AIAG - NIST
PRODUCT DATA MANAGEMENT INTEROPERABILITY PILOT FINAL REPORT

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AIAG-NIST

PDM PILOT

STATEMENT OF WORK

AIAG-NIST PDM Pilot: Statement of Work

Introduction

Increased collaboration in many phases of the product lifecycle is the norm today. This has been caused by a number of business factors: M&A activity, competitive pressures, and cost and time considerations are forcing activities to be performed by entities that can carry them out most efficiently. A consequence is that the extended automotive enterprise now often comprises first and second tier suppliers that have significant design responsibility. Some tier 1 suppliers are turnkey-responsible for entire vehicle modules[1]. They follow OEM specifications, but have full responsibility for design, engineering, and manufacturing.

The collaboration needs of this extended automotive enterprise are significant and the degree of success in meeting them can make the difference between success and failure in meeting cost, time, and quality metrics.

This pilot concept proposes a flexible, standard-centric, and extensible approach to design and engineering collaboration within an extended automotive enterprise without the use of complex and expensive systems integration approaches. Instead, it advocates the use of enterprise application integration (EAI) techniques to provide rapid and focused exchange of PDM data in the context of well-defined business processes.

The Need

Collaborative product design between partners in a supply network is fraught with inefficiencies: the costs of maintaining and using disparate CAD and PDM systems, the delays due to the transfer of information on paper and its subsequent reentry into destination systems, and the quality problems introduced by the movement of data across media boundaries (e.g. electronic to paper to electronic).

Today, reliable and repeatable exchange of product data within an extended automotive enterprise is not possible. It will continue to be a challenge since not only is the data becoming more rich and complex, but exchanges are becoming more frequent[2]. These issues are aggravated by the following:

- The product data to be exchanged represents incomplete snapshots of a complex design still in the process of evolution (imagine a multi-part assembly tree with many of the components not yet designed and others designed partially).
- The product data is subject to many changes at different locations and these changes are made on copies of the original data, thereby spawning variants that are hard to manage and control, and easy to lose track of.
- There are no commonly accepted methods for data exchange under different business scenarios. For example, there is no standard way to send product data to a business partner with a request to perform certain actions and return the modified product data. Similarly, there is no standard way to manage engineering changes, the most common information bundle exchanged between design collaborators.

[1] These are sometimes termed tier 0.5 suppliers.

[2] The OEMs and upper-tier suppliers are addressing this problem by natively using the OEMs' PDM system and format to exchange data. This adds cost and data quality problems of its own.

Contrary to common belief, these problems are frequent at levels below the first tier companies as well. While the problem is often characterized as a PDM-to-PDM issue, it is part of a broader problem within the supply chain. Studies done in the automotive industry indicate that collaborative encounters between members of a design chain are on the rise and will increase significantly in the near future[3] and tier 0.5 suppliers grow their businesses and act more like OEMs. The other reason is globalization caused by organic expansion and M&A activity. As company locations grow in number, the greater the need to exchange data among locations. Furthermore, the systems of acquired companies are usually different from that of the acquirer, causing the same exchange problems described earlier.

The need is therefore to not invest in point-to-point PDM exchange solutions, but to explore the application of common web technologies to specific business processes to offer a simple solution that is commonly applicable to all instances of those business processes. This approach can then be repeated for other business processes and a portfolio of common processes offered for specific segments of the product development lifecycle.

A Pilot Project

In this document, we propose a pilot project to apply a standards-based approach to product data exchange in the context of well-defined and specific design-related business processes. The business processes will serve to bound the data content necessary for the successful transfer of semantics every time a *transaction* representing a business process is executed. A set of related transactions can then be defined that will enable significant and repeatable execution of a business activity[4]. As an activity that demonstrates value (time, cost, quality improvements) and proposes adoption of its results if successful, this pilot project will have the following objectives:

- Identify business area where high transaction costs inhibit the flow of product data
- Develop candidate transaction sets for exchanging PDM data
- Pilot the use of these transactions and validate their effectiveness in use
- Advance transactions to standard bodies for adoption
- Attract software product vendors to implement transactions and deploy in automotive industry

Proposed Approach

Studies conducted by AIAG have identified various design-related business processes and offered detailed descriptions of the information content exchange between partners executing them. The results of these studies clearly point to the overwhelming anticipated benefits of collaborative design. However, in order to pinpoint the areas where the gains may be significant and to win industry acceptance, the pilot project team will invite broad participation in the various phases of its activities.

A five-step approach is proposed:

- Create a team of first and lower tier suppliers (who have design responsibility), PDM system vendors, project facilitators, and

[3] A document entitled "B2B Requirements and Strategy for Product Data Management" resulted from a significant study conducted by the Automotive Industry Action Group (AIAG) in 2000. This proposal draws from it.

[4] Here we use "business activity" to mean a task that is made up of a small number of simple business processes.

- Using current AIAG studies, isolate, prioritize, and group business processes that are both simple to automate and are valuable by virtue of their frequency of execution.
- Develop standard descriptions of each business process transaction, providing business rules for transaction execution, and exception handling.
- Package these transactions with the PDM data (content) that *must* accompany each transaction, documenting them in a standard format using XML as the format for exchanging content and existing PDM data representation standards to ensure common semantics for data elements.
- Prototype a transaction set through extensive testing between heterogeneous PDM systems. This will involve developing software adaptors for the PDM systems, a much more lightweight approach than systems integration solutions between systems.

Participants

To be successful, this pilot project will require

- Users companies to provide user input and requirements,
- Selected PDM vendors as active participants,
- Industry groups, and
- Technology and project management experts to help execute the business and technical components of the pilot create the transaction sets and data exchange specifications, and to manage the project.
- Technical and Project Managers: ERIM

Tasks and Deliverables

Form pilot team and project plan

Recruit project team. Kick off pilot project, draw up milestones and deadlines assigned to each task. Team shall include auto suppliers that will serve as users, PDM product vendors and developers of industry portal solutions, project and technical team members, and the customer. Project will be executed and managed by ERIM and AIAG staff with the participation of NIST staff.

Deliverables: Project roster, project plan, milestones and deadlines.

Develop business case framework and prioritize business activities

Develop business case for candidate business activities that will be piloted in this project. This will be developed using past knowledge gathered by AIAG and new data gathered from project team members. The business case will provide data on the potential benefits of each activity which will be prioritized accordingly.

Deliverables: Business case, recommended business activities for piloting.

Agree on common semantics for data elements

Conduct workshops with users and vendors to agree on the scope, semantics, and form of the datasets to be exchanged. Document agreements.

Deliverables: Agreement document detailing common, agreed semantics and form for all data in the scope of exchange.

Package data elements (content) in XML DTD

Develop standard-based XML DTDs for the datasets and gain agreement of users and vendors.

Deliverables: XML DTDs based on the STEP PDM schema upon which the exchanges will be based.

Document transaction groups for specific scenarios

Generate scenario storyboards and use cases for real-life exchanges using the DTDs and document the transaction sequences to accomplish each business process being piloted. Deliverables: Use cases and transaction sequences (including pre and post conditions) for each business process to be piloted.

Develop software adaptors (import and export) for Vendor packages

The PDM system vendors participating in the pilot project will carry out this task. The project team will monitor this activity and ensure adherence to deadlines.

Execute pilot exchange program to test the concept

Set up systems to record data on the transactions. Work with users to pilot the transactions and document the results. Iterate this process as problems are detected and fixed. Demonstrate successful transaction-based exchange of product data between customer and supplier companies. Propose the alignment of the specifications developed in this project with standard bodies (OAGI, OMG, etc.) active in the field of product data exchange.

Deliverables: Demonstration of successful exchange to auto industry representatives, standard development bodies. Measure the quality of the exchanges

Measure and record metrics for transactions. Compute the benefits of the improvement (cost, time, data quality). Report to project team and customer.

Deliverables: Benefits report.

PRODUCT DATA INTEROPERABILITY

HISTORY

Product Data Interoperability - History

History

The Automotive Industry Action Group's (AIAG) Collaborative Engineering & Product Development Steering Committee, with assistance from its various work groups, has spent the last few years addressing interoperability issues in the product data arena. The primary focus has been to study the existing standards, identify requirements, quantify the waste and establish guidelines and recommendations to achieve integration within the automotive supply chain product data management (PDM) and computer-aided design (CAD) systems.

AIAG's D-14 document, "B2B Requirements and Strategies for PDM Interoperability," estimates that within the automotive PDM environment alone there is a $1.4 billion annual waste due to the lack of interconnectivity between dissimilar systems. Daratech Inc., a high-tech analyst firm, estimates that the total global cost of un-interoperability can be estimated conservatively at $20 billion.

The problem is not only an auto industry concern; aerospace, shipbuilding and other industries face the same issues on a daily basis. In recognizing AIAG's past efforts and present activity in this arena, the National Institute for Standards and Technology (NIST) has awarded AIAG a $300,000 grant to prove out the possibility of standards-based integration. Since the major players in the vendor community are the same and business requirements across the many industries are quite similar, the impact of this project will be felt beyond the automotive industry.

A Little Background

The AIAG AutoSTEP Pilot (1995-1998) investigated the use of the ISO 10303 (STEP) standard as a means for the exchange of product data between partners in the automotive industry. The goal was to identify barriers to design collaboration between supply chain partners, validate the deploy ability and usability of the STEP standard, and provide feedback to standard developers and STEP product vendors. This project afforded valuable industry and technical experience to the execution team.

In July 2000, AIAG and NIST sponsored an automotive industry workshop on interoperability issues. The workshop brought together representatives of automotive OEMs, suppliers and supporting organizations. In multiple parallel sessions, the participants addressed two main phases of the product life cycle: (1) product development and (2) production control and material release.

The sessions generated the following list of key elements to address interoperability:

- Heterogeneous systems
- Security of electronic systems
- Visibility of product development information
- Sharing production data throughout the supply chain
- Data integrity
- Optimizing engineering changes
- Standards implementation
- Standards development

By comparing the workshop results with other industry workshops and studies, interoperability was confirmed as a key element for improving the operations of the automotive supply chain.

Concepts such as the 12-month car are highly dependent on substantial improvements in the supply chain information sharing processes.

Based on these findings, AIAG's PDM Work Group undertook the task of a proof of concept demo on automotive PDM systems using existing STEP standards. At the 2000 AUTO-TECH Conference in Detroit, Mich., successful interconnectivity was demonstrated between Enovia - IBM, Metaphase EDS and ISS InSync. Effective information exchanges were enabled by:

- Open Systems — neutral standard information models and semantics (ISO 10303 PDM Schema)
- Web Infrastructure — neutral standard information technology (XML, Java)
- Secure Data Transport — ANX

This PDM interoperability demo was a success...or was it? The industry decision makers were impressed but still skeptical as the software used in the demo was "out of the box." The question placed to the PDM Work Group was: Can similar success rates be achieved between "customized and configured" automotive PDM systems? A new challenge! So, the work continues...

Phase II — NIST/AIAG PDM Interoperability Pilot Logistics

The goal of this project is to achieve interconnectivity between "customized" versions of automotive OEM-supplier PDM systems.

Collaborative product design between partners in a supply chain network is fraught with inefficiencies: the cost of maintaining and using disparate CAD and PDM systems, the delays due to the transfer of information on paper and subsequent reentry into destination systems, and the quality problems introduced by the movement of data across media boundaries. Today, reliable and repeatable exchange of product data within an extended enterprise is not possible. It will continue to be a challenge, because not only is the data becoming richer and more complex, but also the frequency of exchanges is growing exponentially.

This pilot proposes a standards-based approach to product data exchange in the context of well-defined and specific design-related business processes. The business processes will specify and bound the data content necessary for the transfer of semantics every time a transaction representing a business process is executed. A set of related transactions can then be defined, enabling significant and repeatable execution of a business activity.

The pilot has the following objectives:

- Identify business areas where high-transaction costs inhibit the flow of product data
- Develop candidate transactions sets for exchanging PDM data
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- Advance transactions to standards bodies for adoption
- Attract software product vendors to implement transactions and deploy in the automotive industry

> "Solutions to supply chain interoperability problems exhibit a number of key threads," said Rick Bsharah of Ford Motor Company and chair of AIAG's Vehicle Product Data Project Team. "Pilot projects are very important for proving the effectiveness of new approaches, whether they be standards, tools or business practices.

Ultimately, a concerted effort by industry, government and the research community will be needed to significantly reduce PDM interoperability problems, and this reduction will be manifested through the development and implementation of tools and best practices," Bsharah added.

Getting Started

The first step taken by the AIAG Collaborative Engineering & Product Development Steering Committee's Vehicle Product Data Project Team was to form four Pilot Work Groups:

(1) Requirements Work Group — Mike Gorden, Ford Motor Company, chair
(2) Software Development Work Group — Seema Jetli, Altarum (formerly ERIM), chair
(3) Deployment Work Group — Eric Wines, Siemens-VDO, chair
(4) Data Model/Schema Work Group — Raj Birla, Ford Motor Company, chair

Next, two important responsibilities were assigned: Shantanu Dhar of Altarum was named technical project manager and Akram Yunas of AIAG was named lead program manager.

Global Collaboration and Harmonization

Since its inception in 2000, AIAG's Collaborative Engineering and Product Data Steering Committee has not only advocated, but also insisted that the objective of any initiatives undertaken by the committee should seek global solutions and be in harmony with other standards which exist in or are being developed for today's global automotive industry.

AIAG has expanded the scope of the project by creating working relationships with other international standards-setting bodies. Automotive Steering Group (ASG), Object Management Group (OMG), PDES Inc., Japan Automobile Manufacturers Association (JAMA), Verband der Automobilindustrie (VDA) in Germany, Groupement pour l'Amelioration des Liaisions dans l'Industrie Automobile (GALIA) in France, and Odette-Sweden, are a few of the major organizations coordinating with the development of the pilot.

The task of standardizing the requirements for ensuring global acceptance was led by PDES Inc. and the ASG. In this task, the AIAG B2B PDM requirements document (D-14) was mapped against PDES Inc.'s STEP PDM modules and the ASG's PDM exchange requirements document to create a common set of functional and data requirements.

AIAG has also signed a Memorandum of Understanding with the Open Applications Group (OAGI) to develop new Business Object Documents (BODs) based on the requirements and data model recommendations from the PDM work groups. OAGI has established a work group to take AIAG recommendations and harmonize existing BODs for PDM deployment. Dr. Tim Thomasma of Ford Motor Company is the liaison lead on this aspect of the project.

Strategic Automotive product data Standards Industry Group (SASIG), a global consortium of standards organizations, has created an ad hoc committee to coordinate and harmonize the PDM activities in Europe, Asia and the U.S. The Global PDM Work Group will link the three PDM pilots under development in Germany, Japan and the U.S.

The primary reason for this activity is to eliminate waste, leverage expertise, reduce timelines and ensure global acceptance.

> “The recent economic downturn in the industry has taken a toll on resources needed to work on key initiatives like the PDM interoperability pilot,” said Andrew Brown, Jr., director of engineering for Delphi Automotive and chair of the AIAG CEPD Steering Committee. “We must leverage what others have done or are doing. Collaborations are the only way to survive in today’s standards development world. If not eliminated, redundancy will stay as the single largest hurdle hindering timely development of globally accepted, meaningful standards,” Dr. Brown added.

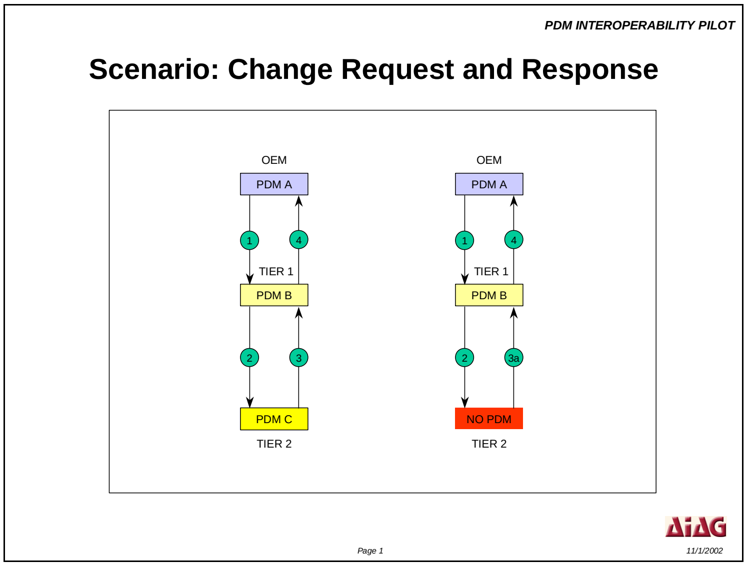
Deployment Scenarios

The first thing the project team decided was to address the skepticism associated with the “out of the box” software in the AUTO-TECH 2000 PDM demo. The scenarios finalized for the AIAG-NIST pilot are “real case scenarios” and will involve engineering change exchanges between customized PDM systems of the trading partners, including Ford Motor Company, Siemens-VDO, a tier two supplier and a supplier without a PDM system. VPM, I-MAN, MetaPhase and PTC’s I-Pro will be the PDM systems utilized.

The team decided to focus on two common scenario hybrids (see Figure 3). The first is a change request and response scenario that propagates from an OEM to a tier-one and then on to a tier-two supplier. The response then propagates back to the OEM. The second scenario, involving a tier one and an OEM, is aimed at enabling the tier one to provide new product data to the OEM. The new data will incorporate the part number, name, etc. provided by the OEM.

A combination of scenarios three and four in Figure 1 is called a Change Request Propagation. The OEM issues a design change request to the tier one for a particular part (assembly) that is already present in the tier one’s PDM system. The tier one processes the request and propagates it to a tier two that has designed the component of the assembly affected by the change.

Figure 1



This step has two variations:

(1) The tier two uses a PDM system in-house and processes the request by making the change to the component and sending the updated PDM and CAD data to the tier one; or

(2) The tier two does not have a PDM system. It processes the request by making the change and incorporating the changed PDM info in the CAD file or keeps the changed PDM data separately, then it sends the data to the tier one. The tier one incorporates the new data into its PDM system and generates a change response for the OEM. It then propagates the change to the OEM where it is incorporated into the OEM's PDM systems.

Next, consider the two-step combination of scenarios one and two from Figure 3, known as New Product Data Transfer:

(1) The OEM places a contract on a tier one for a new vehicle program.

Since this is a new program, the OEM has no PDM or product data for this part in its PDM system. The OEM creates a blank spot in its PDM system and assigns the part a part number, name, version, etc. It sends this empty tree to the tier one.

The tier one, who already has the product designed (done for a different OEM), creates a copy of it and incorporates the new PDM data into this copy. It then sends this new copy to the OEM. The OEM incorporates this received data into the "blank spot" in its PDM system.

What to Expect

In 2001, the Center for Automotive Research (CAR) and Altarum conducted a detailed study of 16 tier-one automotive suppliers with annual North American sales of $70 billion or more. A question was asked regarding their future predictions for interoperability/collaborative engineering. The suppliers responded that in two or three years, 75 percent of suppliers will be able to transfer interoperable CAD files and control engineering changes electronically, compared with only 18-25 percent today. These are very optimistic projections. If we can achieve half of the expected progress, the savings to the automotive industry will be significant.

PRODUCT DATA INDUSTRY WORKSHOP

AIAG - NIST

Product Data Industry Workshop by AIAG-NIST

Executive Summary

Interoperability, the ability for data and information to move unimpeded between different systems, is a critical issue for the automotive industry. Interoperability is a necessity in current business operations and even more in new approaches to business operations,. Substantial savings in both cost and time can be achieved if the interoperability issues are addressed.

AIAG/NIST Workshop

In July, 2000, the Automotive Industry Action Group (AIAG) sponsored an automotive industry workshop on interoperability issues at the request of the National Institute of Standards and Technology (NIST). The purpose of the workshop was to give guidance to NIST on industry needs related to improving interoperability across automotive supply chains. NIST interest in this issue was driven by a NIST-funded study that concluded that interoperability problems cost the North American automotive industry $1 Billion annually. The actual cost of interoperability problems is undoubtedly much higher, because that study focused only on product data exchange, which is just a part of the interoperability issue.

The workshop brought together representatives of automotive OEM's, suppliers, and supporting organizations. In three parallel sessions, the participants addressed two main phases of the product life cycle, product development and production control and material release. The sessions generated the following list of key elements of addressing interoperability:

- Heterogeneous systems
- Security of electronic systems
- Visibility of product development information
- Sharing production data throughout the supply chain
- Data integrity
- Optimizing engineering changes
- Standards Implementation
- Standards Development

By comparing the workshop results with related workshops that looked at automotive supply chain issues at a higher level, interoperability was confirmed as a key element for improving the operations of automotive supply chains. Such concepts as the 12-month car are highly dependent on substantial improvements in these supply chains.

What is needed

A process built around piloting new approaches in automotive supply chains is the most effective way to move the industry towards common, cost effective solutions. A set of pilot projects that would improve the overall automotive design and production process, benefit the industry, and provide cross pilot knowledge includes:

- Engineering change (before product launch)
- Engineering change (after product launch)
- Data synchronization during product development
- Design using reusable components
- Production scheduling and material release
- Integrated logistics

Each of these projects would require a Federal Government support budget of roughly $2 Million, in addition to substantial industry resources.

The solutions to supply chain interoperability problems exhibit a number of key threads. Pilot projects are very important to the effective adoption of new approaches, whether they be standards, tools, or business practices. Ultimately, a significant reduction in interoperability problems will require a concerted effort by a number of organizations from industry, government, and the research community in the development and implementation of tools, practices, and processes.

Introduction

This report documents the results of a workshop held by the AIAG in Farmington Hills, Michigan in response to a request by NIST. The workshop was designed to identify and prioritize key interoperability issues that act as barriers to effective collaboration across automotive supply chains.

Workshop Motivation

A recent study sponsored by NIST and conducted by the Research Triangle Institute concluded that the annual cost of interoperability problems in the automotive industry is greater than $1 billion.[5] As significant as this number is, it is almost certainly low, as it was based primarily on CAD data exchange.

This cost documentation defined the overall need for improved interoperability. NIST's purpose for the workshop was to assist in planning its future efforts to address the interoperability problems that most concern industry.

Scope of Interoperability Problems of Concern

Interoperability is an issue across the product life cycle. The product life cycle can be broken into four major stages:

1. Technology development (non-product specific)
2. Product development
3. Manufacturing equipment development
4. Production control and material release

The workshop focused on items 2 (product development) and 4 (production control & material release). The other two were left for future work.

Objectives of workshop

The workshop had two objectives. The first was to identify a list of interoperability problems that limit or prevent effective collaboration across automotive supply chains in each of the focus areas. The second goal was to *prioritize* those issues based on the order in which they should be addressed.

Structure of Workshop

The workshop used a structured process with three subgroups working in parallel, each focusing on one part of the life-cycle list provided above. The three primary steps each subgroup undertook were:

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[5] "Interoperability Cost Analysis of the U.S. Automotive Supply Chain," 99-1 Planning Report, National Institute of Standards and Technology, 1999.

1. Describe problems and issues
2. Categorize problems and issues
3. Prioritize problems and issues

If the necessary knowledge and information was available, the following were also to be done for each of the problems and issues:

4. Identify root causes
5. Identify solutions and "work-arounds"
6. Attach costs to problems and issues
7. Identify likely industry-level solutions

Each subgroup had its own facilitator, plus there was an overall facilitator watching over the entire process. In addition, each group had a designated person (not an active participant) with the job of taking notes of the discussions.

Workshop Participants

The 24 direct workshop participants (not including facilitators and note takers) represented a wide view of the automotive industry, including OEM's (original equipment manufacturers), suppliers, and several types of service providers. Participants included people from the companies shown in Table 1 (next page), some of which had representatives from more than one department or group.

Document Content

Section 3 describes the results of the workshop as developed by the three subgroups. The information from each subgroup is presented separately. Section 4 compares the results of this workshop with results from two other recent workshops looking at strategic directions for the automotive industry. Section 5 summarizes the results, describes a "roadmap" toward solutions and provides a description of the roles to be played by various types of organizations.

Table 1 – Companies represented by workshop participants.

- CIMdata, Inc.
- DaimlerChrysler Corporation
- Dana Corporation
- EDS Corporation
- ERIM
- Federal Mogul Corporation
- Focus: HOPE
- Ford Motor Company
- General Dynamics Land Systems
- i2 Technologies
- Modine Manufacturing Company
- SAP America
- Structural Dynamics Research Corporation
- The Gates Rubber Company
- TRW, Incorporated
- Visteon

Workshop Results

The following sections describe the results of the three subgroups.

Subgroup A Discussions

Looking at product development issues, this subgroup developed a list of problems that they condensed into four prioritized (and not totally independent) issues:

1. Heterogeneous systems
2. Security
3. Standards Implementation
4. Standards Development

The prioritization is based on the following assumptions for efforts to address these issues:

- Short time frame – putting solutions in place within 1-3 years
- Quick payback – positive effects of new approaches realized very quickly after implementation
- Multiple pilot activities – pilot projects on a 12 month scale (start to finish) will be the best way to address the issues
- Leverage existing technologies – Quick, effective solutions will need to depend on existing technologies rather than the development of new technologies

One of the key concepts generated by this group was the matrix shown in Table 2. This describes the solution space for interoperability problems. The matrix rows represent three major areas in which interoperability problems can be addressed. The columns represent the different levels at which problems can be addressed. What is key about this matrix is that though it describes the solution space, the cells of the matrix are not independent, neither across rows nor down columns.

The following subsections describe the four major problems listed above in greater detail.

Heterogeneous systems[6]

[6] The problem of heterogeneous systems is, in effect, a restatement of the interoperability problem.

Table 2 – Interoperability solution space.

	Company	Industry	National	International
Technology				
Data				
Business Processes				

Problem Description: Product development depends on CAD and CAE. Each of the many different kinds of such software has its strengths and weaknesses. Because each company has its own set of requirements, different software solutions better fit different companies, especially when the global nature of the automotive industry is considered. Working together across a supply chain to develop a product depends on communicating data between these various systems.

Parties Impacted by Problem: Those who take part in product development, including OEM's and suppliers at all levels

Problem Significance: This problem exists throughout the product development process and is the primary source of the $1 billion cost referred to in the introduction.

Problem Sources/causes:

- Proprietary solutions required by customers (particularly large OEM's), particularly in CAD, CAE, PDM, and FMEA
- Lack of robust, effective translation tools to move data between dissimilar systems, especially given the complexity of product data and the need for information such as data development history trees
- Lack of an overall plan or architecture for systems that defines how they should work together, either on a company and an industry level
- Substantial customization of and extensions to software systems lead to unique data requirements
- Lack of experience and knowledge by users, especially with PDM data exchange
- Resistance to change by users and companies,
- Fear of lost market share by software system vendors
- Software acquisition decisions are often made on a local basis, without considering effect on business as a whole, while at other companies, there is no control over procurement of software systems so systems are purchased for the wrong reasons
- Cost of replacing legacy systems is too high, or when replaced, cost of moving old data over to new system is too high
- Integration of one set of tools (e.g., CAD and PDM) tends to exclude other tools of the same type
- Government regulations can require specific systems or system capabilities

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Despite that, this section serves as a more complete description of the whole problem area.

Problem Examples:

- Ford, GM, and DaimlerChrysler all insist that their suppliers work on the same CAD systems as they do (I-DEAS, Unigraphics, and CATIA, respectively). Furthermore, suppliers are expected to use the same customizations and extensions to those systems. Nearly all suppliers have more than one of the three companies as a customer, so they are required to maintain and support multiple systems, at significant cost. Now similar pressure to use the same PDM system as the customer is beginning to be felt, which is likely to be even more difficult to accomplish as PDM systems are even more customized than CAD systems.
- Ford and Visteon have spent a great deal of effort to convert from one CAD system to another. The lack of interoperability between the systems is a major cause of the long costly changeover effort.

If Problem Disappeared: If the problem of heterogeneous systems were to suddenly be gone, the resulting seamless movement of data between systems would allow the auto industry to accomplish much more rapid product development at a lower cost.

Potential Problem Solutions:

- "Middleware" to help integrate legacy software systems into new systems
- E-business solutions that encourage new ways of exchanging and sharing data
- Implementing what is available now in terms of standards and technologies
- Developing an industry culture of openness

<u>Security</u>

Problem Description: A variety of security-related concerns impede interoperability, ranging from basic lack of trust between organizational groups to the need to control intellectual property and what specific users can see to management of networks. Every additional security requirement tends to reduce interoperability.

Parties Impacted by Problem: People from different organizations that have to work together, which is to say, virtually all trading partners.

Problem Significance: Impedes daily activities by interfering with the effective flow of information and data. Although quantifying the effect is difficult without a proper study, time is wasted every time a person cannot obtain needed data because of security limits or inaccessibility of a network. In addition, the need to protect intellectual property and determine what can be shared can interfere with what really should be routine exchanges.

Problem Sources/causes:

- Lack of trust between trading partners even while collaborative work increases
- Fear of loss of control over data
- Failure to implement existing security technology
- Lack of experience and knowledge in security technologies and approaches

Problem Examples:

- One supplier of major subsystems has its machines connected directly to a customer's network. When the customer automatically conducts regular software deletion and reinstallation across its network to enforce its own system security requirements, it includes the connected supplier's systems, thereby removing software the supplier owns and its people need to do their work.

- One OEM maintains separate networks for its internal people and on-site suppliers. This creates a barrier that constantly interferes with data exchange.
- The well-publicized problems created a few years ago when GM intentionally gave intellectual property it obtained from one supplier to another to obtain lower part costs.

If Problem Disappeared: If the security issues could be resolved in such a way that they did not interfere with collaborative work, the lead time for products would be reduced along with the cost of development.

Potential Problem Solutions:

- Effective intellectual property agreements between customer and supplier
- Implementation of existing security tools on existing systems
- Determining what data is needed for a particular purpose then setting up systems to efficiently support that data exchange (as opposed to routinely demanding all data from a supplier, whether needed or not)
- Developing a culture of trust

Standards implementation

Problem Description: Standards for supporting interoperability exist that have not been implemented by software system vendors, or if available on systems are not used by users. Standards already exist and are being produced on a regular basis, whether parts of STEP, CORBA, XML, or other standards efforts. The lack of standards implementation by vendors clearly limits the availability of trading partners to take advantage of potential alternatives to using the same system. Similarly, if users do not use standards that have been implemented, then the value of the standard is effectively zero.

Parties Impacted by Problem: Anyone needing to exchange data between dissimilar systems could benefit from exchange standards.

Problem Significance: Difficult to assess in detail without a specific study (which has not been done), though this is also a significant part of the annual $1 billion cost cited in the introduction. On the other hand, software vendors have not implemented some parts of STEP that have been approved as International Standards. Thus STEP capability is not available to users even though it could provide a needed capability. Users are also not taking advantage of capabilities that have been implemented (see the common system requirements discussed in 0), but again, quantifying the effect is difficult.

Problem Sources/causes:

- Lack of appropriate standards to implement for many kinds of data exchange.
- Vendors see no economic incentive to implement data exchange standards. They question users' willingness to pay for the capability. Limited resources are seen as better spent on improving system functionality than on adding support for interoperability.
- Vendor fear that adding interoperability capability puts their system at risk of more easily being replaced (as it is, the cost of changing systems is so high that it rarely happens).
- Data exchange standards inherently require multiple vendors to implement them. If only a small number of systems support the standard, there is a low probability that the standard will be of use a given exchange combination.

- User resistance to change, especially to what the potential user may consider an unproven technology.
- Cost of retrofitting legacy systems (those no longer under common use) is too high
- User fear that using a data exchange standard will lead to less information being exchanged than using native, whether that reduction actually matters or not.

Problem Examples:

- STEP AP203 (Configuration Controlled Design), the most commonly implemented part of STEP, is good as far as it goes, but it does not cover many needed kinds of information. New STEP application protocols are gradually appearing, but the pace has been very slow.
- STEP AP202 (Associative Draughting) provides useful capabilities that, to date, only one or two vendors have implemented in their software, in spite of AIAG's repeated request for its wide implementation.
- Ongoing resistance by Ford, GM, and DaimlerChrysler to any use of STEP in spite of many corporate statements to the contrary.
- First-tier suppliers' unwillingness to use STEP with sub-tier suppliers, even though common system requirements are generally not practically enforceable at 2^{nd} and lower tiers.

If Problem Disappeared: Product development costs in the supply chain could go down and product development time could be substantially shortened.

Potential Problem Solutions:

- Middleware for legacy systems to adapt them to the new standards
- More rapid and responsive standard development processes, resulting in more useful standards
- Documentation of cost benefits to both vendors and users from increased use of data exchange standards
- Documentation of methods to both reduce the cost of implementing standards in software as well as of implementing the standards in actual use

<u>Standard development</u>

Problem Description: Additional standards are needed to cover the various kinds of data exchange that take place during product development, but standard development has been a relatively complex and slow process at best. Standards are not needed just for the mechanics of data exchange and translation, but also for the business processes and content that determine when and what needs to be exchanged.

Parties Impacted by Problem: Anyone exchanging data between different systems.

Problem Significance: Related to the standards implementation issue described in 0 without more in-depth study, the lack of appropriate standards is significant. A key issue in the delayed adoption of STEP is that it does not cover the capabilities that users most need. This is especially important in supply chain interoperability because the data exchanged often are to be used to generate manufacturing equipment, tooling, and the like, all of which require accurate information regarding manufacturing requirements such as manufacturing tolerances that are not currently supported.

Problem Sources/causes:

- Complexity of product data that needs to be exchanged
- Resource limitations for standards development
- Technology being chased by standards is a moving target
- Cumbersome, time consuming standard development and approval process (e.g., ISO)
- Lack of harmonization across related standards (e.g., STEP and CORBA), the various standards are not independent
- Lack of cooperation among standards developers and implementers, leading to duplication of effort as well as overstretched resources
- Lack of recognition of need for standards beyond the traditional exchange/translation standards

Problem Examples:

- Slow development of STEP, both from subject complexity and lack of resources
- STEP supports "snapshots in time" rather than continuous access and exchange of data
- Lack of agreement between customers and supplier on what data are needed and when in the product development cycle.

If Problem Disappeared: If all the standards with capabilities people needed were to exist, then the industry could select what it needed and implement them across customers and suppliers, thereby improving the supply chain product development process.

Potential Problem Solutions:

- Adoption of faster standards development, evaluation, and approval mechanisms, both reducing the time and the resource requirements to generate new standards, e.g., along the lines of what RosettaNet has done for the electronics industry. Included in this is the concept of voluntary consent standards, as opposed to formal standards.
- Adapting existing standards and their development tools instead of starting from scratch, as was done with STEP.
- Better understanding of user needs for standards.

Subgroup B Discussions

This subgroup also focused on the product development part of the life cycle. The result of their discussions was two key high-level problems, which they did not prioritize:

- Visibility of information
- Reducing and optimizing engineering changes (ECs)

This group also identified the importance of metrics, looking closely at the metrics associated with engineering changes such as:

- Where ECs occur in product development process
- Priority of ECs
- Cost of ECs
- EC cycle time from initiation to completion
- Source of EC

Information visibility

Problem Description: Having needed information in a timely manner and in an understandable form when stored in multiple locations and formats.

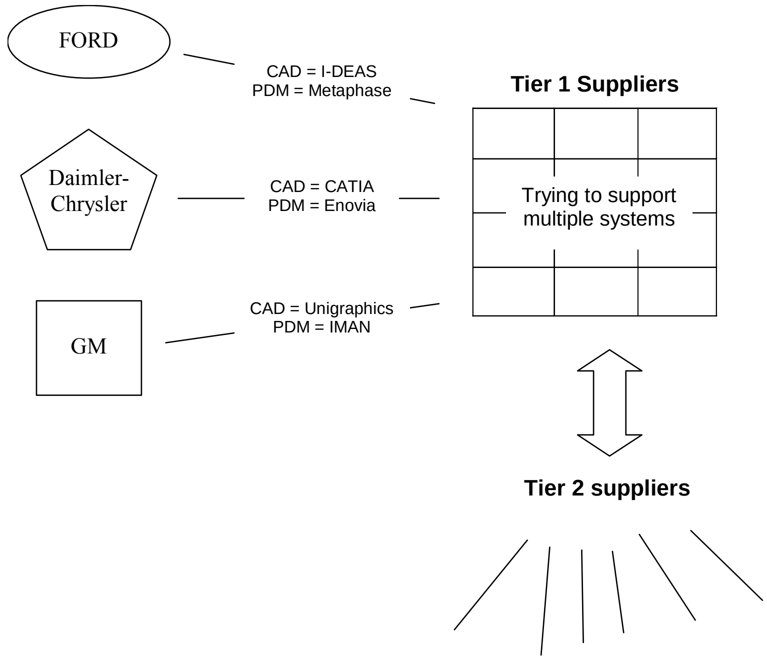


Figure 2. Evolving PDM systems in auto industry.

Parties Impacted by Problem: All parts of supply chain

Problem Significance: Key to concept of 12-month car, designing and producing a new vehicle in a year.

Problem Sources/causes:

- Information stored in many places is not linked
- Communication technologies do not support broad access to data
- Proprietary systems limit access, distribution, and understandability of data
- Security and intellectual property rights interfere with data exchange
- Limitations in the global information infrastructure impedes information flow

Problem Example: The current implementation of different PDM systems in automotive OEM's is leading to complexity in the supply chain as suppliers try to integrate with these different systems (see Figure 22).

If Problem Disappeared: Product development would become much more efficient

Potential Problem Solutions:

- Effective linking of PDM systems
- Appropriate standards developed and implemented

<u>Reducing and optimizing ECs</u>

Problem Description: Inefficient and error-prone engineering change processes lead to delays in bringing products to market, added cost, and poorer product quality

Parties Impacted by Problem: All parts of supply chain

Problem Significance: Also key to concept of 12-month car

Problem Sources/causes:

- Ineffective deployment of standard approaches such as the QS9000 APQP process
- Failure to distinguish between changes that are needed versus those that would be nice to have (in effect, a failure to effectively choose which changes should be implemented).
- Lack of empowerment across supply chain to initiate or address problems
- Lack of knowledge-based engineering systems that could catch problems early in the design process

Problem Example: A very high portion of an engineering budget can be taken up dealing with ECs. GM processes around 25,000 ECs per year[7].

If Problem Disappeared: The time and cost required to develop a product and bring it into full production would be substantially reduced.

Potential Problem Solution:

- Standards-based PDM data exchange (see Figure 33), which in turn would require
  - Defining the transaction superset for the EC process
  - Defining the information content
  - Piloting potential solutions
  - Validating standards, identifying shortfalls
  - Filling gaps in existing standards
  - Developing a certification process for PDM systems
  - Ensuring solutions are accessible to small suppliers (minimal infrastructure required, making use of MEP centers in states)

[7] "Engineering changes are responsible for as much as 20% of the cost of a vehicle." J.T. Battenberg, CEO of Delphi Automotive, in speech at University of Michigan Management Briefing Seminars 2000, Traverse City, Michigan, August, 2000.

Subgroup C Discussions

This subgroup focused on the production control and material release part of the life cycle with a special emphasis on engineering changes (ECs). The subgroup identified a number of individual problems, then identified two major themes that cut across all of these items:

1. Sharing production data throughout the supply chain
2. Data integrity

More detail on these two problem areas is provided in the subsections below. Table 3 shows relationship of good data to forecasting and the likelihood of success.

Table 3 – Integrity of data and forecasting.

	Good Forecasting	**Bad Forecasting**
Good Product Data	Ideal situation	Easily salvageable
Bad Data	Big trouble	Disaster

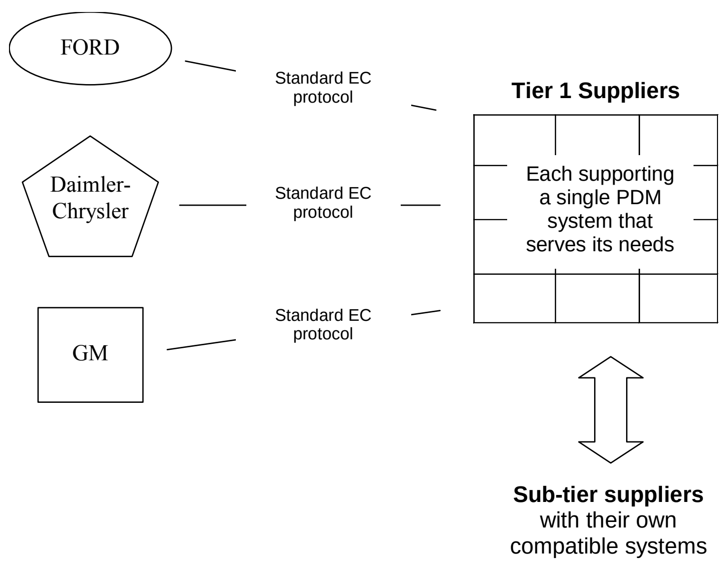


Figure 3. Evolving PDM systems in auto industry.

This subgroup also developed a matrix that shows the many business processes that need to be developed across a supply chain as shown in Table . The rows are the various functions within a company. The columns are the supply chain tiers. Note that this matrix only shows one particular supply chain. It is multi-dimensional as you consider the possible supply chain permutations. To keep this huge number of processes under control requires interoperable

Table 4 – Business process needs for one supply chain.

	Tier n	Tier 3	Tier 2	Tier 1	OEM	Customer
Engineering						
Finance						
Production						
Purchasing						
Quality						
Sales/Mktg						
Etc.						

processes, which can therefore link as needed with related processes at trading partners. Note that most trading partners achieve an adequate level of interoperability with each other, though it may be costly or painful to do so. Otherwise they would not be able to do business.
Subgroup C also developed the following definition of interoperability:

> *Business processes working well together (effectively and efficiently) to minimize costs and time and maximize quality both within an organization and cross-organizationally, supported by standards, technology, and computer systems that communicate compatibly.*

Sharing production data

Problem Description: All members of the supply chain need accurate production information to be as efficient as possible. In this context, production data include such data as: inventory, master schedule, production plan, capacity plans, and build schedules.

Parties Impacted by Problem: All members of the supply chain, but especially the lower tiers.

Problem Significance: The AIAG's Manufacturing Assembly Pilot estimated over $1 billion in annual costs to the automotive industry due to schedule fluctuations across the supply chain.

Problem Sources/causes:

- Customer providing incomplete or conflicting requirements coupled with the supplier's perception (whether true or not) that the customer does not want to hear about problems or issues, prompting the supplier to guess at the solution.
- Customer refusal to accept that there is a problem based on a supplier's analysis.
- Failure to maintain systems
- Use of systems that do not support established standards
- Inadequate production planning
- Inadequate forecasting
- Delays in passing forecasting and schedule information down the supply chain
- Poor data integrity

Problem Examples:

- Conflicting information from the customer leads to confusion for the supplier, especially when the supplier is uncomfortable raising the issue with the customer for fear of being seen as not a team player.
- Numerous systems are involved in the process of making and delivering parts, from material release systems to bar coding systems on the finished parts. A failure in any of these many production support systems could result in part delivery problems.

If Problem Disappeared: If accurate production information were widely shared, the need for inventory buffers, people buffers, information buffers, and capacity buffers would decrease, lowering costs across the supply chain

Potential Problem Solutions:

- Have systems based on standards so that replacement systems can be put in place quickly.
- Have backup methods to process parts and information when the primary systems break down.
- Better data gathering techniques via collaborative master forecasting/scheduling and production modeling within the full supply chain.
- Remove delays in passing schedule and forecasting information down the supply chain by using automated systems and transport mechanisms such as EDI as much as possible and by using the most efficient possible human processing where it is necessary.
- Fully integrated product and production data systems, including appropriate business models that can be easily communicated. Some PDM and ERP systems are close to providing this level of functionality, but are typically beyond the reach of small to medium sized companies.
- On forecasting side this may mean forecasting data goes from OEM directly to all members of supply chain instead of filtering down.

Data integrity

Problem Description: The production data and supporting product data received by trading partners is too often incorrect due to such problems as outright errors and arriving later than needed.

Parties Impacted by Problem: Data recipients throughout the supply chain, but mostly suppliers.

Problem Significance: Shipping data, whether production data or supporting product data does not help unless the data is correct and timely.

Problem Sources/causes:

- Customer refusal to accept that there is a problem based on a supplier's analysis.
- Failure to maintain systems
- Use of systems that do not support established standards
- Inadequate production planning
- Inadequate forecasting
- Delays in passing forecasting and schedule information down the supply chain
- Slow or cumbersome formal engineering change processes tend to encourage people to work in unauthorized parallel paths.

Problem Examples:

- Delays of as much as four weeks in propagating forecast information down the supply chain lead to wild swings in what the supplier must do, even if the forecast information was originally correct. When the need for a sudden increase in production comes that late, the resulting need for quickly changing over and spending overtime producing parts on an expedited schedule increases costs.
- Many times production is based on drawings (or CAD models) that were originally released some time before, sometimes many years before. The accuracy of the drawings can be a problem because companies do not always maintain drawings properly. The uncorrected drawings then lead to problems later when uninformed people refer to the drawing for reuse of the part or a new round of manufacturing.
- To save time and money, especially in a production situation, the customer may expect the supplier to make a product or manufacturing equipment change based on a verbal description, faxed sketch, or other unofficial change communication method. This can lead to real problems if the change is later rejected in the approval process but the supplier has already implemented it.

If Problem Disappeared: The manufacturing cost of automobiles would be substantially reduced along with many of the production delays seen today.

Potential Problem Solutions:

- Have backup methods to process parts and information when the primary systems break down. Have systems based on standards so that replacement systems can be put in place quickly.
- Better data gathering techniques via collaborative master forecasting/scheduling and production modeling within the full supply chain.
- Remove delays in passing schedule and forecasting information down the supply chain by using automated systems and transport mechanisms such as EDI as much as possible and by using the most efficient possible human processing where it is necessary. This may mean that forecasting data must be disseminated directly from an OEM to all members of supply chain instead of filtering down.
- Interoperable EC systems and processes that rapidly move an EC through the formal system, eliminating the delays that cause people to try to “beat the system.”
- Use concurrent engineering techniques, especially to the point of bringing the manufacturing people, whether internal or supplier, into the product development process in the early design stages.
- Fully integrated product and production data systems, including appropriate business models that can be easily communicated. Some PDM and ERP systems are close to providing this level of functionality, but are typically beyond the reach of small to medium sized companies.
- Employ collaborative problem solving, so both sides understand issues and are confident of the end result.

Comparison with Related Activities

This section summarizes the findings of two other recent meetings soliciting auto industry input and information regarding issues and needs. The first was a conference in Dearborn, Michigan in May, 2000 with the goal of initiating a dialog with the automotive industry on e-business (hereafter referred to as the OSAT conference). The sponsors of that conference were the University of Michigan Office for the Study of Automotive Transportation (OSAT), Deloitte & Touche/Deloitte Consulting, and IBM.

The second was a workshop held in June 2000 to identify auto industry needs conducted by the Auto Body Consortium (ABC) and ERIM (the ABC workshop).

OSAT Conference

The OSAT conference[8] involved approximately 400 participants. The conference was comprised of both speakers and breakout discussion sessions. The breakout sessions were primarily a mix of roughly 60% automotive suppliers (mostly tier 1) and the rest IT vendors, consultants, and service providers.

At the time of the OSAT conference, the e-business exchange being formed by Ford, DaimlerChrysler, and GM (then known as "NewCo.", now as "Covisint") had just recently been announced. Not surprisingly, issues related to that initiative dominated the discussion. Some of the key findings from that conference:

- *The OEM and supplier perceptions of Covisint differed widely*. Many of the supplier concerns were based directly on their past experiences, the same experiences that drove many of the concerns found in the AIAG/NIST workshop.
- *Suppliers are cautious about the e-business paradigm.* There are many concerns about the effects of e-business approaches on suppliers, especially hardware, software, and cost issues. There is also a distinct lack of understanding or agreement on what e-business is. Furthermore, past experiences with CAD/CAM integration in the industry, the slow adoption and limited use of the ANX network, divergent EDI paths and standards in the 1980's and the high cost of QS 9000 certification all lead to substantial skepticism about what the real effect of Covisint will be.
- *Suppliers want a "road map".* They want to know exactly what Covisint is going to do and what will be expected of them.

There are significant concerns about interoperability, especially when suppliers realize they are likely to have to work through more than one such e-business trade exchange. Many questions remain to be answered.

The overall conclusion from the OSAT conference was that many suppliers are sitting on the fence, waiting for more information and answers to questions before deciding how to address e-business issues.

Although the OSAT conference subject matter was somewhat different from the AIAG/NIST workshop, there are significant alignments as shown in Table 5.

Table 4 – OSAT conference compared to AIAG/NIST workshop.

OSAT Conference	AIAG/NIST Workshop
Suppliers see Covisint as yet another OEM mandate that will cost them (the suppliers) time, money, and effort.	Concern based in part on the experience with proprietary CAD system mandates identified in the workshop
Interoperability and standards are necessary for Covisint and other related e-business elements to work.	The whole focus of the workshop was interoperability

[8] The report that describes the OSAT conference and its results ("The Automotive Industry: Moving @ eSpeed") can be obtained from OSAT at the University of Michigan.

In effect, for trade exchanges like Covisint to work, the interoperability issues raised by the AIAG/NIST workshop will have to be addressed.

ABC Workshop

ABC and ERIM brought together senior manufacturing leadership from auto OEM's, large tier 1 suppliers, manufacturing and equipment suppliers, and some researchers from OSAT. The workshop[9] was built around the auto industry's effort to move from the current business model to a new business model based on e-business, faster clock speed, lean operations, and agile organizations. The result of the workshop was nine prioritized core industry needs as shown in Table 5 (next page). Also shown in the table is how interoperability, the concern of the AIAG/NIST workshop, is related to these issues. As can be seen, interoperability is an important element of most of them.

[9] Although no formal report from the workshop was created, further information on the workshop can be obtained from ABC or ERIM.

Table 5 – The ABC workshop needs and interoperability.

Industry Need	Role of interoperability
1. *12-month car* – Reducing the time required to develop new vehicles in just 12 months.	Critical to rapid transactions and information exchange necessary for short development cycle.
2. Manufacturing processes – Need for new manufacturing processes to support greater use of aluminum and new engineered materials.	
3. Parametric engineering – Capture knowledge from the supply chain to embed in automated design tools.	Interoperable systems necessary for best approach, which is to have suppliers maintain and provide the information automatically.
4. Standards – Developing standards and common approaches wherever there is potential value to be gained.	The whole point of standards is interoperability at one level or another.
5. Math-based tools – Tools based on mathematical representations of parts need to be developed to support design and manufacturing processes across the multiple systems that appear in a supply chain.	These software tools need to be usable in a wide variety of environments, hence they need to be interoperable with many other systems.
6. Business streamlining – In today's rapid pace of business, there is no time to establish business processes over time, so they need to be more standardized, crossing organizational boundaries and including roles and responsibilities.	Interoperable business processes and information technology systems and the standards that support them are key to streamlining business.
7. Industry-wide coordination – The industry needs to find a way to smooth out the peaks and valleys of production, gaps of downtime followed by frantic production periods.	Effective coordination will be impossible without interoperable systems to support it.
8. Personnel/manpower issues – Suppliers need more engineering and science skills as they take on more of the design responsibility.	
9. Strategic collaboration opportunities – Collaboration opportunities within supply chains need to be identified and implemented.	Collaboration among companies cannot happen without interoperability of business process and information systems

Addressing Interoperability

This workshop and others demonstrate that interoperability is the foundation of most of the initiatives and efforts designed to improve the speed and effectiveness of the processes required to develop and build a vehicle. So what are the key issues and how should they be addressed?

Summary of Issues

When the results of the three workshop subgroups are combined, the list of major issues is:

- Heterogeneous systems
- Security of electronic systems
- Visibility of product development information
- Sharing production data throughout the supply chain
- Data integrity
- Optimizing engineering changes
- Standards Implementation
- Standards Development

Note that this combined list is not prioritized. That was not a goal of the workshop, because they items were derived from different parts of the product life cycle and hence the comparisons required to achieve a ranking are not useful. Of course, much of the interoperability problem stems from the wide use of heterogeneous systems. If everyone used the same set of systems (including implementation details), then a majority of the interoperability problems would disappear. With no hope of that happening, other solutions must be found.

Solution Road Map

Major elements of the interoperability solution include:

- Adapt and develop business practices to take advantage of existing interoperability standards
- Implement interoperability tools
- Implement existing interoperability standards in software
- Develop new interoperability standards

Accomplishing these solutions will require substantial work by a number of organizations.

Adapt and develop business practices

As is often the case, business practices and processes lag behind the new electronic data and communications technologies. How best to take advantage of use tools generally comes from experience. Add that to the resistance to change most organizations show and the lag is no surprise. An active approach to modifying business processes and practices, however, can greatly speed up the migration into more effective way to work.

What to do:

- Conduct research into business processes, organization structures, and socio-cultural issues that affect interoperability (e.g., develop behavioral models that allow low-risk experimentation with new processes)
- Conduct industry pilot projects that experiment with and demonstrate new business practices and processes
- Generate industry-wide common processes and practices (“standards”), especially those that span multiple companies (e.g., the automotive QS 9000 approach to quality)

- Provide assistance to smaller companies on identifying and implementing new business processes and practices
- Develop and deliver training programs to educate trading partners on how to work together more effectively.

Who should be involved:

- University and other research organizations to develop new theoretical and experimental approaches to modeling, analyzing, and designing business processes
- Research organizations to develop new business process concepts
- Industry associations and consortia to initiate and conduct pilots with support of research organizations
- Industry associations to develop and provide training (perhaps with certification) with assistance from research organizations
- Governmental support organizations (such as NIST's MEP Program) and large company supplier support programs to help suppliers develop and adopt appropriate business practices and processes
- Companies to tackle the often challenging goal of improving business processes, both internally and in conjunction with trading partners

Implement interoperability tools

Some tools that help improve interoperability already exist in the marketplace, but are not used to full advantage. More such tools are needed.

What to do:

- Use existing tools that support interoperability and to pressure software vendors to develop new supporting tools (e.g., tools that check data integrity)
- Develop new interoperability tools
- Conduct industry pilot projects that experiment with and demonstrate the effective use of new tools
- Generate and deliver training on the use of interoperability tools
- Generate industry-wide recommendations for tools and effective tool use
- Provide assistance to smaller companies on identifying and implementing new tools
- Develop and deliver training programs to educate trading partners on how to effectively use tools

Who should be involved:

- University and other research organizations to develop new tools and underlying technologies to address interoperability problems
- Industry associations and consortia to initiate and conduct pilots
- Governmental support organizations (such as the MEP Program) and large company supplier support programs to help suppliers determine the capabilities of tools and how they should best be used
- Software vendors and research organizations to develop new interoperability tools both to support technical elements and business process elements of interoperability
- Software vendors and industry associations to develop and provide training in the use of tools (perhaps with appropriate certification)
- Companies to determine their real needs (perhaps with the help of consultants or assistance organizations) and purchase and implement the tools that will support those needs

- Companies to pressure software and other vendors to develop tools to meet currently unsupported needs

Implement existing standards

Existing standards are clearly not being fully used. An example of this would be companies using data translation capabilities they already have (or their software vendors already provide) where appropriate rather than always insisting their trading partners use the identical systems. However, that only works when the software vendors provide the translation capabilities.

What to do:

- Pilot projects that demonstrate effectiveness of existing standards (e.g., AIAG's AutoSTEP and Manufacturing Assembly Pilots)
- Provide assistance to smaller companies to help in identifying and implementing tools that support existing standards
- Develop and deliver training programs to educate potential users about existing standards
- Create new software implementations of existing standards (e.g., CAD implementations of STEP AP202), both as part of current software upgrades and development efforts
- Create "middleware" for legacy systems (no longer under development), software that allows users of those systems to still take advantage of the existing standards

Who should be involved:

- Industry associations and consortia to initiate and conduct standards demonstration pilots
- Governmental support organizations (such as the MEP Program) and large company supplier support programs to help suppliers determine the capabilities of the standards and how they should best be used
- Software vendors and industry associations to develop and provide training in the use of the standards (perhaps with appropriate certification)
- Companies to determine their real information needs and implement appropriate existing standards
- Companies to pressure software vendors to support existing standards, with a willingness to pay a fair price for the new capability

Develop new interoperability standards

The current standards for interoperability include product data standards such as STEP and IGES as well as production data standards such as ANSI X12 (EDI) and EDIFACT. While the existing standards meet some needs, the all have gaps, inefficiencies, or other problems that leave major aspects of interoperability un-addressed.
Making use of existing standards is an approach companies are clearly not fully using.

One aspect of this is companies making use of translation software capabilities they already have (or their software vendors already provide) rather than always insisting their trading partners use the identical systems.

What to do:

- Determine what aspects of interoperability will be most useful to standardize
- Encourage and participate in the development of new standards

- Develop and use new rapid standard development approaches such as voluntary consent standards

Who should be involved:
- Industry associations and consortia to identify areas where standards are needed but lacking
- Governmental organizations such as NIST's Laboratories to support standards development efforts
- Universities and research organizations to develop the intellectual bases for standardization (e.g., the mathematical representations of geometry and data structures that underlie CAD data exchange)
- Research and government organizations such as NIST's Laboratories to work on improving standardization processes and approaches.
- Large companies to represent the industry by taking part in the standards development process

Recommended Projects

Projects designed to address aspects of the above issues should be organized around collaborative supply-chain business processes. The overall structure of each project should be:
1. *Analyze as-is* – Determine how the automotive supply chain accomplishes the particular business process now, including the nature of problems and potential solutions.
2. *Identify solution set* – Determine the most likely solution or set of solutions that will address the issues impeding the business process, based on the as-is analysis and benchmarking in this and other industries.
3. *Pilot solution set* – Implement the solution(s) in real supply chains, evaluating the successes and failures and capturing the implementation details
4. *Capture results* – Document what worked and what did not in a form usable by the broader automotive industry
5. *Disseminate across industry* – Spread good solutions across automotive supply chains, through a combination of publishing, advice, and direct assistance to suppliers via MEP centers, supplier assistance programs, AIAG training programs, and various publishing methods

A properly scoped instantiation of this approach would require approximately $2 Million in government support over a period of 12-18 months. The government support would assist in the riskiest part of the process, steps 1-4, which companies are not in a position to do entirely on their own or in the small groups that would comprise a pilot team.

The dissemination process, on the other hand, would be largely funded by industry since the benefits would have been established by the pilot.

The following recommended set of projects would serve such a comprehensive approach:
- Engineering changes, both before and after product launch (two projects in series)
- Product development data synchronization
- Design with reusable components
- Product scheduling and material release
- Integrated Logistics

Engineering changes

Formal engineering changes start once models are formally "released." Released models are those that have been approved for use in downstream applications such as tooling design, fixture design, manufacturing equipment design and, ultimately, production. Because no design process is perfect, released models occasionally must be modified which is done via a formal, documented change process (with names such as Engineering Change Order and Engineering Change Notice). Engineering changes tend to be costly, both in direct cost to implement them and in delays to the product's eventual production. Those costs tend to increase dramatically the closer to production the change occurs. Furthermore, the process of disseminating engineering changes is subject to error, which results in further costs and delays.

Because implementing engineering changes is complex and because there are substantial differences in the effects and handling of engineering changes that occur before production begins versus after production begins, two separate projects should be undertaken:

- Engineering changes before launch – focusing on the generation and propagation of engineering changes during the development of the manufacturing capability to make the product.
- Engineering changes after launch – focusing on the generation and propagation of engineering changes when the issues of affectivity, scrapped materials and other effects due to ongoing production.

Product development data synchronization

Formal release of a model is, in effect, a statement that the design can now be taken as complete. Before release, the design is, by definition, incomplete and subject to change. In fact, a design is likely to change frequently and radically over the course of a design process leading up to release. With the dispersion of design responsibility over the supply chain, keeping parallel design efforts coordinated and consistent is far from simple. For example, one company may be designing the instrument panel, another the steering column. The two must fit together properly, both physically and functionally, so the companies doing the design work must communicate effectively, regularly, and consistently. Thus a project that addresses the synchronization of product data across a supply chain during product design is very important.

Design with reusable components

The cost of product development is often higher than necessary due to the failure to take advantage of the many alternatives available. Design engineers and designers simply cannot manually search through all the available options. They do not have the time or resources to look for the "best" solution in existing catalogs and part libraries, so they either settle for an acceptable (but not necessarily optimum) solution or design a new solution from scratch.

Either way, the resulting design may be more expensive, less capable, or both than a design that uses previously existing parts. Taking advantage of the many available options requires the assistance of software tools that can search comprehensive catalogs and libraries of existing parts. Some of those tools are starting to come into use, but the solutions are not interoperable, even when using XML or similar supporting technologies. This is an excellent opportunity for the industry to become more efficient, with outside help.

Production scheduling and material release

Once a product is being manufactured, cost effective production depends on maintaining minimal inventories while delivery what is needed. To accomplish that requires accurate information in a timely manner, especially forecast, schedule, and material release information.

While the AIAG's Manufacturing Assembly Project (effectively completed in 1996) looked at some aspects of this (especially EDI), new technologies have since become available and exploded into use. The Internet was then just being considered as a possible means for communicating information. XML had not even been thought of yet. New approaches are available even though supply chains have not yet fully implemented the previous methods. A new project addressing this side of the business would provide not only a look at new approaches, but also a way to directly learn from what happened in the recent past.

Integrated logistics

With parts production and assembly plants spread across the world, the logistics of moving material, parts, subassemblies, and related information from one place to another quickly and at the right time is a complex problem of its own. Packaging, warehousing, and transportation are non-value added activities. They add nothing to the product except cost. Hence, the most efficient logistics system is the goal. Achieving that goal will depend heavily on interoperable information exchange and systems that take advantage of new technologies such as GPS and wireless networking.

Faster Improvements

Perhaps more important than the individual projects, undertaking such a set of pilots provides the opportunity to develop a faster and more efficient method for bringing new approaches into the industry. Ideally, the industry, in the form of AIAG or similar organizations, would have the knowledge and support to be able to take this new method and "run with it," effectively turning on a self-sustaining improvement process. Examples of this fundamental concept in other venues include RosettaNet and the Open Application Group Inc. (OAGI). Both organizations have developed more efficient ways to bring new, common technologies and "standards" into being and use. AIAG and NIST can take this general concept to a broader level, but only with a series of linked projects such as are proposed here to develop an efficient approach.

Summary

The AIAG/NIST interoperability workshop identified a number of issues affecting interoperability in automotive supply chains. The solutions to those problems exhibit some common threads. First is that pilot projects are very important to the effective adoption of new approaches, whether they be standards, tools, or business practices. Second, a significant reduction in interoperability problems will require a concerted effort by a number of organizations from industry, government, and the research community.

This report has presented both the major problems and the overall means to address those problems. Further, if undertaken in a coordinated manner, the projects proposed here can serve as the means to develop a better, faster approach to bringing new methods and technologies into the auto industry.

The interoperability problem in the automotive industry is clearly significant; undoubtedly more than the $1 billion annually that has been documented so far (probably much more). Unfortunately, interoperability is a complex and diffuse problem that straddles many aspects of supply chains. It is, therefore, not simple to address. Nonetheless, what needs to be done is known and much of the solution already exists, needing only to be implemented.

NIST AWARD: 70NANB1H0059

NIST Award: 70NANB1H0059

Special Awards Conditions

"The National Institute of Standards and Technology hereby enters into this Cooperative Agreement number 70NANB1H0059 with the Automotive Industry Action (AIAG) to support the work described in the Recipient's proposal entitled "Product Data Interoperability" dated May 16, 2001, revised dated June 15, 2001 and clarification E-mail dated July 3, 2001, which is hereby incorporated into this award by reference.

Federal Program Officer

Simon Frechette, (301) 975-3335
NIST, MEL Manufacturing Systems Integration Division
100 Bureau Drive, STOP 8260
Building 220, Room B246
Gaithersburg, Maryland 20899-8260

Description of Work

"The recipient will deploy standards for exchange product data management information in a representative subset of the automotive industry in order to improve the ability of different manufacturing activities. They seek to take existing product data management standards, implement them using common internet based mechanisms, and prove the ability of these standards to improve the efficiency of product engineering and manufacturing activities."

Automotive Industry Action Group Project Manager

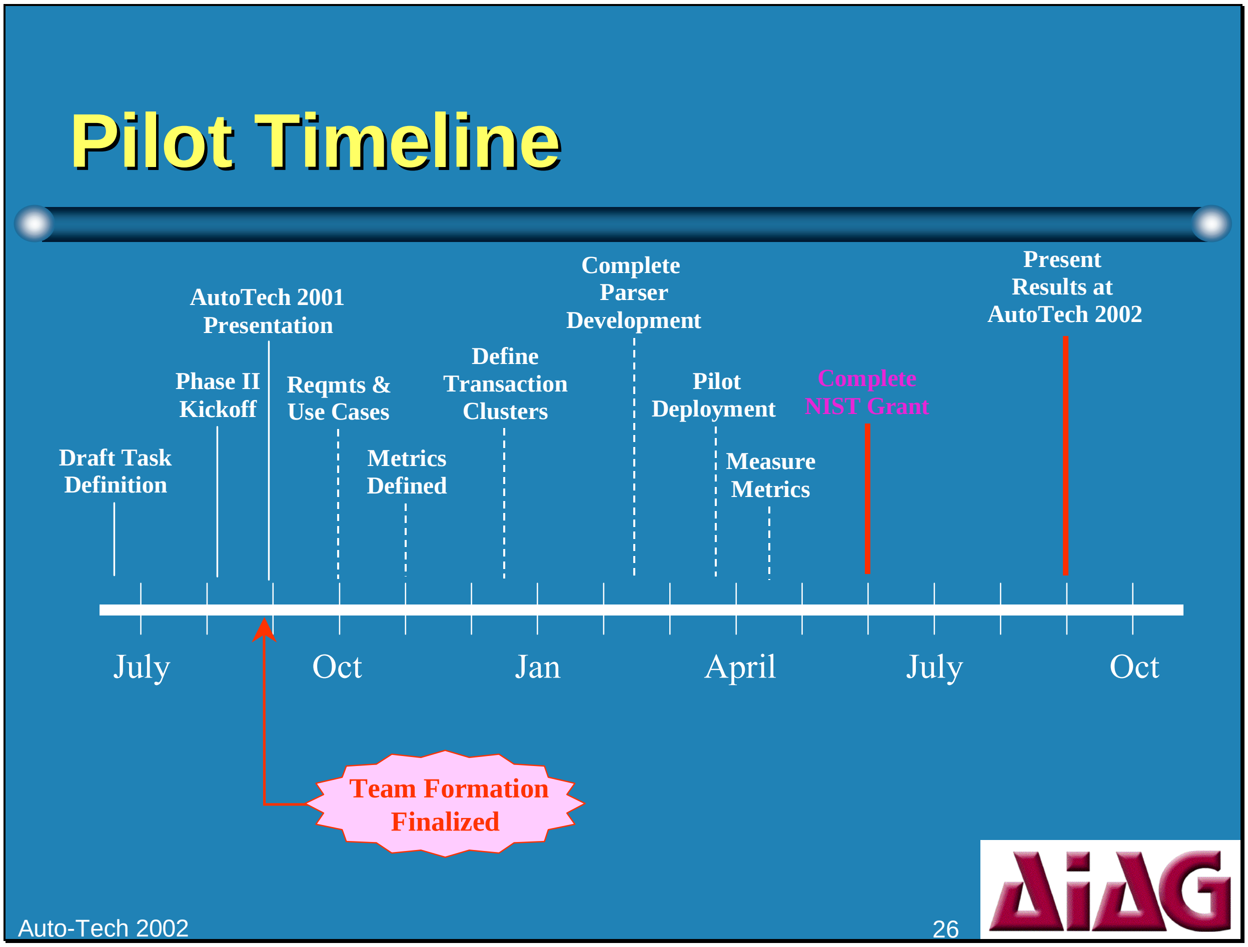
Akram Yunas, (248) 358-9758
Program Manager
Collaborative Engineering & Product Development
26200 Lahser Road
Southfield, Michigan 48033
Ayunas@aiag.org

PROJECT KICK-OFF

and

TIMELINES

Project Kick-Off & Timelines



INDUSTRY DEPLOYMENT PARTICIPANTS

PDM Interoperability Pilot

Corporate Participants

Automotive Industry Action Group (AIAG)
Altarum
Electronic Data Systems (EDS)
Ford
IONA
Johnson Controls (JCI)
MatrixOne
Parametric Technologies (PTC)
PDTec GmbH
Renault
Siemens Automotive
TRW

TECHNICAL APPROACH

Technical Approach

Introduction to Technical Approach

The current state of practice for PDM interoperability rests on two common approaches. PDM-to-PDM interchange is accomplished through point-to-point integration between systems. In this approach, the public APIs of the PDM systems involved is used to develop and deploy the interchange capability. There are a number of problems with this approach that lead to sustained costs

- Difficulties in implementation due to functionality gaps in system APIs,
- High cost of custom development and maintenance as the PDM systems transition through upgrades and version changes,
- Need for separate integrations for each pair of systems

The other common approach is file-based PDM data exchange using a common standard format like the STEP PDM Schema or AP214. In this approach, vendors develop capabilities to import and export PDM data based on the standard. The weaknesses in this case are:

- The standards are complex and the effort requires substantial development and testing effort. Furthermore, the standards themselves change, necessitating more development,
- The files generated are large and complex and not targeted at specific business processes. This makes file-based exchange of PDM data difficult to incorporate into users' business processes,
- Often, user companies have internal policies that require the use of native data. Such policies discourage vendors from investing in standard-based translators.

The PDM Interoperability Pilot project is based on the premise that the exchange of PDM data within a supply chain is best addressed at the level of individual business processes. By exchanging a well-defined PDM data-set (and not large files) that is specifically needed to transact a specific business process, the process of import and export can be made less expensive and simpler to deploy while addressing fully the needs of that business process. This approach is well suited for incremental expansion – new transactions can be defined for business processes and implemented, tested, and deployed in a planned fashion.

Transaction-based PDM Exchange

Business processes between companies in a supply chain can be viewed as transactions in which one party requests an action or a set of actions from a responder, who upon receipt of the request and the accompanying data, executes the request and sends back a response. This view of PDM exchange addresses a number of the problems discussed above.

- Transaction-based PDM exchange seeks standardization in manageable pieces and enables vendors to implement the standards incrementally. This allows flexibility in resource management and commitment.
- The complexity and level of effort is much smaller than traditional file translator development projects.
- This approach also provides user companies the opportunity to experiment before making wholesale changes to their policies.
- Finally, the lower cost of the incremental approach brings PDM exchange within the reach of smaller suppliers.

Implementing a transaction-based approach to PDM exchange requires careful determination and prioritization of user needs, and identification of meaningful transactions that constitute meaningful business actions. Project team members from OEM or supplier companies have identified many such business actions. Some are described below.

- OEM creates new product data and provides the data to supplier. Acknowledgement by the supplier of receipt of the data signals the conclusion of the transaction.
- OEM requests supplier for specific dataset associated with a node of the product structure tree and receives a response. This is a round-trip "transaction" that is initiated by the OEM and concludes when the response (sent by the supplier) is received by the OEM and stored in its PDM system.
- A part revised by a supplier (PDM A) will be communicated to the OEM (PDM B) and the receiving PDM system automatically updated. The supplier, having received an empty product structure tree from the OEM, attaches a part design (CAD) to a node of the product tree, and sends it back to the OEM.
- A document (e.g. a specification associated with a part or assembly) has to be updated. The OEM attaches a new spec to the appropriate node of the product tree and sends it to the supplier. The OEM, having changed the document, will associate it with the appropriate node of the product tree and send it off to the supplier. The supplier will then update its PDM system with the new document, attaching it to the right product data node.

All of the above business action can be modeled as transactions that are “request-response” in nature (Figure 4). The requesting party provides the necessary data to be processed and specifies precisely the action required. The responder, in turn, performs the action and responds with the updated data, or a simple acknowledgement if no data has to be returned. This concludes the transaction.

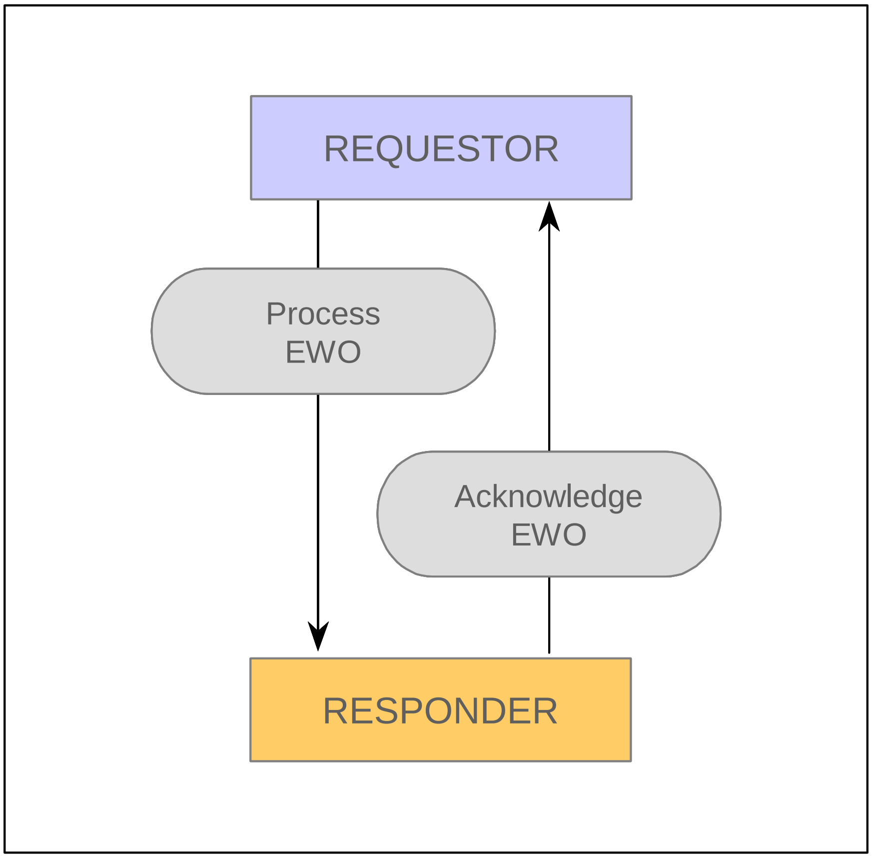


Figure 4. The EWO process as a round trip transaction

Each transaction thus consists of two part or “legs” – a process request, and an acknowledgement. Each PDM transaction has to be designed so that it contains all the data for each leg. Furthermore, each leg consists of three pieces of information:

- Control information, like transaction id, name, etc.
- Verb, or the action requested, like: update, process, acknowledge, etc. Each verb is has a precise semantic.
- Product Data, which can be PDM information and file attachments (CAD, specification documents, etc.).

Engineering Work Order

An Engineering Work Order (EWO) is typically issued by an OEM after a change request has been approved. It is intended to provide the supplier with all the data required to execute the action required. Upon receipt, the supplier acts upon the request and when complete, responds with an acknowledgement that includes the updated data (e.g. a design change).

To respond to an EWO, a supplier may have to request a design change from its supplier. In this case, the supplier would issue an EWO to *its* supplier.
Typical steps in the lifecycle of an EWO are as follows:

1. OEM issues an EWO containing a design change request to Tier1 supplier (T1) for a particular (existing) part (assembly) that is already present on T1's PDM system.
2. T1 processes the EWO and discovers that the affected component is designed by its supplier (T2). It generates another EWO for T2.

This EWO contains enough information for T2 to complete its modification of the part and issue a response to T1.

3. This step has two variations
   a. T2 uses a PDM system in-house and processes the request by making the change to the component and sending the updated PDM and CAD data to T1.
   b. T2 does not have a PDM system. It processes the request by making the change and incorporating the changed PDM info in the CAD file or keeps the changed PDM data separately. It then sends the data to the T1, which may take one of two forms - translation of CAD and PDM data into a neutral format (STEP) and sending that, OR sending native CAD with accompanying PDM data.
4. T1 incorporates the new data into its PDM system, and generates a change response for the OEM. It then propagates the change to the OEM where it is incorporated into the OEM's PDM system.

A variation to the above scenario is to perform a document revision instead of a part revision. The steps are the same as above, but the content changes for a CAD file to a document (Word, Excel, etc.)

The members of this pilot project team determined that EWOs are a very common form of interaction between OEM and supplier. Further, it is meaningful at the lower tier as well. The EWO is a round-trip transaction that demonstrates true system-to-system interchange of PDM data.

STEP, XML, and OAG BODs

A key technology that enables the exchange of data between systems is XML. A language for creating markup languages, it describes data and rules about the data. It enables the definition of exchange formats that can be easily shared among exchange partners. The definition of these exchange formats is done through the use of the Document Type Definition (DTD), which defines the tags and rules within XML for a well-formed XML document. Once defined to meet the needs of a business activity between parties, it can serve as the medium of information interchange between their respective computer systems.

Since XML is database-neutral, operating system-neutral, and device-neutral, it is an effective tool for defining heterogeneous interoperability. It allows for easy translation of data from and to native formats and its extensibility makes for easier changes and upgrades. It is the exchange technology of choice for thousands of projects big and small and is also the consensus exchange technology for the PDM Interoperability Pilot. All of the major PDM system vendors have an XML-based exchange strategy, with some possessing mature capabilities. It is therefore a logical choice for this project.

As discussed above, each leg of the EWO transaction (or any other transaction) consists of control information, action information (verb), and content (noun). The Open Applications Group (OAG) develops standard DTDs that incorporate these three pieces of information for a variety of generic transactions between companies. These DTDs are called Business Object Documents (BODs).

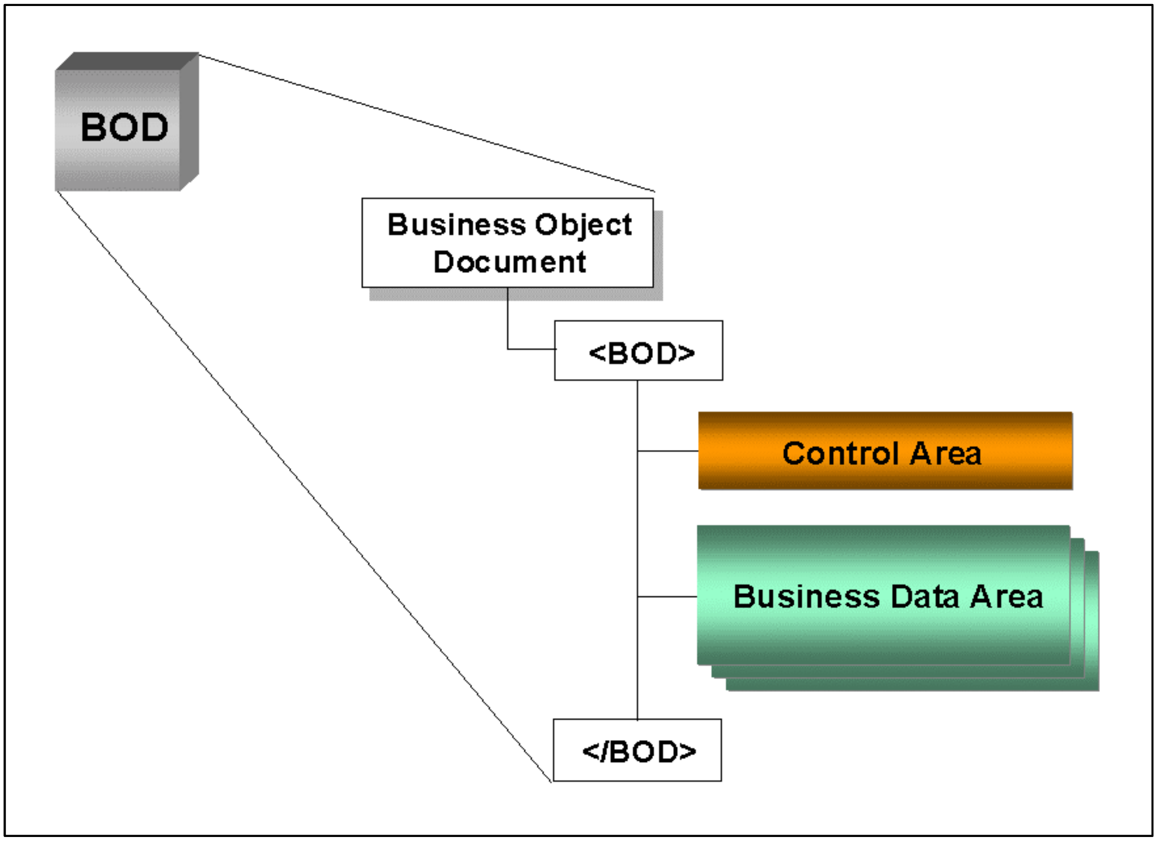


Figure 5. High-level BOD Architecture (Source: OAGI)

Once accepted by OAGI's membership, a BOD is available for implementation by vendors. In this project, team members have worked to align their technical work with OAGI's core BOD framework. By working closely with OAGI's well-understood BOD model, which has withstood significant scrutiny, the robustness, usability, and implement ability of the EWO DTD is enhanced.

The content of the EWO DTD itself consists of information elements like part metadata, EWO details, person and organization info and the linkages between these elements. Rather than model these data elements from scratch, this project has made extensive use of the STEP standard. STEP has mature and comprehensive models of product data in all phases of a product's lifecycle and provides nearly all the data objects required to fill the content portion of the EWO DTD. However, STEP data models are written in the EXPRESS language. To be useful, the EXPRESS data model has to be mapped to XML and incorporated in the DTD.

XML Exchange Structures

Project volunteers and staff worked closely together to develop the EWO DTD, making sure that the requirements prioritized by the requirements team (this team's role is detailed on) are adequately addressed. The development of the DTD content itself was strongly influenced by the STEP standard.

STEP AP 214[10] defines nearly all the building-block elements of an EWO: objects like *product* (or part) which may be a component or an assembly, represented as a *product structure*; *part identification*, which provides uniqueness and naming for a part; *work request* which is initiated and approved by a *person*, and converted into a *work order*; *external references* which are datasets that detail specific views of the product in question, etc. These objects were mapped from the application reference model (ARM) of AP 214 into the EWO DTD.

The benefit of this approach is that as more DTDs are defined for other engineering processes in the automotive industry, they will all share the common STEP-based core. This will allow developers to leverage a core framework of common data objects and their relationships, reducing development and testing effort and dramatically improving the chances of interoperability.

The XML DTD developed for this project is provided in full in Appendix A. It has been designed with flexibility in mind and to allow later enhancements.

[10] ISO/FDIS 10303-214: Core data for automotive mechanical design processes

SOFTWARE ARCHITECTURE

Software Architecture

Introduction to Software Architecture

Two main considerations formed the basis for the architectural decisions for this project:

- It was very important to minimize the amount of new development that the participating PDM vendors have to do. In a voluntary, consortia project, vendors lack the resources that are normally available to revenue-earning projects. Since each PDM system has either STEP (AP214, AP203, or PDM Schema) or XML output capability, it was decided that either format would be acceptable. Translations between formats would be done on the EWO server (see below) using modules built for the purpose. The following translations were facilitated by the project team:
    - STEP to XML
    - XML to STEP
- The application developed for this pilot must be able to execute the steps of an EWO (described in 3.2) and accommodate the variations in the steps. Since at least four different PDM systems are involved, there are bound to be variations in how each processes an EWO. Web technology provides a way to handle these process differences: obtain STEP or XML output from each PDM system and orchestrate the processing steps in an integration server running on a networked but independent integration server. This approach allows flexibility in accommodating the variations and makes it easy to add new PDM systems as they join the pilot project. Also, this enables the project to remain independent of the workflow details of a specific system, seeking only data interoperability between them.

Import – Export

The proposed architecture is based on the assumption that the PDM systems deployed in the pilot have STEP (Part 21) or XML read/write capability to support the scenarios.

- STEP Export: The sending PDM system generates a STEP Part 21 file based on AP214, AP203, or PDM schema. This file is converted into an XML representation based on the EWO DTD developed for this project. This transformation is done using the Step2XML Converter Module.
- XML Export: The sending PDM system generates an XML file based on either proprietary format or using a known published DTD for the engineering change scenario. The XML file is converted into an XML representation based on the EWO DTD developed for this project. This is done by the XML-Transform Module.
- STEP import: At the receiving end, the receiving PDM system may have the capability to read in a STEP Part 21. In this case, the XML Transform Module transforms the XML file (which is based on the EWO DTD) into a STEP Part 21 file for consumption by this system.
- XML import: The receiving PDM system may have an XML interface, allowing reading a XML content based on a proprietary DTD. In this case, the XML file (which is based on the EWO DTD) is transformed into the proprietary format of the receiving PDM system by the XML-Transform Module.

EWO Server

The EWO server is a web application that automates EWO transformation between PDM systems, provides users with a simple web-based interface for creating, sending, and receiving EWO transactions, and orchestrates and tracks the state of each EWO from initiation to completion.

EXCHANGE SCENARIOS

Exchange Scenarios

The Exchange Scenarios

Ford – Siemens-Yazaki – Siemens VDO

This scenario demonstrates EWO exchange in an OEM-TIER1-TIER2 configuration, with one of the members of the chain, SY, not using a PDM system. It shows how supply chain members may handle EWOs without a PDM system. This is, in fact, representative of lower tier suppliers.

Process EWO

- Ford engineer extracts CAD data files from Metaphase and uses the EWO server to initiate a new *Process EWO* action. This *Process EWO* request, along with the CAD files, is sent to Siemens-Yazaki (SY).
- SY is not using a PDM system. The SY engineer views and downloads the *Process EWO* request using a web browser.
  - Upon studying the request, he realizes that to complete his response to the request, he needs to send a *Process EWO* request to Siemens VDO.
- The SY engineer initiates a *Process EWO* request, attaches the appropriate CAD files to it (which may be different from the CAD files received from Ford), and sends it to Siemens VDO.
- The SVDO engineer views and downloads the *Process EWO* request using a web browser.
- The SVDO engineer saves the CAD files into his PDM system, Windchill, checks them out and opens them in his CAD system and makes the changes requested in the EWO. Then he checks the modified files back into Windchill.

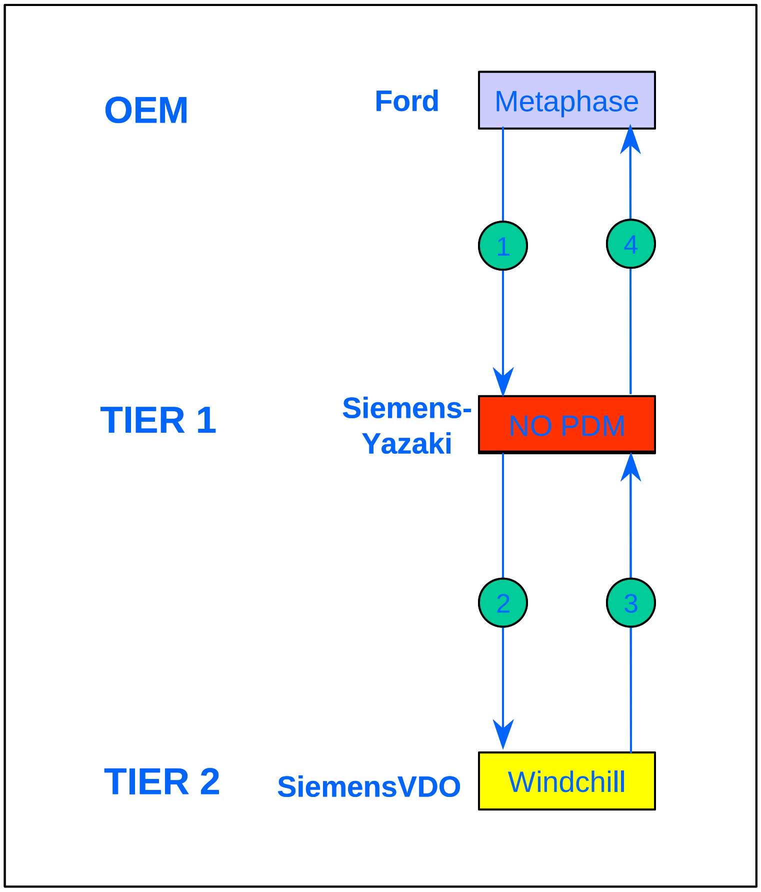


Figure 6. Ford, Siemens-Yazaki, SiemensVDO

Acknowledge EWO

- The SVDO engineer is now ready to initiate an Acknowledge EWO action. He extracts the modified CAD files from Windchill and uses the EWO server to initiate an *Acknowledge EWO*. This acknowledgement, along with the CAD files is sent to SY.
- The SY engineer, upon receiving the Acknowledge EWO notification connects to the EWO server and extracts the CAD files from it. He uses them to complete all the changes requested in the request from Ford.
- The SY engineer then initiates an *Acknowledge EWO* action using the EWO server. This acknowledgement, along with the CAD files is sent to Ford.
- The Ford engineer upon receiving the Acknowledge EWO notification connects to the EWO server and extracts the CAD files from it. He reviews them and checks them into Metaphase.

Ford – Johnson Controls

This scenario demonstrates EWO exchange in an OEM-TIER1 configuration, between different PDM systems.

Process EWO

- Ford engineer extracts CAD data files from Metaphase and uses the EWO server to initiate a new *Process EWO* action. This *Process EWO* request, along with the CAD files, is sent to Johnson Controls (JCI).
- The JCI engineer views and downloads the *Process EWO* request using a web browser.
- The JCI engineer saves the CAD files into his PDM system, eMatrix, checks them out and opens them in his CAD system and makes the changes requested in the EWO. Then he checks the modified files back into eMatrix.

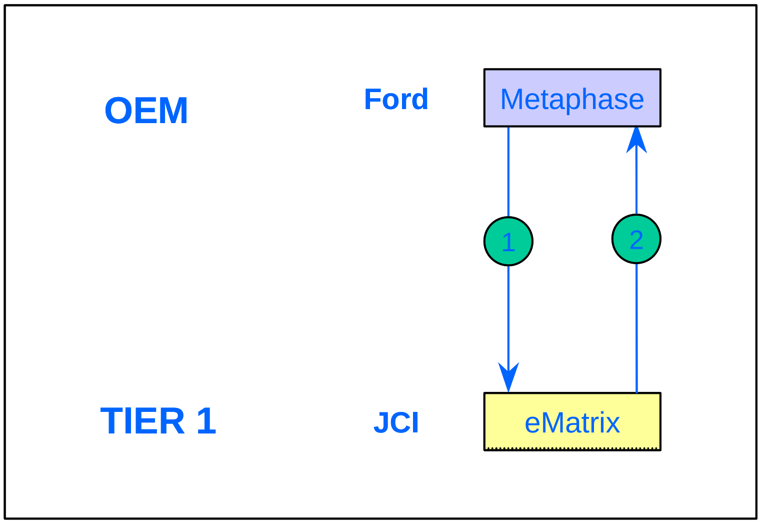


Figure 7. Ford - JCI

Acknowledge EWO

- The JCI engineer is now ready to initiate an Acknowledge EWO action. He extracts the modified CAD files from eMatrix and uses the EWO server to initiate an *Acknowledge EWO*. This acknowledgement, along with the CAD files is sent to the Ford engineer who initiated the *Process EWO* request.
- The Ford engineer, upon receiving the Acknowledge EWO notification connects to the EWO server and extracts the CAD files from it. He reviews them and checks them into Metaphase.

Ford – TRW Automotive

This scenario demonstrates EWO exchange in an OEM-TIER1 configuration, between different PDM systems. It is similar to the Ford-JCI exchange scenario.

Process EWO

- Ford engineer extracts CAD data files from Metaphase and uses the EWO server to initiate a new *Process EWO* action. This *Process EWO* request, along with the CAD files, is sent to TRW Automotive (TRW).
- The TRW engineer views and downloads the *Process EWO* request using a web browser.

- The TRW engineer saves the CAD files into his PDM system, iMAN.
- Then he checks them out, opens them in his CAD system, and makes the changes

requested in the EWO. Then he checks the modified files back into iMAN.

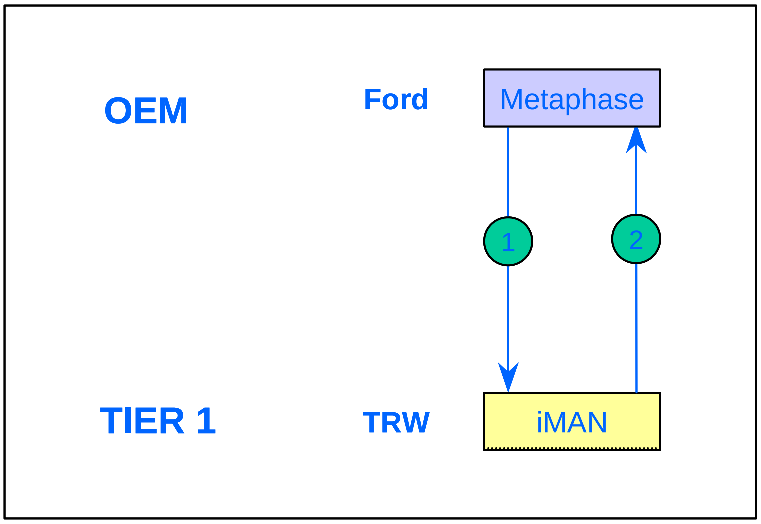


Figure 8. Ford - TRW

Acknowledge EWO

- The TRW engineer is now ready to initiate an Acknowledge EWO action. He extracts the modified CAD files from iMAN and uses the EWO server to initiate an *Acknowledge EWO*. This acknowledgement, along with the CAD files is sent to the Ford engineer who initiated the *Process EWO* request.
- The Ford engineer, upon receiving the Acknowledge EWO notification connects to the EWO server and extracts the CAD files from it. He reviews them and checks them into Metaphase.

Renault – Faurecia

This scenario demonstrates EWO exchange in an OEM-TIER1 configuration, with the TIER1, not using a PDM system. It shows how supply chain members may handle EWOs without a PDM system.

Process EWO

- Renault engineer extracts CAD data files from GDG and uses the EWO server to initiate a new *Process EWO* action. This *Process EWO* request, along with the CAD files, is sent to Faurecia.
- The Faurecia engineer views and downloads the *Process EWO* request using a web browser.
- The TRW engineer saves the EWO and the CAD files. Then he opens them in his CAD system, and makes the changes requested in the EWO.

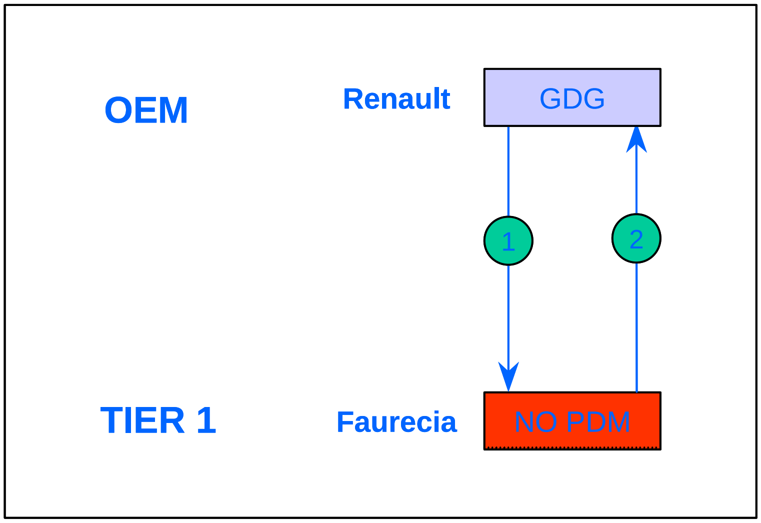


Figure 9. Renault - Faurecia

Acknowledge EWO

- The Faurecia engineer is now ready to initiate an Acknowledge EWO action. He uses the EWO server to initiate an *Acknowledge EWO*, which includes the CAD files that have to be sent back to Renault. This acknowledgement, along with the CAD files is sent to the Renault engineer who initiated the *Process EWO* request.

The Renault engineer, upon receiving the Acknowledge EWO notification connects to the EWO server and extracts the CAD files from it. He reviews them and checks them into Metaphase.

DELIVERABLE

SOFTWARE

Deliverable: Software

Software Programs

The STEP2XML software developed by AIAG to facilitate the interoperability is attached as attachment 1.

NOTE: The file is a zip file that should be opened with Microsoft Word after unzipped.

CONCEPT PROVE OUT

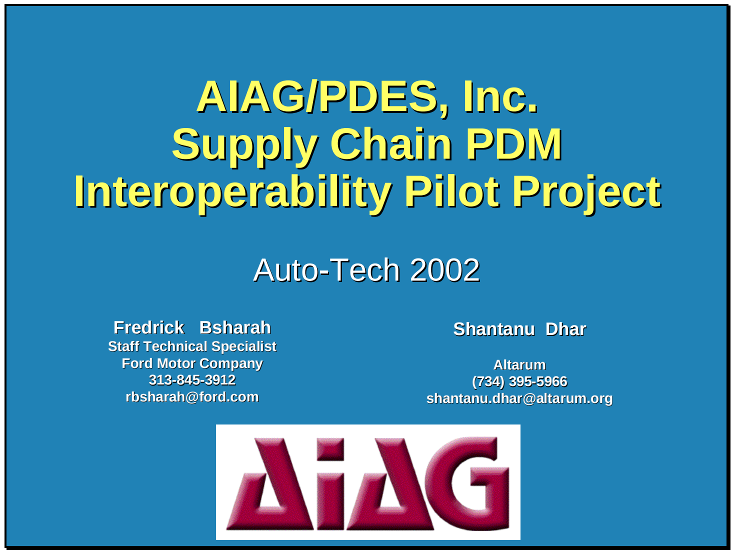
AUTO-TECH 2002 DEMONSTRATION

AIAG-NIST SUPPLY CHAIN

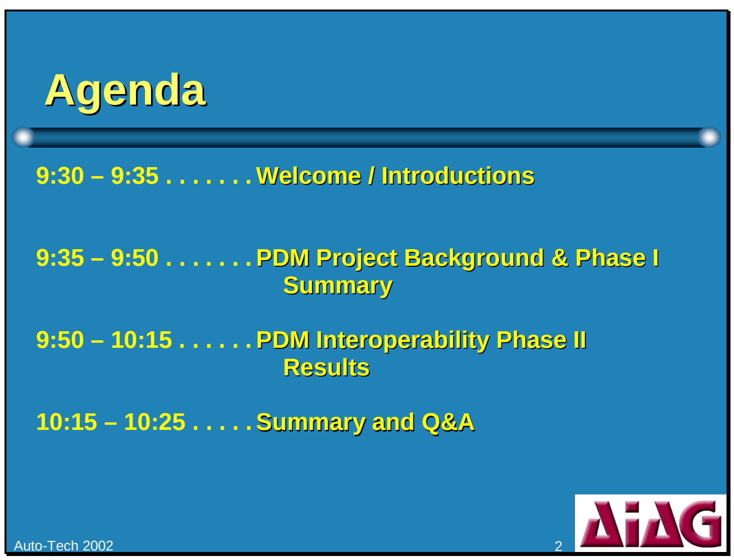
PDM INTEROPERABILITY PILOT PROJECT

AUTO-TECH 2002 - Presentation 1

Slide 1



Slide 2



Slide 2

There's a movement, these days, toward globalization and collaboration, two factors that create an unprecedented need for information exchange. And it's these two factors – globalization and collaboration – that are the driving force behind the case study that you'll see in this demo.

In addition, the trend in the industry towards joint ventures, mergers and team projects has created a need to support a PDM computing environment that's distributed and heterogeneous – that is, it's comprised of different systems.

Another major trend in the automotive industry is the shift in responsibility for design and manufacturing. Whereas OEMs have been taking that responsibility, it's shifting to members of the supply base, in effect outsourcing more of the product development.

We're also seeing the creation of localized centers of excellence for product development. Having these centers enables users all over the world to access and apply functions that are of importance to the product development life cycle.

These business cases were analyzed and quantified by the AIAG in 2000, forming the rationale for undertaking the initial Pilot Demo for PDM Interoperability

Slide 3

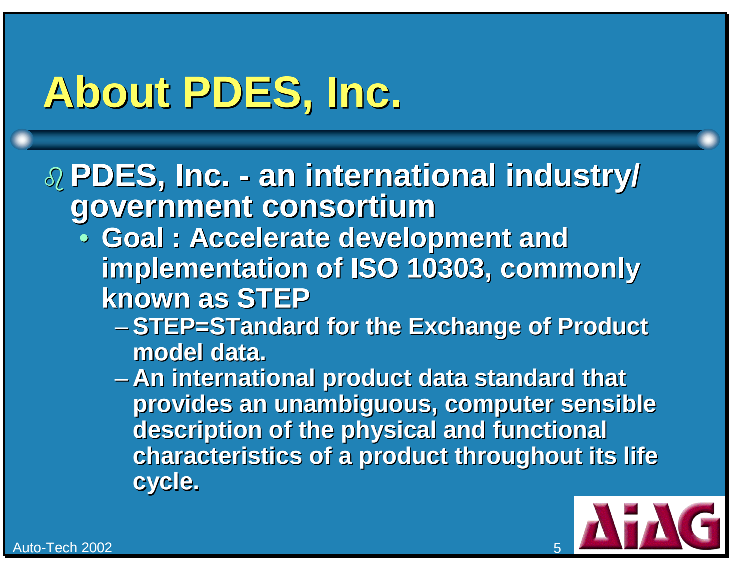
Slide 4

Slide 4
So, the changing needs of the production process have created a greater need for the exchange of information throughout the supply chain. The information that we're talking about exchanging is typically referred to as Product Data Management, or PDM.

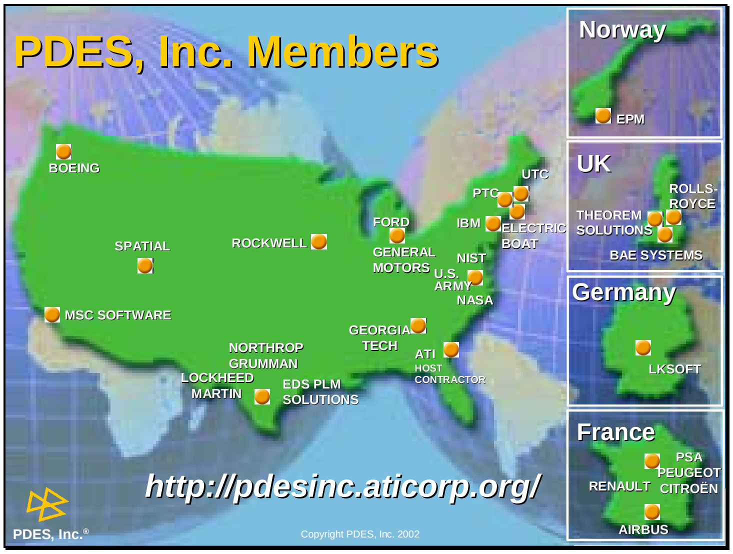
You can describe Product Data Management as the collaborative management of product definition data throughout the extended enterprise. The extended enterprise refers to an environment characterized by globalization and the need for collaboration.

AIAG's document D14, "B2B Requirements and Strategy for PDM Interoperability" gives a more thorough explanation of how PDM is creating a greater need for information sharing.

Slide 5



Slide 6



Slide 6

This slide builds

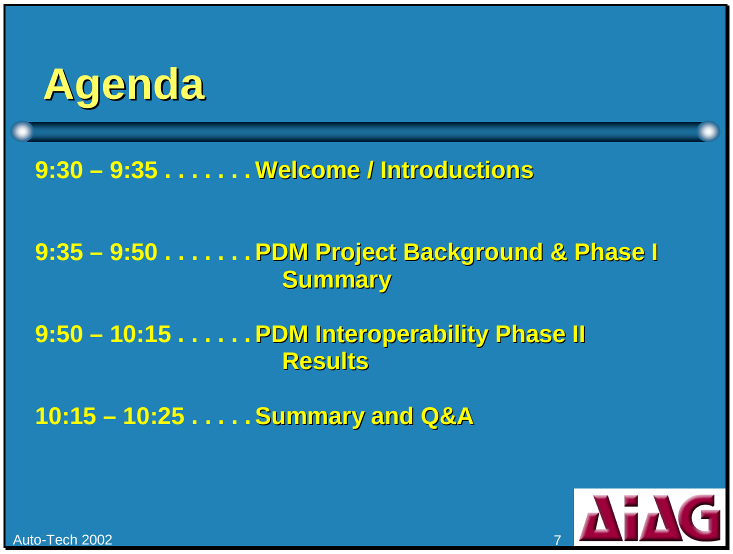
1. The approach draws upon the input of OEM's, suppliers, and industry organizations like ASG.

2. The approach is extensible to accommodate the specific business needs of specific partner pairings.

3. STEP is the source for the core data elements. XML is the basis for expressing those elements, but we still have to agree on the specific XML schema; the schema has to take into account multiple business contexts for product data exchange. Today we are showing two examples, PDTNet schema is used in the Renault demo, OAGI BODs are used in the other demos.

4. CAD vendors, PDM vendors, and middleware vendors need to be involved early so their new products will support the standards.

Slide 7



Slide 7

In 2000 the first generation demonstration was created by the In the environment of distributed, heterogeneous PDM, interoperability is the most important element needed for the successful exchange of information. Simply put, interoperability is the capability of different systems to share information and work together effectively.

It's simple in concept, but often hard to put into practice. For one thing, for interoperability to succeed, you have to use open systems over an open communication infrastructure like the Internet. Why? Because open systems use neutral, standard information models that facilitate communication, whereas closed, proprietary models make it difficult – if not impossible – to exchange information.

In this demonstration we're using the open information model provided by the international standard ISO 10303, commonly known as STEP.

The Web infrastructure is built upon a standard information technology base and provides efficient, accessible and secure data transport.

With the realization that the automotive industry has coalesced around certain standards groups to aid in reaching agreement on common definition and semantics for processes and data, input from these groups was solicited and incorporated.

By establishing a framework for interoperability, it becomes possible to demonstrate the exchange of real design data in real process contexts. And this interoperability can be demonstrated across a range of PDM vendors, data models, and exchange scenarios**!**

Slide 8

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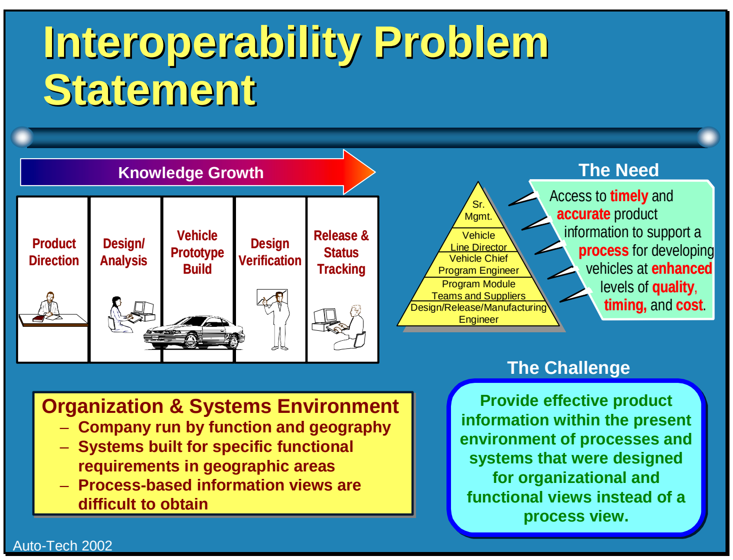

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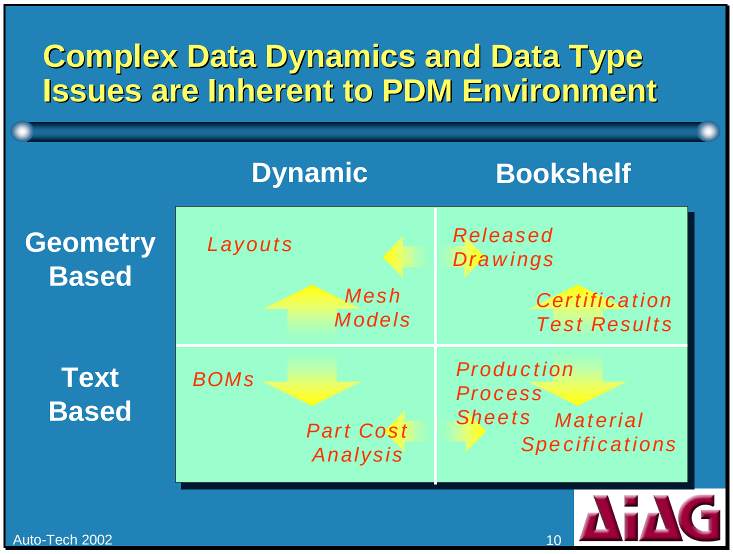

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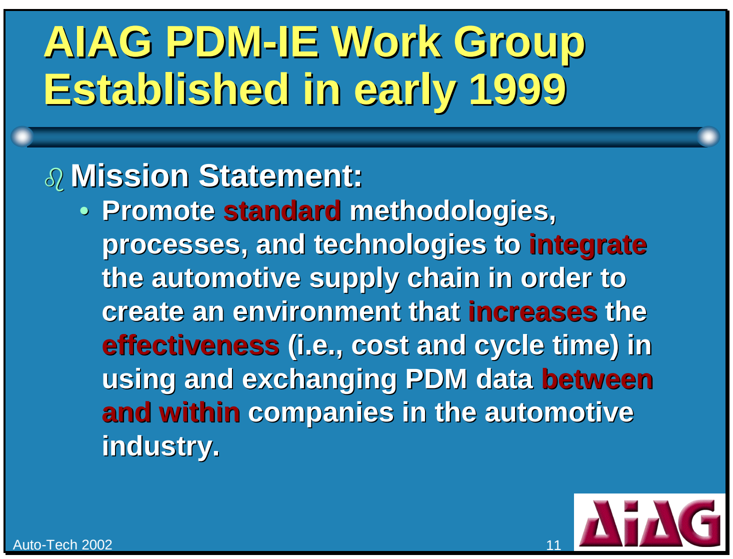

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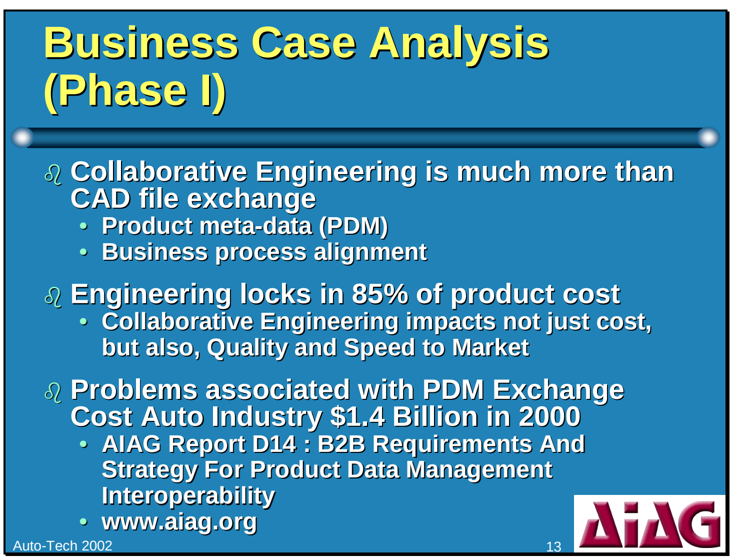

Slide 14

Slide 14
The Renault demo involved a Web exchange site that was built-in translators between STEP and the PDTNet flavor of XML. Using a Web exchange involves a sending user logging on to a web site ourside of his PDM system to create an EWO and a receiving user logging onto the same site to retrieve the EWO upon email notification.

The other demos used common translation capabilities for converting data between STEP and the OAGI flavor of XML. These two demos also involved a Web exchange. The third, the Ford/TRW demo used industry standard Web Services Integration to allow direct PDM2PDM communication. Web Services integration with ebXML enables guaranteed delivery without a separate web site login by sender and receiver.

The demos reflected the exchange of product information between different enterprises with various (or no) PDM systems. Multiple-tier collaboration is also shown.
This variety in the demos is proof of the robustness of the STEP/XML approach.
Organizations involved in producing the translation capabilities include PDTec, NIST, and Alterum.
IONA Technologies provided the Web Services Integration platform.

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PDM Data Exchange Usage is Increasing to Meet Global Business Needs

TO-BE Scenario Matrix	Exchange of Product Meta Data Only					Exchange of Product Meta Data with CAx Bulk Data				
	Commodity Design	Black Box Design	Gray Box Design	Collaborative Design	Customer Design	Commodity Design	Black Box Design	Gray Box Design	Collaborative Design	Customer Design
Company WG PDM to/from WG PDM	0.56	0.44	0.44	1.00	0.67	0.67	0.89	0.89	1.00	1.00
Company Entr. PDM to WG PDM	1.11	1.44	1.33	1.56	1.33	1.33	1.44	1.44	1.56	1.56
Company WG PDM to Entr. PDM	0.78	1.11	1.22	1.67	1.44	1.00	1.33	1.44	1.67	1.56
Customer Entr. PDM to Supplier Entr. PDM	1.00	1.67	1.89	2.33	2.22	0.78	1.78	1.78	2.67	2.56
Customer Entr. PDM to Supplier WG PDM	0.22	0.44	0.44	0.67	0.89	0.44	0.78	1.00	1.00	0.89
Customer WG PDM to Supplier Entr. PDM	0.44	0.67	0.67	0.78	0.56	0.44	0.67	0.67	0.78	0.89
Customer WG PDM to Supplier WG PDM	0.44	0.44	0.44	0.78	0.56	0.44	0.89	0.89	0.89	0.89
Supplier Entr. PDM to Customer Entr. PDM	1.44	1.67	1.78	2.22	1.67	1.11	1.89	2.00	2.44	2.22
Supplier Entr. PDM to Customer WG PDM	0.22	0.22	0.33	0.67	0.56	0.33	0.56	0.67	1.00	0.67
Supplier WG PDM to Customer Entr. PDM	0.56	0.56	0.56	0.89	0.44	0.67	0.89	1.00	0.89	0.44
Supplier WG PDM to Customer WG PDM	0.56	0.56	0.67	0.78	0.44	0.67	0.89	1.00	0.89	0.56

Enterprise (Entr.) PDM: Refers to an environment where the data is accessible by all members of the enterprise. (e.g., multiple teams/projects)

Workgroup (WG) PDM: Refers to environment where data is only accessible by members of the workgroup; i.e., a set of individuals focusing on a particular matter.

LEGEND: High Usage = 2.0 Medium Usage = 1.0 Low Usage = 0.0

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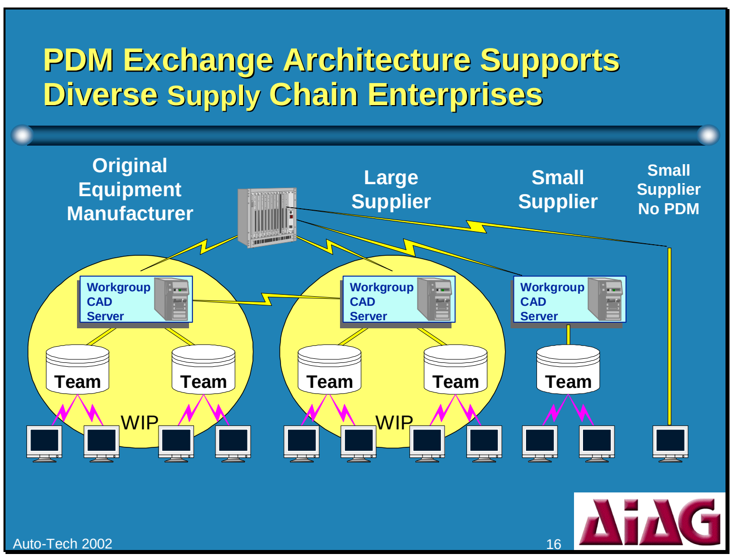
Slide 16



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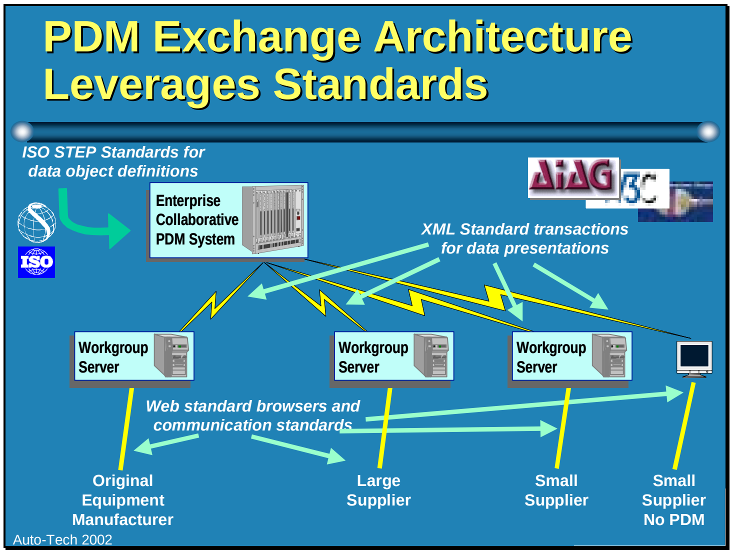

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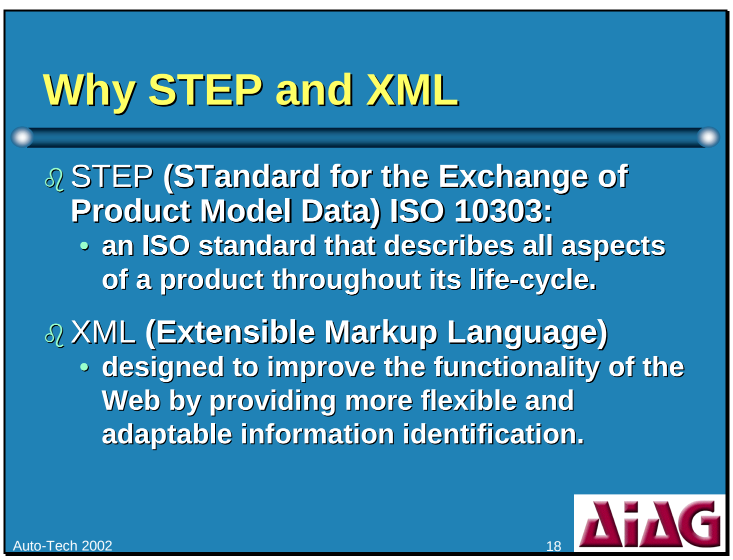

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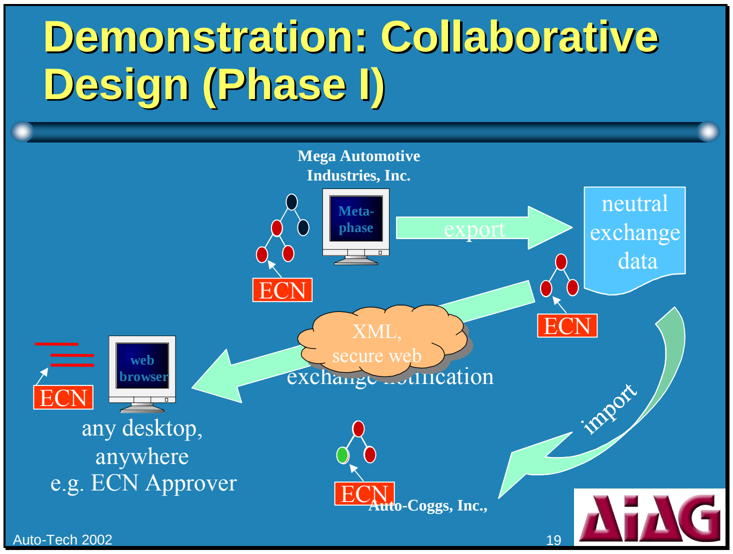

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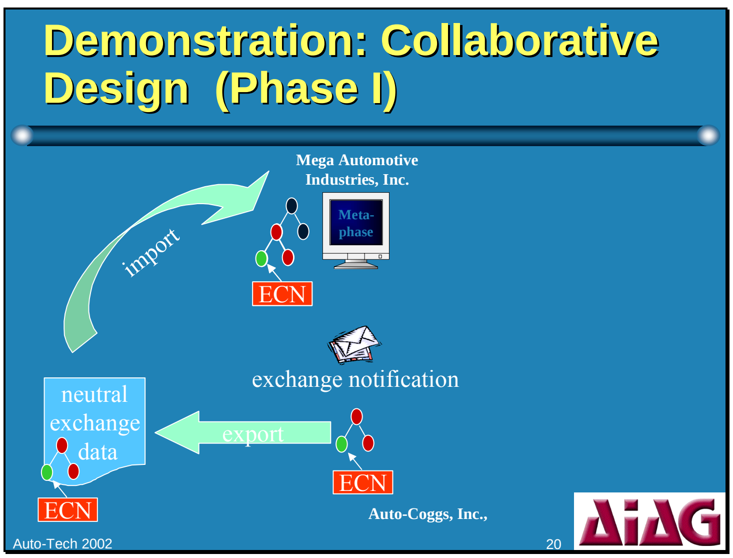

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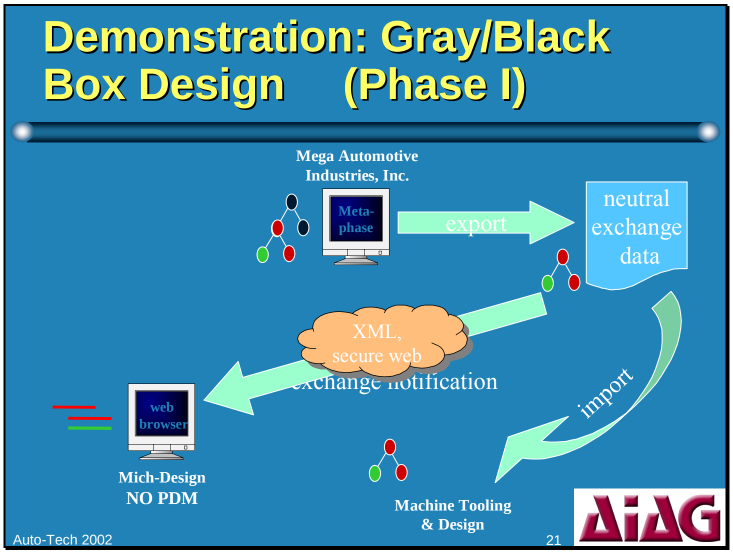

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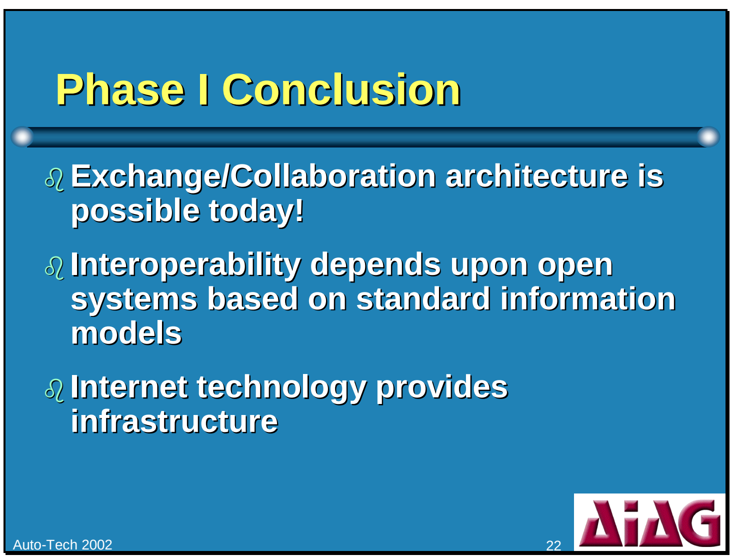

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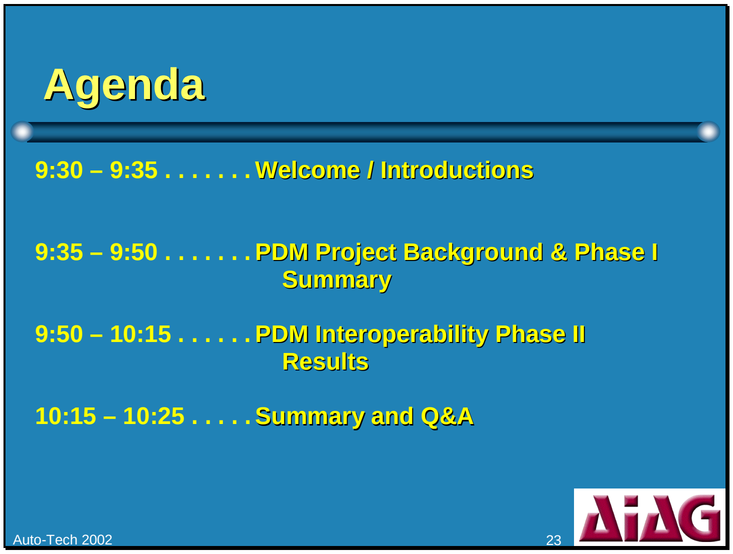

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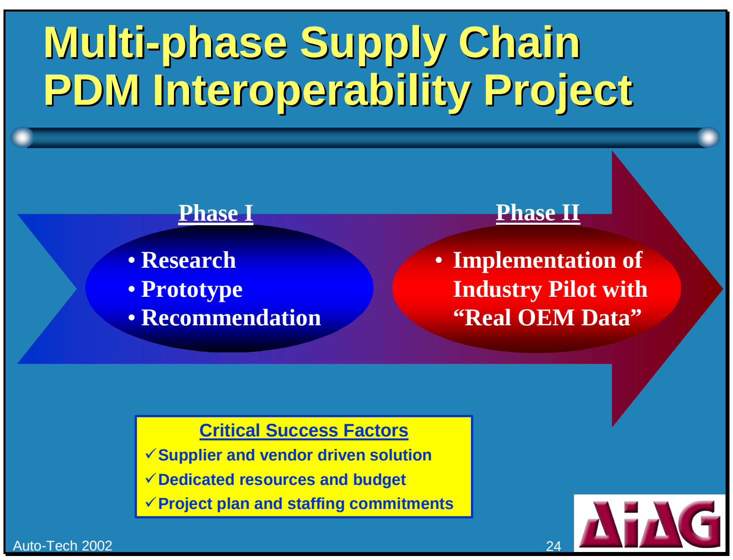

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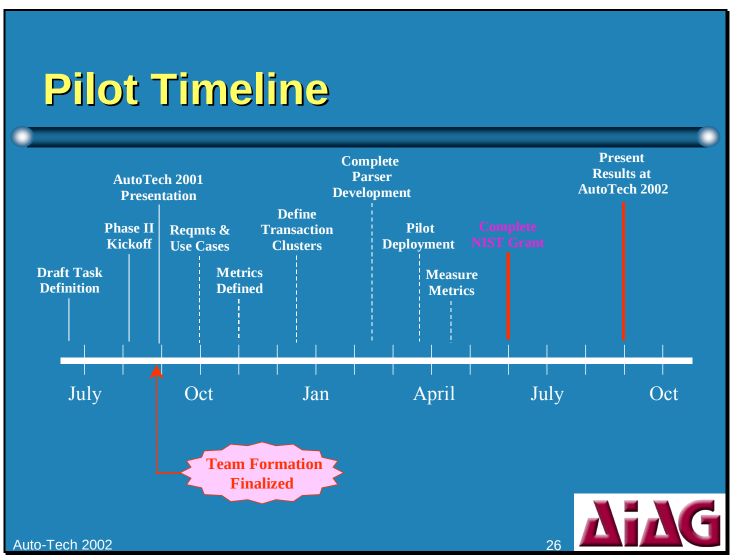

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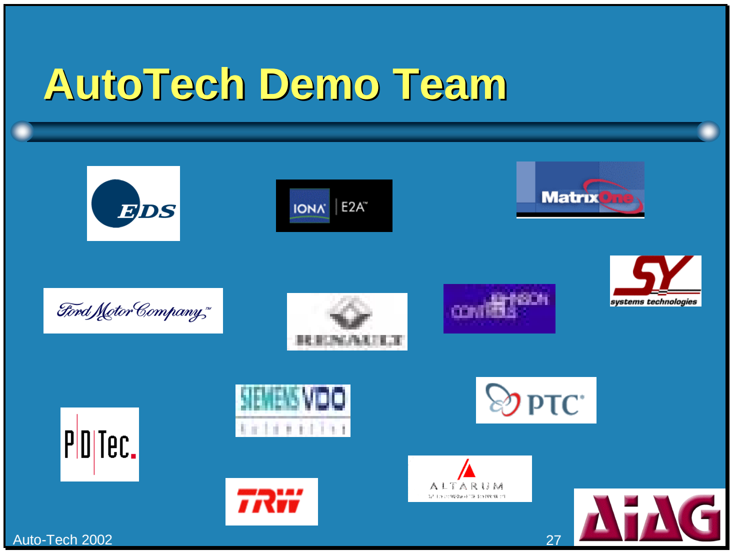

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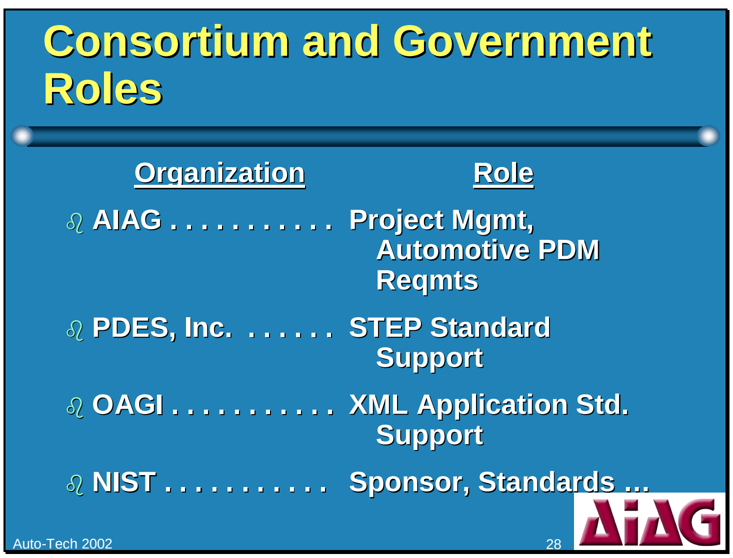

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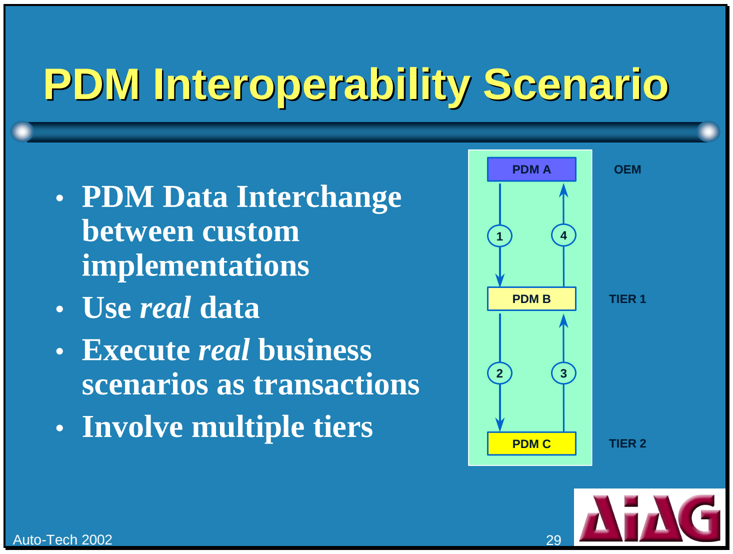

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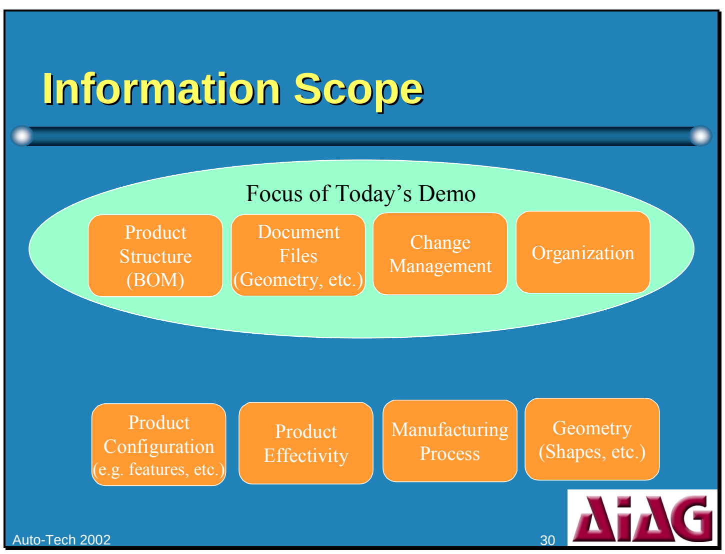

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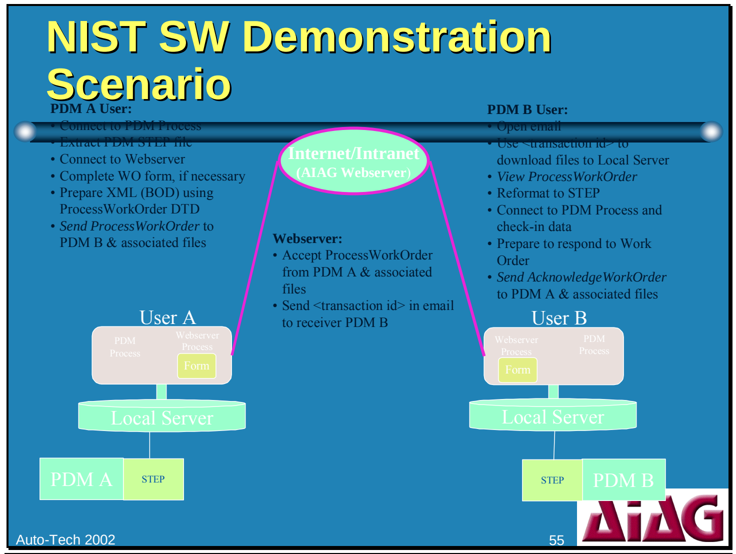

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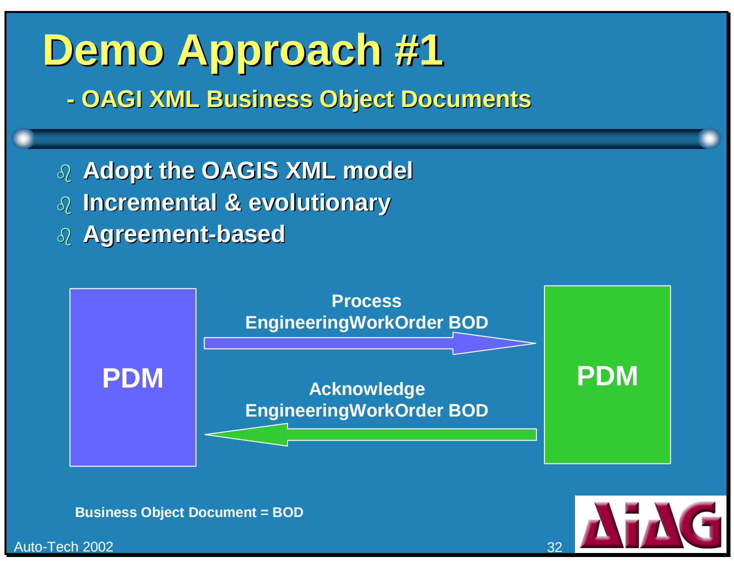

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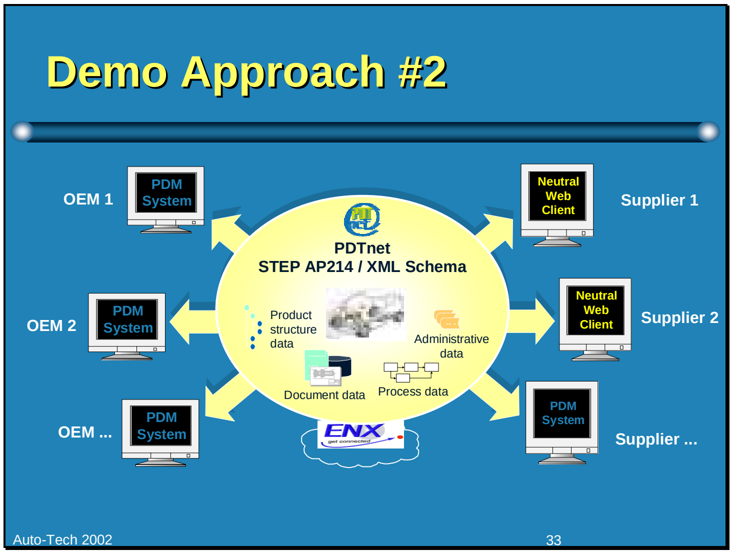

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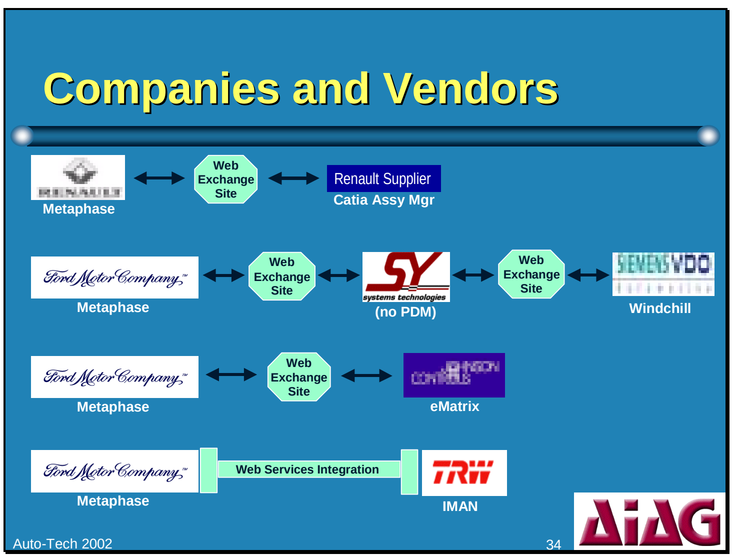

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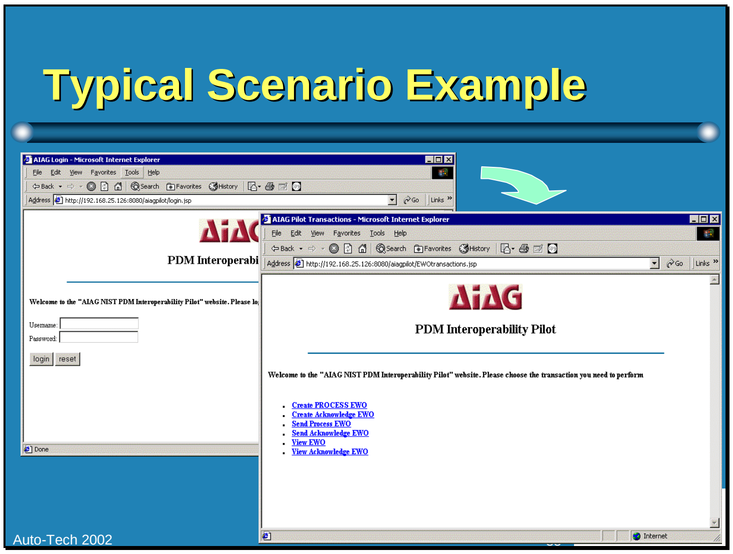

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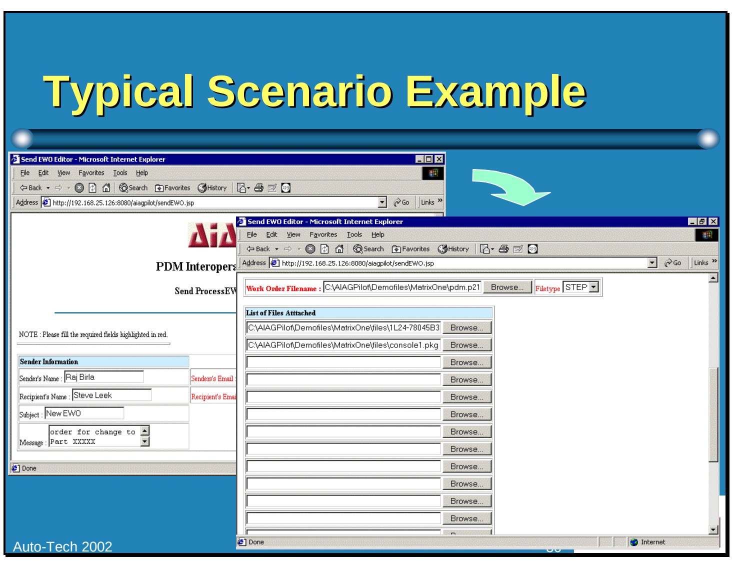

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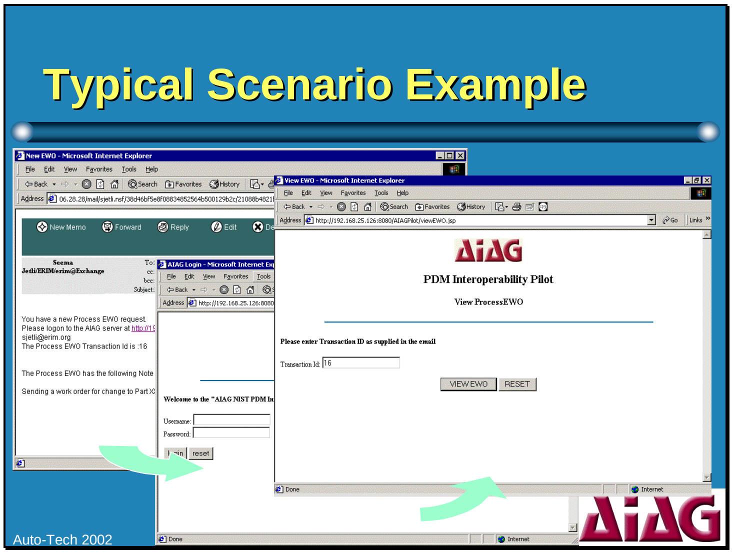

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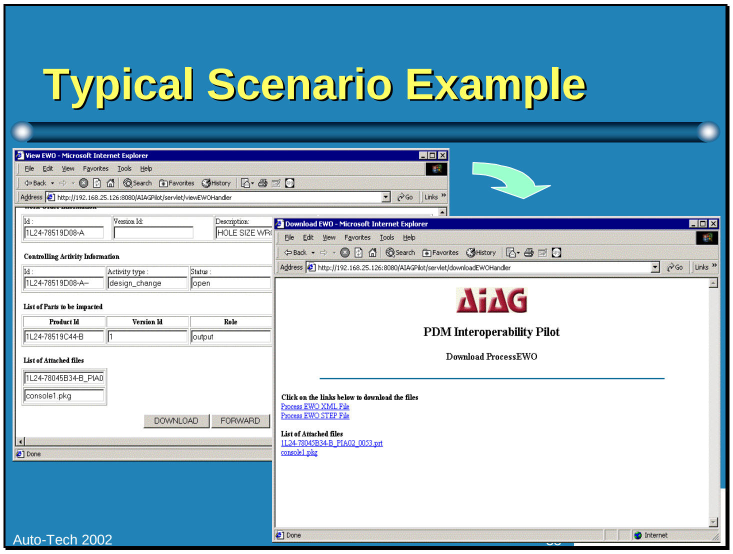

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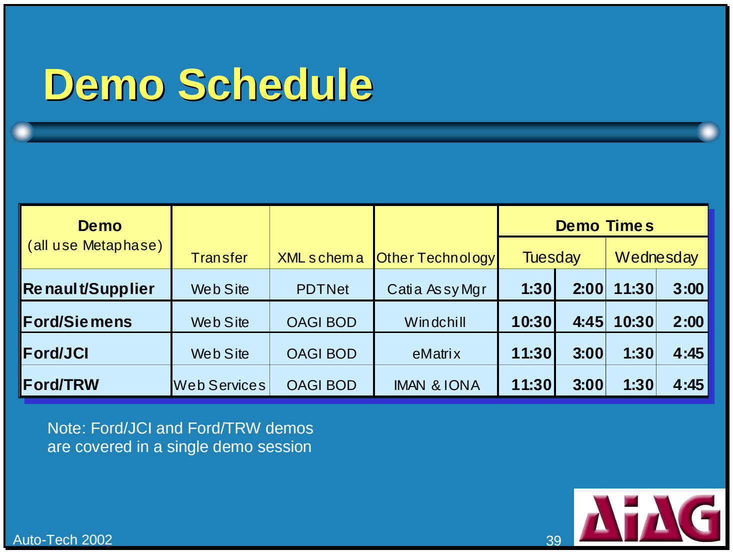
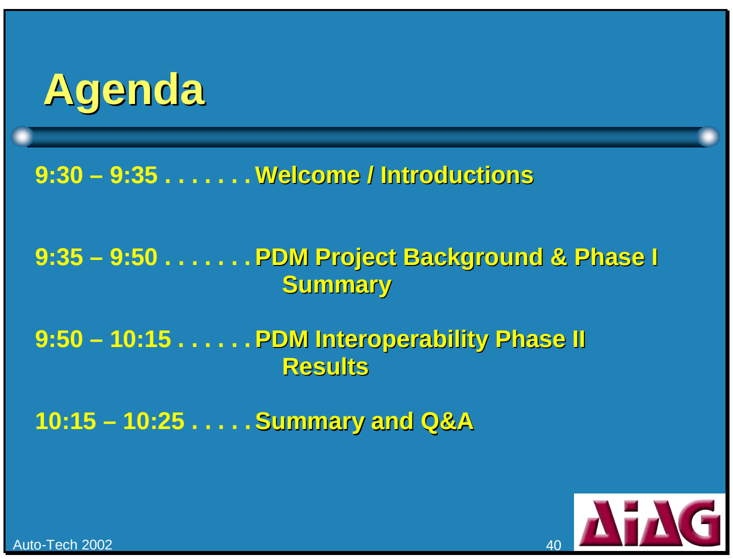


Demo (all use Metaphase)	Transfer	XML schema	Other Technology	Demo Times			
				Tuesday		Wednesday	
Renault/Supplier	Web Site	PDTNet	Catia Assy Mgr	**1:30**	**2:00**	**11:30**	**3:00**
Ford/Siemens	Web Site	OAGI BOD	Windchill	**10:30**	**4:45**	**10:30**	**2:00**
Ford/JCI	Web Site	OAGI BOD	eMatrix	**11:30**	**3:00**	**1:30**	**4:45**
Ford/TRW	Web Services	OAGI BOD	IMAN & IONA	**11:30**	**3:00**	**1:30**	**4:45**

Slide 40



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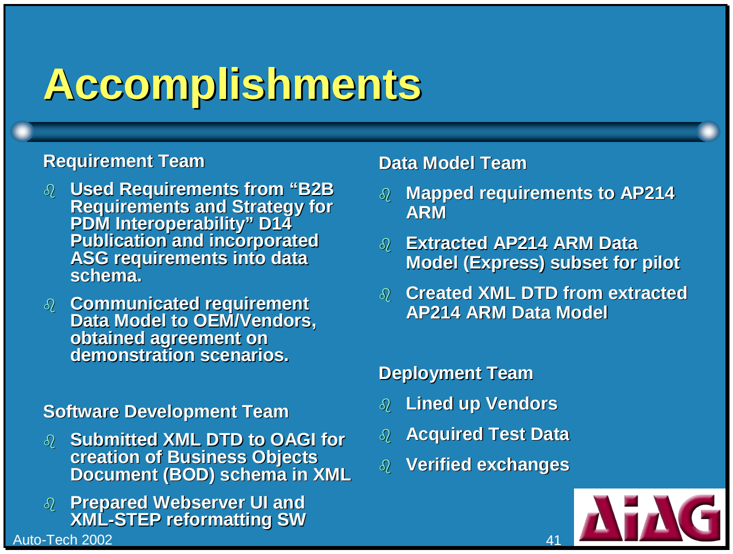

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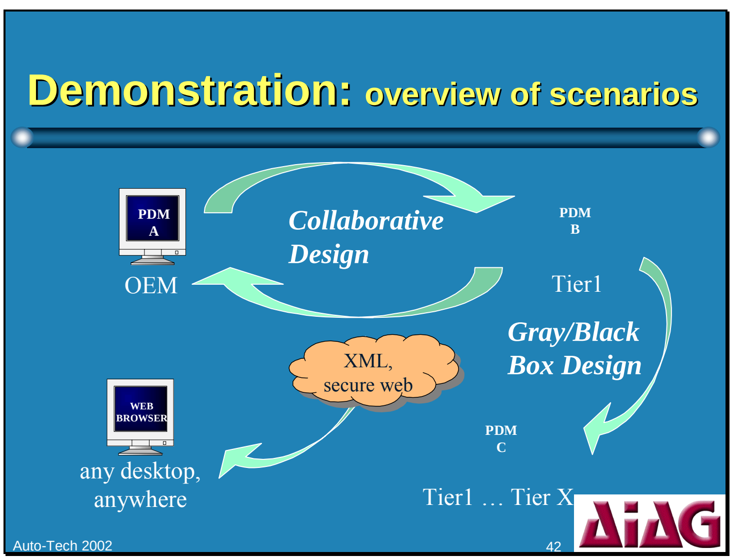

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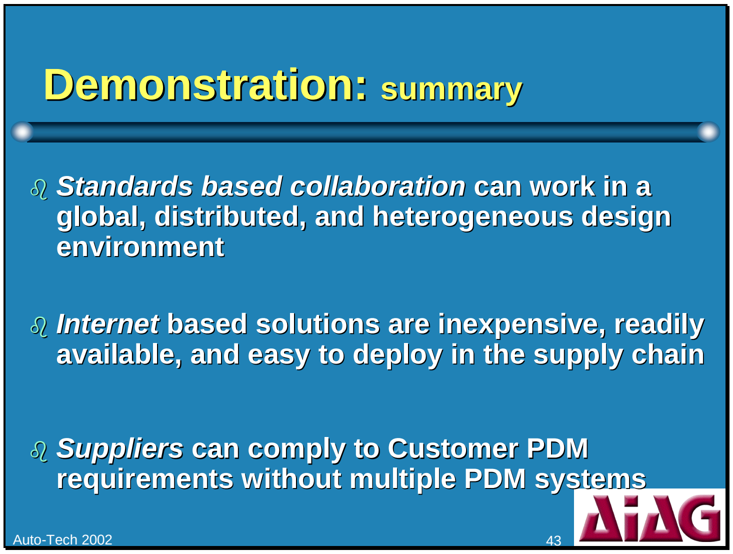


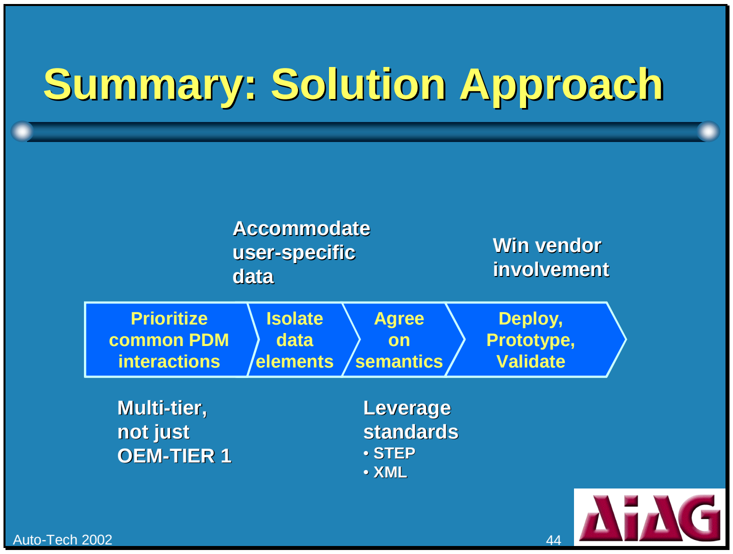
To summarize and highlight the major points from this demonstration:

•Collaboration can work in a global, distributed, heterogeneous design environment!

•Internet applications can help facilitate communication up and down the supply chain in either a browser-mediated pull model or a Web Services push model, and

•Suppliers who face the prospects of supporting multiple OEMs can comply with their customer PDM requirements without the burden of having to support and maintain multiple PDM systems that are different.

Slide 44



Slide 45

Phase III - Pilot Objectives

- Prove the ability of these standards to improve the efficiency of product engineering and manufacturing activities
  - Metrics: Quality, Cost, Timing . . .
- Communicate and Harmonize with other standards groups

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AiAG

Slide 46

Next Steps and How to Get Involved

- The Collaborative Engineering & Product Development Steering Team will be continuing its interoperability focus.
  - Metrics Analysis
  - Continue OAGI schema development
  - Complete Web Services demo implementation
  - Global collaboration will be a mandate
- Point of Contact
  - Akram Yunas, AIAG
    - ayunas@aiag.org
    - 248-358-9758

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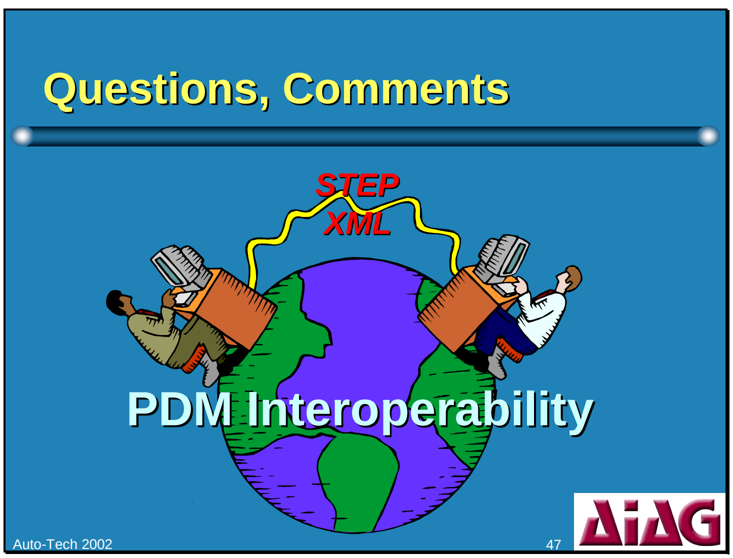

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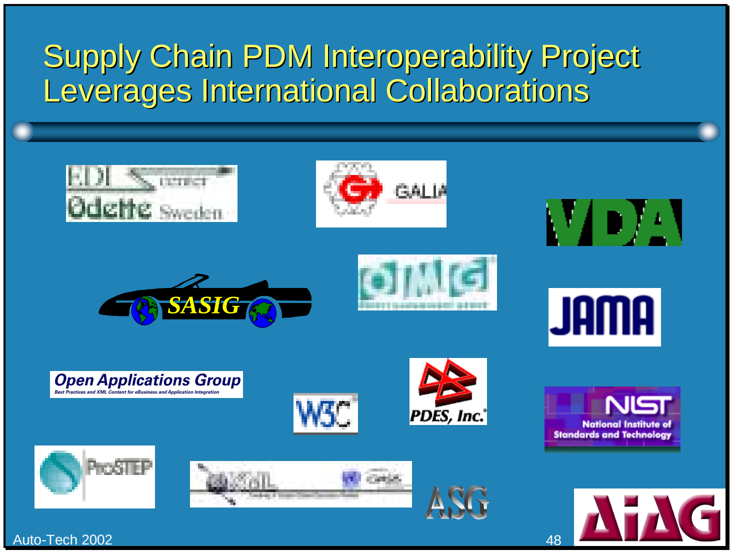
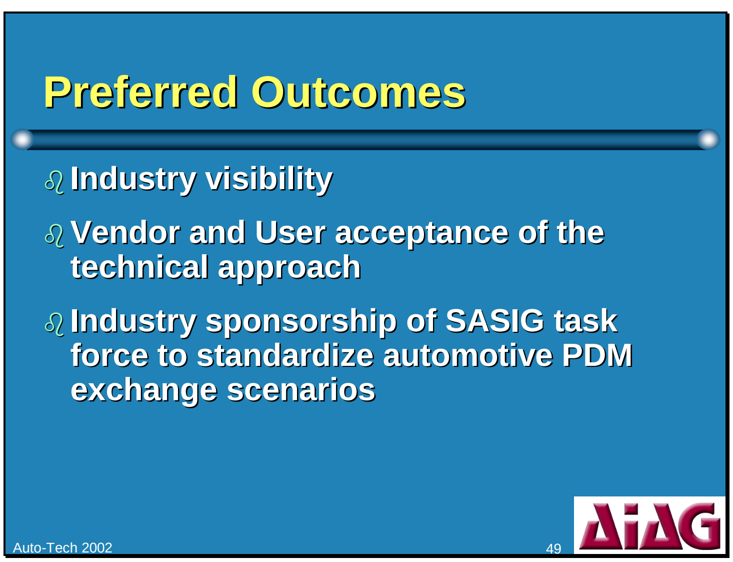
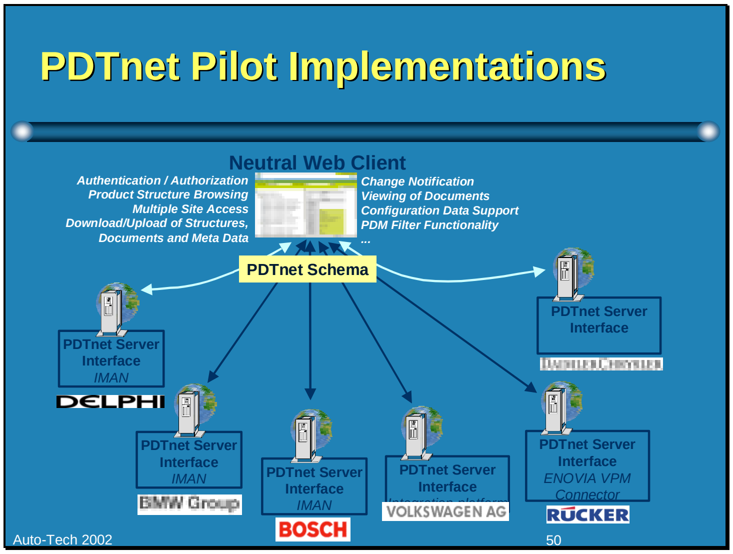


Above SASIG symbol are the icons of the members
Below the SASIG symbol are some of the organizations that deal with standards that SASIG members are leveraging.
Mention previous PDM Integration pilot efforts of AIAG, JAMA, and Odette (including GALIA and VDA)
SASIG recently formed a workgroup to harmonize these efforts, and we've already agreed on a common set of underlying data elements.
The group is now working on a common specification that makes use of those data elements.

Slide 49



Slide 50



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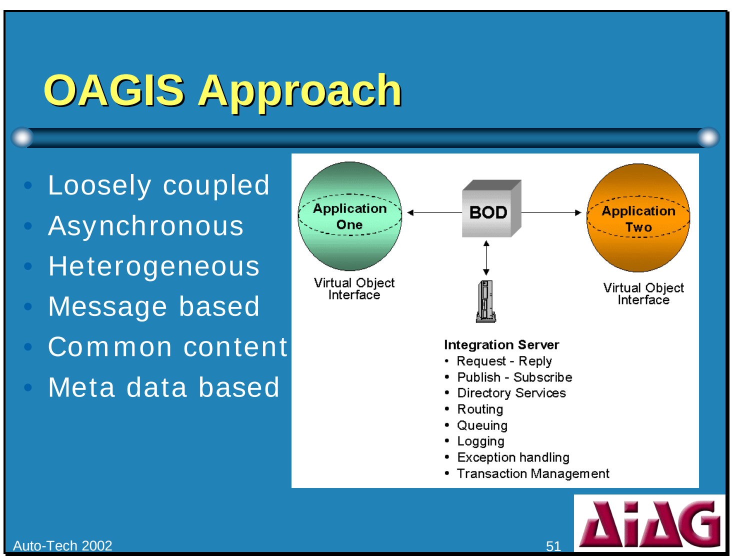

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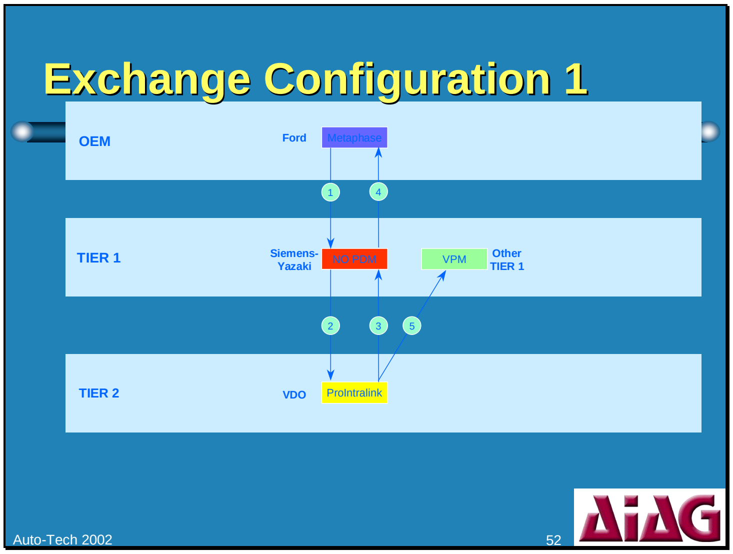

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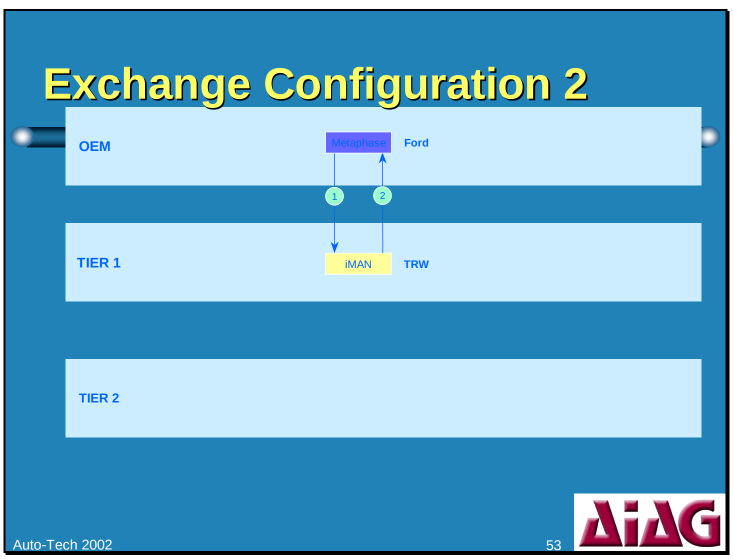

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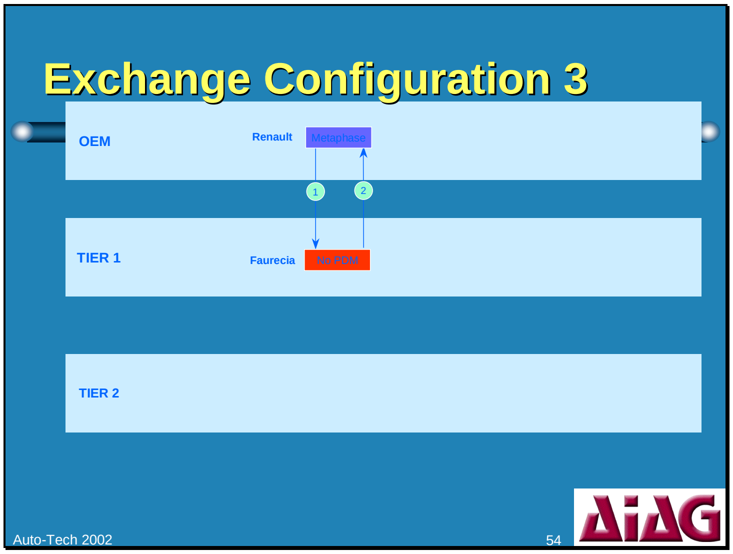
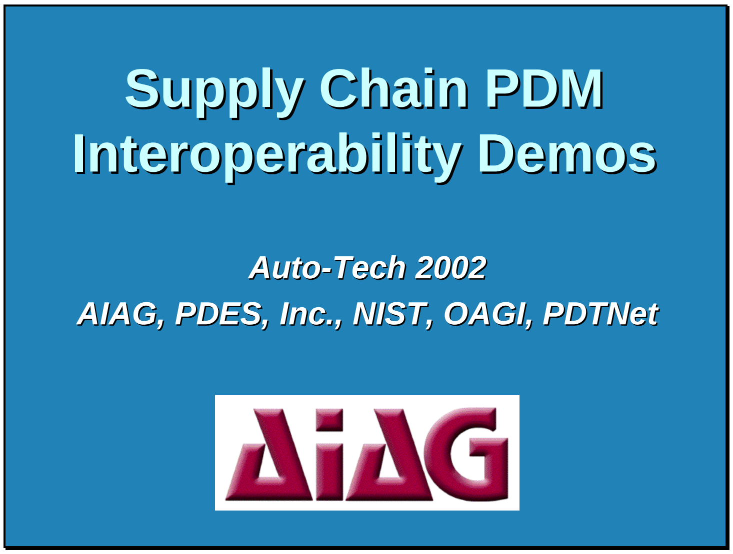

Exchange Configuration 3
OEM
Renault
Metaphase
1
2
TIER 1
Faurecia
No PDM
TIER 2
Auto-Tech 2002
54

AUTO-TECH 2002 - Presentation 2

Slide 1



Slide 2

Slide 3

Business Case

Collaborative Engineering is *much* more than CAD file exchange

- Product meta-data (PDM)
- Business process alignment

PDM Exchange Cost Auto Industry $1.4 Billion in 2000

Engineering locks in 85% of product cost

- Collaborative Engineering impacts not just cost, but also
  - Quality
  - Speed to Market

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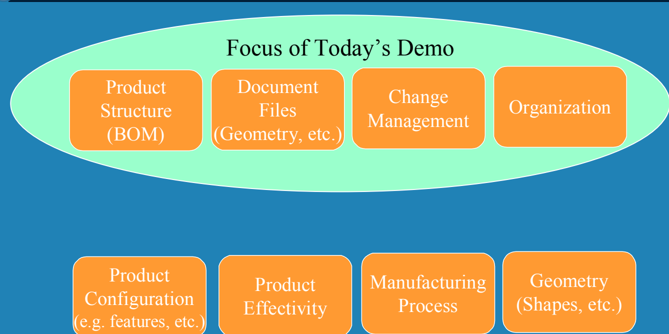
Slide 4

Information Scope



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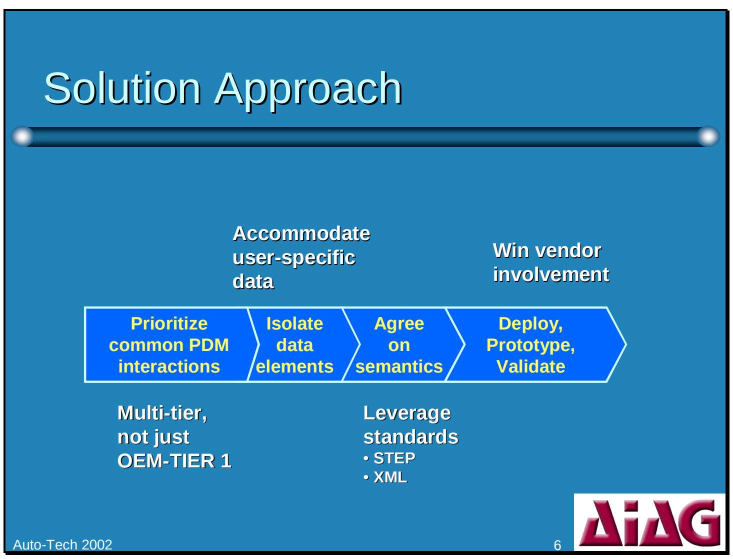
Slide 5

Slide 6



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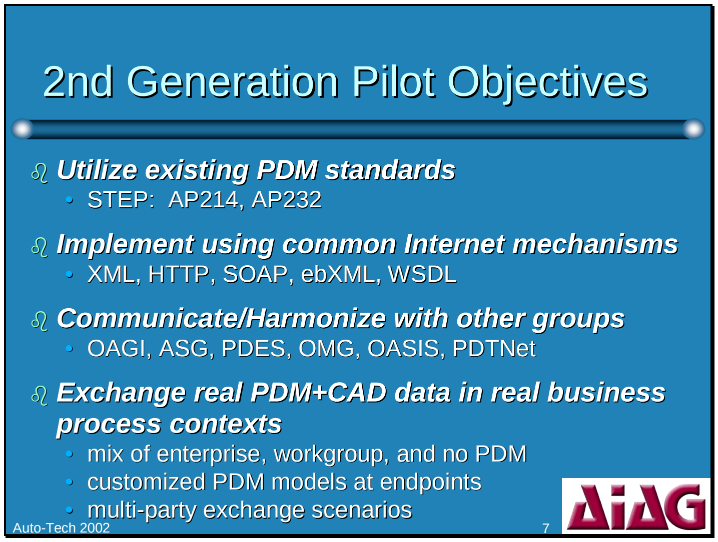

Slide 7

In the environment of distributed, heterogeneous PDM, interoperability is the most important element needed for the successful exchange of information. Simply put, interoperability is the capability of different systems to share information and work together effectively.

It's simple in concept, but often hard to put into practice. For one thing, for interoperability to succeed, you have to use open systems over an open communication infrastructure like the Internet. Why? Because open systems use neutral, standard information models that facilitate communication, whereas closed, proprietary models make it difficult – if not impossible – to exchange information.

In this demonstration we're using the open information model provided by the international standard ISO 10303, commonly known as STEP.

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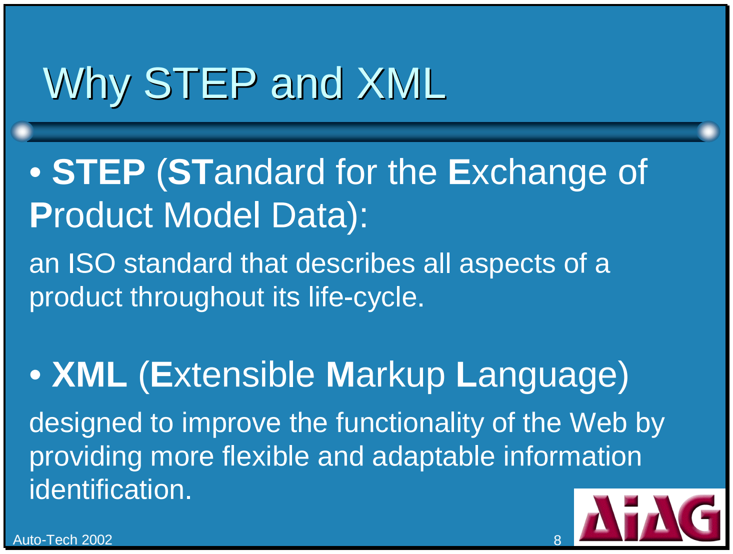
With the realization that the automotive industry has coalesced around certain standards groups to aid in reaching agreement on common definition and semantics for processes and data, input from these groups was solicited and incorporated.

By establishing a framework for interoperability, it becomes possible to demonstrate the exchange of real design data in real process contexts. And this interoperability can be demonstrated across a range of PDM vendors, data models, and exchange scenarios!

Slide 8



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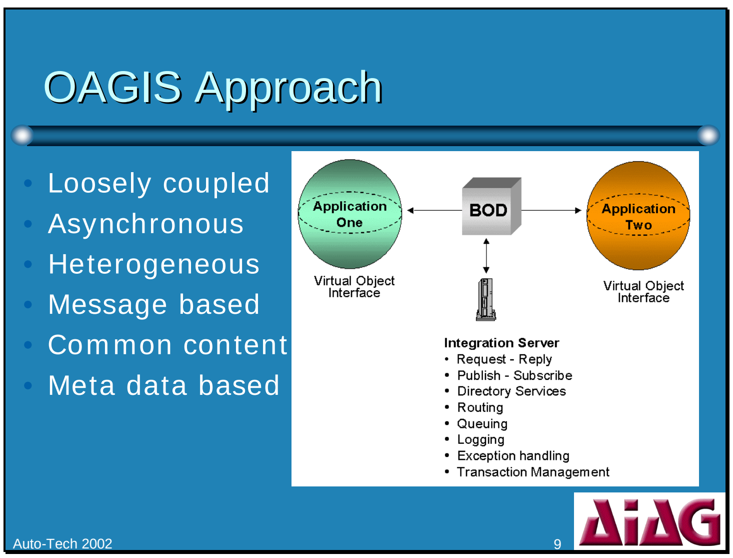

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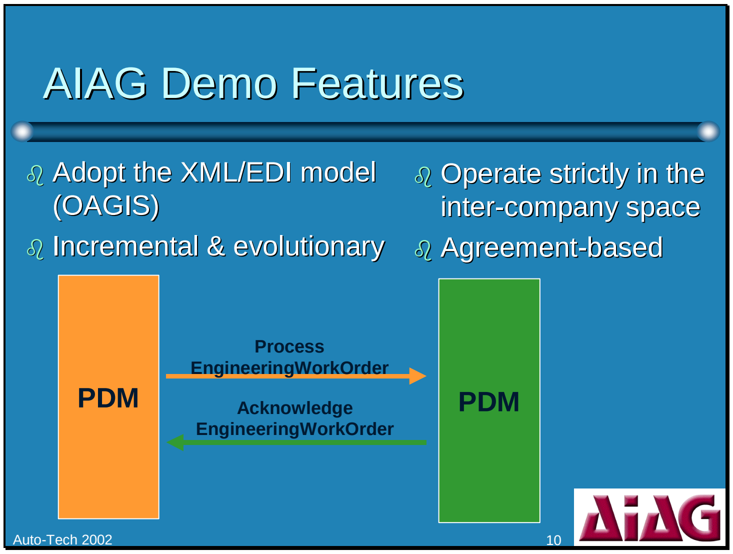

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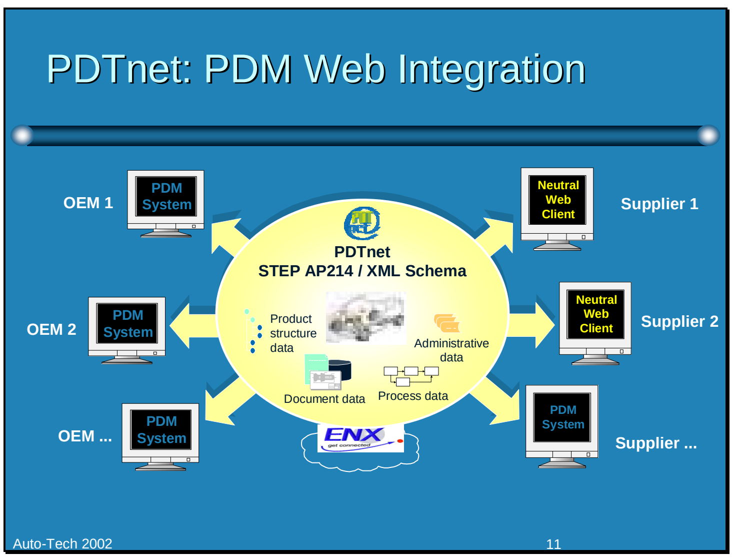

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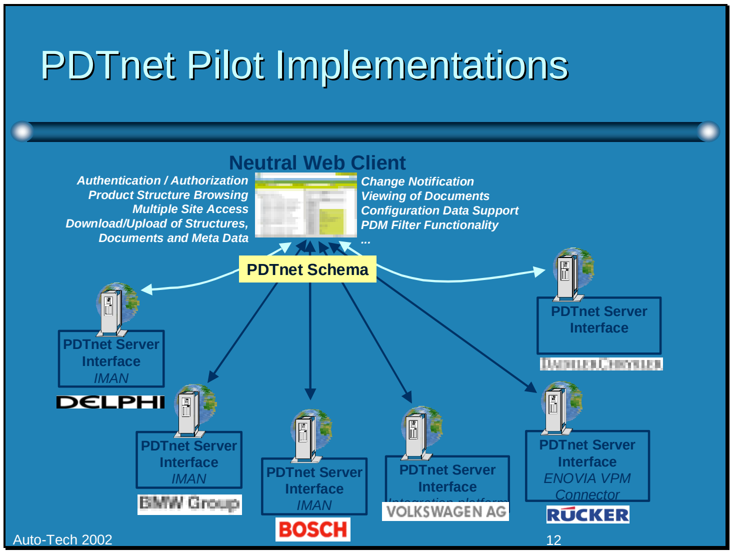

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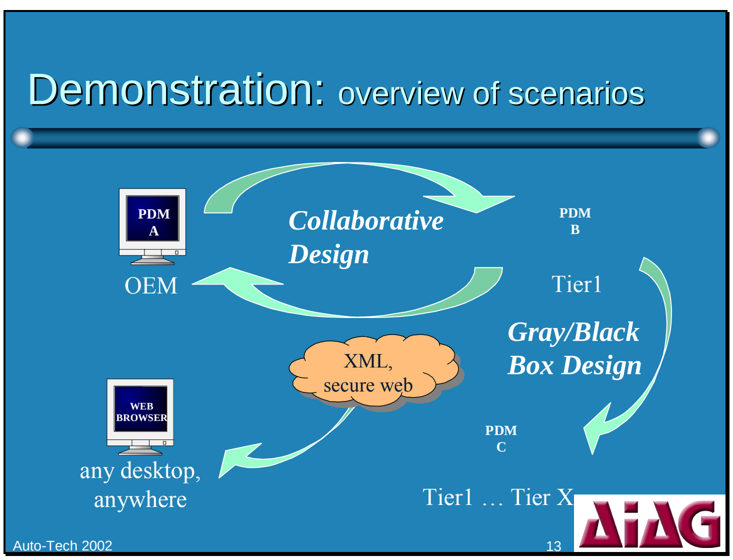


Slide 13

VO**:** The following slides illustrate two typical design scenarios: Collaborative design, and gray box or black box design.

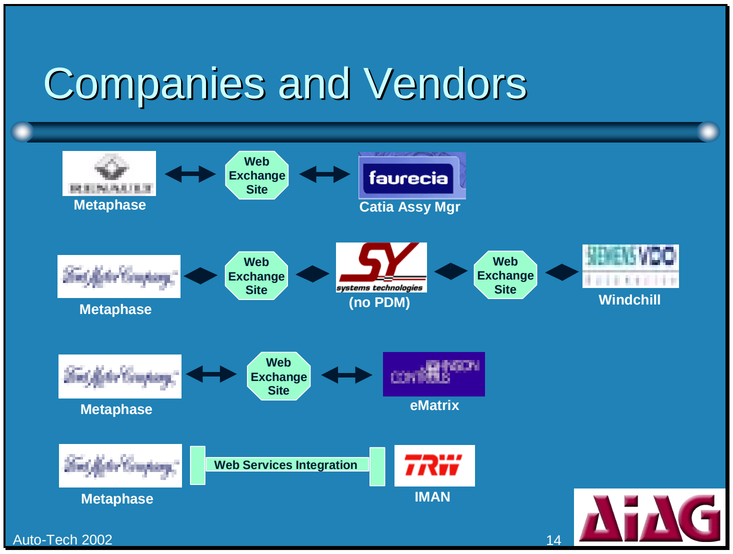
In the collaborative scenario, a joint customer-supplier team does the design to meet the overall design requirements of a project. On the surface it's a fairly simple scenario; however, it requires the highest degree of collaboration and exchange between the design partners – and that, I assure you, isn't all that simple.

In the Grey Box scenario, a supplier does a custom design according to customer-supplied requirements, but with certain additional specified design aspects that the customer provides. The Black Box scenario is pretty similar: Here, the customer specifies only high-level requirements for the supplier to use in producing a custom design.

What do these scenarios illustrate? In a simple way, they show interoperability between heterogeneous PDM systems; they also show that the neutral, standard STEP data model enables these PDM systems. Finally, the slide shows that we're using XML technologies over the Internet to make this standard PDM data available on any desktop, anytime, anywhere.

Now, let's take a look at these scenarios is more depth.

<u>Slide 14</u>



Slide 14
The Renault/Faurecia demo involves a Web exchange site that has built-in translators between STEP and the PDTNet flavor of XML. Using a Web exchange involves a sending user logging on to a web site out side of his PDM system to create an EWO and a receiving user logging onto the same site to retrieve the EWO upon email notification.

The other demos use common translation capabilities for converting data between STEP and the OAGI flavor of XML. Two of these demos also involve a Web exchange. The Ford/TRW demo uses industry standard Web Services Integration to allow direct PDM2PDM communication. Web Services integration with ebXML enables guaranteed delivery without a separate web site login by sender and receiver.

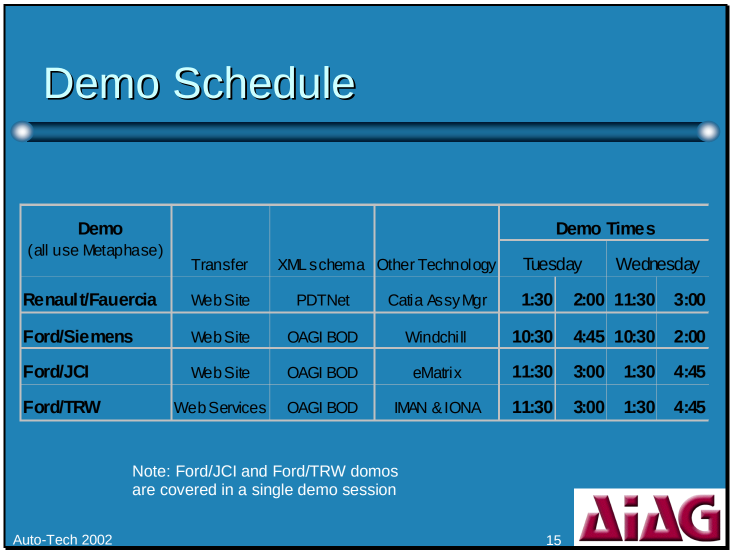
The demos reflect the exchange of product information between different enterprises with various (or no) PDM systems. Multiple-tier collaboration is also shown.

This variety in the demos is proof of the robustness of the STEP/XML approach.

Organizations involved in producing the translation capabilities include PDTec, NIST, and Altarum.

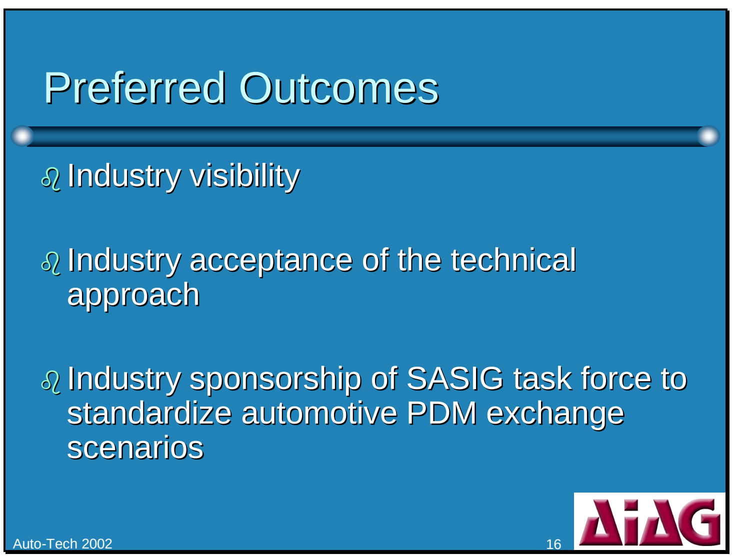
IONA Technologies provided the Web Services Integration platform.

Slide 15



Demo (all use Metaphase)	Transfer	XML schema	Other Technology	Demo Times			
				Tuesday		Wednesday	
Renault/Faurecia	Web Site	PDTNet	Catia Assy Mgr	**1:30**	**2:00**	**11:30**	**3:00**
Ford/Siemens	Web Site	OAGI BOD	Windchill	**10:30**	**4:45**	**10:30**	**2:00**
Ford/JCI	Web Site	OAGI BOD	eMatrix	**11:30**	**3:00**	**1:30**	**4:45**
Ford/TRW	Web Services	OAGI BOD	IMAN & IONA	**11:30**	**3:00**	**1:30**	**4:45**

Slide 16



Slide 17

Demonstration: summary

- *Collaboration* can work in a global, distributed, and heterogeneous design environment
- *Internet* based solutions are inexpensive, readily available, and easy to deploy in the supply chain
- *Suppliers* can comply to Customer PDM requirements without multiple PDM systems

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Slide 18

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CONCLUSIONS

and

NEXT STEPS

Conclusions & Next Steps

Summary & Conclusion

The PDM Interoperability Pilot project was based on the premise that the exchange of PDM information within a supply chain is best addressed at the level of individual business process transactions. To this end the project team developed a solution to showcase the efficiency and cost effectiveness of exchanging a well-defined, business process specific PDM information set pertaining to product work order and change management. Additionally, the business process specific approach was deemed well suited for incremental expansion – new transactions can be defined for new business processes, and then implemented, tested, and deployed in a planned fashion. And finally, the business process specific approach is inherently modular and therefore provides a high degree of transaction isolation that shelters a change in business process for one transaction affecting another (when the process events are not coupled).

The results of the project have led the team to conclude that the business process specific transaction hypothesis was indeed viable and achievable with today's technology. Specifically the project validated two strategic assertions.

- Standards based collaboration can work in a global, distributed, and heterogeneous design environment.
- Internet based technology solutions are inexpensive, readily available, and easy to deploy in the supply chain.

With respect to standards based collaboration, the project utilized two key standards to illustrate collaborative PDM data exchanges among different PDM systems employing different native schemas. The first is the ISO 10303-214: Core data for automotive mechanical design processes (AP214 STEP) standard. This standard was used to define the logical structure of the data content to be exchanged between the collaboration partners. The second key standard leveraged by the project was the WC3 Extensible Markup Language (XML) standard. XML was used to define the primary physical file format or packaging mechanism of the data instances being exchanged.

The exchange demonstrations showcased at the 2002 AIAG AUTO-TECH Conference were designed to highlight that web based technology solutions are inexpensive, readily available, and easy to deploy. In all, four different exchange scenarios involving seven different trading partner organizations, using three different exchange mechanisms, and five different PDM products were shown at the conference. All involved web-based exchanges of real PDM+CAD data in real business process contexts.

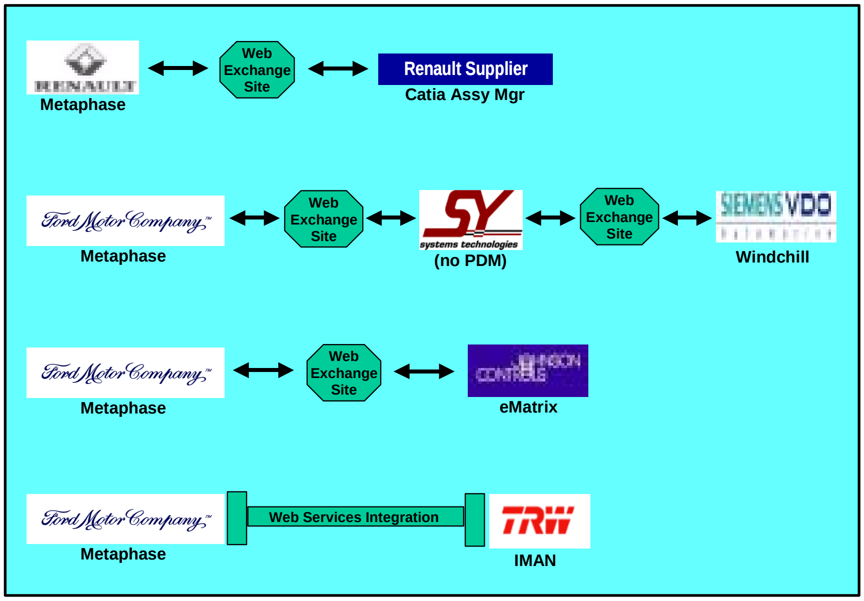

Figure 10 – Exchange scenarios showcased at AUTO-TECH 2002

When the project began, four objectives were identified and by the end of the project all were achieved. The four objectives were as follows:

1. Utilize existing PDM standards
2. Implement using common Internet mechanisms
3. Communicate/Harmonize with other groups
4. Exchange real supply chain relevant PDM+CAD data in real business process contexts

The first objective of utilizing existing PDM standards was satisfied through the use of the ISO STEP standard, in particular AP214. STEP AP214 was found to have a very rich PDM subset that could be used to support all the exchange scenarios.

The project's use of XML tagging by means of Business Object Document and XML Schema approaches fulfilled the scope of the second objective. In addition, the Ford/TRW scenario used industry standard Web Services Integration to allow direct PDM2PDM communication. Web Services integration with ebXML enables guaranteed delivery without a separate web site login by sender and receiver.

Communication and harmonization with other industry and standardization groups/organizations was pursued throughout the life of the project. Extensive alignment occurred between the AIAG, the PDES Inc., the ASG, and the SASIG organizations. One example of this alignment is that the AIAG team, in collaboration with the OAGI, has submitted the Engineering Work Order XML DTD to the OAGI for adoption as a Business Object Document (BOD) schema.

Finally, by defining a set of multi-party exchange scenarios that involved a mix of enterprise, workgroup, and no PDM exchange partners - each with their own customized PDM models - the project team felt that it achieved the fourth objective. Specifically that of exchanging real PDM+CAD data in real business process contexts.

Next Steps

The Collaborative Engineering & Product Development Steering Team will be continuing its Supply Chain PDM interoperability focus. The plan for 2003 is to obtain the necessary funding and resources to pursue four tracks.

1. Define additional PDM+CAD file exchange scenarios and corresponding STEP based XML schemas.
2. Pilot the additional exchange scenarios to verify schema definition.
3. Continue supporting the development/adoption and publication of STEP based OAGI Business Object Documents for the scenarios defined in track 1.
4. Measure the ability of the STEP based XML schemas to improve the efficiency of product engineering and manufacturing activities by capturing metrics pertaining to Quality, Cost, and Timing.