From information overload to data-driven decisions:

How to put your manufacturing data to work

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INTRODUCTION

You can't fix what you haven't measured, and you can't measure unless you collect, correlate and analyze the right data.

What is the right data? That's a trick question – all the data is the right data. Collecting it is seldom a problem. Discrete manufacturers have been collecting data in various ways from their production line processes and equipment for decades. But not all data is the same, nor is it useful in the same way. The challenge is to get all the data flowing in an integrated and organized way so people can understand it and gain quick insight to take timely action.

In a digital smart factory, this happens with ease. Today's data management and analytics tools have substantially reduced the cost and complexity of unlocking the full potential of your data.

What you will get out of this e-book

The data gap:

Identify whether there is a gap between the data collected in the plant and the ability to lever that data to quickly trace and address the root cause of any issue impacting quality or yield.

PART 1 →

Turn big data into better data:

How to use your part data to maximize its utility for real-time visibility and insight to address the needs of the hour on the production line.

PART 2 →

Put that data to work:

What data management and analysis tools and capabilities do you need?

PART 3 →

The Sciemetric advantage:

How we help manufacturers bridge the gap between data and insight to drive continuous improvement.

PART 4 →

PART 1

The data gap

There is a gap in industrial data management today where part data is not collected and organized in a cohesive fashion to drive quality and efficiency improvements in the plant. Part data is often trapped in silos up and down the line, neglected, even discarded, after it has been used for basic pass/fail determinations for a process or test.

But manufacturers can cost-effectively deploy the tools that will allow them to bridge this gap and maximize the utility of this data.

Signs that you have gaps to address

Consider these questions:

How long does it take to determine the root cause of an issue to deal with a quarantine, quality problem or other situation?

If trying to track down the root cause of an issue that has affected quality or productivity takes days or weeks, you may be missing data that would allow you to get to a faster resolution.

Are you overwhelmed with data you can't use?

Despite understanding the value of production data and making an effort to collect it, many manufacturers lack the tools to retrieve and analyze their data to quickly trace root cause when quality issues affect production.

Do you have databases scattered across the production floor, all with different data types, making it difficult to review the data?

Many manufacturers suffer with a hodge-podge of database systems sourced from different vendors or built in-house. They lack the tools to parse this data into a standardized format and flow it in real-time into a centralized database for rapid analysis.

Is setting up test stations a matter of guesswork or trial and error?

Setting up a test station, or even commissioning a whole new product line, can be executed in a fraction of the time it once took using data analytics software that can automatically calculate statistically based limits and the correct processing algorithms.

Does your team struggle to make the right tradeoff between cycle time and repeatability?

By the same token, modern data analytics can mine your archive of stored data, to conduct a range of tests and simulations without having to run additional parts through a process to validate parameters. Review that historic data and run those simulations to see where and how a test cycle can be shortened without impacting quality assurance. This boosts productivity and can reduce the number of test stations.

How easily can production and test data be compared and overlaid to visualize a problem?

These same tools come with visualization capability that makes it easy to rapidly compare and overlay hundreds, if not thousands of process signatures. Quality engineers can quickly find trends and patterns that reveal the "how" and "why" of decreases in yield, then test and apply refinements to test limits or other upstream quality control benchmarks.

Are any test stations plagued by false passes or false failures?

Many quality engineers don't know the Gage Repeatability and Reproducibility, or Gage R&R, of their test stations, such as leak. Many, frankly, don't want to know because they fear how poor it may be. We encourage our customers to focus on the first R – repeatability.

By focusing first on Gage R you can exclude all the controllable variables that can impact the test regardless of the equipment – sealing variations, operator behaviors and so forth. The goal is to determine what the test system – including the part and connectors – is capable of in the absence of all these other external variables. Once you have confidence in your test equipment, you can systematically tackle the controllable variables to improve the second R, reproducibility.

The key to mastering Gage R lies with data – you must collect and analyze the part data generated by the system through each test cycle, just as you would for any process on the line.

Did you say yes to any of these issues?

A single yes is a sign that there is a something missing in the plant's approach to data collection and the tools to use it.

The next step

Just as ERP, MES and OEE significantly improved data collection and analysis to improve decision-making, the fourth industrial revolution (Industry 4.0) takes data collection for manufacturing to a whole new level. While traditional systems remain an important part of the manufacturing ecosystem, new digital tools that can push standards higher are becoming more common and more economical to implement.

The goal is to close the gap between the presence of a quality issue, awareness and resolution.

The right data collection for the job

There are many types of systems that collect data on a production line, each with a different role and focus. Many are about recording processes or production without being specific to the parts being manufactured. Others perform specific functions. Some examples:

- MES and ERP systems are needed to collect data from across manufacturing and the enterprise. Because of the breadth of data – from raw materials to finished goods – their depth is unsuitable for hands-on analysis to fix quality or productivity issues.
- OEE is useful for managing the health of a machine and its maintenance schedule and for reducing inefficiencies and downtime. What it doesn't do is directly monitor or measure what is happening to the parts.
- Some SPC systems include databasing functionality or the ability to draw from a range of sources. Critical to monitoring trends in production to spot deviations and provides insight through statistical correlations.
- Historians are featured in many different variations and typically are time-based. They're useful for recording trends and production information though limited in the impact they can have on identifying root cause of an issue and for traceability.
- Machine-specific databases are very common as many vendors have their own approach to capturing the data from their stations. These can be good tools on their own but don't necessarily provide a full view of the manufacturing process.

PART 2

Turn big data into better data

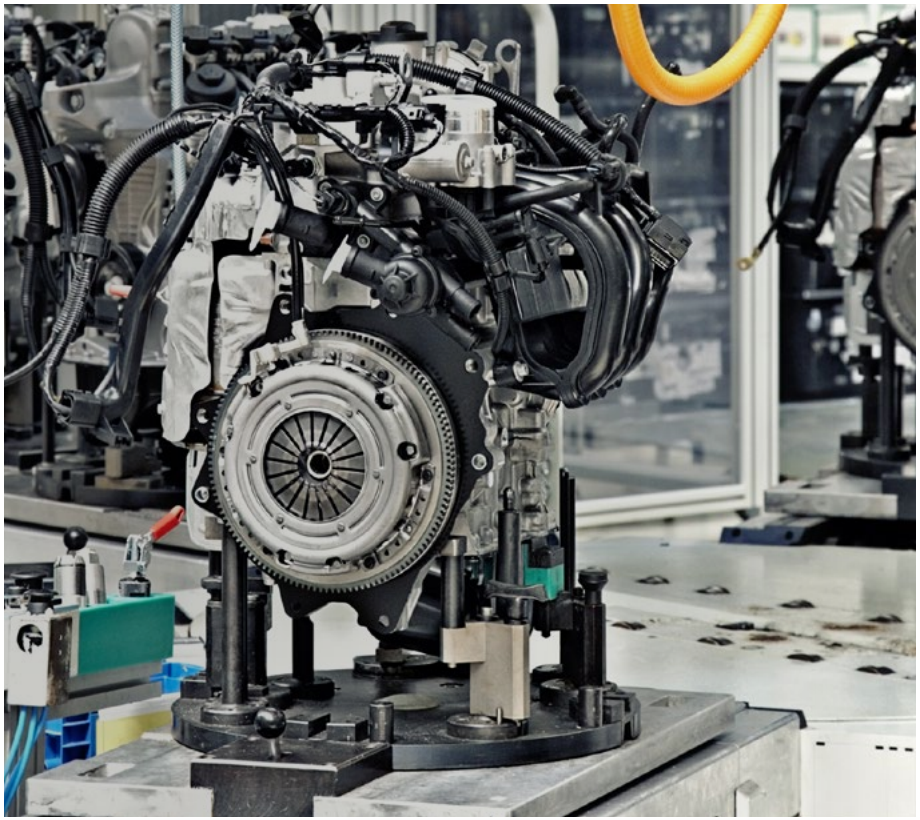
As discussed in **Part 1**, volumes of production parts data that is collected often isn't used to its full potential. Consider the following best practices:

Use your part production part data, as much of it as possible: Every cycle of every process and test station on the line generates data related to the part being produced or tested, including scalar, digital process signatures and images.

The more data you collect, the more insight you have into what has happened to that part at every assembly step. Anything that happens upstream can have a bearing on a problem that arises further downstream.

Take an engine assembly that fails a leak test. What is the cause of the failure – a faulty gasket due to improper dispensing, an improperly installed gasket due to incorrect position, bolts that didn't tighten down correctly, poorly machined surfaces due to excessive vibration at a machining center? How many different gaskets and bolts are we talking about?

Getting to the root cause of this flaw could require investigation of a dozen or more machining, dispensing, fitting and rundown operations, each with its own dataset. By having all the datasets relevant to a part collected into a single birth history record and indexed by part serial number, tracing root cause won't be a nightmare.



Consolidate the data: Bring all of the data together and consolidate it into an accessible structure. A modern data management and analytics platform has the capability to ingest data from disparate sources – it is flexible and agnostic. This will eliminate the data silos and allow you to scale down what it takes to manage the data, i.e., the various types of software and hardware on the production floor.

Standardize the data reporting model: Having a standard data model for your plant floor systems greatly simplifies implementation and assures project success by levering standard off-the-shelf reporting. For instance, if your data model standard identifies traceability to a specific part by serial number (highly recommended), this will ensure all tooling suppliers program their logic controllers accordingly, or have the appropriate barcode readers/scanners or part-marking systems in place.

Consolidating data from multiple processes into a single source makes it easier for front-line workers and plant managers to access the information they need.

Digital process signatures bring data to life

By capturing and using the entire waveform, or digital process signature, generated during each cycle of a manufacturing process or test, much more accurate and reliable pass/fail decisions can be made by the operator. Instead of just a few data points, pass/fail can now be determined from hundreds of thousands of data points.

Take a hockey game with your favorite team on the ice. A contentious goal is scored and the referees go upstairs for a review of the play to decide if the goal will count.

Now, what would you prefer as the basis for that decision – an instant replay or snapshots of only a few isolated points in time as the puck passed through the goalie's crease?

A process signature is that full replay, while scalar data offers only a few snapshots.

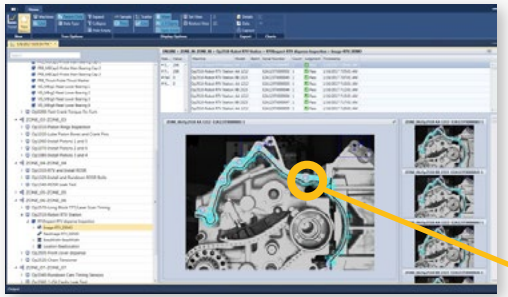
This full replay ensures parts are produced, tested and assembled with objective and repeatable criteria. The data can be analyzed on the spot to be certain a product matches customer specifications. The archive of all the various types of data for a part, process or test can be used to prove quality compliance or to minimize the scope of recalls and repairs.

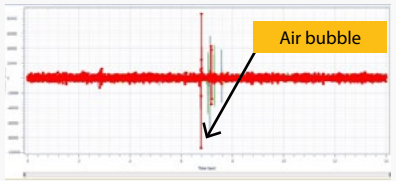
A part failure can easily be distinguished from a test malfunction. Detailed, signature-specific mathematical modelling can be used to find anomalies that require further investigation, pinpoint where problems occur during a process, and even optimize a test station by understanding how to shorten the test.

Leak Test Station

Fastening Station – Bolt 3

RTV Bead Dispense and Inspection Station





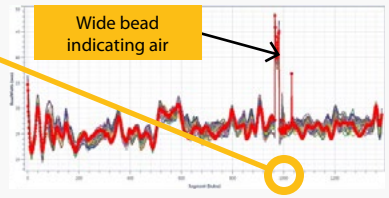


Figure 1: In the above example, there is an issue caught at leak test. The signature data from the upstream processes – the RTV sealant dispense, dispense inspection and bolt fastening stations that went into creating the seal – provide visual information that can be interpreted to identify root cause. See how the bead dispense pressure, bead width and location and fastener torque angle waveforms clearly characterize the process and enable engineers and operators to quickly diagnose the root cause of the leak.

PART 3

Put that data to work

How many *addressable* issues can you spot?

This is a true story.

A manufacturer of agricultural machinery struggled to make effective use of its production data without any consistent and centralized means of data collection, storage and retrieval. Scalar pass/fail data from end-of-line engine hot test cells would end up in one silo, entered manually and indexed by time and date stamp. Further up the line, some process stations, such as torqueing for bolts, did collect full process signatures, indexed by serial number, but this data ended up trapped in a different silo.

These silos included a self-built SQL database as well as vendor-specific databases that lacked the functionality and connectivity to quickly pull full birth history for a part or unit by serial number. The data wasn't lost, but any exercise at retrieval and analysis to address an issue was a search for the proverbial needle in a haystack that required custom query tools.

The entire global operation suffered from a mashup of databases and data retrieval systems. Each plant operated with its own standards, processes and metrics for quality management. A quality engineer at a plant in Mexico could do nothing to help their counterpart in France who had an issue with a comparable machine or line because there was no standardization across the enterprise.

When a product came back from the field due to a customer complaint or warranty issue, it routinely took as long as a week to retrieve all the related scalar and waveform data scattered across the plant.

The result? A lengthy feedback loop to trace the root cause and scope of a quality issue. This created uncertainty and lengthy production delays since the manufacturer didn't want to take the risk of continuing to ship what could be defective products. In one example, a faulty gear system caused high-risk issues for customers in the field. Full production was halted until the cause of this defect could be found and addressed. That took several weeks – money and time wasted.

A checklist to live by

This above example encapsulates the pain points common to many discrete manufacturers. They understand the value of production data and attempt to collect it, but they lack the tools to retrieve and analyze the data to quickly trace root cause when quality issues impact production. Data that can't be retrieved, correlated and analyzed on demand is of limited value, regardless of how much is collected.

When evaluating a modern digital data management and analysis platform on which to standardize and consolidate quality assurance and process improvement in your factory, seek the following:

- **Data is accessible:** All the data related to a specific part, assembly or finished product can be quickly pulled by serial number. This is referred to as the full birth history.
- **With web-based access:** Quality and production staff should have access to web-based tools for analysis – data is not trapped in silos or accessible only through specific workstations.

Data that can't be retrieved, correlated and analyzed on demand is of limited value, regardless of how much is collected.

✔ **And real-time insight:** Data should be accessible in production real-time, which we define as within one cycle of when the cycle ended.

✔ **To support quick reporting and dashboarding:** Dashboards and smart alerting systems can quickly give notification if processes are drifting out of control.

✔ **With easy visualization for overlay comparisons and trending:** Many systems capture and store signatures as flat image files and lack on-demand visualization tools. Data must be exported into spreadsheets, in which each test or part has its own tab with its signature's waveform image. There is no way to overlay and correlate these images. Making any sense of this pile is time-consuming and frustrating.

With the right data management tools, signatures can be converted into histograms that can be correlated with other data types associated with the part to illustrate the profile of a good part and the range of acceptable deviation. This makes it easy to create and visualize a baseline against which to compare all parts.

The more signatures you have, the easier it becomes to understand what anomalies to watch for and what they signify.

✔ **So you can determine your top priorities:** With this kind of insight, plant staff can apply the 80/20 rule to determine which adjustments or refinements on the production line will have the biggest impact to improve quality.

This is called the Pareto Principle. In Figure 2, production problems are organized from left to right in order of importance or occurrence with a Pareto chart. The old 80/20 rule is usually true of most processes, meaning 20 per cent of the effort can fix 80 per cent of the issues – the chart helps to understand this quickly.

When applied to managing quality, this exercise helps quality practitioners focus their attention on the issues that will have the greatest return.

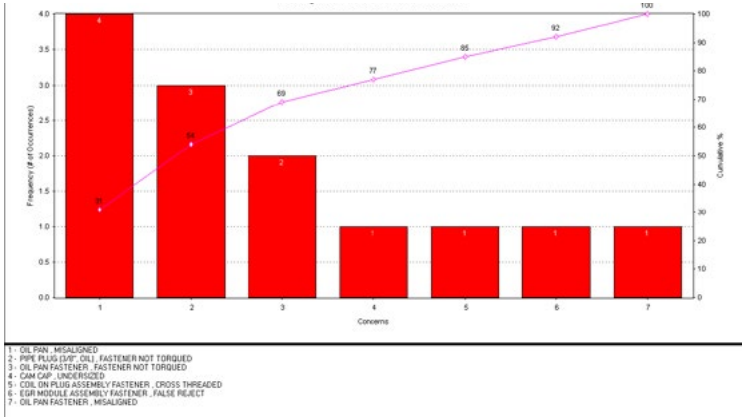


Figure 2: A Pareto chart provides an overview of the top priorities to address

What organized and correlated data allows you to do

With the right tools, here are some of the day-to-day benefits you can expect:

Set up new test systems quickly with objective data for limit setting and management: At one component company, it took weeks to find the correct test limits for an automotive sensor – it even took days for a simple calibration. By adding signature analysis capability to the test system already installed on the line, scalar data and the associated signatures could be collected and analyzed together. The data analytics software did the work to automatically calculate statistically based limits and the correct processing algorithms within *30 minutes*.

Test "what-if" using historical data without affecting production: It's easy to also review such historic data and run simulations to see where and how a test cycle can be shortened without impacting quality assurance. This boosts productivity and can reduce the number of test stations.

In Figure 3, a manufacturer was only looking for peak breakaway torque as part of a torque to turn test. Analysis showed that ending the test cycle sooner would have no impact on quality. By adding a new test and terminating the cycle based upon this result, a seven-cycle savings per eight-hour shift could be achieved. For this plant, that amounted to a production increase of 132 parts per month.

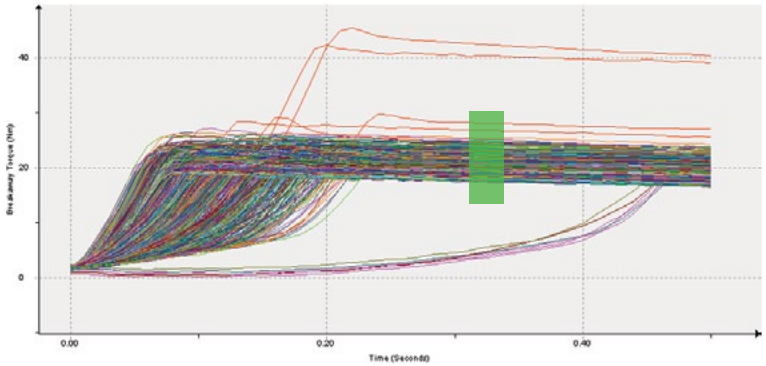


Figure 3: The green highlight shows where the cycle can be safely ended without affecting quality

Troubleshoot and run off new equipment and new lines faster: This is particularly valuable for large manufacturers that may be launching lines with 50, 100 or even 500 machines strung together. One weak link will hold up the entire line.

Bottlenecks can be identified immediately. Root causes can be diagnosed and eliminated systematically. New control limits can be verified and easily adjusted. Process signatures from the new line can be matched against existing ones to give a strong indication of conformance.

Compare, manage performance for parallel stations or like stations…anywhere: Innovations in one plant can be reliably applied to other plants, providing a many times increase in yield. We worked with one customer that could launch new lines around the world an average of four times faster, for estimated average savings of US$4 million per plant, using its data in this way.

In addition, don't suffer the consequences of the same problem occurring twice. Once the root cause of a production or quality issue has been identified, the comparable process, test or machine on other lines or at other plants can be adjusted before they can suffer the same problem. Learn the lesson once, then apply it as often as needed for continuous improvement.

You can also avoid situations where additional parallel process or test stations must be installed and staffed to maintain quality and production quotas. Any insight from your data that enables seconds to be shaved from each cycle of a process or test can yield substantial savings in equipment and staffing costs.

Visualize the problem and fix it: For example, a fuel rail leak was detected at an automaker's plant. This slowed production and caused a quarantine situation for thousands of vehicles. Analyzing the test data revealed that all failures were marginal passes. This meant they had just barely passed the quality tests. In this case, the test limits being used on the test stand were those originally supplied by the part designer and had not been monitored after production startup.

The quality manager used one week of manufacturing test data to assess the impact of applying more scientific statistically-based limits. It was determined that tightening the test limits would have caught the faulty fuel rails and yet would have had a very minor impact on throughput. Two months' worth of part data was retested, applying the new limits to identify other suspect parts.

Three additional suspect parts were found and their serial numbers forwarded to the assembly plant. Production resumed at full speed since confidence in the parts had been restored. Not only was this urgent bottleneck addressed, but the potential recall situation by end customers was entirely averted.

Learn the lesson once, then apply it as often as needed for continuous improvement.

Quality you can prove: More and more, component manufacturers must provide proof to OEMs that show their parts/sub-assemblies meet specifications and don't pose a quality risk. When a potential recall arises, it is all the more important to be able to quickly demonstrate compliance to the spec or analyze the data to determine whether the component issue can be traced and fixed.

PART 4

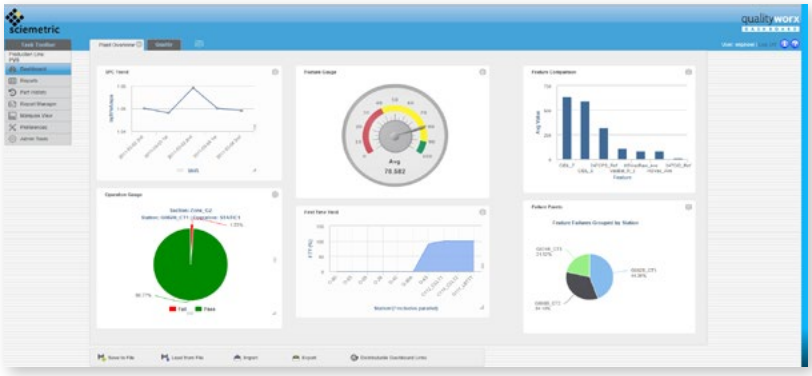
The Sciemetric advantage

When problems happen on the production line, you need to take immediate action – and you need to be able to trust the choices you make. Data-driven decision-making is the most reliable path towards faster issue resolution and factory optimization.

At Sciemetric, data is in our DNA. For over a decade, we've been showing some of the world's leading manufacturers in automotive, off-highway and medical how to collect data – the right data – and how to make practical use of it to achieve the greatest impact on some of their toughest challenges for quality and productivity. First time yield increases of 18%. Tens of millions of dollars saved. New lines launched in two months instead of eight. Achievements like these are reality for our customers.

QualityWorX is Sciemetric's solution for Data Management and Manufacturing Analytics in the connected factory. Using this software suite, you can store part data from all your production processes in a centralized database for easy access by any personnel who need it. You can organize it in a logical hierarchy that mimics the production line, and index it by part number so it's easier to pinpoint exactly where something went wrong. Create a multitude of reports and conduct advanced analysis, testing out scenarios based on real data – not guesswork or trial and error. And, it fits easily into your IT architecture, feeding into the family of software that's already on the line, such as MES, ERP and others.

All these capabilities will have you solving problems and improving your processes in hours instead of weeks. Visit **www.sciemetric.com** to learn more.



QualityWorX Dashboard

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