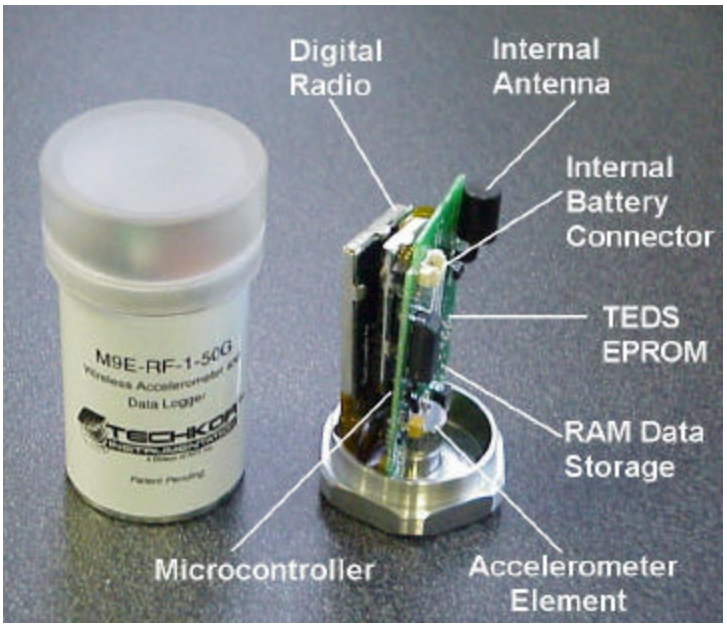
Wireless Condition Monitoring Sensors

Not just for difficult applications



The cutaway of the wireless accelerometer shows the major components of the sensor. The complete sensor on the left includes an internal battery (not shown on right) and a durable, environmental resistant package.

Wireless sensing no longer needs to be relegated to locations where access is difficult or where cabling is not practical. Wireless CM systems can be cost effectively implemented in extensive applications that were historically handled by running routes with data collectors. The result would be a lower cost surveillance program with more frequent data collection, increased safety, and lower spare parts inventories. Facilities would be able to run leaner because they will have more confidence in their ability to avoid downtime[1].

Cost justification

The key to widespread CM sensors is low cost: both installation and operating costs. Data collectors are considered by many to be the lowest cost method for monitoring vibration. With monthly or quarterly route running, companies can prevent many failures and provide an acceptable cost justification to management. While the installed costs of data collectors are typically the lowest, operating costs are higher due to continuing labor expense. When analyzed over a period of time, the overall cost of a data collector system will be comparable to a low cost surveillance system, such as wireless CM sensors[2]. In addition to comparable costs, wireless systems provide more frequent readings for better identification of short time-to-failure situations.

Cost justifications for many predictive maintenance practices tend to be complex and rely on some intuition, fudge factors, and an experienced practitioner/consultant. A

traditional method for vibration analysis is to assess the speed degradation to failure and the cost consequence of the machine's failure[3]. This method is well proven, but as technology changes, the justification chart also changes. On-line surveillance systems have become more cost effective, so they have migrated down to the data collector area where there is more overlap of appropriate systems (Figure 1).

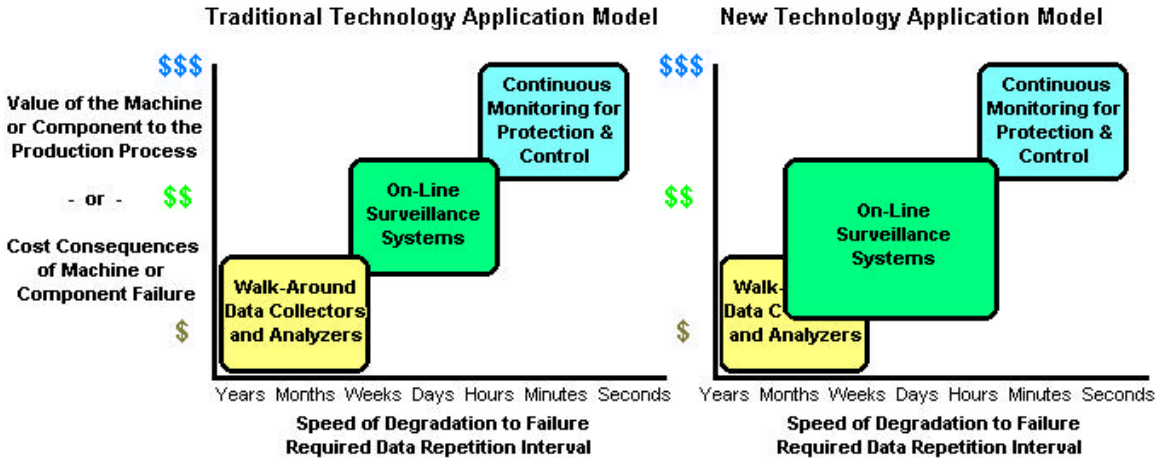


Figure 1. The Traditional Technology Application Model evolves as technology reduces the costs of on-line surveillance systems. Low-cost wireless sensors provide the same cost per point as data collectors while providing more frequent readings.

An example of good candidates for a lower cost surveillance system are a blower motor on top of a furnace or a drive motor protected by heavy guards. The cost to analyze the furnace blower or drive motor might include hard-wired accelerometers, cables, and a switch box (totaling several hundred dollars). Companies are electing to install on-line surveillance systems on the more difficult applications, because these areas are expensive to analyze with data collectors. A low cost wireless accelerometer allows more of these applications to be monitored.

Paradigm shift

These traditional cost justifications only touch upon a portion of the benefits of widespread CM sensors. Much like cellular phones, low-cost, wireless CM sensors can change the way manufacturing facilities are run. Many companies understand the importance of vibration analysis, but only apply it to critical applications. The most expensive or rapidly declining components are monitored, but these companies still experience unplanned stoppages because the entire facility is not being monitored; a $100 motor, for example, can shut down a $10,000 / hour production line.

Many facilities account for unplanned downtime with excess production capacity. In petrochemical and petroleum refining plants, up to 10% of production capacity is required to account for unplanned maintenance[4]. For typical heavy process industries, unplanned downtime costs can represent 1-3% of revenue, potentially 30-40% of profits, annually[5]. Widespread usage of condition monitoring sensors can provide up-to-date machine condition so that unscheduled downtime can be significantly reduced. Maintenance tasks can be coordinated with production stoppages so that most, if not all, stoppages can be planned and optimized.

Ease of implementation

Very few companies can afford to implement any type of widespread system. Capital investment is not the only consideration, but also installation costs, training, documentation, spare parts, and cost of production losses. The key for widespread implementation is ease of installation and ease of maintenance of the system.

Wireless sensors must have:

- Plug-and-play connectivity
- Intelligence to assist with start-up and maintenance
- Ease of expansion
- Long life

Plug-and-play connectivity means physically installing the sensor, turning it on, and configuring. In the case of a wireless accelerometer, attaching the sensor with a standard ¼-28 threaded mounting stud and plugging in the battery. The sensors are configured at a main computer, which should take less than a couple minutes per sensor.

Intelligent sensors and software that assist with start-up and maintenance are also important for ease of use. A wireless sensor should be able to determine a path back to the main computer database without configuration by an operator. System components such as repeaters should work seamlessly with no operator interface required. Sensors mounted within range of several transceivers should allow overlapping and be error tolerant. As network conditions change the system should also adjust and adapt so that data collection remains reliable without operator interface.

The next step in widespread implementation is an easy-to-expand system with no discrete input limitations (8, 16, 64, etc.). Companies can purchase and install a handful of sensors on a monthly basis. Installation doesn't require extensive planning or extended shutdown periods. Sensors can also be relocated very easily.

Battery life becomes very important when dealing with large quantities of sensors. Power management is critical to battery life because frequently replacing batteries on hundreds of sensors would be unmanageable.

Typical installation

A possible installation scenario might be a manufacturer who has considered an on-line system for 50 points on critical components. While not being able to justify the $1,000 per point installed costs of a wired system, a $750 per point wireless system is more manageable. Included with the 50 wireless sensors are transceivers and software that can be used for additional sensors, so future wireless sensors are only $500 per point or less.

Next, the plant overhauls a production line. Due to infant mortality rates during wear-in periods, 100 wireless sensors are installed to monitor the refurbished production line for several months. By documenting saves during the wear-in period, cost justifications can be determined in that short period of time. After a sufficient wear-in period, the 100 sensors can either remain where they are or be redistributed to other areas of the plant. A reasonable plan would be to start with the most critical bcations and work towards the less critical. By simply installing a number of sensors every month on fairly critical applications or installing on overhauled equipment, a plant can slowly work towards complete coverage. Over several years, a plant could install hundreds of sensors that will eventually provide a complete picture of the plant equipments' health.

Overall plant health data can be included with production information so that facilities will run more efficiently. Process control parameters are already present and provide valuable production data. By incorporating this data with predictive maintenance data, plant managers will have access to not only the existing condition of the factory, but also how degrading equipment is affecting production. A motor might still have a couple months of useful life, but if the motor begins lowering product quality or increasing scrap rates, managers can make the best decision for plant performance.

With complete coverage of condition monitoring sensors, unscheduled downtime due to maintenance failures can be greatly reduced. In addition to traditional cost savings, widespread usage of CM sensors will have additional benefits, particularly a reduction in excess production capacity. The key to widespread usage of CM sensors is the ease of installation and low cost of ownership.

References

1. Christopher McLean and Dave Wolfe, "Intelligent Wireless Condition-Based Maintenance," *Sensors,* June 2002, p 16.

2. Christopher McLean and Dave Wolfe, "How Wireless Condition Monitoring Sensors Can Change How Factories Operate," Tenth Annual Society of Maintenance and Reliability Conference Proceedings, pp 129-133.

3. Bob Craft, "Appropriate Use of Wireless Technology in Condition Monitoring," SKF *Revolutions,* Volume 9, # 2, pp 4-5.

4. Brad Law, "Asset Management and Condition Monitoring," Bently-Nevada *Orbit,* Second Quarter 2000, pp 18-21.

5. David R. Bell, "The Hidden Cost of Downtime," Smart Signal White Paper, February 2001, p. 1.

The Maintenance Watchdog™ System

The Techkor Maintenance Watchdog system (shown below) operates thousands of wireless sensors utilizing the 902-928 MHz license-free band. In large quantities, the cost of the sensor is less than $ 400. With plug-and-play connectivity and a sensor battery life of more than 3 years, a system of thousands of sensors can be easily maintained.

Wireless accelerometers sample data and send it to the network access points for upload and storage on a primary control PC. The network access points connect to the factory LAN with standard Ethernet connections. Simply, provide an Ethernet hook up, assign an IP address, and provide 120 Volt power.

Techkor wireless CBM system including accelerometer, laser tachometer, network access point, and repeater.

Operators can monitor sensor data, be informed of alarm conditions, and configure parameters from the convenience of a standard PC. The ODBC compliant database engine provides a method of interfacing with various existing software packages.

The wireless CBM system addresses cost, reliability of RF communication, battery life, ease of configuration, scalability, and intelligence, all while retaining the accuracy, bandwidth, and robustness of traditional sensors. The wireless CBM system includes accelerometers, laser tachometers, and network access points. Repeaters are used where necessary.