Empirical POD Studies

Status Report for MAPOD-WG For June 2005 Meeting

Irving Gray,

NDE Technologies, Inc.

Acknowledgements

Mike Bode, Sandia
Dave Galella, FAA
Floyd Spencer, Sandia
Dave Forsyth, NRC-CNRC

John Aldrin, Computational Tools

Goals for the non-Model POD Review

- Identify any past failures

 No equipment calibration characterization done (FAA 737/EC, Engine Disk data, ...)
- Literature review
- Identification of Primary Research Centers and Principle Researchers
- Compile a list of POD methods
- Identify Primary Industries using POD methods

Availability of sample sets

Prior Work

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Have Cracks will Travel

✓ Three Decades of NDI Reliability
 Assessment* – Ripudaman Singh
 * Provided by Karta Technologies

RESULTS TO DATE

Material Provided for MAPOD-WG Website



✓ EC Model Review** – Norio Nakagawa
 ✓ UT Model Review** – Lester W. Schmerr Jr.
 ** Provided by NDE Technologies, Inc. with funding from Phase II SBIR with AFRL
 NDE/Branch

Types of Studies

Procedure Assessments (PA)
Equipment Calibration (EC)
Full POD (with/without Human Factors)
Parametric Studies

Performance Demonstrations (PD)
POD empirical (POD-e) (POD-m)
ROC & Clinical Trials (ROC)

Examples

FAA Reports and Studies

 Mike Bode

 Nuclear Power Example

 "Estimation of Probabilities of Detection for Cracks in Pipes in Swedish Nuclear Power Plants" Lina Tidström

Literature Review

TheoreticalApplicationsFull Studies

Collected 80+ articles and references

• What is to be done with them?

Full Article Access

- PDF format
 ISU Library Source
 Non-ISU access

 Copyright
 \$
- AF RestrictedPUBLIC ACCESS
 - FAA, ...
 - Cut a CD?
 - Internet access

Restriction Levels

- 1. View
- 2. View, Enter & Modify
- 3. Full Text Access
 - 1. ISU
 - 2. AF
 - 3. Other
- 4. Administrative

Resource Server

 Input - Manual – Auto Feed (EndNotes)* Output - Search Reports – Full Articles - Abstracts Input to EndNotes*

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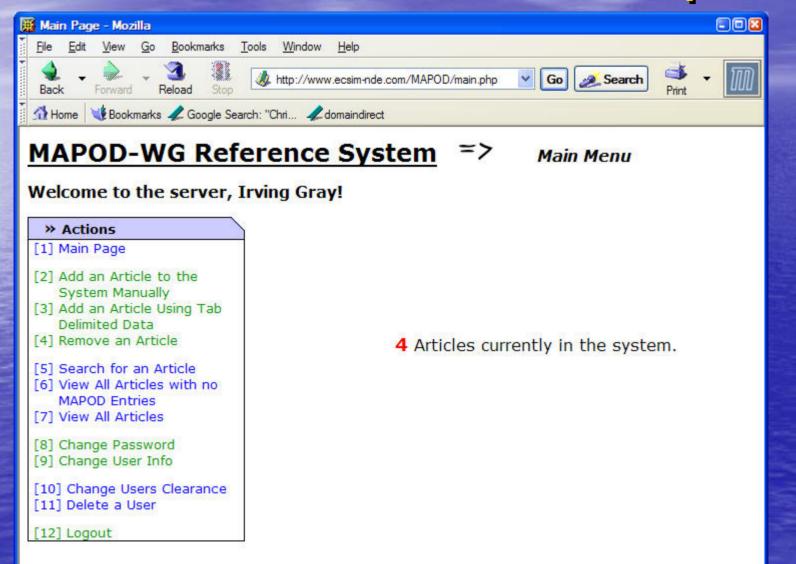
MAPOD-WG Reference System

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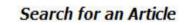
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Why not just Google?

NDE to us isn't

IndyMac Bancorp Inc (NDE)
Near death experience
Nebraska Dept of Education

POD to us isn't

Payable on Death

Can't perform a detailed focused searchs
Limited Full Text access & unknown quality

Detailed Focused Searching

 Search for Round Robin Eddy Current studies done within the last 5 years in the US or UK on Ti Aircraft components.

Review Method

- Location/Group
- Sponsor
- Problem
- Sample Type
- Model
- Simulated Factor
- POD
- PFA / POFC
- Equipment
 - IC
 - AP
 - Flaw Size
 - Flaw Range
 - Flaw Orientation
- HF
- Cost / Benefit

- Industry
- Material

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- Modality
- Study Type
- Validation (Model Validation and POD Validation)
- Flaw Type

MAPOD-WG RATING

Title, Pub Source, Pub Year, Author, sub-Authors, Keywords, Abstract \rightarrow From Citation (e.g., EndNotes database search

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MAPOD-WG Key Code	Citat	ion Title	Pub Sou	rce	Pub Year	A	Author		Keywords act Text		Location / Group	Ind) J		Sponsor	
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Industry

╸∦	AERO	=	Aerospace
、]	V	=	Nuclear
• }	ν	=	Pressure Vessel
• }	PIPE	=	Pipeline Inspection
• (C/P	=	Chemical / Petroleum
• (OS	=	Offshore
•	MAN	=	Manufacturing
•]	MED	=	Medical

• Other

Material

- AI, AI356, AI7075,
- Ti-T6
- Steel
- Composite
- Other

[Possible future link to MatML]

Modality

- EC
- UT
- AC
- UT-L
- RT
- CT
- MT
- VT
- Thermal
- FPT
- Other

- = Eddy Current
- EC Pulsed = Pulsed Eddy Current
 - = Ultrasound
- UT Phased = Phased Array Ultrasound
 - = Acoustic
 - = Lamb Wave
 - = Radiographic
 - = Computed Tomography (RT)
 - = Magnetic Testing
 - = Visual
 - = Florescent Penetrant

Study Type

• EXP

- MOD
- EX&MOD
- EMP
- EMP&MOD
- ALL
- Other

- = Experimental Only
- = Model-based Only
- = Experimental and Model Assisted
- = Empirical Only
- = Empirical and Model Assisted

Validation (Model Validation and POD Validation)

- Yes (destructive examination, CT scan, ...)
- No
- Partial
- Other

Flaw Type

 A-FBH
 A-EDM Machining

• A-F/C

= Artificial Flat Bottom Hole= Artificial Electronic Discharge

= Artificial Fatigue Crack

• R-C	= Real / In service Crack
 R-Cor 	= Real / In service Crack

S-C = Simulated Crack
 S-Cor = Simulated Corrosion
 S-C/Cor = Simulated Crack with Corrosion

Flaw Type - continued

- CIDSCC
- CODSCC
- IGA
- TW
- LIDSCC
- LODSCC
- ODSCC
- Fatigue cracks

Other?

- Corrosion

.... C

- = Circumferential inner diameter stress corrosion crack/cracking
- = Circumferential outer diameter stress corrosion crack/cracking
- = Intergranular attack
- = Throughwall
- = Longitudinal inner-diameter stress corrosion crack/cracking
- = Longitudinal outer diameter stress corrosion crack/cracking
- = Outer diameter stress corrosion crack/cracking

FAA Studies

EC 737
 NASA Studies

Shuttle

Commercial Studies

 Pratt & Whitney UT validation and Transfer Function

Untold "proprietary" studies
 – Small Jet Engine Ti-inclusion X-Ray POD

Air Force Studies

Full POD Studies
EC "tissue box" POD
Fast FOCUS Phased Array Ultrasound – Hertzog
<u>"mini-POD's"</u>
<u>DRIP – Buynak & Stephes</u>

DR image intensifiers at Tinker Buynak & Stephes

Nuclear Energy

Argone
EPRI
TVA

International Studies

TNOAustralian NDT

NRC Canada

Generic Bolt Hole EC on CP140 Aurora

Subject: briefing presentation	Attachments:								
From: "Forsyth, David " <david.forsyth@nrc-cnrc.qc.ca></david.forsyth@nrc-cnrc.qc.ca>	GBHET-POD Project Briefing v1.ppt								
Date: 5/26/2005 4:28 PM									
To: Irving J. Gray (E-mail) ⊲igray@ndetechnologies.com>, Joseph Gray (E-mail) ⊲igray@cnde.iastate.edu>									
1.8% Br	~								
Hi gentlemen:									
I am OK with this being discussed/presented at next MAPOD, as long as the presentation is not distributed widely (I don't have formal approval to release). I would be happy to read and comment on any "Strawman" documents which are being circulated for the next meeting.									
Irving, regarding cost benefit, my ROM estimates are:									
\$250-500K for a "traditional" POD. Add 25 to 50% for more specimens, n "interpolated" POD, \$50K. Ergo:	\$250-500K for a "traditional" POD. Add 25 to 50% for more specimens, modeling work, etc. to generalize. For each new "interpolated" POD, \$50K. Ergo:								
5 "traditional" POD's = \$1.25M to \$2.5M	Savings Estimate for								
1 MA-POD and four new "interpolated" POD's = \$0.60M to \$0.85M	"interpolated" POD's =								
I think those are reasonable numbers. I would be happy to talk to Jim Ma									
Dave.	\$650,000 - \$1,650,000								
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David S. Forsyth									
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National Research Council Canada Conseil national de recherche	es Canada								
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Summary

Source literature review mostly completed
Reference Server program done

Need consensus on coding categories
 Input of references into Reference Server