Wireless Condition Monitoring
The Business Case for Wireless Sensor Systems
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It's all about the Dollar$!

"Unscheduled downtime is the largest single factor eroding plant performance. Over $20 Billion, or almost 5 percent of total production, is lost each year in North America alone due to unscheduled downtime."

~ ARC 2002

Today's hot topics of plant management discussions concern business continuity, machinery reliability, Overall Equipment Effectiveness (OEE), Reliability-Centered Maintenance (RCM), Preventative and Predictive Maintenance (PM or PdM) and a host of other acronyms relating to improving plant operations. In support of these program initiatives, companies are finding that their existing Maintenance, Repair and Operation (MRO) programs can be improved by employing wireless remote monitoring and diagnostic systems. Indeed, remote monitoring via the Internet can help companies cut production costs, improve quality, minimize downtime and increase their operational efficiency.

In fact, remote monitoring and the Internet have gained widespread use by plant CM personnel over the past few years, as evidenced by the following survey:

Results of a survey conducted by Philip Higgs, Research Student at Loughborough University, UK

| Is your condition based monitoring system connected to a network for remote access? |
|---------------------------------|---------------------------------|
| Yes                             | 84 (39.81%)                     |
| No                              | 127 (60.19%)                    |

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<th>Can your condition based monitoring system be accessed through a company Intranet or over the Internet?</th>
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Just 5 years ago, these numbers would probably be a fraction of what they are today. In addition, these numbers have room to grow over the next 5 years.

Thanks to the Internet and telecommunications networks, plant personnel can collect and analyze data from remote or offsite locations, providing the ability to monitor and protect plant assets. Cutbacks in maintenance staff and the new wave of computer literate maintenance technicians are driving the adoption of new technologies in condition monitoring. Unlike their predecessors, the new breed of maintenance technician is more likely to adopt new wireless technologies. In
addition, the growing shortage of maintenance experts is creating a parallel demand for remote access to vital condition data. The new wave of maintenance technicians is demanding remote access to machinery condition information.

Constantly asked to do more with less, technicians are turning to wireless technologies to perform their jobs effectively. This "grass roots" approach underscores the acceptance of wireless technologies even while their management does not understand the benefits of these technologies. Indeed, there is a great degree of confusion among consumers and corporations regarding the value, applications, reliability, security, and maturity of wireless technologies.

For example, Deloitte Consulting surveyed more than 650 business executives across Europe, North America, and Asia recently. Deloitte found that 51 percent of respondents did not understand the benefits and uses of wireless technology. Twenty percent of those surveyed blamed the maturity of wireless technology, saying that companies are not confident it has been developed sufficiently. However, 75 percent of employees in the survey stated that wireless could increase revenues and productivity and 79 percent stated wireless could improve their roles.

Although wireless sensors have been around for years, they have been in an infancy stage until recently due to primitive radios and bulky, complicated sensors. Now that advanced radio frequency integrated circuits are available (less than $3 in high volumes) and smart sensor integrated circuits are becoming widespread, the wireless sensor market is poised to take off.

Within the next ten years, wireless sensors will be used in a range of applications that are only limited by our collective imagination. According to a report by emerging wireless research firm ON World, more than half a billion nodes will ship for wireless sensor applications in 2010. ON World also projects that by 2010, wireless sensors will also be widespread for consumer markets such as monitoring and controlling heating, lighting, venting and appliances. This Machine-to-Machine (M2M) market will help drive down the cost of wireless sensors for industrial plants because of the sheer size of the M2M market.

Looking specifically at Asset Management and Condition Monitoring, the worldwide market, which totaled almost $900 million in 2002, surpassed $1.3 billion at the end of 2007. It is expanding at a Cumulative Annual Growth Rate (CAGR) exceeding 7 percent, according to a study by the ARC Advisory Group.

Wireless sensor technology will greatly reduce the complexity of linking the outputs of condition monitoring sensors to current Process control systems. The population of equipment able to be monitored continuously will expand, and control room operators will be able to determine the current condition of the bearings or alignment or balance or gears on an individual machine.

Certain standards, such as OLEPC (Object Linking and Embedding for Process Control) are currently used for integration of Process Control Data with Condition Monitoring data. In order to achieve greater integration, wireless systems for Condition Monitoring and Process Control must to be able to interface with one another using common standard protocols.
In summary, we now have new maintenance technicians using the internet for remote diagnostics, while at the same time the markets for condition monitoring are growing, and we have a need for standards to communicate between the plant floor and remote diagnosticians and management. Fortunately, most of the “backbone” of standards is in place with the current state of the internet. That leaves only the so-called "last mile" for communications standards, and the IEEE (among others) is working with vendors to establish this connection.

A new architecture called mesh networking, which is based on low-cost, low-powered radio transmitters and combines the performance of wired networks with the economy of wireless networks. Mesh networks can carry data in short "hops" between radio powered modules embedded with networking intelligence. These hops enable mesh networks to bypass interference by finding new paths around any interference the signal encounters.

Wireless Mesh Sensor Networks are being deployed today in various monitoring and control applications. Low-cost RF components, advances in low-level system integration and protocol standardization have made deploying mesh sensor networks affordable. Wireless building control systems that form multi-hop, self-configuring networks are monitoring air-quality levels and securing valuable assets in commercial buildings. In the Industrial sector, applications are being pursued in asset management, industrial safety and condition-based monitoring. Wireless mesh sensor networks resemble a canopy over industrial machines, when viewed from the top, as shown at right. *Courtesy Sensicast Networks, Inc.*

**Wireless System Case History – Paper Machine Suction Roll Drive Side**

In January 2008 a suction roll was tested in a rebuild facility using a wireless system. The system consisted of a wireless node with six regular accelerometers wired to it, along with a power cord. The node is wirelessly connected to a laptop computer where the analysis is performed in real time. The total set up time was less than 10 minutes and in actual practice would be less than 1 minute. Data was taken at a series of roll speeds since this was an acceptance test. The wireless range is approximately 1 mile to the receiver, without using any other nodes. If other nodes had been used, the range would be extended through the mesh network capability of the nodes, effectively indefinitely.
A bad bearing was found on the drive side of the roll. When the suction roll was at slow roll, we can clearly see that impacts are the dominate energy content of these waveforms. The vibration peaks increased about 5-fold from the peaks recorded at 200 RPM to the final speed of the roll, which was considered excessive. The bearing was replaced with a new one, which was tested and accepted.

Note that the end user (paper plant, in the above case) demanded that vibration analysis be performed as a test of acceptance of the roll. (Fortunately, as it turned out). Wireless condition monitoring techniques are witnessing strong demand as organizations across the globe are using such solutions for improving their performance from plant assets. Technological developments such as circuit miniaturization, battery power, faster processing capabilities and open communication protocols as well as advanced software are resulting in less expensive, enhanced condition monitoring solutions. Improvements in wireless and sensor technologies, along with the market acceptance of modular, open-architecture systems are expected to further drive down costs.

The expanding use of the Internet as a prominent report delivery mechanism (pdf’s) and medium for plant personnel and management interaction (WebEx, Glance, IM) is also aiding wireless sensor system expansion. Plant technicians will want to drill down to the sensor system, grab the data and collaborate (or in some instances, commiserate) with each other, perhaps in the same room, perhaps remotely.

Intelligent, informed repair or replace recommendations made by experienced analysts (either remote or in-house) to management will enable them to make sound decisions that apply to, and are integrated with, the overall business strategy of the plant or corporation. Development of the wireless sensor system "canopy" (mesh network) will be an enabling technology to the plant in achieving these goals, which will in turn provide them with a path to world-class performance. Sure beats the alternative – encountering premature machinery failure, which was narrowly avoided in the case history presented here. Cost Avoidance is hard to quantify, but it really is all about the dollars!