In particular, close communications and relationship building should start from the early stage of product design, continue through engineering, and manufacturing, to sales, service, and warranty stage. During the product life cycle, these three components send/receive so much information as well (although not shown in Fig. 2.2). For example, sales and service experiences are fed into design and engineering process for current product design improvement or new product development. We need to create a far-reaching connectivity covering the entire space of product life cycle.

As of today, there is no standard universal way of communications between business partners that enables to share necessary business information, such as product specifications, manufacturing specifications, logistics requirements, customer demand, warranty claim records, etc., along cross-functional business units.

Figure 2.3 presents primary tasks for each stage of product life cycle. Companies have used piece meal approaches to fix problems on an occasional basis. As a result, companies have to maintain so many different information and communication systems and tools that cannot talk to one another. As the number of information sources is increasing, lack of interoperability becomes worse than before and moreover, companies are locked in those information systems and tools. As an example, suppose two business units are interdependent and need to share their business information to each other. Because of the lack of interoperability, a change in one business unit cannot be properly reflected to the other business unit. AMR Research Alert (AMR Research 2003) found that 60 % of companies polled have limited or no integration between their frontend and backend systems.

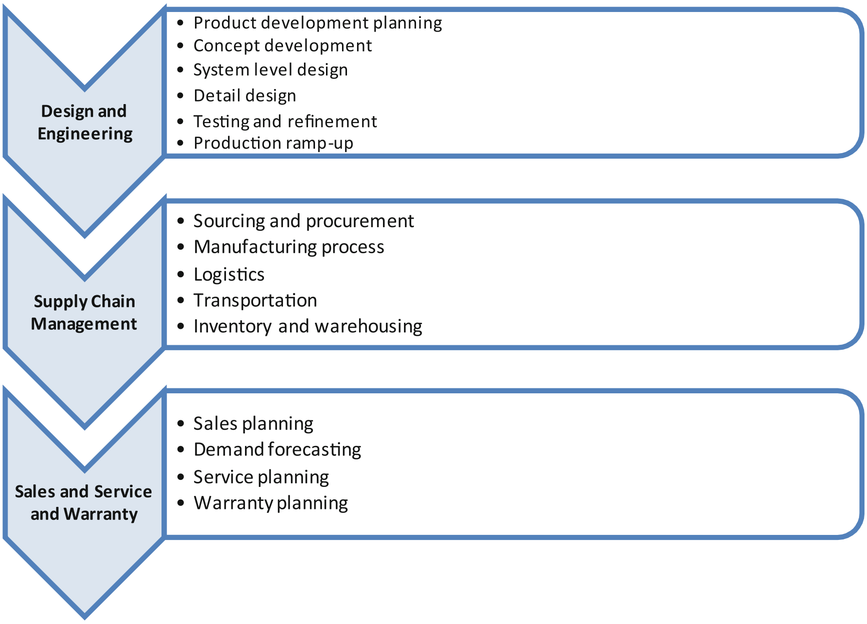


Fig. 2.3 Task breakdown of product life cycle

2.1.2 Proprietary Solutions and Tools

In addition to no communication standard for product life cycle management, companies have implemented vendor-dependent proprietary solutions. Information technology (IT) vendors have mandated customers to use their proprietary solutions instead of open standard-based solutions. Although companies obtained certain short-term benefits from those proprietary tools, this created a big problem later; that is, the lack of interoperability in communicating with other business information sources. Making those vendor-dependent tools talk to other information systems is a very labor intensive effort requiring financial commitment. In addition, maintenance burden for legacy systems may exceed the effort of new system development in some cases. Companies have to pay for IT consultants or contractors to sustain the existing systems. The fundamental reason for this is that no orchestrating planning and execution existed for accommodating the business needs of the entire corporation. For example, when a business unit introduced a new technology, if it knew the needs in other business units, then it would capture those needs and seek a way of adopting a standard technology rather than a proprietary one. Proprietary middleware does not solve this problem when a company uses a variety of applications from different vendors, nor does it incorporate new best-of-breed solutions (QAD Inc., 2003).

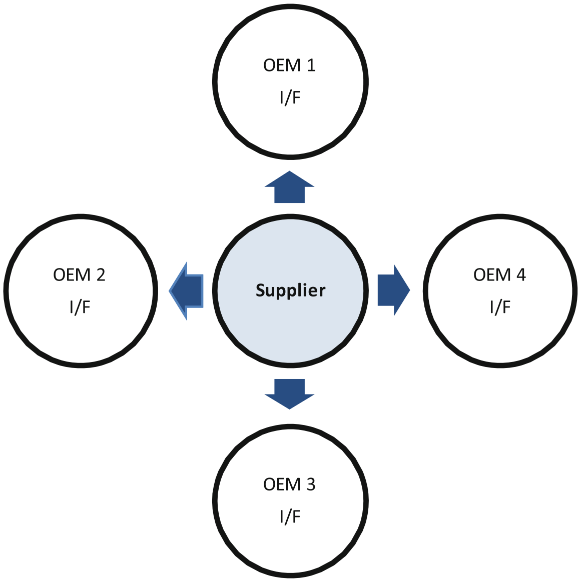


Fig. 2.4 One-to-many relationship between a supplier and OEMs

2.1.3 OEM-Driven Relationship

A big client company has dominated business relationship with its suppliers using its purchasing power. Business information exchange is not an exception. An OEM could mandate its suppliers to use the same information systems, including user interfaces. When a supplier has business with several OEMs and every OEM directs the supplier to use its own information system, the supplier has to establish and maintain multiple information systems for the same purpose. Refer to Fig. 2.4. This seems not an issue to OEMs, however, it is a serious problem to suppliers. This may cause potential errors to business transactions, because the OEM-mandated systems use different data types, names, and structures. AMR Research Alert (AMR Research 2003) learned that 45 % of companies polled required the same customer to place orders through separate systems.

2.1.4 Disconnected Business Processes

Business units of a company have developed and maintained information specifications and systems from an isolated functional silo view, not taking into account its impact on other business units. By so doing, disconnect has occurred between business units. Each business unit has self-interest to deliver its own business profit and performance. This is one of the biggest reasons for the low performance from the entire enterprise perspective, including supply chains. Each business units may use different data names, formats, and structures for similar or same purposes.

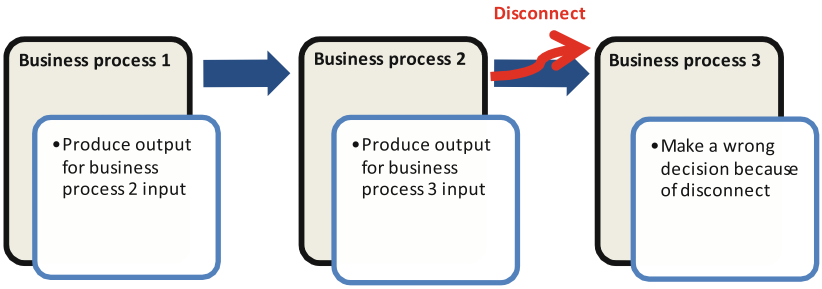


Fig. 2.5 Disconnected business process example

When we see the business performance from a multi-business unit standpoint, a mismatch is often found even in the same purpose data entries. The mismatch in one data entry seems trivial and people may think it can be filtered out by humans. However, when there are numerous mismatched data entries and business transactions are frequently updated, its resulting impact is not trivial. It causes many disconnects in business processes between units. Refer to Fig. 2.5 for an example. The output of one business process is not correctly transmitted into another business process as an input. The recipient business process receives wrong or imperfect information and consequently, it makes inappropriate decisions. Considering more successive interrelated business processes, this disconnect is propagated to next business processes and its impact is inflated like a snow ball. This disconnect harms the function of information systems as a ligament to connect business units.

Discussion Points

For the project you are involved, if any, what aspects of the current state of supply chain interoperability does your project have? Is there any additional aspect for the state of the technology you plan to bring in?

2.2 Issues of Supply Chain Interoperability

Many issues exist in achieving supply chain interoperability. Although there are some variations in issues depending on business sector and environment, this section presents commonly encountered issues in implementing the interoperability. Refer to Fig. 2.6.

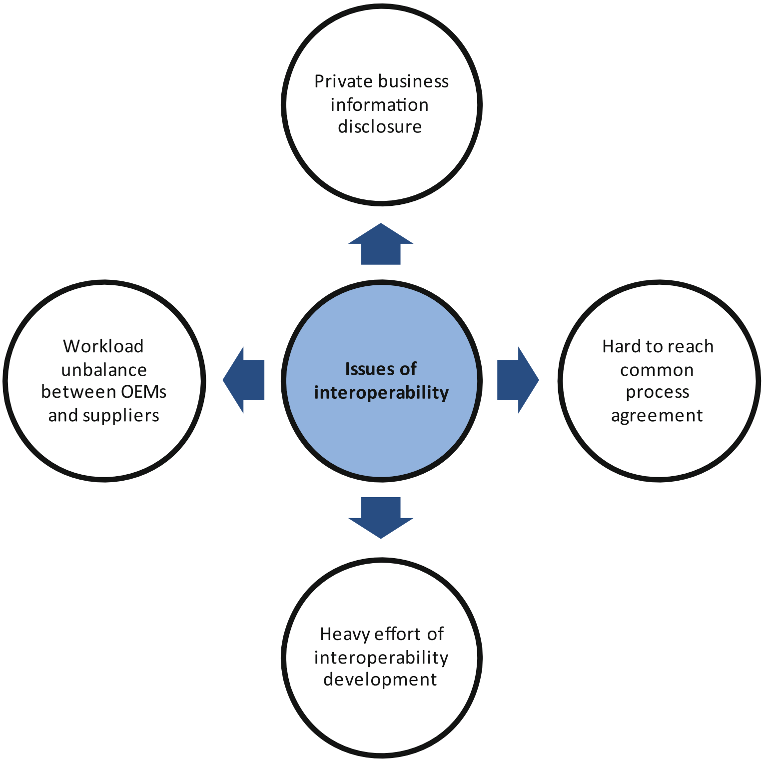


Fig. 2.6 Issues of achieving supply chain interoperability

2.2.1 Private Business Information Disclosure

The biggest barrier to reach supply chain interoperability is the reluctance of disclosing private business information. In particular, under rapidly expanding globalized market environment, companies may have multiple interconnected relationships in both domestically and internationally. A single supplier may have business with multiple OEMs in which one OEM is in competition with other OEMs. Although a secure reliable interoperable practices and systems are established, potential risks may exist in sharing and communicating an OEM's sensitive business information. Nondisclosure agreement helps to protect company confidentiality, but there might be risky situations that both business partners cannot manage the confidential information leakage by hacking, security attacks, and intentional disclosure. Thus, companies are not willing to cooperate developing agreeable interoperability specifications with other companies. With a trustable information security guard, *semantic mediation* technology could be an effective alternative to achieve interoperability between partners.

2.2.2 Hard-to-Reachable Common Business Process Ontology Development

For an operation, say, production material receiving, the corresponding business process could be different among business partners. Because each partner has its own inherent business process and runs its process using unique terms and procedures, it takes time to unify mediation contents of different partners. Although a similarity exists between partners in defining the same thing, it is hardly expected to have the exactness between the partners and still there may be a discrepancy to a certain degree. When a supplier delivers a part to two OEMs, each OEM uses its own ‘material receiving’ business process in addition to different terms, formats, and structure. Even when we develop a simple ontology module for interoperability for interpreting the material order and delivery information, reaching an agreement between two OEMs and the supplier is not easy and time consuming. The OEMs want to keep what they have been doing and they are reluctant to change to fit to another OEM’s formats.

2.2.3 Heavy Development Time and Efforts of Interoperability Tool

The development of an interoperability tool requires comprehensive mutual understanding between partners. When numerous partners are involved, it will take an enormous amount of time and efforts for developing it. It also has different roles and responsibilities, such as OEMs, suppliers, government agencies, and technology vendors. In the course of reaching an agreement, each company tries to keep its own perspective and influence others. This selfish behavior causes a delay of agreement. In order to reach a no-doubt agreement, all different kinds of voices and requirements should converge to one agreeable format and on top of that, a prototype or a test-bed needs to be developed to verify and validate the agreement. This process is not trivial. Sometimes, government initiatives would be desirable to mediate conflicts among industry partners.

This self-interest behavior can also be found in technology standards establishment committees. Vendors gather together to establish a new technology standard by which they can make the technology be known to the public and attract more potential clients. When they start establishing a standard, some of them have already been working on technology product prototypes. Those vendors want to keep what they have done so far and try to push the committees to adopt their specifications. Political conflicts are unavoidable and a delay takes place. Likewise, developing an interoperability tool among multiple partners involves more political conflicts and delays.

2.2.4 Workload Unbalance Between OEMs and Suppliers

As earlier mentioned in the OEM-driven relationship of the previous section, OEMs may want to take a dominant position in creating the interoperable mediation contents. This OEM dominant relationship causes workload unbalance of interoperability implementation between OEMs and suppliers. OEMs may mandate guidelines and regulations, and therefore suppliers may have to take too much work. However, for the past decade, the role of suppliers becomes more important, because they are more responsible for improving part design and quality. As Chopra and Meindl (2006) stated, today typically 50–70 % of the spending at a manufacturer is through procurement, compared to only about 20 % several decades ago. About 80 % of the part cost is fixed during the design stage. Hence, listening to suppliers' voices is an important factor to foster a long-term successful mutual relationship. It is imperative for the OEMs to involve suppliers for making business plan for the entire product life cycle. Active participation of suppliers in the entire product development, manufacturing, delivery, and service and warranty processes enables to split and share risks as well as to increase supply chain profits.

Discussion Points
For the project you are involved, if any, what aspects of the issues of interoperability implementation does your project have? Is there any additional aspect with respect to the issues?

2.3 Benefits of Supply Chain Interoperability

Companies can obtain many benefits from supply chain interoperability that enables supply chain partners to seamlessly communicate information. Among many ways of achieving interoperability, semantic mediation is an efficient method that requires less effort in implementing supply chain interoperability. Figure 2.7 shows the concept of semantic mediation. A supply chain network includes many multi-partner relationships in which one partner serves multiple customers and one customer deals with multiple suppliers. A typical business relationship example is one supplier replenishes production materials to multiple manufacturing customers (frequently found in supply chain environments). Without interoperability, if the customers do not belong to the same company, the supplier needs to develop and implement a certain communication tool for every customer. This requires so much time and financial commitment to both parties. Instead, we can think of a way in which a guy in the middle is able to mediate the requests from both sides. The guy should be capable of interpreting a request from a supplier and transmitting it to one or more customers and vice versa. Replenishing production materials is a good example in the automotive industry. If we can develop this guy for mediating the information exchange in-between semantically, we can obtain so many benefits.

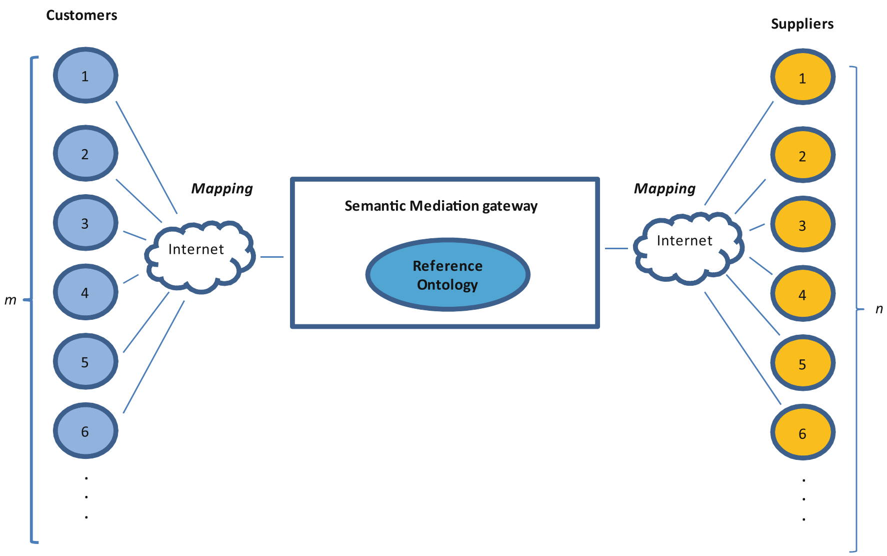


Fig. 2.7 Concept of semantic mediation

The semantic mediation can provide a means to move up to next level of communications across numerous partners of a specific business sector. Each business sector probably needs to define its *semantic reference ontology*. The reference ontology accommodates all the terms and data formats and data structure that are used at both sides. In order to do that, sufficient discussions and agreements are required within all the parties involved. This section limits only the benefits of the semantic mediation-based supply chain interoperability. The benefits of this semantic mediation-based interoperability will provide a glimpse of light of the interoperability benefits as shown in Fig. 2.8. Refer to Oh and Yee (2007) for more details. Other ways of achieving supply chain interoperability may have other benefits. We cannot cover a complete set of those methods of achieving interoperability in this section.

2.3.1 Burden Relief on Information Infrastructure Establishment

Semantic mediation can relieve tremendously the burden of establishing an information infrastructure; in particular, when suppliers need to create multiple business information exchange infrastructures to meet OEM's requirements. Tier-1 suppliers have used multiple software applications and portals for similar purposes to exchange business transactions data with more than one OEM. Using the semantic mediation tool, suppliers and even OEMs do not need to develop and

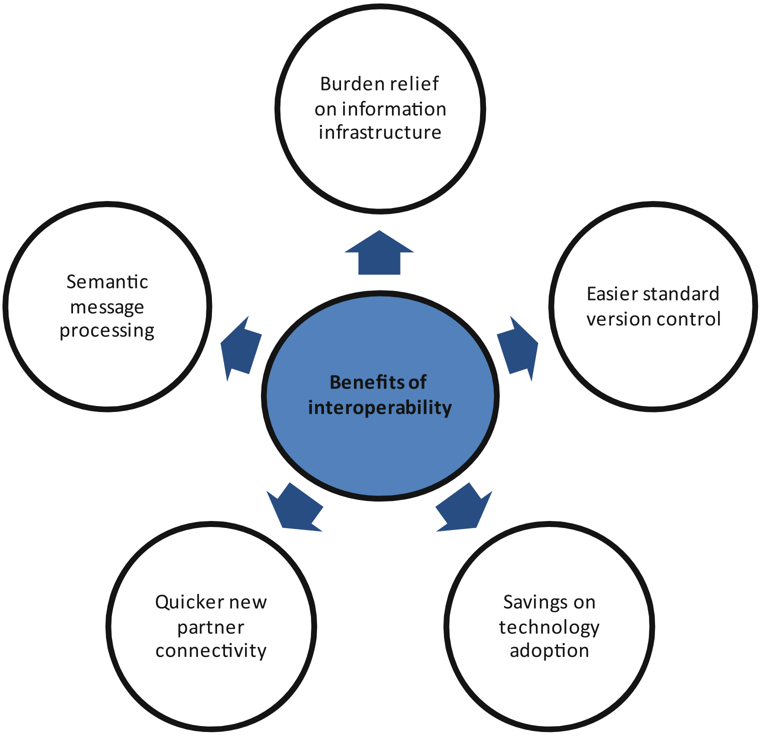


Fig. 2.8 Benefits of supply chain interoperability

implement unnecessary information exchange infrastructure and can save investment money.

2.3.2 Easier Version Control of Industry Standards

Whenever a software application has a version change, users need to upgrade to the correct version and pay a maintenance fee to the vendor. When a supplier has multiple applications running for daily business, sustaining those systems is also a big burden. The semantic mediation eliminates this problem because when there is a need of change, only modifying the mediation part would be enough in most cases, and this can save duplicate upgrade works for all the partners. Consider the business relationship of Fig. 2.7 where there are m customers and n suppliers. If no semantic mediation gateway exists, each of n suppliers may have m applications or portals for exchanging business information with m customers. The version change of only one application or portal in either supplier side or customer side requires multiple upgrades. The semantic mediation can eliminate this burdensome upgrade effort by only upgrading the semantic gateway and/or reference ontology accordingly. The higher the number of customers and/or suppliers is, the higher the benefit of version control is.

2.3.3 Savings on New Technology Adoption Time and Effort

When a new technology emerges, a company spends a lot of time and effort to make it work to real business environments. Suppose a high performance technology is available and all the supply chain partners should implement it. The required time and effort would increase depending on the number of communication channels. Under semantic mediation, we only need the mediation component and as a result, minimal time and effort are spent.

2.3.4 Quicker New Partner Connectivity

When a new partner is engaged in the existing supply chain network, the current environment requires a lot of interface works for the new partner to successfully enter into the network. In addition, when that new partner needs business relationships with more than one partner, the necessary task is not marginal. The semantic mediation can straightforwardly provide the new partner with connectivity to the existing partners without pain.

2.3.5 Semantic Message Processing

Under the current multi-application setup, unifying ontology is a big challenge due to heterogeneous definitions and uses of business processes, naming, and data structures and formats. Therefore, data filters and adaptors were implemented mandatorily in Business-to-Business (B2B) environment. The semantic mediation can resolve this issue. Once partners reach an agreement for the data fields to be shared, then a single ontology is defined and the mediation gateway is implemented accordingly.

2.3.6 Interoperability Value Proposition Efforts

National Institute of Standards and Technology (NIST) explored the opportunity of interoperability through several studies. At an Automotive Industry Roundtable co-sponsored by NIST and Automotive Industry Action Group (AIAG) in 2002, it was reported that there is a $1 billion annual penalty due to lack of interoperability and end-to-end integration in the exchange of engineering data in the automotive supply chain. A follow-up study conducted by NIST in 2004, entitled to "Economic Impact of Inadequate Infrastructure for Supply Chain Integration", presented the total cost of inadequate supply chain infrastructure in the automotive industry was estimated to exceed $5 billion.

The NIST study concluded that business partners could eliminate almost all of this cost if they implemented true business process integration and supply chain interoperability. Such integrated supply chain is needed to address the typical problems, such as manual data entry (even when computing sources are available), interventions from purchasing clerks, order processors, and expeditors, use of translators to convert data from one format to another (even when systems are nominally compliant), and use of informed estimates instead of production plan data. Moreover, the study stated that investments need to be made in infrastructures to support global supply chain, including hardware and software standards, information languages and protocols, and financial accounting and clearing systems. These investments also need to cover increasing foreign business presences beyond national boundaries.

Discussion Points
For the project you are involved, if any, what benefits does your project have from the interoperability perspective? Is there any additional benefit in addition to those benefits in this section?

2.4 Obstacles of Supply Chain Interoperability

In order to achieve interoperability technology integration to business, we need to be aware of and deal with obstacles. Although some deviation exists by industry sector and company type, the following obstacles are commonly found. Refer to Fig. 2.9.

2.4.1 Loosened Vertical Integration and Split Business Ownership

A few decades ago, one company owned almost every business division, including sales and marketing, purchasing, design, engineering, manufacturing, logistics, and services. All these business functions were tightly vertically integrated within a company. Because of increasing competition and cost reduction pressure, the *vertical integration* became loosened. In other words, companies started spinning off business functions as shown in Fig. 2.10. Meanwhile, the spin-off business functions depended on the parent company until they are stabilized to newly aligned business environments. As time goes by, the involvement of the parent company is reduced, and in the end the spin-off companies stand up independently.

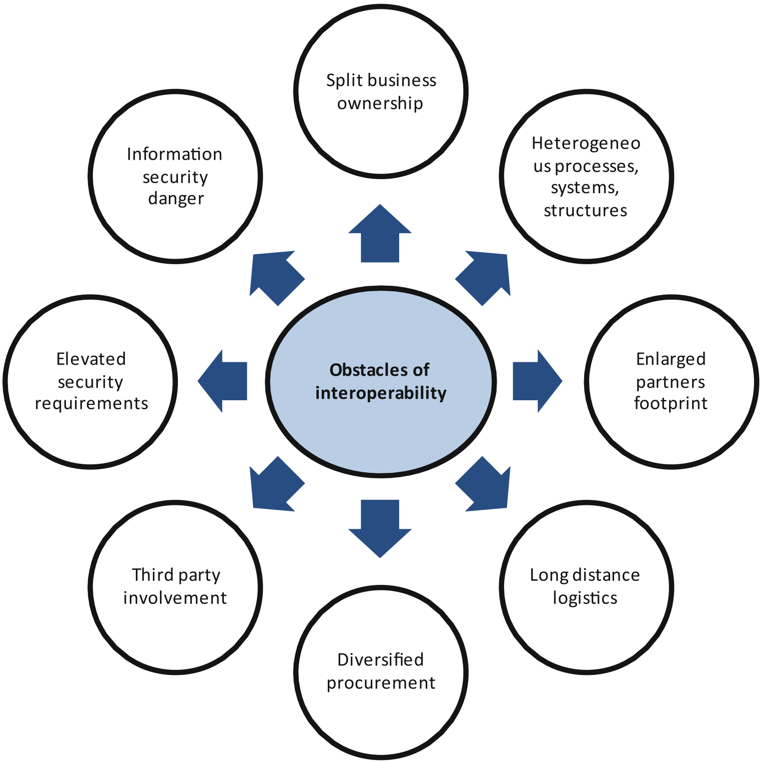


Fig. 2.9 Obstacles of supply chain interoperability

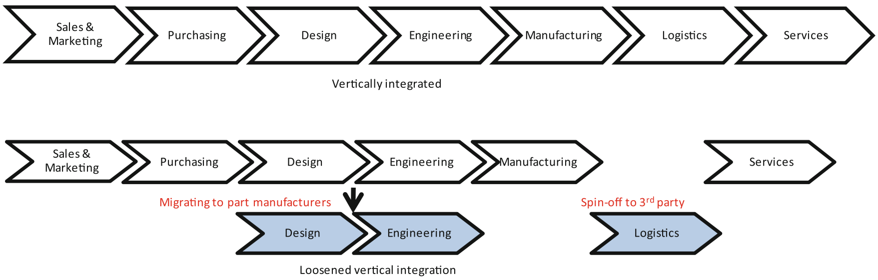


Fig. 2.10 Loosened vertical integration

In the automotive industry, we have seen many cases like this. Delphi was spun off from General Motors (GM) and Visteon from Ford. Still both Delphi and Visteon have a large portion of part orders from their parent companies, but the portion is decreasing year-by-year.

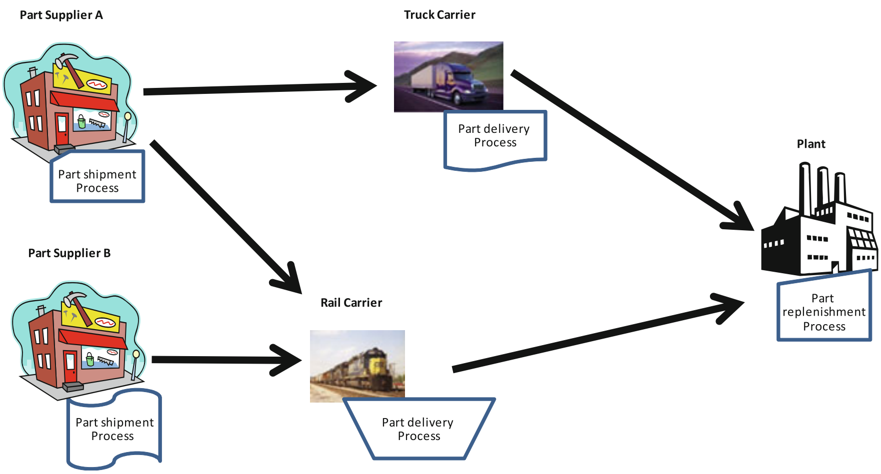


Fig. 2.11 Part replenishment process

Logistics industry is the outcome of loosened vertical integration of OEMs. Many OEMs owned logistics function and gradually, they spin off the logistics function or outsource to third-party service providers. Outsourcing as a result of loosened vertical integration left OEMs benefits in terms of cost reduction, less resource requirement, and smaller organization size. However, today's business environment requires all the supply chain members to work together closely. Re-coupling those outsourced business functions with the business of the OEMs is a big challenging task. The spin-off companies would have different business processes and transaction systems. Bringing that connectivity back will take a lot of time and work to make two parties work as one.

2.4.2 Heterogeneous Business Processes, Systems, Data Structures

Business partners have their own technology and information infrastructure that define and use unique processes, systems, and structures. This heterogeneity causes challenges in putting together multiple parties for technology integration. A typical example is the production part replenishment process in the automotive assembly plant. How many players are involved in the typical part replenishment process? They include OEM material department, part suppliers, rail carrier, and truck carrier as shown in Fig. 2.11. Material department is in charge of part replenishment process. Part suppliers have part shipment process and carriers have part delivery process. If all those partners are aligned with the same processes, formats, and terms, no problem exists. However, in reality, almost every company has its own process (denoted by different shapes in Fig. 2.11). Unifying the heterogeneous processes, formats, and terms requires so much time and effort. First of all, when an OEM plans to integrate a technology to the part replenishment environment, the OEM should convince all the players for the purpose and objectives along potential benefits. The OEM will face the following challenges:

1. Identify the benefits that will be evenly distributed to all the players
2. Address possible business process changes
3. Address possible contract regulation changes
4. Address possible changes in the existing systems in place
5. Resolve potential conflicts between players, for example, when there are more than one transportation carrier, a conflict could take place between carriers
6. Split the required budget and resource needs

Although the OEM makes an effort to explain the benefits to the partners, they may not be convinced until they are confident of the benefits from the technology adoption. A brainstorm meeting would be useful to draw potential benefits by inviting all the players. During the brainstorm meeting, we can discuss about possible business process changes, contract regulation changes, existing system changes, and more. Also, we can identify potential conflicts between players in advance. In particular, when the OEM has business with multiple contractors for a certain business function, the conflicts would occur between contractors. An automotive plant may have relationships with more than one truck carrier that loads and delivers parts from the suppliers to the plant. If this is the case, those carriers may not want to change their business processes and follow those of competitors. Contract regulation changes are also big interests to contractors.

Through the adoption of the new technology, the OEM wants to improve the performance of part replenishment. Owing to the new technology, e.g., part delivery visibility, parts will be delivered faster than before and more accurately. Thus, the regulation for the part delivery time can be reduced. This will bring a change to the total part delivery lead time restriction on the contract. Then, this will increase carriers' responsibility. The OEM should be able to convince the carriers that although the delivery time reduction is a pressure to the carriers, in the end, the new system will improve the performance of the carriers' operations. Once all the parties agree upon the benefits, next step is to discuss on how to split the budget and resources for the technology integration. OEM would take a primary role; however, all the players need to participate in this direction.

2.4.3 Enlarged Footprint of Business Partners

When an OEM acquires another company via M&A, the OEM should integrate its business processes with those of the company bought. In addition, when the OEM has alliance partner relationship with another company located in a foreign country, the OEM needs to consolidate its business processes with those of the alliance partner. For example, an OEM acquired a company located in Asia and that company produces parts or products for the OEM. The merged company may

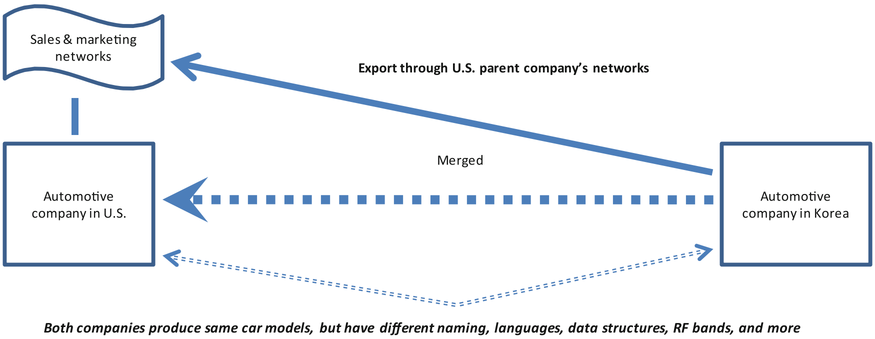


Fig. 2.12 Discrepancies between parent company and merged company

export parts or products to other countries using the sales and marketing networks of the OEM. What kind of business process integration needs to be established in this example? First of all, manufacturing process needs to be aligned together, and then so sales and marketing process does. It is obvious that business process becomes more complicated after acquisition of the company in Asia than before, and this is another barrier to the integration of technology to business. When the alliance partner is a foreign company, so many challenges occur as follows:

1. Address heterogeneous systems, processes, formats, terms, language, and culture
2. Consider technical regulations and standards of the foreign country
3. Consider import/export rules and regulations of the foreign country
4. Establish relationships with management leadership of the foreign partner

Consider an automotive OEM starts an alliance with another automotive company in Korea. Refer to Fig. 2.12. The Korean company produces multiple vehicle models and some of them, say, two models, are exported to the globe using the OEM's sales and marketing networks. In addition, one OEM plant in the US produces the same two models and exports globally. First of all, supplier footprint is different between the OEM plant in the US and the alliance plant in Korea. When they share common part supplier information, discrepancies may take place between them. Even for the same part, say, a bumper, discrepancies may be found in part name, part number, supplier name, supplier id, and supplier location. Both plants would have defined and used the part information in their own languages. In addition, the processes for part delivery, shipment, and acceptance will be different. What if the country the alliance plant is in puts a barrier to the technology vendor? In the RF world, this happens in real. The US continent uses different radio frequency bands compared to Asian countries. In order to make the RF system work in Korea, the technology vendor should modify the design of the RF system to work in the frequency bands of Korea. Lastly, when an alliance was created, both companies would have realigned management leadership. For

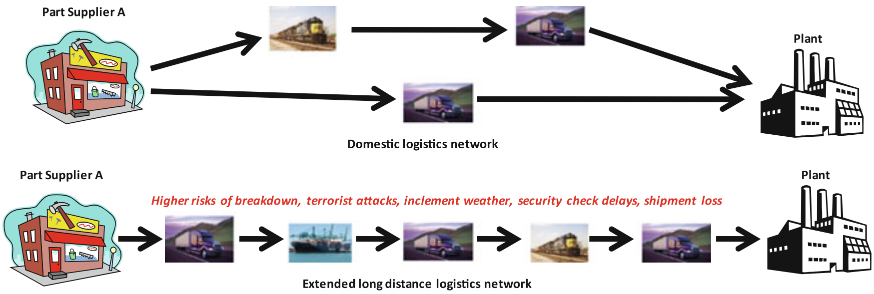


Fig. 2.13 Long distance logistics network and its risks

example, the alliance partner company is typically realigned to the OEM's organizational structure. If the OEM plant manager is in a higher position than the alliance plant manager, it will be fine. The opposite will cause issues. There may be certain resistance from the alliance plant because, if the technology is integrated in a full scale, the alliance plant will have to undergo process changes and the plant manager will hesitate to do it.

2.4.4 Long Distance Logistics Networks

Cost reduction pressure drove western OEMs to source suppliers in remote regions. As a result, logistics networks become prolonged and complicated spanning from the US to Europe to South America to Asia. Long distance logistics networks involve high risks in bringing raw materials, parts, and assemblies to the OEM manufacturing plants in the US. Refer to Fig. 2.13. Compared to domestic logistics network, the extended long distance logistics network involves higher number of transportation carriers. Potential risks include (1) breakdown of transportation carriers like vessels, rails, or trucks, (2) terrorist attacks, (3) inclement weather conditions, (4) security check delays, (5) possible shipment loss on the way, and others. As the distance of logistics becomes longer, the magnitude of potential risks increases. Exceptional events in the course of logistics networks may cause serious disruptions to production planning and execution. Although a manufacturing plant sets buffer inventory, these exceptions have an adverse effect on regular production. During technology integration, these long distance logistics issues need to be considered as well.

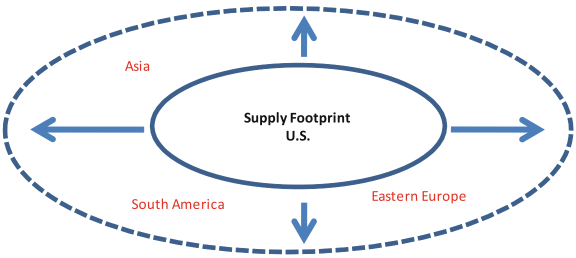


Fig. 2.14 Expanded supply footprint

2.4.5 Diversified Acquisition and Procurement Channels

Cost reduction pressure also led OEMs to diversify the supply footprint, and the OEMs procure materials from more diversified suppliers than before and most likely, from the suppliers located far away. Refer to Fig. 2.14. When the supply footprint is only in domestic regions, obtaining and integrating the supplier information and supply status information was not a big issue, because both OEM and its suppliers have been in business for a long time. In the US, all of them have used English-based terms and similar business processes. However, when we look into a foreign country, it is completely different. Languages are different and business processes are heterogeneous. For each and every supplier, the OEM should establish business transaction network by integrating its process with the supplier's. When the number of off-shore suppliers increases, this is another barrier to the implementation of technology integration.

Emerging supply footprint, primarily located in Asian countries, involves numerous issues in spite of the merits of cost reduction. Although the OEMs want to examine various capabilities of those suppliers in Asia in terms of design, engineering, manufacturing, reliability, quality, and services, the unit cost is regarded as the most important factor for selecting suppliers. What it means is that the suppliers chosen could not be qualified to meet the requirements of part quality. Although the OEMs can decrease total part procurement costs by selecting the lowest cost suppliers, they undergo challenges and difficulties at the expense of quality and reliability. More importantly, the role of suppliers becomes more important than ever. OEMs tend to give more responsibility to suppliers for part design and improvement. In particular, tier-1 suppliers' responsibility becomes much more increased and they take a larger portion in acquisition. OEMs are heading toward modularized production and in other words, tier-1 suppliers need to deliver bigger components to the OEMs with increased responsibility. If the tier-1 suppliers are not capable of doing this, the overall quality of finished product will be deteriorated.

Technical capability of those suppliers including tier-1 suppliers is an important influencing factor for the success of technology integration. A certain supplier in Asia offers the lowest unit cost and is not ready to be integrated with the OEM technologically, and then the OEM may not be able to achieve the technology integration. However, often times, an OEM may not consider this aspect in

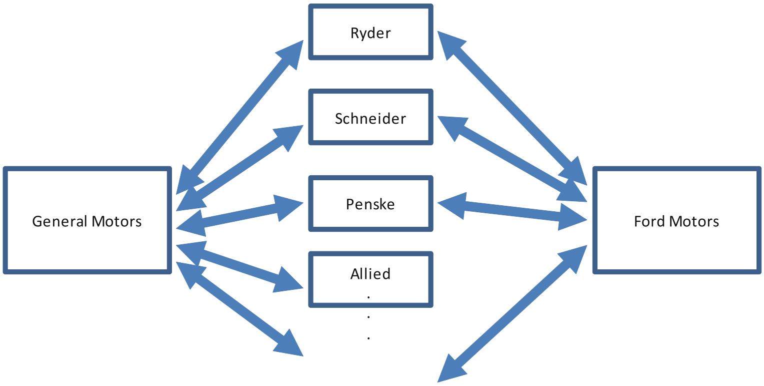


Fig. 2.15 Increased third party involvement

choosing a supplier. Consequently, although the OEM can save material costs, the OEM will not be able to attain business continuity and sustainment using technology integration.

2.4.6 Third Party Involvement

When a technology integration project involves a third party, e.g., logistics provider, the project should integrate the technology with the process of the third party. One-on-one involvement is easy to do the integration. When an OEM deals with more than one logistics provider, the integration becomes complex, because it needs to take into account multiple heterogeneous business transaction processes. Refer to Fig. 2.15. A compromise must occur between the OEM and the logistics providers. From the logistics provider perspective, it is a very important issue because after a pilot project is successfully done and the process is finalized, then the logistics provider should modify their process in other locations that have business relationships with the same OEM. For example, when Penske, a logistics provider, has a business relationship with GM for shipping vehicles at ten assembly plants, Penske should modify business processes at ten related locations during the entire rollout phase of technology integration. For this case, Penske may need to spend money for business process modification. Penske also needs to make an assessment of the impact of the modification on its internal operations. If Penske provides services to another automotive company, say, Ford, and GM and Ford have different vehicle shipment processes, Penske could be in a delicate situation as to which direction to follow. Penske may hope both GM and Ford to implement a standardized new process and system. However, both GM and Ford may use different processes or systems anyway, because they are in competition and may want to have their own unique process or system to pursue performance improvement in vehicle shipment using technology integration.

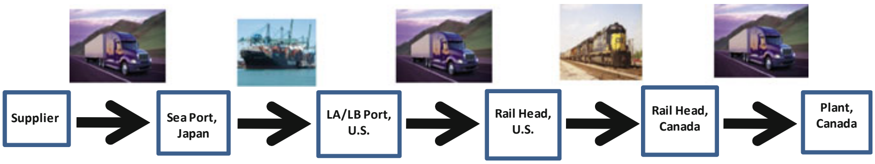


Fig. 2.16 Sea container transportation route

2.4.7 Elevated Security and Stricter Customs Regulations

Since the 9/11 incident in 2001, the US increased the security level to a great extent. In particular, the level of security for import to the US was extremely increased. At the US ports, customs security checks become tighter and as a result, much delay occurred to deliver the shipment to the US destinations by passing the elevated security level. As an example, Nguyen and Wigle (2011) presented that the delays at US and Canadian border crossings would result in the cost of $15 and $30 billion every year to Canada. The economic impact of border delays has the same disruptive effect on the US economy, especially the automotive industry in Michigan.

Security check systems and policies have been developed and tested at the borderlines and seaports. The US seaports require both domestic and foreign transportation carriers to provide advance shipping notice (ASN) before shipment arrival. As part of Operations Safe Commerce III (mhlnews.com), one of the pilots was conducted for testing an RFID system to track sea containers from Japan through Los Angeles/Long Beach (LA/LB) seaport to a Canadian destination. The purpose of the pilot is to develop policies and systems to ensure secure tamper-proof shipment between the US and a foreign country. This pilot is the US Department of Homeland Security-initiated project that involved many players. With one security company as project manager, one US automotive OEM and its one supplier was participated. All the logistics carriers along the logistics route were also involved, which include vessel, rail, and truck carriers. Refer to Fig. 2.16 for transportation route of the pilot project.

From an automotive part manufacturer in Japan, automobile transmissions are loaded onto returnable steel containers and transported via truck to the seaport nearby. The steel containers are unloaded from truck and reloaded onto 40-foot sea containers. The sea containers are loaded onto a vessel that goes to the LA/LB seaport. According to the departure schedule, the vessel leaves the seaport and travels through the sea. When the vessel arrives at the LA/LB seaport, the sea containers are unloaded at seaport yard. According to the delivery schedule, trucks come to the seaport yard and pick those sea containers. Each truck passes the security check after verifying truck driver identity and bill of lading of the sea container shipment. The truck moves the sea container to the rail carrier yard nearby where the container stays until a railcar is available for transportation. According to the rail schedule, the sea containers are loaded onto railcars and transported to another rail carrier yard in Canada, close to final destination. When the railcars arrive at the rail yard, the sea containers are unloaded to the yard. Another truck carrier comes and loads the sea container onto truck and moves to the final destination, i.e., OEM assembly plant.

An active RFID tag system was tested with several sensors for tamper-proof secure shipment. At each junction point of the logistics route, the RFID readers are installed, such as at the Japanese seaport loading/unloading area, the LA/LB seaport loading/unloading area, the Canadian rail yard, and the final OEM loading and unloading area. The active RF tag is attached to the door of the sea container and sealed after loading the returnable steel containers. Inside the sea container, sensors for detecting motion and temperature and humidity are attached to the wall. When the sea container arrives at the final destination, the RF tag is checked whether its seal is broken. When the sea container passes through junction points, RF readers read in the RF tags of containers and track the locations of the containers. Along with RFID testing, interoperability between different carriers was established in the central information visibility tool.

In addition, customs and regulations of each country are getting tighter because of self protection. If a country is not part of trade agreement organizations like NAFTA, the country may be in a difficult situation for export and import.

2.4.8 Information Security Danger

As business networks become diversified, the information security danger increases. Increasing number of business partners may cause security holes by which business information could be leaking to dangerous parties. As we mentioned in Sect. 2.2.1 Private business information disclosure, companies are very concerned about their sensitive business information exposed to competitors. In addition, corporations increase the level of security to protect their computer networks from various harmful attacks. A breakdown of computer networks could occur because of many reasons: hacking, terrorist attacks, malwares, and payload overflows. Sans.org recognized that the most prevalent attack categories were server-side HTTP attacks, client-side HTTP attacks, PHP remote file include, cross-site scripting attacks, and finally SQL injection attacks.

> During the last few years, the number of vulnerabilities being discovered in applications is far greater than the number of vulnerabilities discovered in operating systems. Due to the current trend of converting trusted web sites into malicious servers, browsers, and client-side applications that can be invoked by browsers seem to be consistently targeted (sans.org).

Nowadays, most business transactions are processed using computers and transferred and shared among different business units. Intrusion to transaction databases may cause serious problems in decision making. In the worst case, we can lose all the transaction data if we do not have a proper storage system.

When technology integration involves multiple business partners, in particular, external partners, system vulnerability assessment should be conducted, and thus security standards and guidelines and best practices should be established and applied to all partners. All the users need to be compliant for regulations. Otherwise, the entire technology integration effort could be futile.

Discussion Points
For the project you are involved, if any, what obstacles stated in this section does your project have? Is there any additional obstacle in implementing a technology?

2.5 Interoperability Research in Europe

Advanced Technologies for interoperability of Heterogeneous Enterprise Networks and their Applications (ATHENA) (Athena 2004) is an integrated project sponsored by the European Commission, aiming to make a major contribution to interoperability by identifying and meeting a set of interrelated business, scientific and technical, and strategic objectives. To deal with data interoperability, ATHENA worked for development of semantic data transformation as a way to translate information stored in different formats and systems between different enterprises. Figure 2.17 shows overall ATHENA concept. The ATHENA structure consists of four layers: business, processes, services, and data. At business level, collaborative enterprise models are predefined using adapted enterprise modeling tools. At processes level, business processes are constructed across all involved organizations. At services level, flexible execution is done through composition of available services. At data level, the data are transformed from a sender format to a receiver format and vice versa. Overall, the artifacts are based on model-driven developments that are platform independent service-oriented architectures (SOA), and semantics are handled using ontology management and semantic annotation tool.

ATHENA tried to solve the problem occurred when running different applications on different architectures and developed appropriate artifacts for interoperability. ATHENA group looked for a business partner in the US to test the artifacts in a real business environment so that ATHENA approached NIST and AIAG. Both NIST and AIAG worked together to come up with testing scenarios and involved a few more US companies. GM as a member of AIAG participated in the ATHENA project as a provider of business testing scenarios. This involvement of the US organizations subsequently accelerated the interoperability research in the US by drawing attentions and supports from the US government and private industry.

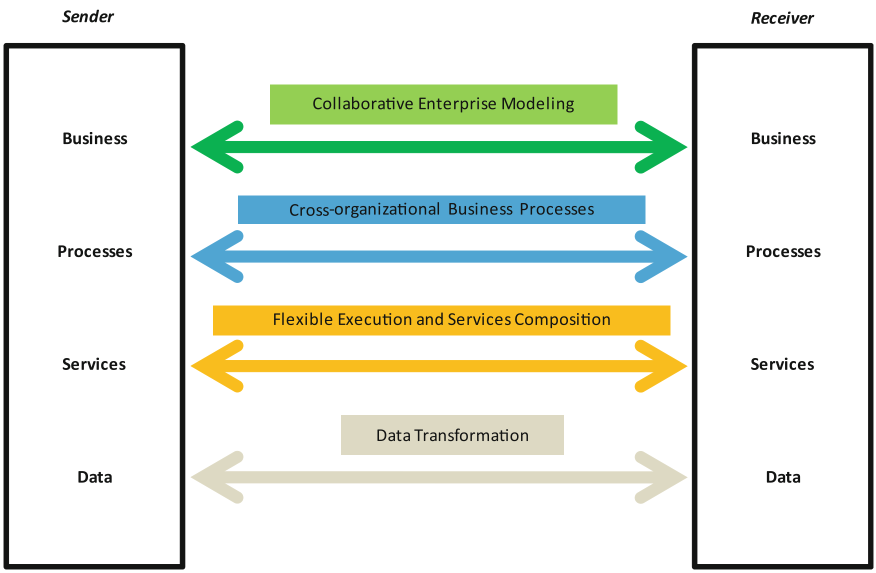


Fig. 2.17 Structure and artifacts of ATHENA

2.6 Interoperability Research Agenda in the U.S.

The National Science and Technology Council Interagency Working Group on Manufacturing R&D held a Supply Chain Integration Workshop in Huntsville, Alabama (2006). The leading sponsors were NIST and National Aeronautics and Space Administration (NASA). The workshop brought together experts from government agencies, industry, technology vendors, and researchers. It was aimed to explore the challenges of integrated and interoperable supply chains and to develop a research and development agenda, that is, a technology roadmap, to achieve the vision for future enterprises. The workshop was intended to deliver a consensus plan for successful supply chain integration and management for the US-based enterprises around which industry, government, and academics can agree upon. This section summarizes the discussion points of the workshop. After the workshop, the Working Group worked on budget planning and project support for conducting interoperability R&D in the US settings. This section only presents the interoperability portion among other topics discussed during the workshop.

2.6.1 Vision for Interoperability Standards Within and Across Supply Chain

The Working Group sets the vision statement from an interoperability standards perspective as follows:

> Supply chains exhibit an affordable and seamless interoperability that is equally accessible by all partners. The infrastructure fully supports all relevant business needs in an accurate, secure, predictable, and legally traceable manner. As business needs change or new technologies emerge, the supply chain data exchange dynamically reconfigures to enhance interactions among all appropriate partners.

Important elements in the vision statement for interoperability standards include: (1) value proposition that provides increased innovation and economic growth with lower cost, (2) on-call interoperability that find and connect to appropriate partners or system anytime, (3) affordable cost of interoperability, (4) system extensibility to new technologies and practices, (5) accurate, secure, and predictable, (6) operating across supply chain, (7) interconnectivity fully supporting appropriate business needs, and (8) traceability of documents for how process was performed.

2.6.2 Current State of Interoperability Standards Within and Across Supply Chain

First the Working Group made an assessment for the current state of interoperability standards within and across supply chain in the US as to the following aspects.

2.6.2.1 Software Version Changes

Software version changes create varying degree of issues in software products. Software vendors publish new versions periodically through enhancements of existing ones to maintain their competitive edge. Along with the upgrade, the need for backward compatibility with previous versions is highly desirable but not always possible and so, after the upgrade, different versions of the same product could be incompatible. This presents a serious dilemma to software developers because they need to catch two rabbits at the same time, making software more capable as well as maintaining backward compatibility. Within the supply chain domain, upstream supply chain members have to keep compatibility with downstream members and customers. When an upstream member has an outdated software version and a customer uses an up-to-date version, backward incompatibility could occur and it will have an adverse effect on business continuity with the customer. Considering numerous supply chain members, backward incompatibility could cause serious problems.

2.6.2.2 Intellectual Property

Increased protection of intellectual property limits to disclose the information about software structure or business applications. When the software or applications are proprietary, it is very hard to know for what they do, what structure they have, and what interfaces are needed to communicate from outside. We live in a "lack of trust" culture where we must protect intellectual property and related information, although this often creates technical barriers. Corporately, we must protect the privacy of business sensitive information and intellectual properties. Internationally, there is a tremendous lack of enforcement in protection of intellectual property. The United Nations has set up an agency named the World Intellectual Property Organization (WIPO) dedicated to protecting intellectual properties, as does the World Trade Organization (WTO). These international agencies are establishing the best practices that will, in time, alleviate some of the intellectual property issues.

2.6.2.3 Software Incompatibility

With respect to product design, the STandard for the Exchange of Product (STEP) model has been widely used more and more. Nearly every major CAD/CAM system now contains a module to read and write data defined by one of the STEP Application Protocols (APs). The most commonly implemented protocol is called AP-203. This protocol enables to exchange design data represented by solid models and assemblies of solid models. In Europe, a very similar protocol called AP-214 performs the same function. But different software products are known to be incompatible and often times, only proprietary solutions, ad-hoc approaches, and translators are utilized. This creates semantic and syntactic differences and protocol requirements discrepancies for accessing product design files. Companies want to keep the legacy software packages and avoid additional investments for new software until absolutely necessary.

On the brighter side, forced compatibility emerges like the recent agreement between SAP and Microsoft. Neutral CAD data translators are beginning to appear like NX CAM Express which is designed to be used independently of any specific CAD system, but have key industry translators for data import. Small European companies are using the Enterprise Application Integration (EAI) approach.

2.6.2.4 Security Issues

Encryptions, permissions, organizations tables, certification services, firewalls, and passwords are some of the current methods for cyber security (www.sans.org). These methods are generally complex and often do not provide perfect protection. Access policies and the ability to maintain control over the information still create issues around cyber security methods utilized. Business Rules for E-Commerce (BREC) is an emerging practice with application to security issues. Higher level of security imposes a burden to interoperability.

2.6.2.5 Business Sensitive Information

Complete control over all business sensitive information is imperative when sharing confidential information with other companies. The common control is to use nondisclosure agreements and confidentiality agreements signed between the companies. However, these are often difficult to negotiate and slow, not computer sensible, and very difficult to enforce. The competitive world of business fosters a large lack of trust even with these agreements in place. This is compounded by the fear of losing reputation or competitive advantage. When it comes to a new product, there is a fear of losing innovation to competitors. An example of emerging practices is found in Lockheed Martin's Supplier Net through which suppliers to Lockheed Martin can establish relationships, gain information about, and effectively work through supply chain opportunities.

2.6.2.6 Common Vocabulary for Communications

Today's world of communications technologies does not have a standard vocabulary for communications, i.e., a same content may have various labels. Business experiences incompatible standards, definitions, and abstraction levels all the way down to document level. A formal vocabulary is greatly beneficial and appears to be emerging. For example, a semantic web appears to be the next generation technology for the World Wide Web (W3C) technology. It provides a common framework that allows data to be shared and reused across applications, enterprises, and community boundaries. It is a collaborative effort led by W3C with participation from a large number of researchers and industry partners.

2.6.2.7 Product Design

Product Development Management/Product Life cycle Management (PDM/PLM) software packages are currently used for product design and development. Attribute data that further defines the product as well as contract languages are also used. However, there is no standard way of communicating full product specifications and the standards are not widely adopted. Emerging practices include adopting production information sharing and STEP-based technical database packages that some larger commercial players take, including Boeing, and Lockheed Martin.

2.6.2.8 Product Search

With the lack of standard technical data packages, proprietary solutions and manual searches are the current state of practice in product searches. Emerging services include the use of Object Name Services (ONS) which serves as a global cross reference between a unique product identification number and the corresponding product information. Another is the use of agent-based data mining and data normalization. As the name suggests, this technique attempts to use software agents to dig into massive quantities of data sources to search for relevant data.

2.6.2.9 Supplier Search

Finding the "right" supplier is another interoperability standard issue. Industry lacks a global supplier repository and standard product and services descriptions; hence, proprietary or often manual solutions are the current approach for supplier searches. Web search services and supplier/product registries are only just beginning to emerge to address this deficiency.

2.6.2.10 Manufacturing Processes

Notation of drawings or the bill of materials allows a human to read, but not computer readable. Electronic interpreting tools for manufacturing processes are not mature yet. Some trials had shown significant delays in computer speed. Often the OEM must develop the machine readable electronic process first if it is so important to improve the quality of product. For example, manufacturers use process planning on numerical control (NC) systems to increase its performance and accuracy, which is being viewed as the emerging best practice.

2.6.2.11 Business Process

The business processes above the transaction level are often ad-hoc based on a negotiated contract driven by proprietary solutions and manual processes. Business processes may be subject to various legal systems and widespread jurisdictions, including environmental regulations.

Universal Business Agreement and Contracts (UBAC) aims to align the concepts defined within International Standard organization (ISO) Open Electronic

Data Interchange (EDI) lifecycle stages of an e-Business relations—Planning, Identification, Negotiation, Actualization, and Post actualization—with the legal processes. UBAC is seen as an emerging practice, as is electronic business standards using eXtensible Markup Language (ebXML) and business process specification schema (BPSS). These practices seek to address a foundational open infrastructure which enables the global use of electronic business information to be used for an interoperable, secure, and consistent practice by all trading partners.

Between companies, the business process is commonly a communication and contract negotiation between individual entities, which is often transacted through EDI or computer-to-computer exchange of information. Of course, problems can arise because of the ambiguity of human negotiations and the brittleness of EDI. Small size enterprises may not have EDI access or capabilities. Hoping to address these business process issues, companies like Covisint were formed and aimed at efficiently matching the supplier requirements with the customers'. Covisint was founded in 2000 by DaimlerChrysler, Ford Motor, GM, Commerce One, and Oracle, with the mission of creating a virtual marketplace and auction house for automotive supplies. Nissan, Peugeot, and Renault joined this collaboration network later. The business has failed to take off because the technology was more complex than originally anticipated, and suppliers were sarcastic for the idea of competing for business online.

The United Nations is driving for a core-component compatibility focus. The Standardized CORporate Environment (SCORE) model is emerging, which can be used to address the supply chain issues. The Society for Worldwide Inter-bank Financial Telecommunication (SWIFT) in January 2007 began a pilot program of its SCORE model for corporations to interact with multiple SWIFT member banks, focusing on cash management and treasury services. SWIFT offers this interbank connectivity to select corporations, permitting corporate-to-corporate communications via SWIFT SCORE.

2.6.3 Solutions for Interoperability Standards Issues Within and Across Supply Chain

In order to achieve the vision for the future, a technology roadmap needs to be developed to resolve the issues of the current state of interoperability. From the product life cycle management perspective, the Working Group identified the following potential solutions for the industry's challenging issues.

2.6.3.1 Different Standards Among Industry Sectors

Interoperability across supply chain is on a company-by-company or an industry-by-industry basis, and different standards exist among industry sectors. Traditional

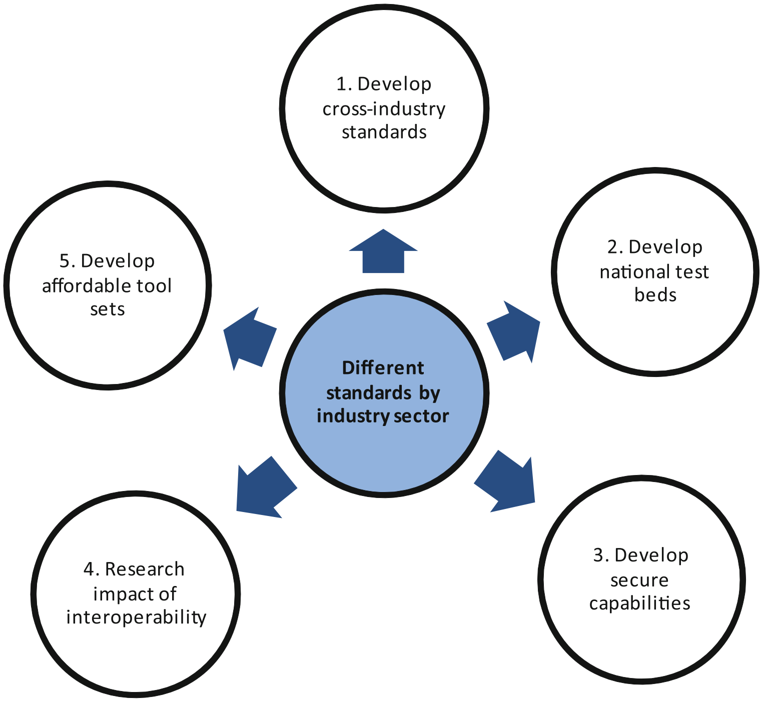


Fig. 2.18 Different standards among industry sectors

one-on-one solutions have fostered highly specialized solutions to data communication requirements. This led to complex, rigid, and costly solutions framework. Lack or misinterpretation of standard infrastructure resulted in incompatible implementation with other business partners and restricted the agility of supply chain to adjust to rapidly changing market environments. Possible solutions include (refer to Fig. 2.18):

Solution 1—develop, promote, and support cross-industry standards for terminologies, protocols, processes, and ontology

This solution seeks to develop a standard representation of digital thread across the supply chain and make formal expression in a computable form in which the differences in meanings become manifest.

Solution 2—develop national test beds for interoperability

This solution develops test beds to assure effective implementation of standards and perhaps certify the validity of a particular implementation. The test bed would start with XML conformance testing but grow to test new interoperability capabilities.

Solution 3—develop secure interoperability capabilities across supply chain

Security is one of the most contentious issues requiring attention. Sharing sensitive information with other members of the supply chain requires a high degree of trust that only those who "need to know" will see the data. However, developers must balance between sensitive information exchange and necessary security measures with minimal interruption.

Solution 4—perform research to understand better the impact of supply chain interoperability techniques and approaches

This solution supports an interoperability discipline to understand better the full scope and breadth of current activities directed toward improving interoperability. The solution proposes supporting a research effort to document and catalogue existing efforts. Full exploitation of this solution will establish interoperability as a university level curriculum.

Solution 5—promote development of affordable tool sets to facilitate interoperability

This solution seeks to encourage independent developers to develop tool sets that assist software application developers by adding interoperability features to their applications.

2.6.3.2 Proprietary Software

Proprietary software packages or application suites lock users in specific technology vendors. These vendors use different methods and philosophies for sharing data among their applications, and this leads to a lack of interoperability between software applications. No single technology provider should be monopolistic in any area. Refer to Fig. 2.19.

Solution 1—create a government procurement policy on interoperability

This solution seeks to establish requirements policy for all government purchase of interoperability software. This will encourage vendors to develop products that comply with the requirements and make such capability more available.

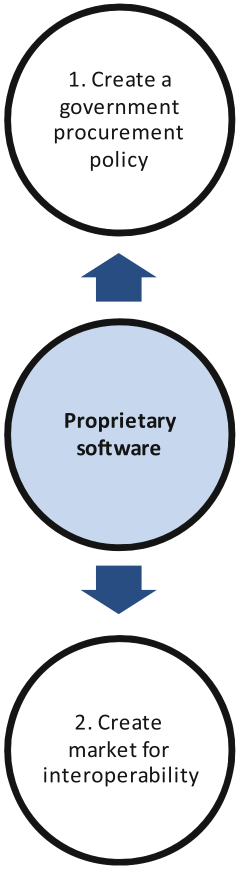
Solution 2—create the market for interoperability solutions

A general consensus for interoperability solutions encourages related market to grow and anyone can participate in developing interoperability solutions.

2.6.3.3 Migration Challenge Between Applications

Migrating new capabilities across the supply chain is difficult because changes do not propagate from one application to another automatically. Existing interoperability solutions are not easily extensible. As software capabilities advance, the need to exchange more data becomes complex and even if the data exists in a neutral format, the downstream software applications must accommodate these changes. This causes costly changes, incompatibility issues, and complex processes, and in general an inability to take advantage of new technologies and practices. The solutions make sure that changes have no harm, while providing new capabilities. Refer to Fig. 2.20.

Fig. 2.19 Proprietary software



Solution 1—develop and use modular software systems that allow upgrading of individual modules without adversely affecting networked applications across the supply chain

This solution would instantiate holonic (autonomous self-reliant) techniques in software systems that enable software to tolerate changes in input data format without deleterious impact. The holonic system allows each component to advance at its own rate as an autonomous self-reliant unit but still function within the system.

Solution 2—develop capabilities that permit new technologies to proliferate across the supply chain

This solution supports the development of advanced programming techniques that allows networked software to recognize and modify itself to take advantage of new data generated within a networked supply chain environment.

Solution 3—develop standards to support modular software systems and adaptable applications

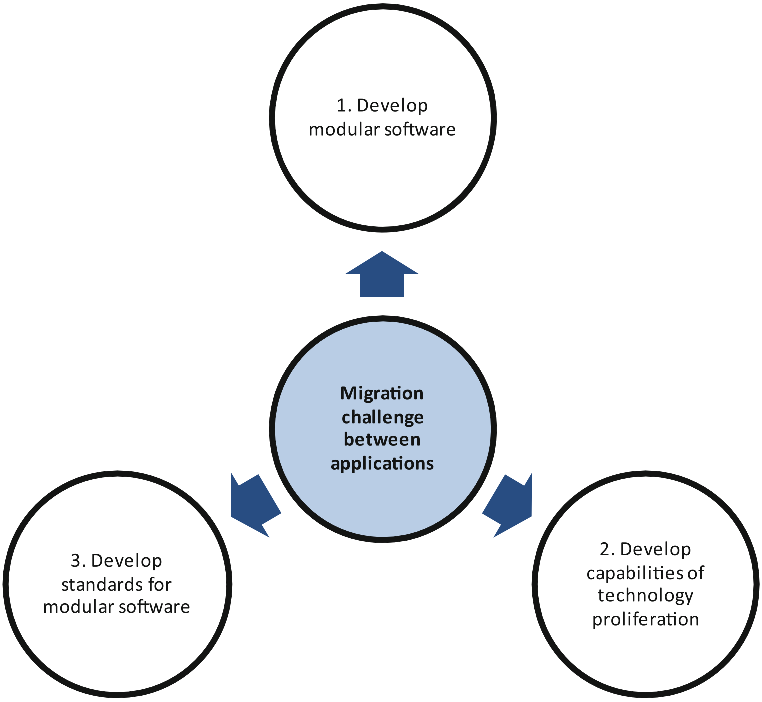


Fig. 2.20 Migration challenge between applications

The holonic software techniques will require a whole new approach to the protocol and Application Programming Interface (API) standards to make modular approaches working for interoperability.

2.6.3.4 OEM-Mandated Different Interoperability Standards

OEMs often require their suppliers to be compliant to a particular software suite they use. A supplier, on the other hand, who supplies the same or similar product to other OEMs may need to communicate with each of OEMs using a different system. As a result, the cost of interoperability is heavily imposed on the first and/or the second tier suppliers. Refer to Fig. 2.21.

Solution 1—encourage industry associations to embrace standards

Industry associations representing both OEMs and suppliers encourage the development of standards that will allow the neutral exchange of data between software applications that their members use. This solution seeks to educate those associations as to the benefits for their members and encourage advocating the development and acceptance of such capability.

Solution 2—educate business reasons to use same interoperability standards

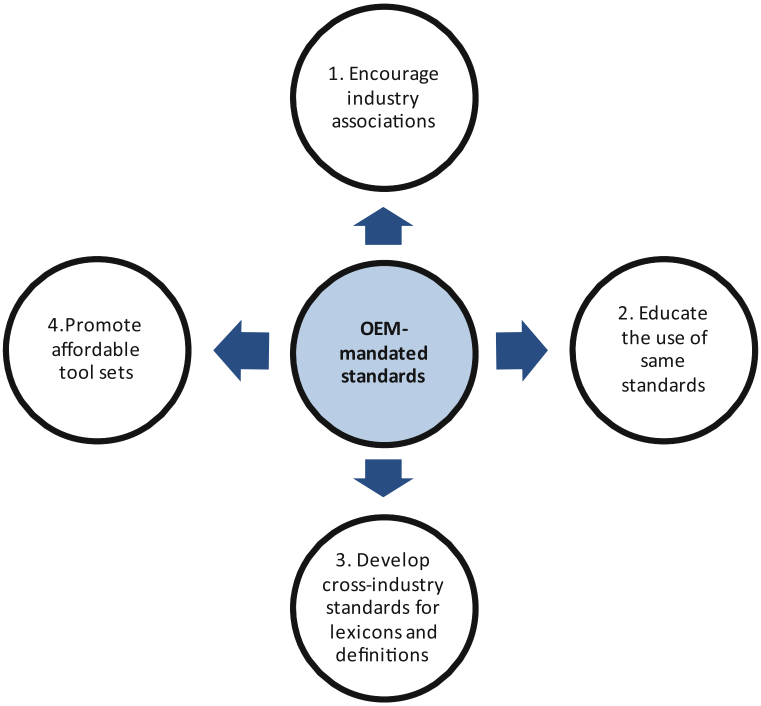


Fig. 2.21 OEM-mandated different interoperability standards

Similar to Solution 1, this solution seeks to educate companies for the advantages afforded to software users encompassing interoperability standards. Case studies, workshops, conferences, personal testimony, and other methods would provide data needed to build the business case for an investment in using interoperability standards

Solution 3—develop, promote, and support cross-industry standards for terminologies, protocols, processes, and ontology

Because supply chain members work together, individually and collectively, it is imperative to develop standard lexicons and definitions for use.

Solution 4—promote affordable tool sets to facilitate interoperability

Software developers will need software tool sets to help them implement the standards, lexicons, philosophies in their software. A common set of tools would help propagate techniques in a common and effective way.

2.6.3.5 U.S. Manufacturers not Capitalizing Interoperability Benefits

Lack of interoperability impedes US manufacturers from capitalizing on other competitive advantages, such as, proximity, response time, and lower inventory levels. The US manufactures are losing commercial opportunities because foreign

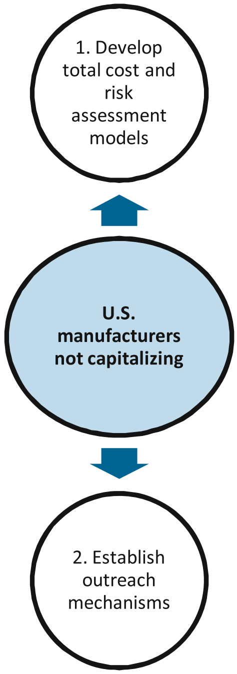


Fig. 2.22 U.S. manufacturers not capitalizing interoperability benefits

competitors have less cost of manual data translation and can override the advantages of proximity. Increasing application of interoperability within the US supply chain members will reduce this effect, and thereby increase the positive impact on other US product discriminators, such as, proximity, response time, and reduced inventory levels. Refer to Fig. 2.22.

Solution 1—develop total cost and risk assessment models that quantify the potential benefits, value, and risks of interoperability to all US manufacturers

Solution 2—establish outreach mechanisms to educate and encourage adoption of interoperability

2.6.3.6 Other Governments Act More Strategically in the Standards Development

US democratic system of governance has, over the years, developed rules and laws that seek to impede monopolistic and collusive behavior among groups of suppliers within an industry. Other governments actually encourage such behavior when dealing with foreign entities. The US needs to develop a more strategic view toward helping domestic supply chain members in dealing with foreign competitors. Refer to Fig. 2.23.

Solution 1—encourage industry groups to be actively involved in national and international standards development activities

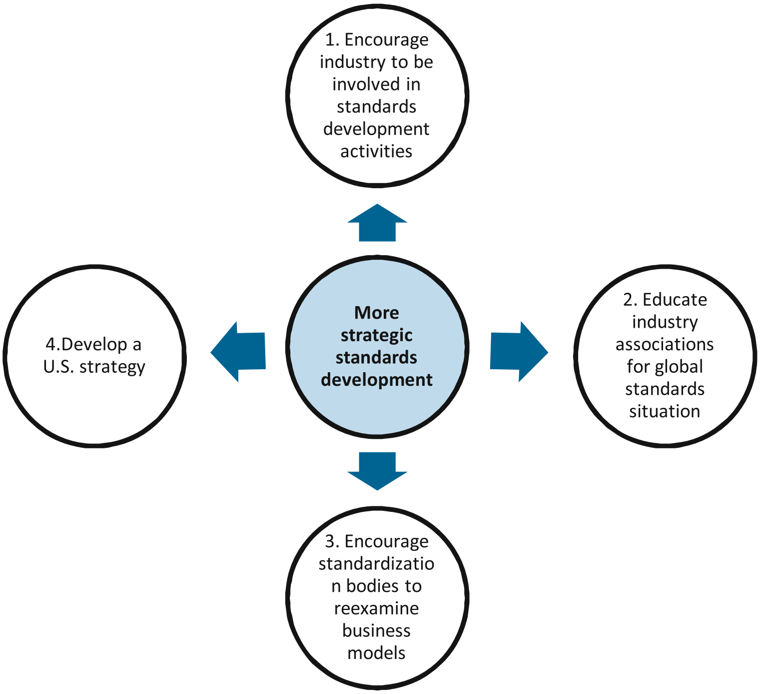


Fig. 2.23 More strategic standards development

Solution 2—educate industry associations about the global standards situation

Solution 3—encourage standardization bodies to reexamine business models

Solution 4—understand the impact of current standards policy on the US economy and develop a US strategy for supply chain interoperability standards.

In addition to these issues, other issues are discussed as follows:

- Lack of interoperability could increase cost of legal compliance
- No standard infrastructure exists to facilitate integration across supply chain
- Organizational culture focus for within organization versus extended supply chain (narrow scope of interest) because of resistance to change and short-term payoff expectancy
- Lack of universal and interoperable electronic catalogs makes it difficult to identify potential parts, services, and partners—time consuming and labor intensive process and missed opportunities

2.7 Supply Chain Interoperability in Product Development Process

In 1980 and 1990s, the entire Product Development Process (PDP) was an isolated functional area of a manufacturer. After product designers and/or product engineers finished a new product design with engineering specifications, they passed it to manufacturing engineers. Then manufacturing engineers produced the product using manufacturing processes. In other words, when there is a new product development triggered by customer needs, the PDP only considered its boundary as design and engineering, right before production.

This traditional PDP concept is no longer valid in such a way that new product development should take into account supply chain management aspects during the entire PDP. The linkage between PDP and supply chain management becomes much more important in a global economy. These two big areas in a product life cycle are inseparable. Globalization drives companies to expand more the boundary of production material sourcing and finished product marketing to foreign countries. As previously stated, we are living in an infinite inter-country competition world, not any more in an intra-country competition world. This imposes much more pressure on companies to reduce product price and supply chain costs. Before early 2000s, most companies regarded these two areas separately and it was fine at that time. In a single company, no much close interactions were required between these two areas. However, nowadays, unless these two areas of business communicate and coordinate to each other well, the company would be in a big trouble and get behind competition and not sustain the market share any more.

As shown in Fig. 2.24, rapidly changing consumer buying behavior, shorter product life cycle, and lower price competitors make the communication and coordination between these two areas critical. Companies should be aware of what consumers want and how to capture those needs to new product design. Without quicker detection and response for rapidly changing consumer purchasing preferences, companies cannot catch up with the consumers needs and will lose customers. Shorter product life cycle requires companies to have agile product life cycle management from design, through engineering, manufacturing, logistics, and to services. It is also important to know how competitors are doing in their business sector. If competitors sell for less, companies should lower the prices accordingly. Otherwise, consumers would select competitor products.

Having proper communications and coordination among all business functions of a company is not easy and so many issues exist to reach to this level of interoperability. This section discusses about how PDP relates to supply chain management and how to achieve a seamless connectivity in-between.

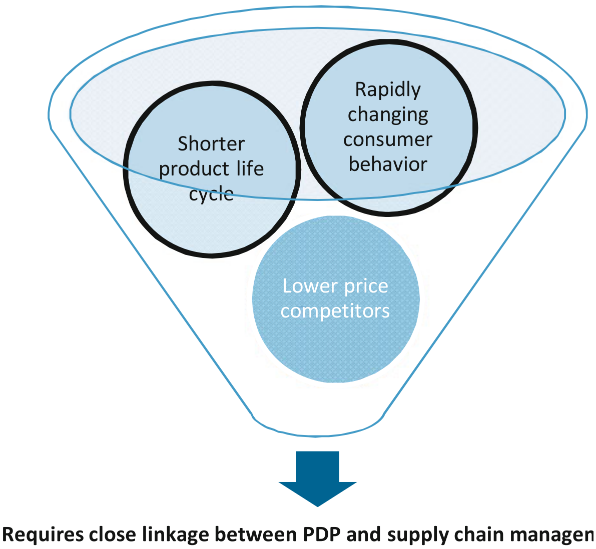


Fig. 2.24 Linkage between PDP and supply chain management

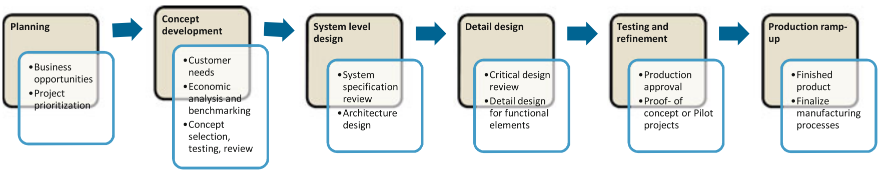


Fig. 2.25 Generic product development process

2.7.1 Product Development Process

Figure 2.25 shows a generic PDP in which concept development, system level design, detailed design, and testing and refinement are four primary phases. The product planning precedes the PDP. After testing and refinement, production ramp-up follows for a large-scale production. Refer to Ulrich and Eppinger (2004) for more details.

The product planning phase begins with identifying business opportunities for a new product. It evaluates and prioritizes projects for new product development by considering budget, resources, and timing. A mission statement, a starting point for a new product development, needs to be developed, which includes product description, key business goals, primary and secondary market, assumptions, and stakeholders. When there are multiple projects planned, we will have several mission statements. We should consider numerous factors in prioritizing projects, such as, market segment, market share increase potential, related process capability, and technology maturity.

During the concept development phase, first of all we need to identify customer needs. Based on the mission statement, we conduct economic analysis and benchmark competitive products and establish target specifications for the new product. The target specifications are made using customer needs and benchmarking. And we generate multiple product concepts, select a couple of product concepts, and test them. Then, we set a final product specifications and move to the next product development phase. The final specifications are based on selected concept feasibility, modeling, and testing results. Necessary metrics are defined for target and final specifications. The metrics are defined in physical units, such as, hertz in dB, power in Newton, weight in gram, time in second, and length in meter. Of course, physical dimensions of a product are used as a basis to make a robust design of the new product.

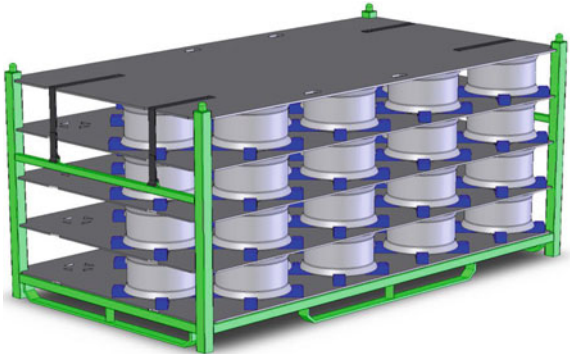
The system level design phase decomposes and assigns functional decisions to architecture. Product architecture is determined early in the PDP and it is the arrangement of functional elements into physical chunks which become the building blocks for the product or the family of products. The detail design phase makes it further detailed for each functional element. The testing and refinement phase conducts various tests to filter out potential defects and improve its final design. The production ramp-up phase starts regular production of the product.

2.7.2 Linkage Between Product Development Process and Supply Chain Management

When do we need to consider supply chain interoperability during the PDP? For a new product development, from the concept development phase, we first need to look at product specifications from the perspective of supply chain management. What impact does a product specification have on supply chain management? The product specification determines the dimensions of parts and components and further it affects manufacturing process decision, sourcing decision, and logistics decision. If the existing manufacturing process is unable to produce the new product, the current manufacturing process needs to be modified or developed. If the product requires a new part, we need to seek a new supplier to procure the part.

Product design specifications also influence logistics requirements. Here is an example on how a part design change affects the design of corresponding container. Through system level design phase, detail design phase, and testing and refinement phase, the part design could change too. This change should be correctly reflected to the design of the container. Part design progress should be synchronized to container design because reflecting the change of part design is vital to supply chain design, planning, and operation. Otherwise, reflecting it later on will require much more time and effort. During the entire PDP, we should align

Fig. 2.26 Returnable shipping rack example



each phase of the PDP with that of supply chain management. If not, when a new product design is finalized for production, manufacturing capability could not be ready for production and logistics network not be set up for operations. Let us consider a returnable shipping rack, the container for loading and delivering production parts, shown in Fig. 2.26 as an example.

As an illustration, we think of one part that has an incremental design improvement. Figure 2.27 shows the front bumper of an automobile with the dimensions of 25 in. × 2 in. × 5 in. (L × W × H). In the assembly plant, the front bumper is assembled in two operations: one is picking operation that a handling robot grabs a front bumper and aligns to a vehicle coming in a vehicle carrier, and the other is assembling operation that an assembling robot finishes assembly. The front bumpers are transported from a supplier in a returnable shipping rack holding 10 front bumpers.

According to the launch of the new model year vehicle, assume that the length of the front bumper is increased to 25.5 in. A design change of the existing part requires changes of logistics elements. The current shipping rack cannot hold the front bumpers and its dimensions also need to be changed. If no prompt communication is conducted between a front bumper design team (including a supplier) and a related manufacturing team, even though the new front bumper design is finalized, its manufacturing may not be possible in time. In this simple situation, two important activities, communication and coordination, are needed. First, the change in the length of the front bumper should be transmitted to the manufacturing team at the assembly plant by which they can adjust the picking and assembling robots. Second, the front bumper design change needs to be communicated to the container design team. Of course, the manufacturing team and the container design team should work together closely. The manufacturing team needs to talk to manufacturing planning, manufacturing control, material management, and quality control teams at the plant as well.

The container design team also needs to communicate with container engineering, container purchase, and container operation teams. Another business function that should be in the line of communication and coordination is logistics. The increase in the length of the shipping rack container may change the

Fig. 2.27 Front bumper dimensions

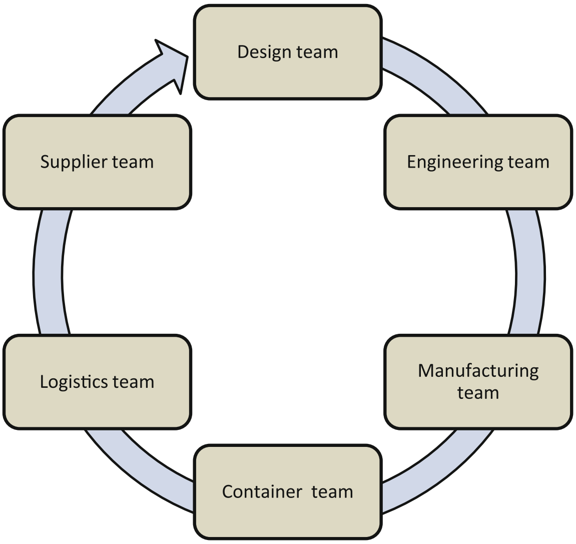


Fig. 2.28 Synchronization and alignment between PDP and supply chain management

transportation footprint. In other words, because racks are transported via truck or rail, the rack size increase can change the shipment capacity of its transportation carrier. For example, before the design change, a truck was assumed to hold 50 racks. However, after the design change, the truck may hold 45 racks. This also causes a change in shipment frequency. Furthermore, this requires the plant to increase the inventory level of racks. When the racks are delivered from overseas, they are held in a bigger container, e.g., 40-foot ocean container via a ship. All of these activities require several teams to work together in harmony. Otherwise, the new model year vehicle production cannot be possible in conjunction with right manufacturing, containerization, and logistics. We can see here a glimpse of light for the significance of alignment and linkage of the PDP and supply chain management as shown in Fig. 2.28 that emphasizes a continuous circle among several teams.

2.7.3 Interoperability Needs

Let us think about possible interoperability issues for our example above. It is obvious that we have both internal and external interoperability needs. First we think about internal interoperability. There are two types of internal interoperability needs: one is single unit interoperability, and the other is multi-unit interoperability.

For an illustration purpose of the single unit interoperability, we use the container team. Within a container management organization, there are many different teams. The container planning team makes a plan of container needs for next year vehicle models production and determines total container fleet size accordingly. The container design team designs new containers for loading new parts for new vehicle models. The container purchase team identifies potential suppliers and buys containers from them. The container operation team manages and controls container quantity in a daily basis to make sure there is no shortage to replenish production parts. Excel spreadsheet has been the most popular tool because of its availability and ease of use. Every computer has Excel and it is easy to learn and use. Unfortunately, due to its popularity, users can develop their own spreadsheet documents in which each user defines the names of data entries differently for the same contents. For example, one user at the container planning team defines the front bumper rack name as ‘Front bumper, Chevrolet Suburban’ and the other user at the container design team defines the container name for the same part as ‘Bumper front, Chevy Suburban’. When either of them wants to consolidate those spreadsheets, will it be automatically done? A manual effort is required to sort every entry out to make sure that right columns are combined together. When every team in the container organization does the similar way, the consolidation work is not trivial. This could require another IT tool development to seamlessly consolidate different spreadsheet documents.

How about the multi-unit interoperability? The single unit interoperability issues are much easier to resolve than the multi-unit interoperability. Although there is a discrepancy in data, it is relatively easy to fix in a single unit. Most likely, different business units would use rather different definitions for the same purpose. In the example of the front bumper, the part design team may define and use the name of the front bumper like ‘Ft bumper for Chevy SubUrbn’. When the design team transfers the data for the new front bumper to the manufacturing planning team, there should be interoperability problems between two teams. In addition, when the design team may use different CAD tools, another interoperability problem occurs because of different file formats.

Let us think about the external interoperability issues. When the container team sends part and container data for the new front bumper to supplier and logistics carrier, respectively, more serious problems can take place. The supplier team is part of tier-1 suppliers. The logistics team is outsourced to a third-party transportation company. Typically, suppliers and logistics companies may have business with multiple OEMs. It is obvious that suppliers and logistics carriers should have additional data entries to distinguish different OEMs in addition to the discrepancies in names and formats of the part and container itself. Also, they use different information systems provided by different IT vendors. Once again, we can see even in the simple scenario above that the first step of interoperability is to identify mismatch in a common data set.

Furthermore, we may want to ask ourselves the following questions regarding the linkage between PDP and supply chain management: how to maximize the benefits of the linkage? when does the linkage need to be considered in PDP? what relationships exist in each stage of PDP? what feedbacks need to be considered based on supply chain operations? and more.

2.8 Summary

You have learned from this chapter the current state, issues, benefits, and obstacles of technology integration. In addition, you have seen interoperability research in Europe and the US using the example of sharing information between PDP and supply chain management, you have realized the importance of interoperability linkage in-between through communications and coordination. You will understand new and emerging business technologies in next chapter, focusing on technology forecasting techniques.

2.9 Exercises

1. Select one company you are interested in. Collect information for that company as well as its industry sector. Each industry or company may have essential technologies to sustain its business. Lay out what technologies are needed for the company chosen. Consider the current state of those technologies. Can you find any other characteristics regarding the current state in addition to the things presented in Sect. 2.1? Which characteristic do you think would be the most critical to that company? What technology would need to be newly introduced?
2. Make a group of four. Assume two people of the group belong to an OEM and the other two to different suppliers. The OEM has proposed a new project and invited the people from two suppliers. The new project intends to build an information infrastructure to share mutual business transactions data. During the very first meeting, the group faced so many conflicts that fall in the four issues in Sect. 2.2: private business information disclosure, hard-to-reachable common business process, heavy development efforts, and workload unbalance. Discuss each of those issues and write a summary in a couple of pages. Each member of the group should speak as a representative of his/her company.

3. Discuss about the benefits of supply chain interoperability. Consider one specific technology that could improve supply chain interoperability by and large, and discuss what benefits the technology would bring in?
4. In addition to those obstacles stated in Sect. 2.4, what other obstacles can you think regarding supply chain interoperability? Use one project you did or are doing at your company or school. Which obstacle would be the hardest to overcome? Why? How to overcome it?
5. Pick one product, e.g., cell phone, iPod, TV, or digital camera. You are responsible for developing a next generation product that would be a totally brand new one or an incremental improvement one. Explain why and how your new product development process should consider its impact on other related business units, such as, engineering, manufacturing, logistics, quality, and services. In conjunction with those related business units, what tasks should be done for a seamless launch of the new product in time?

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