The Framework Implementation Project

Andrew Dugenske, P.E.

Standardized factory information systems will enable manufacturers to easily integrate assembly machines from different vendors in the same production line.

Among the projects emerging from the 1997-99 Plug and Play Project sponsored by the National Electronics Manufacturing Initiative (NEMI, Herndon, VA) is the Framework Implementation Project. This project is currently underway at the Manufacturing Research Center (MARC) at the Georgia Institute of Technology (Atlanta, GA). With initial sponsorship from several industry leaders, the project is developing factory information system (FIS) products based on the IPC's extensible mark-up language (XML) standards for electronics manufacturing.

The project's overall goal is to develop a framework that reduces costs and decreases cycle time throughout the industry, by fostering interoperability among assembly equipment and software applications. Whatever final form the framework may assume, it will be based on IPC-approved, internationally accepted standards. To understand the value that a standards-based FIS will deliver to the industry, first consider the critical need for such a framework product in today's electronics manufacturing environment.

Currently, no consistent method exists for transmitting production data in real time from one assembly step to the next, accessing the data along the way and transferring it to other information systems as needed. Any commercial product used as a FIS must be modified to fit the line on which it is installed and the specific needs of the user.

Assembly equipment with software to capture process data must be integrated into any existing system. This task is more difficult to accomplish on lines with equipment from different vendors. Some equipment suppliers have developed proprietary systems to encourage the purchase of an entire line from them. Others have incorporated SMEMA interfaces, SECS/GEM protocols and, most recently, TCPIP networkability to facilitate the integration process.

A few large manufacturers have developed customized, in-house FIS systems, but these systems provide only partial answers. A representative of one major company refers to "parochial interfaces" that make the system inflexible. In addition, firms with multiple facilities find it difficult, if not impossible, to replicate a FIS from one location to another and even more challenging to transfer the system when assembly is outsourced.

Obviously, money and time are the primary problems that arise from a lack of FIS standardization. The Manufacturing Execution Systems Association (MESA) estimates that, for every dollar spent to purchase software, $4 is required to install and integrate it. Once a proprietary FIS is operational, it must be maintained, thereby consuming more precious information technology (IT) dollars and resources. Inevitably, it must also be modified as business needs change over time. The time factor is perhaps the most critical piece of this equation; waiting for software to be written and integrated can consume an excessive amount of time.

The OEM-EMS Communications Challenge

For electronics manufacturing services (EMS) providers, these problems are compounded by the different original equipment manufacturers (OEMs) with which they work. Each OEM may require a different system, and, in some cases, different business units within a single OEM may have varying requirements. One large EMS provider noted that every customer describes the same process information in a different manner and exchanges information in a variety of ways. The EMS provider's need to interface simultaneously with numerous FIS programs poses a significant challenge.

Maintaining several FIS programs is a task that many EMS providers, who operate on razor-thin profit margins, cannot afford. Instead, equipment and software suppliers have often assumed this burden as part of their customer-driven business practices. Only the very largest EMS providers can invest in managing a FIS, but even they find that the time required to develop and update programs makes it difficult to keep up with today's rapid new product introductions.

Team Members' Perspectives on the Framework Implementation Project

Team members of the Framework Implementation Project currently include: Agilent Technologies; Avaya Inc. (Lucent); Celestica Inc.; DEK Printing Machines, Ltd.; Fuji America; GenRad Inc.; Intel Corp.; Siemens Corporate Research; Siemens Electronic Assembly Equipment; and Talarian Corp. A few representatives commented on the benefits of such a project:

"The beautiful thing about developing a Web-based framework for FIS products is that we're not inventing any new technology. We're using the infrastructure of the Internet and refining the specific XML messages for different kinds of applications and equipment. This will establish an infrastructure for OEMs and EMS providers to share a common language..."

—Allan Fraser, solutions architect, GenRad Inc.

"Visibility into an EMS provider's operation is essential to the OEM. The architectures emerging from the project will support on-line monitoring of both in-house and contracted production operations. Meanwhile, machine vendors will compete on performance. When you can put any vendor's equipment on your line, the only thing that's going to determine which one you install is the best performance."

—Robert Voitus, distinguished member of technical staff, Advanced Technology Engineering Group, Avaya Inc.

"The lack of integration standards limits an EMS provider's flexibility and increases both costs and time to market. What do we expect from a standardized FIS? Faster time to market and reduced cost to get the product to market. Those are the two key drivers, coming from the efficiencies that would be generated."

—John Cartwright, shop floor control manager for system manufacturing, Intel Corporation.

"The benefit will be the ability to choose equipment without worrying about how it will interoperate with other pieces of equipment. That will make us very agile in how we configure the factory floor. A standardized FIS will also help to realize the benefits of e-business."

—John Minchella, senior engineer, Celestica Inc.

"We want our machines to be completely open, so people can integrate them into their factory environment as seamlessly as possible. If there's an industry standard, we will use it, as we have with GEM/SECS, Host Communications, SEMI and SMEMA. When a standards-based FIS product is available, our equipment will cooperate with it."

—David Baker, software engineering manager, DEK Printing Machines, Ltd.

"Fuji would like to see more standards being applied to the industry, to help us to meet the needs of our different types of customers, both OEMs and EMS providers. The Georgia Tech project, with many of our major customers involved in it, is our first step. Once a standard is available, we will embrace it and begin to work with it."

—Tony Picciola, manager of information systems, Fuji America.

"This whole concept of interoperability drives efficiency into processes by driving inefficiency and cost out. It allows people to remain in business in very slim margin environments, by keeping them from having to pay for the inefficiencies of integration and lack of interoperability. In the end, the big winners are going to be the consumers. That's what brings you set-top boxes for $19.95."

—Robert Neal, program manager, Intelligent Test Business Team, Manufacturing Test Division, Agilent Technologies.

One large telecommunications producer stated that even a week's delay in a product launch can determine the difference between selling a new product profitably and having to discount it deeply, to overcome an entrenched competitor. Another major manufacturer complained about spending "millions of hours and dollars on the no-value-added translation of information out of one machine format and into another." Until factories can adapt more rapidly to changing demands, manufacturing flexibility will continue to lag far behind the industry's business needs, wasting time, money and market opportunities.

Current Systems: Expensive and Outdated

The current FIS programs are expensive and outdated. The SECS/GEM protocol, developed in the early 1980s for the semiconductor industry, was designed to handle large amounts of data with low transaction rates. In electronics assembly, where boards have 10-second cycle times and cell phones are assembled every three seconds, much higher transaction rates are required for much smaller amounts of data. Additionally, GEM's dependence on RS-232 cabling renders it obsolete in today's web-based, object-oriented software environment.

To develop a solution to these concerns and help define the IPC standards on which that solution will be based, members of the Framework Implementation Project have been working together since January 2000. Georgia Tech's MARC, an interdisciplinary research center, provides development resources and a "test bed" of assembly equipment to demonstrate and analyze feasibility at each stage of research.

Numerous steps have been taken since the project's inception. The team determined that the most promising software architecture was one based on message-oriented middleware (MOM), in the form of a centralized message broker, using an HTTP interface to pass XML messages within a framework. In effect, the message broker acts as a web server, with each entity—an assembly system or a software application—functioning as a web client. MOM services include multi-user connection capabilities, message routing, load balancing, publish and subscribe services, security and fault tolerance. The framework may be viewed as a linear backbone, with messages flowing along it, as well as in and out of it at various points along the line.

Two elements of this architecture are crucial to the creation of reliable, scaleable, low-cost, commercial FIS products: XML and an economically feasible message broker. XML, the newly adopted language for transferring dynamic infor-

mation over the Internet, allows new messages to be added to the framework without impacting previously defined messages, in direct contrast to the closed structure of the GEM protocol.

Identifying an optimal message broker has been an ongoing process and demonstrates the consensus-building nature of the project. As in all project phases, off-the-shelf rather than customized products are used whenever possible. After several message brokers were considered, one was selected and adapted for use in the development stage.

During a conference call, one team member suggested a more cost-effective alternative that had been located through an Internet search. In a later conference call, an extended conversation about load testing of the message broker benefited from the input of a new project member, a software supplier specializing in real-time messaging. The ongoing addition of team members with specific expertise in various aspects of the project helps to ensure that, as the framework evolves, it builds consensus for solutions based on a broad range of input.

Team Expansion

Other firms have been joining the project, and additional companies are welcome to participate throughout the project's projected three-year lifespan. For all team members, the Framework Implementation Project demonstrates what is called "co-opetition." In such a group effort, competitors may find themselves sitting across the table from each other and their customers, working to determine areas of opportunity. Once agreement has been reached, competing parties can develop products based on the IPC FIS standards. Users can also implement the products with confidence, knowing that the foundation of interoperability has been established.

Co-opetition responds to the rapid pace of change in the electronics industry. One project member recalled when a four-year research-and-development effort could be devoted to a single product introduction. Given today's drastically reduced development cycle, such an investment of time and money is no longer feasible. Rather, by pooling resources to establish standards that serve as a springboard to competition, the development cycle becomes more cost effective and accelerates to meet market-driven timetables.

For the project team members, participation in standards development helps to jump start their own efforts to bring products to market. As one team member stated, a company can wait until standards are published to begin work on a new product or, by participating in a consortium and being aware of how

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standards are evolving, a team member can be ready with compliant products well ahead of others in the industry.

Along with the message broker, the project team has developed a generic wrapper structure to transfer information within the framework. An XML schema for the wrapper has been proposed as an IPC 2501 standard, and additional XML schemas are nearing acceptance for the IPC 2541, IPC 2546 and IPC 2547, which define generic assembly equipment messages that may be exchanged within the framework. Other standards within the 2540 Series are at varying stages of development and review.

Standards development and acceptance are key elements of the Framework Implementation Project's mandate. Historically, standards development can consume years. However, the process has recently been accelerated through the use of consortia such as NEMI's Plug and Play Project. One member of the NEMI Plug and Play Project estimated that, by using Georgia Tech's research and assembly facilities to test the IPC committee's ideas, "iterative standards development cut our time by half and led to achieving IPC standards in less than three years," a remarkably short time for such an activity.

The Framework Implementation Project is working to accomplish its goals within a similar timeframe. Indeed, had the project not been undertaken, the current XML schemas probably would not have been published. When the standards are available, companies will be able to incorporate them with confidence, knowing that they have been tested on the MARC assembly line.

To accomplish that testing, the research team developed adapters that emulate the emerging IPC standards and allow real-time messages to be exchanged as if the equipment were already IPC 2541 compatible. This step was necessary because the machines currently on the MARC line are SECS/GEM compatible. These systems include donations of a screen printer, placement systems and an in-circuit tester. By adapting the existing equipment interfaces to the new framework, test results provide accurate predictions of the framework's ultimate behavior. Plans are also underway to install the system and its adapters in team members' factories for real-world testing.

For the entire industry, demonstration of the "proof of concept" FIS and its most recent development—a new graphical user interface—are being presented at trade shows, starting in early 2001. Displays in the booths of various team members provide real-time viewing of activities in progress at Georgia Tech and illustrate the system's potential benefits.

Industry-Wide Benefits

The creation of a flexible, low-cost and adaptable FIS is expected to provide benefits throughout the industry. Once a suitable standards-based framework has been designed, tested and documented, the electronics manufacturing industry should realize significant economic advantages.

All electronics manufacturers will reap greater efficiencies on their assembly lines. OEMs will be able to obtain consistent production data from all lines within one facility as well as from multiple facilities. EMS providers will no longer have to integrate different data collection systems into their facilities.

Perhaps most importantly, standards-based FIS products will enable OEM-EMS communications to flow seamlessly along the entire supply chain, from material supplier to finished product shipper. Visibility across the boundaries that currently divide OEMs and their EMS providers will enhance the entire outsourcing process. The dynamic flow of information using web-based technologies will also help companies realize the benefits of interactive business-to-business electronic commerce.

As equipment manufacturers incorporate FIS compatibility into their machines, the concept of interoperability will become a reality. Manufacturers will be able to select best-in-class machines and integrate them easily into assembly lines that can be adapted or reconfigured quickly to meet changing market requirements. Equipment vendors will continue to compete on features and capabilities, with a strong incentive to produce high-performance machines.

For all industry members currently engaged in developing, customizing, integrating and maintaining existing systems for transferring information along the factory floor, support for these non-value-added activities will no longer be needed. Engineering resources may be reallocated more productively, generating considerable savings of time and money. Ultimately, when standards-based FIS products enable electronics assembly to operate more efficiently, the ultimate winners will be the consumer. ■

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Andrew Dugenske *is the director of the Framework Implementation Project and manager of research services at the Georgia Institute of Technology, Atlanta, GA; e-mail: andrew.dugenske@marc.gatech.edu.*