Accenture Asset and Operations Services

Data Integrity: Enabling Effective Decisions in Mining Operations

High performance. Delivered.
Measurement is fundamental to process control in many industries, and it is especially so in mining. To work efficiently, plants need to constantly track several process variables—flow, temperature, level, pressure, pH, weight and so on—and keep measurements stabilized in the desired ranges so that processes run correctly.

Across industries, the number of variables being measured automatically by sensors is growing quickly. Cisco Consulting Services estimates that by 2020, 40 percent of all data will come from sensors. Companies are adding new measurements and calculations to every process, monitoring things such as on-line noise, vibration, humidity, chemical elements concentration and ore-size distribution. This expansion is enabled by the declining costs of sophisticated sensors and the advent of image processing-based measuring devices.

In this environment, uncertainty about measurements can be a significant issue. Defects or anomalies in instruments can cause measurements to be unreliable, making it difficult to ensure that the data being collected is accurate. If it is not, it will introduce errors into downstream calculations and make process control ineffective. Key performance indicators (KPIs), material balances, production reports and performance dashboards will not provide accurate information, which will impair effective decision-making—and cause users to have less confidence in information systems.

On the other hand, the ability to identify poor-quality data and detect instrument failures has the potential to help reduce downtime, improve maintenance, accelerate troubleshooting processes, and support effective, fact-based decision making. The question is how can companies develop those capabilities quickly and implement them as an automatic function? The answer lies in using today’s digital technologies, including smart instruments.
The Contribution of Digital Technologies

Smart digital instruments represent an evolutionary step forward from conventional analog instrumentation, and they differ from the traditional approach in three fundamental aspects. First, they are not limited to measuring and transmitting the value of only one process variable, such as temperature. Instead, they also have the ability to diagnose their own internal health, detecting failures in sensors, electronic boards, communications and in some cases, the process they are measuring. Second, they can communicate bi-directionally, sending and receiving data over the network. And third, they can store valuable data such as equipment type, supplier and model; engineering characteristics; date of calibration; and other useful information. This basic information set is called the electronic data sheet.

Figure 1 shows examples of the types of information that smart instruments—based on digital instrumentation standards—can provide.

The main objective of smart instrumentation is to provide automatic diagnostics of field devices in order to understand their condition and reduce unplanned maintenance. Condition-based monitoring systems are used to track each device from the time it is installed to the time it is decommissioned.

To help companies take advantage of smart instruments, the International Society for Automation is developing ISA-108, Intelligent Device Management. This standard is designed to help companies make use of new technologies and realize the full potential of digital plant asset management.

Figure 1: Smart instrumentation offers a rich set of diagnostics and alerts.

Environment Diagnostics
- Supply Pressure Alerts
- Temperature Limit Alerts

Electronics Diagnostics
- Drive Current Alerts
- Drive Signal
- Processor Impaired

Sensor & Valve Diagnostics
- Travel Sensor Alerts
- Pressure Sensor Alerts
- Pressure Fallback
- Temperature Sensor Alerts
- Travel Deviation Alerts
- Travel Hi/Lo Alerts
- Proximity Limits Alerts
- Cycle Counter Alerts
- Travel Accumulator
- Performance Alerts

Source: Accenture
Automation Asset Management

The monitoring of digital equipment is conducted on three levels. At the lowest level, the individual instrument is monitored. At the intermediate level, the control loops are monitored. At the highest level, the whole production unit is monitored.

At the intermediate level, process companies are using control loop performance monitoring tools that can detect problems and support control loop diagnostics and tuning. A control loop is a triplet formed by a controller, typically implemented in a Digital Control System (DCS) or Programmable Logic Controller (PLC)—along with a measurement instrument and a control valve.

At the highest level, the health of the entire operating unit is supervised. In the mining industry, an operating unit corresponds to a set of equipment and control techniques used to perform a single process—for example, a crushing circuit, a grinding circuit, a flotation cell, a thickener or a stacker. Production-unit monitoring requires a model-based monitoring and diagnostic application, such as a multivariate statistical performance monitoring application. The process of monitoring instruments or automation devices (control networks, intelligent relays, power converters, etc.) in order to detect abnormal conditions is called automation asset monitoring.

The specialized diagnostic tools used for each of these levels are often different, but Accenture uses the same health management, web-oriented interface to address all three levels.

Figure 2 shows a possible basic architecture for an asset management solution, in which production equipment and instruments are treated in a standardized manner. Ensuring data integrity is a key element in such a solution.

Figure 2: Asset management architecture

Source: Accenture
Focusing on Data Integrity

As discussed, digital smart instruments make valuable process data available, including internal diagnostics—and they have the potential to bring significant improvements to mining operations. In practice, however, such instruments are by no means the norm in the industry. The use of traditional analog instrumentation that transmits only the value of the process variable (PV) in a closed 4-20 mA loop is common practice. Figure 3 illustrates the difference between device diagnostics of a conventional measurement supplied by a smart instrument and a measurement diagnostic supplied by an abnormal behavior detection algorithm.

Even if traditional 4-20 mA instruments are used, it is possible to automatically detect some “bad patterns” when using these traditional instruments (Figure 4). When such patterns emerge, it affects an instrument-level KPI called the “measurement confidence level.” If that KPI is low, it indicates potential problems with the measurement data. Of course, the rich electronic data sheet provided by smart equipment can enable deeper insights into data quality.

In general, the techniques used for detecting abnormal conditions in instrumentation fall into two categories:

**Univariate**
Analyzes just one isolated variable time series, and no process model is used.

**Multivariate**
Analyzes a combination of correlated variables as a set, using statistical or first-principle models. These models can express material and energy balances, gross-error analysis or statistical models such as Principal Component Analysis (PCA), Projection to Latent Structures (PLS), Similarity-Based Model (SBM) or others.

Accenture has developed a library of algorithms that can be used to detect instrument failure, diagnose abnormal situations and send notifications to a maintenance team. The library currently includes univariate-based stalled signal detection, outlier detection, variable out-of-range detection and rate-of-change/out-of-range detection. Multivariate algorithms detect inconsistent measurement and bias in weight meters. The algorithms also provide several reports that document and trace problems, calculate equipment availability and manage how much time it took the maintenance team to normalize the condition.

The list of abnormal conditions detected is still growing as additional algorithms are being developed.

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**Figure 3:** Smart instruments provide the process value, complementary digital information and diagnostic information. Conventional analog instruments track only the process variable.

**Figure 4:** Possible abnormal signal patterns

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**Asset Tree**

- **Instruments**
  - **KPI**
  - **Status**
  - **Failure**
  - **Diagnostic**
  - **Impulse line clogged**

- **PV**
  - **12.34 bars**
  - **Cf=0%**

This is the device diagnostic

This is the measurement diagnostic

**Source:** Accenture

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**Source:** Device in a process system for determining statistical parameter, Patent No 6,539,267 B1 Mar 25, 2003, Evren Eryurk and Jogesh Warrior
As mentioned previously, data integrity is a discipline within an asset-management solution, which also encompasses production equipment and instruments. Within the asset management application, devices are shown in an asset tree, based on the ISA-95/ISA-88 standards, that facilitates the aggregation of KPIs. The upper levels of that tree are synchronized with the enterprise’s plant maintenance system. For each asset, an effectiveness KPI is calculated.

For each piece of digital equipment, a KPI related to that equipment is calculated. The equipment involved can be anything from a belt conveyor, hauling truck or stacker to digital or analog instruments and devices such as PLCs, smart relays, frequency inverters and control networks. These KPIs are typically named OxE, with x standing for the asset being monitored.

OCE, for example, means Overall Controller Effectiveness, ODE means Overall Device Effectiveness, and so on (Figure 5).

An asset-monitoring KPI is calculated with the function $KPI = f(PA, U, A, P, Q)$. Here, the variables are:

- **PA**: Asset Physical Availability
- **U**: Asset Utilization
- **A**: Asset Activeness (for sensors)
- **P**: Asset Performance
- **Q**: Quality (only for sensors)

This KPI summarizes the equipment’s behavior for operational decision makers. With these types of KPIs in use, companies can also explore new approaches to managing assets and suppliers, including the implementation of the asset-as-a-service concept.

With this approach a company can hire a compressor or a belt conveyor scale, for example, and pay only for the time the equipment is working properly—using the asset condition KPI to track equipment uptime.

**Figure 5: Example of an asset tree and OxE indicators**

![Asset Tree Diagram](source: Accenture)
Data Integrity and the Digital Revolution

Digital technology is disrupting the mining industry and bringing new opportunities to reduce costs and improve production and safety. Ensuring data integrity is an important element in taking advantage of this revolution.

Today, automation systems are collecting rapidly growing volumes of data. Creating a single version of the truth to achieve efficient operations requires an effective condition-based monitoring system—making data integrity a critical capability for miners.

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References


ISA-108 does not focus on a specific protocol, but covers all intelligent devices.


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