Enterprise Wide Manufacturing Intelligence for Complex Electronics

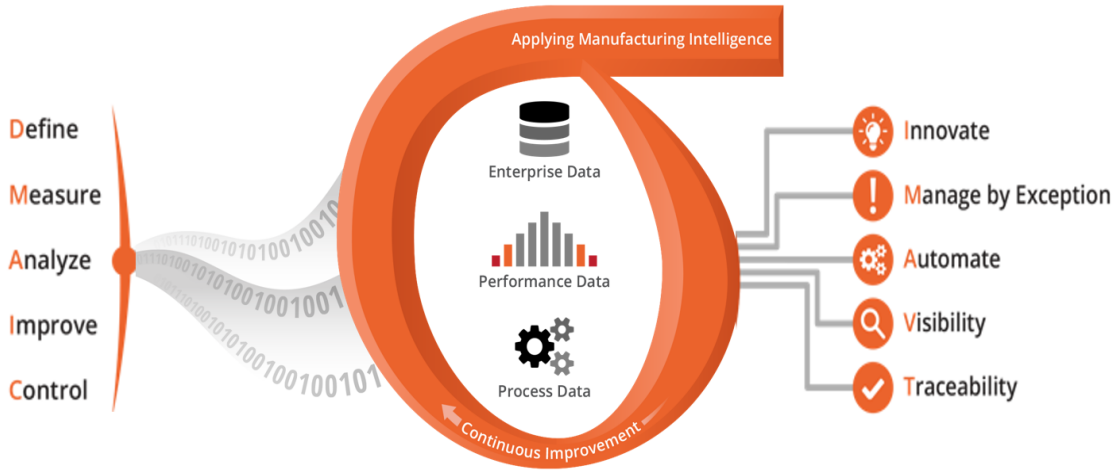
“CARNAC is all about Teradyne’s journey towards of the Factory of the Future”

-Dan Fabrizio

Director Continuing Engineering

Summary

This IntraStage Case Study describes the expected benefits by Teradyne’s application and use of the real-time IntraStage BlackBelt Manufacturing Intelligence System. The expected end state benefits of the implementation of the IntraStage solution included faster production time, better quality, and lower costs for the manufacturing of Teradyne’s world-class highly complex test instruments.



Incorporating performance and enterprise data to improve manufacturing quality and efficiency

Background

Teradyne is a word leader in the manufacturing and support of semiconductor test, storage test, wireless test and Circuit Testers (CT) instrumentation. Teradyne's Industrial automation offerings include collaborative and mobile robots that help manufacturers of all sizes improve productivity and lower costs. With a company-wide credo of ‘testing matters,’ Teradyne embarked on a global project to implement a performance and reliability analytics system that would synthesize data from PLM, MES and performance test data across all of their products’ lifecycles and ultimately reduce manufacturing defects, optimize production throughput and improve product quality.

Teradyne embarked on a global project to implement the first stage of an analytics system that would synthesize data from Teradyne PLM & their largest contract manufacturer's MES systems across all of their products' lifecycles to obtain a clearer picture of the manufacturing process, help in reducing manufacturing defects, better understand production throughput and increase product quality. The next step in this endeavor would be to

i) Upload field service data and begin monitoring instrument field performance against design margins and manufacturing history.
ii) Integrate more contract manufactures processes and test data to begin continuously monitoring production and product qualilty, gaining a deeper insight into manufacturing failures and associated electrical test performance

Bill Duggan was chosen to lead the initiative, nick-named "CARNAC" as a tongue-in-cheek reference to the famous Johnny Carson character gifted with clairvoyance. As Teradyne desires to proactively identify quality, manufacturing, test, design headroom, and field reliability issues, the CARNAC project would need to incorporate enterprise and performance data from multiple, discrete data silos. A large part of the complexity of the project came from organizing and correlating those disparate data silos in a robust and flexible system providing an "as-built" single source of truth for their families of highly complex instrumentation.

Examples of Teradyne's world-class ATE solutions

Requirements

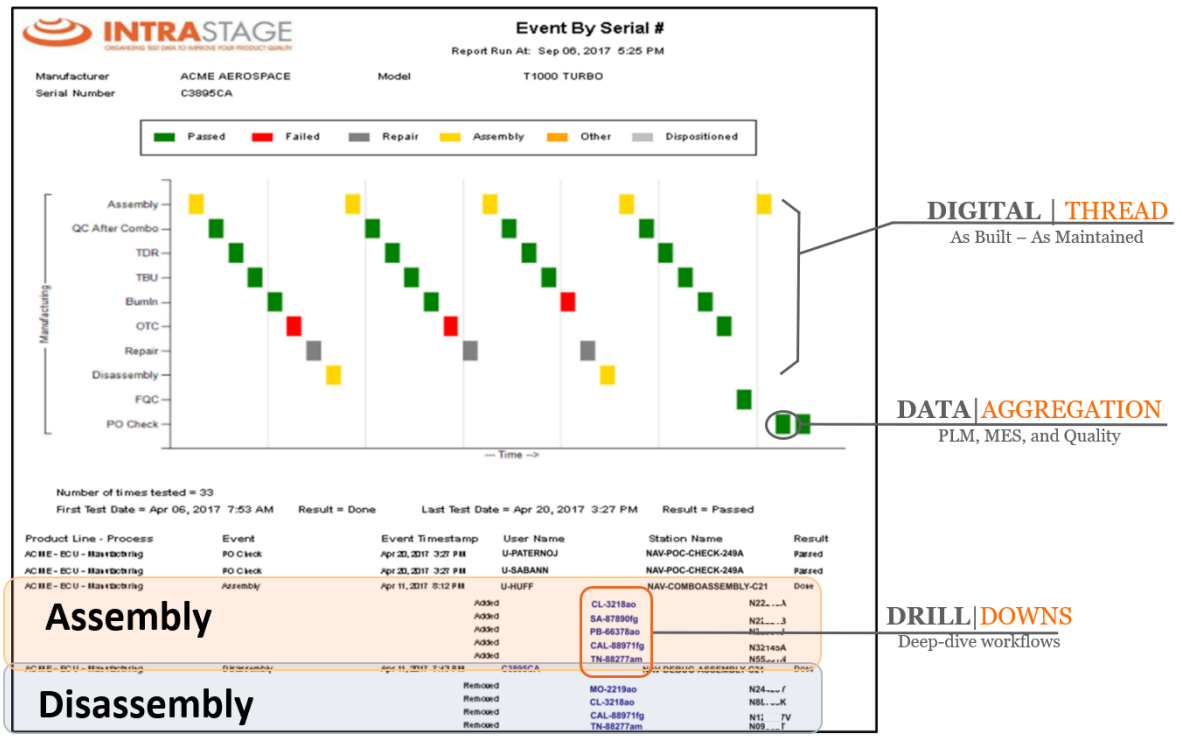
As is common for any complex manufacturer, the data was centered not only on a single finished instrument but was also focused on subassemblies/lower level assemblies (LLA)s and the parent assemblies/high level assemblies (HLA)s into which those LLAs were incorporated. This meant that a critical capability of the CARNAC system would be being able to 'drill down' into failures or performance issues from an HLA all the way down to the specific component installed on a constituent LLA that was responsible for a failure or performance issue. In addition, the system would have to track genealogy of LLAs removed from their parent assembly, being reworked, and re-assembled into new parent assemblies/HLAs. This rework and reassembly to achieve high-performing assemblies happen repeatedly in some instances, and the system would have to track the disposition of the LLAs and the HLAs and their evolving configurations

With that relationship of products and hierarchy in mind, Teradyne needed to analyze manufacturing data from the following silos in order to achieve their goals of improved product quality and efficiency:

- Contract manufacturing data, which included assembly level information for serialized LLAs and HLAs
- PLM data from Siemens Teamcenter (including BOM, Part, and AML)
- MES process data, including repair and rework data from the contract manufacturer
- A subset of parametric test, which was stored in a separate structured data warehouse and summary data extracted into Carnac containing terabytes of performance information from individual boards. This parametric data was extracted to correlate failing parametric measurements with rework data.

These disparate silos needed to be mapped and organized so that they would integrate together seamlessly, allowing engineers to drill down into the performance of not only a single serialized LLA and its failed components, but also aggregate and trend the overall performance for the LLAs and the HLAs. In addition to the product quality performance so important to customers. A requirement to track and improve upon manufacturing process performance to enable rich visibility into the “Hidden Factory” in complex manufacturing environment such as assembly, disassembly, failure and root cause correlation reporting and detailed click through serial number history.

Product Lifecycle Intelligence – System Level



Gantt Chart of unit history and genealogy

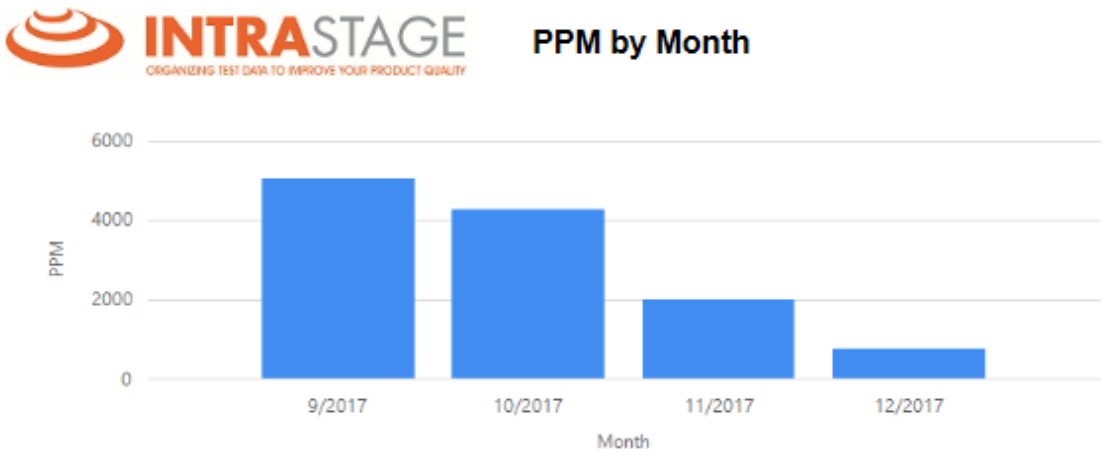
Business stakeholders identified that a unified solution with visibility into global quality, process and manufacturing efficiency was key in delivering business outcomes.

A few of the analytics needed for quality and increased efficiency implemented were:

- Analysis of Instrument historical data
    - A full on-demand accounting of each serialized product and its pass/fail status along with associated attribute data. This includes genealogy data so that a user could query an HLA, and quickly see the performance of each constituent LLA.
- Analysis of correlation between location and component behavior
    - Paretos and yield, which users would be able to characterize on attribute data points and graph on multi-axis chart reporting
- Paretos of failing tests for HLAs
    - The HLA tests would have to feature drilldown to the specific LLA on which the HLA test was failing, and would have to enable drilldown to the exact parametric measurement and component that was failing on the LLA

- Analysis of Manufacturing process quality data via Yield by a broad selection of attributes, (including Yield by: Test, Event, Product Line, Measurement, Process, Station, etc.) for every constituent or high-level manufactured part or product.
- Analysis of Manufacturing WIP and cycle time by various factors
    - Time for each LLA and HLA at each manufacturing step, and aggregating that data into trends for ongoing analysis
- Process yield rate by verified defective Parts Per Million (PPM) across all product lines from final assembly and models down to discrete components, over time, across products, orders, vendors and processes.

- Additional variations of yield/PPM like pull rate, unverified PPM and other related analytics.



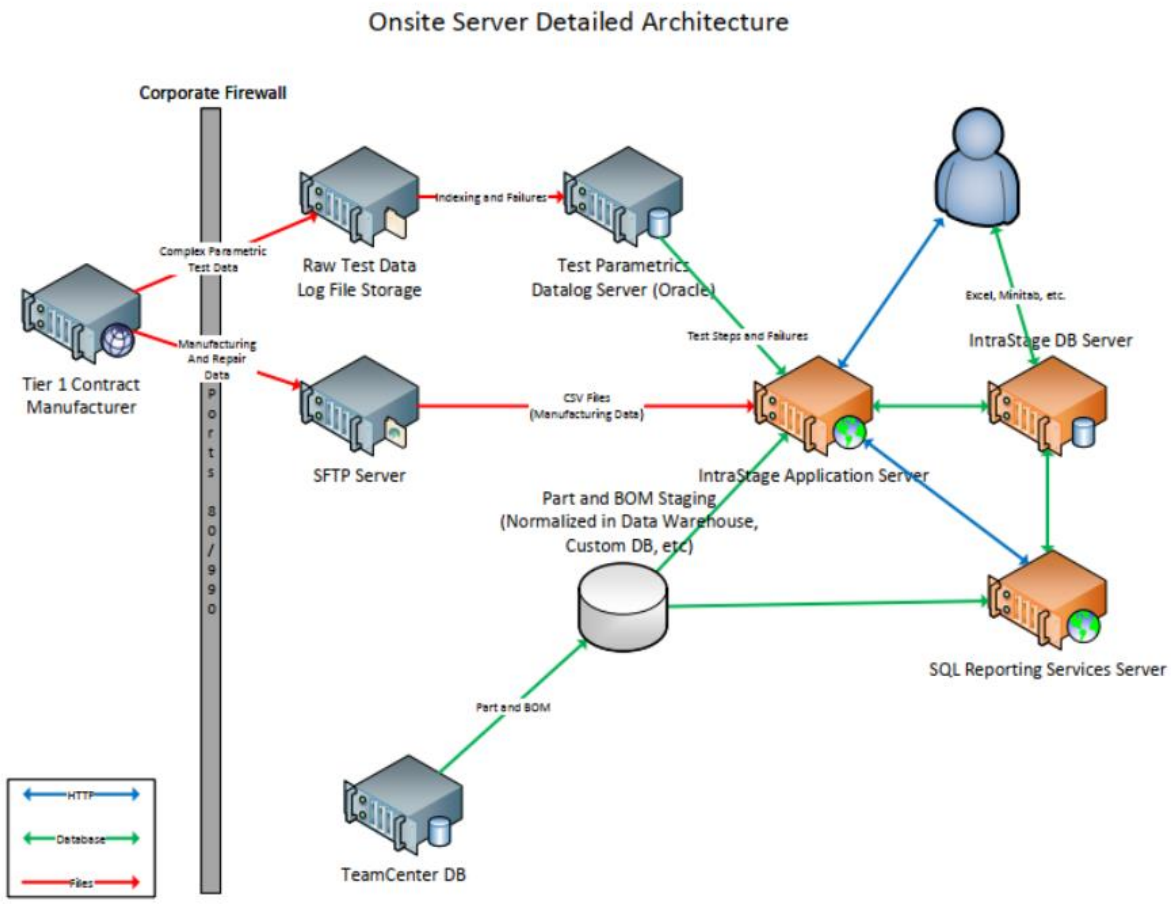
PPM Report

Note

Implementation:

Due to business requirements, each data silo would need to stay active, undisrupted and separated. That meant that a quality and manufacturing data warehouse would have to pull data from each silo on a near real time basis and normalize it within a shared database without

alteration or deletion of the original source files, databases, or silos. IntraStage's adapter technology extracts and converts the source data continuously into the new BlackBelt database. The new database would have to correlate data for each serialized part to make a single system of record, or 'source of truth' within a complex distributed architecture.



Server Architecture

The CARNAC implementation team was a cross-functional group of engineers from across the manufacturing and IT process. Subject Matter Experts (SMEs) were needed who knew the manufacturing process of each part for each product line in order to translate the mapping of the raw manufacturing test and MES data from the CM into the off-the-shelf IntraStage database model. Similarly, SMEs for the PLM and BOM systems were consulted to create the integration links between those systems and IntraStage.

As a first step in the timeline, IntraStage adapted a sample of manufacturing performance data into an IntraStage hosted mockup. This provided stakeholders a means to review IntraStage-recommended data-mapping and understand how that mapping enabled different drilldown reports, capability analyses, and correlation of performance metrics across multiple models and parts. The CARNAC team used this low-risk, iterative approach to collaborate internally and with the IntraStage partner team to improve the mapping and validate that each required report and analysis workflow process would be possible with the final mapping and integration details.

Analysis:

For Teradyne, the digital transformation to the factory of the future began with a phased approach to knit together individual data islands into a cohesive manufacturing intelligence system. This first step, an off-the-shelf implementation of IntraStage BlackBelt, is intended to start the process of fusing individual enterprise and performance data silos into a cohesive, on-demand Manufacturing Intelligence System. With full deployment of the Carnac system bringing global visibility and a single system of record of performance and quality, Teradyne engineers will be able to identify problems, collaborate to improve efficiency, quality and innovate with unprecedented speed and confidence.

Lessons learned:

The data integration plan involved a full understanding of each HLA, LLA, and constituent component on the manufacturing line and a deep understanding of the data that represents both the process and performance. Early in the implementation process, the Teradyne and IntraStage team learned that in a high-mix environment, a best practice would be to map this relationship fully and dynamically.

Teradyne needs to rapidly respond to customer requirements and evolving market demands. Therefore, new parts and products are constantly being developed, manufactured, and introduced with new data. This drives a requirement to include this new, unmapped data in the CARNAC platform for analysis without complex customization (NRE). In this environment, there has to be a dynamic data-mapping process to make sure that the components and their data are properly modeled in the analytics system. To address the requirement for a dynamic data-mapping process, the CARNAC team implemented a parking lot/reload capability for parts not currently mapped into the database. This gives Teradyne the ability to continuously import most of their production data automatically, as well as a means to elegantly provide on-demand analytics for newly mapped parts as they are introduced.

The richness and depth of the manufacturing and lifecycle data in CARNAC has ‘opened the eyes’ of Teradyne engineers for continuous improvement, with new report requirements,

analytics, and needs. As users continue to utilize existing stock reports and custom analytics, the need for further insights have and will continue to occur. Teradyne users will consider leveraging available IntraStage mechanisms (including an open platform for 3rd party analytics tools, developing internal report-building skills, and utilizing IntraStage professional services) to achieve efficient analytics development. The IntraStage solution is a springboard for enabling a cultural change by democratizing the data and analytics to achieve the factory of the future.

For more information, contact sales@intratage.com and prcontact@teradyne.com

About Teradyne

Teradyne (NASDAQ:TER) brings high-quality innovations such as smart devices, life-saving medical equipment and data storage systems to market, faster. Its advanced test solutions for semiconductors, electronic systems, wireless devices and more ensure that products perform as they were designed. Its Industrial Automation offerings include collaborative and mobile robots that help manufacturers of all sizes improve productivity and lower costs. In 2018, Teradyne had revenue of $2.1 billion and today employs 5,300 people worldwide. For more information, visit teradyne.com. Teradyne® is a registered trademark of Teradyne, Inc. in the U.S. and other countries.

About IntraStage

IntraStage is a company with a unique vision to collect, organize, visualize and generate insights on the vast amounts of complex electronics manufacturing data that is produced by companies in the electronics design and manufacturing industry. Our mission is to help our customers improve their product quality and manufacturing efficiency. Fortune 1000 companies rely on our business intelligence to keep them competitive when product quality and customer satisfaction are key differentiators.