

# NDIA Test & Evaluation Conference



Producing Anywhere, Anytime Test,  
Evaluation and Diagnostics Capable  
Products to Eliminate the T&E  
Logistic Burden

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# Introduction

## What is Agilent?

- Although Agilent sells a diverse number of products, my part of the company designs, manufactures, and sells extremely complicated & state-of-the-art RF instruments
- Even though we are an industry leader and our core competency is test & measurement, we struggle with “sustainment”



**Agilent Technologies**

## Who am I?

- I am the product manager for an Agilent software product named Fault Detective
- My background is software development



**Agilent Technologies**

Anywhere, Anytime Diagnostics  
Agilent Restricted  
March 14, 2007

# What is “Anywhere, Anytime Diagnostics”?

## Anywhere

A single diagnostics technology used across the entire product lifecycle

1. Manufacturing/production
2. Service centers/depots
3. In the field (Both remote and local)

## Anytime

Fast, accurate diagnostics regardless of location and operator skill

### Agilent Vision

- One of our instruments fails on a customer’s manufacturing line... halting production
- The instrument self-diagnoses and notifies an Agilent service center
- An Agilent repair technician contacts the customer knowing exactly how to fix the problem

### A/D Vision

- A failure occurs on a jet in mid-flight
- The jet self-diagnoses and communicates the failure to a ground crew
- The ground crew is prepared by the time the jet lands

# “Anywhere, Anytime Diagnostics” in Action

Two Agilent instruments are equipped with “Anywhere, Anytime Diagnostics”:



## E6601A Wireless Communications Test Set

Functionality of a base station

Number of printed circuit assemblies: 7

Number of interconnects: 16

Push a button and the instrument automatically troubleshoots itself.

## N9020A MXA Spectrum Analyzer

Frequency range: 20 Hz to 26.5 GHz

Number of printed circuit assemblies: 12

Number of interconnects: 25



# Challenges We Faced

## 1. Design a product with adequate diagnosability

If a product is too difficult to repair, any sustainment strategy will be a challenge. Typically, diagnosability is not known until production, when it's often too late to fix the problem.

## 2. Create a test plan with appropriate coverage & diagnostic resolution

Poor test coverage puts faulty products in the field. Poor diagnostic resolution produces test results that provide little insight into failures. Quantifying the effectiveness of functional test is notoriously difficult, making it hard to know when your test process is "good enough".

## 3. Automate trouble-shooting

A worthy goal, but difficult to achieve without a lot of investment.

## 4. Embed the entire solution in the product

How do you create an effective test solution without any external test equipment?

# Agilent Fault Detectives Software

**Q: The issues on the previous slide are really tough to address, so how did we do it?**

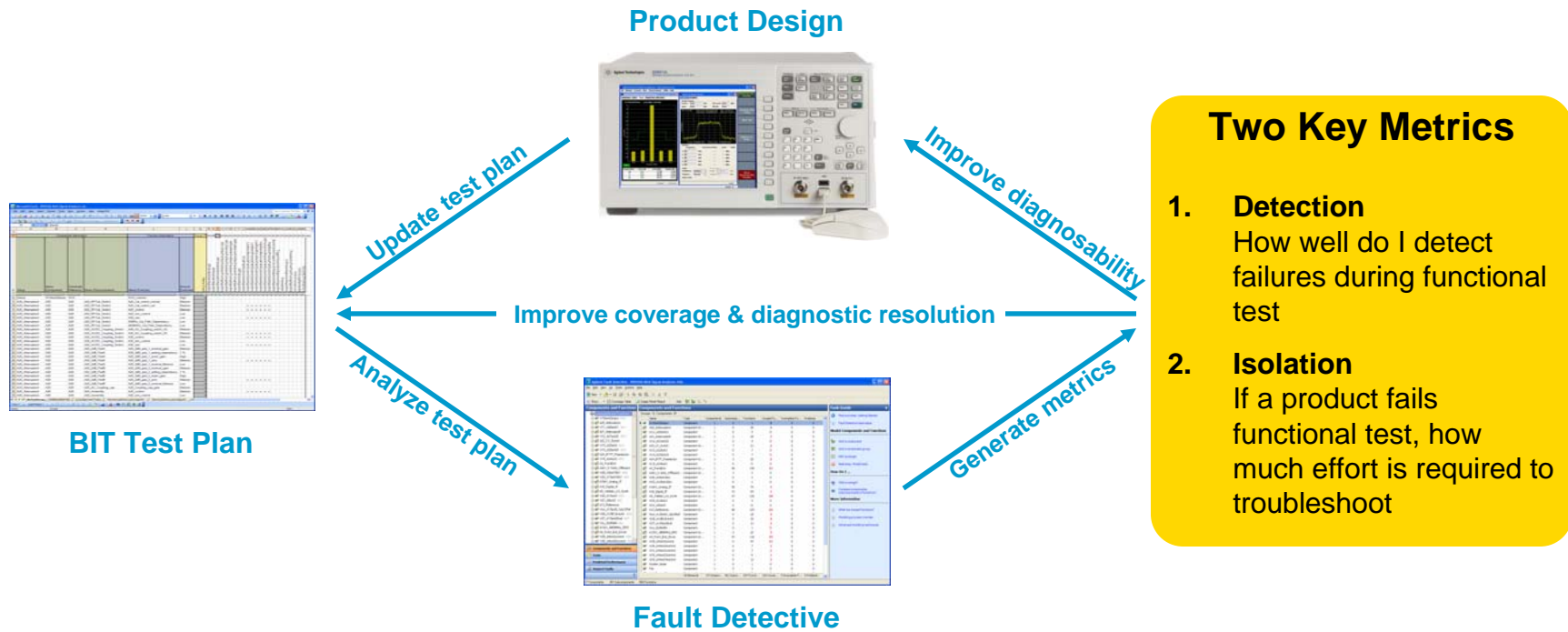
**A: We used an in-house software tool named *Fault Detective*.**



## ***Fault Detective:***

1. Create/document your test plan
2. Assesses the effectiveness of a functional test plan
3. Assesses the diagnosability of a product
4. Automatically troubleshoots defective products

# Process Overview



## Process Overview

1. Create/capture test plan in Fault Detective
2. Analyze the test plan in Fault Detective to generate metrics
3. Use metrics to improve product diagnosability
4. Use metrics to improve test coverage and diagnostics resolution



# Creating/Documenting Your Test Plan

Group	Name (Component)	Schematic Reference	Name (Subcomponent)	Name (Function)	Amount Exercised	Name (Test)
[None]	W10toA20input	W10		W10_connect	High	0
A20_AttenuatorA	A20	A20	A20_RF/Cal_Switch	A20_Cal_switch_normal	Medium	6
A20_AttenuatorA	A20	A20	A20_RF/Cal_Switch	A20_Cal_switch_cal	Medium	6
A20_AttenuatorA	A20	A20	A20_RF/Cal_Switch	A20_control	Medium	6
A20_AttenuatorA	A20	A20	A20_RF/Cal_Switch	A20_min_control	Low	0
A20_AttenuatorA	A20	A20	A20_RF/Cal_Switch	A20_use	Low	6
A20_AttenuatorA	A20	A20	A20_RF/Cal_Switch	50MHz_Cal_Path_Dependency	Low	0
A20_AttenuatorA	A20	A20	A20_RF/Cal_Switch	4800MHz_Cal_Path_Dependency	Low	0
A20_AttenuatorA	A20	A20	A20_AC/DC_Coupling_Switch	A20_AC_Coupling_switch_AC	Medium	0
A20_AttenuatorA	A20	A20	A20_AC/DC_Coupling_Switch	A20_AC_Coupling_switch_DC	Medium	6
A20_AttenuatorA	A20	A20	A20_AC/DC_Coupling_Switch	A20_control	Medium	6
A20_AttenuatorA	A20	A20	A20_AC/DC_Coupling_Switch	A20_min_control	Low	0
A20_AttenuatorA	A20	A20	A20_AC/DC_Coupling_Switch	A20_use	Low	6
A20_AttenuatorA	A20	A20	A20_2dB_PadA	A20_2dB_pad_1_nominal_gain	Medium	0
A20_AttenuatorA	A20	A20	A20_2dB_PadA	A20_2dB_pad_1_setting_dependency	1 %	0
A20_AttenuatorA	A20	A20	A20_2dB_PadA	A20_2dB_pad_1_exact_gain	High	0
A20_AttenuatorA	A20	A20	A20_2dB_PadA	A20_2dB_pad_1_zero	Medium	6
A20_AttenuatorA	A20	A20	A20_2dB_PadA	A20_2dB_pad_1_nominal_flatness	Low	0
A20_AttenuatorA	A20	A20	A20_2dB_PadB	A20_2dB_pad_2_nominal_gain	Medium	0
A20_AttenuatorA	A20	A20	A20_2dB_PadB	A20_2dB_pad_2_setting_dependency	1 %	0
A20_AttenuatorA	A20	A20	A20_2dB_PadB	A20_2dB_pad_2_exact_gain	High	0
A20_AttenuatorA	A20	A20	A20_2dB_PadB	A20_2dB_pad_2_zero	Medium	6
A20_AttenuatorA	A20	A20	A20_2dB_PadB	A20_2dB_pad_2_nominal_flatness	Low	0
A20_AttenuatorA	A20	A20	A20_AC_Coupling_cap	A20_Coupling_cap_gain	Medium	0
A20_AttenuatorA	A20	A20	A20_Assembly	A20_control	Medium	6
A20_AttenuatorA	A20	A20	A20_Assembly	A20_min_control	Low	0

**Key Benefits**  
Standardized process for documenting functional test.

**Step 1**  
List tests

**Step 2**  
List hardware components (nouns)

**Step 3**  
List functionality (verbs) of each hardware component

**Step 4**  
For each function, assign “amount of component exercised” (High, Medium or Low)

**Step 5**  
For each test, put an ‘X’ for the functions it exercises



# Assessing Functional Test & Product Diagnosability

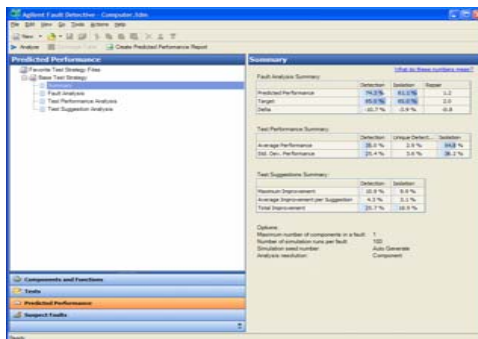
## Key Benefit

Using the model, Fault Detective generates metrics needed to:

1. Improve the product: *diagnosability*
2. Improve functional test: *coverage & diagnostics resolution*

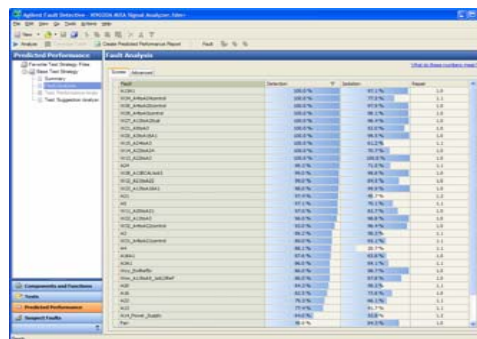
## Summary

1. Overall, how likely are test escapes?
2. Overall, how difficult is it to troubleshoot this product?



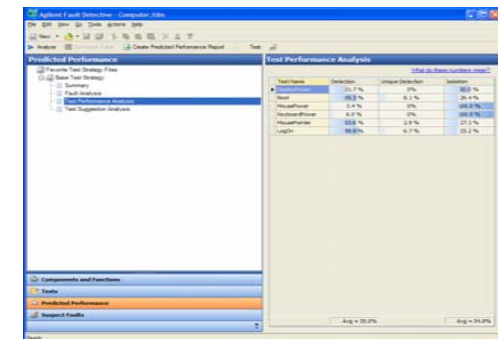
## Fault Analysis

1. How likely are specific failures to escape?
2. How difficult is it to troubleshoot specific failures?

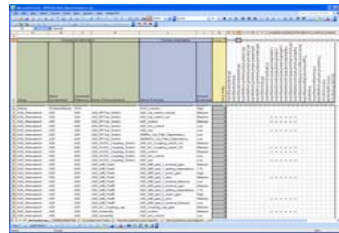


## Test Performance Analysis

1. How good is a specific test at catching escapes?
2. How much does a test contribute to diag resolution?



# Automating Diagnostics

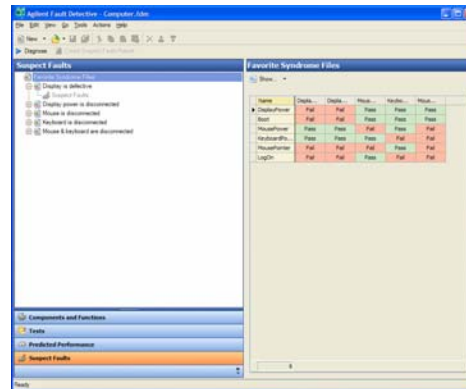


Fault Detectable Model

**Key Benefit**  
 Automated diagnostics are fast & accurate, yielding consistent results, and can be embedded directly in the product.

Name	Result
Input_Pwr_Chk_at_30Hz	Pass
Input_Pwr_Chk_at_400Hz	Pass
ECM_Gain_Cal_Connectors?	Pass
Dynamic_Range_Cnt_Gain?	Pass
External_Ref_Phase?	Pass
ISI_VCO_Tuning_Curves?	Pass
Tune_Voltage_Offset_Dist?	Pass
Trigger_Delay?	Pass
Wf_Sync_Trigger?	Pass
Scale_P_Pres_Step?	Fail
Complex_P_Pres_Resp?	Fail
A16AntennaAlgorithm	Fail
A16SigGenAlgorithm	Pass
A16VariableAttenuatorAlgorithm	Pass
A16ClockInFilterPassbandTuningAlgorithm	Pass
A16ClockInFilterPassbandTuningAlgorithm	Pass
A16ClockInFilterPassbandTuningAlgorithm	Pass
A16ClockInFilterPassbandTuningAlgorithm	Pass
A16ClockInFilterPassbandTuningAlgorithm	Pass
A16ClockInFilterPassbandTuningAlgorithm	Pass
A16ClockInFilterPassbandTuningAlgorithm	Pass
MechanicalAttenuatorAlgorithm	Fail
MechanicalAttenuatorAlgorithm	Fail
MechanicalAttenuatorAlgorithm1	Pass
MechanicalAttenuatorAlgorithm2	Pass
MechanicalAttenuatorAlgorithm3	Fail
MechanicalAttenuatorAlgorithm4	Pass
MechanicalAttenuatorAlgorithm5	Pass
MechanicalAttenuatorAlgorithm6	Pass
MechanicalAttenuatorAlgorithm7	Pass
MechanicalAttenuatorAlgorithm8	Pass
MechanicalAttenuatorAlgorithm9	Pass
MechanicalAttenuatorAlgorithm10	Pass
MechanicalAttenuatorAlgorithm11	Pass
MechanicalAttenuatorAlgorithm12	Pass
MechanicalAttenuatorAlgorithm13	Pass
MechanicalAttenuatorAlgorithm14	Pass
MechanicalAttenuatorAlgorithm15	Pass
MechanicalAttenuatorAlgorithm16	Pass
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MechanicalAttenuatorAlgorithm35	Pass
MechanicalAttenuatorAlgorithm36	Pass
MechanicalAttenuatorAlgorithm37	Pass
MechanicalAttenuatorAlgorithm38	Pass
MechanicalAttenuatorAlgorithm39	Pass
MechanicalAttenuatorAlgorithm40	Pass
MechanicalAttenuatorAlgorithm41	Pass
MechanicalAttenuatorAlgorithm42	Pass
MechanicalAttenuatorAlgorithm43	Pass
MechanicalAttenuatorAlgorithm44	Pass
MechanicalAttenuatorAlgorithm45	Pass
MechanicalAttenuatorAlgorithm46	Pass
MechanicalAttenuatorAlgorithm47	Pass
MechanicalAttenuatorAlgorithm48	Pass
MechanicalAttenuatorAlgorithm49	Pass
MechanicalAttenuatorAlgorithm50	Pass

Test Results



Fault Detectable Diagnostics Engine

Score	Sch...	Fault	Detail
83.9	A16A1	A16A1	A16A1,A16A1_Anti_Alias_N_Filter + FO:A16A1_Anti_alias_filter_N_stopband
7.3	A13	A13	A13,A13_3rdLO_Detector + PF:A13_322MHz_CW_Cal_Use_Relative
5.1	A16	A16	A16,A16_PRN_Generator + PF:A16_Dither_on
1.7	W28	W28_A13ECAL...	W28_A13ECALtoA3
<1	W23	W23_A13toA1...	W23_A13toA16A1 + PF:W23_Connect
<1	A3A1	A3A1	A3A1,A3A1_LPF + PF:A3A1_5.1GHz_Offboard_filter_passband
<1	A3	A3	A3,A3_4.8GHz_LO_Cal_in + PF:A3_ECal_in_to_AIF_in
<1	W20	W20_A3toA16A1	W20_A3toA16A1 + PF:A3_ECal_in_to_AIF_in

Diagnosis



# Summary of Benefits/Results

**Near 100 percent diagnostic accuracy**

**Incremental effort is minimal (for A/D, coverage requirement is mandatory on most programs)... “it’s a no-brainer”**

## Manufacturing/Production

**Perform self-diagnosis after final assembly, before final verification.**

1. Standardized test documentation → Consistency across the company
2. Coverage assessment → Fewer test escapes
3. Diagnostics assessment → Predictable time-to-volume
4. Automated diagnostics → Fewer resource requirements (fewer repair technicians & less capital equipment)  
→ IP protection

## Service Centers/Depots

**Perform self-diagnosis before manual troubleshooting.**

1. Automated diagnostics → Fewer resource requirements (less time ramping-up technicians at each service depot)  
→ Faster turn-around time
2. Coverage assessment → Fewer no-trouble-founds

## In the Field

**Perform diagnostic from anywhere in the world.**

1. Automated diagnostics → Fewer resource requirements  
→ Increased product up-time
2. Coverage assessment → Fewer failures in the field