Session 4
Defect Detection/Characterization

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Attendance Breakdown

Approximate total attendance	60 persons at peak
PHMSA, Federal Regulators	2
National standards	1
International standards	1
Pipeline operators	20
Service providers	20
Researchers	20

Note: only 30 (5 pipeline operators) present when priorities were voted

GAP Analysis – Summary of Capabilities

Industry Needs – Threats / Technical Areas - Activities	MECHANICAL DAMAGE Dent, gouge, dent+gouge	CORROSION Ext (int)	SCC Ext (int)	CONSTRUCTION DEFECTS Girth Weld, Seam Weld, Body
DETECTION	✓	✓	?	✓
DISCRIMINATION	✗	✓	✗	✓
SIZE / DEPTH				
ILI	✗	✓	✗	✓
IN-DITCH	✗	?	✗	?
ASSESS				
FAILURE PRESSURE	✗	✓	?	✓
GROWTH RATE	✗	✗	✗	?(BENIGN VS. ACTIVE)
UNDERSTANDING MECHANISMS Inc WHERE TO LOOK	✗	? GROWTH RATE, MIC	? GROWTH RATE	✓
EFFECTIVE CODES Inc VALIDATION, QUALIFICATION, TRAINING	✗	✓	✗	✓

✓= largely OK, ✗ = needs improvement

Phase 1 – Identified Gaps and Issues

DETECTION & DISCRIMINATION

- Discriminate MD secondary features… cracks, corrosion
- Benign vs. active construction defects
- ILI for SCC in gas pipelines
- Other in-ditch inspection technologies
- Guided wave performance: Influence of coatings, applicability to cased crossings, range extension, reproducibility, size thresholds etc
- Inspection through coating, internal scale
- Quantified Probability of Detection
- *Note … leak detection …. not discussed!*

SIZE MEASUREMENT

- Sizing MD features, including secondary features
- Size accuracy… depth is critical, then length, width …
  → ILI performance specifications (MD & SCC, corrosion)
- Interacting cracks

SIZE CHANGE – GROWTH & DEGRADATION

- Growth rates for corrosion, SCC & MD
- Growth monitoring (online, real time)

Phase 1 – Identified Gaps and Issues (cont'd)

ASSESSMENT

- Failure Pressure of MD
- Screening Assessment for MD; discriminating secondary features
- Effects of residual stress, secondary loading, (ground movement, frost heave)
- Defects are more critical for high strength steels, high design factors
- Assessment of SCC & corrosion at MD
- Toughness vs. Charpy correlation
- Uncertainty of other properties, dimensions
- Delayed Failure: Assessment of MD
  Influence of changing operation, load,
  Influence of changing environment
- SCC crack coalescence
- Collate & review damage experience and learn from it
- Validation of Models….pool of ex-service samples for testing (MD, SCC)
  → code improvements

Phase 1 – Identified Gaps and Issues (cont'd)

UNDERSTANDING THE MECHANISMS, KNOWING WHERE TO LOOK

- Microbial corrosion
- SCC, corrosion: site selectivity
- Distinguishing between rock dents and impact damage
- Coating degradation and disbond: when does corrosion/SCC start?
- Influence of toughness / ductility on delayed failure of MD

CODES, STANDARDS AND INDUSTRY GUIDANCE

- Field testing & demonstration of prototype vehicles, technologies
  → building confidence in capabilities, performance
- ILI performance specifications (corrosion, then SCC, MD)
- Use of complementary techniques to improve POD
- Independent loop test facilities; learning &training, calibration, certification
- Technology packages to support code improvements

Top 4 Identified R&D Gaps

Defect **Sizing from Outside the Pipe**
(New / Improved Technology)

Defect **Sizing using ILI**
(New / Improved Technology)

Validation, Testing & Qualification
(Consensus Standard)

Severity Assessment of Mechanical Damage, [SCC, Corrosion]
(New / Improved Technology)

Defect Sizing from Outside the Pipe

- New or improved technology, relevant to onshore (and offshore) gas and liquids lines, low (and high) pressure applications
- Addresses corrosion, mechanical damage and SCC defects
- Technology needs:
  - Improved sizing and location accuracy
  - Requirement for improved range
  - Focus on depth as opposed to cross-sectional area
  - Address influence of external condition of pipe – coating, soil etc
  - Address internal pipe condition (as necessary)

- Implementation and deployment issues:
  - Certain coatings may be show-stoppers
  - Property variations of material
  - Availability of performance criteria, standard calibration
  - Knowledge, qualification and operator skill
  - Cost

- Timescale to complete research:
  - Guided wave : 1 – 3 yrs
  - Laser mapping, high resolution eddy current methods 1- 3 Yrs

Defect Sizing using ILI

- New or improved technology, relevant to onshore and offshore gas and liquids lines, high and low pressure applications
- Addresses corrosion, mechanical damage and SCC defects
- Technology needs (ILI for 'piggable' systems):
  - Improved sizing accuracy (depth, then length, width), resolution
  - Crack detection in gas pipelines (esp SCC)
  - Discrimination of secondary features (esp mechanical damage)
  - Requirement to increase range for low-pressure-system vehicles
- Technology needs (vehicles for 'unpiggable' systems):
  - Improved location and sizing reliability
  - Focus on depth as opposed to cross-sectional area
  - Address influence of external condition of pipe – coating, soil etc
  - Address internal pipe condition (as necessary)
  - Range

- Implementation and deployment issues:
  - Piggability
  - Availability of standard calibration and facility to examine calibration
  - Uneven coating for ultrasound

- Timescale to complete research: 1 – 3 yrs – accelerate if possible

Validation, Testing & Qualification

- Revised standards, guidelines and recommended practices, relevant to onshore and offshore gas and liquids lines, high and low pressure applications
- Addresses corrosion, mechanical damage and SCC defects
- Impacts on a wide range of existing industry standards (ASME, API, NACE etc) and government regulations
- Needs:
  - Validation of new inspection/detection technologies and analysis methods for defect detection and characterization, using
    - Full-scale laboratory-based testing – pipe failure tests, vehicle pull-through tests; this requires a pool of ex-service pipe samples
    - Field trials/demonstrations to establish capabilities and build confidence
    - Quantification of performance specifications
    - Independent calibration/certification of accuracy and reliability (detection,identification, false calls, dimensions)
    - A 'learning test loop' for capability assessment, training and qualifying operators
  - Technology packages to support improvements in codes and regulations

- Timescale for completion: 2-5 years

Assessment of Mechanical Damage, (and SCC, Corrosion)

- New or improved technology, relevant to onshore and offshore gas and liquids lines, high and low pressure applications
- Addresses mainly mechanical damage, but also SCC and corrosion defects
- Technology needs:
  - Improved screening assessment (Level 1), including discrimination of secondary features affecting damage severity
  - Improved methods for detailed assessment (Level 2, 3)
  - Methods for assessing immediate failure and delayed failure of mechanical damage (including the effects of changed loading, environmental conditions)
  - Growth rate data (esp depth) for time-dependent failure of corrosion, SCC
  - Defect criticality in higher strength steels and at higher design factors
- Implementation and deployment issues:
  - Critical to maximize collaboration between inspection companies and pipeline operators in order to learn from trials, early operational experience etc
  - Damage + corrosion/SCC is an additional complication, requiring assessment methods
  - Impact of new fuels on internal corrosion/SCC

- Timescale to complete research:
  - Screening assessment: 1-3 years; accelerate if possible
  - Detailed methods for all situations: 3-10 years

Additional Gaps

See the earlier slides on

- Detection and discrimination
- Size measurement
- Size change – growth and degradation
- Assessment
- Understanding the mechanism – knowing where to look
- Codes, standards and industry guidance