Vol. 44 No. 2

February 2003

Review

IPC
ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES®

www.ipc.org

Speaking a Common Language

APEX/Expo Free Programs

Executive Compensation Report Highlights

Embedded Passives Technology Update

Speaking a Common Language

by Von Campbell, Agilent Technologies

"Islands of automation" – The term rings true for engineers and managers throughout the electronics industry. Manufacturing consists of numerous steps, each of which often centers around one vendor's equipment. Although the steps are generally well-automated within themselves, they only peripherally connect to one another. Proprietary data formats and communications protocols represent a proverbial "Tower of Babel" – preventing the islands from talking to one another and therefore preventing factory managers from monitoring, understanding, and possibly correcting the manufacturing process to improve throughput and product quality.

Now, however, the landscape may finally be changing. In 1997, the National Electronics Manufacturing Initiative (NEMI) funded a project that attempts to standardize data syntax and semantics in electronics assembly, establishing rules for data exchange both on a single factory floor and between that floor and the rest of a manufacturing organization. IPC picked up the program in 1999, added input from international members, and completed the project with publication of the IPC CAMX (computer-aided manufacturing using the extensible markup language [XML]) standards:

- IPC-2541 – *Generic Requirements for Electronics Manufacturing Shop Floor Equipment Communication*
- IPC-2546 – *Sectional Requirements for Shop-Floor Equipment Communication Messages (CAMX) for Printed Circuit Board Assembly* and
- IPC-2547 – *Sectional Req. for Shop Floor Equipment Communication Messages (CAMX) for Printed Circuit Board Test*

Allan Fraser of **Teradyne** describes the accomplishment as an extension of the "plug-and-play" hardware concept to factory floor software.

At the heart of the standard is a framework with an intermediary – a "message broker" – that handles information exchange and complies with the IPC-2501 Standard (*Definition for Web-based Exchange of XML Data*). **Andrew Dugenske,** manager of Research Services at **Georgia Tech's** Manufacturing Research Center, thinks of it as a post office or a mail server. "If you send an e-mail to me, you don't connect directly to my laptop. You send it to a server, and when I'm ready, I ask for it." In a factory, several lines of equipment and several applications may connect to the message broker at the same time. Individual elements need not know any details about the nature, configuration, or format of the others. They communicate directly only with the broker. When people and equipment need specific information, the broker provides it in the correct format.

Two recent pilot trials took this idea off the drawing board and into the real world. In August 2002, a team of collaborators constructed a controlled manufacturing simulation experiment, exercising the message broker at the Georgia Tech Manufacturing Research Center in Atlanta. In September, the team constructed an experiment in a real manufacturing environment at **Motorola's** plant in Seguin, Texas. More than a trial, more than a simple demo, **Bob Neal** of **Agilent Technologies** called it an "in-plant deployment".

Following these events, members of the team assessed their success and their implications.

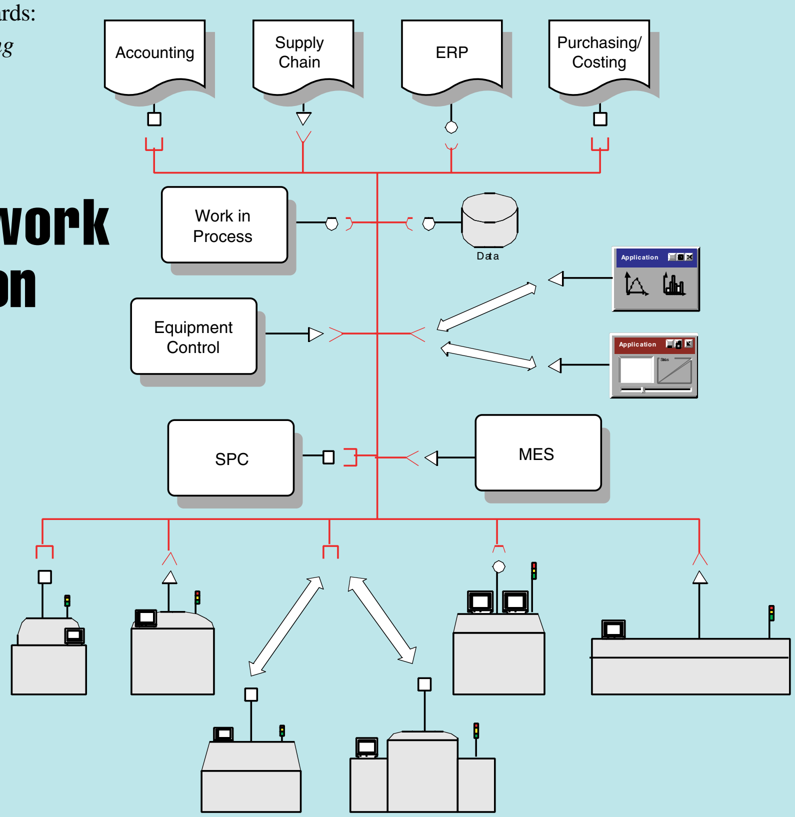
What Happened?

Brent Bohmont, Motorola's senior manufacturing engineer at the Seguin plant, described the scene:

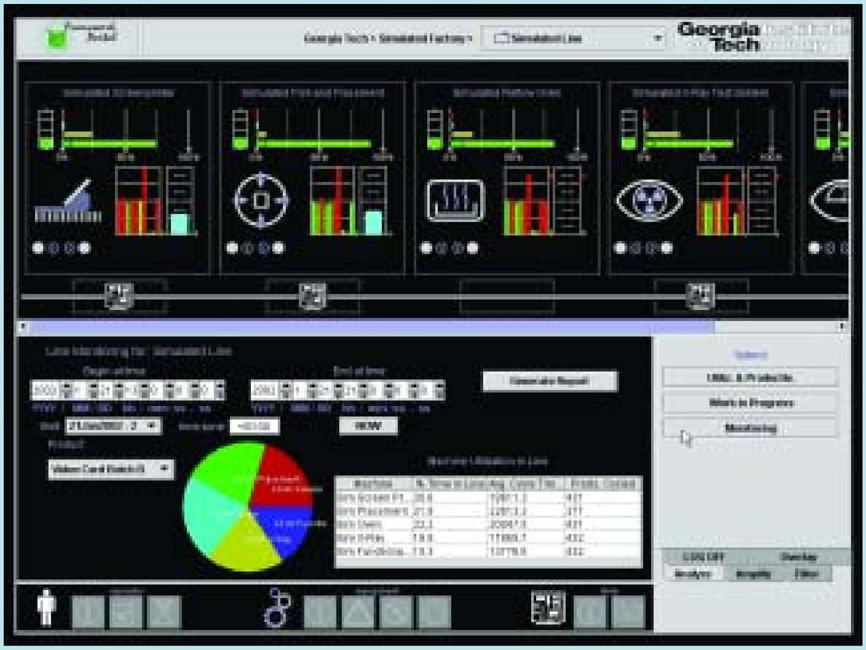
"We set up infrastructure and Web-based tools to monitor several sets of manufacturing equipment, including Agilent 3070 in-circuit testers, **Fuji** CP-7 and **Universal** GSM pick-and-place machines. Over the next week, we gathered performance and functional feedback data on the message broker – with very positive results. We got the message broker up and running in two days, which we considered pretty good. We were able to connect reasonably easily with both legacy equipment and the XML-ready Agilent equipment using infrastructure already in place. We encountered some site-specific problems, but dispensed with them quickly. Initially, for example, the network at Seguin ran very slowly. The problem turned out to be an incompatibility between the **Linux** message-broker servers and Seguin's Ethernet infrastructure. Once we corrected that error, packet collisions went away and the trial ran smoothly. We also managed to avoid compromising network security requirements."

Also, this information was delivered via the message broker to a **Siemens** application, Motorola's Manufacturing Pulse™ monitoring and execution software, and Teradyne's SCE manufacturing execution system where web-based cycle time and yield reports were generated.

Framework Definition



Cord Burmeister of Siemens comments, "It was very exciting to integrate an application based on the .NET framework written in C# into a communication platform implemented in Java running on Linux. Using internet standards like HTTP and XML ensures the interoperability between different platforms. Although the application had never run against a running message broker before this test, it was able to adapt the application into the communication framework on site. One important goal of the IPC CAMX standards was to lower the technological barrier to ease the integration of sophisticated equipment like pick-and-place machines and test equipment, as well as simpler equipment like board handlers. I think we proved the ability to interconnect all kinds of equipment with a simple and well known technology."



Neal observed: "The CAMX standards provide data about the products under manufacture, the processes, and the shop-floor equipment." According to him, applications receiving messages from the equipment included:

- Work-in-process (WIP)
- Tracking, capacity, and throughput monitors
- Equipment utilization and line-balancing monitors
- Product quality monitors that incorporated data from test and inspection

Tom Baggio of **Panasonic's Factory Automation Company** echoed these thoughts. "The purpose of the test was to demonstrate that the broker could run a production floor and provide all the necessary information that we need in real time. As a next step, several manufacturers will have to invest the necessary time and money to implement the system in their own factories."

Fraser stressed the importance of this development to the industry at large: "This standard will do for manufacturing data collection and reporting what **Gerber** data did for designers. That is, a common format will support everyone's data collection and reporting requirements. Gerber was standard, simple, and ubiquitous. We can apply those same adjectives in this case."

Tying the Factory Together

People have been talking for years about linking all parts of a manufacturing operation through a single hub. The CAMX message-broker approach provides an extraordinary array of tools to accomplish that task. **Dieter Bergman,** Director of Technology Transfer, IPC, put it this way: "The message broker can connect any number of clients together. Clients can be factory equipment, a host computer, or the data hub at my desk. You get a visual representation of whatever the manager wants to know. Perhaps I'm trying to communicate with someone in Singapore. I can check the status of their work-in-process using a snapshot of the data in any number of preset formats. I pick the format I want, instruct the software how frequently I want updates, and the broker does the rest."

According to **Tom Dinnell** of Universal Instruments, the system's ability to incorporate legacy equipment is one of its major strengths. "The standard allows for transition. The current setup can work with the older GEM standard, which is proprietary for each equipment manufacturer, as well as with the new Web-based CAMX. And because the major equipment manufacturers have involved themselves in this effort from the beginning, they already support our efforts to extract information from their machines in the standard format."

Critical to the success of this new tool is its "plug-and-play" construction. That is, any piece of equipment on the floor can connect to the supporting architecture and data-gathering software. As equipment technology changes, augmenting or replacing existing equipment will involve much less pain and process disruption than it has in the past. Baggio comments: "By using a standard like XML, we can ensure that no one will misinterpret what the data means. For example, suppose someone sends you an invoice as a Web page that uses the term 'shipper' rather than 'shipping address'. Your receiving system has to know that the two terms are equivalent. Standardizing around XML code tells people the exact structure of the commands and information that we expect. In this case, everyone would use the term 'shipping address'. All parameters are clearly defined. If I see the number '32' for speed, I know that it means 32 mm/sec. There is no other choice".

Dinnell points out that process correction and product improvement require traceability of faults – that is, regardless of where a fault is identified, knowing where it came from and its root cause are critical. In addition, increasing product quality and reducing costs require understanding the actual fault spectrum. Historically, the same fault may be called by several names at different process points. Applying the CAMX standard, fault names can be consistent from step to step within the manufacturing operation, thereby improving the overall level of communication.

For electronics manufacturing services (EMS) providers, the CAMX standards permit manufacturing flexibility without sacrificing data coherence and comprehensive data analysis, regardless of the process under evaluation. The software is more streamlined and less complex than with GEM because all of the equipment now conforms to the single standard. The result is equipment that is both easier to use and easier to support.

Motorola's **Mark Williams** also hopes that this flexibility will spawn seamless point-to-point communication between parts of the manufacturing process. In many respects, GEM implementations resembled the headaches created by proprietary instrumentation extensions of the VME standard before the introduction of VXI. Manufacturers could use VME to drive instruments and equipment, but the standard provided no guidelines and the setups offered no level of compatibility. Companies had to invent their own interfaces between one vendor's instruments and another's.

Such an approach to standardization will likely open up opportunities to perform more elaborate data analysis because the standards will reduce the effort required to gather information. IPC-2501, as implemented in the CAMX message broker, provides the simplified Web-based XML messaging activity for the other IPC standard vocabularies. Equipment vendors who need a particular piece of information will merely “subscribe” to an application or system using the existing Web-based and universal XML messaging SOAP protocol, regardless of the architecture of the other interfaces, and download responses in real time. SOAP is an XML messaging standard supported by all major computing and software vendors. It forms the foundation of their Web-services infrastructures.

No Good Deed Ever Goes Unpunished

Despite the enormous advantages that CAMX provides, however, universal adoption will not come overnight. Baggio contends that the biggest impediment to proliferation of the new equipment is the current economic slowdown. Companies focus on reducing costs rather than on optimizing operations and increasing efficiency. In addition, companies are reluctant to invest in new equipment right now when existing equipment (and therefore spare capacity) lies idle. Dinnell also notes that GEM is entrenched in perhaps 15 percent of manufacturing operations – where the need for such communication was most critical. The people who would otherwise need the CAMX standards most will hesitate to invest time and money for the transition. As a result, acquisition of equipment supporting the new standard will take time.

Fraser agrees. “I've heard it said that it is hard to introduce new technology into manufacturing and impossible to get rid of it. The greatest challenge will be to get legacy systems to support the new standard. We have to face the fact that we will be living in a mixed environment for some time. Implementation will occur fastest where there are no legacy systems – in new lines being built, primarily in Asia.”

Bohmont describes CAMX as an “evolutionary step”. He notes that, through GEM, the semiconductor end of the industry has offered these capabilities for 20 years. Unfortunately, the tight profit margins characteristic of board-level SMT assembly operations generally make the cost of GEM implementations prohibitive. CAMX combines new tools with much more attractive economics – a maturation of manufacturing operations, more tightly controlled processes for capacity and quality, and good, solid data to replace the anecdotal methods of the past.

Dugenske also contends that the idea of the technology as earth-shattering is open to debate. According to him, “The difference today is that we have assembled an outstanding group of participants. The collaboration itself changes the landscape. Georgia Tech isn't defining something and saying, 'Use it'. The industry itself is coming together with a common approach that works. Forward thinkers realize that this approach will provide flexibility and save money. We have every confidence that deploying these standards can provide a competitive advantage to the early adopters and a competitive disadvantage to those who wait.”

Wider Acceptance

In evaluating the new standards, Williams stresses easier product life-cycle management because each level in an organization can analyze the data to its own best advantage. He cautions that to encourage universal adoption, the standard should be regarded as such, with minimal or no licensing fees. Reducing the cost of implementation increases the speed and level of acceptance. It is important to recognize that manufacturing people will know about the standard and watch its progress, and will therefore represent a relatively “easy sell”. To truly realize its potential, however, the standard must also come to the attention of IT people and managers in the upper levels of an organization. Such cross-pollination of the information will get everyone working on the same page, so to speak.

Dan Pattyn of Motorola notes that the package cost represents only a small portion of the actual implementation cost of both CAMX and its GEM predecessor. The remainder covers support, which for GEM required systems programmers and elaborate software development. By relying on the ubiquity of XML and HTTP protocols, the IPC standard permits support by applications programmers, reducing the cost and increasing the reliability and the usefulness of the result.

According to Baggio, one way to encourage acceptance of the CAMX standards is for OEMs to demand it from their EMS companies. The standards create much closer communication between the OEM and EMS company. It’s very much a step closer to virtual integration between customer and supplier. One consequence of the universality of data formats is the ability of suppliers to monitor inventory of their products to prevent disruptions of the manufacturing line. For example, component suppliers can monitor usage of their components on the factory floor, scheduling purchases and taking over similar functions that otherwise fall to the EMS company or OEM.

Where Do We Go From Here?

In looking at the progress of the standard's development and the results of the Seguin deployment, Dugenske comments, “We believe we have brought the technology to the point where adoption is now feasible. In the past, we developed prototypes and demonstrated them at trade shows. The experiments at Georgia Tech fell into that category. But Seguin involved installing the standard in a factory and facing the production challenges to see if the capabilities that we need are actually there. Initial installations will undoubtedly have bugs, of course, but we have to go through those initial deployment trials. We have to turn the system on to test it. We understand the hurdles ahead, but we also know that you always miss 100 percent of the shots you don't take. We are at the point now where we are ready to move, and we have high enough confidence in what we have done to make it a significant accomplishment.”

All of the participants agree that this new standard offers a lot of promise to reduce costs, increase flexibility, and provide more functionality to manufacturers. We as an industry must move it forward for the benefit of all by adopting it, using it, incorporating it, implementing it, buying it. The Seguin experiment verified that it really works. Now comes the push. The risk is getting lower every day.

Special Thanks

Special thanks go to the following members of the IPC Shop Floor Equipment Communications committee who were willing, when asked, to contribute their thoughts to this article:

Dieter Bergman, Director of Technology Transfer, IPC; Andrew Dugenske, Manager of Research Service, Georgia Tech Manufacturing Research Center; Brent Bohmont, Senior Manufacturing Engineer/Seguin, Motorola; Dan Pattyn, Technology Manager, Global Software Group, Motorola; Mark Williams, Development Engineer, Global Software Group, Motorola; Bob Neal, Engineer-Scientist, Agilent Technologies; Tom Baggio, Assistant Manager, Engineering, Panasonic Factory Automation Company; Cord Burmeister, System Engineer, Siemens Dematic Corp., Electronics Assembly Systems; Allan Fraser, Director, Industry Relations, Teradyne; Tom Dinnel, Software Engineer, Universal Instruments Corporation

Other committee participants: Celestica; Fuji America Corporation; Supply Chain Solutions, GTC, Inc.; JOT Automation; Electronic Information Technologies Group, National Institute of Standards and Technology; Router Solutions, Inc. ☐