CRACK DETECTION TECHNOLOGY DEVELOPMENTS – EMAT ILI SERVICES

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Introduction to EMAT technology

Basic principle; crack detection and coating disbondment detection.

Qualification and validation of EMAT ILI technology

What has been done to demonstrate sensitivity, accuracy and repeatability of the EMAT inspection technology?
What has been done to increase the confidence in the technology?

Quality assurance of EMAT ILI service / process

How is it ensured that EMAT technology was successful applied along the entire pipeline? How is it ensured that critical anomalies are addressed reliably?

Case Studies

Performance validation

EMAT ULTRASONIC MEASUREMENT

EMAT = Electro-Magnetic Acoustic Transducer

Current Pulse   Transmission Signal

Sender   Receiver

Pipe Wall
Coating

Ultrasonic Sound Wave
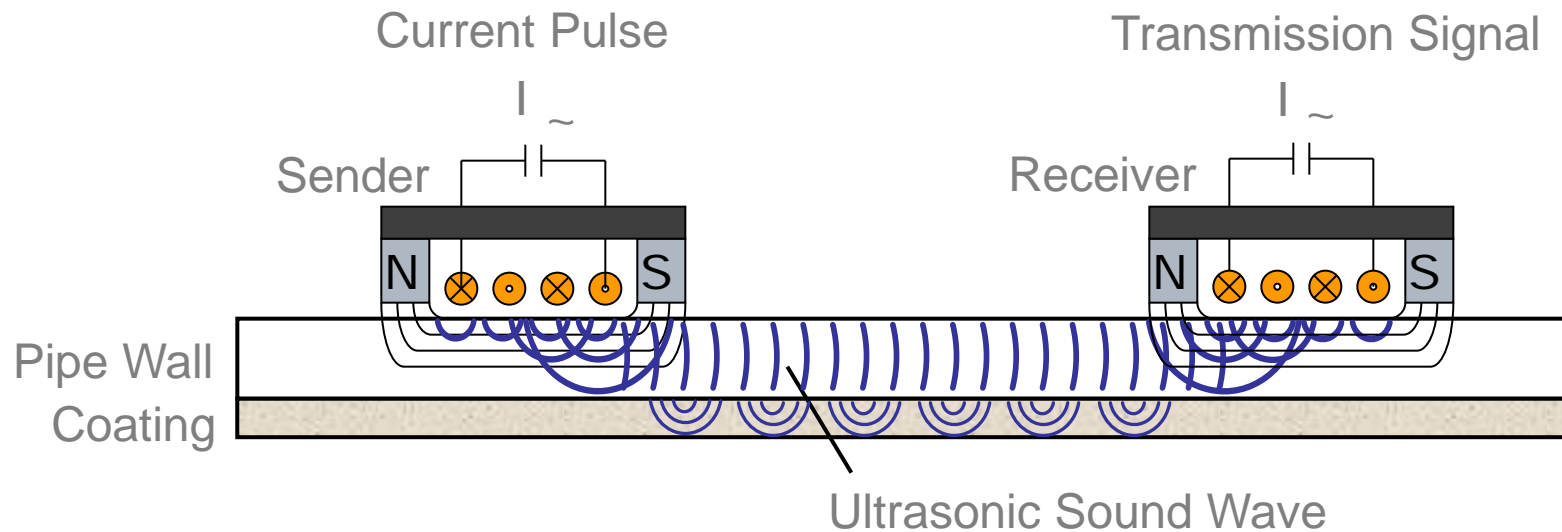
- EMAT generates **shear waves**

- EMAT is suitable for **gas and liquid pipelines**

- EMAT discriminates **coating types**

- EMAT detects **disbonded coating**

HIGH – RESOLUTION EMAT FOR ILI

- High number of EMAT sensors

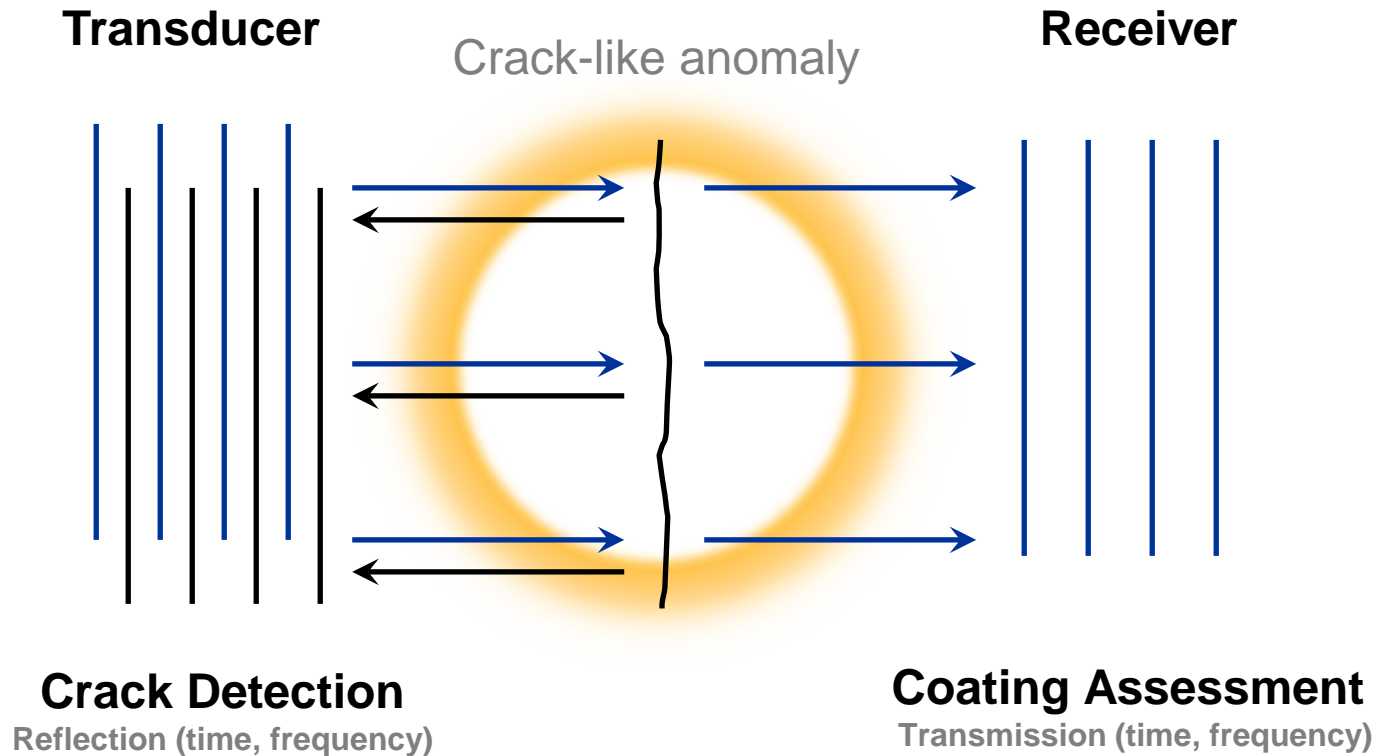- No unwanted damping of signal due to short travel path around the circumference

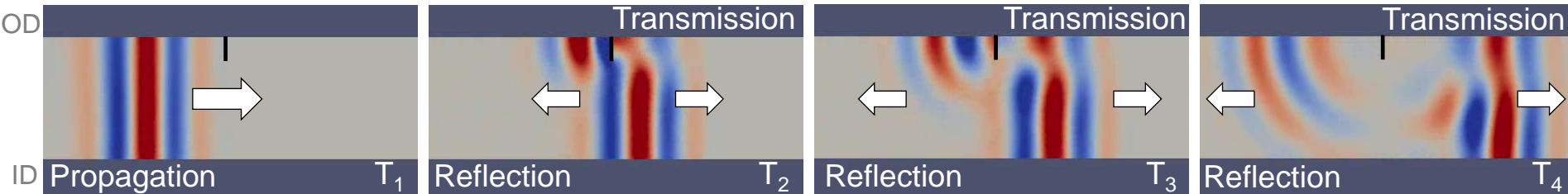**High-resolution EMAT**
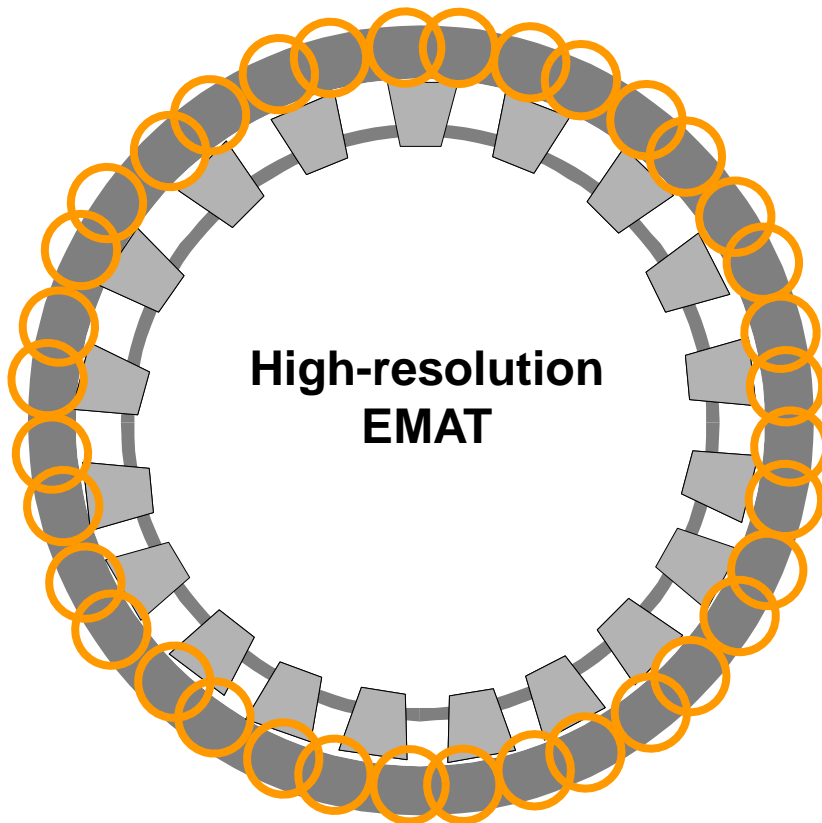
24" Tool
60 channels crack detection
60 channels coating disbondment

36" Tool
88 channels crack detection
88 channels coating disbondment

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OD

ID

| Propagation T_1 | Transmission / Reflection T_2 | Transmission / Reflection T_3 | Transmission / Reflection T_4 |

Transducer

Crack-like anomaly

Receiver

Crack Detection
Reflection (time, frequency)

Coating Assessment
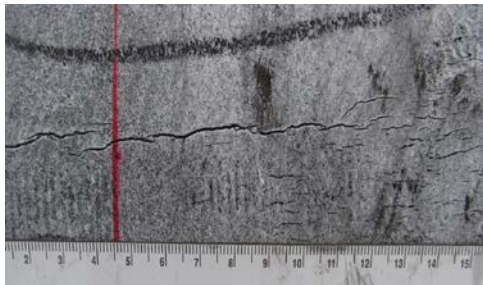**Transmission (time, frequency)**

EMAT CRACK AND COATING SERVICES

EMAT ILI Tools
12" – 48"
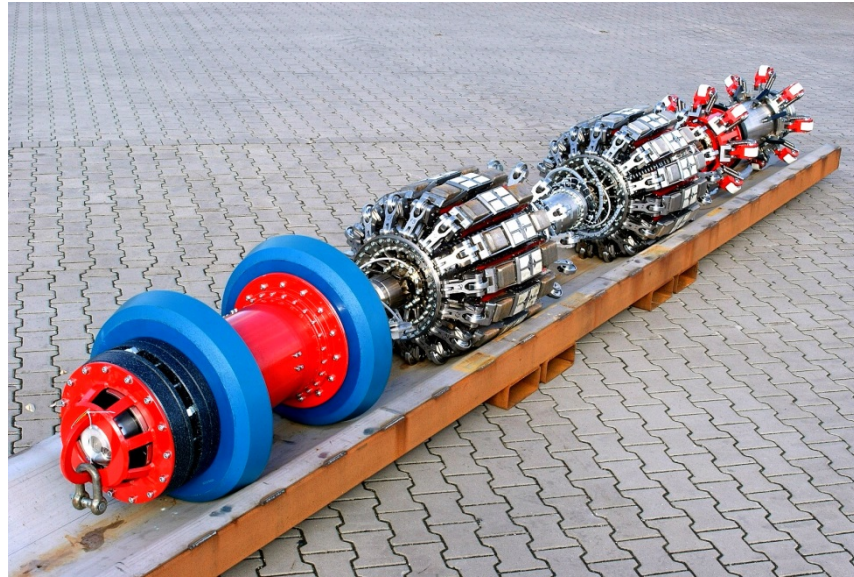
Crack Detection

Coating Disbondment

Coating Identification

PROCESS: COOPERATION & CUSTOMIZATION
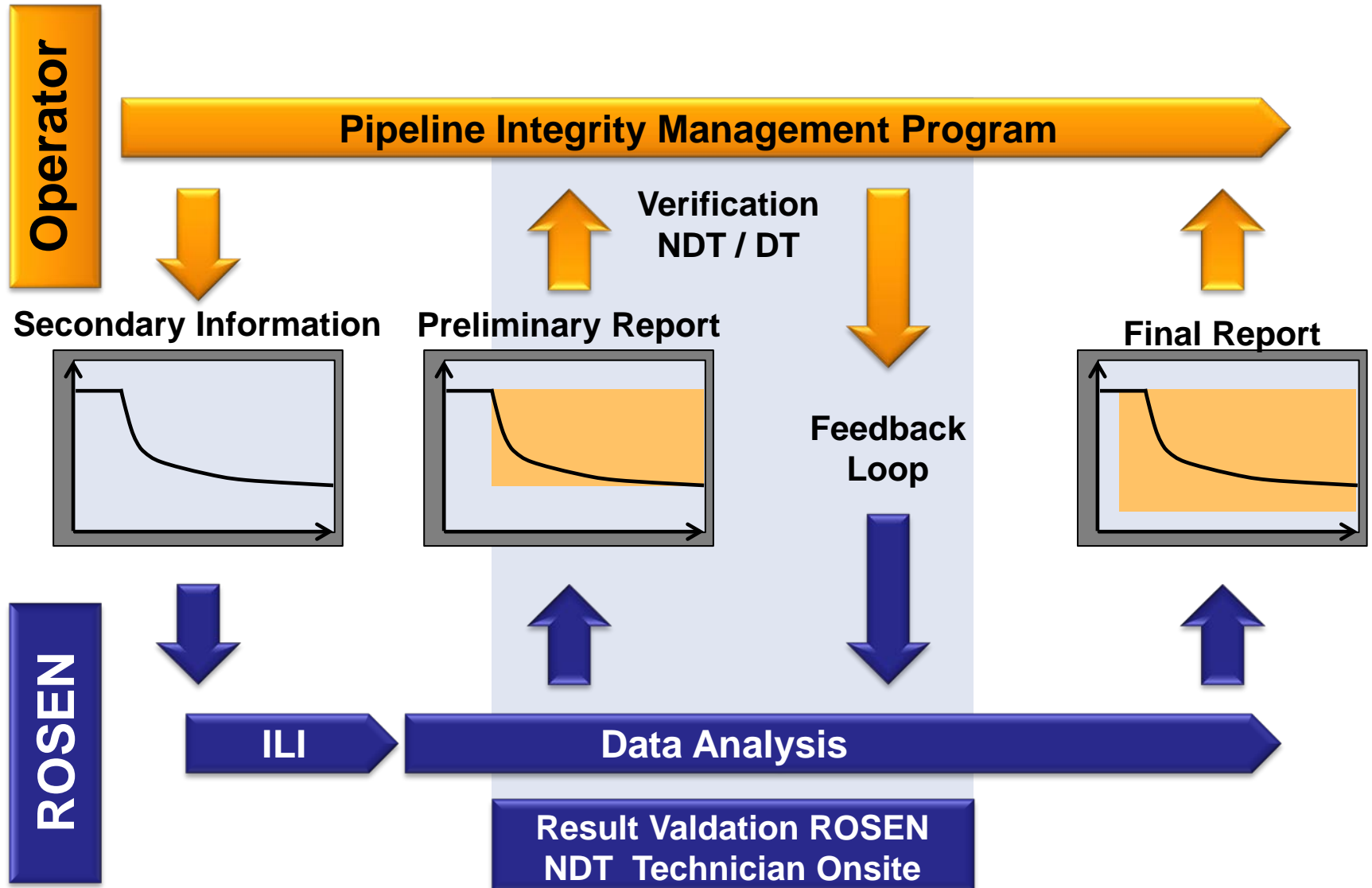
PROCESS: COOPERATION & CUSTOMIZATION

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Operator

project   mindset   process

knowledge &   investment   operational
communication   excellence

Pipeline Integrity Management Program

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Pipeline Intergity Solutions

procedures   regulatory
and   acceptance
cooperation

technology   transfer from   continuous
validation   pipeline to   QS &
                                        network   improvement

QUALIFICATION AND VALIDATION OF EMAT ILI TECHNOLOGY

What has been done to demonstrate sensitivity, accuracy and repeatability of the EMAT ILI inspection technology?

- **Full scale tests on artificial anomalies**
  pull-test; high number of features can be generated, full control of geometric parameter (length, depth, shape); new machining methods are currently developed
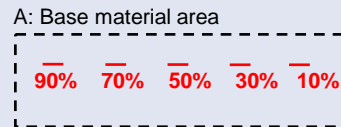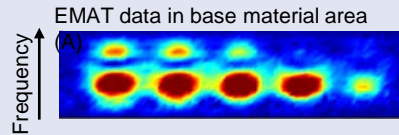
- **Full scale tests on real anomalies**
  pull-test; cut outs; limited number of features; crucial to weight results from artificial anomalies; provision of samples
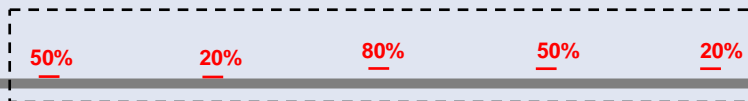
- **Field verification results**
  real anomalies; high number of features; in the ditch NDE; automated phased array becoming an acceptable reference

ILI qualification is typically done for specific OD, WT-range and sensor technology. Results from different tests can be accumulated where appropriate to increase the database. POD and Sizing is characterized. Limited assessment of POI
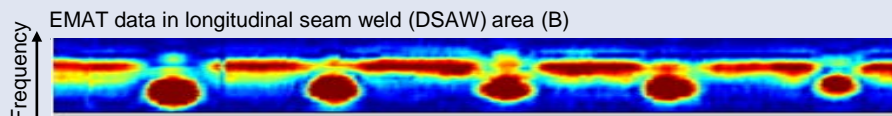
EMAT - FULL SCALE TEST ON ARTIFICIAL ANOMALIES

EMAT data in base material area (A)

A: Base material area

90% 70% 50% 30% 10%

100 mm

50%   20%   80%   50%   20%

B: Longitudinal seam weld (DSAW) area

EMAT data in longitudinal seam weld (DSAW) area (B)

- Double submerged arc welded (DSAW) test joints with 0.438" (11.1 mm) WT

- Test defects: Electro-Discharge-Machine (EDM) notches at 0.5 mm opening in base material and longitudinal weld

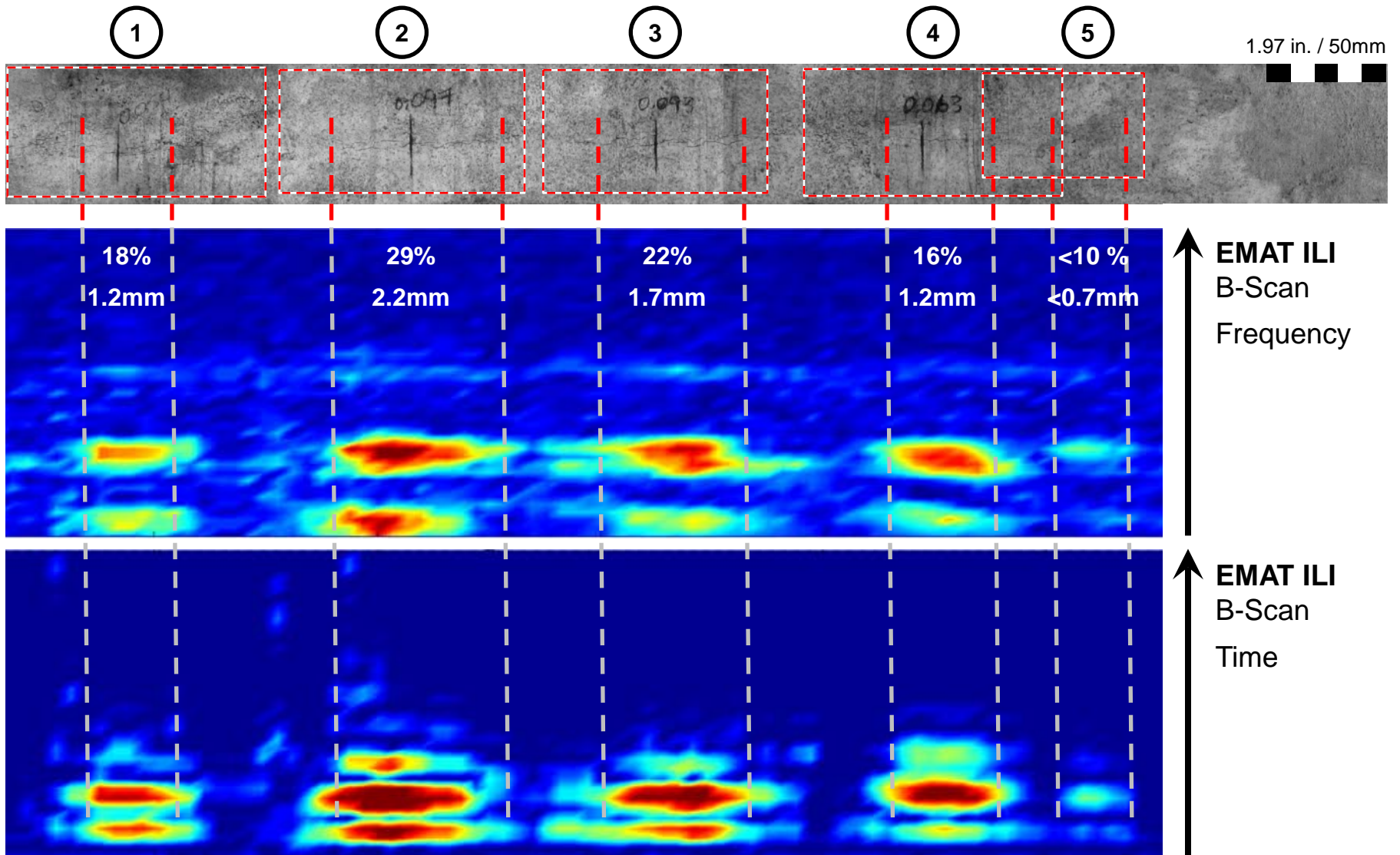- Notches with various depths

- All features detected

EMAT - FULL SCALE TEST ON ARTIFICIAL ANOMALIES
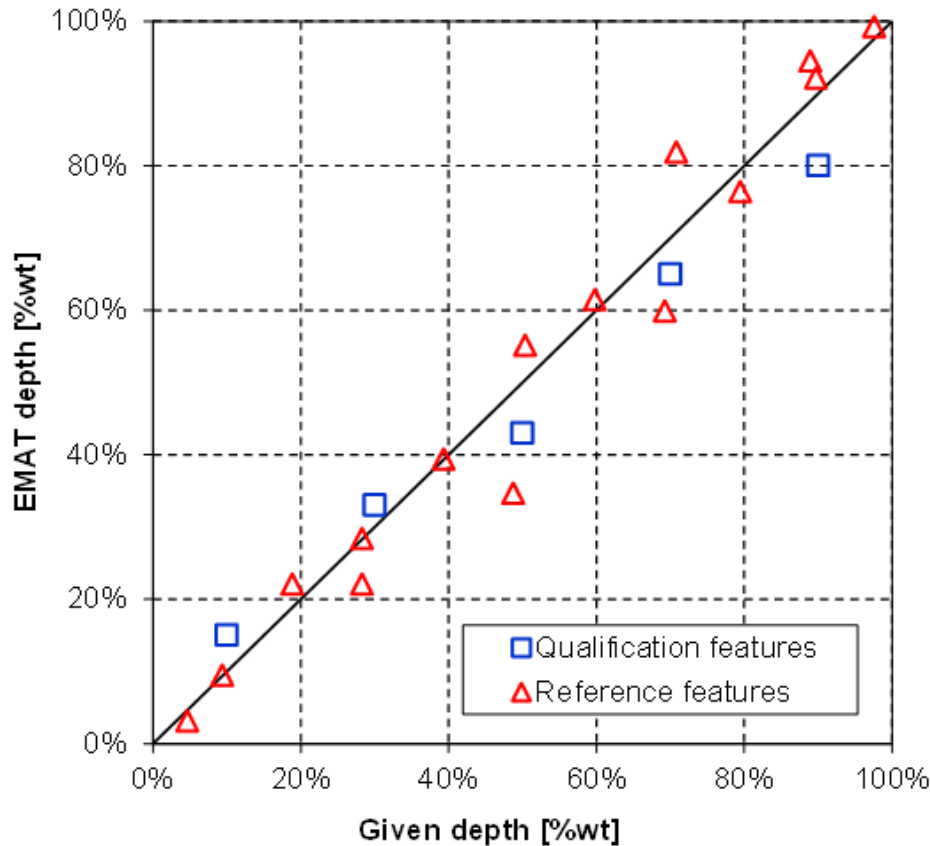
- Highly accurate crack depth sizing through EMAT

- Continuous depth sizing as prerequisite for FFS

PULLTEST ON CUT-OUTS

1.97 in. / 50mm

① 18% 1.2mm
② 29% 2.2mm
③ 22% 1.7mm
④ 16% 1.2mm
⑤ <10 % <0.7mm

EMAT ILI B-Scan Frequency

EMAT ILI B-Scan Time

FIELD VERIFICATION RESULTS

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- More than 4254 linear anomalies have been verified since 2008
- Standardized in-field NDT procedures and correlation to ILI results
- Verification results are stored in an EMAT feature database

- Provides for validation and continuous improvement

QUALITY ASSURANCE OF
EMAT ILI SERVICE - PROCESS

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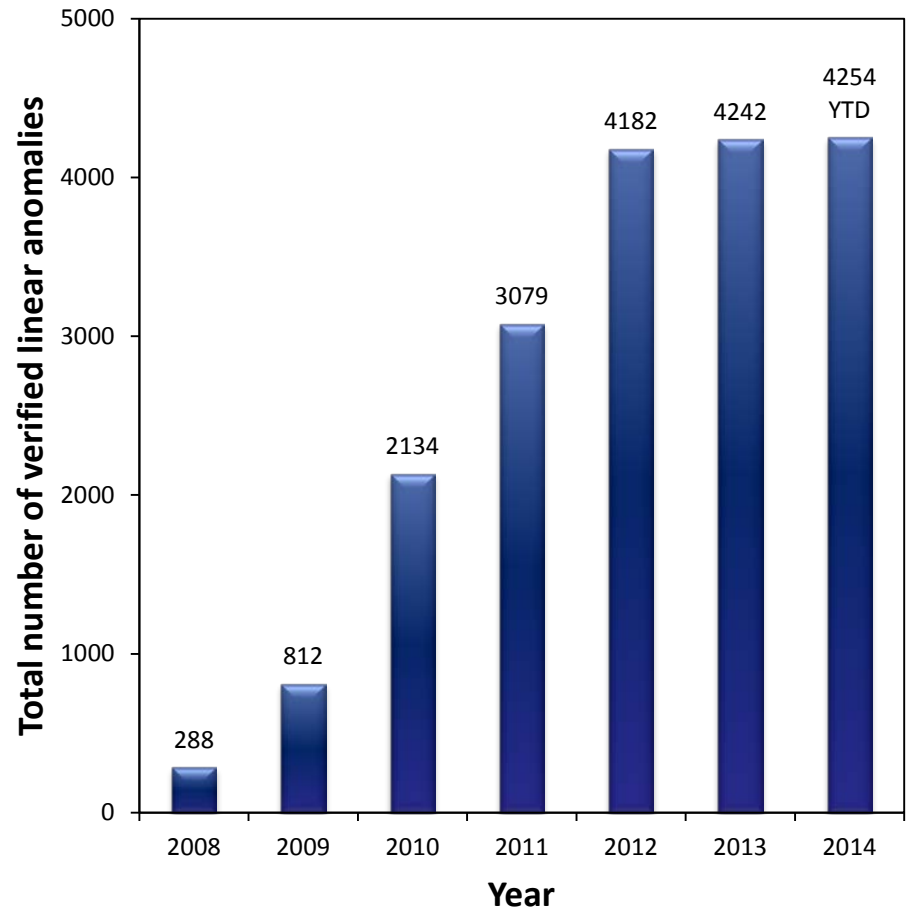
How is it ensured that the qualified ILI technology performed in a particular pipeline?

- **Qualification on pipeline specific samples**
  pull-test; on artificial and real anomalies; specification of critical features; utilization of historic data

- **Combined ILI technologies and operator data**
  CMFL to support POI; input to support susceptibility models

- **Field verification results**
  360⁰ verification; confirmation of threshold; POI confirmation; adjustment of reporting conservatism, where applicable

- **Application of EMAT service – process**
  data analysis automation and screening; sound process to identify critical anomalies with highest reliability; support FFP, ECA and integrity management; utilization of standards: API1163, ASNT ILI-PQ, POF, NACE SPO102

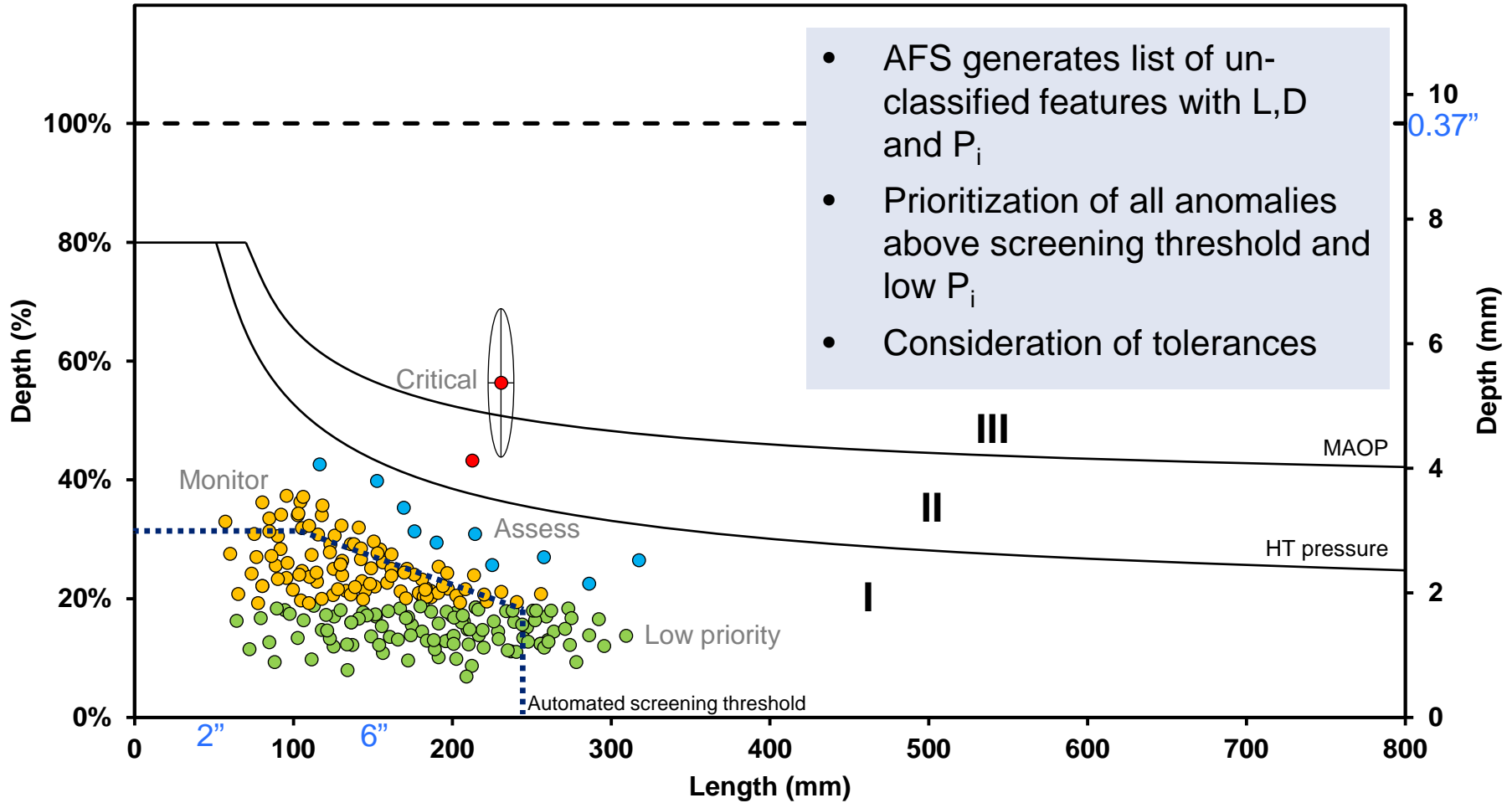# EMAT PROCESS QUALITY ASSURANCE AND QUALITY CONTROL
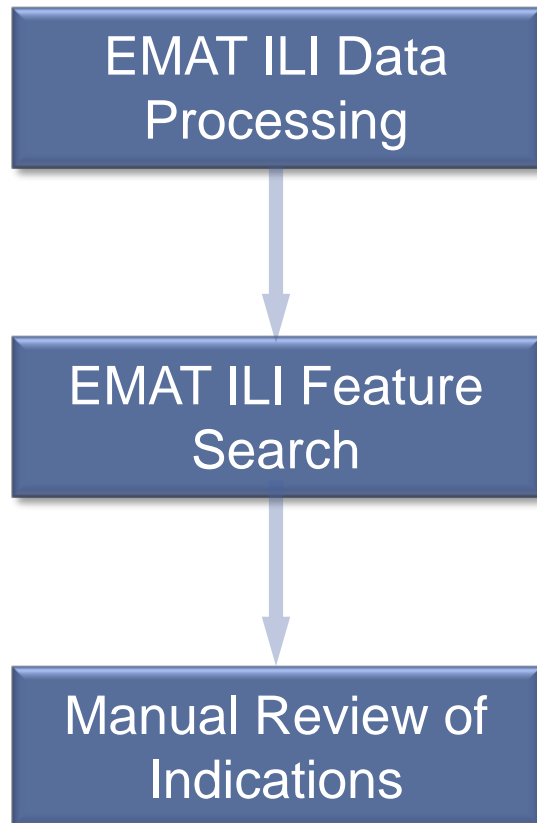
EMAT ILI data processing is performed using a **standardized software framework** also applicable for other ILI technologies e.g. MFL and UT with all parameters being stored and documented

```
┌─────────────────────┐
│   EMAT ILI Data     │
│    Processing       │
└─────────────────────┘
          │
          ▼
┌─────────────────────┐
│  EMAT ILI Feature   │
│      Search         │
└─────────────────────┘
          │
          ▼
┌─────────────────────┐
│ Manual Review of    │
│   Indications       │
└─────────────────────┘
```

Fully automated feature search is applied to the EMAT ILI data do identify indications for review
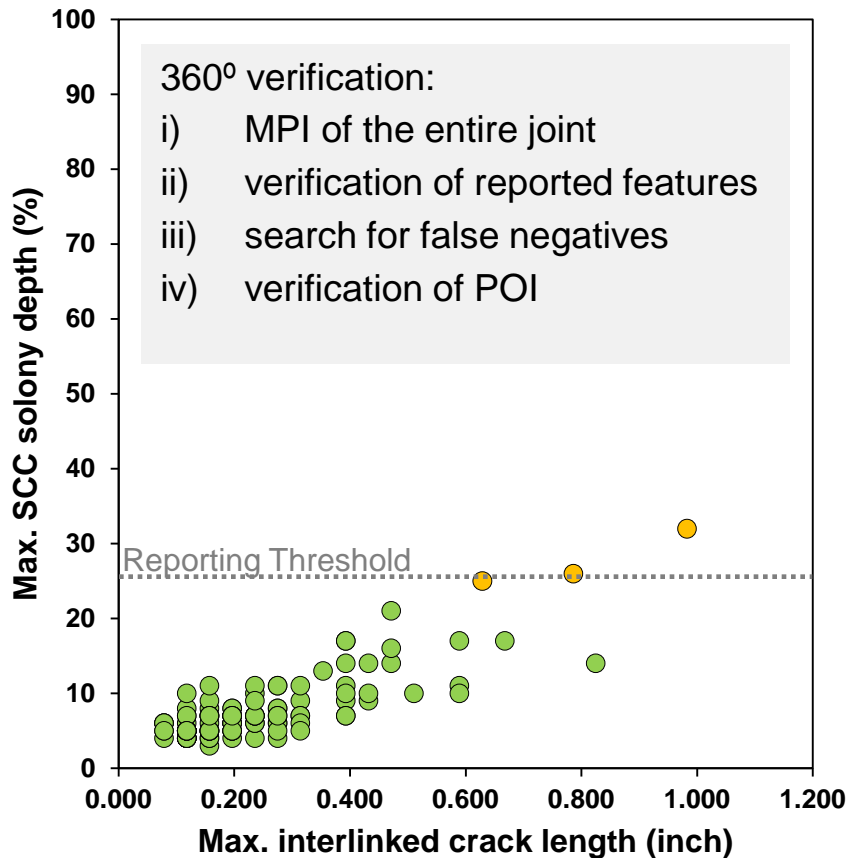
All detected indications are reviewed manually by analysts. All settings and **parameter selections are stored in SQL databases** to allow for post analysis quality assurance by Level III team leads

# AUTOMATED FEATURE SEARCH, IDENTIFICATION AND GRADING OF CRITICAL ANOMALIES

- AFS generates list of un-classified features with L,D and P_i
- Prioritization of all anomalies above screening threshold and low P_i
- Consideration of tolerances

360° verification:
i)   MPI of the entire joint
ii) verification of reported features
iii) search for false negatives
iv) verification of POI

Plot: Max. SCC solony depth (%) vs. Max. interlinked crack length (inch), with a dotted "Reporting Threshold" line at ~25%.

- 1960; 30" NPS 5L X60; 0.298" (7.6mm) WT; A.O. Smith

- 3 Anomalies reported.

- 115 SCC colonies detected (360° MPI) and documented in joint

- All above threshold anomalies correct identified by ILI

- No false negatives (missed) features

- Sub threshold features visible in raw data

CASE STUDY II
EMAT ILI PERFORMANCE VALIDATION
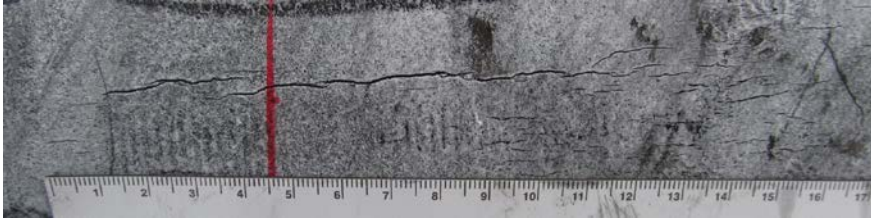
- In total 66,694 total unclassified EMAT indications detected

- In total 755 crack-like indications reported

- 56 crack-like indications (16 joints) positively verified (100%)

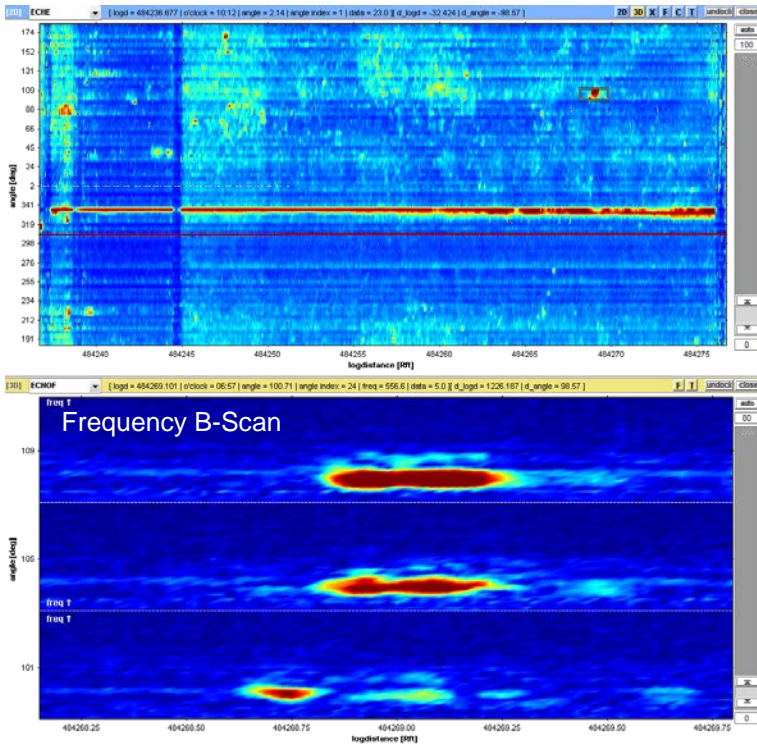- No indication exceeding 2mm x 40mm (0.08"x1.57") has been missed
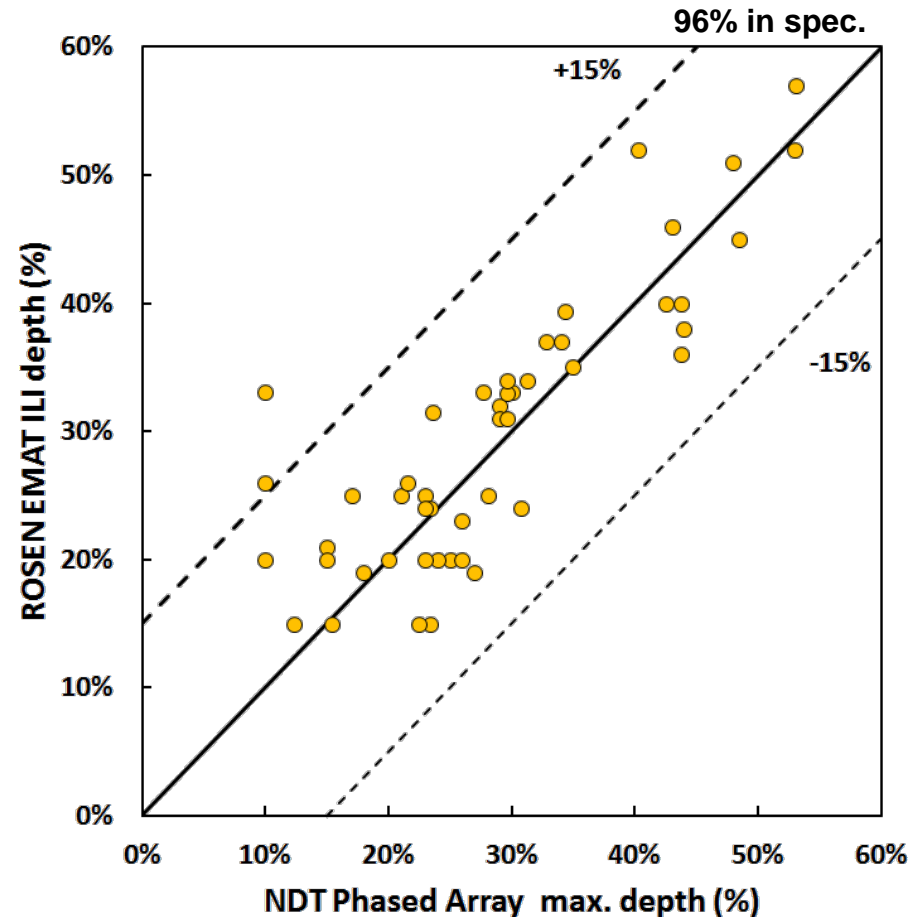
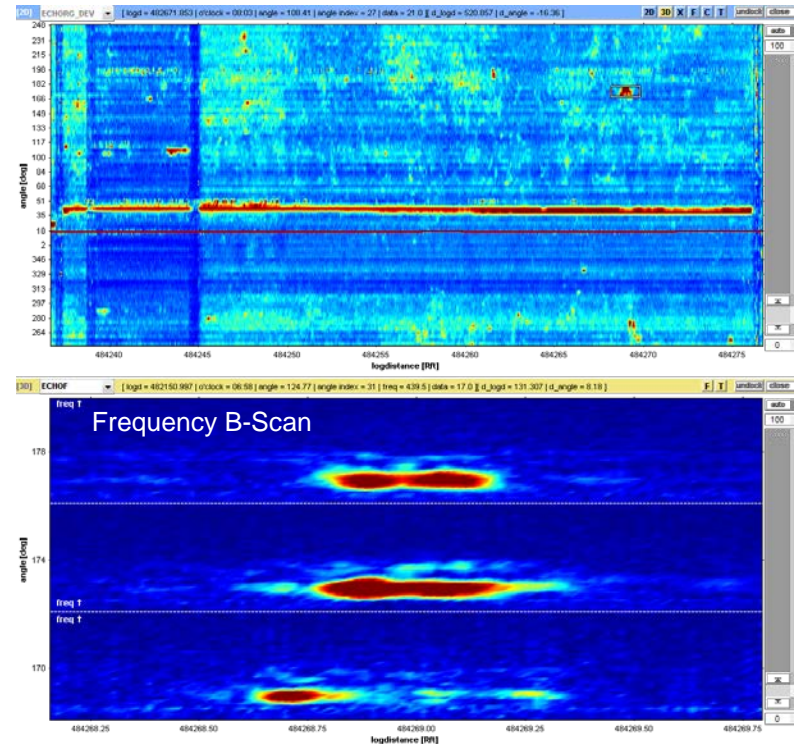20"x 168km x 0.25" (6.35mm) ERW/SML X60; tape wrap; 1967

CASE STUDY III
RUN COMPARISON AND CRACK GROWTH

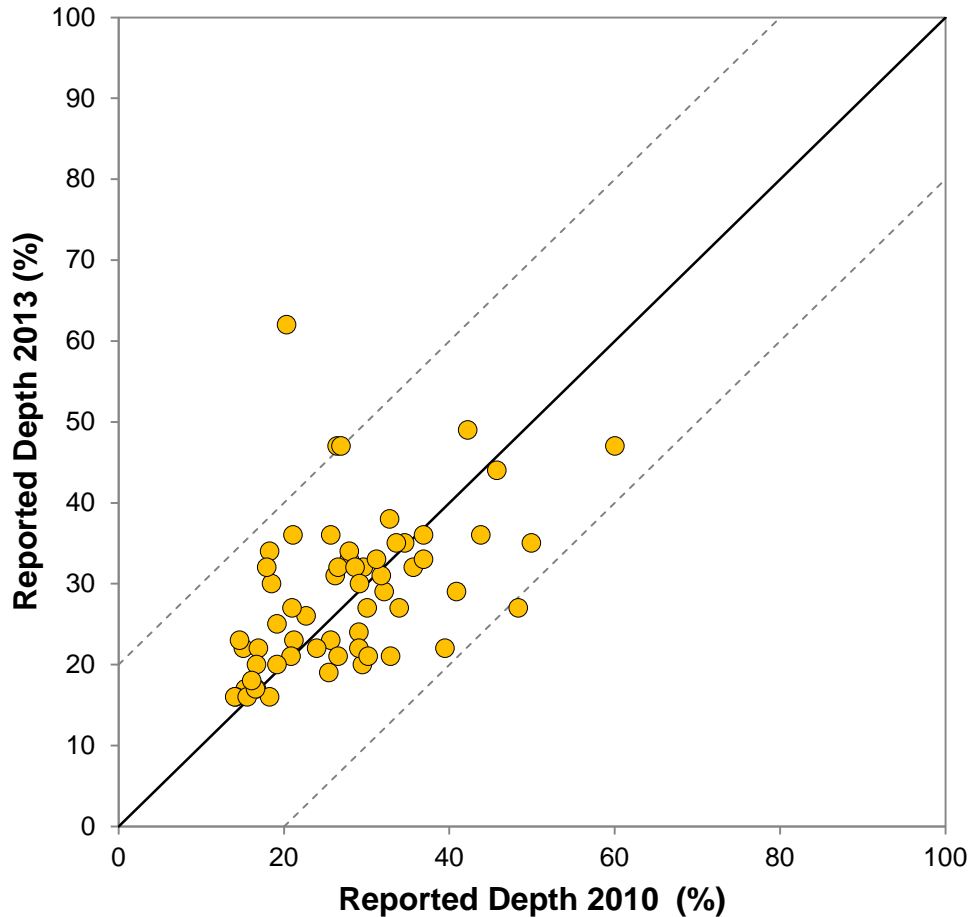Pipeline: 36"x 113km x 0.44" (11.7mm); DSAW; API 5L X65; 1969

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Sample defect from run comparison

For one (1) feature significant growth was measured exceeding tool accuracy (+/- 20%).

Feature excavated and repaired.

Run comparison based on raw signal data.

CONCLUSIONS

- Crack detection services require a transparent process to demonstrate the confidence in the service. This has been adapted to EMAT ILI services as well

- Fullscale tests, field verification and historic data are the basis to increase confidence in performance validation

- Based on qualified EMAT technology continuous improvement is conducted to achieve operational excellence

- Quality assurance process to ensure EMAT ILI service performance along the entire pipeline

THANK YOU FOR JOINING THIS PRESENTATION.

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