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E-Diagnostics Definition & Benefits

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Executive Summary

E-Diagnostics (Remote Monitoring and Diagnostics or RM&D) is not a new concept: however, today's technology has enabled many new levels of deployment. These various levels provide for a variety of new functionality and a wider range of cost options, thus enabling solutions better tailored to specific needs. However, this variety has generated significant confusion as to what constitutes e-Diagnostics. This paper will define e-Diagnostics from both the equipment maker's (supplier) and manufacturer's (end user) perspectives. Beginning with the simplest elements and ramping up to the most complex, this paper discusses the various levels of e-Diagnostics functionality and applications. The many benefits of e-Diagnostics are also discussed from both the supplier and end user perspectives.

Definition

At a basic level, e-Diagnostics is the ability to connect to a remote site to share information and collaborate on operations data. Examples of this include remote experts and end users working together to solve various problems with equipment/processes or to commission new equipment. At a more advanced level, e-Diagnostics provides suppliers and end users the ability to work remotely with the same results as if on site. At its highest level, e-Diagnostics positions an organization to achieve new productivity levels by enabling functionality such as statistical comparison of different sites in real time and predictive maintenance (e.g. Notification that a machine will fail in the next 30 days if maintenance is not performed).

A Reference Model

The International SEMATECH (ISMT) model for e-Diagnostic capability levels is shown here to represent the variety of e-Diagnostic solutions available. This clear, easy to understand model is applicable to many industries.¹

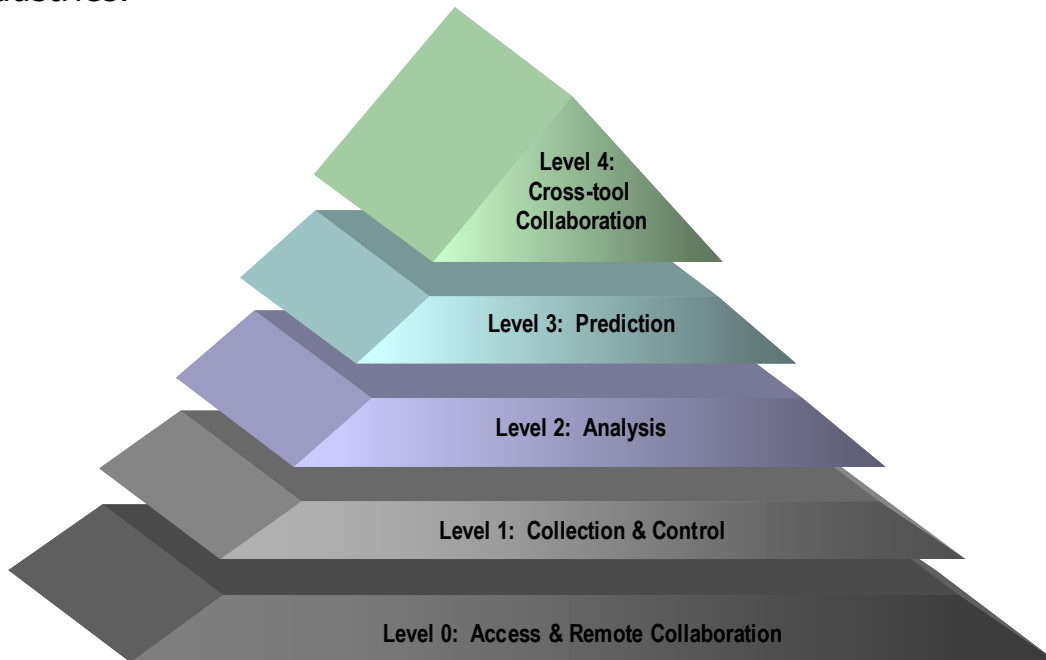


Figure 1: ISMT e-Diagnostic Levels

¹ International SEMATECH (ISMT) is a global consortium focused on advancing semiconductor manufacturing technologies.

Referring to figure 1, each layer of e-Diagnostics adds critical capabilities, driving to a more complete solution. The layers are cumulative, with each new layer including all the capabilities from the layer(s) preceding it. Thus, Level 4 represents the most comprehensive e-Diagnostics functionality.

Level 0 – Access & Remote Collaboration

Level 0 provides remote connectivity to a tool or process and collaboration capabilities with remote parties (i.e. voice, video, text). In order to implement this level, the security policies of both the supplier and the end user must be observed when establishing connection and collaboration tools must be jointly adopted and implemented. The implementation process often has numerous hurdles that can only be cleared by key decision makers in both organizations. For example, the IT department *and* the control engineers from both parties may have responsibility for the security and uptime of the equipment being connected.

Level 1 – Collection & Control

Level 1 takes the networking technology implemented in Level 0 a step further – beyond the information systems. At level 1, the ability to retrieve real-time data directly from machines to troubleshoot and repair fault situations, in real time, is added. Therefore, this level requires data collection, machine configuration, and data storage. The ISMT model includes remote operation (control) as part of Level 1 and with respect to the technology involved, it is logical to group this functionality together. However, for some users and suppliers, there are legal and insurance ramifications related to remote operation of process equipment. These situational factors dictate significantly tighter controls and can delay deployment of this functionality. For other users, remote operation is a very exciting revenue enabler (e.g. the spot power generation market.). Ultimately, most customers view Level 1 as the ability to troubleshoot problems with real-time data, and correct those problems from a remote location.

Level 2 - Analysis

Level 2 adds automated reporting and analysis functionality such as Statistical Process Control (SPC) and visualization software. At this Level, the system provides both historical and real-time information formatted to be meaningful and user-friendly. The organization is remotely transforming raw data into information used to monitor processes and determine if operations are in control or outside of tolerances. Such analysis can unlock powerful productivity improvements for end users (further discussed later in this paper).

Level 3 - Prediction

Level 3 builds on the reporting and analysis functionality of Level 2 by incorporating algorithms that perform automated diagnosis and notification, thus enabling predictive maintenance. It is technically possible within the scope of level 1 to have automated notification (alarms) on a reactive basis. Many companies choose to operate in this fashion during initial deployment of e-Diagnostics. For example, if a controller which has fault logging capability needs to be monitored, one can elect to use auto-notification of particular faults to service personnel (e.g. via a pager). At Level 1, the service engineer could remotely pull down real-time data and attempt to resolve the problem. However, the engineer would be severely limited by the lack of historical trending data. This data captured and available in Level 2 and higher e-Diagnostic solutions can greatly simplify the fault resolution process.

Level 4 – Cross-tool Collaboration

Level 4 builds on all the previous levels by aggregating data from many remote machines, factories, and/or suppliers, and leveraging this information to troubleshoot entire operations and processes. For example, if a machine has 50% greater uptime in factory 1 than an identical machine in factory 2, an analysis can be conducted to discover and correct the deficiencies in the second machine based on the success of the first. Another example is correlating data across multiple tools in a single line for problem resolution or process optimization. These are powerful productivity enablers not possible at the lower levels of e-Diagnostic solutions.

Anywhere, Anyone, Anytime

The above reference model provides a good framework in which to consider e-Diagnostic solutions and competing implementation strategies. However, it is important to realize that underlying the success of each level of the model is the ability to reach the appropriate experts anywhere and at anytime. If a critical machine goes down at 2AM, that alarm must be directed to the maintenance/engineering expert(s) whether the individual(s) is at home, out of town on another job, or anywhere else in the world. Additionally, the expert(s) must be able to access the critical information for troubleshooting and fixing the problem, per level 1 of the ISMT model, wherever and whenever problems occur. This robust, flexible, reliable two-way communication is at the heart of e-Diagnostics and is the key deliverable of any e-Diagnostics installation.

Benefits of e-Diagnostics

The benefits of e-Diagnostics extend to both the supplier and end user. To understand these benefits, first picture a model where an equipment manufacturer has customers all over the world. This 'supplier' receives calls from his/her customers when the customer experiences a problem. This often results in an emergency dispatch of a service engineer to solve the problem. First, let's review the supplier benefits in this context.

Supplier Benefits

Every call to the service organization is an emergency to the caller, but with the right data available to the right domain expert, the problem could often be resolved remotely. When calls come in without access to real-time data, each call is often treated as an emergency because the service organization is "flying blind" - even though the problem is often relatively minor or has a simple work around. Treating the call like an emergency typically means dispatching an engineer. However, without the data, you might send the wrong expert, or send an expert with the wrong replacement parts. That increases the mean time to repair (MTTR), causes customer dissatisfaction, and wastes valuable resource time and travel and living expenses (T&L). With e-Diagnostics, T&L can often be eliminated, and when it cannot, the right expert will be dispatched with the necessary parts and tools. For warranty work, this represents significant productivity savings for the supplier.

Also, the service experts dispatched are often from a pool of engineers working on next generation equipment. Thus, there is opportunity cost associated with re-directing these experts to handle installed equipment emergencies. Having an e-Diagnostics command center enables resource centralization. Therefore, rather than having expensive, hard to find expertise located all over the world near customer sites, these experts can be centrally located to handle global support through RM&D and assisting 'generalists' on the site.

e-Diagnostics also positions suppliers to provide new value added services. Increased uptime leads to enhanced Service Level Agreements (SLAs) and extended warranty contracts on a pay for performance basis. Domain experts apply their knowledge to information delivered by e-Diagnostics and create opportunities for preventative maintenance and maintenance part sales. e.g. Based on the trend of critical parameters a domain expert can determine that a machine is likely to fail unless serviced in the next 3 months, or that

upgrading to a new component can increase output for the end user. e-Diagnostics is a enables enhanced supply chain management as well. For example, knowing when a machine/process will require re-supply means not running out of inputs and avoiding costly downtime.

Finally, it is important to remember the power of a closed loop development cycle. Data on customer issues and resolutions can more effectively drive future equipment developments. Aggregate data can compare and contrast similar machines' performance at different sites.

Figure 2 - Summary of Supplier Benefits

Lower costs	New or Increased Value Added Services
T & L Reduction – reach the expert at any location	Enhanced Service Level Agreements
Resource Centralization	Preventative Maintenance
Intelligent Re-supply	After Market Parts Sales
Opportunity Cost Reduction – more time for new development	Knowledge Management
Increased Customer Satisfaction	Data to Decision Makers
Shorter MTTR	Feedback to New Development
First Call Resolution % Improvement	Comparative data across many sites
Faster Commissioning of New Equipment	

End User Benefits

Anywhere a critical process exists, downtime is the bane of that process. First and foremost, if a failure occurs stopping production, a work around to continue with at least limited capacity is sought. This is followed immediately with the desire to return to full capacity. Lost production often costs tens of thousands of dollars per hour or more. Clearly, improving MTTR has a direct impact on this cost. With an e-Diagnostics deployment, time is saved via auto-notification to the vendor of the problem, which in turn allows the vendor to begin working on the solution remotely.

Fixing what is broken faster is a clear benefit, but the true desire is to prevent failures in the first place. e-Diagnostics makes this a reality via continuous data collection and analysis for domain experts. Additionally, preventative maintenance can now be selectively scheduled when it is convenient for the end user. This is often attempted today, but without advance data, it is often unknown as to which equipment really needs the work. Having data to show which equipment truly needs work enables informed decisions to be made about where to apply budget and resources. Users and vendors alike

can make better choices understanding, for instance, which equipment has been used 24/7 vs. what equipment has been relatively idle.

Access to data across multiple facilities leads to several benefits for end users. For example, comparing the raw material usage or output between identical lines in different facilities, along with the ability to drill down on this data can lead to reduced consumption, higher output, and increased quality.

In today's Industrial environment, the equipment used has become increasingly complex and specialized. So much so that to get the most out of the various machines deployed at any one facility requires expert knowledge not only of the process it is used for, but also of the machine itself. It is typically not possible for one organization to have all of this expertise, let alone have it at every physical location it is required. Fortunately, e-Diagnostics enables enhanced collaboration between vendor and customer, so that the end user can leverage the knowledge of various equipment manufacturers to increase yields and productivity. In a well-deployed e-Diagnostics system, this collaboration is enabled while keeping the Intellectual Property (IP) of both parties secure.

Figure 3 - Summary of End User Benefits

Increased Productivity Improved MTTR from: Auto-notification of problem to correct expert(s) Resolution begins remotely, immediately Increase in first contact resolution %	Data and Information to Decision Makers Comparative Data Across Many Sites Reduction of Scrap / Increased Yield Improvement in Quality Greater Best Practice Sharing Between Facilities
Preventative Maintenance Data Showing Device Wear and Time to Fail Appropriate Scheduling of Downtime	Greater Collaboration with Specific Experts Faster Commissioning of New Equipment/Facilities Improved Utilization of Equipment

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