



Small Indication Analysis in Airframes and Powerplants

Benefits of NDT Using Highest Definition Remote Visual Inspection (RVI)

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September 23, 2019

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A shifting industrial landscape

 The need for faster, more accurate, more precise inspections has never been greater.

What this means for the NDT industry

Uptime and safety continue to be critical.

"Visual inspection is the first line of defense for safety-related failures on aircraft..."

Visual Inspection Research Project Report on Benchmark Inspections, DOT/FAA/AR-96/65





RVI Surface Evaluation

- * Turbine blades, combustion section
- * Hydraulic cylinders and valves pitting, scoring, porosity, tool marks
- * Recip engines cracked cylinders
- * Foreign Object Damage (FOD) aircraft, airframe powerplants
- * **FOSAR** Foreign Object Search & Retrieval in engine or airframe
- * General inspections in hard to reach places verify proper placement and fit of seals, bonds, gaskets, and sub-assemblies

AC 43.13



Direct vs. Remote Visual Inspection (RVI)

Direct Visual Inspections

Generally understood as an examination of a surface which allows an Inspector's eye within 24"/610 mm of a surface to be examined, at a viewing angle not less that 30° to that surface, and illuminated with a minimum light intensity of 100 fc.

Remote Visual Inspection - RVI

Visual examination of surface not accessible for direct visual inspection typically aided by rigid borescopes, fiberscopes, or VideoProbes .

THE CHALLENGE:

RVI technology must offer a high degree of Probability of Detection as well as greater Resolution of indications on a surface.



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Remote Visual Inspection (RVI) NDT Method

Find Indications When Visual Testing is Not Possible in Inaccessible areas:

- Corrosion
- Cracking
- Erosion
- Impact Damage

APPLICATIONS

- Aircraft engines
- Landing Gear
- Control Surfaces
- Hydraulic System

- APUs
- P/N & S/N Validation
- Lube Systems
- Wire Harnesses

THE Solution:

Highest Definition Remote Visual Imaging allowing for better spatial resolution to find and analyze the smallest surface indications.



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The Inspector in the Process

AC No: 65-31B

(H)

- a. Required Examinations.
- (1) Physical Examination.

(a) **Vision**. An examination to ensure near vision of at least one eye, either corrected or uncorrected, such that the individual can read Snellen equivalent of 20/25 (Jaeger #1). (.37mm / 0.015" from 14" distance)The examination must be on a periodic basis, not to exceed 1 year.

(b) Color Perception. Distinguish and differentiate between colors necessary for the inspection method for which qualification is sought. **Color vision testing** need only be accomplished one time, usually at the initial vision examination. The responsible Level III qualified examiner should evaluate any limitations in color perception prior to certification and approve in writing.

Training on the tasks, techniques, and required test equipment is paramount to success!



Limitations of Standard Definition Cameras

- Lower resolution imaging technology
- Digital zoom ineffective with pixelated images
- Limited working range* from camera
- Multiple optical tip adapter changes* or position adjustments needed
- Requires extra time* to assess the severity of nearly invisible indications
- * Especially true when measuring with Stereo measurement technology







New advancements in portable RVI solutions are transforming the NDT industry today!

Revolutionizing Remote visual inspections with Hi-Def

• New advancements in higher definition RVI technology provides unprecedented image quality with 1.2-megapixels

> 1.2-mp Highest Def .79-mp







HD Probe Basics

- 1.2-megapixel camera imager
- Video resolution is 1024 x 768 (XGA)
- Saved HD Image size (1280 x 960) vs. Saved SD Image size (752 x 576)
- HD Digital Zoomed to 1.8X = SD pixelation at 1.0 X (no zoom)
- **BENEFIT**: Measurement cursor placement in some scenes, and especially with Stereo measurement where pixel matching is hyper-critical, allows for improved precision of cursor placement due to increased spatial resolution

Standard Definition



Truesight Imaging HD Visuals







What is Resolution

Resolution is a measurement of an imaging system's ability to reproduce object detail, and can be influenced by factors such as the type of lighting used, the pixel size of the sensor, or the capabilities of the optics.

The smaller the object detail, the higher the required resolution.

Edmund Optics



Resolution Standard - USAF 1951 1X Target

- In use since 1951, MIL-STD-150A
- Resolution test chart for validating spatial resolution
- Groups / Elements are presented as line pairs (one black line + one white line)
- All following images taken from Edmonds Optics USAF 3"X3" POS Res Target ; NIST Cal Due 04/2020



* TTTD – (camera) Tip-To-Target Distance





Standard for Resolution Measurement

USAF 1951 1X NIST Traceable 3" x 3" Standard – Edmunds Industrial Optics

	LP/mm									Line Width - in.							
	Group									Group							
Eleme	it -2	0	1	2	3	4	5		Element	-2	0	1	2	3	4	5	
1	0.25	1.00	2.00	4.00	8.00	16.00	32.00		1	0.0787	0.0197	0.0098	0.0049	0.0025	0.0012	0.0006	
2	0.28	1.12	2.24	4.49	8.98	17.90	35.90		2	0.0701	0.0176	0.0088	0.0044	0.0022	0.0011	0.0005	
3	0.32	1.26	2.52	5.04	10.10	20.10	40.30		3	0.0625	0.0156	0.0078	0.0039	0.0019	0.0010	0.0005	
4	0.35	1.41	2.83	5.66	11.30	22.60	45.30		4	0.0556	0.0140	0.0070	0.0035	0.0017	0.0009	0.0004	
5	0.40	1.59	3.17	6.35	12.70	25.40	50.50		5	0.0496	0.0124	0.0062	0.0031	0.0016	0.0008	0.0004	
6	0.45	1.78	3.56	7.13	14.30	28.50	57.00		6	0.0442	0.0111	0.0055	0.0028	0.0014	0.0007	0.0003	
		LP width - mm								LP width - in.							
		Group								Group							
Eleme	it -2	0	1	2	3	4	5		Element	-2	0	1	2	3	4	5	
1	4.000	1.000	0.500	0.250	0.125	0.063	0.031		1	0.1575	0.0394	0.0197	0.0098	0.0049	0.0025	0.0012	
2	3.559	0.893	0.446	0.223	0.111	0.056	0.028		2	0.1401	0.0352	0.0176	0.0088	0.0044	0.0022	0.0011	
3	3.175	0.794	0.397	0.198	0.099	0.050	0.025		3	0.1250	0.0312	0.0156	0.0078	0.0039	0.0020	0.0010	
4	2.825	0.709	0.353	0.177	0.088	0.044	0.022		4	0.1112	0.0279	0.0139	0.0070	0.0035	0.0017	0.0009	
5	2.519	0.629	0.315	0.157	0.079	0.039	0.020		5	0.0992	0.0248	0.0124	0.0062	0.0031	0.0016	0.0008	
6	2.247	0.562	0.281	0.140	0.070	0.035	0.018		6	0.0885	0.0221	0.0111	0.0055	0.0028	0.0014	0.0007	



Groups / Elements are presented as line pairs

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SD Camera

SD camera with 6" (152 mm) tip-totarget distance with 1.0X zoom

Spatial resolution can be observed in Group 1 Element 2

Group 1 Element 2 LP are 0.018" (0.45mm) wide







SD Camera

SD camera with 6" (152 mm) tip-totarget distance with 2.0X zoom

Spatial resolution can be observed in Group 1 Element 4

Group 1 Element 4 LP are 0.014" (0.35 mm) wide





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HD Camera

HD camera with 6" (152 mm) tip-totarget distance with 1.0X zoom

Spatial resolution can be observed in Group 1 Element 5

Group 1 Element 5 Resolved LP are 0.012" (0.32 mm) wide







HD Camera

HD camera with 6" (152 mm) tip-totarget distance with 2.0X zoom

Spatial resolution can be resolved in Group 2 Element 1

Group 2 Element 1 Resolved LP are 0.010" (0.25 mm) wide





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SD Camera on ACCU-CHART

SD camera with 9" (229 mm) tip-to-target distance

Both vertical and horizontal resolution at this TTTD is ~350 lines pairs per inch (350 / 25.4 mm)

Pixilation noted in outer circles







HD Camera on ACCU-Chart

HD camera with 9" (229 mm) tip-to-target distance

Both vertical and horizontal resolution at this TTTD is ~600 lines pairs per inch (600 / 25.4 mm)

Notice outer circles are not pixelated







"I can see it!"

"How Big is it?"

"Is it safe to fly?

HD Camera

Group 4, Element 3 Line pairs are 0.0020" (0.050 mm) wide

G4E6 LP are 0.0014" (0.035 mm) wide and are resolved in the Point Cloud

Image quality and cursor placement were assisted with TrueSight[™] HDR processing

HDR – High Dynamic Range imaging provides a greater dynamic range of luminosity in a given scene







Z=0.003"



HD Camera

Group 5, Element 3 Line pairs are 0.0010" (0.025 mm) wide

Image quality and cursor placement were assisted with TrueSight HDR processing

HDR – High Dynamic Range imaging which provides a greater dynamic range of luminosity in a given scene

BAKER

UGHES a GE company



More comprehensive Real3D long distance measurement advancements

Full 3D surface scanning with new long-range 3D measurement optical tip adapter for more accurate measurements of larger features and more challenging surfaces at greater distances



F company







Long-Range 3D measurement advancements





Besults can vary based on training, experience and surface conditions. Always perform gage R&R for any application.

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HD Far Focus

Group 0, Element 1 Line pairs are 0.0394" (1.00 mm) wide

G1E6 LP are 0.011" (0.28 mm)

Image quality and cursor placement was assisted with TrueSight HDR processing

HDR – High Dynamic Range imaging which provides a greater dynamic range of luminosity in a given scene





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Innovations Applied in A&P



Pushing the boundaries of RVI technology

More accurate inspections, and less downtime



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HD Visuals
Improved image quality
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Real3D Measurement

Detect smaller indications from further away



Expanded Digital Zoom

Faster decision making with clearer visuals on-device



TrueSight[™] Imaging

Crystal clear live HD video & still images with HDR unlocks the power of digital zoom with new image processing for enhanced image brightness and daylight readability





Gaining the Benefits



HD Far Focus Powerplant Inspections

Measuring with long Tip-to-Target Distances is now possible

Large-area indication analysis now possible

Areas previously accessible only with significant disassembly now accessible easier/faster

BENEFIT: Reduced maintenance & down time

A "bad" call on a CF6-80C2 on a 747 is in excess of a \$1.2M decision







NONDESTRUCTIVE TESTING FORUM

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HD Airframe Inspections

Measuring intergranular corrosion under floorboards or in other airframe structure via >0.250" access

Allows for pre-inspection planning allowing parts to be on-hand for C or D checks

Reduces time to complete repairs once aircraft is grounded with needed parts ordered and onhand

BENEFIT: Return to service faster







Clearer Inspection Data Improved POD Increased Precision Faster Inspections



Thank You! Paul Thompson W: 912.335.8969 M: +1 512.213.8369

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