In Search of the Perfect Bill of Materials (BoM)



a white paper by the NEMI Perfect BoM Team March 2002

Connect with and Strengthen Your Supply Chain

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Executive Summary

OEMs turn to outsourcing to gain manufacturing efficiencies, but the efficiencies (and accompanying cost savings) they hope to achieve can be elusive. Some of the greatest obstacles are problems associated with bills of materials (BoMs). Supply chain interactions are seriously hindered by the lack of a standard data format for BoMs, unacceptably high error rates and a lack of technology and tools to validate BoMs. The problems are pervasive, and the consequences, far-reaching. The cycles required to clarify or correct data can directly affect time-to-market and time-to-volume.

In 2001, the National Electronics Manufacturing Initiative (NEMI) organized a team of industry leaders (*see Appendix A*) to investigate and define the issues surrounding BoMs. This team is recommending a solution that calls for industry to adopt a common format with standardized contents — the "Perfect BoM" — to ensure that data is consistent, correct and complete, and that errors are resolved *before* exchanges are made among business partners. The team has identified the Product Data eXchange (PDX) specifications, developed by NEMI's Virtual Factory Information Interchange Project, as the foundation for the Perfect BoM. These specifications provide an industry-standard approach to exchanging BoM and change order information and will be used to define data structure. In addition, the team has developed a recommended list of data to define standard BoM content.

Implementation of the Perfect BoM will require a higher level of industry awareness and a commitment to standard solutions. The NEMI team's action plan calls for an education effort to raise awareness of problems and proposed solutions in an effort to encourage rapid acceptance and implementation.

This paper discusses the problems and challenges that exist with today's BoMs, and outlines NEMI's recommended solutions for creating and implementing the Perfect BoM.

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Problem Statement

The bill of materials (BoM) is, in its simplest form, a list of parts or components required to build a product. It provides the manufacturer's part number (MPN) and the quantity needed of each component. At its most complex, the BoM is a multi-level document that provides build data for multiple sub-assemblies (products within products) and includes — for each item — part number, approved manufacturers list (AML), mechanical characteristics and a whole range of component descriptors. It may also include attached reference files, such as part specifications, CAD files and schematics.

Originally used internally within a company, the BoM served as a means of tracking product changes and maintaining an accurate list of components needed to build products. As manufacturing has become increasingly distributed, the BoM has taken on even greater importance, serving as the primary reference file for product data. It is used to transfer product information from OEM to EMS provider and from the EMS to its vendors and suppliers. As outsourcing expands the number of companies involved in the manufacturing process, the need for accuracy is more critical than ever. At the same time, the transfer of manufacturing data across multiple companies magnifies problems and increases challenges.

As the primary conduit for data transfer among manufacturing partners, the BoM is central to the product life cycle from the very beginning. Figure 1 illustrates the flow of information from design to manufacturing. As indicated, a diverse set of information systems feed into the BoM, each providing different pieces of the information required to manufacture the final product. Typically, this wide variety of design, PDM and ERP tools output BoMs in different formats and at varying levels of completeness. File type and structure vary by company and, sometimes, even within a company, particularly if several groups have been merged into a single organization. This lack of standard format leads to redundant data processing.

EMS providers use parsers to "neutralize" data — i.e., convert it to a neutral format, such as a standardized text or XML file, that can be used by the EMS provider's tools. Parsers extract key data from customer data files and build a standard data format. Today, EMS providers must

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develop parsers and scripts for each different format received. One EMS provider reports that it maintains an internal organization of about 80 people whose function is to interpret customer data and translate it into their own production system.

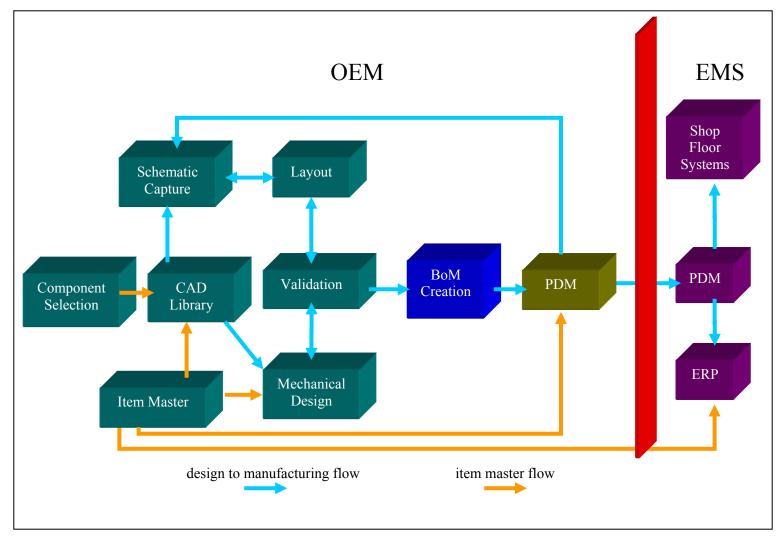


Figure 1: This diagram represents the flow of information between OEM and EMS provider, from design through manufacturing.

Data Errors / BoM Defects

The most significant problem plaguing BoMs is errors. EMS providers report that the data received from their OEM customers is often incomplete, inconsistent and/or outright incorrect. One EMS provider told the NEMI Perfect BoM team that seven out of 10 customers consistently need BoM corrections, and three in 10 components have bad or missing data. Several EMS providers said that error rates of 80% are not uncommon.

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EMS providers are spending a great deal of time and resources correcting deficiencies in the BoMs they receive. Errors must be communicated back to the OEM for resolution, and valuable cycle time is lost. BoM errors typically fall within three categories: completeness, consistency and correctness.

<u>Completeness</u>. Incomplete data is the most common BoM defect. Critical pieces of information, such as quantity, part description, reference designation and approved manufacturers list, are often omitted. Missing AMLs reportedly cause the majority of problems.

<u>Consistency</u>. Information in the BoM sometimes conflicts with information provided in engineering drawings and design files. For example, quantities may not match — there may be 10 locations for a particular component indicated on a board, but only a quantity of nine components specified in the BoM. Another consistency problem is format. The format of the BoM, even though it is from the same customer, can change from one transmission to the next, making it difficult to match and confirm data. Even language can vary from BoM to BoM.

<u>Correctness</u>. Incorrect data is a serious problem. Common errors include invalid manufacturer or supplier information, obsolete data and incorrect part numbers (i.e., the MPN given does not match the description of the part, or the MPN is not recognized by the manufacturer/supplier). Again, AMLs seem to be the predominant problem. Additional errors can result from receipt of information in hard copy format, which requires manual entry of date, an error-prone and time-consuming task.

One leading EMS provider reports that, in the first two to three months of engagement with a new customer, an average of 80% of the BoMs received contain errors that must be resolved with the OEM. Of the component information received, 40% of the parts are found to have errors that require correction by the OEM. These errors include inconsistent content, invalid manufacturer or supplier information, incomplete or truncated information, missing information, obsolete data, and customer-specific information that requires the customer to send a letter of authorization before the supplier will release information to the EMS.

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The same EMS also says that, of the 40% defects at the parts level, 20% of the defective data (or 8% of the entire BoM) is due to parts on allocation to the customer or parts that have become obsolete. Obsolete parts typically have a replacement; however, the EMS cannot procure new parts until confirming the change with the customer. It is possible, for example, that the OEM may have a lifetime buy on the old part because the new version will not work in a particular application.

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Supporting Data

The NEMI team gathered anecdotal information from several OEMs and EMS providers, and discovered that companies consistently cited errors and lack of a standard format as leading causes of problems when working with BoMs. Estimates of error rates and of the time required to resolve data problems were also similar from company to company.

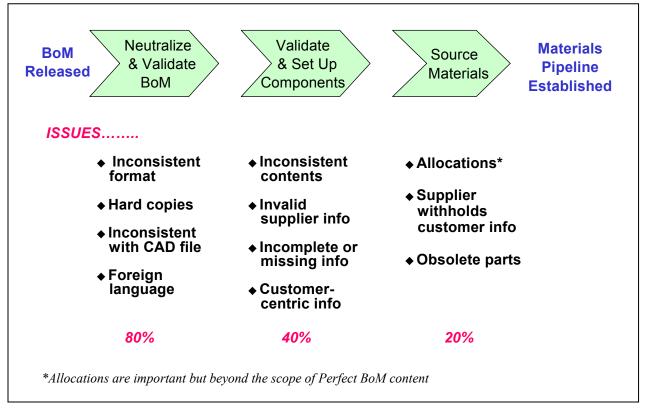


Figure 2: This chart indicates defect levels experienced by an EMS provider at various steps in the BoM data set-up process.

One major EMS provider provided estimates of defect levels according to process steps. This information is depicted in Figure 2. Their estimate of an 80% error rate for neutralizing and validating BoMs received from customers is surprisingly high but, unfortunately, does not appear to be unique, based on information received from other EMS providers. Data collected by a second EMS (*see Table 1*) corroborates and quantifies the problems identified by the first EMS. In particular, their data highlights the pervasiveness of incomplete and missing information.

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	Neutralize & Validate BoM (Yes / No)				Validate & Set up Components (#/total)			
Customer	Inconsistent Format	Hard Copies	Inconsistent with CAD File	Foreign Language	Inconsistent Contents	Invalid Supplier Info	Incomplete Info	Missing Info
Customer A	NO	NO	NO	NO	0/6	N/A	0/6	0/6
Customer B	YES	NO	NO	NO	0/1	0/1	0/1	1/1
Customer C	YES	NO	NO	NO	0/40	N/A	10/40	10/40
Customer D	NO	NO	NO	NO	0/6	N/A	6/6	6/6
Customer E	NO	YES	NO	NO	0/1	N/A	0/1	0/1
Customer F	YES	NO	YES	NO	0/30	25/30	25/30	25/30
Customer G	YES	NO	YES	NO	20/200	N/A	100/200	10/200
Customer H	YES	NO	NO	NO	0/200	50/200	150/200	10/200
Customer I	YES	YES	NO	NO	2/5	5/5	1/5	1/5
Customer J	NO	NO	YES	NO	0/10	N/A	0/10	0/10
Customer K	YES	NO	NO	NO	25/80	N/A	60/80	60/80
Customer L	NO	NO	YES	NO	0/30	N/A	2/30	2/30
Customer M	NO	NO	NO	NO	N/A	N/A	N/A	N/A
Customer N	NO	NO	YES	NO	0/8	N/A	1/8	1/8
Customer O	NO	NO	NO	NO	0/8	0/8	2/8	2/8
Customer P	NO	NO	NO	NO	N/A	N/A	N/A	N/A

Table 1: Defect data collected by an EMS provider.

A leading OEM that works closely with its EMS providers to resolve data issues told us:

Ability to start up new products rapidly is impacted by the quality of our documentation. Thirty-five percent of the component data have problems. If we do not have a process in place that will check and correct the errors in the audit report prior to sending the AVL to the EMS, these errors will continue to occur.

Another leading OEM made the following observations, based on a study it conducted to characterize internal processes involved when outsourcing to contract manufacturers:

The number-one outsourcing issue identified was related to sharing data with EMS providers. There is no standardized or automated way to exchange data and, most of the time, the process is accomplished by manual means... There seems to be no clear ownership of the correct BoM version being transmitted

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to the EMS, which means invalid data may be exchanged. Current perception is that the ERP BoM information is only about 80% accurate.

The document control group of a major EMS provider had this to say:

I agree with the estimate that 80% of the BoMs I get have some kind of a problem. They are almost always incomplete in terms of what we need to estimate product cost. We usually end up asking more questions of the customer, searching through all the other assembly files we receive with the quote package, or making an educated guess at the missing information. Some items that almost always need attention are:

- Assigning schematic reference numbers to hardware.
- Reconciling hardware requirements between the BoM and what's actually required.
- Removing items that should not be part of the BoM (such as specifications, drawings, etc.).
- Structuring programmed devices in a parent/child relationship (so that, for example, a blank part and the software needed to program that part are differentiated).

Cost to Industry

Despite the pervasiveness of the problem and the magnitude of its impact, the issues associated with BoMs do not have a high level of visibility among senior managers in OEM and EMS provider organizations. Time and energy are spent on dealing with the immediate day-to-day issues and "fire-fighting," while little or no time is spent addressing the root of the problem. The perception is that, as long as the EMS has received data, the situation is manageable. Little thought is given to whether the data sent is error-free, how much time is required to "clean" the data, and what the impact on cycle time is. The reality is that more resources are devoted to correcting data than to correcting the problems that cause bad data in the first place — i.e., to make sure that the data is clean and consistent before it is passed to a partner. The industry's design, PDM and ERP tools are all creating different file formats. Time and energy must be spent on developing format translators, or data neutralizers, before the data can be evaluated for accuracy and consistency. Currently, none of the leading PDM or ERP systems includes tools to validate data for accuracy and completeness.

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The time lost in dealing with data issues can greatly impact the ability of the EMS to deliver products to its OEM customers on schedule. Each defective part adds an estimated 40 minutes to the processing time of the BoM, and the lag time is much longer. On average, delays can range from one day to several weeks, depending on the responsiveness of the information provider.

For example, if a BoM has 100 unique parts and 40 of the parts have issues, the processing time would increase by 26 hours or approximately 3.5 working days (assuming the EMS and OEM resolve the discrepancies right away). If the queue/wait time required for resolving issues is added to the calculation, the overall cycle time can increase by weeks.

One leading EMS provider estimates that it takes 10 minutes of engineering time to analyze each error and recommend a correction to the OEM. When the volume of parts produced and defect rate are factored in, the time spent on correcting errors becomes significant. For example, 10,000 parts (which is what a leading EMS typically sets up on a quarterly basis) with a 40% defect rate would require 40,000 minutes (66 hours) of engineering time. In addition, there is time spent tracking each issue, reporting back to the OEM, following up and finally entering the correction into the systems.

Another EMS reports receiving a 75-line-item BoM with 40 errors. It took two days of cycle time to prepare the product for manufacturing. Yet another EMS provider estimates that, given the volume of BoMs and new parts going through their system, they are losing six personmonths *each month* to finding, reporting and correcting data errors and inconsistencies.

The greatest cost, which is difficult to quantify, is how lost time impacts time to volume and time to market. Until the last issue on a BoM has been rectified, the product build cannot be completed and, in many cases, the manufacturing process cannot even begin.

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Solution Statement

The NEMI team is recommending that industry develop, define and strive to attain a "Perfect BoM." This BoM will not only contain data that is consistent, correct and complete, but it will be communicated between data systems and manufacturing partners in a clear, unambiguous manner.

The Perfect BoM should provide all of the information needed to describe the product and enable EMS providers and suppliers to proceed with purchasing, manufacturing, etc. with minimal back-and-forth between partners. Key to achieving these goals is implementation of a standard data format. By adhering to a common format, any company receiving a BoM will know what data is included and where it is located. Standardization will minimize the need to create parsers and adapters and will also minimize all three types of errors (incomplete, inconsistent and incorrect data). Although errors cannot be totally eliminated, the Perfect BoM team is targeting an error rate of only 10% to 20% which, compared with today's 80% error rate, will be a significant gain for industry.

A standard exchange mechanism will provide a good start toward achieving the Perfect BoM, but it only addresses part of the problem. In addition, OEMs need tools that can catch conflicts between BoM data and engineering drawings and design files. They also need the ability to "pre-scrub" data and audit for a complete data package prior to transmission. PDM providers must work with OEMs to define user needs and determine how existing tools can be enhanced, or new tools developed, to check BoM integrity and validate data.

Attaining the Perfect BoM requires a two-fold approach that addresses the technical/process aspects and also "educates" the key companies that have the resources to implement the recommended technical and process changes. The NEMI Perfect BoM team's proposed action plan is discussed below.

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Technical Solution

Today, there is no agreed-upon set of BoM characteristics or fields, and there is no universally recognized format for structuring BoM data. By standardizing on what is included in the BoM (data content) and how the data is formatted, OEMs and EMS providers can significantly reduce the errors and inconsistencies that currently erode efficiency and time to market. A major advantage of adhering to standardized format and content is that it makes standard tools possible. Today, EMS providers have their own sets of tools to deal with the different data formats they receive from customers. If all BoMs provide the same information using the same data format, solution providers can develop tools to translate the data into the EMS providers' systems. Such tools will allow EMS providers to stop wasting time interpreting content and format, and go straight into execution, and that means improved time to market and time to volume for their OEM customers.

Standards-based data structures already exist that can serve as the data exchange mechanism for the Perfect BoM. The IPC Product Data eXchange (PDX) standards, originally developed by NEMI's Virtual Factory Information Interchange Project (VFIIP) and published by IPC in the fall of 2001, provide for a standardized BoM format and file type. The PDX standards suite includes:

IPC-2571 Generic Requirements for Supply Chain Communication

This sectional standard provides an "overview" of the entire suite of standards for supply chain communications and describes how PDX is expected to work in conjunction with other related standards and formats.

IPC-2576 Requirements for Supply Chain Communication of As-Built Product Data

This sectional standard defines how manufacturing product genealogy information — the build history of boards and final assembly — is exchanged. All characteristics of the product are represented as well as its serialization, lot information and how it was manufactured. This information may be used to support products through the life of the equipment.

IPC-2578 Requirements for Product Design Configuration

This sectional standard facilitates quote, simulate, manufacture, configure, test and kit interactions among supply chain partners. It defines an XML encoding scheme,

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which enables a total product definition to be encoded at a level appropriate to facilitate supply chain interactions. An encoding scheme is defined for the BoM, approved manufacturers list (AML), approved vendors list (AVL), changes (engineering, manufacturing, product), and references to documents describing geometric and other part characteristics.

IPC-2577 Supply Chain Communication of Manufacturing Quality Assessment

This fourth PDX standard is currently a working draft. It provides an XML encoding schema to allow electronics manufacturing supply chain partners to exchange as-built quality assessment and manufacturing process yield information. The information represented by this standard may be used to improve manufacturing processes and design criteria to incorporate design for excellence principles. The information represented in this standard includes: board fabrication characteristics related to form, fit and function; serialization; batch/lot information; manufacturing site; manufacturing date; part number; component and sub-assembly data.

The PDX standards were developed through a partnership between NEMI and IPC. In addition, RosettaNet, an industry consortium focused on development of open e-business process interfaces, worked with NEMI and IPC to integrate the PDX standards into its own Cluster 2 and Cluster 7 Partner Interface ProcessesTM (PIPs[®]). These PIPs relate to distribution and update of production information and to the exchange of technical data for manufacturing.

The three organizations coordinated closely to ensure consistency of naming conventions and structure between the IPC standards and RosettaNet dictionaries and specifications.

RosetteNet's Cluster 2 Product Information PIPs (2C1-2C10), which have been voted into production, enable distribution and periodic update of product and detailed design information, including product change notices and product technical specifications. Cluster 7 Manufacturing PIPs, which will allow the exchange of "as-built" factory floor information, collaborative design and reporting of quality information, are currently in development.

The PDX standards, coupled with the RosettaNet PIPs, give industry the ability to exchange information through a single port of the exchange software rather than requiring a different solution for each trading partner. As such, they are an excellent foundation for the Perfect BoM.

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Elements of a Perfect BoM

While data format and file type are defined by the PDX standards, there is still the need to standardize BoM content. Industry needs an agreed-upon set of BoM characteristics or fields. To be "perfect," the BoM should include everything that goes into the product, from raw materials such as wire, tape and solder paste, to the box that will be used to ship the product. It should make parent-child relationships clear, differentiating between components and materials that are part of a subassembly versus the overall assembly. For example, information about programmed parts is typically structured differently from BoM to BoM, and is often open to interpretation. The Perfect BoM should include blank parts as well as the software required to program the blanks, indicating the relationship between components and ensuring that all necessary parts and data are provided.

The NEMI Perfect BoM team developed a list of desired data to be contained in the Perfect BoM, identifying mandatory as well as optional characteristics. This list was then correlated to the contents of the PDX specifications and is included in this paper as Appendix B. Appendix C shows an excerpt of a PDX file.

Education

Several activities are needed to drive improvement in industry metrics, as illustrated in Figure 3. One of the key elements for success is an education effort. While issues with bills of materials may be widely known, the bigger picture that spells out the breakdown of problems as well as the cost and schedule impact are not well understood. As companies gain a better understanding of the scope of the problems, choices regarding where to focus energy for developing solutions and to improve metrics will become more straightforward.

Education is needed within OEMs, EMS providers and PDM vendors to ensure proper focus and resolution. Audiences should include:

- Designers
- New product introduction (NPI) managers, including component commodity managers
- Documentation managers
- Senior managers (support for change/investment)

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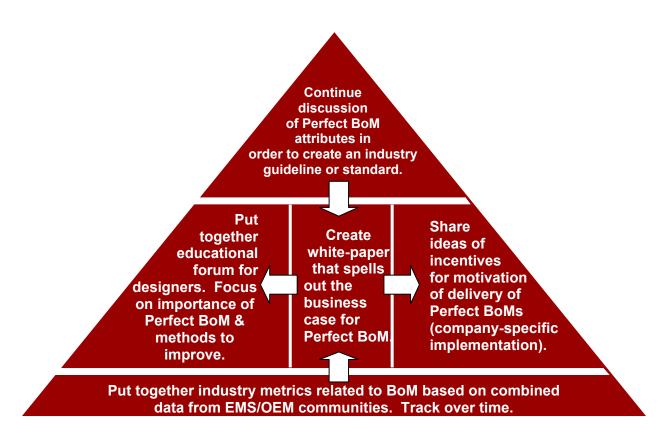


Figure 3: Industry education is a key element in implementation of the Perfect BoM.

When trying to reach such diverse audiences, multiple techniques may be required to effectively deliver the message. Several alternatives have been proposed and will be pursued based on need, prioritization of impact, and resource availability. Alternatives include:

- Sponsor a forum for designers that will address the issues/opportunities of achieving the Perfect Bill of Materials. Hold in conjunction with an established industry conference for designers or similar venue.
- Write magazine articles that document success stories by companies that have made significant progress in this area.
- Organize workshops that bring together OEMs, EMS providers and solution providers to focus on specific aspects of problems.
- Produce and communicate industry-wide metrics as well as improvements over time.

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Recommendations

Based on the proposed solution, the first step is for NEMI to develop an action plan with project owner and schedule. This plan should include:

- 1. Begin the education process with NEMI members. The primary vehicle will be this white paper, which should be distributed by NEMI at industry conferences and seminars to reach the design and manufacturing communities, and the suppliers who support these communities.
- 2. Validate use of the PDX format for the Perfect BoM through multi-lateral exchange demonstration efforts among NEMI members. Solution providers that participated in the NEMI Virtual Factory Information Interchange Project should be able to help jump-start validation exchanges. Companies will also need to correlate PDX with data stored and produced by their internal IT systems.
- 3. Work with PDM vendors to develop prototype solutions that incorporate the Perfect BoM in PDX format. Also work with vendors to develop data integrity checking tools.
- 4. Select OEM and EMS companies to beta test the PDM prototypes. Make modifications until everyone is happy with the solution(s) provided. Publish the new tools/capabilities to the industry.
- 5. Develop and agree upon a standard specification for BoM content, to be submitted to IPC for formal standardization.
- 6. Work through NEMI to promote and track implementation and acceptance. Tracking implementation has been key to RosettaNet's success and this approach should be put in place by NEMI.

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Glossary of Terms

- AML Approved Manufacturers List a list of manufacturers and MPNs that are acceptable/preferred/disqualified for use as a given OEM part number.
- ANSI American National Standards Institute mission is to enhance global competitiveness of U.S. business and quality of life by promoting and facilitating voluntary consensus standards and conformity assessment systems www.ansi.org
- AVL Approved Vendors List similar to, sometimes used interchangeably with, AML; usually focuses on where a part is purchased rather than who manufacturers the part.
- ASL Approved Suppliers List similar to AVL.
- BoM Bill of Materials list of components required to build a given product.
- CAD Computer-Aided Design software used to design an electronic or mechanical product.
- EDI Electronic Data Interchange industry standard for exchanging manufacturing procurement data electronically.
- EMS Electronics Manufacturing Services a company specializing in manufacturing electronic products for other companies.
- ERP Enterprise Resource Planning software that plans use of material, labor, financial resources, etc.
- FIS Factory Information Systems software that tracks/records status of manufacturing work in progress.
- IPC Association Connecting Electronics Industries an industry association of designers, printed circuit board manufacturers, electronics assembly companies, suppliers and original equipment manufacturers www.ipc.org
- MPN Manufacturer's Part Number part number assigned to a product by component manufacturer; used to procure components.
- NEMI National Electronics Manufacturing Initiative an industry-led consortium focused on facilitate leadership of the North American electronics manufacturing supply chain www.nemi.org
- NPI New Product Introduction process of bringing new product to market.
- OAGIS Open Applications Group Interface Specification <u>www.openapplications.org</u>
- OEM Original Equipment Manufacturer
- PDM Product Data Management software to track all aspects of product data.
- PDX Product Data eXchange standards IPC standards that utilize an XML encoding scheme to enable supply chain partners to exchange product content, changes and subsequent manufacturing information in a common language webstds.ipc.org.
- PIPTM Partner Interface ProcessTM (PIPsTM), developed by RosettaNet to define business processes between trading partners.

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- RosettaNet a consortium of computer makers, reseller, and users creating e-commerce standards for transaction-centered data exchanges using a standardized set of terms for product, partner and transaction properties www.rosettanet.org.
- TIG Technology Integration Group all NEMI projects are organized under one of five TIGs (Board Assembly, Environmentally Sustainable Electronics, Factory Information Systems, Optoelectronics, Substrates)
- VFIIP Virtual Factory Information Interchange Project a NEMI project focused on developing a set of XML-based standards that will shorten the time and reduce the cost required to establish and maintain information exchange partnerships across the manufacturing supply web.
- XML eXtensible Markup Language the universal format for structured documents and data on the Web www.xml.org or www.w3c.org.

References

- IPC-2571 Generic requirements for supply chain communication (published)
- IPC-2576 Requirements for supply chain communication of as-built product data (published)
- IPC-2577 Requirements for supply chain communication of quality data (working draft)
- IPC-2578 Requirements for product design configuration (published)

Specifications for all of the PDX standards are available at webstds.ipc.org

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Appendix A

Companies participating in, or contributing information to, the NEMI Perfect BoM Team:

AMR Research

Celestica

Delphi Delco Electronics Systems

Motorola

NIST

Nortel

Sanmina-SCI

Solectron

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Appendix B

Following is the Perfect BoM framework constructed by NEMI's Perfect BoM team and correlated to the IPC PDX standards.

Characteristics of a Perfect BoM (M = mandatory, O = optional)

Characteristic	M / O	Please see PDX 1.0 IPC2571/2578 All questions raised thus far are covered.
Assembly number, description, and assembly revision	M	The BillOfMaterial element is a collection of BillOfMaterialItem elements that describes an assembly, kit or a single item Some Attributes: description, revisionIdentifier, versionIdentifier, proprietaryProductFamily, category, minimumShippableRevision
Component part number and revision	M	See above plus attribute: manufacturerPartIdentifier
Component description	M	description
Component quantity per	M	itemQuantity
Component reference designator	M	referenceDesignatorName
Unit of measure	M	globalProductUnitOfMeasureCode
Qualification status	M	GlobalLlifeCyclePhaseCode (Design Preliminary Prototype Pilot Conditional Production Pending Inactive Unqualified Disqualified Obsolete Other)
Manufacturer name and PN	M	An ApprovedManufacturerList element contains one or more ApprovedManufacturerListItem elements. It identifies all the approved manufacturers for a specific Item. Attributes: manufacturedBy manufacturerPartIdentifier
Supplier name and PN (if different from manufacturer)	О	Approved Supplier Lists (ASL) are managed with the ApprovedSupplierList element. The ApprovedSupplierList element is used to hold a collection of ApprovedSupplierListItem elements. Some attributes: suppliedBy supplierPartIdentifier
Supplier contact information for custom parts (name, phone and fax #)	M	SupplierPartContactUniqueIdentifier - reference to IPC2571 contact information
Sourcing strategy (consign, buy- sell, turn key) Not part of build package, part of business agreement.	М	MakeBuy (optional) (Make Buy Consigned VendorManaged Subcontracted Unspecified Other)
Reference drawings (e.g. custom mechanical parts, schematics, etc.) - files preferred attached to part, not as separate document item on the BoM	M	The attachment element is a pointer to a file either through a URL or within the Product Data eXchange zip file. If the file is zipped and included in the Product Data eXchange package, the FileName contains the name of the file. Otherwise, the full URL of the file location is contained in the FileName. There is one attachment element for each attachment associated with an object. (an object may contain multiple attachments - drawings, engineering notes, manufacturing notes, etc.) The Product Data eXchange package may include attachments that are necessary as part of the product content. These may be any kind of file including a Universal Resource Identifier (URI) reference, other XML/DTD documents, corresponding XSL files, drawings, Gerber files, test specifications, etc. Attachments may be handled in the following

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		ways: (1) Included in the package — The attachment is included as part of the Product Data eXchange package and is delivered with the package. The "isFileIn" attribute is set to "yes" to indicate that the product data includes an attachment referenced via a URI. This requires careful communication as the contents of a URI are not managed as part of the package and can change independently. The "isFileIn" attribute is set to "no" to indicate that the product data references an attachment, but the attachment is not included as part of the package. (2) Referenced via FileName — The metadata, including the FileName that is associated with the attachment is included, but the attachment itself is not included. The "isFileIn" attribute is set to "no" to indicate that the product data includes an attachment, but the attachment is not included as part of the PDX package. One use of this feature is when the sender knows the recipient already has the attachment and does not wish to resend it. (3) Excluded from the package — The attachment can be excluded from the package entirely by giving no reference to the attachment in the package.
PNs for blanks listed for programmed parts	M	Item Element: Attribute: category Category of parts (electrical, mechanical, software, etc.)
Component/assembly technical attributes M for custom parts (definition needed for custom parts)	O / M	The Characteristics element is a collection of MeasuredCharacteristic, EnumeratedCharacteristic, RangedCharacteristic and TextualCharacteristic elements. All of the MeasuredCharacteristic and EnumeratedCharacteristic elements apply to the Item to which it is attached. One potential use of the value attributes within the four characteristics elements is to capture the query parameters used to select an item during a QuickData (RosettaNet PIP 2A9) query for an electrical device. Another potential use of the value attributes is through concatenating them together to create a description of the Item when displaying a list of Items. A MeasuredCharacteristic is a distinguishing measurable value that is used to characterize the item. Examples of MeasuredCharacteristic include current, voltage, resistance, capacitance, inductance, and mechanical dimensions A RangedCharacteristic provides a distinguishing measurable value that is used to characterise an Item. Examples of RangedCharacteristic include current, voltage, resistance, capacitance, inductance, and mechanical dimensions An EnumeratedCharacteristic is one of an enumerated list of potential values, such as a performance rating, a purchasing unit (ea, gross, carton). The allowed enumerated values of the EnumeratedCharacteristic are defined in the source referred to in the definitionSource attribute. A TextualCharacteristic refers to a list of allowed textual values. The allowed values of the TextualCharacteristic are defined at the source contained in the definitionSource attribute.
Raw materials (wire tape, solder paste, adhesives)	M	BillOfMaterialItem Element : Attribute : GlobalProductQuantityTypeCode (PerAssembly PerSetup AsNeeded Shrinkage Other)
Build structure (showing multi-level BoM)	M	IPC2571 describes this in detail. Attribute: isTopLevel The IsTopLevel attribute is used to indicate how an object (of type item, ManufacturerPart, or SupplierPart) fits into a Product Data eXchange package. The IsTopLevel attribute provides Product Data eXchange parsers an efficient mechanism to identify the top-level item of an assembly.
Shipping package information	О	An EnumeratedCharacteristic is one of an enumerated list of potential values, such as a performance rating, a purchasing unit (ea, gross, carton). The allowed enumerated values of the EnumeratedCharacteristic are defined in the source referred to in the definitionSource attribute.
Programming software	M	Item Element: Attribute: category Category of parts (electrical,

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-if part of assembly process		mechanical, software, etc.) NOTE: A programmed part (software component) can have version, revision and other attributes. For proper engineering change management all parts of a BoM whether physical or not should have part numbers. An example would be an image for a computer production which would contain the software for the physical computer. As the individual software programs are changed or updated, appropriate version and revisions along with manufacturer or software owner or bundler should have the appropriate attributes described in the PDX standard (IPC2571/2578).
Line items	M	This is described in great detail in IPC2578 including change information in various sections. See in particular: AffectedItems Element and associated sub elements and attributes. This is primarily used in engineering change and the management thereof.
Part substitutions - expected for pre-approved substitutions	О	An AlernateItems element contains one or more AlternateItem elements. An alternate item is a functionally identical or comparable part that may be used anywhere the containing primary item is used. An item that is not functionally comparable or identical but is an acceptable substitute in a specific application should be listed as and AlternateItem in AlternateItems element within a BillOfMaterialItem. This applies to manufacturer parts as well as to alternate approved suppliers
Effectivity date (component level)		Although this is stricken, it is covered in IPC-2578
Package style field	M	SupplierPartType - also can be identified in the enumerated description (each, Reel, etc.) There should be only one part number for each type of package style and in many cases (with passives) is described within the part number. Unless this is referencing the final product package style in which case the product should have a different part number (top) which as a subcomponent would indicate the number of units packaged (each, dozen, pallet, container, etc.)
Assembly drawings	M	PLEASE SEE ANSWER TO REFERENCE DRAWINGS
FRU status flag	M	(Field Replaceable Units) - These are referred to as Kits in IPC2571/2578 and are a Bill of material element. The status flag would be that of the bill of material part itself. FRU's used in this context would be a different orderable part number than that used in the production of the unit and would include packaging BoM information.
Point of Use (routing)		If this is referencing use in manufacturing then this would be included as a manufacturing note to the item used. NOTE: This is not covered if this is logistical procurement in nature.
Title block info: Ref. ECO that created BoM Release status of BoM BoM Effectivity date		This is covered in detail in IPC2578 - Please see Change Element. All items are covered (too much to paste here)
Component packaging -if deviates from EIA	О	Please see comments on Package Style Field
Procurement specification	M	How the EMS should source the component (from OEM, AVL, free to choose own supplier based on specification, etc.)
Environmental status flag	M	Recycled, hazardous, etc.

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Appendix C

Following is an example of a PDX file using XML format. This is an excerpt from a file that was prepared for a proof-of-design demonstration by NEMI's Virtual Factory Project. It provides data that, for demonstration purposes, was passed between Nortel Networks and Sanmina-SCI. Although this file uses an earlier version of PDX, it shows how the standardized PDX format provides for inclusion of all pertinent BoM information. The original file is lengthy and has been truncated to provide a brief sample of PDX.

<?xml version="1.0" ?> <?pdx version 1.0?> <?generated by GenRad/SFDM/4.7/Prototype?> - <ProductDataeXchangePackage UniversalUniqueId="475665074" DateOriginated="1-08-01</p> 12:45:44" DateLastModified="1-08-01 12:45:44" Originator="GenRad" OriginatorContactIdentifier="FurbushD" Type="Test" Description="APEX Show" Copyright="Genrad (c) 2001" ContentLanguage="EN" IsFileIn="YES"> <AsBuiltProduct GlobalProductIdentifier="KJIO" Quantity="12" TopLevel="yes"</p> ManufacturerUnitOfMeasure="cm" CustomerProductNumber="12-222" CustomerIdentifier="4rf1" PrimaryIdentifier="121212" SecondaryIdentifier="212121" /> - <Items> - < Item Site="CAE" Identifier="9101-4701-M001" UniqueIdentifier="9101-4701-M001A" Description="" LifecyclePhase="Production" Type="Assembly" SubType="PCB" Revision="A" Version="" ProductLine="9100" Category="Electrical" UnitOfMeasure="EA" MakeBuy="M" SerializationRequired="S" CertificationRequired="YES" TopLevel="YES"> - <BillOfMaterial> <BillOfMaterialItem Site="CAE" ItemId="602-0705023" ItemUniqueId="602-0705023A" Revision="A" Quantity="1.00" QuantityType="EA" Description="BOX.PIZZA D/C ASSY 26X15.875X" SequenceNumber="1" SerializationRequired="M" Type="" ref des="" notes=""/> <BillOfMaterialItem Site="CAE" ItemId="006-0085579" ItemUniqueId="006-0085579A" Revision="A" Quantity="1.00" QuantityType="EA" Description="LABEL.""ACCESSORIES **ENCLOSED""** SequenceNumber="1" SerializationRequired="M" Type="" ref_des="" notes=""/> <BillOfMaterialItem Site="CAE" ItemId="006-3300273" ItemUniqueId="006-3300273A" Revision="A" Quantity="1.00" QuantityType="EA" Description="LABEL. POLY 2.0""X5.5"" ZEBRA" SequenceNumber="1" SerializationRequired="M" Type="" ref_des="" notes="" /> - <ApprovedVendorList> <ApprovedVendorListItem SupplierPartId="006-3300273" SupplierName="KMS"</p> Status="ACTIVE" /> </ApprovedVendorList> <BillOfMaterialItem Site="CAE" ItemId="007-9714402" ItemUniqueId="007-9714402A" Revision="A" Quantity="12.00" QuantityType="EA" Description="NONE" SequenceNumber="1" SerializationRequired="M" Type="" ref des="" notes="" />

CURRENT)" SequenceNumber="1" SerializationRequired="M" Type="" ref_des=""

notes=""/>

<BillOfMaterialItem Site="CAE" ItemId="006-3300229" ItemUniqueId="006-3300229A" Revision="A" Quantity="1.00" QuantityType="EA" Description="LABEL. WARNING(HI

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- <ApprovedVendorList>
 <ApprovedVendorListItem SupplierPartId="006-3300229" SupplierName="MAC"</pre>
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    </ApprovedVendorList>
- <ApprovedVendorList>
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    Status="ACTIVE" />
    </ApprovedVendorList>
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    NUMBERS" SequenceNumber="1" SerializationRequired="M" Type="" ref_des="" notes=""
    />
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    ref des="" notes="" />
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    WASHER 8-32" SequenceNumber="1" SerializationRequired="M" Type="" ref_des=""
    notes=""/>
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    SequenceNumber="1" SerializationRequired="M" Type="" ref des="" notes="" />
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    Revision="A" Quantity="4.00" QuantityType="EA" Description="SCREW-METRIC PAN HD
    M8 X 16MM" SequenceNumber="1" SerializationRequired="M" Type="" ref_des=""
    notes=""/>
- < Reference Designators >
```

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