

# e-Diagnostics Program Report

[www.sematech.org/public/resources/ediag/index.htm](http://www.sematech.org/public/resources/ediag/index.htm)

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# e-Diagnostics Project Summary

**Background:** The internet is revolutionary productivity enhancer. Semiconductor fabs have not yet broadly incorporated its advantages due to concern for security, lack of standards, and diverse and inadequate supplier support. Many ad hoc implementations are being initiated.

## **Objectives:**

**Focus on e-Diagnostics first:** Create guidelines, best practices, prototypes, compliance assessments, and drive commercialization of open, internet-based access for suppliers to monitor their equipment. This should provide improved uptime, optimized predictive maintenance, and faster repair. Project can add scope per MC direction.

## **Stakeholders:**

- Primary: Fab equipment engineers and operations managers; equipment suppliers
- Secondary: Infrastructure software suppliers

**Competitive Benefit:** Member companies create industry-leading direction for driving suppliers to support a new generation of data gathering in fabs. Assured common supplier implementations (to reduce cost and enable data analysis applications) and encourage competition around standardized approaches. Leverages value from other ISMT investments in automated data collection (TP2™), sensors (AEC/APC), and SW interface standards.

# Response to IEF e-Diagnostics Direction

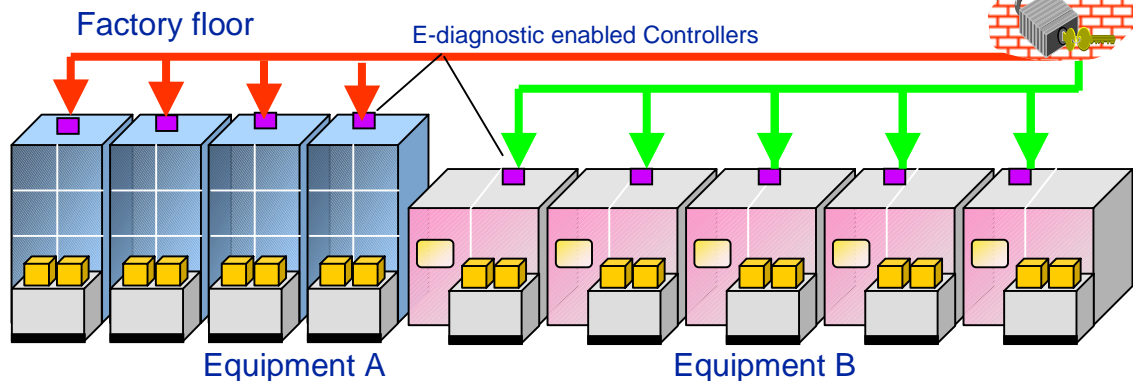
- **President's Day / ISMT BOD / IEF meetings**
  - e-Diagnostics was identified as a critical need for the industry  
⇒ a call for swift action  $\equiv$  *internet speed*

## Since then...

- **Incorporated into the ITRS**
  - Basis for international action
- **ISMT formed e-Diagnostics Working Group**
  - Drive commercialization of open, internet-based access methods for suppliers to monitor their equipment
  - IC Companies and Suppliers

# Why e-Diagnostics?

- Goal is 66% reduction in equipment support dollars
- Goal is 50% reduction in MTTR = Higher Availability = Increased Output
- Anticipate problems before they occur
- Provide data to support continuous improvement and new product development



Internet

- Mainstream Computing Technologies
- Open Architectures

Protocol Options

- Serial line IP
- Remote Cntl
- Telnet
- Ethernet IP
- VPN

Firewall & Authentication

- Data Security
- Safety Infrastructure

Remote monitoring  
Remote diagnostics  
Remote de-bugging/fix  
Remote sensing  
Model tool behavior

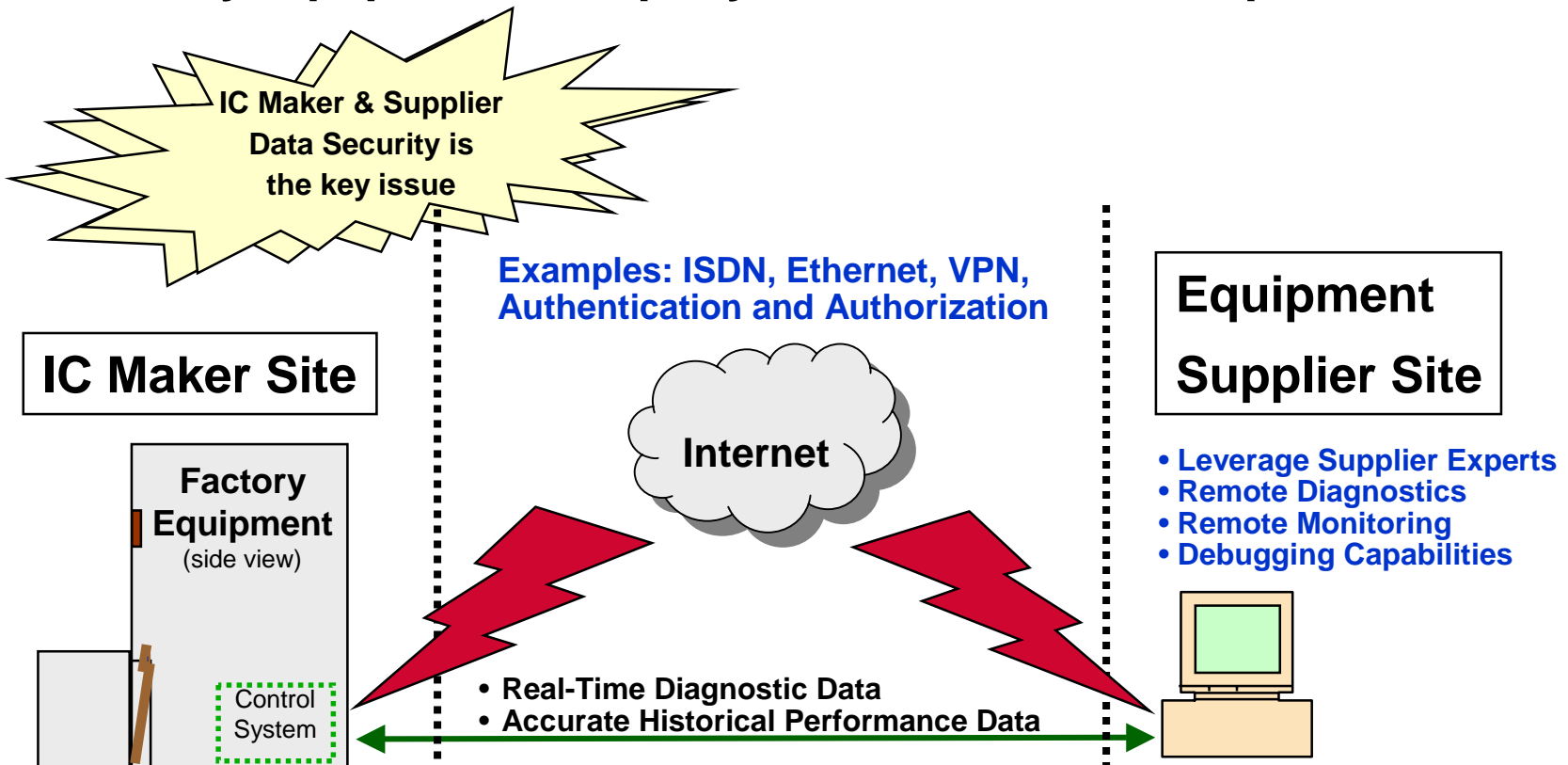
**Supplier A Main Office**

Remote monitoring  
Remote diagnostics  
Remote de-bugging/fix  
Remote sensing  
Model tool behavior

**Supplier B Main Office**

# e-Diagnostics Overview

1. Remote monitoring & diagnostics allow supplier experts to rapidly fix factory equipment issues from their sites.
2. Suppliers need accurate historical performance data from factory equipment to rapidly drive continuous improvement.



# In Scope

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- ❑ Establish e-Diag. Guidelines, Lessons Learned, and BKM
- ❑ Facilitate definition of which fab tool data to provide suppliers
- ❑ Identify functions that can be executed during specific equipment states
- ❑ Roadmap for what should be done first, next, ...
  - **Synchronize to the ITRS**
- ❑ Create and communicate industry consensus
  - **Open architecture**
  - **Workshops, Semicon forums**
- ❑ Compliance assessment

# Out of Scope

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- ❑ **Methods for data analysis**
- ❑ **Data mining algorithms and implementations**
- ❑ **Industry benchmarking of tool data**
- ❑ **Expert systems algorithms and implementations**
- ❑ **e-business, e-commerce, Supply Chain Management**
- ❑ **Business practices**



**Currently, each company must resolve these issues**

# e-Diagnostics Workshop Summary - 6/29

## Objectives:

- 1) Approve the e-Diagnostics Guidelines (Requirements)
- 2) Identify roadmap steps needed to establish e-Diagnostics
- 3) Identify data elements necessary for effective e-Diagnostics

## Actions:

**Publicize Guidelines:** Press release, ISMT (Resources for the Industry) web site, Semicon West briefing packet.

**Working Groups focused on:**

- 1) definition of data needed
- 2) model for bandwidth requirements
- 3) capabilities definition
- 4) definition of data transfer protocols
- 5) resolution of single wire guideline
- 6) implement security, with Security Council support

## Summary:

**Strong agreement on:**

- 1) need for e-Diagnostics
- 2) initial steps include basic infrastructure improvement

# e-Diagnostics Workshop (65+ Participants)

## Member Companies

AMD  
Conexant  
HP  
Hyundai  
IBM  
Intel  
Lucent  
Philips Semiconductors  
ST  
TI  
TSMC  
ISMT

## IEF Suppliers

Applied Materials  
Axcelis Technologies  
DNS Electronics  
Hitachi  
KLA-Tencor  
Lam Research Corporation  
Nikon Precision  
Novellus  
PRI Automation  
SVG  
Tokyo Electron America  
Varian Semiconductors  
SISA

# e-Diagnostics Next Steps - 6/29

Scope		Within the Tool	Within the Fab	Within the World
Levels	Actions			
<b>1) Reduce MTTR</b>	Define capability taxonomy			
	Define data taxonomy			
		Analyze Network Bandwidth requirements	Analyze Network Bandwidth requirements	Analyze Network Bandwidth requirements
		Define protocol for data access	Define protocol for data access	Define protocol for data access
		Resolve 1-wire guideline		
	Define security		Define security	Define security
<b>2) Proactive Monitoring</b>	Define capability taxonomy			
	Define data taxonomy			
		Analyze Network Bandwidth requirements	Analyze Network Bandwidth requirements	Analyze Network Bandwidth requirements
		Define protocol for data access	Define protocol for data access	Define protocol for data access
		Resolve 1-wire guideline		
	Define security		Define security	Define security
<b>3) Predictive / Preventative Maintenance</b>	Define capability taxonomy			
	Define data taxonomy			
		Analyze Network Bandwidth requirements	Analyze Network Bandwidth requirements	Analyze Network Bandwidth requirements
		Define protocol for data access	Define protocol for data access	Define protocol for data access
		Resolve 1-wire guideline		
	Define security		Define security	Define security

**Need WGs to complete these actions**

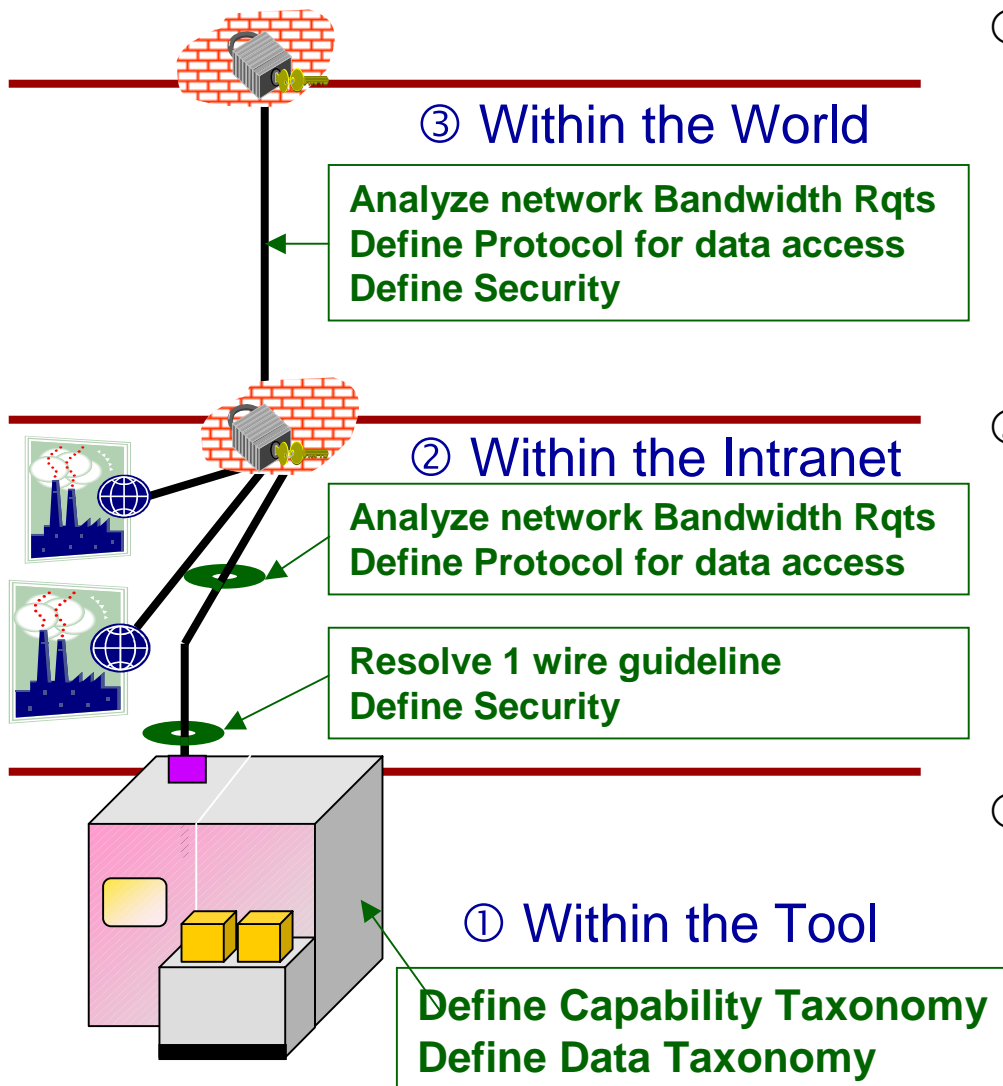
# e-Diagnostics Teams

Team	Leader	Members
Network Bandwidth Requirements	Harvey Wohlwend (ISMT)	ISMT Reza Bonabi (KLA-T) Juan Bocanegra (AMAT) Kirbey Hess (AMAT) Anant Raman (Intel)
Capability Taxonomy	Gary Viviani (Varian) Dave Bloss (Intel)	Bill Ramus (IBM) Bob Wiggins (IBM) Shay Assaf (AMAT) Scott Smith (Nikon) Roger Eastvold (KLA-T) Chris Stambaugh(Schlumberger) Ray Peterson (TEL) Frank Kennedy (Teradyne)
Data Taxonomy	Ed Kaz (AMAT) Nick Nikolic (KLA-T)	Ray Bunkofske (IBM) Shay Assaf (AMAT) Dave Busing (KLA-T) Regina Qiu (KLA-T) Scott Smith (Nikon) Ray Peterson (TEL) Patrick Splinter (Axcelis)
Single Wire Resolution	Dave Bloss (Intel)	Reza Bonabi (KLA-T) Dave Busing (KLA-T) Jim Chalmers (KLA-T) Ray Bunkofske (IBM) Bob Wiggins (IBM) Juan Bocanegra (AMAT) Shay Assaf (AMAT) Neil Frank (AMAT) Margaret Pratt (ISMT)

Team	Leader	Members
Protocol Definition	Roger Eastvold (KLA-T) James Martin (Intel)	Anjali Sridhar (KLA-T) Melvina Mazin (KLA-T) Nick Nikolic (KLA-T) Pete DelMastro (SVGL) Michael Laine (Axcelis) Ben Bergarian (Nikon) Ray Bunkofske (IBM) Scott Smith (Nikon) Frank Kennedy (Teraydne) Robert Brandom (Schlumberger) Helmut Klotzsch (Schlumberger) Neil Frank (AMAT) Frank Kaplan (AMAT) Shay Assaf (AMAT)
Data security model	TBD	Reza Bonabi (KLA-T) Anjali Sridhar (KLA-T) Roger Eastvold (KLA-T) Shay Assaf (AMAT) Juan Bocanegra (AMAT) Kirbey Hess (AMAT) Gerry McMahon (Teradyne)
IT Security Council	Michael Sigman (ISMT)	Debbie Christofferson (Intel) Elaine Cole (Motorola) Greg Herbst (TI) Richard Hnath (Lucent) Carol MacNaughton (ISMT) Greg Nelson (AMD) Joe Norman (STMicroelectronics) Dave Reisenauer (IBM)

**Leaders are to drive progress offline with the team members**  
**Sub-teams meet at least once per week**  
**15 suppliers participating on e-Diagnostics team, expanding**

# e-Diagnostics Capability Definition



- ③ Predictive / Preventative Maintenance
  - Automatic identification of pending failures by the process tool
  - Automatic action of tool to fix the issue
- ② Proactive Monitoring
  - Monitor leading indicators / summary data
  - Some external system or people analyze the data and predict future tool behavior
- ① Reduce MTTR
  - Basic remote access to tool data
  - Equipment experts can review and analyze 'raw data' from anywhere in the world

# e-Diagnostics Capability Model

## Level 0: Collaborative trouble shooting with basic remote connectivity

- Remote view of log files
- Collaborative trouble shooting
  - **Text based messaging/communication**
  - **Audio/Voice**
  - **Video**

## Level 1: Remote performance monitoring and basic real-time diagnostic capability

- Monitor equipment performance in real time
- Remote equipment configuration
  - **Installation/Setup**
  - **Updating/upgrading**
- Remote equipment operation

## Level 2: Automated data collection and diagnostic capabilities

- Collection of performance data
- Historical data
- Replay/simulate past activity logs (playback feature)
- Ability to remotely execute any diagnostic functionality/command

## Level 3: Predictive maintenance, self diagnostics, and automated notification

- Predictive/proactive equipment self diagnosis
- Internal/external knowledge base (source of documentation or info sharing)

# Data Taxonomy Requirements

- **Purpose:** To categorize tool data with regards to e-Diagnostics use cases. Includes key concepts, general requirements and terminology.
- **Scope:**
  - Define data structure boundary, not specific data acquisition or Fault Detection Classification (FDC) methods.
  - Specific data coverage not defined in several areas, e.g. exception events.
  - Certain data requirements defer to SEMI standards.
  - Not limited to on-tool data.

# Document Organization

## ■ General Requirements:

- Preserve tool performance: Data should not inhibit tool performance
- Data Formats: Suggest existing SECS-II and new XML formats
- Off-tool Data: Not all data will be merged or manipulated on tool
- Data Availability Classes: (1) always, (2) conditional, (3) servicer only

## ■ Event Data: **Instantaneous occurrences or changes in equipment state**

- Non-exception Events: Associated with normal tool function
- Exception Events: Represent unplanned or abnormal tool behavior
  - Closed-loop metrics (e.g., OEE ) needed to identify unreported exceptions

## ■ Recipe Performance Data:

- Definition of Recipe Success (Success, Marginal, Failure)
  - Potentially different for Metrology versus Process equipment

# Document Organization (continued)

- **Tool Health Monitoring Data: Daily monitor, PM tests, etc.**
  - Diagnostic Scope: System, Subsystem and FRU/Component.
  - Result Types: Pass/Fail, Parametric, Specification Status, Vector.
  - Wafer/Reticle-based: Test ID includes wafer/reticle coordinate.
- **Operational Performance Data: Calculated performance metrics**
  - e.g., Time in E10 state, OEE, MTBF, MTTR, etc.
- **System Baseline Data: Basis of comparison for e-Diagnostic data**
  - Software version, recipe revision control, tool configuration
  - Best Known Method results, Benchmark data and design specifications
- **Tool Usage Data: Represents status of tool and/or what the tool is doing moment-to-moment**
  - Status Data: Current User ID, Recipe, Tool Mode, etc.
  - Accumulators: Event counters, continuous accumulators, etc.

# Network Bandwidth Requirements

- **Assumptions**

- RS232 rate = 115.2Kbits per second
- TCP/IP and HSMS rate = 1 gigabit per second per pipe
- T1 rate = 1.5 Mbits per second
- T3 rate = (up to) 45 Mbits per second
- Data is needed in near real-time, not hard real-time
- 400 tools per fab, each capable of producing e-Diagnostics data
- Each tool variable must be available for e-Diagnostics
- Burst: 5000 variables per tool, each variable can be output once per second, and is 48 bits (6 bytes) long, including formatting (non-ASCII)
- Volume needed for equipment tracking is 1% of data needed during Unscheduled Downtime, excursions
- Metrology tool data is 10% of a process tool e-Diagnostics data
- 86,400 seconds per day

# Network Bandwidth Requirements - Data Points

- MC1 = 1 kilobyte / tool / second or 8 Kbits / tool / second
- Varian (6/29) = 1/2 gigabyte / tool / day or 46.3 Kbits / tool / second
- TP2 = 10 Mbytes / tool / day or 0.93 Kbits / tool / second
- Full defect wafer map = 160 Mbits /second
- Pre-1998 class PC = 10 Mbits / second transfer rate
- New PC with ethernet card = 100 Mbits / second transfer rate

# e-Diagnostics Scenarios

(Data once per Second)

- **Worst Case**

- 5,000 variables \* 48 bits \* 400 tools  
= 96,000,000 (96M) bits / second / fab

- **Typical Case**

- 10 tools during Unscheduled Downtime, 390 tools tracking (1%, 50 variables / second)
- (5,000 variables \* 48 bits \* 10 tools) +  
(50 variables \* 48 bits \* 390 tools)  
= 3,336,000 (3.3M) bits / second / typical fab

# Network Bandwidth Requirements

## Draft Conclusions

- **RS232 is inadequate**
- **Internal fab network of TCP/IP with HSMS will be sufficient to support e-Diagnostics**
- **External networks are likely to be an issue**
  - Dedicated T3 may be needed for e-Diagnostics
- **Data storage and length of retention is a major issue**
  - 6,415.2 Gbytes per 6 months

\* Encryption not included in calculations

# e-Diagnostics Schedule

#	Item	Owner	7/27	8/3	8/10	8/17	8/24	8/31	9/7	9/14	9/21	9/28	10/5	10/12	10/19
1	Finalize scope/levels/action matrix	Dave Bloss	Original Estimate												
2	Network Bandwidth Requirements analysis	Harvey Wohlwend	Original Estimate	Original Estimate	Original Estimate										
3	Define Capability Taxonomy	Gary Viviani Dave Bloss	Original Estimate	Original Estimate	Original Estimate	Added Time	Added Time								
4	Define Data Taxonomy	Ed Kaz Nick Nikolic	Original Estimate	Original Estimate	Original Estimate	Added Time	Added Time								
5	Japan Engagement Defined	Randy Goodall	Original Estimate	Original Estimate	Original Estimate	Original Estimate	Original Estimate	Original Estimate	Original Estimate						
6	ISMT Security Council Guidelines	Mike Sigman	Original Estimate	Original Estimate	Original Estimate	Added Time	Added Time								
7	ISMT Security Council e-Diag Imp Spec	Mike Sigman					Original Estimate	Original Estimate	Original Estimate	Original Estimate	Original Estimate				
8	Single Wire Resolution	Dave Bloss			Original Estimate	Original Estimate	Original Estimate	Original Estimate	Original Estimate	Original Estimate	Original Estimate				
9	Protocol Definition	Roger Eastvold James Martin			Original Estimate	Original Estimate	Original Estimate	Original Estimate	Original Estimate	Original Estimate	Original Estimate				
10	Data Security Model Defined	Ray/Bill/Dave to talk				Original Estimate	Original Estimate	Original Estimate	Original Estimate	Original Estimate	Original Estimate				
11	Update guidelines w/ decisions	Harvey Wohlwend							Original Estimate	Original Estimate	Original Estimate				
12	<b>e-Diag face to Face - Ratify Guidelines</b>	<b>Harvey Wohlwend</b>									Original Estimate				
13	SEMICON Southwest Workshop	Harvey Wohlwend													10/19
14	Validation / proof of concept	TBD											Original Estimate	Original Estimate	Original Estimate
15	Implementation Roadmap	TBD											Original Estimate	Original Estimate	Original Estimate
16	SEMICON Japan Workshop	Harvey Wohlwend													12/7

Original Estimate  
 Added Time  
 Initial rev. done

- **Progress made offline to ensure October rollout**
- **Basic analysis to be completed by late August**
- **Core 'standards' to be completed by September**
- **Roll out core standards during SEMICON Southwest**

# 2000 Deliverables

## Key Program Outputs

- ✓ e-Diagnostics Guidelines, rev. 1.0 - 06/29/00
  - Structured, consensus MC requirements for suppliers
- ✓ Pre-SEMICON/West press release - 07/05/00
- ✓ e-Manufacturing included in the ITRS - 07/10/00
- ✓ Data Definition, rev. 0.1 - 07/07/00
- ✓ Data Definition, rev. 1.0 - 08/24/00
- ✓ Implementation Roadmap, rev. 0.1 - 07/14/00
- ✓ C/Network Bandwidth requirements - 08/03/00
- ✓ C/e-Diagnostics Capability Taxonomy - 08/24/00
- ✓ IT Security Council Guidelines - 08/24/00
- e-Diagnostics Protocol Definition - 09/00
- e-Diagnostics Workshop - 09/00
- SEMICON Southwest seminar - 10/00
- e-Diagnostics Guidebook - 11/00
- SEMICON Japan workshop - 12/00

# e-Diagnostics Guidelines V1.0

## **Purpose/Scope:**

**The fundamental purpose of e-Diagnostics is to increase the availability of production and facilities equipment, reduce mean time to repair and provide significant reduction in field service resources/costs. This capability must be available for 200mm and 300mm fab equipment, Probe/Assembly/Test equipment, and key Facilities equipment.**

## **e-Diagnostics Definition:**

**Capability to enable an authorized equipment supplier's field service person to access any key production or facilities equipment from outside the IC maker's facility/factory via a network or modem connection. Access includes ability to remotely monitor, diagnose problems or faults, and configure/control the equipment in order to bring it into full productive state rapidly, within security, safety, and configuration management guidelines.**

**The e-Diagnostics solution consists of equipment and auxiliary hardware and software applications.**

# e-Diagnostics Guidelines V1.0

## Safety and Security:

- Safety is imperative. Potential solutions must address worker, product, and equipment safety. An operational interlock is required to ensure safety.
- Data security is paramount. Potential solutions must address network, communications, data encryption and other relevant issues. Only authorized personnel may be able to access the view based, relevant data to perform diagnosis.
- Remote data and control access must be selectively provided. Therefore the e-Diagnostic system must have built-in capability that determines when to allow specific remote functions to be executed based on specific states or condition of the equipment.

## Architecture:

- The solutions must support remote accessibility of equipment diagnostic data from outside the IC maker's firewalls. Two-way communications between these two locations is needed to support interactive problem solving.
- The solutions must permit sharing of key diagnostics and monitoring data between multiple factory and supplier sites on an as-needed basis to enable remote detection of issues and proactive trouble-shooting.
- The solutions must enable predictive maintenance, including notification when equipment will need service or repair.
- e-Diagnostics solutions must be implemented using an open architecture based on mainstream computer technologies, non-proprietary standards and data models.

## Collaboration:

- The solutions must provide the same equipment monitoring/diagnostics data at the local and remote sites. Identical representations and user interfaces at both sites are highly desired.
- The solutions must enable run-time data collection, storage, and retrieval. The e-Diagnostics system must enable analysis of this data and decision support capability.
- The solutions must allow audio-visual collaboration such as video teleconferencing or video over Internet Protocol to enable remote experts to view/diagnose equipment and sub-assembly problems in real-time and communicate with factory personnel.

# Next Steps

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- **Perform options analysis for single wire, protocol, and data security during Q3'00**
- **Define “standards” based on the results of the analysis by SEMICON Southwest (Oct '00)**
  - Adopt existing computing industry standards
  - Define new standards initially at an International SEMATECH level, adoption by SEMI or other standards organization to follow
- **Kickoff Japanese collaborations in Q4'00**
  - Expected output is new working group with ITRS, EIAJ, Selete, Equipment Suppliers, and Software Suppliers

# ISMT e-Diagnostics Program

## *Program Goal*

**Drive pre-competitive technology  
& standards development within  
the industry for eDiagnostic  
capabilities**