GSR: A Reliability Improvement Platform For OEMS Who Service What They Sell.

Chris Plumlee, MSEE
CAE Integration, LLC
President

Contents

Introduction

Quality Management Systems typically employ statistical methods to determine whether and when processes are competent and in control. Statistical process control applied to a large scale process can even provide warnings prior to a process going “out of control” or starting to produce unacceptable parts. This paper describes a different approach to quality management, one in which a company can detect and quantify product weaknesses in even small scale production.

High Cost of Performance Tests

Performance tests at a lab are the traditional first line of defense in product quality. These are contained to the beginning of (or prior to) the product lifecycle because they are both expensive and destructive. Tens of thousands of dollars produce a short list of weaknesses. Improving the design and repeating the process reveals a few ever-so-slightly less weak areas of the product. The alternative is even more expensive -- the uncontrolled tests customers perform in the field. Some of these impact the warranty budget, others the brand image. There is no way to “opt out” of the customer-conducted performance tests, but there are ways to turn the resulting data into actionable intelligence.

GSR is a reliability improvement platform that collects field feedback through the repair center for continuous improvement. GSR is short for General SQL (Structured-Query-Language) Repair interface. It provides a convenient way to collect, store, and retrieve the test data generated by UFT and other tests, as well as pre- and post-shipment repairs.

Test data is generally ignored until there is a negative event. This is not as bad as it sounds, so long as all the data that one will need later has in fact been captured and organized in an easily accessible manner. GSR accomplishes this in its dataflows as depicted in the following block diagram:

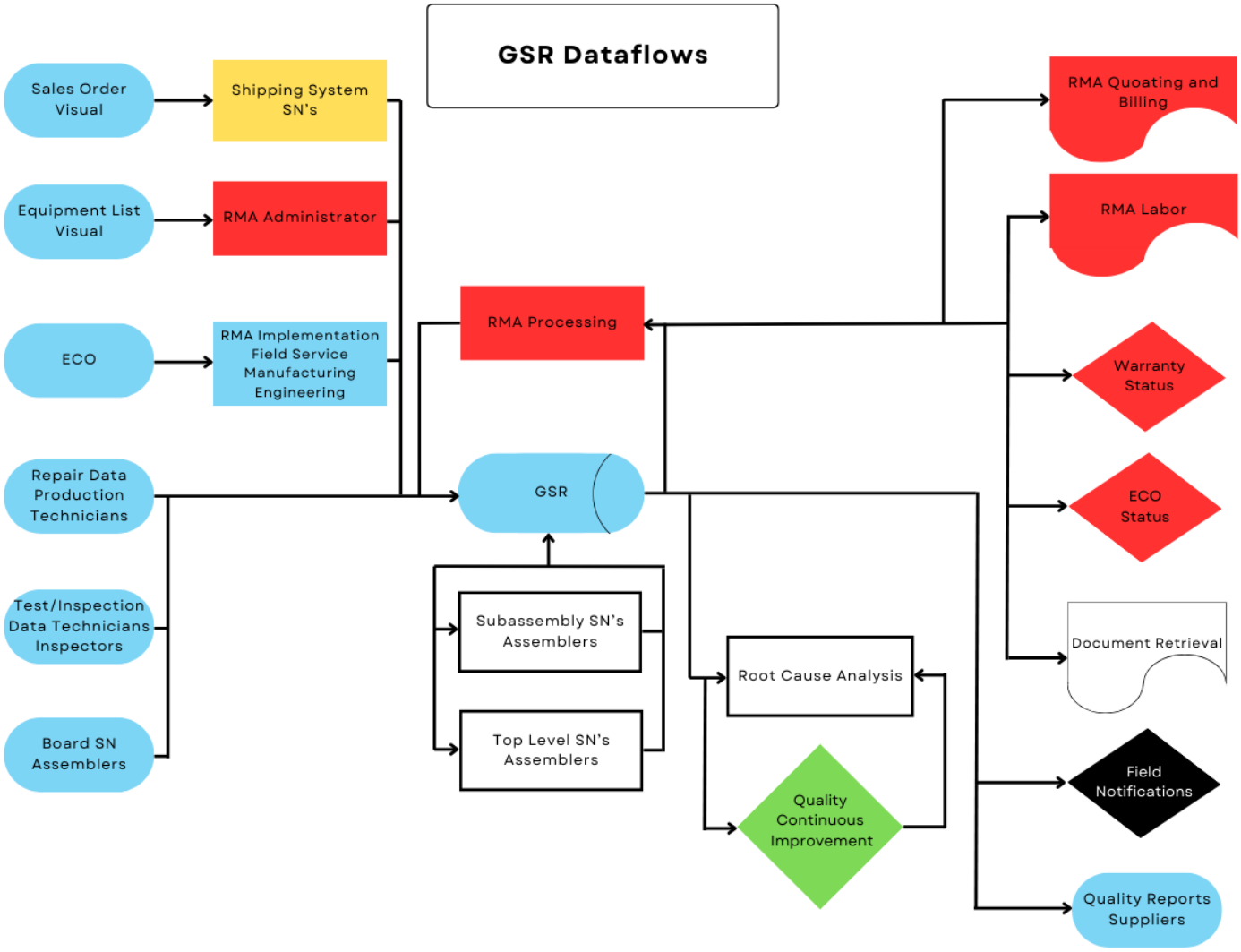


Figure 1: GSR Dataflows

Device History Record

The product serial number (SN) is represented in the lower left corner of the dataflow. GSR presents a history of all recorded data against a SN, whether that SN represents a board, subassembly, or shippable product. This history is commonly referred to as a “Device History Record”. Sequencing it in reverse-chronological order places the most recent events on top. Tests and repairs are presented along with other events such as Engineering Change Orders (ECO), shipment to or return from a customer. ECO and repairs are in the center left of the dataflow. Shipment and field service operations are in yellow and red, respectively. For multipart products, SN hierarchy is recorded during assembly. The point of view can be moved up and down the assembly tree, always showing the history of the selected item and its subordinates.

Data Entry or Collection of Testimony

The importance of convenience during data entry cannot be overstated. Each user perceives a certain amount of value to the data he or she enters, and will expend a commensurate level of effort to the task. Given a fixed level of effort: The easier it is to enter the data, the more thought is put into entering good data. A technician troubleshooting a product selects the correct record by scanning its SN barcode or searching on Part Number, Owner, or other convenient records.

From here the technician:

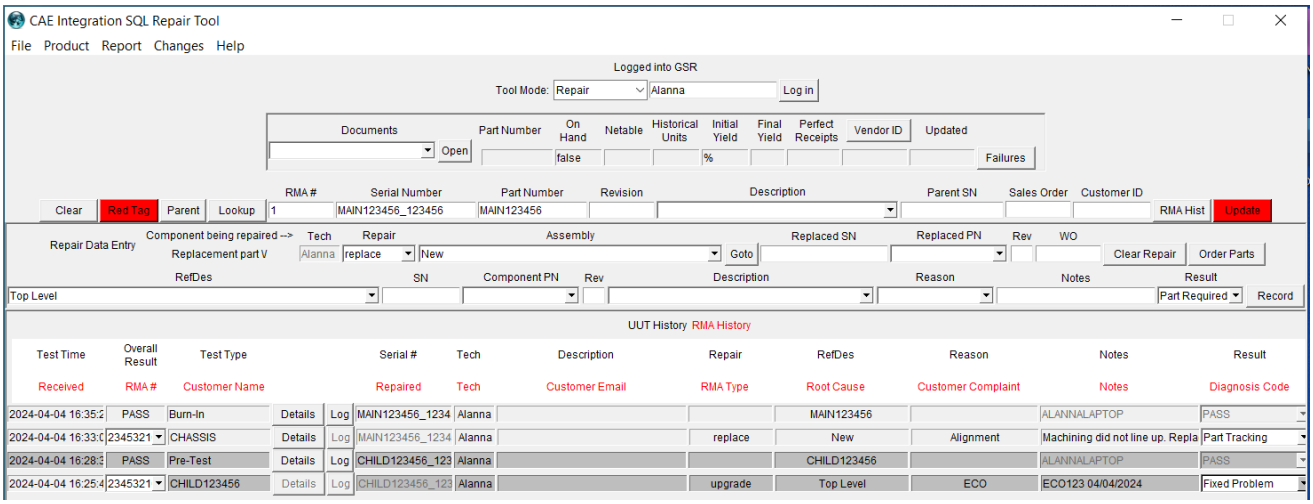
- pulls up test results and trends or retrieves original test logs from the history for viewing.
- retrieves related documents such as schematic, BOM, and procedures.
- records board-swaps or component-level repairs.
    - With optional ERP integration this data entry automatically places orders related to the repair.

GSR does not attempt to enforce data collection through regimented process control, instead accepting “best effort” testimony conveniently during natural technician interaction with the product and its documentation. Field returns and other service activities must be tracked – whether that be in GSR’s RMA interface or through integration to another system. The serial number of the unit being repaired ties it back to the manufacturing data from when it was built and shipped. This not only determines warranty status and revision level, but provides a baseline product condition from shipment and a record of its field failure. At the point of failure it is important to capture the customer’s description of the problem for later use. While the customer’s testimony may be embellished towards warrantee policy compliance, it still contains useful information about the failure event. Next step is to track the repair of the product, capturing the repairing technician’s actions, tests, and notes. The notes tell the other side of the customer’s story. While the technician’s story may also contain bias, the two provide references from which to negate embellishments. If repair centers perform board-swaps rather than troubleshooting down to the component level, it is important to save the bad boards for a period of time. It is not necessary to troubleshoot every failure to the component-level, but the ability to locate and troubleshoot selected boards is crucial to the improvement process.

With the tests and repairs organized in reverse-chronological order, effects follow causes. GSR can use this causal relationship to determine what repairs resolved various problems.

- Repair trends can be used to generate a list of repairs to suggest for a given test failure, ranked by % of boards resolved.
- Repair trends can be used to prioritize failure analysis that leads to product improvements which prevent said failure modes. This activity yields better results with less data.

Data Retrieval



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Level	Description	sn	pn	currentPn	parentSn	assemblerWo	assembled	pcb	rev	fwRev	bootRev	otherRev	mac	owner	lastUpdated
2	0		MAIN123456_123456	MAIN123456	Main123456		Alanna	2024-04-04 16:20:28								2024-04-04 16:37:52
3	1		CHASSIS_12	CHASSIS	CHASSIS	MAIN123456_123456				2						
4	1		CHILD123456_1234	CHILD123456	CHILD123456	MAIN123456_123456				A						2024-04-04 16:28:34
5	1		TOPA123456_1234A	TOPA123456	TOPA123456	MAIN123456_123456				A1						

This is what it looks like to retrieve data from GSR and Excel.

Reliability Improvement Cycle

With data collection measures in place – they need not be perfect – the Reliability Improvement Cycle can begin. Statistical and scientific methods are used like hammer and anvil to forge the chain of questions and answers needed for product improvement as follows:

1. A quality or failure analysis engineer skims through the Product Return Trend Report, sorting the data various ways to comes up with some first-pass categories.
2. On a periodic basis (such as monthly) the engineer reads RMAs and assigns categories that *seem* appropriate for each. This gives the statistics some handles for manipulating the data. Correctness is not crucial at this stage because individual cases can be

recategorized later when the scientific approach disproves the engineer's initial assumptions.

3. The Product Return Trend Report now organizes RMAs by the specified categories. Pivot tables quickly reveal the relative size of each failure type (category) by dollars, quantities, or other factors for prioritization.
4. Focusing on a single failure type, several avenues of investigation are available:
    a. Sorting of the report or query to check for patterns like:
       Who assembled the most failing units? (training/technique causes)
       When were the most failing units Assembled? (seasonal causes)
       Who returned the most failing units? (customer-specific causes)
       How old were most units when they were returned? (wearout causes)
    b. Reading of the RMA story to check for patterns like:
       Before it broke, I was… (root causes)
       It broke when… (environmental causes)
    c. Use Plot Part Operating Life report to view the bathtub curve related to a specific failure:
       Trends infant mortality failures (design and manufacturing defects)
       Trends wear out failures (inherent weaknesses in the design)
    d. Customizing report logic to find instances answer specific questions like:
        i. What rev of board A and firmware B was present when board C failed?
        ii. The same component is used on multiple assemblies produced at different CMs.
            Which CM's assemblies have better longevity of this component?
        iii. A fit problem was identified in production, but we did not have time to resolve it in the design.
             Is this resulting in failures?
             What is the total cost of these failures?

Regardless of the approach, this stage of the investigation leads to a collection of boards or subassemblies that share a common failure mode.

5. The engineer selects a statistically significant sample of serial numbers from the list for root-cause analysis. Often all samples share a single point of failure, so it is not necessary to examine the entire collection to determine why the identified pattern of failures occurred. Failures that do not fit the pattern are recategorized, resulting in a report showing a precise failure rate and associated cost of the specific problem.

6. Perform corrective action to alleviate the identified weaknesses, for example:
    a. Update the design to provide additional voltage/current capacity or control
    b. Update training regarding assembly/repair steps to add the necessary technique to avoid the defect.
    c. Update customer training/agreement to avoid a destructive use-case.
7. Each investigation leads to monetary and customer-impact metrics for a specific failure mode. This provides a basis for:
    a. Selecting improvements to make first, leave for later, and skip entirely.
    b. Measuring the actual effectivity of the improvement against the expected result using GSR's Plot Part Operating Life function. While many solutions can be tied to a revision, some may be process changes or other delineations. GSR supports a broad basis of delineation for "Before" and "After" to provide accurate after-action statistics.

There will occasionally be key pieces of data missing from the investigation. These can often be back-filled by personally interviewing the party who did not record the data. This personal interview step has the added benefit that it reinforces the value of the recordkeeping in the mind of the interviewee. Occasionally there will be some facet that nobody considered, making it necessary to ask the technicians to look for a particular condition in future cases. As the team gets a feel for the product improvement process the questions and data required becomes more intuitive.

Standard and Causal Reports

A variety of reports are required for each investigation, depending on what questions come up and how the investigator decides to pursue them. GSR contains several instant reports available from drop-down menus. It runs on a Standard Query Language (SQL) database that can be queried with industry standard database tools such as HeidiSQL or Microsoft Query for simple reporting requirements. It also has a back-end that generates specialized reports on a scheduled basis to support failure analysis and other activities. These specialized reports apply an iterative combination of statistics and sequential logic to wade through and categorize failures into meaningful trends.

These specialized reports have long runtimes because there is no database design approach that is optimized to handle causal relationships. While computer scientists have found ways to represent maps in specialized special databases, causality is still a prickly problem for computers to tackle, with research still struggling with the whys of the database itself. For further reading on causality in databases see the following publications:

Title	Source
Causality in Databases	https://people.cs.umass.edu/~ameli/projects/causality/
Causality in Databases	https://www.cs.cornell.edu/home/halpern/papers/DE_Bulletin2010.pdf

Table 1: Causality in Databases References

GSR is most powerful when integrated with ERP so its various canned and custom reports can pull related data to cover areas such as:

- Product Return Trend Report – all equipment returned from the field in a 1-year sliding window. All pertinent details to the return are listed with the equipment by

serial number. Returned product is classified into product families. Sub-reports break out the same data into just product families for focused study.

- Open RMA Report – lists all open RMA #'s as well as how long they've been in the building. Used to manage repair workflows.
- Quality vs Quantity in Field: This is a separate report for each product family, tracking the return rate against the estimated number of units in the field (# sold – number scrapped, stolen, or aged out). Reliability is expressed as MTBF or Customer Uptime %.
- Plot Part Operating Life – issue-specific reports, these depict field failures of the described collection of product in the "bathtub curve" form, or number of failures in each 30-day time block. GSR allows recording of changes such as ECOs or processes. When this report references a change, the data is broken into "before" and "after" to present the outcome, or effectiveness of the change on field returns.
- MasterBoardAVL – for supply chain risk activities -- this report dives in to the BOMs of the boards to indicate updated consumption and material on-hand. Ties in third-party lifecycle and component availability services to produce a short list of high-risk parts.

System Integration: Common Questions

- What if my products consist of multiple boards and subassemblies?
  - Assembly mode records hierarchy of boards and subassemblies into a system for subsequent assembly operations and/or shipment into the field.
  - Repair mode allows easy navigation up and down the hierarchy of a product's assembly tree.
- What if I have 3rd party or manual test, inspection, and other steps?
  - GSR is designed to seamlessly import and store logs from other systems.
  - Test mode allows direct entry of simple data or the use of templates to record tabular results.
- What if my ERP system does not track shipments of my products to the serial number level? Can this information be collected and tied in?
  - GSR has a packaging mode that interfaces with ERP to read an order and explode BOMS down to two kinds of products:
    - Serialized items – allowing your shipper to record serial numbers into the shipment, recording by date for future reference against RMA warranty status.
    - Counted items – allowing your shipper to provide quantities for validation against the order from ERP.

For More Information

Call: 571-601-0744
Email: support@CAEIntegration.com
Schedule a video call: CAEIntegration.com/contact-us