

Electronics Factory Integration: The National Electronics Manufacturing Initiative (NEMI) Factory Information Systems (FIS) Roadmap and Projects¹

Barbara L. M. Goldstein
National Institute of Standards and Technology
Technology Administration
U.S. Department of Commerce

Electronics Industry Overview: The Trend Towards Outsourcing

Electronics manufacturers are contracting an increasing breadth of production processes to their network of suppliers—a trend which is global, but highly pronounced in North America. Initially the industry saw the OEMs (Original Equipment Manufacturer) divest of component technologies such as PWB (Printed Wiring Board) where today, for example, it is the exception to find an OEM that has internal PWB manufacturing capability. From the mid-nineties, and continuing today, the shift towards outsourcing continues with board assembly operations. This trend has led to the explosive growth of the Contract Manufacturing sector, more appropriately referred to as the Electronics Manufacturing Services (EMS) industry due to the expanded scope of the services they provide. Figure 1 shows the evolution of OEM-supplier relationships due to increased outsourcing.

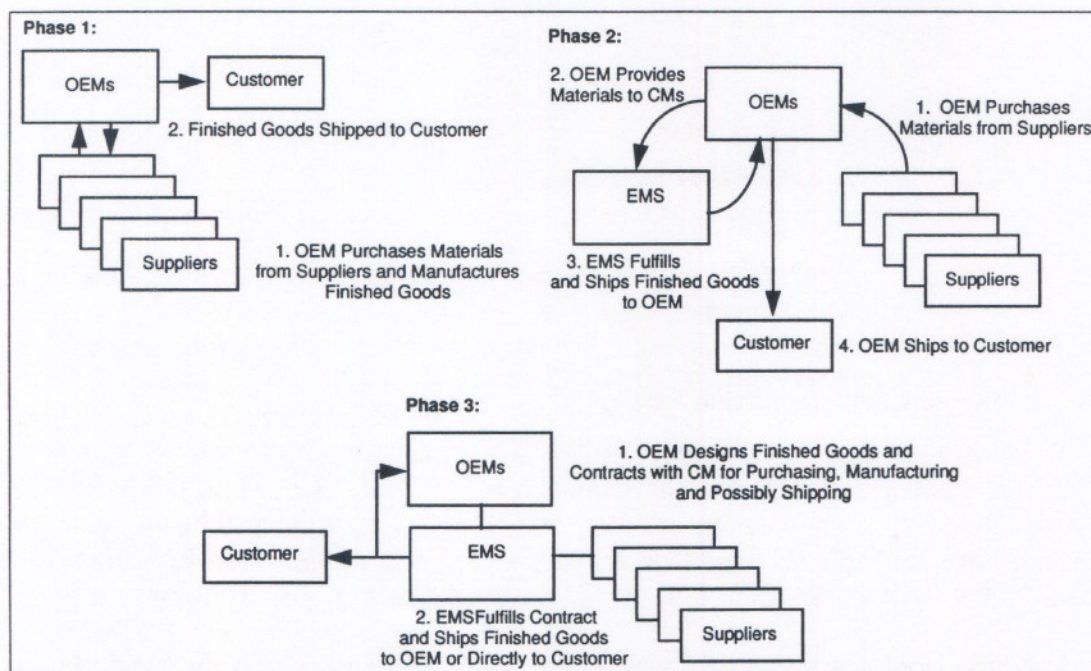


Figure 1 Evolution of Relationships in Electronics Supply Chain¹

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Figure 2 shows that, while electronics compound annual growth rate has been on the order of 9%, the EMS segment in the North American region is expected to grow at a compound annual growth rate (CAGR) of 25% through 2001. Many, such as AMR, an industry and market analysis firm specializing in enterprise applications and related trends and technologies, consider this to be a conservative estimate². Since there is no indication that this lop-sided growth scenario will change, the implication is that electronics manufacturing leadership will shift from the traditional players to the EMS industry. While currently fueled by board assembly, other trends include the outsourcing of final product manufacturing, product distribution, field support, and even detailed product design (with the OEMs still retaining responsibility for defining the high-level product specifications/architecture). For some companies, outsourcing has become the cornerstone of their overall corporate strategy.

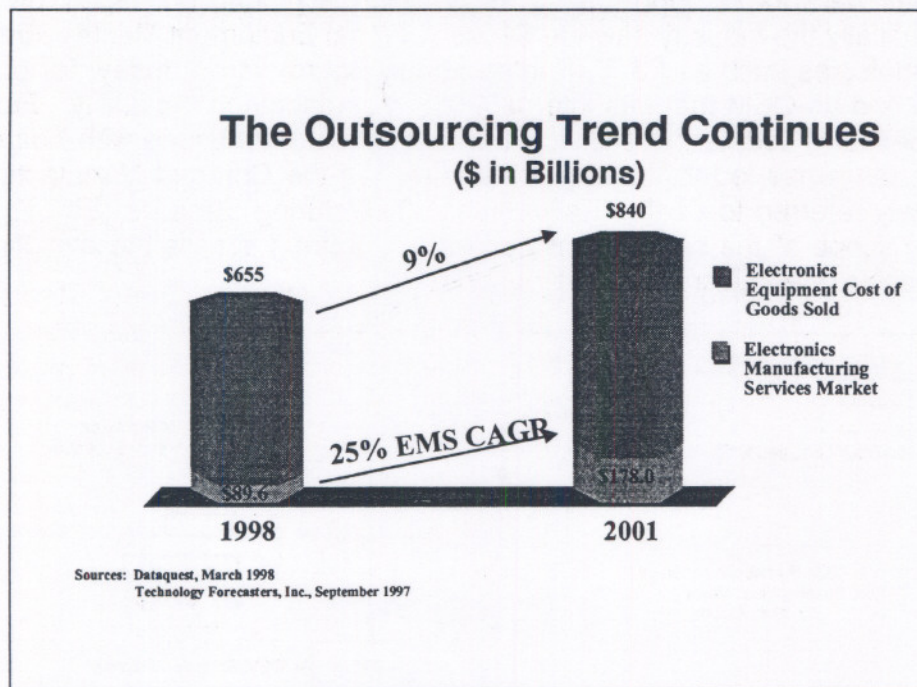


Figure 2. International Outsourcing Trends

As Figure 3 shows, while other parts of the world have moved quickly towards outsourcing, North America still leads in absolute terms.

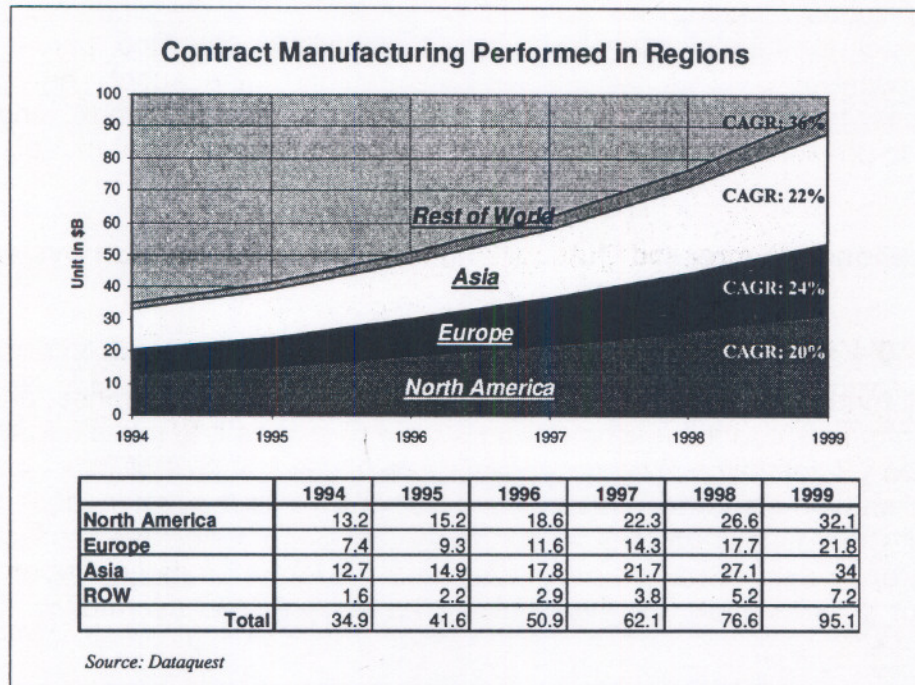


Figure 3 Regional Growth Rate of Electronics Contract Manufacturing

Increased outsourcing is one way in which the industry has responded to growing competitive pressures, which were characterized as follows in the 1996 National Electronics Manufacturing Technology Roadmap on Factory Information Systems³:

- **Complexity** of products and processes forces manufacturers to maintain flexible factories of high-capital equipment and best-of-breed software applications.
- **Competition**, both national and global, fuels user expectations of increasingly lower prices for increasingly more sophisticated products. Competition further requires short Concept to Market and Order Fulfillment cycle times.
- **Cost** of end products pressures manufacturers to save money and increase factory utilization and product velocity through the manufacturing process.
- **Customer Expectations** are pushing the industry to produce custom products at mass-volume prices. Since customers have little brand loyalty and low tolerance for defects, manufacturers are under pressure to be the first to market with flawless, innovative products.
- **Globalization** of the customer base is driving the need for globally distributed manufacturing facilities and suppliers, and OEM partnerships.

The current environment with shrinking product half-lives is very unforgiving in terms of missing market introductions or incorrectly estimating product demand. Increased reliance on a broadly distributed supply network can allow an OEM to rapidly modify their manufacturing capacity by adding or subtracting new suppliers for any element of the production process with little or no impact to their investments (since they own a shrinking percentage of the manufacturing capability). This dynamic reconfiguration of the supply network provides significant flexibility to a system that has found it is easier to react to market conditions rather than to attempt to predict the exact acceptance of any particular product or model.

Implications of Increased Outsourcing for Factory Information Systems

What are Factory Information Systems?

Factory Information Systems form the nervous system of an enterprise, analyzing data and delivering information to the machines and people who need it to make information-based decisions. Factory Information Systems provide a bi-directional flow of information between the factory floor and the rest of the enterprise. Flowing down to the factory floor is work order and product data. Information that is returned from the factory includes product genealogy, defect rates, scrap, yields, utilization, process and other production data. Factory Information Systems do not process material; they collect and process the information necessary to process material efficiently.

New Demands on Factory Information Systems

Factory Information Systems are increasingly expected to interface with systems outside the four walls of a single organization. The most recent version of the NEMI Factory Information Systems Roadmap identifies the following drivers of expanded, distributed FIS capability⁴:

- Shorter production cycle times, higher volumes, and smaller lot sizes mean production managers want and need to manage by exception. Current FIS products are not integrated, and therefore cannot timely provide the integrated factory view needed by managers to take preemptive corrective action.
- Short product life cycles are pressuring manufacturers to turn rapid prototypes of new designs quickly and then rush them into volume production. Monitoring and optimizing this New Product Introduction (NPI) process is a high priority for manufacturers.
- The rise of the EMS industry requires the two-way transfer of manufacturing data between the OEM and the EMS provider. While large manufacturers may currently be able to replicate their suite of in-house FIS applications at their contractor's site, replication does not scale to the entire industry and will not remain practical in even isolated cases.

While greater reliance on a supply network provides some flexibility in response to unpredictable market conditions, the lack of integration among cross-company information systems acts to limit the potential efficiency gains. Most companies have found integration of

their design and production functions a difficult task, even when manufacturing is a captive activity. Such problems are amplified for the EMS, who must be able to accept designs produced by a variety of systems and return both product and formatted information back to their OEM customers. Even when a common tool is used by more than one OEM, they often customize its use so that its output is non-standard across implementations. One EMS indicated that they maintain 90 separate software translators to interpret customer design information.⁵

The NEMI Response

What is NEMI?

The National Electronics Manufacturing Initiative (NEMI; www.nemi.org) was formed in November 1994 to facilitate long-term North American leadership in electronics. This industry-led consortium is made up of more than 50 electronic equipment manufacturers, suppliers, associations, government agencies and universities. NEMI member companies represent 1997 revenues of \$247 billion and employ more than 946,000 workers. NEMI's goal is to help its member companies become global leaders in volume electronics manufacturing. The principal efforts undertaken by NEMI to achieve its mission include:

- Roadmapping the needs of the North American electronics industry. The National Electronics Manufacturing Technology Roadmaps quoted above are products of NEMI working groups.
- Identification of the gaps (based on the roadmap projections) in the North American electronics infrastructure.
- Stimulation of R&D projects to close the longer term gaps.
- With its member companies, establishing implementation projects to eliminate the nearer term gaps.
- Conducting educational forums to encourage deployment of competitive technology.
- Supporting and encouraging standards activities to speed the introduction and broaden the introduction of new technology.

Figure 4. Shows how the NEMI organizational structure supports its roadmapping and implementation activities⁶.

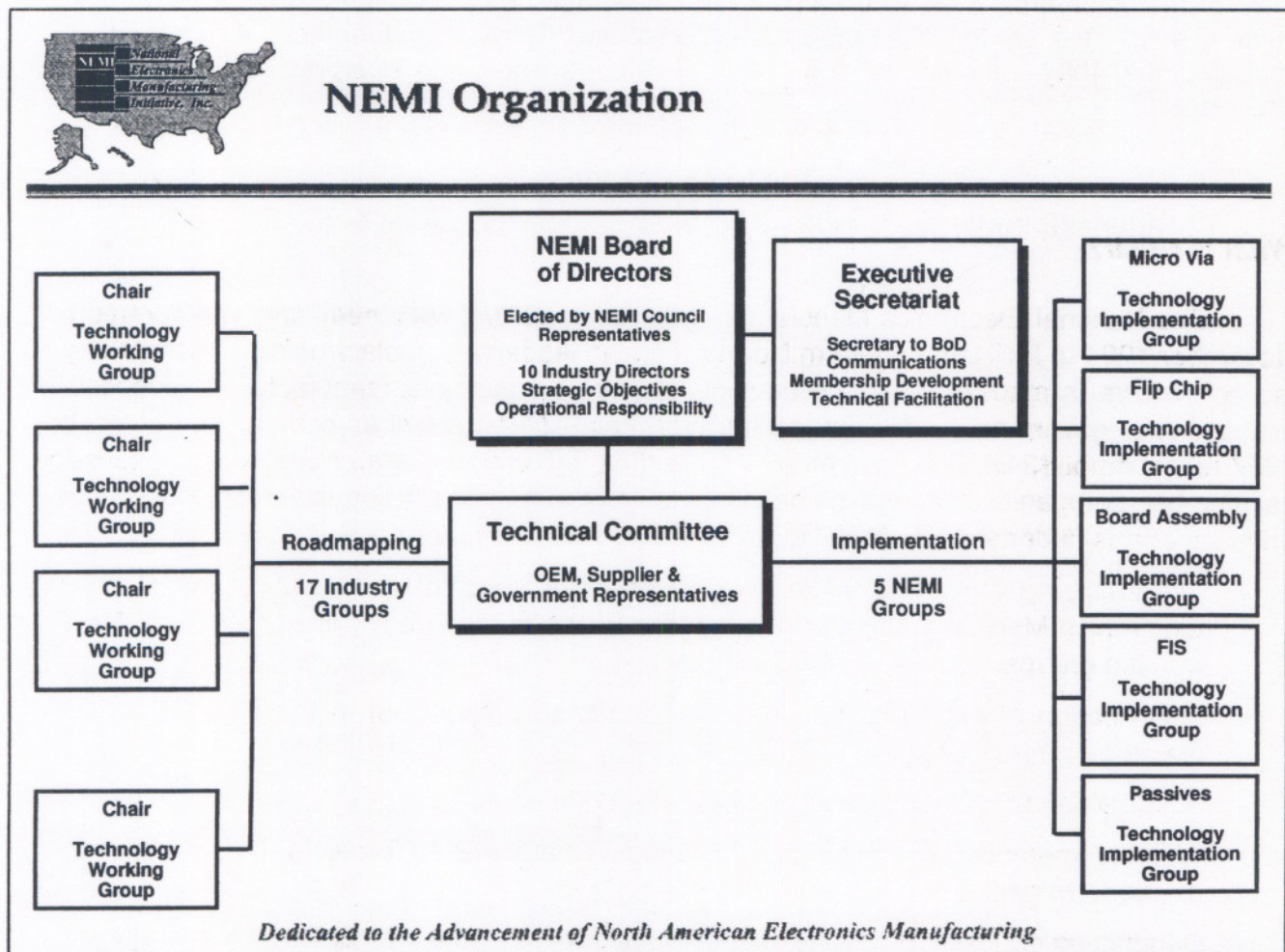


Figure 4 The National Electronics Manufacturing Initiative Organization

NEMI Factory Information Systems Technical Implementation Group

The Factory Information Systems Technical Implementation Group (TIG) is responsible for performing a Gap Analysis based on the Roadmap and further member input, and a five-year implementation plan. Guided by these requirements and vision documents, the TIG then establishes and conducts technology development projects to address identified gaps. The over-arching gap identified by the TIG is "an industry-accepted framework for electronics assembly that simplifies interoperability between applications and equipment"⁷. Addressing

that gap is the TIG's Plug and Play Factory Project. Also planned is a project to specifically address Supply Chain issues.

The Plug and Play Factory focuses on the development of standards necessary to achieve interoperability — i.e., plug and play capability — among hardware components used by North American electronics manufacturers. Activities of the group are broken into three areas:

- Definition of standards for a software framework that will allow interoperability among software and equipment produced by different vendors.
- Development of process-specific machine communication interface standards for surface mount equipment, leveraging the Generic Equipment Model (GEM) specification developed for semiconductor equipment and web-based standards for data transmission.
- Establishment of a test bed manufacturing line at the Georgia Institute of Technology (Atlanta) to prove the concepts developed by the project.

The project periodically demonstrates the capabilities of the evolving Plug & Play framework at public events, such as NEPCON and the IPC/SMTA Assembly Expo. The current iteration of the demo involves data collection over the Internet from a diverse set of electronics manufacturing equipment, all made by different vendors. A PC-based Web browser in Providence, Rhode Island collected data and process information from assembly, inspection, test, placement and other types of equipment located on the Plug and Play Factory Test Bed line at Georgia Tech.

At the core of the demonstration is a software framework, based on XML (extensible mark-up language), which provides a common interface among all the hardware components on a PCB manufacturing line (in this case, the Georgia Tech test bed). It allows data to be collected from all the machines on the line and displayed inside the Web browser.

In the past, manufacturing systems have typically been proprietary, and for the screen printer equipment (for example) to be able to interface with the solder paste inspection equipment, they both had to be made by the same vendor. With the Plug and Play framework, the component placement equipment from company ABC can interface with a piece of functional test equipment from company XYZ.

According to Allan Fraser, Director of Component Software Engineering for GenRad, Inc. and NEMI Plug & Play Factory project leader, "If the industry can develop a set of standards for interoperability, hardware and software vendors will be able to introduce component-based solutions, similar to what has happened in the PC industry. The advantage is that it will enable electronics manufacturers to greatly reduce the costs of integrating new pieces of hardware and software into their operations. It will also allow them to tailor functionality to meet their needs at a specific point in time, while at the same time providing them with the flexibility to easily adapt as their needs evolve."⁸

Plug and Play Factory participants include original equipment manufacturers (OEMs), Electronics Manufacturing Services (EMS) providers, suppliers to the North American electronics industry, and government and academic agencies. OEM/EMS participants are AMP Incorporated, COMPAQ Computer, DELPHI Delco Electronics Systems, Intel, and Lucent and Solectron. Participating suppliers are EDS, GenRad, Inc., ICC/GR Software, and Universal Instruments. Government and academic agencies include the Georgia Institute of Technology, the National Institute of Standards and Technology (NIST), and Sandia National Laboratories and the State University of New York – Binghamton.

References

- ¹ KPMG Consulting, Draft report to NIST on Electronics Commerce in the Electronics Industry, August 1998.
- ² Swanton, Bill, "Are Electronics Plants Outgrowing Their Software?", AMR Report, June 1998.
- ³ National Electronics Manufacturing Initiative (NEMI) *National Electronics Manufacturing Technology Roadmaps*, Chapter on Factory Information Systems, December 1996, p. 212.
- ⁴ National Electronics Manufacturing Initiative (NEMI) *National Electronics Manufacturing Technology Roadmaps*, Chapter on Factory Information Systems, expected to be published by NEMI in December 1998 (Herndon, VA; www.nemi.org).
- ⁵ From discussion during NEMI FIS Technical Implementation Group planning meeting, Rhode Island, October 29, 1998.
- ⁶ National Electronics Manufacturing Initiative Member Guidelines and Directory, 1998.
- ⁷ Internal National Electronics Manufacturing Initiative (Herndon, VA; www.nemi.org) Factory Information Systems document: Gap Analysis, current revision October 1998.
- ⁸ NEMI's Factory Information Systems Group Demonstrates "Plug & Play" Manufacturing Capabilities at IPC/SMTA Electronics Assembly Expo, Press Release, Providence, RI, October 28, 1998, press contact: Cynthia Williams, Edelman/GTT, cwilliams@mindspring.com.

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