Remote Repair, Diagnostics, and Maintenance

An overview and comparison of the U.S., Japanese, and German machine tool industries.

In a perfect world, engineers would always maintain and repair products from their current locations without ever incurring the costs and time spent physically traveling. Although not currently possible in many situations, industry trends are moving in this direction. What began over 30 years ago as a means for vendors to support users of mainframe computers grew to include applications such as teleservice and tele-maintenance and has now expanded to a wider field referred to as remote repair, diagnostics, and maintenance (RRDM).

RRDM is a broad term that incorporates various technologies and applications. At its most basic, it can be a phone call for simple troubleshooting support. At its most complex, it consists of fully integrated computer and network applications that automatically monitor performance, diagnose problems, and request attention from service technicians for specific problems.

RRDM’s main growth driver was the manufacturing industry [1]. The advent of very complicated and expensive capital equipment such as flexible manufacturing systems (FMS) made it necessary to run those machines at high utilization rates. For example, GM found that the cost-effectiveness of machine tools had dropped by 40% between 1955 and 1975, leading to a subsequent drop in the number of machine tool manufacturers in the U.S. during the 1980s. The ones that remained in business turned to advanced technologies. To improve performance, data links were set up between the FMS and the FMS manufacturer so the latter could quickly troubleshoot malfunctioning machines. The increasing computerization of manufacturing environments further drove the development of RRDM.

Predominant application areas for RRDM include office equipment, building and facility maintenance, computer maintenance, and control of IT and telecommunications networks. For example, Xerox has developed a technology that

1Is GM knocking machinery builders or buyers? [Industry Week], (Apr. 14, 1975), 32.
sends data from high-end copiers to a central service center via phone lines. At the service center, the copier’s status is monitored and maintained by an expert system. Other application areas include PC and computer networks. A popular example for RRDM software includes Symantec’s SystemWorks, which alerts users to suboptimal performance and major problems of their computer systems. Hewlett-Packard and Stratus are capable of remotely monitoring customers’ hardware around the clock without user interaction and send technicians or replacement parts before the machines become unusable. In telecom networks, next-generation digital loop carriers are introducing switches with remote provisioning, monitoring and maintenance capabilities, ensuring a higher level of customer service.

The potential benefits of RRDM are tremendous [7]. In manufacturing, the bottom line of most efforts is to reduce the cost of technical service. For example, RRDM is estimated to save between 20% and 30% of after-sales costs, improve service efficiency, improve customer relations, and aid in expanding manufacturing facilities both nationally and internationally [11]. Lastly, RRDM can provide a cost-effective tool for small and medium-sized machine manufacturers to provide a high service level to their customers without having to incur the cost of international travel and expensive unproductive time spent by their service technicians, which can sometimes reach as much as 50% [11]. Beyond the manufacturing industry, RRDM can provide an efficient way of providing services to consumers. For example, telemedicine is slowly starting to be used to service patients in rural areas in the U.S. that are understaffed by physicians. In addition, firms increasingly outsource RRDM services to countries such as India that possess well-trained and English-speaking engineers employed at comparatively low wages.

Although manufacturers and other industries have recognized the strategic potential of RRDM, surprisingly little literature exists that addresses its overall potential and global growth. The most comprehensive report to date is an industry study of RRDM in Germany and three other countries and available only in German. In addition, a number of noncomprehensive articles have been published in trade journals. In this article, we intend to fill this gap by reviewing potential applications and benefits of RRDM in a number of industries, but focus primarily on manufacturing. We draw upon information from brochures, trade publications, and interviews we conducted with manufacturers to compare how the U.S., Germany, and Japan are using RRDM and subsequently provide our view of the future development and possible applications of RRDM.

**RRDM in Manufacturing in the U.S., Japan, and Germany**

In the U.S., the manufacturing industry drives the spread and further development of RRDM. Due to their capital intensity, complex manufacturing systems must run at high utilization rates. For example, it is estimated that “in continuous-process industries such as chemical plants and oil refineries, RRDM could save U.S. companies as much as $60 billion a year” [1]. In response, some chemical companies have developed their own RRDM systems. Honeywell has designed two systems for chemical plants named Equipment Health Management and Abnormal Situation Management (ASM). Both are sophisticated software packages that constantly monitor important equipment in the plant. Plant operators can monitor their entire facilities from a central control room. The systems also allow Honeywell to monitor customers’ operations centrally from its facilities in Colorado [1].

A key problem in implementing RRDM is that at the hardware level many machine manufacturers use proprietary standards. A National Institute of Standards and Technology (NIST) engineer estimates that “more than 50 manufacturers make sensors that do not work together” [1]. NIST is now trying to bring the industry together and develop common standards. In contrast, on the controller and net-
working level, the U.S. is now working toward implementing Web-based controls [8]. At the contractual level, however, U.S. machine tool manufacturers still prefer an environment “where the customer is a slave to their maintenance policies and prices” [1].

Due to these difficulties and despite the benefits RRDM promises, in the U.S., machine tool manufacturers have been slow in introducing RRDM to the industry. Until now, the application standard is defined by simple remote alarm systems. For example, when running over the weekend without operators present, some machines can automatically page an engineer when operations stop. The engineer then has to travel to the plant to fix the problem.

**RRDM in Japan.** Until the mid-1990s, RRDM was little used in Japan, for several reasons. First, many RRDM solutions were proprietary so that firms were not able to help service their machines and learn from the mistakes [10]. For example, Toyota uses RRDM for its flexible manufacturing systems that feature controllers by Makino. Even though the systems work well, there is little enthusiasm for RRDM at Toyota. One engineer commented they use it because they have to. Due to Makino’s proprietary technology and the complexity of Makino’s RRDM application, it is difficult for Toyota to gain an understanding of the system and build in-house expertise for remote diagnostics.

Another hindrance is that Japanese firms tend to invest in machine tools only after having observed the actual operation of the tool and are convinced that a high level of after-sales service will be provided. Hence, machine tools are often sold with attractive service packages, including 24-hour service and quick replacement part shipments. From the perspective of the machine tool user, the additional value of investing in an RRDM system is limited, particularly since machines are fairly reliable and numerical controllers rarely break down. This slows the diffusion of RRDM even with the advent of more advanced, improved systems.

Yet RRDM is moving slowly toward general acceptance [10]. Several new RRDM systems were developed recently. For example, Hitachi Software Engineering now sells the monitoring system Tel Staff that can announce trouble by means of a computer, telephone, pager, or fax. Machine tools can be repaired by remote control. Mori Seiki and Itochu Systech use video cameras to transmit additional information of a machine’s state via ISDN. Hitachi-Seiki has introduced Universal User Port Ethernet connections for its Sigma controls allowing standard communication between the controllers and any computer. These changes not only impact the functions RRDM systems provide but also the way RRDM is disseminated. In all likelihood, these more user-friendly systems will lead to an increased use of RRDM in Japan.

**RRDM in Germany.** In Germany, RRDM first surfaced in the mid-1980s. It was developed predominantly by machine and component manufacturers. However, due to an expensive telecommunications infrastructure and slow transmission speeds it took until the mid-1990s for RRDM to break through [5].

German machine tool manufacturers are mostly mid-sized firms. Since they sell their products internationally, they are heavily affected by globalization. Service contracts with customers rarely exist. Instead, manufacturers guarantee the machines’ operability and, in case of defects, fix them at no cost to the customer [5]. Few German manufacturers, however, have service centers outside the country. Hence, particularly during the installation and warranty phase of new machines, German manufacturers incur high costs in terms of travel and diminished productivity when sending their engineers to international sites. Moreover, customers usually demand a 24-hour response time, which manufacturers are rarely able to fulfill.

As a result, RRDM is quite important to both the German machine manufacturers and their customers. Manufacturers have begun exploring possibly offering RRDM as a service by allowing special service firms to support their products. Such service firms can provide assistance to customers of various machine manufacturers through both on-site visits and RRDM [5]. Alternatively, manufacturers can provide RRDM themselves and rely on a third party if site visits are required.

RRDM will likely become an even more important issue as machine controllers become increasingly complex and difficult for customers to service themselves. The increased use of RRDM within and outside of Germany will allow manufacturers to increase customer satisfaction; reduce costs (particularly during installation and warranty periods) as well as preventive maintenance and repair; more efficiently use internal resources; support sales; and gain data for product improvements [5].

**International Comparison.** The technological state of the machine tool industries in the U.S., Japan, and Germany is similar. The U.S. machine tool industry, however, “lacks the clear competitive profiles of Germany (specialized products meeting customized demands and “high-end” applications) or Japan (general-purpose products and high-volume markets, with
standardized designs and product lines)” [6]. Regarding controllers, the U.S. and Germany now tend toward open concepts and interfaces while Japanese machine manufacturers still prefer their own, proprietary interfaces [11]. Indeed, documentation of technical standards used in Japan is not easily available [10].

Reasons for advancing RRDM are also different across countries, as apparent from the preceding discussion. While Japanese firms are interested in RRDM primarily to remotely control manufacturing processes and support logistics, the main benefit for German machine manufacturers lies in remote maintenance and repair of systems. One key issue motivating both Japanese and German firms is the concern regarding the cost of travel. In recent years, potential savings in travel costs have driven firms in these countries to substantially invest in the further development of RRDM. In contrast, because the cost of travel throughout North America tends to be comparatively low, travel cost is not typically an issue for U.S. companies and technicians are sent to customer locales more readily than their Japanese or German counterparts.

All three countries recognize the strategic potential of RRDM applications with only long-term benefits [11]. The research support for these long-term applications, however, differs between the countries. In Japan, research is mostly funded by private firms whereas in Germany, local governments have historically provided a great deal of research funding. In the U.S., the federal government supported the further development of RRDM mostly through research funding to NASA, DARPA, and the U.S. military in support of specific space and defense-related issues. NASA and DARPA, for example, were interested in RRDM capabilities for tasks such as remote telemetry, space probes, and satellites. Still, the research of RRDM in the U.S. is more likely to result in incremental rather than revolutionary innovations. The table provides an overall comparison of RRDM in Japan, Germany, and the U.S.

### Outlook

Clearly, various concerns still exist regarding RRDM applications. We now discuss short-term and medium-term developments that address RRDM’s current limitations and may affect its dissemination in manufacturing and other areas.

<table>
<thead>
<tr>
<th>RRDM development: A triadic comparison (sources: [4-7] and interviews with manufacturers).</th>
<th>Facilities, Inc., provide technical support in building transmitter towers. They also provide on-site maintenance and RRDM in such areas as point-to-multipoint and wireless local loop networks.</th>
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<tr>
<td>New Application Areas for RRDM. One major extension of RRDM includes remote computer network management. For example, Phoenix Technologies is currently offering a BIOS extender—a resident software utility that runs and diagnoses problems before computers boot. Even if a boot failure occurs, the software can connect to a remote system via modem or LAN. The remote technician can then examine the system and run diagnostics.</td>
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As the current interest in wireless systems expands, RRDM is bound to control and maintain the hardware of these systems as well. At a basic infrastructure level, there is the need to maintain the cellular transmitters. Companies such as Wireless

### Technological Developments.

Some industry experts believe that the increased use of intelligent software systems using artificial intelligence techniques—such as expert systems and neural networks—will allow the machine to perform more human-like functions such as learning and self-correction. Others are convinced that while a wide interest in artificial intelligence prevailed in Japan a few years ago, many firms have cooled to their use. Still, given the capability of artificial intelligence systems for detecting unusual occurrences, these technologies seem promising for remote diagnostics.

The Internet has become an important component of RRDM systems. The use of the Internet as a communications device provides an inexpensive means of data transfer for the remote maintenance of even complex manufacturing equipment. The advantage of using text-based transmission (such as HTTP) is that the communications medium and protocol on the Web are universal. Hence, any stan-

### Table: RRDM in Japan, Germany, and the United States

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<tr>
<th>Dimension</th>
<th>Japan</th>
<th>Germany</th>
<th>United States</th>
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<tbody>
<tr>
<td>Interfaces</td>
<td>Proprietary</td>
<td>Open</td>
<td>Open</td>
</tr>
<tr>
<td>Technical Standards</td>
<td>Not easily available</td>
<td>Accessible</td>
<td>Accessible</td>
</tr>
<tr>
<td>Geographic Dimension</td>
<td>Manufacturing sites across Southern Asia</td>
<td>Remote maintenance and repair with mainly European customers from Germany</td>
<td>Traditionally less expensive to let technicians travel to locations within the U.S.</td>
</tr>
<tr>
<td>RRDM Application Issues</td>
<td>Recent investment throughout Asia brings Japan nearly on par with Germany in machine tool applications; proprietary standards</td>
<td>Traditionally more advanced in machine tool applications; move toward open standards</td>
<td>Growth toward service applications (e.g., OnStar); move toward HTTP-based standard</td>
</tr>
<tr>
<td>Support of RRDM Research</td>
<td>Supported to a smaller extent</td>
<td>Supported to a greater extent by state governments (Länder)</td>
<td>Not supported in general unless space or defense related</td>
</tr>
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Sources: [4-7] and interviews with manufacturer.
standard software can be used to access and process data [12]. For example, Makino offers an optional remote monitoring system with standard Ethernet connectivity for some machines, thus allowing the controller to connect directly to the Internet or accessing it via direct dial-up. This development indicates a major shift from proprietary to standard controller interfaces.

Lastly, Java further widens the possibilities of using standard Web technology for more complicated applications. “With a Java-enabled servlet located on a remote system containing an embedded processor, the system designer would not be limited to just diagnosing and monitoring a device remotely. A Java-enabled servlet, using the dynamic downloading features of the language, will be able to upgrade, repair, and replace code in the embedded application” [4]. For example, GenRad and ACUNI, market leaders in diagnostics systems for the automotive industry, have announced a collaboration to establish an architecture for remote vehicle diagnostics services using a Java-based open software system.

Finally, RRDM will probably become smaller and more portable in the future. With wireless personal digital assistants, alpha pagers, or integrated cell phones, RRDM can be used on a personal basis. For example, technicians at Lucent’s fiber-optic plant have installed sensors at various positions on the manufacturing line that will output a steady stream of data to their alpha pagers. They can then make adjustments at the other end of the line and immediately see the results, allowing a single worker to diagnose and tune equipment.

Lessons Learned

Firms in the U.S. should focus on the service implications of RRDM. Both GM and OTIS already use RRDM as a service to differentiate their product offerings. Machine tool manufacturers and firms with international manufacturing networks can significantly benefit from using RRDM as a service tool. They can use RRDM to reduce support costs by providing maintenance, with the assistance of untrained workers and without the extremely high costs of sending service teams to remote sites [9]. RRDM can also be offered as a separate service, possibly even by third parties, that may include not only breakdown response but also preventative maintenance as an option.

Businesses using RRDM should embrace the Internet. The advent of the Internet has changed the frequency and ease with which information is retrievable. Its widespread use has led to the adoption of some common communication standards, including TCP/IP and HTTP. This has slowly led manufacturers to offer TCP/IP-based RRDM interfaces. The use of TCP/IP makes it very simple to hook up a machine tool controller to any computer. Moreover, as more controller manufacturers use TCP/IP for their controller-to-controller interfaces, machine tools from different manufacturers become able to communicate with each other. With a unified user interface, engineers can then control and diagnose machines either on-site or remotely by using a simple Web browser [2]. The relatively low costs and high data transmission rates of even low-tech connections such as analog DSL make the Internet an excellent potential tool for offering in-depth RRDM services. In an extension to this trend, academics have already begun to develop a theoretical, Web-based structure that would include remote prototyping, service, and security systems for manufacturing [8].

Businesses should look for RRDM to become common in technical support centers. Some experts expect that in a few years time, RRDM may become widely available through technical call centers, much like hotlines for customer support in the computer hardware industry [3]. This commoditization will also reduce the cost of RRDM systems and further contribute to their dissemination. Another factor promoting the acceptance of RRDM in service centers is the increasing complexity of both machines and controllers. Similar to the increase in complexity in automobiles, this phenomenon will make it too difficult for firms to fix their machines themselves and instead make them more dependent on machine manufacturers. For manufacturers, service centers can provide a cost-effective means of servicing their
customers quickly and without wasting the valuable time of their service technicians traveling to customer sites [2]. In certain cases it is even possible to outsource this service to locations in countries such as India.

Look for RRDM to “trickle-down” into more basic products and services. For example, the use of RRDM by heating and cooling firms will allow them to service home HVAC systems remotely. This is a simple extension of the service OnStar is providing to car owners. Since the U.S. market is increasingly consumer services oriented, these types of applications will be especially important to U.S. firms.

Conclusion
The bottom line for all firms is clear. Whether firms are involved in manufacturing or not, it will soon be time for managers to start thinking about taking advantage of the possibilities RRDM has to offer. Experts agree that the “benefits are numerous. The use of long-range diagnostics will undoubtedly increase rapidly” [7].

References