IIW commission V activity

IIW International group for extending and Exchanging Welding knowledge

Publish Technical documents (Guidelines, Handbook,…)

Create ISO Standards

15 Commissions, One dedicated to Quality Control and NDT

IIW commission V activity

UT WG : Eric Sjerve (Canada):

Phased array Handbook;

Phased array calibration block,

Guided waves (LRUT) guidelines

XRay WG: Uwe Ewert (Germany) Recent developments in standardisation of digital radiology for weld inspection

Electromagnetic techniques WG: Gerd Dobmann (Germany) Stress measurement

INTERNATIONAL INSTITUTE OF WELDING

A world of joining experience

IIW commission V activity

<u>New group :</u> NDE reliability including simulation activities

1.Objectives for simulation:

- Guidelines for simulation use in NDT (Continuation of the ENIQ document)

- How to validate models ? (Guidelines)

- Internationnal data basis and benchmarking

IIW commission V activity

New group : NDE reliability including simulation activities,

2.Objectives for reliability:

- - Guidelines for POD assisted by Simulation : approach, extension of the existing approach in different area (importance of aeronautics, MAPOD)

- Have a frame to continue some new aspects in progress (Multi parameter, mixing empirical / simulated data,…)

IIW commission V activity

Structure of the group:

- Experts from different countries, companies, institutes
- Most of the work is done through email for document
- Maximum 2 meetings/year, in conjunction with other events (ECNDT, QNDE, IIW annual seminar, ASNT,….)

Linked Projects or Group:

- French SISTAE
- European PICASSO
- ENIQ
- MAPOD group

The SISTAE project: Simulation and Statistics for Non Destructive Evaluation

Evaluation of POD Curves Based on Simulation Results

Background

- **Inspection reliability:** one of the key issues in ensuring safety of critical structural components

- Increasing use of probabilistic approaches based on statistical criteria such as **POD curves** and **PFAs**

- Are currently obtained thru **expensive and time consuming** experimental campaigns

Objective

- To replace some of the experimental data with **simulation results** such as those obtained with the software CIVA

Evaluation of POD Curves Based on Simulation Results

Factors affecting the probe signal response due to a flaw:

- NDI system (transducer, scan plan, electronic device)
- Part (geometry, material properties, surface roughness)
- Flaw (size, shape, orientation, position)

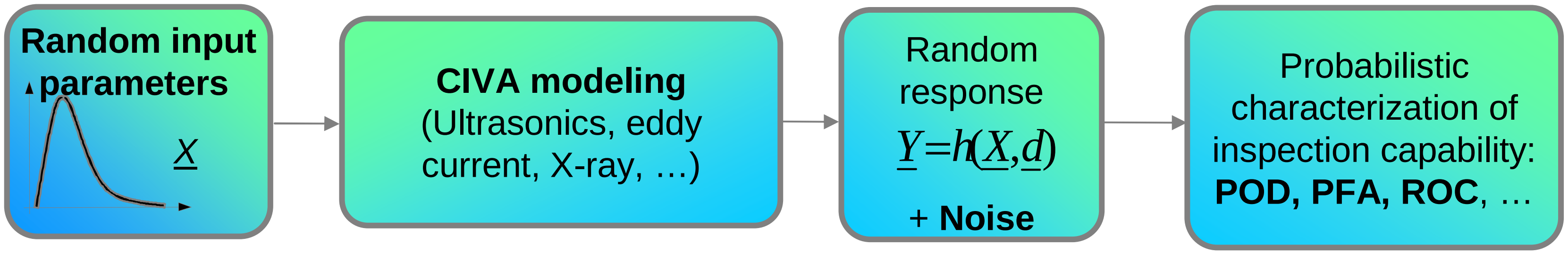
These factors are either deterministic or random in the simulation

Examples of random factors:

- Detail of metallurgical microstructure: structural noise, beam distortions
- Flaw morphology: for a fixed size, various parameters such as shape, orientation, position, elastic properties, and conductivity can vary in a random manner
- Lift-off variations and/or probe orientation during a manual inspection using an eddy current pencil probe

Modeling POD in CIVA: a general approach

1. Definition of the inspection setup using the CIVA graphical user interface
2. Description of uncertainties on a set of input parameters
3. Propagation of uncertainty and computation of noise using CIVA models
4. Evaluation of probabilistic criteria such as the POD, PFA, ROC…



A global methodology for the quantification of uncertainties by a CIVA model-based approach

Estimation of the POD curve using a functional form

- POD curves relate the detectability of a flaw to its size (or to another geometrical characteristic)

- Usual approach consist in:
  - ➢ assuming a functional form for the POD curve
  - ➢ estimating the parameters of the function from the inspection results
  - ➢ estimating the associated confidence bound

Berens

- Hit/miss data format:

$$POD(a) = \left\{1 + \exp\left(-\frac{\pi}{\sqrt{3}}\left(\frac{\ln a - \mu}{\sigma}\right)\right)\right\}^{-1}$$

Log-odds function

- Signal response data format:

$$POD(a) = \Phi\left[\left(\ln a - \mu\right)/\sigma\right]$$

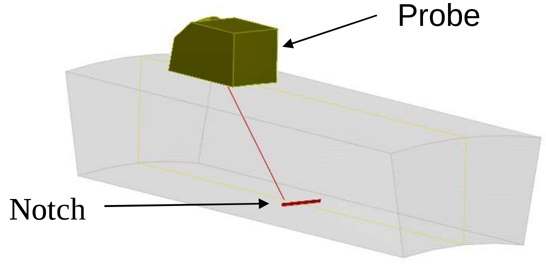
Cumulative log-normal distribution function

Cheng

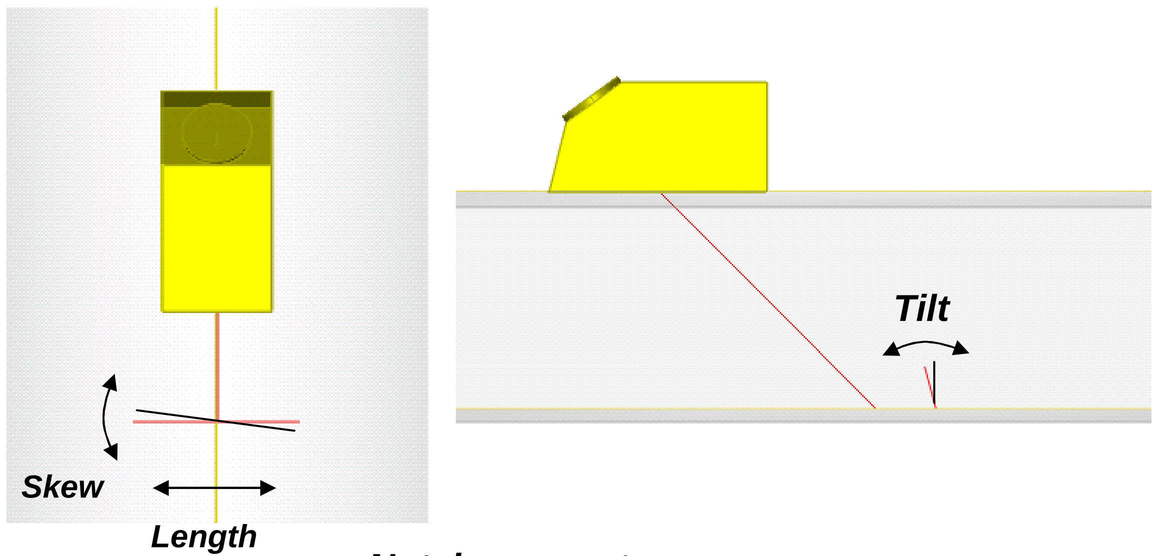
- Estimated from a finite size data sample ⇨ sampling uncertainty ⇨ confidence bound

Application case: UT inspection of a tube section containing back wall breaking notches

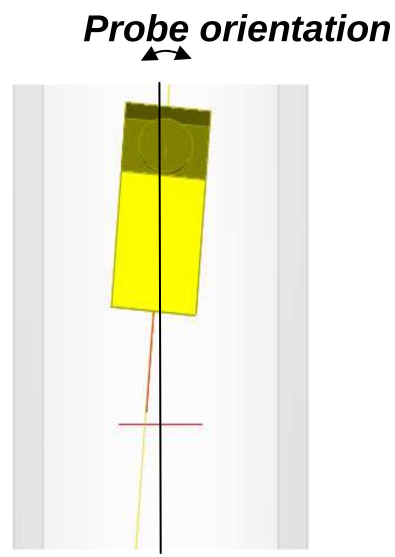
Inspection setup



Definition of uncertain parameters

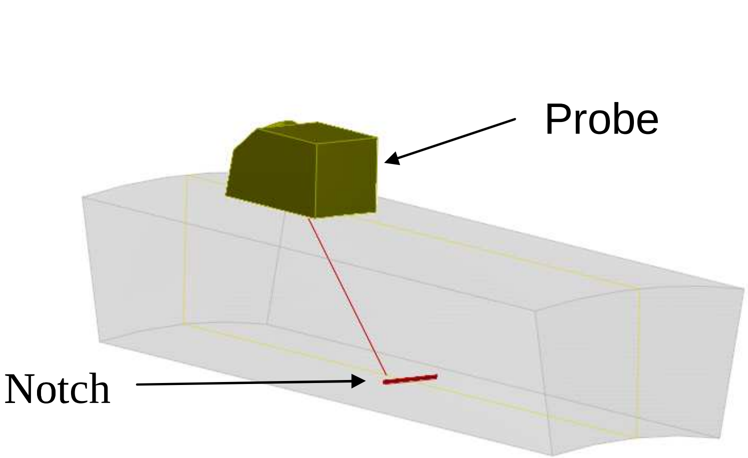


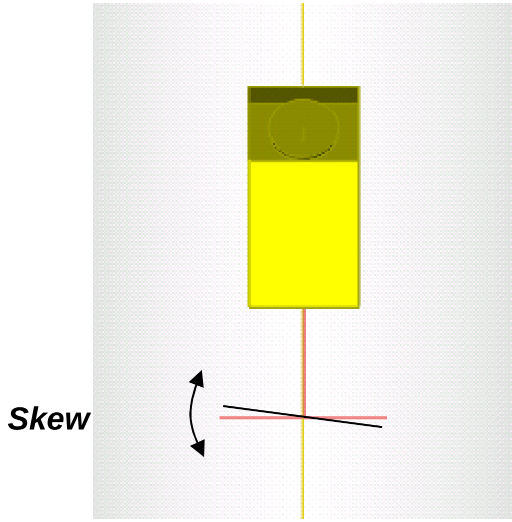
Notch parameters

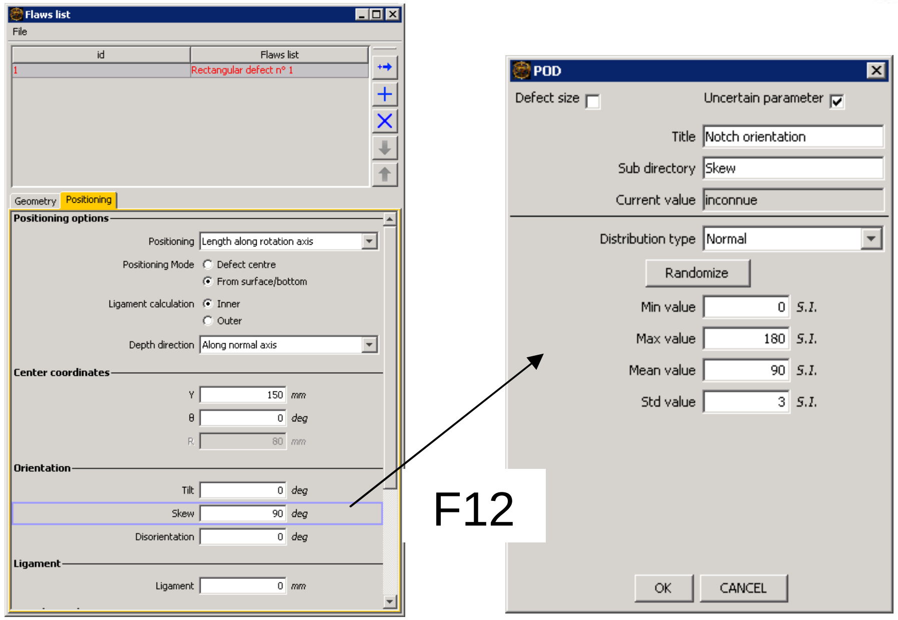


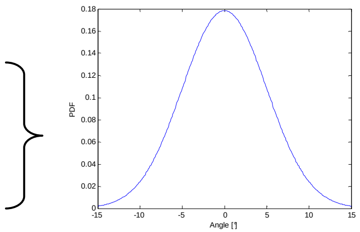
Scan parameter

Modeling uncertainty sources using statistical distributions









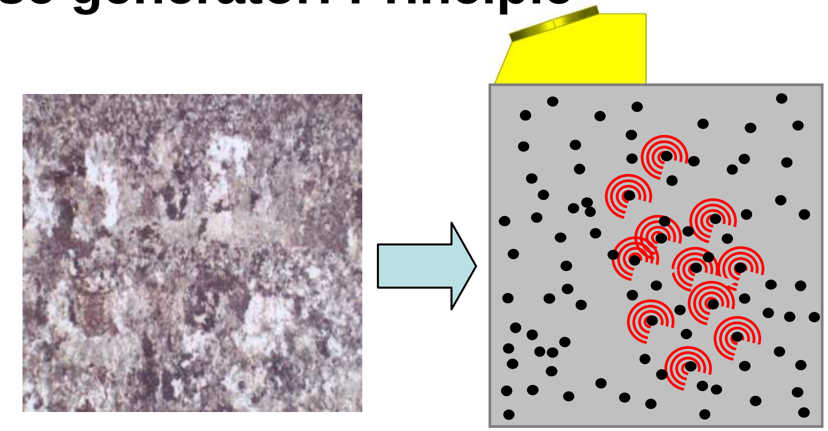
Statistical distribution

Parametric distributions:

Uniform
Normal
Log-normal
Rayleigh
Exponential
…

Modeling complex noise sources using specific algorithms

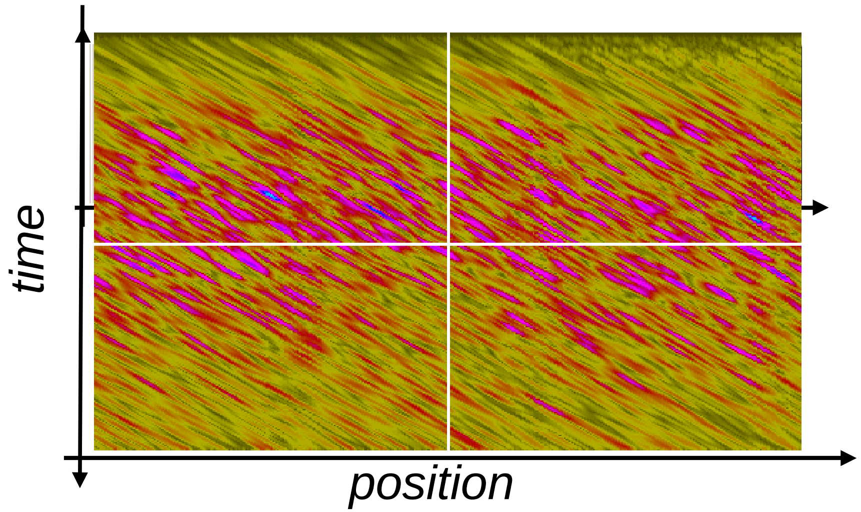
The ultrasonic grain noise generator: Principle



• Synthetic microstructure: The polycrystalline structure is modeled as a set of randomly positioned scatterers. The scatterer density ρ is fixed by the user.

• A reflectivity is associated to each scatterer according to a zero mean Gaussian distribution. The standard-deviation σ characterizing the strength of scatterers is fixed thru the GUI.

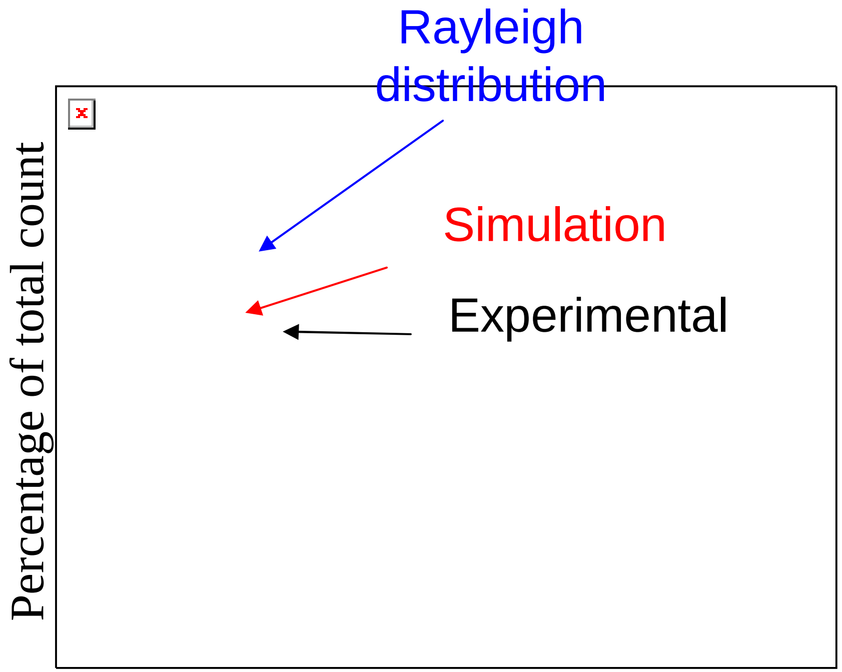
• For each scanning position, the backscattered signal results from the super-imposition of signals coming from ideal back-scatterers in the medium.



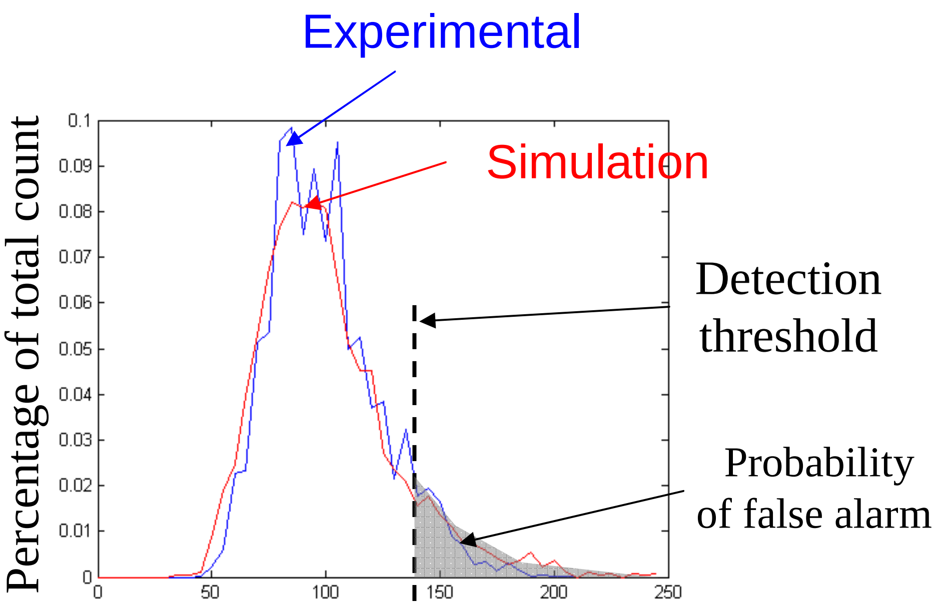
Space and time coherence properties are well reproduced

Modeling complex noise sources using specific algorithms

The ultrasonic grain noise generator: statistical properties and Probability of False Alarm (PFA)



Bins of envelope amplitudes



Bins of C-scan pixel values

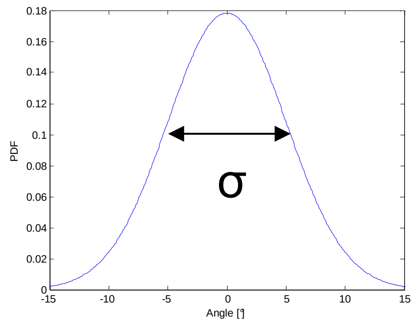
Good prediction of the statistical properties of C-scan pixel values
Important to predict the PFA and an adequate detection threshold

Application case: Inspection of tube section containing back wall breaking notches

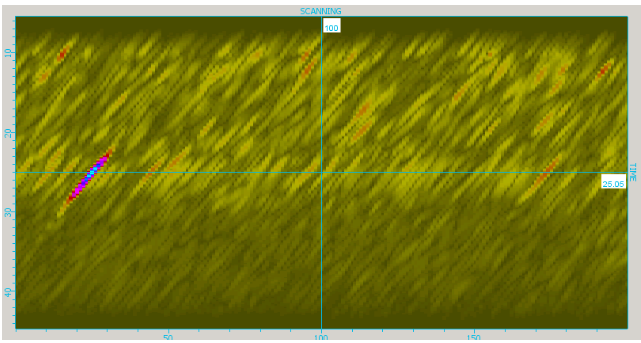
Definition of the statistical distributions defining the uncertain parameters

Notch tilt, Notch skew, Probe orientation: Normal distribution, $\sigma = 1°$

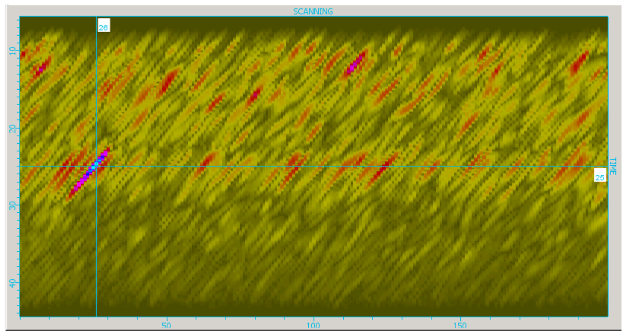
Notch length: Normal distribution, $\sigma = 3$ mm



Selection of two different noise levels



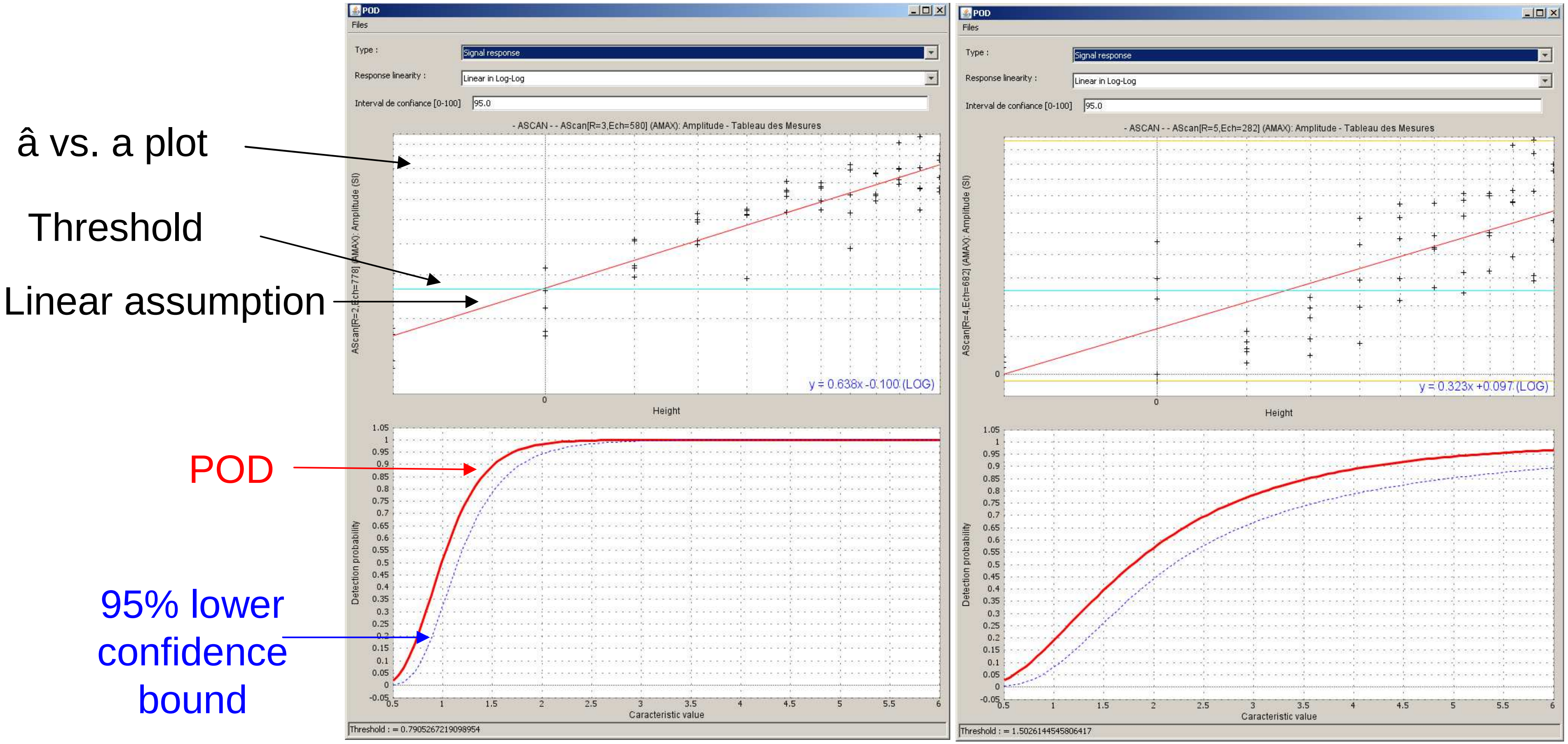
σ=125 ρ=0.1 mm-3
SNR=14 dB



σ=250 ρ=0.1 mm-3
SNR=8 dB

Application case: Inspection of tube section containing back wall breaking notches

â vs. a analysis (signal response data format)



SNR=14 dB

SNR=8 dB

INTERNATIONAL INSTITUTE OF WELDING

A world of joining experience

IIW commission V activity

Structure of the group:

- Experts from different countries, companies, institutes
- Most of the work is done through email for document
- Maximum 2 meetings/year, in conjunction with other events (ECNDT, QNDE, IIW annual seminar, ASNT,….)

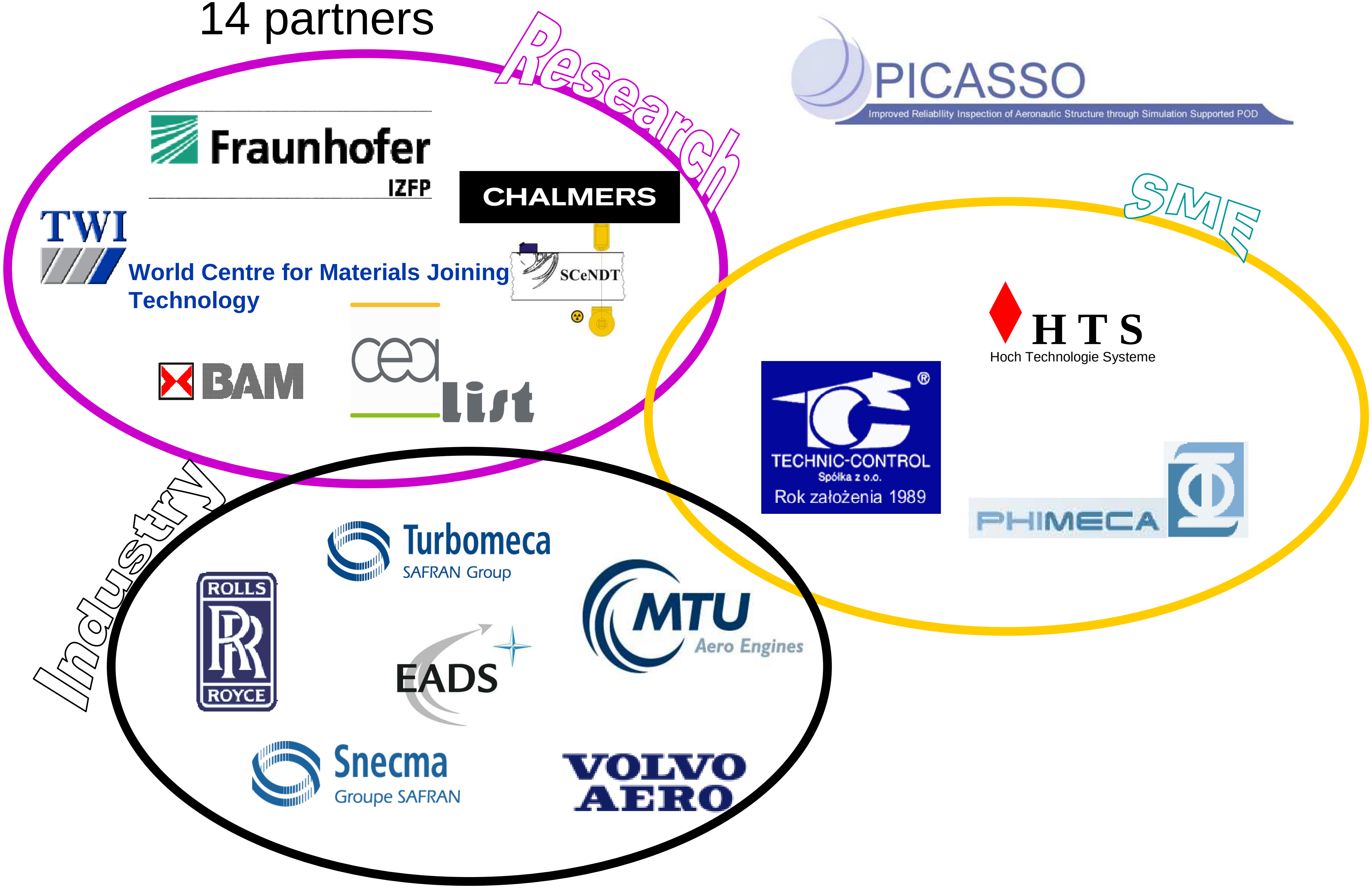
Linked Projects or Group:

- French SISTAE
- European PICASSO
- ENIQ
- MAPOD group

PICASSO

imProved reliabIlity inspeCtion of Aeronautic structure through Simulation Supported POD

14 partners



PICASSO
Improved Reliability Inspection of Aeronautic Structure through Simulation Supported POD
Research
Fraunhofer
IZFP
CHALMERS
TWI
World Centre for Materials Joining Technology
SCeNDT
BAM
cea list
SME
HTS
Hoch Technologie Systeme
TECHNIC-CONTROL
Spółka z o.o.
Rok założenia 1989
PHIMECA
Industry
Turbomeca
SAFRAN Group
ROLLS ROYCE
EADS
MTU
Aero Engines
Snecma
Groupe SAFRAN
VOLVO AERO

WHY PICASSO ?

- **In the context of** aging engines and increase of air traffic **in next 20 years, it is crucial to have a** reliable predictive maintenance **to**

Minimize unscheduled maintenance operations on engines which are cost and time consuming

Increase accuracy of damage tolerance analysis and consequently **the level of safety**

Main impacts of the project :

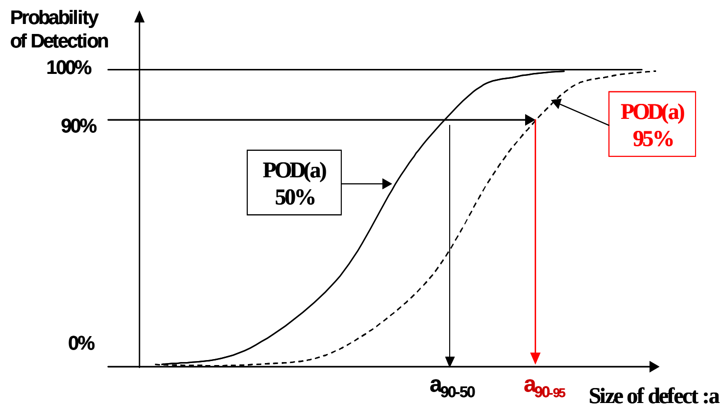
Improve the answer to FAA/EASA damage tolerance requirement with higher knowledge and accuracy on NDT inspection PODs

Savings in costs concerning aircraft maintenance and engine development
(avoidance of the manufacturing of expensive samples with defects)

Objectives

PICASSO
Improved Reliablity Inspection of Aeronautic Structure through Simulation Supported POD

« simulation supported POD curves based on NDT simulation in addition to existing experimental data base »



- **Eddy Current**
- **Ultrasonic Testing**
- **Xray**

Objectives (1/2)

PICASSO

Improved Reliability Inspection of Aeronautic Structure through Simulation Supported POD

Complete experimental NDT inspections by simulated NDT inspections

More representative samples population for POD campaign – enhancing the accuracy of the POD samples and increasing their numbers thanks to simulation techniques

Delta POD approach – limiting the need of a new POD campaign for similar part or inspection configurations

Increase the accuracy and overcome cost issue of a Probability of Detection campaign with Non Destructive Testing simulation techniques.

Objectives (2/2)

PICASSO
Improved Reliablity Inspection of Aeronautic Structure through Simulation Supported POD

	Experimental POD		Simulation supported POD
Sample manufacturing	- Difficult to manufacture real defects - Limited number of samples - Limited number of defects	→	- simulation of complex defect geometries, easy positioning by modelling - Large number of samples - Large number of defects
NDT inspection campaign	- Several operators needed - Respect of the NDT procedure (sometimes operators change parameters for a better detection)	→	- NDT procedure is respected - Find equivalence between artificial and real defects by modelling (in order to manufacture only "easy" defects) - Human factor will not be treated in the framework of this project
POD data exploitation	- Data collection	→	- Automatic data exploitation can be implemented with simulation tools
New POD configuration	- Need to do a new POD campaign	→	- Use simulation to find transfer function to find equivalence between POD configurations - Reduced POD campaign sufficient for a new configuration

INTERNATIONAL INSTITUTE OF WELDING

A world of joining experience

IIW commission V activity

Structure of the group:

- Experts from different countries, companies, institutes
- Most of the work is done through email for document
- Maximum 2 meetings/year, in conjunction with other events (ECNDT, QNDE, IIW annual seminar, ASNT,….)

Linked Projects or Group:

- French SISTAE
- European PICASSO
- ENIQ
- MAPOD group

ENIQ : European Network for Inspection Qualification

Qualification in the nuclear area :

For procedure’s QualificationExperimental : open experimental trial + Technical justification including Modelling.

Up to now , very deterministic approach;

Evolution to technical justification including Simulation Assisted POD approach…