



Plug and Play Creates Manufacturing Interoperability

NEMI's Plug and Play Factory Project addresses modern shop floor management issues such as data management. Read on to learn about the results of the two-year study and how it could benefit your operation.

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What is your company's MTBS? What is MTBS you ask? MTBS is yet another new FLA (four letter acronym; it seems that all the TLAs — three letter acronyms — have been taken) for mean time between surprises. MTBS used to be measured in months for most companies. Quarterly reviews were sufficient to delve into operational issues to understand trends, address problems and increase manufacturing efficiency. Now, leading-edge companies are measuring MTBS in days, if not minutes.

The Internet is an excellent tool for immediate delivery of information — via PC, PDA, or cell phone — and it can help companies take the surprises out of day-to-day operations. Rather than spreadsheets and reports being handed from desk to desk, taking weeks or months to go from the shop floor to management and back down again, data transfer is instantaneous. Unfortunately, most electronics manufacturing plants have sophisticated equipment that exists in isolated islands of automation on the plant floor. Manufacturing personnel must either physically walk up to the machine to gauge its performance or peruse several different applications and data sources to try to piece together a picture of how the line is performing.

The emphasis in electronics manufacturing today is on error prevention, rather than on error detection. For example, to prevent errors, a manufacturing engineering manager must know when a placement machine nozzle is starting to perform mis-picks from a certain feeder. Simply detecting placement errors once a board has been built is not adequate to support six sigma processes. Having your shop floor equipment tell you when it is going to make a mistake, and taking corrective action to fix that error before a mistake is made, is required to achieve single-digit defect per million operation (DPMO) rates. Getting the data that is needed from the equipment in real-time, and then being able to transmit that data via paging or the Internet to people who can take the appropriate action, has been a challenge.

The National Electronics Manufacturing Initiative's (NEMI's) Plug and Play Factory Project was created to develop a vendor-independent plug and play environment for electronics assembly, inspection, and test equipment. The project addressed the issues of how to quickly integrate new pieces of electronics assembly equipment into a shop floor line management system and how to manage the vast amounts of data available in today's electronics

manufacturing environment. Plug and Play addressed the questions, "How is shop floor data collected from disparate pieces of equipment?" and "How is that data transferred to the web?"

The need for plug and play

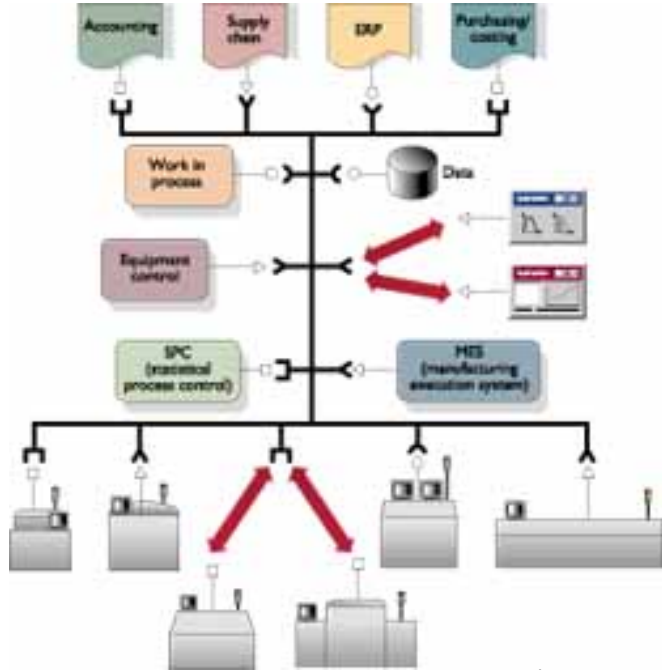
Several changes have occurred in recent years that make plug and play capabilities an absolute must for electronics manufacturers. The increased use of electronics manufacturing service (EMS) firms by original equipment manufacturers (OEMs) means that product managers can no longer walk out to the manufacturing floor to monitor production operations, but must rely on remote production monitoring. Widespread adoption of new enterprise resource planning (ERP) applications has increased the need for detailed operational information from production equipment. Smaller electronic components, coupled with increased board density, often means errors are not as readily detected and prevented unless equipment parameters and performance are closely monitored.

By implementing a line-wide monitoring application, OEMs and EMS providers can achieve more efficient surface mount technology (SMT) assembly operations, increasing equipment utilization, improving quality and decreasing cost. While some vendor-specific line monitoring packages have been available, such packages do not address the desire to "mix and match" equipment from different vendors, so that the best-suited machines can be installed on an SMT line, regardless of the vendor.

GEM/SECS falls short

The Generic Equipment Model/SEMI Equipment Communication Standard (GEM/SECS-II) is an equipment interface intended to enable plug and play integration of multiple-vendor equipment when configuring a production line. Although the GEM interface enjoys broad vendor support in the semiconductor industry, implementations on printed circuit board assembly lines were problematic. A number of issues stood in the way of interoperability.

Interfaces, implementation, and support.



The range of costs for a GEM interface card and associated software drivers for an SMT machine is \$1,000 to \$10,000. Low demand is one of the reasons prices have remained at this level, while similar network interfaces for PCs have fallen below \$100.

But the costs for the equipment interface hardware/software is minor compared with the amount of effort typically required to understand and configure the equipment and host interfaces. Vendors have interpreted the GEM standards covering state models, messaging format, and content and equipment data elements in a variety of ways. Consider, for example, the GEM Status Variable used to convey the current state of a piece of equipment.

Generic host applications. The implementation issues result in costly in-house or custom software line monitoring applications. A simple prototype application to monitor parametric data from machines on a single line can exceed \$200,000. Extend the prototype application to additional pieces of equipment and add monitoring of more than just basic parameters and documentation of the administration and maintenance issues, and the total cost can exceed \$500,000.

While commercial, off-the-shelf line monitoring host applications costing \$50,000 to \$100,000 per line are now available, interfacing issues remain. Some are proprietary, only supporting equipment from a single vendor. Others attempt to be open but often resort to proprietary interfaces where an equipment vendor's GEM implementation is weak, thus negating the plug and play advantages of a generic host interface.

Industry standards pave the way

Seeking to accelerate the development of a plug and play solution for interfacing to assembly and test and inspection equipment, the Plug and Play Factory Project investigated alternatives to the GEM interface and created three proposed IPC equipment-interfacing standards. This set of standards, which are part of IPC's CAMX standards (computer-aided manufacturing using the eXtensible mark-up language) are currently being circulated by IPC for industry review. The Plug and Play standards make up the IPC-2540 series and provide for a generic set of messages applicable to all pieces of shop floor equipment (IPC-2541), along with specific sectional requirements for assembly (IPC-2546) and test and inspection (IPC-2547) machines.

Like the other CAMX standards for shop floor equipment communication, the Plug and Play standards use two freely available Internet technologies to provide the framework for shop floor equipment communication. The first of these is hypertext transfer protocol (HTTP), which is the standard used today for web servers to communicate with web browsers. The second is eXtensible mark-up language (XML), which is the standard developed by the World Wide Web Consortium (W3C) in 1998 for the delivery of dynamic content over the Internet.

In industries as varied as finance and molecular dynamics, groups of companies are working together to define what are known in XML as document type definitions (DTDs) that define the syntax and the semantics of the terms that are pertinent to that industry (see <http://www.xml.org/>). In the electronics industry, IPC has defined the CAMX standards to provide these DTDs

The Plug and Play standards integrate with other IPC CAMX standards, such as product data definition in the GenCAM format (IPC-2510) and the equipment recipe definition in SMEMA Standard Recipe File format (IPC-2530), to enable shop floor communication for electronics manufacturers.

Searching for the right framework

The advantages of plug and play frameworks are well-known in the hardware world. The IBM PC is a good example of a plug and play framework. Different companies could build PC components such as hard drives and graphics cards with a high degree of confidence that they would work together, as long as they followed the open industry standard published by IBM for hardware compatibility. The benefits to PC end users, a plentiful supply of different components, with high reliability and available at low cost, spurred tremendous growth in the PC industry.

One of the primary goals of the NEMI Plug and Play Project involved developing a framework that achieves similar results in the software world, thus permitting equipment and software from various vendors to work together in a seamless fashion. An added goal involved the attendant benefits of a ready supply of a wide variety of software components, available with high reliability and at low cost.

The Plug and Play Project investigated a variety of technologies to determine if they were suitable for the basis of a plug and play framework that could be used in the electronics manufacturing industry. Investigations ranged from comprehensive architectures such as Microsoft's Distributed Component Object Model (DCOM), the Object Management Group's (OMG) Common Object Request Broker Architecture (CORBA), and Sun's Jini, to simple

mechanisms such as raw sockets, HTTP, and XML. Six different technological scenarios were reviewed against the project goals of platform and language independence, ease of implementation, reasonable cost, and adequate performance.

An Internet-based framework

The project team determined that Object Request Broker (ORB)-based systems such as CORBA were difficult to implement in the heterogeneous environment found on most factory floors. They often required sophisticated programming techniques that were time-consuming, costly, and difficult to maintain.

On the other hand, developing a framework based upon simple transfer techniques such as raw sockets did not provide the services, functionality, and infrastructure required to support a plug and play framework.

Consequently, the team adopted a framework consisting of TCP/IP, HTTP, and XML. The final recommendations of the team are to use TCP/IP as the wire protocol, HTTP as the interface protocol among entities, and XML as the messaging syntax and semantics in the form of the IPC CAMX 2500 standards. It was recommended that entities communicate through a web server-based message-oriented middleware, where framework entities act as web-based clients, exchanging messages with other web-based clients. As previously mentioned, a key incentive for the project was the emergence of virtual, or distributed, manufacturing operations. The project team concluded that any successful plug and play framework would need to be distributed and decided to use the Internet, itself a distributed computing platform, as the core of the framework. This provided an open architecture on which to base e-business applications and increased availability of status, quality, and inventory information, both within and among companies.

The resulting NEMI Plug and Play framework is shown in Figure 1. By making use of TCP/IP, HTTP, and the IPC XML DTDs, it is believed that a plug and play framework for electronics manufacturing can be implemented in a cost-effective manner.

Testing, testing, 1,2,3

One of the key factors in the success of this project was a test bed, established at the Georgia Institute of Technology's Manufacturing Research Center in Atlanta to implement and evaluate proposed solutions from the project team.

This test bed allowed implementation difficulties and architectural incompatibilities to be identified in the academic environment, rather than on the production floor, thus reducing the risks and costs associated with adoption of standards that emerged from the project. In addition, the time to develop standards was greatly reduced as proposals were tested and feedback generated in months, rather than the years, associated with the more typical process where standards feedback is not available until drafts are released and independently implemented.

Where do we go from here?

The job of defining a standards-based framework for electronics assembly is a large one. Several of IPC's CAMX standards, including those developed by the Plug and Play Project, are ready to be reviewed by industry. Does this mean everyone has to stop using GEM? The answer, fortunately, is no. Simply wrapping GEM implementations in XML wrappers can conserve the investments made in GEM.

Will you soon be able to receive production alerts on your cell phone or PDA? Again, the answer is no. But the

good news is that the work done to date to lay the technological foundation and build the required open industry standards will enable the construction of these kinds of applications. As with any new technology, the interest shown by industry in having access to this type of information will be what ultimately decides what capabilities and at what costs they will be available in the marketplace.

The Plug and Play Factory Project was completed in December 1999. NEMI is now extending its focus to the supply chain and has launched the Virtual Factory Information Interchange Project (VFIIIP) to develop standards that facilitate the exchange of technical data among OEMs, EMS providers, and their suppliers. The goal is to shorten the time and reduce the cost required to establish and maintain information exchange partnerships across the manufacturing supply web. These standards will enable dramatic efficiency improvements throughout the supply chain by enabling partners to exchange product content, changes, and subsequent manufacturing information in a common language.

Three IPC VFIIIP standards already been have created for industry review. These provide generic requirements for supply chain communication (IPC-2571), for supply chain communication of as-built product data (IPC-2576), and requirements for product design configuration (IPC-2578).

For further information, visit <http://www.nemi.org/>.

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