New Information Technology Increases Productivity from New and Existing Equipment

Abstract

An opportunity has arisen for semiconductor process tool manufacturers, sensor producers, and consumables suppliers to leverage new tool-based information technologies to increase the productivity of manufacturing tools and improve process economics and predictability. Secure, concurrent, real-time remote access can now be provided for new and legacy tools, embedded subsystems, and instrumentation while preserving existing SECS networks.

The Symphony Equipment Server (SES) leverages proven information technologies to facilitate a new generation of automated process analytics. The SES allows the remote browsing of tool status, e-diagnostics, and other process information from authorized remote locations. In this way, the SES facilitates Equipment Productivity Solutions that rapidly produce measurable benefits.

By implementing a true client-server architecture and web-based administration with novel security and arbitration features, the Symphony Equipment Server enforces industry e-diagnostics standards, addresses the shortcomings of typical host/slave approaches, and fulfills the promises of a modular, open-architecture information exchange right from the fab floor.

Background

Despite significant advancements in fab efficiency in the past several years, semiconductor process tools still spend about as much time not producing product as they do making chips[i].

- Maintenance and replenishment schedules are still largely developed and managed based on worst-case heuristics rather than in-process measures.
- Opportunities to close process loops to optimize quality, improve usage, and reduce costs remain overlooked.
- Consumables management remains a manual process, side stepping opportunities to eliminate downtime, reduce middle work, and streamline procurement.

These and other routines of modern fab management are, in part, necessitated by the difficulty of securely accessing detailed and timely tool metrics. The breadth and depth of information provided by generic SECS steams is inadequate to optimize processes and equipment usage beyond today's norms.

Available information is limited and arrives too late for quick remedial action. Metrics for embedded subsystems are frequently under represented in the resulting dataset.

Available measures are limited to sensors and metrology built into the tool and can be difficult to expand or supplement; limitations in on-board tool metrology tend to be perpetuated forward, dampening innovations and efficiencies which might be illuminated by enhanced instrumentation.

Emerging e-diagnostics initiatives and programs on connectivity, interoperability, and open-standards are addressing some of these issues. SEMATECH has highly active efforts to build standards in the area[ii], and these have been fruitful in defining security and safety standards as well as more general areas of functionality.

However, industry efforts to date have centered on conventional host/slave architectures and have consequently failed to mitigate two key issues:

1. The inability to extend current tools' metrology capabilities[iii]

2. The inability of simple Host/Slave architectures to allow responsive, real-time access by multiple applications and users

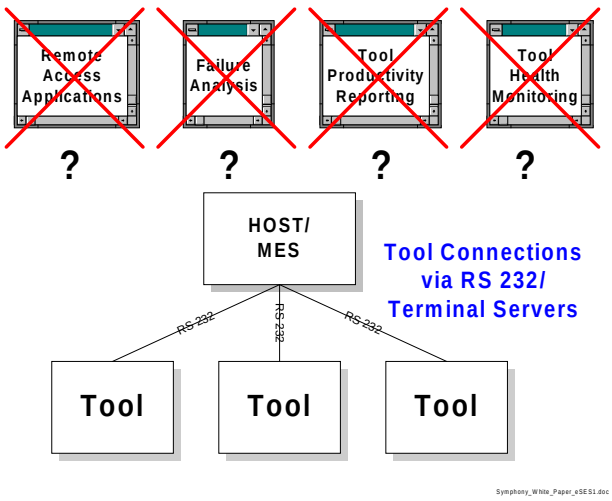
These limits inhibit the integration of tool-based measures into the overall MES infrastructure to facilitate Equipment Productivity Management (EPM).

Extensibility Remains an Issue

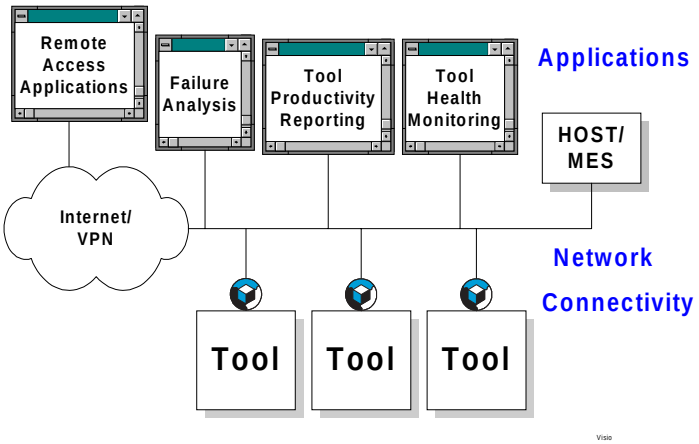
A common lament among tool users and sensor manufacturers is that even in the most costly equipment diagnostic suites offered for major tools, information is available for only a portion of the tools' subsystems and processes, and adding additional tools is difficult and costly. In other data-centric industries and arenas, this shortfall would be readily addressed by applying modular, open-system methodologies, which are central to industry e-diagnostics and e-business standards efforts. Still, information about the performance, status, and activities of embedded subsystems is often unavailable or rudimentary. And in all cases, it is difficult or impossible to integrate new sensors or instrumentation into a tool's monitoring or analytical application.

Concurrent Access/Multiple Applications still Largely Overlooked

Almost universally, the connectivity capabilities of available solutions turn the tool into a glorified computer peripheral, consumed entirely by one application at a time. Stopgap measures such as suite-based architectures have allowed application providers to serve multiple needs and users simultaneously—at least within a suite—but tool owners are forced to live within the confines of that one manufacturer's suite unless the owner invests in costly custom integration efforts.



The fab **before** eSES software is installed.



The fab **after** eSES software is installed.

Figure 1. eSES software provides secure, reliable, and robust equipment connectivity for many semiconductor applications.

Symphony Systems

SES: An Extensible Architecture for Concurrent Access to Tool Information

SES, the Symphony Equipment Server, is a cost-effective extension for all existing tools and subsystems. It provides a wide spectrum of new functionality for e-diagnostics, new MES initiatives, recipe optimization, "virtual fab" implementations, and process engineering. The SES provides

- Secure networking capability that supports multiple concurrent applications, including simultaneous access by many remote users through web-browser user interfaces. Equipment and sensors become shareable resources, accessible anytime by users and applications.
- Easy integration of additional sensors and instrumentation.
- Support for SEMATECH's e-Diagnostics initiative, even for older, legacy equipment.
- Connectivity for devices lacking SECS capability.
- Support for existing network/MES functionality; current SECS/HSMS capabilities are unmodified.
- High-strength security and authentication provisions.
- Quick applications deployment, including autonomous streaming, to process historians (real-time databases) for measurable progress towards Equipment Productivity Management (EPM) goals.
- Easy scaling over private and public TCP/IP networks, allowing global implementations of e-diagnostics and advanced MES applications.

These capabilities make it easy for managers, engineers, and suppliers to securely and concurrently define, collect, manipulate, and analyze data from tools and sensors from any location without impacting existing SECS or HSMS networks or central hosts. Correlations and historic analyses are facilitated, allowing pre-event conditions to be inspected and root causes illuminated. And, like a networked disk drive, each tool can be accessed transparently and simultaneously by virtually any number of users.

The SES Implementation

The Symphony Equipment Server (SES) leverages the latest software object technologies while providing secure network interface and protocol management functionality for concurrent access by users and applications. All necessary services are provided to easily integrate equipment into network applications (LAN and secure WAN).

The **External Symphony Equipment Server** (eSES), available now, implements SES functionality as an application for use on Windows NT, or on a compact, easily deployed NetGateway hardware module. NetGateway, designed for use with equipment in the clean room, is a LINUX-based network appliance. The eSES provides both SECS/HSMS functionality and parallel, concurrent network-applications capability for any tool or subsystem possessing RS-232, such as sensors, and could be extended for analog and digital I/O. SES intercedes between the tool's interfaces and the fab's SECS network, passing through SECS streams while providing separate network services for concurrent access by multiple remote users and applications.

The **Internal Symphony Equipment Server** (iSES) allows equipment manufacturers to offer built-in SES functionality in new tools or as an upgrade to existing tools. Implemented entirely in software, the iSES integrates seamlessly into the tool's controlling computer to provide the full spectrum of SES functionality, including high security, contention management for multiple concurrent users and applications, and transparent protocol conversion.

The Symphony architecture automatically manages arbitration and security issues that allow concurrent access to the tool and its standard or added metrology and reporting capabilities by users over TCP/IP. Unlike typical Host/Slave architectures, there is essentially no limit to the number of users and applications that can access a tool and its resources at a given time, similar to a networked disk drive, which is simultaneously available to multiple users. No user must wait for another to finish a job.

Process Scenario

Consider the case of an etcher in a fab in Asia:

- An operator at an office workstation views the tool's status, monitors alarm states, and views the tool's activities from outside the cleanroom. The information is presented in his browser in his own language.
- Simultaneously, real-time databases compile time-stamped state and sensor information from dozens of subsystems and instruments embedded in the tool. Key parameters are monitored by process engineers in Silicon Valley, allowing the engineers to view the tool's performance and correlate it with others in the field. They review anomalies and look for opportunities to fine-tune process performance, especially in terms of productivity bottlenecks due to material flow and operator responsiveness.
- At the same time, alarm routines alert the maintenance office of any issues with the tool, while the procurement office and the gas supplier are alerted to the consumption of key chemicals by the tool, facilitating automatic replenishment.
- Meanwhile, engineers at the tool's manufacturer use additional measures and note new predictive information available from embedded subsystems that formerly were not included in the SECS stream provided by the tool. The additional information allows the engineers to devise creative approaches for the continuous improvement in tool uptime, MTBA, and MTBF.

All these examples allow the tool's owners, manufacturer, suppliers, and downstream "customers" to be more informed—faster and more conveniently—in their shared efforts to improve equipment productivity and process economics.

The key is the **secure, concurrent access** to current and existing sensors and instrumentation in the tool. The SES makes this possible for new and existing tools without affecting existing SECS streams or networks. The SES redefines current notions of systems integration, allowing a virtually plug-and-play approach to facilitating secure network and remote access to tools and sensors.

Figure 2. Problem Found!

Using the Symphony Equipment Server

The Symphony Equipment Server is easy to use. Equipment driver software is available from Symphony or is readily constructed for any device by simply loading its SECS-stream and command-set definition tables into the server. A user interface (see Fig. 3) enables an administrator to manage access to the equipment. This allows the server to communicate with the tool while pro-viding parallel, concurrent network services that are the foundation for your network applications. Any existing SECS or HSMS streams are not interrupted, impeded, or modified in any way.

Once the server is connected to the tool, the tool is accessible to remote applications through the SES's object interface or other access protocol. This accessibility allows the rapid development of applications of great simplicity or tremendous sophistication.

- Authorized users can immediately browse the tool's key variables and status indicators.
- Applications as simple as an automatically updating Excel™ worksheet can be constructed by managers and MIS professionals.
- Highly sophisticated, database-driven applications can leverage the server's responsiveness and concurrent access capabilities to draw data from across the fab or around the world for review and analysis.

This combination of features empowers process engineers, equipment engineers, and manufacturers' maintenance engineers to drive creative Equipment Productivity Management initiatives and generate measurable benefits quickly.

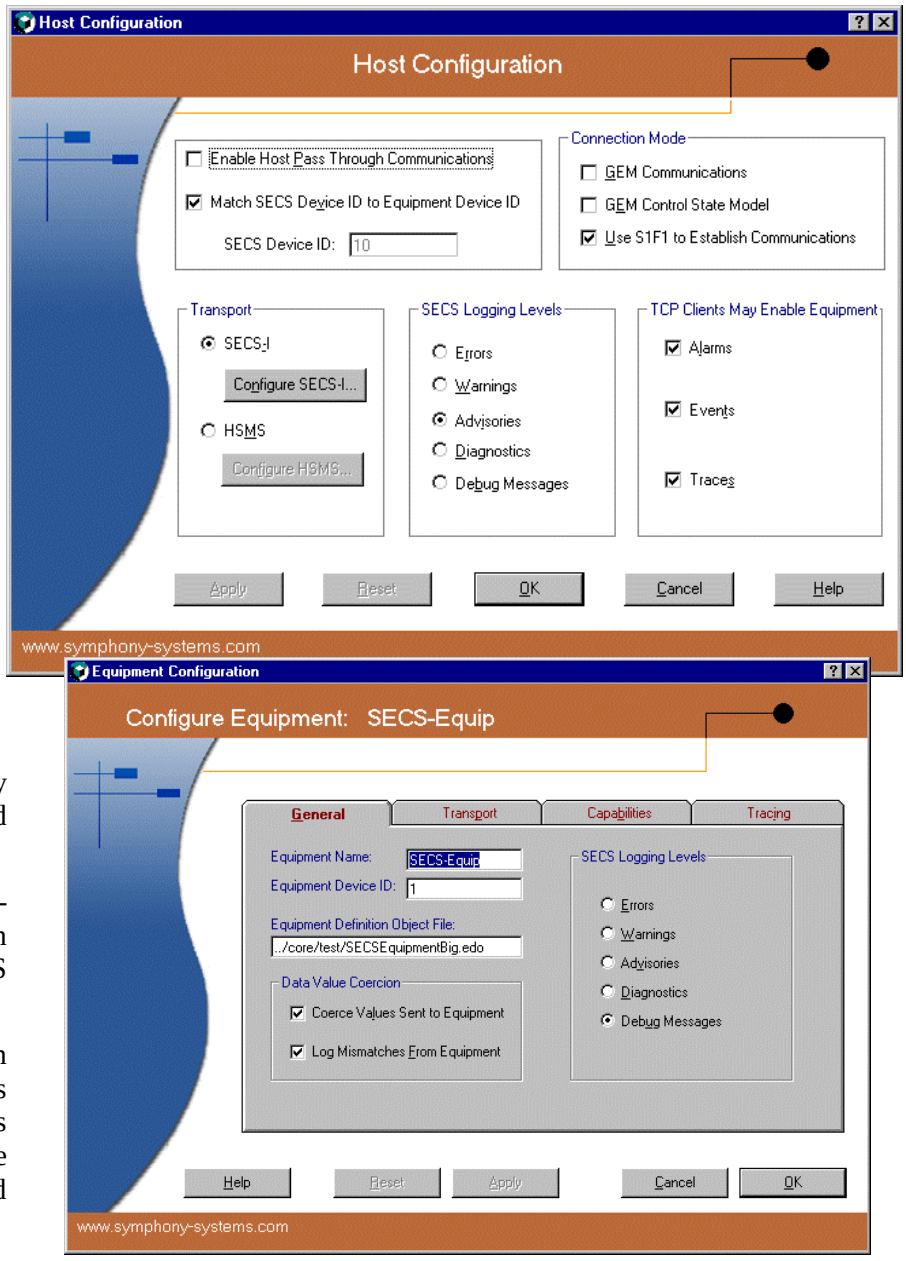


Figure 3. The SES UI offers point-and-click configuration forms for tools with SECS/GEM capability and for tools with a variety of other communication protocols.

The Symphony Equipment server allows variety of network applications concurrent, secure, real-time access to tools and sensors, facilitating a new generation of e-diagnostics and solutions for managing equipment productivity.

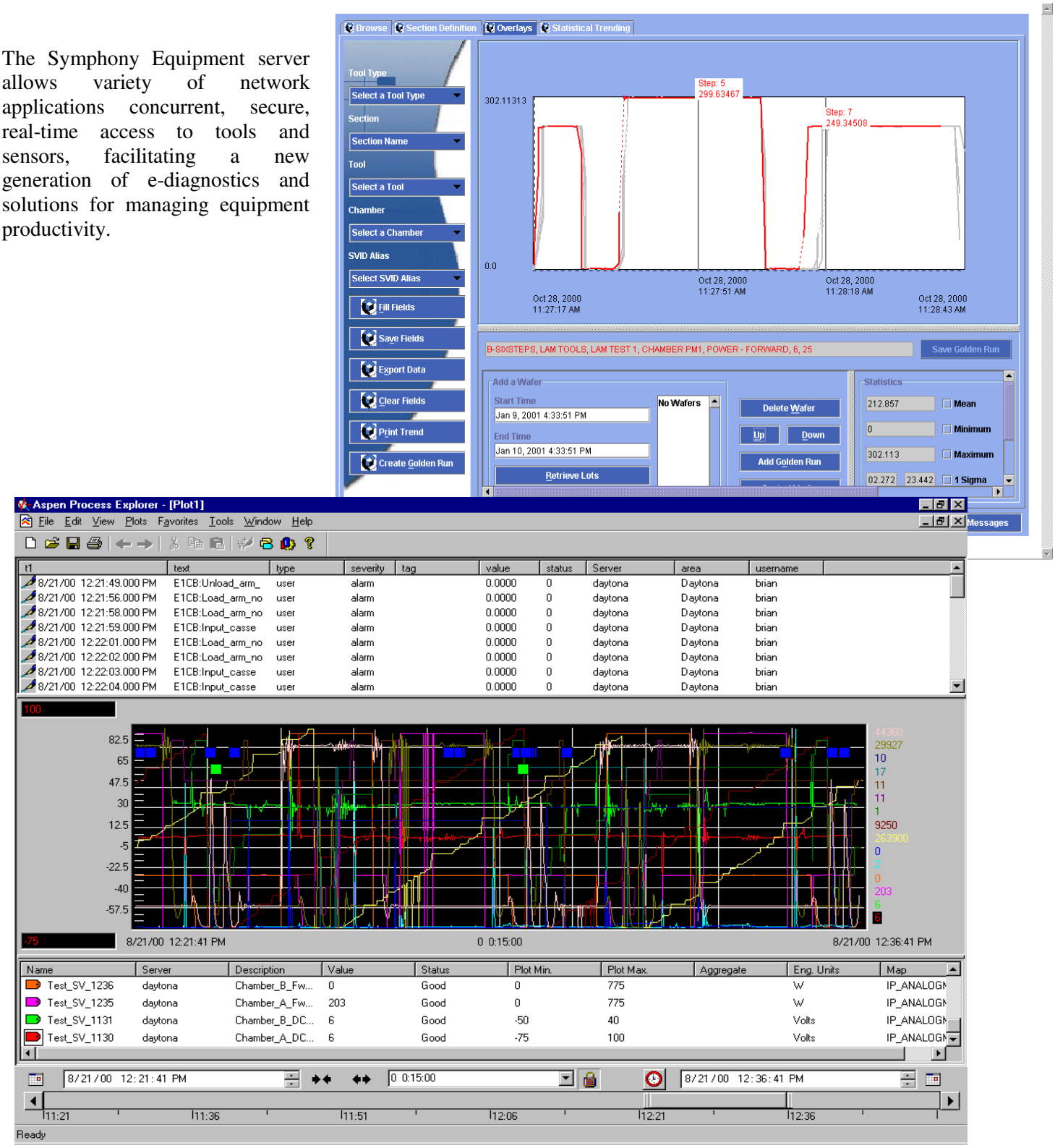


Figure 4. Variety of advanced data analysis applications can access tool using Symphony Equipment server.

Symphony as Implementation Partner

Symphony Systems, working together with its applications partners, offers a spectrum of services including:

- Adding SECS/HSMS functionality to legacy tools
- Implementing complete, turnkey, fab-wide information architectures
- Deployment of next-generation MES and e-Diagnostics functionality

Symphony Systems works closely with tool manufacturers to embed Symphony Equipment Server in new tools, retrofit upgrades and e-diagnostics programs. Symphony Systems also works with fabs to add the SES to the installed base or deploy a suite of Equipment Productivity Management applications that access tools through the SES.

Feature Summary

The Symphony Equipment Server is offered in embedded (software) and external (hardware) implementations. It leverages existing tool capabilities to add secure, concurrent network-application support without impeding or interrupting existing SECS streams. It allows easy integration of additional sensors.

The SES fully supports emerging SEMATECH standards for remote e-Diagnostics while addressing overlooked concurrency issues and missing network-applications functionality, which are fundamental to equipment-productivity-optimization initiatives. It is easily implemented, transparent to existing tool functionalities, secure, robust and proven.

Open tool communications architecture	Allows the user to choose, or easily develop, best-of-breed applications for their needs. Supports true open-standards architecture: the user is not limited to one manufacturer or provider.
Web-based user interface	Universal access.
TCP/IP Network connectivity	Provides remote access to equipment via intranet or extranet. Security features facilitate implementation over the public Internet.
Simultaneous access to the tool data and secure access	Enables collaboration between tool manufacturers and fabs for more efficient tool maintenance and troubleshooting. Responsive, simultaneous support of many users and applications, like a networked disk drive. Facilitates advanced Equipment Productivity Solutions initiatives to rapidly generate measurable productivity benefits.
Designed to e-diagnostic standards	Ready solution for OEMs and sensor manufacturers.
Pass-through to the MES host/cell controller	Reliable, non-disruptive equipment connectivity solution.
Provides unified interface for tools with of without SECS/HSMS capabilities	Easy integration of installed equipment into fab-wide networks.
Object-Based architecture	Easy design of new applications using popular programming tools.

Conclusion

The Symphony Equipment Server represents an opportunity for semiconductor process tool manufacturers, users, and their suppliers of consumables and sensors to leverage new information to increase tool productivity and improve process economics.

The Symphony Equipment Server facilitates a new generation of advanced automated process analytics. The SES allows simple remote browsing of tool status, e-diagnostics, and other instantaneous views from authorized remote locations. By providing secure, concurrent, real-time access to tools, embedded subsystems, and instrumentation while preserving existing SECS networks, the SES facilitates Equipment Productivity Solutions that produce measurable benefits rapidly.

By implementing a true client-server architecture with novel security and arbitration features, the Symphony Equipment Server leverages industry e-diagnostics standards while addressing the shortcomings of typical host/slave approaches, fulfilling the promise of a modular, open-architecture information exchange right from the fab floor.

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[i] Ref. http://www.sematech.org/public/docubase/summary/3688beng.htm or http://www.semi.org/__882568410080b293.nsf/ad09cecebf092f71882565e60016fc57/b9abda3f169ec69c882568b100658dff!OpenDocument

[ii] See http://www.sematech.org/public/resources/ediag/index.htm

[iii] Ref. http://www.sematech.org/public/resources/ediag/documents/062900/amat.pdf