Improving availability

with PlantWeb® digital plant architecture

PlantWeb digital automation architecture improves process availability by using *predictive intelligence* to help you detect and avoid causes of equipment failure that can lead to unplanned downtime. It also helps you improve control and maintenance, for shorter, less-frequent planned downtime and faster startups after shutdowns.

The challenge: Reducing downtime

Many plants operate below their maximum profit potential, often because of inadequate process availability.

Availability is simply a way to quantify how much of the time your process is up and running as it should be:

$$\text{\% Availability} = \frac{\text{Actual production time}}{\text{Possible production time}}$$

The higher the availability, the more you can produce – and the greater your return on assets.

The enemy of availability is downtime. The greatest loss comes from **unplanned downtime** or outages caused by equipment failure or process upset. In such situations, you often have to find what caused the problem before you can fix it. Extensive repairs or cleanup can also delay your return to production.

But even **planned downtime**, such as for routine maintenance and repairs during scheduled shutdowns, eats into production time -- especially if it comes too often or lasts too long. The same is true of **longer-than-necessary** startups after a shutdown or grade change.

Causes not always obvious

Sometimes it's easy to point to the immediate cause of downtime. A pump failed. A key measurement was lost. The process exceeded safety constraints. A scheduled shutdown took too long.

But what led to these situations? Answers typically fall into three categories:

Equipment problems. Over time, even the best equipment can fail because of wear or damage – causes that can be hard to detect before it's too late. What's surprising is that many failures also occur early in the equipment life cycle, often because of improper installation, calibration, or startup.

Operations problems. Process conditions and events trigger many outages, either directly or by causing equipment failures.[1] These operations-related failure sources include

- Constraint violations
- Interruptions in feed, fuel, steam, or power
- Coking, fouling, freezing, plugging
- Corrosion or tube leaks
- Process transitions
- Operator errors

Maintenance problems. Basing maintenance programs on the calendar or run-time rather than actual equipment condition can mean shutting down the process (or extending a shutdown) for work that may not be necessary. When there *is* a problem, finding the cause can be a lengthy process. And maintenance actions themselves can result in equipment contamination, misalignment, and other errors that lead to premature failure – and more downtime.

What if you could minimize these sources of downtime in your operation?

Higher availability = higher profit

Even the best plants have some downtime. What makes them the best is keeping availability as high as possible.

In fact, when major operational drivers such as productivity, feedstock costs, fuel or energy costs, emissions compliance, and waste disposal costs are taken into account, availability is the factor that differs most between the worst- and best-performing plants. That difference covers a span from as low as 72% availability to as high as 95%.[2]

Across industries, best- and worst-performing plants have significantly different levels of availability. [2]

	Quartile			
Process Type	Worst	3rd	2nd	Best
Continuous	< 78%	78 - 84%	85 -91%	> 91%
Batch	< 72%	72 - 80%	81 -90%	> 90%
Chemical, Refining, Power	< 85%	85 - 90%	91 -95%	> 95%
Paper	< 83%	83 - 86%	87 -94%	> 94%

If your plant is **capacity-limited**, higher availability lets you boost output to meet demand -- without investing additional capital in production facilities. That's a sure-fire way to increase profit and ROI.

Consider a typical plant that generates $500 million per year in revenue at 85% availability. Each incremental hour of production is worth approximately $67,000. If variable costs are 60% of total cost, almost $27,000 of that added revenue is operating profit. In this case, increasing availability from 85% to 90% (reducing downtime by 438 hours per year) would boost annual profit by more than **$11.7 million.**

If your production is **market-limited**, on the other hand, higher availability can enable you to use fewer assets to meet existing demand. For example, output levels that previously required five production units might be met with only four – reducing operations and maintenance costs, allowing you to use your most efficient units to meet demand, and freeing the other unit to make other products.

Keeping those units up and running also means fewer efficiency-robbing outages, reducing costs for fuel or energy, materials, and scrap or rework. You'll also gain the flexibility to expand production quickly when higher demand levels require it.

Finally, with higher availability, you won't have to maintain as much **excess production capacity** to allow for downtime. One worldwide refiner has estimated that 10% of their capital is in place to compensate for unscheduled downtime.

But if the benefits are so great, why hasn't every plant already maximized availability?

The information situation: Too little, too late

The best way to increase availability is to detect and correct potential problems *before* they cause downtime. The problem is that early warning signs of these problems can be hard to spot – especially if you're limited to the information available through traditional automation architectures.

A traditional control system can't show you much more than the process variable and any associated alarms or trends. You don't know what's happening in the equipment itself. If an instrument's signal falls within the expected range, for example, it's assumed to be working properly.

But such assumptions can be risky. The signal could have drifted. A sensor may be reading the pressure in a plugged impulse line rather than the process. A control valve may not be responding properly. Unless an

experienced operator notices that something "doesn't look right," the problem may continue until the equipment fails or the process exceeds constraints – causing unexpected downtime.

Stuck with the wrong strategy

Without a clear view of actual equipment condition, plants are largely limited to reactive and preventive maintenance strategies.

Reactive maintenance -- also known as "run to failure" or "fix it when it breaks" -- obviously runs the risk of unplanned downtime when equipment fails. The time and cost to repair (or replace) failed equipment can also be much higher than if problems were detected and fixed earlier.

Calendar or run-time based **preventive** maintenance ("fix it just in case") can reduce the risk of unplanned downtime, but servicing equipment that doesn't need it yet increases the length and frequency of *planned* shutdowns – as well as the risk of maintenance-induced problems.

A typical plant caught in the reactive/preventive maintenance cycle may have plant availability as low as 70-75%, with annual maintenance costs that can exceed 15% of asset replacement value.[3]

Contrast these approaches with a **predictive** maintenance strategy that constantly monitors equipment condition and uses the information to predict when a problem is likely to occur. With that insight you can schedule service when it will have the least impact on availability, such as during a planned shutdown – but before the equipment fails or causes a process upset.

A best-practices plant uses predictive maintenance for most equipment where condition-monitoring is practical, limiting reactive and preventive strategies to equipment that's not process-critical and will cause little or no collateral damage if run to failure. Such a plant can have availability as high as 95% and annual maintenance costs below 2% of asset replacement value.[3]

Before that can happen, however, you need a way to access and monitor equipment information so you can detect potential problems in time.

The answer: Predictive intelligence

With its PlantWeb digital plant architecture, Emerson Process Management offers technology and services that enable you to see what's happening in your equipment and process, identify conditions that lead to

What makes PlantWeb different from other automation architectures?

- It's engineered to efficiently gather and manage a new wealth of information – including equipment health and diagnostics – from intelligent HART and FOUNDATION fieldbus devices, as well as a broad range of other process equipment.
- It provides not only process control, but also asset optimization and integration with other plant and business systems.
- It's networked, not centralized, for greater reliability and scalability.
- It uses standards at every level of the architecture -- including taking full advantage of FOUNDATION fieldbus.
- It's the only digital plant architecture with proven success in thousands of projects.

For more about the architecture and what it can do for you, visit **www.PlantWeb.com.**

downtime, deliver the information wherever it's needed, and take action to maximize availability. We call this *predictive intelligence*.

Providing new insights. Digital technology makes it possible to access and use new types of information that go far beyond the PV signals available through traditional automation architectures. With PlantWeb architecture, both the breadth and depth of this information are unprecedented.

It starts with intelligent HART and FOUNDATION fieldbus instruments – including transmitters, analyzers, and digital valve controllers – that use on-board microprocessors and diagnostic software to monitor their own health and performance, as well as the process, and signal when there's a problem or maintenance is needed.

But PlantWeb doesn't stop there. It also captures information on the condition of rotating equipment such as motors and pumps -- from shaft speed and vibration to temperature and lubricant condition -- and uses the data to identify machine-health problems such as misalignment, imbalance, gear defects, and bearing faults.

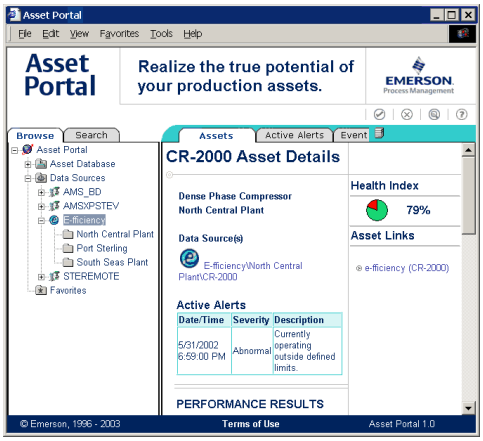
Other tools provide insights on the performance and efficiency of process equipment like heat exchangers, compressors, turbines, distillation columns, and boilers.

Integrating information. PlantWeb uses communication standards like HART, FOUNDATION fieldbus, and OPC, as well as integrated software applications, to make this new wealth of process and equipment information available wherever it's needed for analysis and action – all within the same architecture.

For example, AMS™ Suite: Machinery Health Manager software consolidates machinery information and trend data for faster, easier troubleshooting and maintenance of rotating equipment. AMS Suite: Intelligent Device Manager software provides similar functions for field devices like valves, transmitters, and analyzers.

To make problem detection even easier, PlantWeb integrates many types of equipment information in a single browser-based application, AMS Suite: Asset Portal™. The information is accessible by anyone who needs it, including technicians in the maintenance shop, operators in the control room, or other personnel and applications throughout the plant and business.

AMS Asset Portal provides an integrated view of health and status information from multiple types of instruments and equipment.

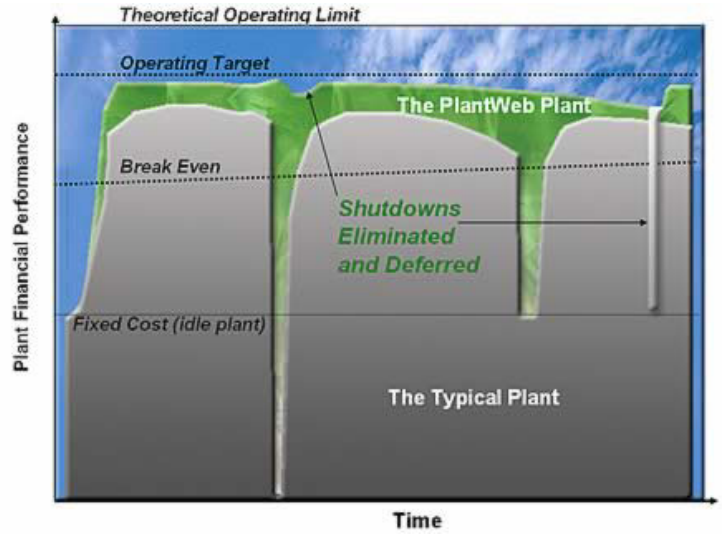


When potential problems arise, targeted online alerts help ensure that the right people get the right information right away – but other users aren't bothered by nuisance alarms. PlantWeb can also send synchronized alerts to applications such as operations historians and maintenance systems, making it easier to establish a cause-and-effect relationship between process events and equipment conditions.

Our DeltaV™ and Ovation® automation systems also use digital intelligence to provide rock-solid process control as well as ensuring operators and others get the information they need – reducing risks of process- and operator-induced downtime.

Maximizing the advantage. In addition, Emerson offers a full range of services -- from monitoring, troubleshooting, maintenance, and repair to technical training and equipment optimization -- to help you take full advantage of PlantWeb's capabilities and sustain the improvements over the life of your plant.

PlantWeb architecture helps reduce both planned and unplanned downtime, so you can keep your process up and running at its best.



In short, PlantWeb architecture's predictive intelligence reaches into the field, monitors and predicts the performance of plant assets, and integrates the information into the architecture to help you …

- Reduce unplanned downtime
- Extend the period between planned downtimes
- Shorten the length of planned downtime
- Speed startup after downtime

Let's take a closer look at each of these four ways PlantWeb improves availability.

Reducing unplanned downtime

PlantWeb helps detect conditions that can lead to equipment failure or a process excursion -- *before* you're faced with an unexpected shutdown.

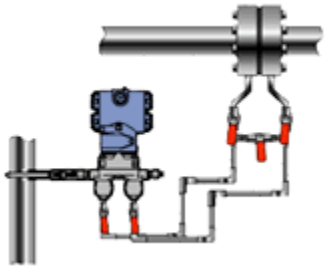
For instruments using FOUNDATION fieldbus technology, this capability starts with automatically labeling the device's signal status as **good**, **bad**, or **uncertain**, so you'll know when the device needs attention, and have early warning that an invalid measurement may be threatening process stability. The DeltaV and Ovation systems use this early warning to avoid controlling off bad data and can automatically make adjustments to keep the process running smoothly.

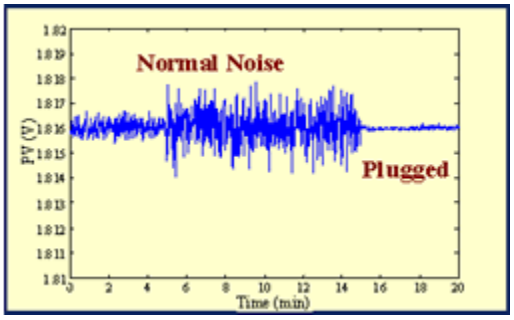
But instrument signal status is just part of the picture. PlantWeb's full set of online and offline tools enables monitoring, diagnostics, and notification of problems for a wide range of HART and FOUNDATION fieldbus instruments and other process equipment.

Bearing failure, for example, is a common problem with rotating equipment. But PeakVue technology in AMS Machinery Manager can detect and identify the very high-frequency noise associated with the earliest stages of bearing wear. You get maximum warning of future problems, before increasing damage significantly increases the cost (and possibly time) for repairs.

In pressure transmitters, impulse-line plugging can block the instrument from reading actual process pressure. Instead, it reads the pressure in the plugged line – leaving you and your control system "blind" and at risk of a process trip if the actual pressure changes beyond what's allowable. PlantWeb uses special diagnostics in the transmitter to detect plugged impulse lines and immediately alert you to the problem.

*With a **plugged line diagnostic** based on statistical process monitoring, PlantWeb detects conditions that can lead to equipment failure or a process upset.*





Freezing can cause similar problems. If heat-tracing fails, for example, liquid can freeze in the impulse lines or even in the cell of a transmitter, where it can cause bursting. Monitoring sensor temperature and alarming on low temperatures, a standard capability in many of our transmitters, can help eliminate this type of failure.

Plugging isn't just an instrument problem. One of the most frequent causes of failure in control-valve actuators is loss of air. A diagnostic similar to that used to detect plugged impulse lines in transmitters enables Emerson digital valve controllers to detect a plugged air supply to the actuator -- and head off a process upset when the valve can't respond as it's supposed to.

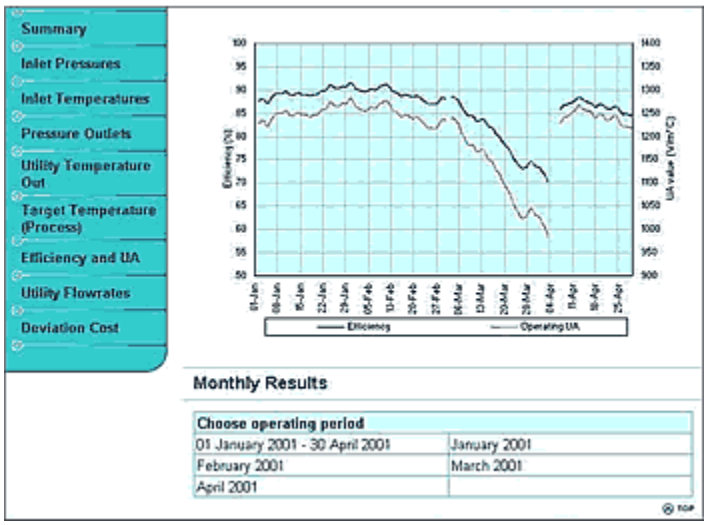
PlantWeb's monitoring and diagnostics capabilities also enable you to predict potential problems in larger process equipment.

For example, if a heat exchanger fouls to the point where there is insufficient flow to run the process, the unit will shut down. Even temporary fouling can cause a loss of capacity that can lead to process disturbances and a resulting trip.

AMS Suite: Equipment Performance Monitor detects and reports performance deviations and loss of efficiency in heat exchangers (as well as compressors, turbines, and other process equipment). It provides a clear trend of performance, so you can see when the unit will have insufficient capacity to run the process – in time to schedule maintenance before conditions deteriorate far enough to cause a shutdown.

PlantWeb diagnostics have also shown their ability to detect conditions leading to a catalyst circulation upset in a fluidized catalytic cracker (FCC) unit – 30 minutes in advance. The total loss from such an upset, including repairs and downtime, can approach $8 million.

AMS Performance Monitor provides a clear view of performance trends so you can see problems developing – before they result in unexpected downtime.



Some unplanned downtime results from instruments and systems that can't measure and control the process adequately or reliably enough to keep it running smoothly within constraints.

PlantWeb can help here, too. Emerson's measurement instruments, analyzers, valves, and valve controllers have a well-earned reputation for accuracy and reliability – and PlantWeb's diagnostic capabilities make it easier than ever to keep them at their best. Our DeltaV and Ovation automation systems add powerful but easy-to-use regulatory and advanced control, and offer multilayer redundancy for in-depth protection from system failures. With many of Emerson's FOUNDATION fieldbus instruments, you also get the option of using control in the field to further distribute control functions or provide backup for system-based control.

The Model Predictive Control technology in DeltaV Predict software not only helps maintain smooth control in applications with excessive dead time, constraints, and loop-to-loop interactions. It also models sequences of process events to detect when current conditions indicate a problem is coming. And autotuning in the Ovation and DeltaV systems helps eliminate tuning problems that can cause plant upsets and trips.

The DeltaV system can notify operators, maintenance personnel, and others as appropriate when human intervention is required to correct problems before they cause unexpected downtime. This capability, called PlantWeb Alerts, relies on powerful software in Emerson field devices, AMS Suite applications, and DeltaV to immediately analyze the incoming information, categorize it by who should be told, prioritize it by severity and time-criticality, and then not only tell the recipients what's wrong but also advise what to do about it.

Extending the period between planned downtimes

Even if equipment problems don't cause unexpected outages, dealing with them can force you to schedule maintenance shutdowns so frequently that availability suffers.

One way PlantWeb architecture extends the time between scheduled shutdowns is by helping you detect and avoid conditions that can **shorten equipment life**.

A common cause of premature transmitter failure, for example, is exposure to excessive temperatures. A 10 degree C increase in steady-state temperature can reduce the life of electronics by half. But PlantWeb's temperature-monitoring and alarming capabilities can alert you to the problem in time to find and remedy the cause.

Excess vibration can shorten the life of rotating equipment. In a plant that was experiencing premature failures in the motor and gear train to a pump, PlantWeb's vibration monitoring tools revealed a resonant coupling between the motor, the gearbox, the pump, and the mountings. This caused very high vibration levels at certain turning speeds. With this insight, the startup procedure was modified to bring the equipment through the critical speed range very quickly – substantially eliminating the premature failures.

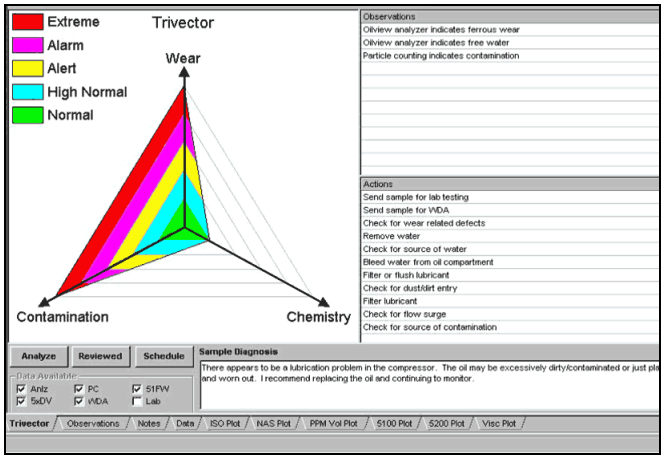
Process variability is an often-unrecognized factor in shortening equipment life, especially for control valves: The more often the valve has to move to compensate for process variation, the more wear on its trim and other components. The precise control provided by our instruments, valves, and automation systems minimizes this problem.

PlantWeb can also help avoid **installation- or maintenance-induced** problems that cause equipment to fail prematurely.

For example, improper installation of pumps, motors, and related equipment can result in shaft misalignment and imbalance that reduces equipment life by as much as a factor of 10. Emerson tools and services for laser alignment and equipment balancing help ensure that shafts are coupled center-to-center, and that vibration levels are low at operating speeds and loads.

Rotating-equipment life can also be shortened by wear that begins with improper cleaning or other contamination during maintenance. Our wear-particle analysis of lubricating oil can detect the type of wear and the exact location so you can head off premature failures.

AMS Machinery Manager's trivector analysis combines multiple information types to help pinpoint equipment-life-shortening conditions such as bearing wear.



Shortening the length of planned downtime

As PlantWeb enables you to shift your emphasis from reactive and preventive maintenance to predictive maintenance, one of the benefits will be shorter planned shutdowns. That's because with PlantWeb's predictive intelligence you'll **know in advance** which equipment needs attention and which doesn't, so you can avoid doing unnecessary work that would prolong the downtime.

For example, control valves are often serviced or rebuilt as part of preventive-maintenance programs during scheduled shutdowns. But one study showed that almost 70% of valves pulled for rebuilding didn't actually need it.

Knowing each valve's actual condition enables you to identify the ones that need extensive work during a shutdown – and which don't.

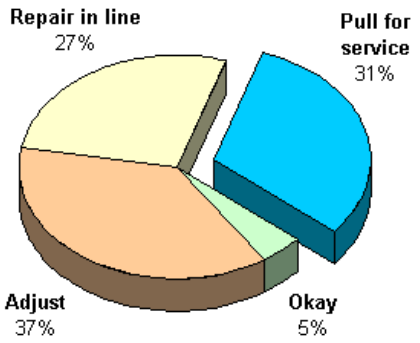


Chart based on sample of 230 valves scheduled for overhaul.

With PlantWeb valve diagnostics, you can check each valve's performance to determine if wear, stiction, or other conditions call for maintenance at the next scheduled opportunity – or if you can leave that valve alone this time and get the process back online that much sooner.

Diagnostics can identify not only which equipment needs work, but also the nature of the problem. Knowing in advance whether a valve's poor performance is caused by trim wear or by too-tight packing, for example,

shortens troubleshooting time in the field as well as enabling you to plan work more efficiently and have appropriate parts on hand when scheduled downtime begins.

AMS Device Manager software also helps shorten scheduled downtime by streamlining tasks such as instrument calibration. And its automatic documentation capabilities reduce the time your technicians spend on data entry and other paperwork.

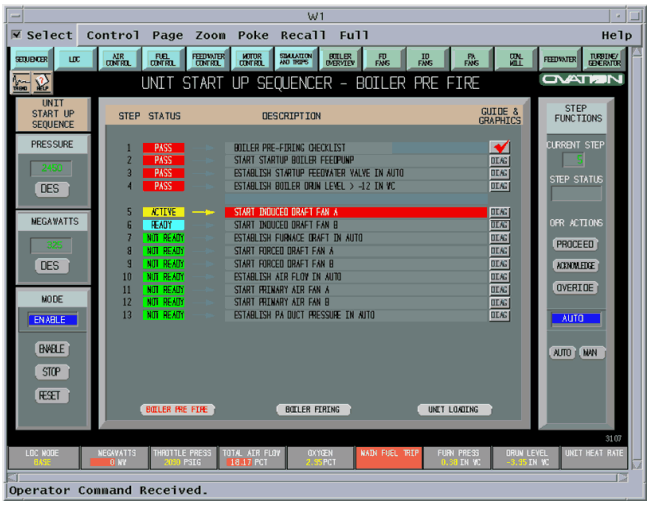
Finally, Emerson can provide a broad range of **services** to help speed turnarounds as well as ongoing maintenance – from performing remote or onsite diagnostics, to carrying out repairs and maintenance, to training your staff on how to make the most of new technologies and work practices.

Speeding startup after downtime

After a shutdown, PlantWeb can help bring your process back to full production as quickly as safety and plant constraints allow. This not only increases total availability, but also reduces the energy, fuel, material, and scrap or rework costs of starting up and lining out the process – which can be twice as high per hour as shutdown costs. The same benefits apply to grade changes.

The DeltaV and Ovation automation systems deliver these gains by automating the startup sequence. They smoothly bring the process and equipment to the appropriate state for each step in the sequence, then automatically move to the next step without the delays that can result when operators control the startup sequence manually.

Automatic logic minimizes human error and helps ensure a smooth startup.



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Automating startup can also eliminate human errors that can cause equipment damage and downtime. In effect, it's like having your best and most experienced operator running the startup -- every time.

Real projects, real results

Better process availability is one of the reasons users have chosen PlantWeb architecture for thousands of automation projects. In plants, mills, refineries, and other operations around the globe, it's helping keep processes up and running with less unplanned downtime, shorter and less-frequent planned downtime, and faster startup after shutdowns and grade changes.

Here are just a few examples:

- "If we had major breakdowns in the past, we had to shut the whole plant down. With this new system, we've got a window on what's actually happening in the plant – and we now feel we can get to problems before they are breakdowns."

  - Brewing company, Australia

- "Without AMS [Device Manager] software, maintenance would have shut down the process for four or five hours to replace a valve that was in perfectly good working condition. The cost would have been more than just for the replacement valve and the crew's time. It would have included several thousand dollars per hour of lost production time."

  - Chemical processor, U.S.A.

- "After installing Ovation we significantly increased plant availability by decreasing steam temperature variation. This reduced scheduled plant outages from tube leaks."

  - Utility, U.S.A.

- "[PlantWeb] allows us to come closer every day to our sought-after 100% availability. Because the system is so integrated into our process, we sometimes forget what an impressive amount of work it is doing for us."

  - Solvent producer, France

- "We immediately eliminated downtime losses. And we calculate payback on the system, based on previous downtime, at 1.8 years -- a rather quick return on our capital expenditure."

  - *Paper maker, U.S.A.*

For additional case histories and proofs of PlantWeb architecture's capabilities, visit **www.PlantWeb.com** and click on "Customer Proven."

Taking the next steps

As you can see, PlantWeb architecture clearly helps increase availability. And the benefits are significant. But how do you get started?

Begin by assessing where you are. How many potential production hours per year do you currently lose in downtime, both planned and unplanned? What are your primary sources of downtime? (An Emerson availability audit can help here.) What is your current mix of reactive, preventive, and predictive maintenance? To what extent are you using diagnostics and equipment monitoring? How do your maintenance costs stack up to industry benchmarks, or to similar operations in your own company?

Next, determine where you want to go. Are you currently market-limited or capacity-limited? What's the value of an incremental hour of production? Which units in your operation are likely candidates for improvement? How much would you gain by increasing their availability to best-in-class levels? Who in your organization would support or sponsor a project to make that happen?

Then work with your local Emerson team to identify which PlantWeb technologies and related services can have the greatest impact on your operation's availability, and how we can put them to work for you.

If you'd like, we can even help you with the assessment and goal-setting portions of this process, including developing the business case for increased availability.

References

1. George Birchfield, "Olefin Plant Reliability," Aspentech.
2. Fluor Global Services – Benchmark Study – NA, AP, EU, 1996.
3. Dennis Berlanger and Saxon Smith, "MRG business case for reliability," as published at http://www.reliabilityweb.com/rcm1.

Other resources

- Improving availability is just one of the ways PlantWeb helps improve process and plant performance. It can also help increase throughput and quality, as well as reducing cost for operations and maintenance; safety, health, and environmental compliance; energy and other utilities; and waste and rework.
  www.PlantWeb.com – then click **Operational Benefits**

- Availability is also a major factor in Overall Equipment Effectiveness, a structured metric for process performance. Emerson Process Management's free online learning environment, PlantWeb University, offers a 5-course introduction to OEE.
  www.PlantWebUniversity.com

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