

# 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

- 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

- Theoretical
  - Applications
  - Full 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 Restricted
- PUBLIC 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\*



# Resource Server Examples

Programmed by  
Todd Brady

NDE Technologies, Inc. File Server - Login - Mozilla

File Edit View Go Bookmarks Tools Window Help

Back Forward Reload Stop  Go Search Print

Home Bookmarks Google Search: "Chri... domaindirect

## MAPOD-WG Reference System

**NOTE:** The login username is case sensitive. Please use the same one you registered with.  
If you forgot your username/password then click on the 'forgot password' link below.

» Login

Username:

Password:

Login

Forget your password? [CLICK HERE](#)

To create new account [CLICK HERE](#)

# Resource Server Examples

The screenshot shows a Mozilla browser window titled "Main Page - Mozilla". The address bar displays the URL "http://www.ecsim-nde.com/MAPOD/main.php". The browser's menu bar includes File, Edit, View, Go, Bookmarks, Tools, Window, and Help. The toolbar contains buttons for Back, Forward, Reload, Stop, Go, Search, and Print. Below the toolbar, there are links for Home, Bookmarks, and a Google Search bar. The main content area features the heading "MAPOD-WG Reference System" with a right-pointing arrow and the text "Main Menu". Below this, a welcome message reads "Welcome to the server, Irving Gray!". A sidebar on the left, titled "» Actions", contains a list of 12 numbered links: [1] Main Page, [2] Add an Article to the System Manually, [3] Add an Article Using Tab Delimited Data, [4] Remove an Article, [5] Search for an Article, [6] View All Articles with no MAPOD Entries, [7] View All Articles, [8] Change Password, [9] Change User Info, [10] Change Users Clearance, [11] Delete a User, and [12] Logout. To the right of the sidebar, the text "4 Articles currently in the system." is displayed.

**MAPOD-WG Reference System** => *Main Menu*

Welcome to the server, Irving Gray!

**» Actions**

- [1] Main Page
- [2] Add an Article to the System Manually
- [3] Add an Article Using Tab Delimited Data
- [4] Remove an Article
- [5] Search for an Article
- [6] View All Articles with no MAPOD Entries
- [7] View All Articles
- [8] Change Password
- [9] Change User Info
- [10] Change Users Clearance
- [11] Delete a User
- [12] Logout

4 Articles currently in the system.

# Resource Server Examples

**Add an Article - Mozilla**

File Edit View Go Bookmarks Tools Window Help

Back Forward Reload Stop <http://www.ecsim-nde.com/MAPOD/addArticle.php> Go Search Print

Home Bookmarks Google Search: "Chri... domaindirect

---

**MAPOD-WG Reference System** => *Add an Article*

**>> Actions**

- [1] [Main Page](#)
- [2] [Add an Article to the System Manually](#)
- [3] [Add an Article Using Tab Delimited Data](#)
- [4] [Remove an Article](#)
- [5] [Search for an Article](#)
- [6] [View All Articles with no MAPOD Entries](#)
- [7] [View All Articles](#)
- [8] [Change Password](#)
- [9] [Change User Info](#)
- [10] [Change Users Clearance](#)
- [11] [Delete a User](#)
- [12] [Logout](#)

**Add an Article -- Citation Source**

Pub Source:	<input type="text"/>
Citation Title:	<input type="text"/>
Pub Year:	<input type="text"/>
Author(s) (separated by ';') e.g. Author ; sub-author1 ; sub-author2:	<input type="text"/>
Model:	<input type="text"/>
Simulated Factor:	<input type="text"/>
Keywords (separated by spaces):	<input type="text"/>
Article Abstract Text:	<input type="text"/>
Link to the Full Text:	<input type="text"/>

☐ Check this box if you are just entering the citation information and don't want to enter the MAPOD items. You can always enter them later.

Continue



# Resource Server Examples

Article Search - Mozilla

File Edit View Go Bookmarks Tools Window Help

Back Forward Reload Stop file:///C:/Documents%20and%20Settings/Irving%20Gray/Desktop/MAPOD1/ResourceServer/search.php.ht Go Search Print

Home Bookmarks Google Search: "Chri... domaindirect

## MAPOD-WG Reference System => Search for an Article

**» Actions**

- [1] Main Page
- [2] Add an Article to the System Manually
- [3] Add an Article Using Tab Delimited Data
- [4] Remove an Article
- [5] Search for an Article
- [6] View All Articles with no MAPOD Entries
- [7] View All Articles
- [8] Change Password
- [9] Change User Info
- [10] Change Users Clearance
- [11] Delete a User
- [12] Logout

**Search for an Article**

with any of the words  All   
Sort by key number   
☒ Ascending ☐ Descending

**Advanced Options...**

Return only articles less than  Any   
Return articles in this **industry**  Any   
Return articles involving the **material**  Any   
Return articles with **modality**  Any   
Return articles with **study type**  Any   
Return article with **flaw type**  Any

Done

# Resource Server Examples

**Remove an Article - Mozilla**

File Edit View Go Bookmarks Tools Window Help

Back Forward Reload Stop <http://www.ecsim-nde.com/MAPOD/removeArticle.php> Go Search Print

Home Bookmarks Google Search: "Chri... domaindirect

## MAPOD-WG Reference System => Remove an Article

**» Actions**

- [1] Main Page
- [2] Add an Article to the System Manually
- [3] Add an Article Using Tab Delimited Data
- [4] Remove an Article
- [5] Search for an Article
- [6] View All Articles with no MAPOD Entries
- [7] View All Articles
- [8] Change Password
- [9] Change User Info
- [10] Change Users Clearance
- [11] Delete a User
- [12] Logout

This is a list of all the articles in the system. Select the ones you want to remove and click the Remove Article(s) button at the bottom to delete them.

	Key	Year	Journal	Title	Author(s)
<input type="checkbox"/>	10001	2002		EDDY CURRENT ANALYSIS ROUND ROBIN USING THE NRC STEAM GENERATOR MOCKUP	D. S. Kupperman,*
<input type="checkbox"/>	10002		TEST		
<input type="checkbox"/>	10003	2222	ewfewfe		
<input type="checkbox"/>	10004				

Remove Article(s)

# 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 searches
- 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
  - Modality
  - Study Type
  - Validation (Model Validation and POD Validation)
  - Flaw Type
  - *MAPOD-WG RATING*
- Title, Pub Source, Pub Year, Author, sub-Authors, Keywords, Abstract** → From Citation (e.g., EndNotes database search)

		Citation							Group	
MAPOD-WG Key Code	Citation Title	Pub Source	Pub Year	Author	Keywords	Abstr act Link	Full Text (PDF)	Location / Group	Industr y	Sponsor
	EDDY CURRENT ANALYSIS ROUND ROBIN		2002	Kupperman, D.S.	EC Array, POD, F		The link to	Argonne Nat Lab (ANL)	Nuclear	US NRC/ONR
	PROBABILITY OF DETERNE		2004	Zeng, Z., Xuan, L., Sun, L., Udpa, L., Udpa S.				MARG-E&EG ISU	Pipeline	
	<a href="#">INSPECTION OF FASTE</a>	ASIP 2003	2003	Herzog, P.G.	UT Phased Array	not availab	<a href="#">Portion of</a>	AF NDI Office Tinker AF	Mil-AF	AF NDI Office

			Modeling Componets			Probability of Detection & False Call			
	Method								
Problem	Method	Study Type	Model	V	Simulated Factor	POD	PFA / POFC	V	Sample Size
crack detection in SG tuk RR		EX&Mod	Argone multiparameter a	good					
parameter study for mag	Parametric Stu	EX&Mod	FEA & parametric functional mod	liftoff			PFA = 5%		
crack detection in AI plates with Phased		EXP	none	n/a	n/a				



		IC				AP			
						Flaw Morphology			
Std Sample	Modality	Equipment	Calibration Method	Noise Distribution	Material	Flaw Type	Flaw Size	Flaw Range	Flaw Orientation
NRC Steam Generator	EC				Inconel 600				
	MT				Al	A-Mach			
	UT-PA	FastFOCUS R/D T			Al				

HF					
Recognition & Analysis	Training	Mood / Enviro / Fatigue / Mgmt	Cost / Benefit	Notes / Comments	MAPOD-WG Rating
not examined		not examined			

# Industry

- AERO = Aerospace
- N = Nuclear
- PV = Pressure Vessel
- PIPE = Pipeline Inspection
- C/P = Chemical / Petroleum
- OS = Offshore
- MAN = Manufacturing
- MED = Medical
  
- Other

# Material

- Al, Al356, Al7075,
- Ti-T6
- Steel
- Composite
  
- Other

*[ Possible future link to MatML ]*



# Modality

- EC = Eddy Current
- EC - Pulsed = Pulsed Eddy Current
- UT = Ultrasound
- UT - Phased = Phased Array Ultrasound
- AC = Acoustic
- UT-L = Lamb Wave
- RT = Radiographic
- CT = Computed Tomography (RT)
- MT = Magnetic Testing
- VT = Visual
- Thermal
- FPT = Florescent Penetrant
- Other

# Study Type

- EXP = Experimental Only
- MOD = Model-based Only
- EX&MOD = Experimental and Model Assisted
- EMP = Empirical Only
- EMP&MOD = Empirical and Model Assisted
- ALL
- Other

## Validation (Model Validation and POD Validation)

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

# Flaw Type

- A-FBH = Artificial Flat Bottom Hole
- A-EDM = Artificial Electronic Discharge Machining
- A-F/C = 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 = Circumferential inner diameter stress corrosion crack/cracking
- CODSCC = Circumferential outer diameter stress corrosion crack/cracking
- IGA = Intergranular attack
- TW = Throughwall
- LIDSCC = Longitudinal inner-diameter stress corrosion crack/cracking
- LODSCC = Longitudinal outer diameter stress corrosion crack/cracking
- ODSCC = Outer diameter stress corrosion crack/cracking
  
- Fatigue cracks
- Corrosion
- ...

❖ Other?

# 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

## "mini-POD's"

- ❖ DRIP – Buynak & Stephe
- ❖ DR image intensifiers at Tinker Buynak & Stephe

# Nuclear Energy

- Argonne
- EPRI
- TVA

# International Studies

- TNO
- Australian NDT

## NRC Canada

- Generic Bolt Hole EC on CP140 Aurora




☐ **Subject:** briefing presentation

**From:** "Forsyth, David " <David.Forsyth@nrc-cnrc.gc.ca>

**Date:** 5/26/2005 4:28 PM

**To:** [Irving J. Gray \(E-mail\) <ijgray@ndetechnologies.com>](mailto:ijgray@ndetechnologies.com) ,  
[Joseph Gray \(E-mail\) <ijgray@cnde.iastate.edu>](mailto:ijgray@cnde.iastate.edu)

**Attachments:**

 GBHET-POD Project Briefing v1.ppt

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, modeling work, etc. to generalize. For each new "interpolated" POD, \$50K. Ergo:

5 "traditional" POD's = \$1.25M to \$2.5M

1 MA-POD and four new "interpolated" POD's = \$0.60M to \$0.85M

I think those are reasonable numbers. I would be happy to talk to Jim Ma

Dave.

<<GBHET-POD Project Briefing v1.ppt>>

Savings Estimate for  
"interpolated" POD's =

\$650,000 - \$1,650,000

-----  
David S. Forsyth

david.forsyth@nrc-cnrc.gc.ca

tel. 613-991-0693

fax 613-952-7136

Institute for Aerospace Research

National Research Council Canada

M-14, 1200 Montreal Road

david.forsyth@nrc-nrc.gc.ca

tél. 613-991-0693

télécopieur 613-952-7136

Institut de recherche aérospatiale

Conseil national de recherches Canada

M-14, 1200 chemin Montréal

# Summary

- Source literature review mostly completed
- Reference Server program done
- Need consensus on coding categories
- Input of references into Reference Server