QSI TEAMS® TOOL SET

TEAMS-Designer®: It is the knowledge capture and analysis component of the TEAMS® toolset. A system is modeled in terms of its components, hierarchy, interconnections and function attributes. The software can then propagate effects of faults across subsystems to help in systems engineering, FMECA and Testability Analysis. The lifecycle cost impact of adding or removing diagnostics can be evaluated, and the resultant model is used by the rest of tools for embedded diagnosis, tele-diagnosis and guided troubleshooting. TEAMS® is considered the de-facto standard tool for Functional Failure Analysis in the NASA Constellation and Space Launch Systems Programs.

TEAMS-RDS®: It is the enterprise scale server component of TEAMS® field service toolset. It enables automatic Machine-to-Machine (M2M) diagnosis where thousands of connected systems can periodically update data, and TEAMS-RDS® automatically assesses and posts their health on a Fleet Health Management Dashboard and is thus well positioned for the Internet of Things (IoT). In addition, it can then guide Service Agents through the process of troubleshooting and restoring system health. NASA KSC has acquired TEAMS-RDS® through sole-sourcing for real-time monitoring of the integrated system-of-systems comprised of complex Launch Systems and Crew/Cargo Modules.

TEAMATE®: It is the Portable Maintenance Aid component of the TEAMS® Toolset that guides service agents through complex troubleshooting tasks covering sophisticated equipment, such as MRI machines and Semiconductor manufacturing equipment. With it, all service agents perform like experts, finding and fixing problems rapidly and accurately. It supports multiple languages and is deployed worldwide by global workforces of our customers.

PackNGo®: It is the Mobility component of the TEAMS® Toolset for Guided Troubleshooting. Based on the initial problem report and machine data, TEAMS-RDS® computes an optimized troubleshooting procedure (decision tree) that can be emailed to the service agent. The PackNGo app (supported in Android and iOS phones and tablets) utilizes the decision tree to guide the service agent step by step through the troubleshooting process, while logging the results of every step. PackNGo can work where there is no network access, for example in hospitals, and it needs to sync with TEAMS-RDS® only to upload log files.

TEAMS-RT®: It is the embedded real-time diagnosis component of the TEAMS® Toolset. TEAMS-RT® can process thousands of test results per second, every second, to assess system health in real-time. It utilizes both presence and absence of error codes to rule-in and rule-out possible failure sources to diagnose root cause(s) in complex systems, such as jet engines or space craft. NASA demonstrated real-time diagnosis with TEAMS-RT® in the Ares-1X launch in 2009, and EFT-1 launch in 2014.

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Time Spent in Traditional "Dispatch, then Diagnose" Service Model

- ■ (blue) Open Case & Dispatch
- ■ (blue) Travel to Site
- ■ (light blue) Troubleshoot Onsite
- ■ (lighter blue) Order Parts & Wait for Delivery
- ■ (gray) Fix, Retest & Restore to Service
- ■ (light gray) Rework (if first diagnosis was incorrect)
- ■ (green) Uptime Gained

Uptime gained with lower cost of service with Diagnose Before Dispatch

Diagnose Before Dispatch (DBD)

Across a wide range of industries, the past decade has ushered in great advances in computer hardware, software, sensors, and control systems. For most equipment and system manufacturers, however, diagnostic and troubleshooting methods have not kept pace with system growth and complexity. The result: longer system outages, costlier and more frequent service calls, and greater numbers of unhappy customers. While the "send someone to figure out what's wrong" or "truck roll" approach to service might be the norm in many industries, customers and vendors alike are finding this dated approach both inadequate and unsustainable. The **drawbacks of this conventional "Dispatch, then Diagnose" method** of troubleshooting include:

- **Unnecessary and expensive truck rolls,** even though many problems could have been solved by the operator with proper guidance

- **Long diagnosis time,** since field technicians are dispatched without relevant information about the problem and have to start troubleshooting from scratch

- **Inconsistent service quality,** since success rate is highly dependent on field technician's experience, familiarity with equipment, and skill level

- **Multiple visits per service event,** since service parts need to be procured and installed on a subsequent visit, leading to extended downtime

- **Poor technician utilization,** since travel time often exceeds the onsite time, and limits technicians to only two service calls per work day

The net result is lower quality of service and customer satisfaction with ever increasing cost of service.

An Innovation in Service

QSI has developed a new service methodology that effectively eliminates many, if not most, of the problems encountered with the traditional "Dispatch, then Diagnose" service model. This service methodology, termed "Diagnose Before Dispatch", reduces the overall downtime and cost of service while significantly improving the Quality of Service and Customer Satisfaction over the conventional "Dispatch, then Diagnose" model.

The magic sauce powering this methodology is QSI's reasoner technology, TEAMS-RDS that is used by NASA, the US Department of Defense, and other Fortune 500 companies, for diagnosis and health management of large complex systems.

> TEAMS-RDS can enable anybody, including a Call Center agent or operator of the equipment, troubleshoot like an expert and help narrow down the problem to a handful of possible causes. If machine-data is available, TEAMS-RDS can analyze them automatically to further refine the list of possible causes.

In many cases, the operator can perform the corrective action, thereby eliminating the need for a "truck roll". The Call Center can also ship certain user-serviceable parts directly to the customer for them to install, instead of scheduling technician visit, saving the customer time and money.

In situations where a field technician visit is necessary, the list of possible causes is analyzed to anticipate and dispatch the service parts that may be necessary, along with the right skill, material, knowledge and tools so that the problem can be corrected in a single visit.

At the customer site, there is no need for the field technician to start over from the beginning. TEAMS-RDS picks up where the Call Center left off, and guides the technician with precise step-by-step instructions to ensure the problem is diagnosed, fixed and service restored in the shortest possible time.

Projected Benefits

| Category	Benefit
Unscheduled Downtime	Down 10 to 50%
QoS for New Products	Up 20 to 50%
Problems requiring Field Service	Down 30 to 50%
Problems requiring "Truck Roll"	Down 30 to 50%
Spares used per service call	Down 50 to 70%

With Diagnose Before Dispatch, many problems are solved over the phone and the equipment is returned to service quickly. In instances where an onsite visit are necessary, the technician comes prepared with the right parts and knowledge, and is able to fix the equipment right the first time. This greatly improves the uptime, while reducing cost of service.

About QSI

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TEAMATE Guided Troubleshooting Application
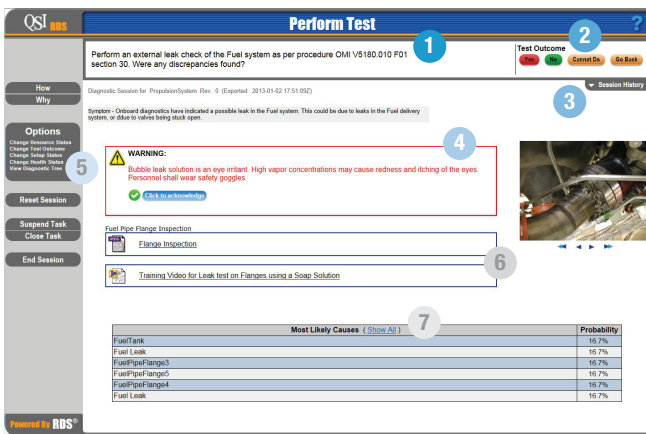
1 The task

2 Available Outcomes

3 Automatic Logging

4 Cautions and Warnings

5 Customization Options

6 Relevant Multimedia Knowledge Nuggets

7 Suspected faults, ordered by probability

QSI's Guided Troubleshooting software is the customer-proven answer to every company's growing list of field service challenges. With Guided Troubleshooting, every FSE performs like an expert, shortening system downtimes, reducing costs, and delivering consistent performance across your entire service organization.

Guided Troubleshooting

Motivation

Keeping pace with the rapid evolution of technology and ever-increasing system complexity is major challenge for any manufacturer. Nowhere is the impact of these forces more strongly felt than in field support organizations, where frequent system updates and short product lifecycles challenge the skills of any Field Service Engineer (FSE). Behind every fault-code or symptom lurks a myriad of possible causes; getting to the true root cause requires an in-depth understanding of the system and years of specialized training that are beyond the reach of many FSEs. Furthermore, conventional linear troubleshooting methods take too long, often overlook the root cause, and result in too many expensive swapped parts.

The casualties of **outdated "trial and error" troubleshooting** methods are numerous and include:

- **Long troubleshooting times,** multiple site visits, and frequent problem escalations

- **High parts usage** that negatively impact inventories and shipping costs

- Too frequent occurrences of **"No Trouble Found"**, followed by recurring problems and growing customer dissatisfaction

- **High employee training costs** and escalating staffing requirements

- **Longer system outages** and poor problem resolution rates, especially for new products

Solution

Guided Troubleshooting is the perfect antidote to resolve the shortcomings inherent in conventional troubleshooting methods. The process of Guided Troubleshooting (or Interactive Electronic Technical Manual (IETM)) assures higher problem resolution rates by guiding the FSE through an optimized step-by-step process of identifying, fixing, and verifying problems. Originally developed

by QSI for the Department of Defense and the aerospace industry, Guided Troubleshooting gives inexperienced eighteen-year-old technicians the ability to fix sophisticated aircraft like the F16 fighter jet. To address growing demand, QSI is now making this easy-to-use and affordable technology available to customers in the commercial sector.

Technology

QSI's powerful reasoning engine uses knowledge about complex equipment, captured in graphical models, to generate optimized troubleshooting instructions. The instructions guide the FSE through the most complex troubleshooting tasks and help to:

- Identify the potential list of suspected causes

- Use available information in the form of fault codes, symptoms, human observations, and test results to progressively reduce the list of suspected causes

- Troubleshoot like an expert following an optimal sequence of steps (shortest path) to identify the root cause

The reasoner generates diagnostic instructions that may include diagrams, videos, and online manuals. It tailors the diagnostic sequence to match the skills and experience of the user and provide, and can also be used in a customer self-help portal to guide the operator through the troubleshooting process.

Throughout the troubleshooting process, the reasoner creates detailed logs for use in billing, training, and auditing. These logs are also used by the reasoner to learn from experience and further optimize the troubleshooting sequence.

Powered by our TEAMS-RDS server software, QSI's Guided

TEAMS PackNGo Guided Troubleshooting Application

Troubleshooting application is accessible from any browser with network access. It is also available on any Android or Apple tablets or smartphones with email access (using TEAMS PackNGo) or as a native PC/laptop application (TEAMATE).
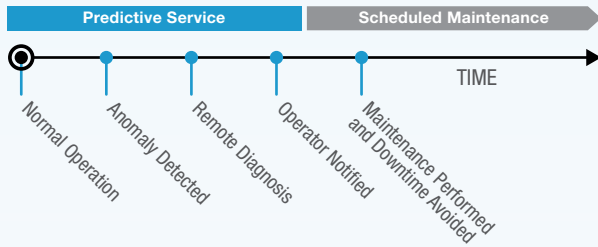
Key Benefits

QSI's Guided Troubleshooting software, utilized on its own, or in combination with QSI's Remote Diagnosis and Diagnose Before Dispatch solutions, delivers an impressive list savings in both cost and time. With it, every technician performs like an expert!

Projected Benefits

Category	Benefit
Unscheduled Downtime	Down 10 to 50%
QoS for New Products	Up 20 to 50%
On-the-job training time	Down 30 to 60%
Repeat service calls	Down 70 to 90%
Spares used per service call	Down 50 to 70%

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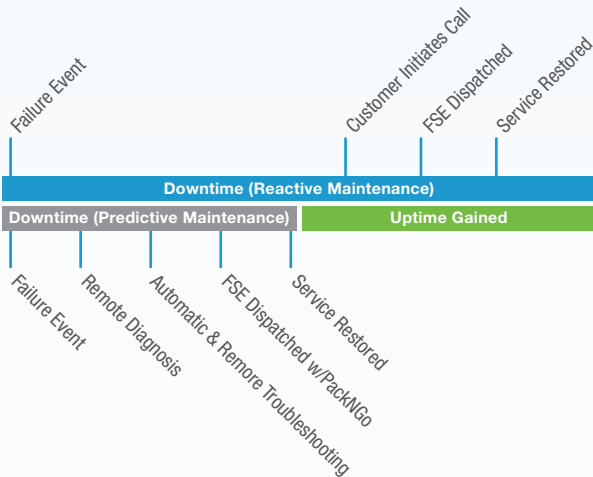
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PREDICTIVE SERVICE

Detect and diagnose developing problems and correct them during a scheduled maintenance before an outage occurs.

Predictive Service	Scheduled Maintenance

TIME

Normal Operation
Anomaly Detected
Remote Diagnosis
Operator Notified
Maintenance Performed and Downtime Avoided

PROACTIVE SERVICE

Detect and diagnose problems, and initiate corrective actions before end-user reports problem.

Failure Event
Customer Initiates Call
FSE Dispatched
Service Restored

Downtime (Reactive Maintenance)

Downtime (Predictive Maintenance) | Uptime Gained

Failure Event
Remote Diagnosis
Automatic & Remote Troubleshooting
FSE Dispatched w/PackNGo
Service Restored

Remote Diagnosis

Introduction

Near universal network connectivity has made it possible to remotely monitor business and mission critical equipment around the clock. With such monitoring solutions, companies are accumulating enormous amount of data from fielded equipment. However, manually processing this huge volume of data to assess equipment health or diagnose failures is neither feasible nor cost-effective. Consequently, this data is not effectively leveraged to reduce troubleshooting time and unscheduled downtime.

Companies need the ability to automatically infer equipment health and identify the Corrective Action in malfunctioning equipment, i.e., a true Remote Service Solution comprising of four essential elements:

1. **Remote Data acquisition:** Securely obtaining data from fielded equipment.

2. **Remote Monitoring:** Detecting alarm and error conditions.

3. **Remote Diagnosis:** Automatic processing of alarms and indicators to determine system health and identify needed corrective action(s). If available information is inadequate to identify the root cause and the corrective action, conduct additional drill-down remote (software-driven) or onsite tests (agent-driven).

4. **Corrective Action:** Executed remotely (for software problems) or onsite by local agents or dispatched FSEs (for hardware problems).

Remote Diagnosis stands in sharp contrast with the simpler task of continuous data monitoring and alarm management, which are often marketed as a Remote Diagnosis or Remote Service solutions. Without automatic Remote Diagnosis capability, service organizations are confounded by the multiple alarms and indications each fault generates, and cannot afford the substantial number of experts needed to manually diagnose the root cause and the associated corrective action. True Remote Diagnosis significantly extends data and alarm monitoring by extracting component-level health status of the equipment and identifies the necessary troubleshooting steps and corrective actions to get the equipment back on-line with minimal unscheduled downtime.

Technology

QSI's real-time diagnosis tool, TEAMS-RDS, is derived from decades of work with NASA and has been proven in the Ares-1X and the International Space Station programs. TEAMS-RDS performs automated reasoning on the monitored data (error codes, indicators, alerts, etc.) from complex equipment to determine equipment health in fraction of a second. Thousands of equipment can be monitored and diagnosed simultaneously by a single TEAMS-RDS server. The resulting information can be presented in a browser-based health management dashboard, providing organizations with complete visibility on the health of their equipment.

System Health Monitoring, Remote Diagnosis and Guided Troubleshooting
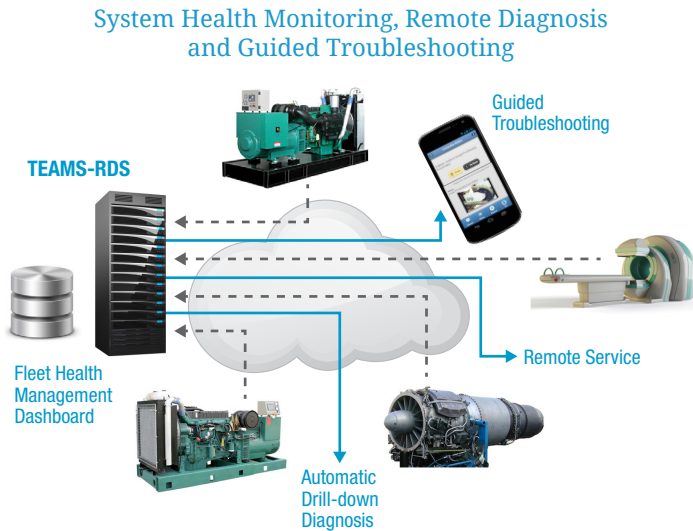
Even in the most advanced equipment, the monitored data may provide sufficient information to narrow down the search space, but not enough to pin-point the fault and determine the corrective action unambiguously. In such situations, TEAMS-RDS powers drill-down diagnosis and guided troubleshooting to further reduce the ambiguity. If the equipment is so capable, TEAMS-RDS can instruct the remote equipment to perform additional automated diagnostic procedures, or it can guide a service agent at the remote service center through additional troubleshooting steps. In cases where physical access to the equipment is necessary, TEAMS-RDS can generate an optimized procedure to identify and fix the problem and send it to the Field Service Engineer (FSE). The FSE can use QSI's PackNGo application to follow this procedure in a tablet or smartphone, ensuring seamless transfer of information from automated diagnosis to manual troubleshooting, thereby significantly reducing the troubleshooting time.

> The ability to automatically detect and diagnose problems in real-time enables service organizations to offer Proactive Maintenance services, where the corrective actions may be initiated even before the operator of the equipment notices the problem. Remote Diagnosis facilitates Predictive Maintenance, where degradations are identified and maintenance scheduled before onset of failure to further reduce, if not eliminate, downtime.

Projected Benefits

Category	Benefit
Unscheduled Downtime	Down 10 to 50%
QoS for New Products	Down 20 to 50%
On-the-job training time	Down 30 to 60%
Problems requiring field service	Down 30 to 50%
Spares used per service call	Down 50 to 70%

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QUALTECH SYSTEMS INC.

Testability
Engineering
And
Maintenance
System

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An advanced health management solution for the aerospace industry

Now manufacturers, dealers, and aircraft aftermarket service specialists can deploy QSI's Testability, Engineering, and Maintenance System (TEAMS®) to isolate faults faster, monitor entire systems, and speed troubleshooting and repair.

QSI has a wealth of aerospace experience building advanced health management solutions for Pratt & Whitney engines, Sikorsky helicopters (including the UH-60 and SH-60 turbine engines), and the Boeing AH-64D Apache helicopter, among others.

QSI's solutions simplify aircraft repair and maintenance

For repair and service organizations, QSI's TEAMS system can

- Improve the performance of all service personnel
- Increase the accuracy and effective of service operations
- Reduce the cost per warranty repair
- Improve First Time Fix Rates
- Reduce Repair Parts Consumption
- Predictive Analytics for Condition Based Maintenance

QSI's PackNGo® or TEAMATE® application translates results from diagnostics, automatic tests, degradation detection tests and manual tests into clear instructions on the action to be taken next. Using this software, inexperienced technicians can perform at expert level.
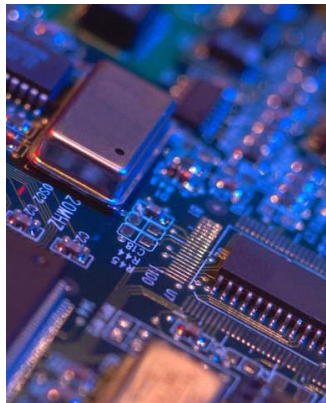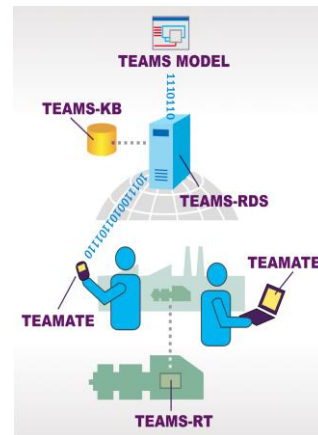

QSI's TEAMS® real-time diagnostic reasoning engine can be embedded or used for Telediagnosis from your IoT

TEAMS-RDS used for remote troubleshooting and TEAMATE/PackNGo on a portable computer or a mobile device used for onsite maintenance. Information from the field is synchronized with the server for case management and machine learning for model evolution.