

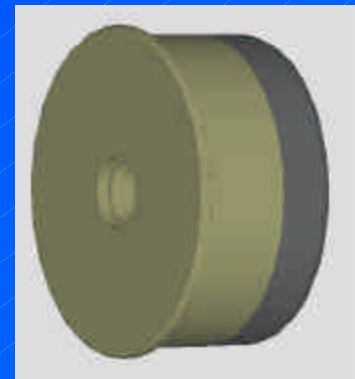


Development of an Ultrasonic Inspection System for the 120MM Case Base

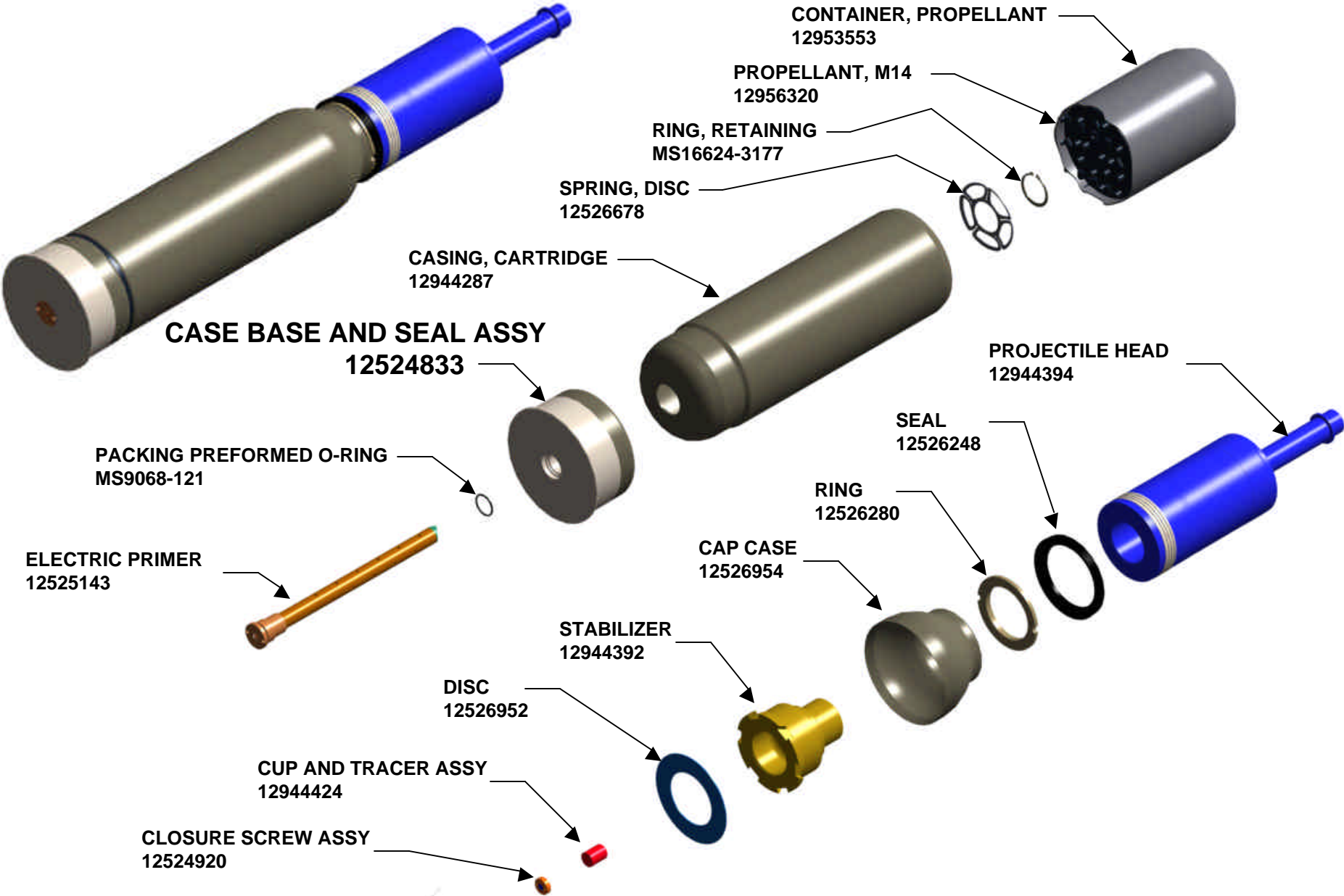
Presented At

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Missiles Symposium & Exhibition
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Art Skeates III
Alliant Techsystems
120mm M831A1 Cartridge Lead Engineer



M831A1 CARTRIDGE, 12944397



Case Base

Manuf



- Forged from High Quality, High Strength Steel
- Heat Treated
- CNC Machined
- Dimensional Inspection
- **NDT Inspection (Critical II Characteristic)**
- Protective Finish / Inspected
- Injection Mold Rubber Seal Assembly
- Final Inspection
- Ship to LAP Facility

Case Base Perf Requirements



- **Requirements**
 - Fit Gun Chamber
 - **Obturation**
 - Provide seal for pressures in excess of 100,000 PSI
 - Failure results in injury or death of Tank Crew
 - **Soundness**
 - No splits or cracks after firing
 - **Extract from Gun After Firing**

NDT History & Concerns



- **Steel Fabrication**
 - Forging and Heat Treat Processes can Potentially Induce Unacceptable Flaws
- **Magnetic Particle Inspection (MT)**
 - 100% TDP Requirement from onset of Program
- **Magnetic Particle Concerns**
 - **Operator Dependent**
 - Reliability, **Visual**, Fatigue, Certification
 - Numerous parameters to control and verify
 - Magnetism, Particle Concentration, Contamination, Black Light Intensity, White Light Intensity, Carrier Fluorescence

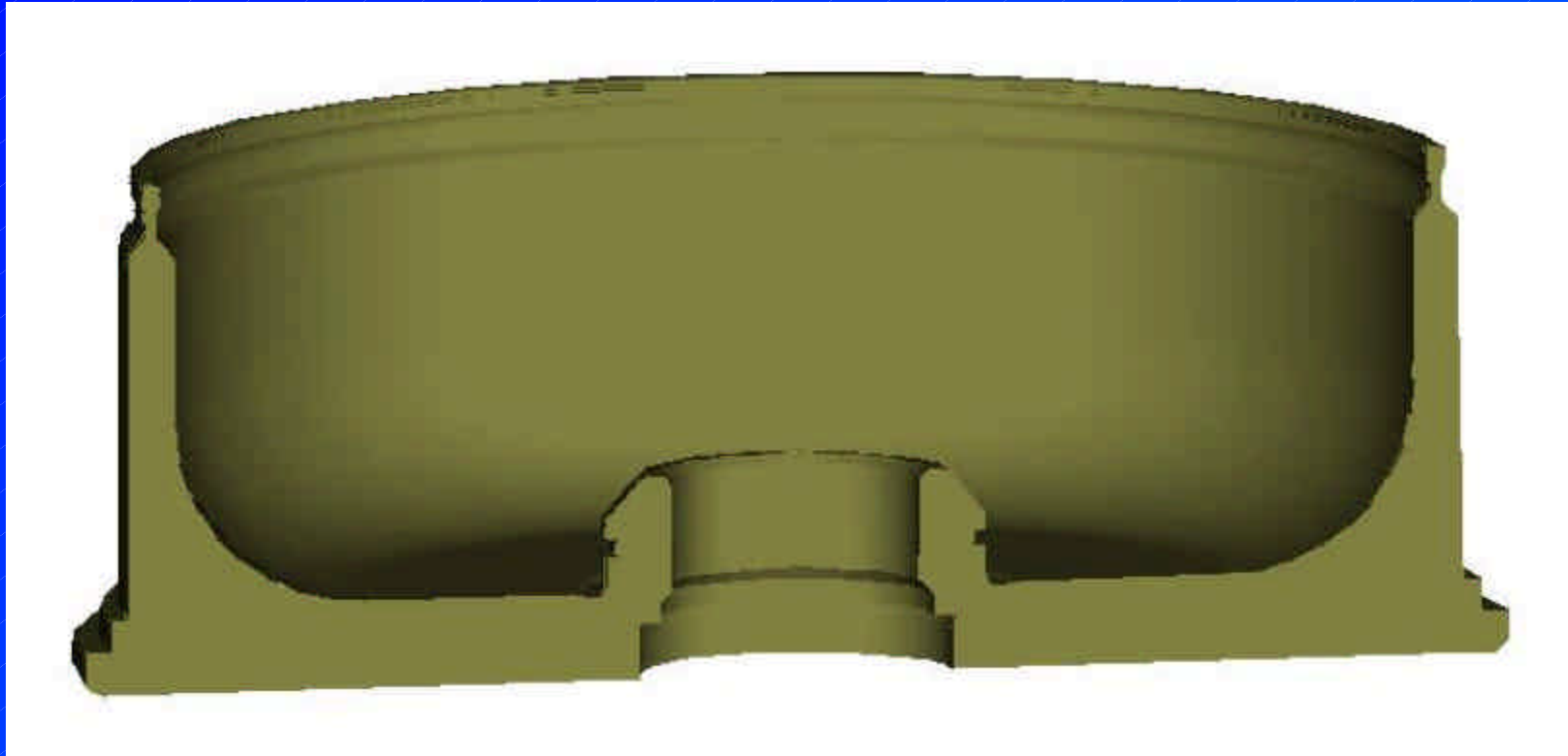
NDT History & Concerns (Continued)



- **Current Tank Ammo Contract**
 - Revised the NDT Requirements
 - 200% MT Required When Critical Flaw Rate > 1 in 40,000
 - Ultrasonic Inspection Required When The Critical Flaw Rate > 1 in 16,000
- ATK Decides to Procure An Automated UT Inspection System For Use As Its Primary Case Base NDT Inspection System

Primary Technical Challenge

- The Case Base Cross Section



- 1st Tank Ammo Production UT of Non-Uniform Cross Section
- 1st Tank Ammo Production UT of a Finish Machined Part

Key Decision

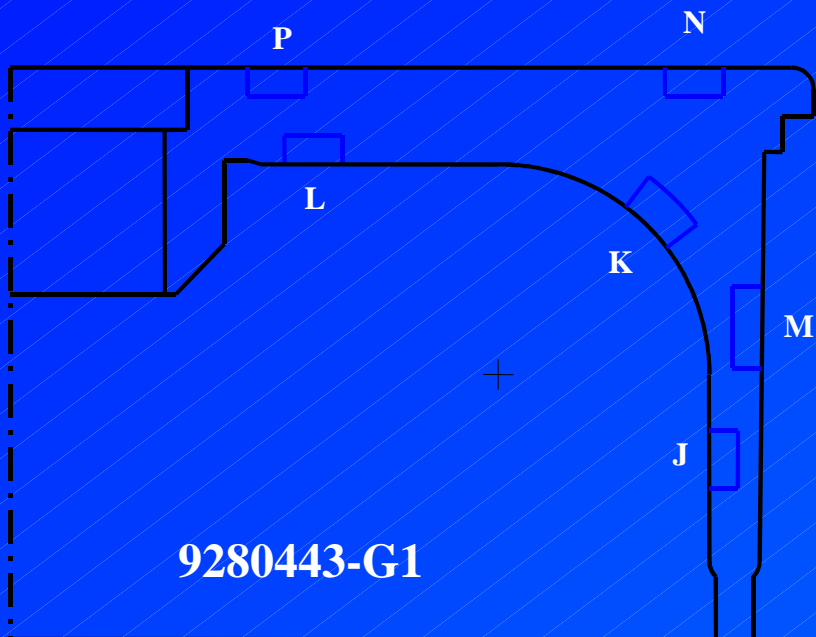
- ATK's Supplemental Standards



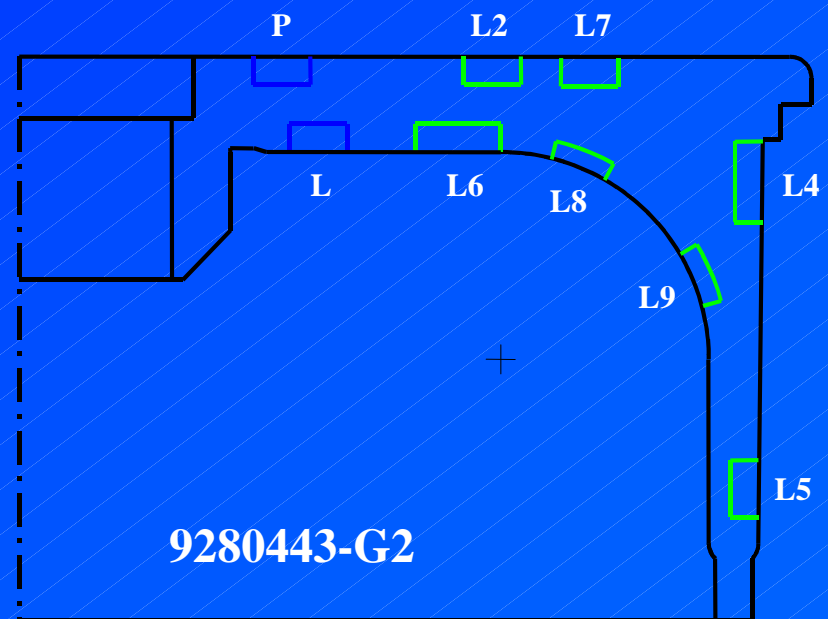
- ATK Designed and Implemented the Use of Additional EDM Notch Standards to Maximize the Systems Inspection Coverage Area
 - Also Maximized the Reliability of Flaw Detection
- Typical Gov't TDP & ATK Standards Notch Sizes

<u>Depth (mm)</u>	<u>Lengths (mm)</u>	<u>Width (mm)</u>
0.28	6.1, 8.64, 12.49	0.18

Longitudinal EDM Notch Standards

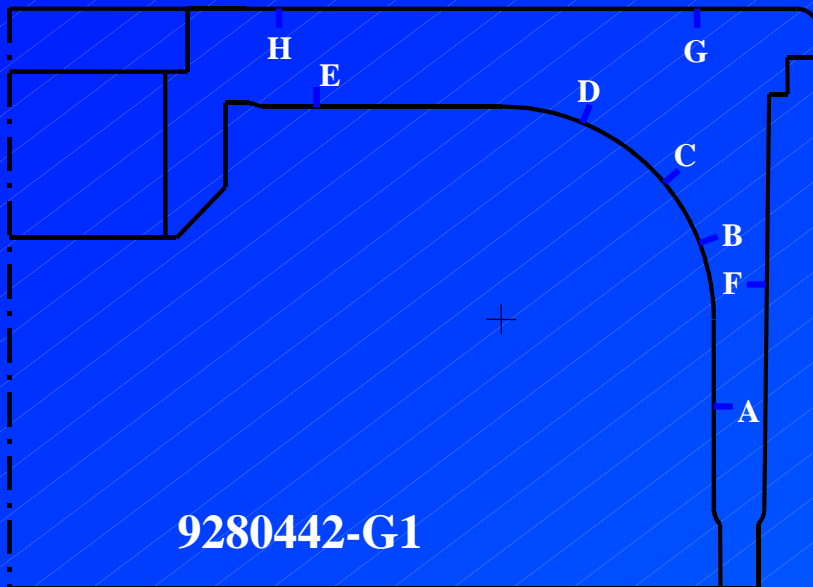


Government TDP Required



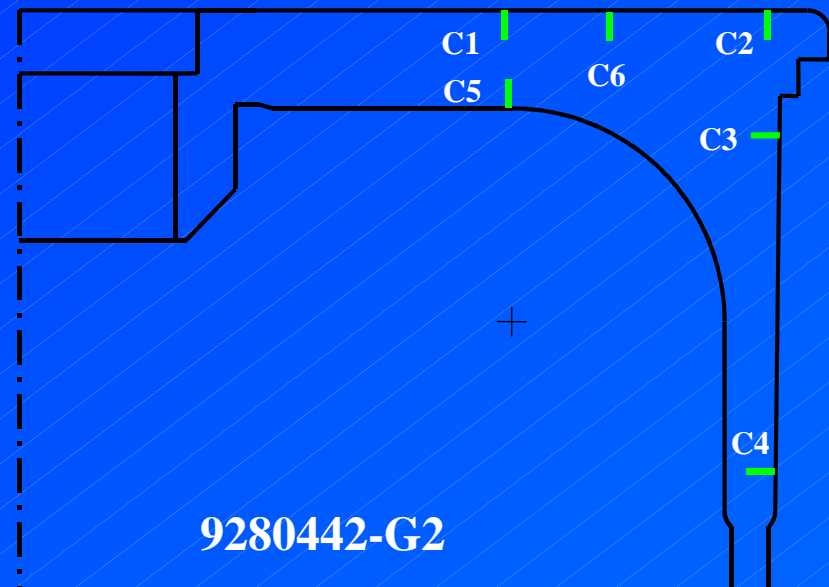
ATK Supplement

Circumferential EDM Notch Standards



9280442-G1

Government TDP Required



9280442-G2

ATK Supplement

Automated UT System Development



- Selected a Supplier to Develop and Manufacture an Acceptable System
- Extensive support and coordination with supplier
- Two Weeks After Witnessing a Pre-ship Validation, Supplier Went into Voluntary Insolvency
 - Pre-ship Validation Identified Some Minor Issues but Performed Well, System Appeared to be 95+% Complete
- ATK Took Possession of the System and Proceeded on Its Own to Complete the Systems' Development and Qualification

ATK Engineering and UT Expertise at Work



- Time of Discovery
 - Installed System in Factory, Discovered that Despite the Apparently Successful Pre-ship Validation, the System has Some Shortcomings that Require Significant Design Changes
- Major Redesign of the Part Rotation System
 - Consistent Rotation Speed Vital
 - Upgraded from 1 Drive Roller to 4 Drive Rollers
 - Optimized Roller Material and Configuration
 - Upgraded Base Plate Design to Reduce Rotational Friction
- Redesign Resulted in Significant Improvement in the UT Inspection Performance

ATK Engineering and UT Expertise at Work

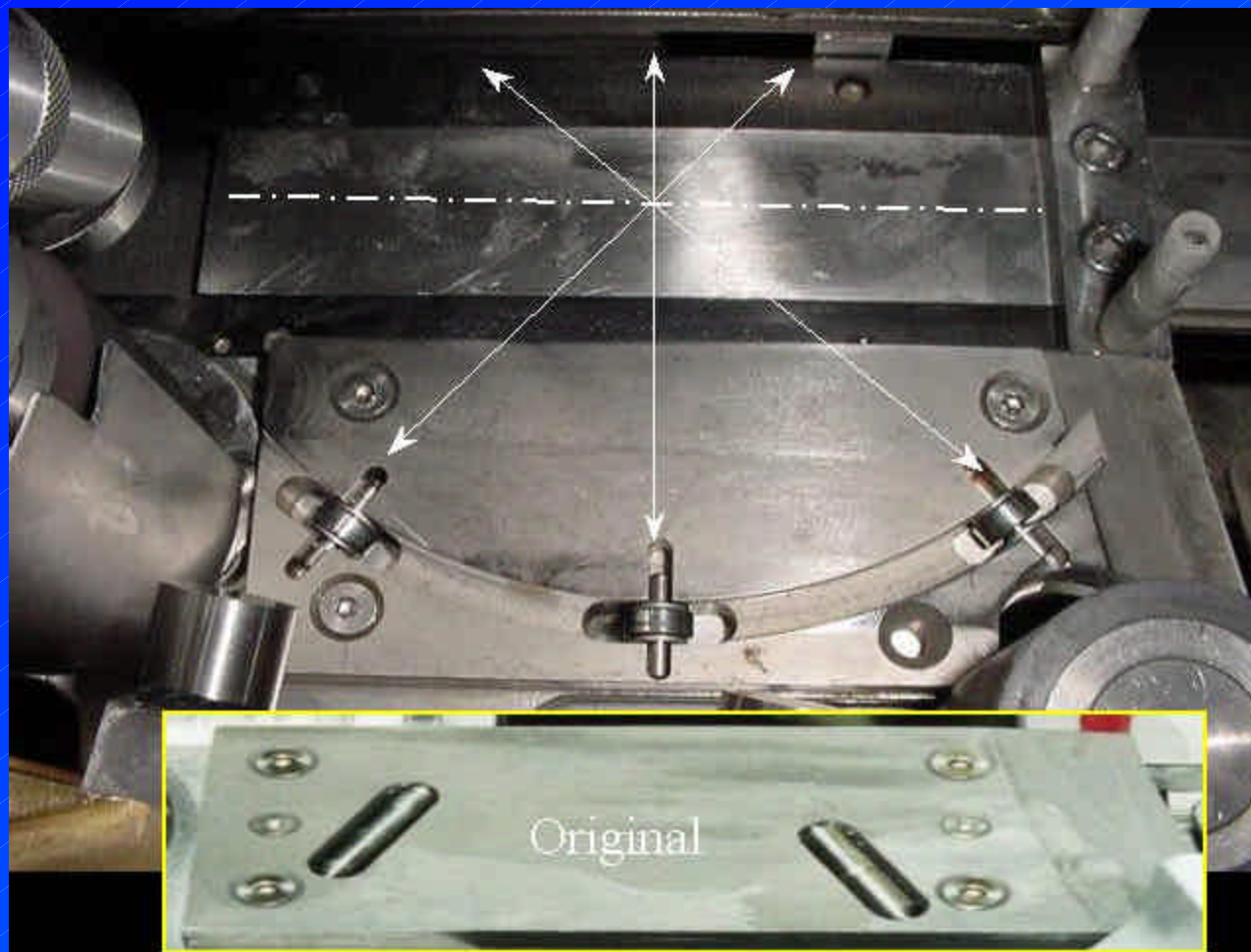


- **ATK's Engineering Challenge**
 - Numerous Additional Issues Discovered
 - Motion Control Code Errors
 - LabVIEW Data Acquisition Code Errors
 - Counter/Timer Circuit Fails (provides trigger pulse for UT instrument)
 - Inspection Coverage Area and Ultrasonic Transducers Inadequate

Case Base in Drive System



Redesigned Base Plate



ATK Engineering and UT Expertise at Work

(continued)



- Revised the Majority of the Ultrasonics
 - Transducer Type, Location, and Orientation
 - Redesigned the Transducer Scanning Heads and the Fixed Transducer Locating Brackets
 - Revised and Optimized the Transducer Inspection Parameters
 - Used ATK Designed EDM Notch “Coverage Standards” to Insure Proper System Performance

ATK Engineering and UT Expertise at Work

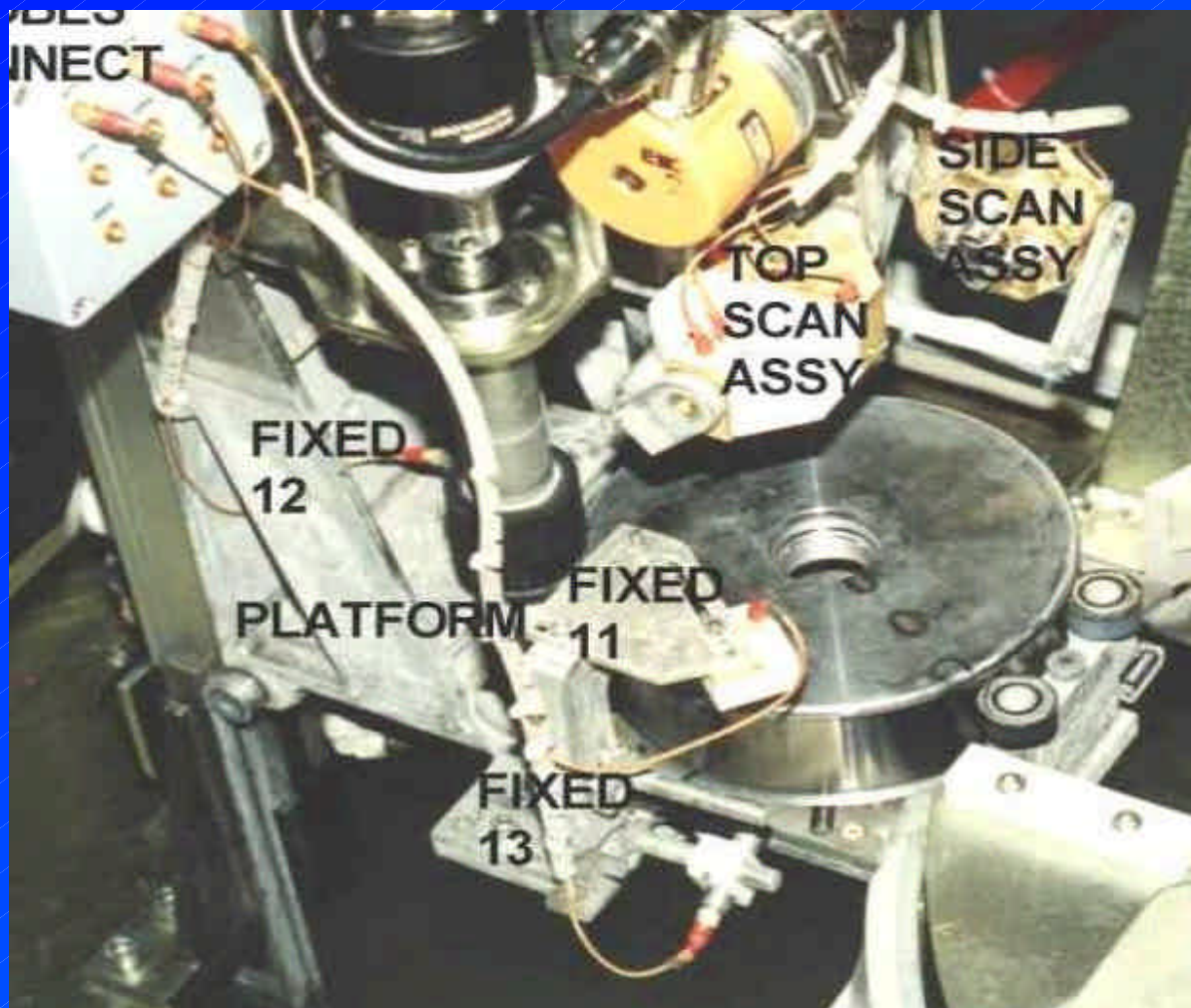
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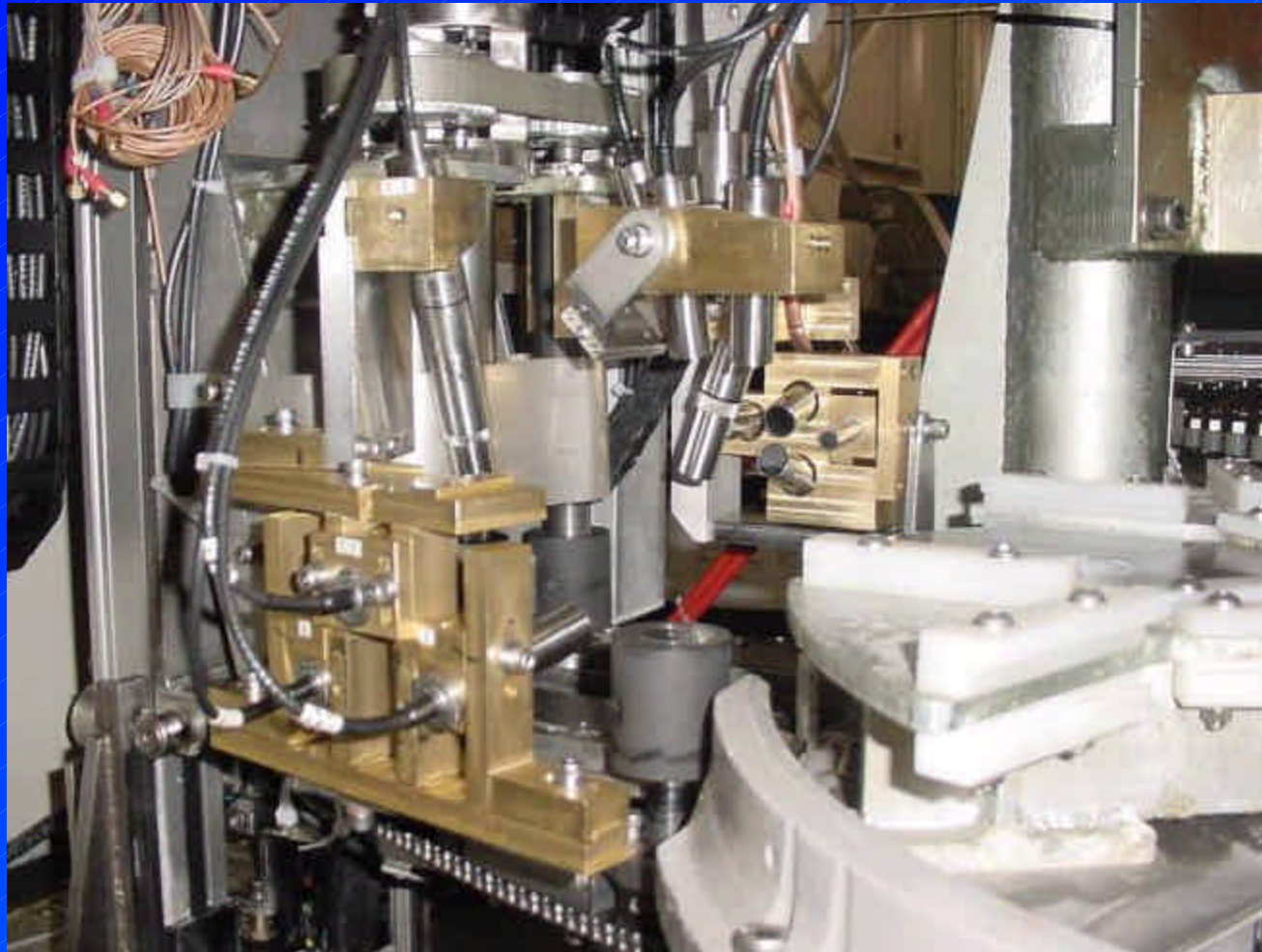
- Replaced Light Duty Vertical and Horizontal Motion Tables with Heavier Duty Versions
- Upgraded and Revised the Motion Control Software to Eliminate Errors
- Upgraded Rotational Motor to Increase Available Torque Output

System As-Received

f



System Af Upgrade



ATK Pre-Validation



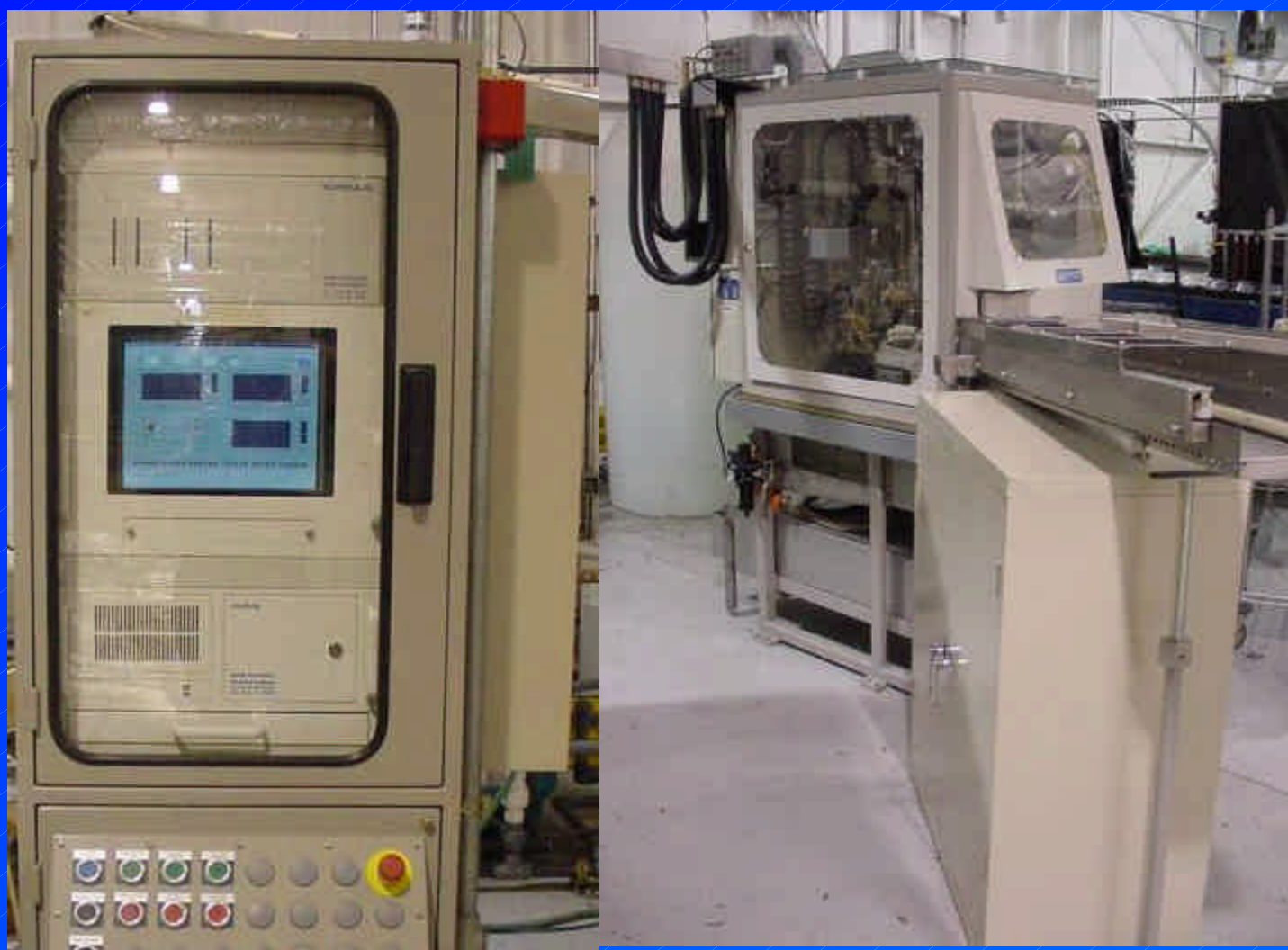
- ATK Performed a 27 Consecutive Hour Pre-Validation Test Run
 - 2 Gov't & 2 ATK Standards Each Inspected 234 Times (7,488 Notches Detected at 100% Reliability)
 - 2 “Good Parts” Each Inspected 234 Times
 - < 1% False Rejects
 - Demonstrates High Reliability for “Critical Characteristic”

System Validation / Qualif



- ATK Performs a 51 Consecutive Hour Government Witnessed System Validation / Qualification
 - System Qualified!!!
 - 2 Gov't TDP & 2 ATK Standards Each Inspected 462 Times (14,784 Notches Detected at 100% Reliability)
 - 2 "Good Parts" Each Inspected 462 Times
 - 4 False Rejects, 0.43%

UT Inspection System



Turntable



System Design Features



- Fail-Safe System Design
 - Any Problems/Issues System Defaults to Reject Status
- Fully Automatic, Semi-Automatic and Manual Operation Modes
- PC Keyboard & Mouse used to Set-Up & Control the System
 - Full Access for System Level Administrator
 - Limited Access for Production Operator
- Automatic Second Scan When Defects are Detected
- Detailed Data Files (Calibration Standards & Flaws)
- Robust Design and Ease of Operation / Maintenance
- Periodic System Verification Utilizing Standards

System Data File



CALIBRATION REPORT

Date and Time 02/19/02 05:01:31 PM
 Heat Lot Validation
 Component Type Base Case
 Component Ref 9280442 G1
 Scan File Scan2001.PRG
 UT File Final_Internal.st3
 Flaws Matched 33 of 33
 Extra Flaws 0
 Status PASS

Top Probes

Flaw #	Test	Gate	Lin-Pos (mm)	Ang-Pos (deg)	Size (deg)	Min-Amp (%)	Max-Amp (%)
1	1	1	5.6	103	9	44.5	125.0
2	1	1	6.8	105	10	40.5	125.0
3	1	1	7.9	109	5	45.0	73.0
4	3	1	20.3	139	6	48.0	71.4
5	3	1	21.5	141	8	44.0	116.6
6	3	1	22.6	144	8	49.5	103.6
7	3	1	23.7	147	2	48.5	48.5
8	3	2	26.0	195	5	50.6	70.1
9	3	2	27.1	198	6	62.1	95.6
10	3	2	28.2	201	5	64.1	83.1
11	3	2	29.4	204	3	43.6	48.1
12	5	1	41.3	210	8	59.4	92.4
13	5	1	42.2	212	7	48.4	62.9

System Design Features (Continued)



- Self Feed Input Chute & Accept Chute
- Locked Reject Chute (Limited Access to Rejected Parts)
- Automated In-line “U” Acceptance Stamping
- Temperature Controlled Electronics & Coupling Media
- Filtering in Both the Upper and Lower Tanks
- Per Channel Instantaneous and Latched Visual Alarms
- Permanent Storage of Inspection History
- Extensive Use of Non-Metallic Pads/Guides/Etc. to Prevent Parts Damage

UT Inspection Specif

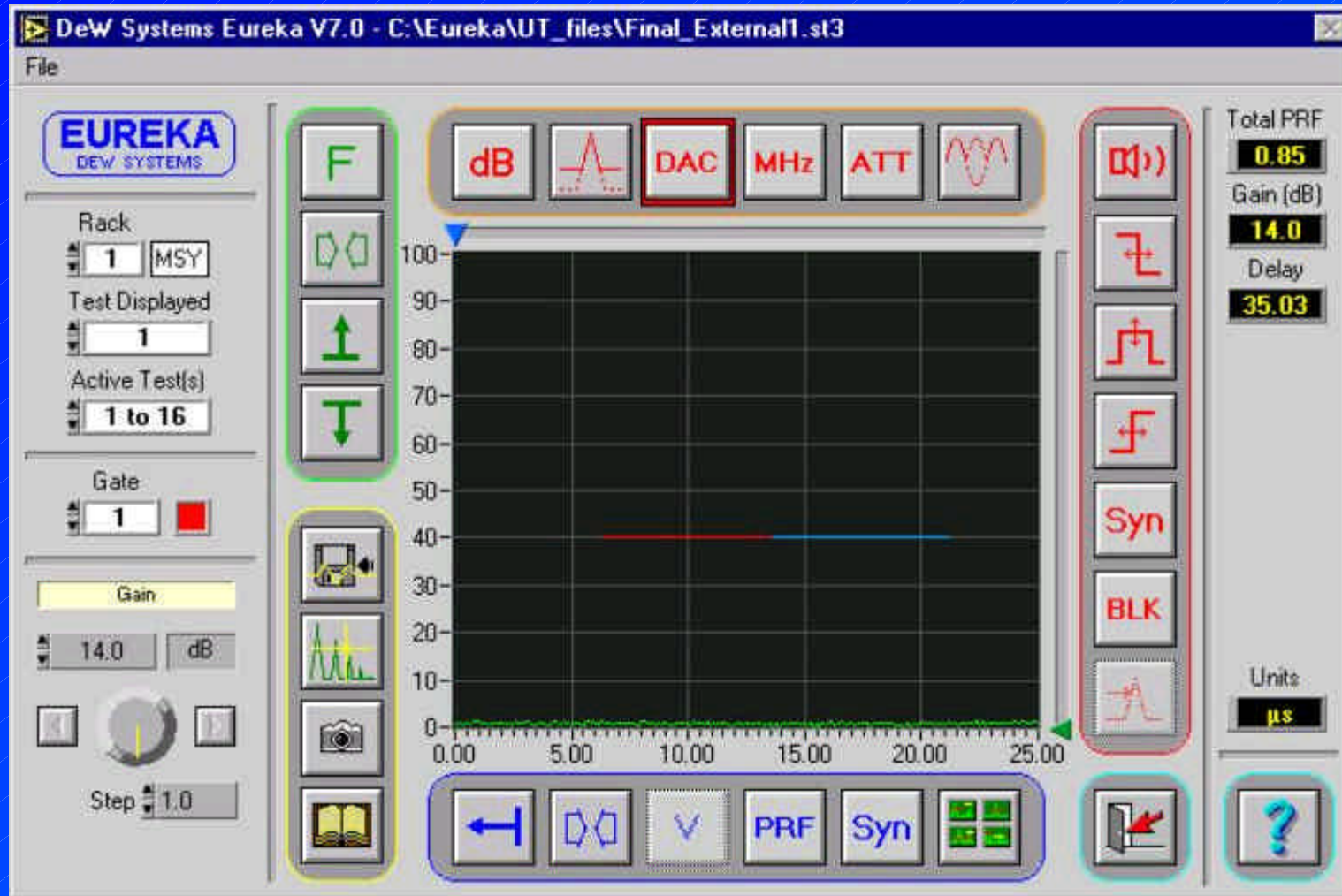


- Horizontal Scanning of the Case Base Aft Face
 - 5 Transducers, 6 Tests
- Vertical Scanning of the Case Base Sidewall
 - 4 Transducers, 5 Tests
- Fixed Transducers to Inspect Specific Locations
 - 5 Transducers, 1 Receiver, 5 Tests
- Inspection Cycle < 1 Minute/Part

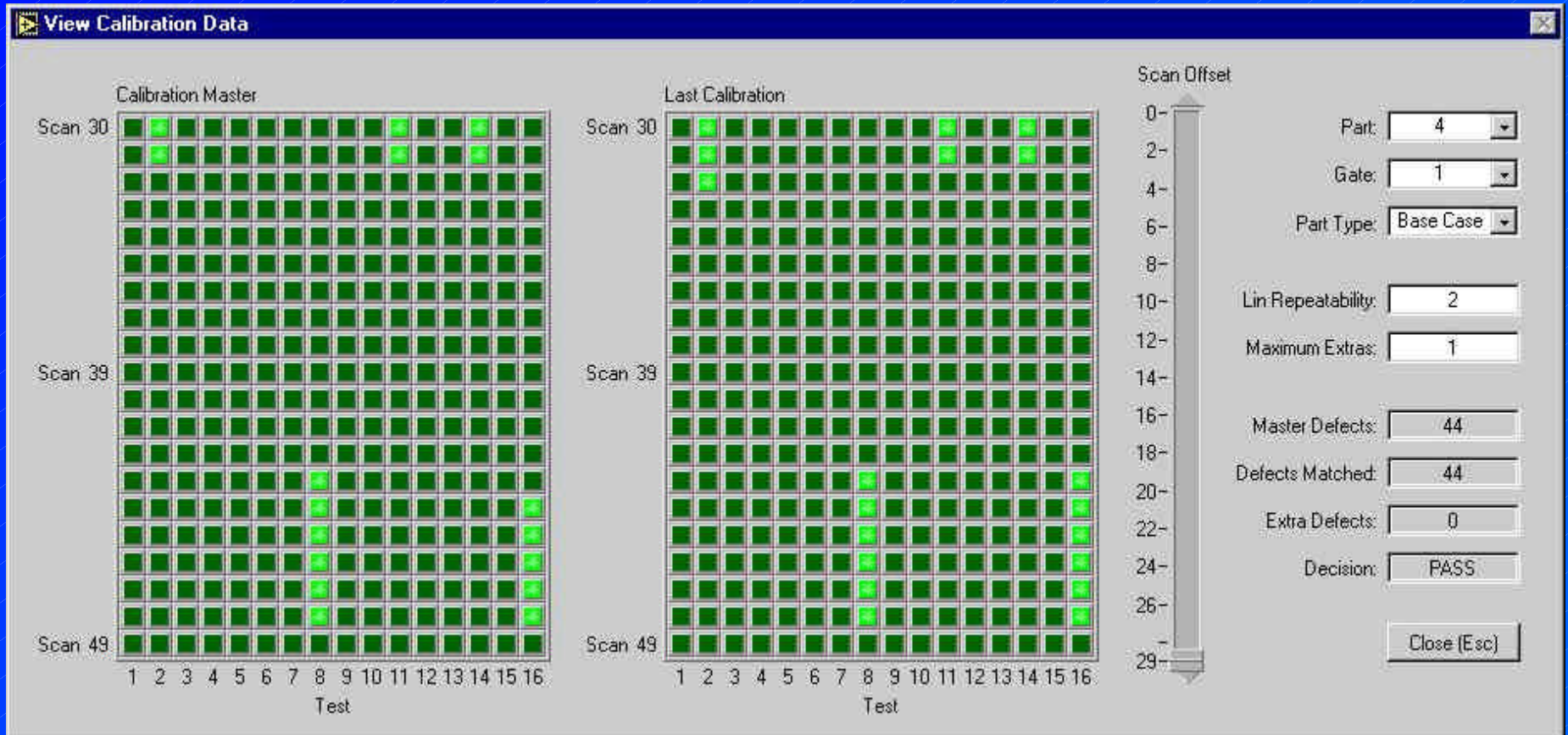
System Main Screen



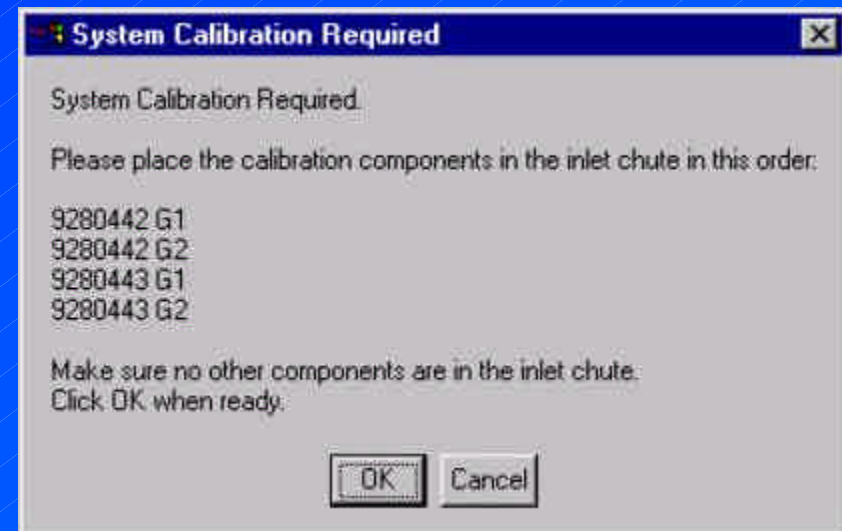
Ultrasonic Instrument



Calibration Data



System Alerts



Conclusion & Recognition



- ATK's Determination and Resolve Has Resulted in a Significant Advancement in the State-of-the-Art NDT Inspection Method for the 120mm Case Base
- Special Thanks & Appreciation Go To:
 - Tom Rockne, Former ATK Tank Ammo Program Director
 - Gary Lamecker, ATK Level III for UT