NYSEARCH

Crack Detection in Unpiggable Natural Gas Pipelines

PHMSA Workshop on Crack Detection

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Overall Goals

- Establish critical crack threshold
- Develop technologies to detect and characterize cracks in unpiggable natural gas pipelines
  - Use Invodane/Pipetel Technologies Explorer family of robotic systems as the platform for deployment of technologies
  - Two parallel efforts; one based on a combination of Transverse Magnetic Flux Leakage (TMFL) and Electromagnetic Acoustic Transducer (EMAT) technology, and the other on advanced Eddy Current (EC) technology

Critical Crack Size Detection Criteria

- Study carried out by Kiefner Applus, RTD
- Determine the minimum defect size (critical and monitoring) detection requirements for an inspection tool to give integrity assurance equivalent to that of a hydrostatic test
  - Longitudinal and circumferential cracks
  - Pipeline steel variability (toughness & wall thickness)
  - Effect of inspection tool measurement error
  - Pipeline stress (class location test)
  - Two approaches
    - Deterministic (modified NG-18)
    - Probabilistic (Monte Carlo simulation – Kiefner database)
  - Normalized results – all pipe sizes and grades

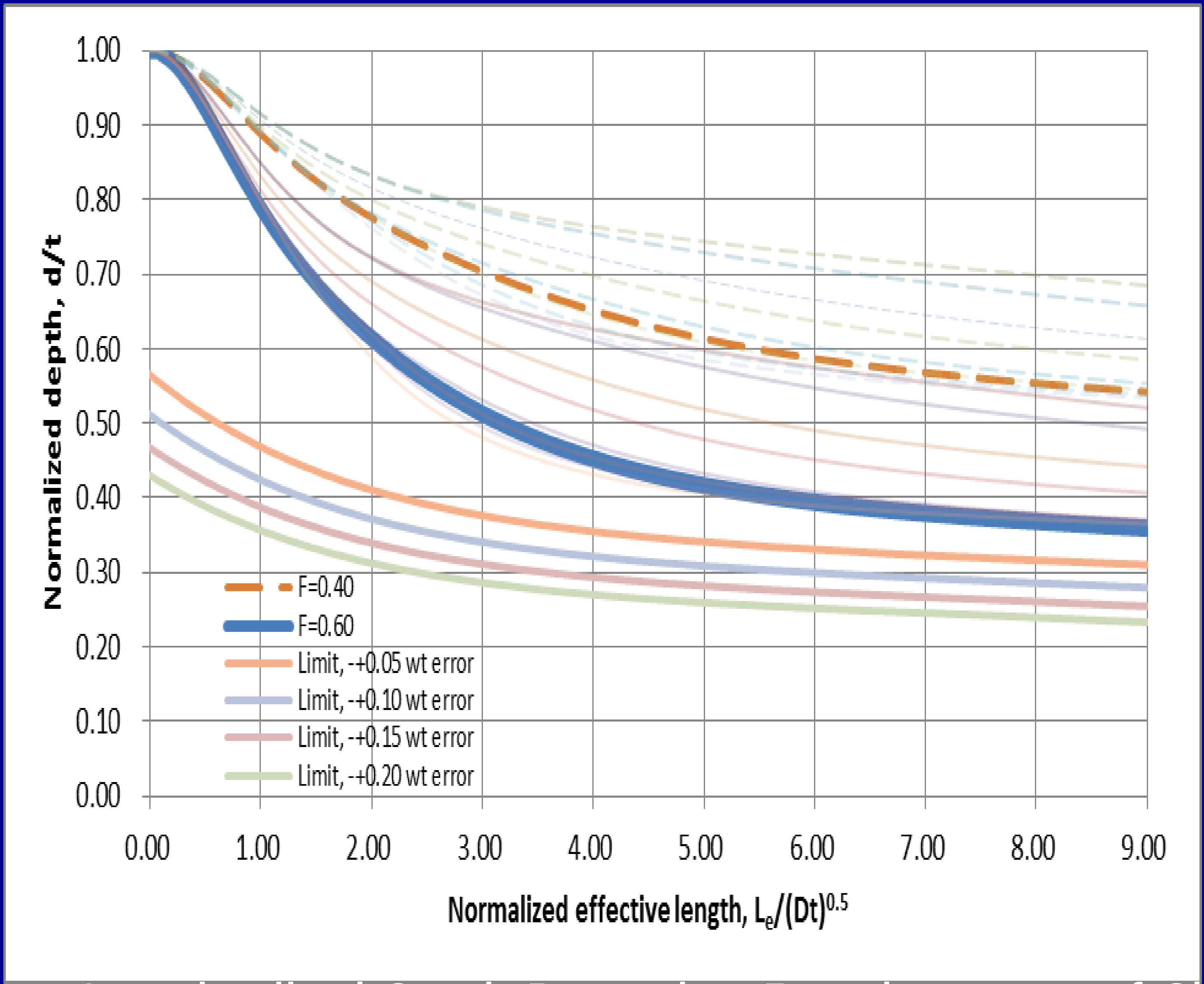
Material Variability

- Variability significantly affects the minimum detection requirement
- Three categories of ductility studied:
  - toughness dependent (vintage ERW)
  - partially toughness dependent (moderate mid-grade)
  - flow stress dependent (high toughness > 1980)

Accounting for Tool Measurement Error

- All tools have error claims based on POD
- First approach – establish POD for defect not to be critical
  - minimum defined by “monitoring” defect
  - max allowed tool standard deviation defined by difference between monitoring and critical defect sizes
- Second approach – establish detection limit so that defect enlarged by measurement error does not exceed “monitoring” defect size
  - detection limit lowered for standard deviations
  - defect enlarged by error < “monitoring” defect

Longitudinal Defects - Example



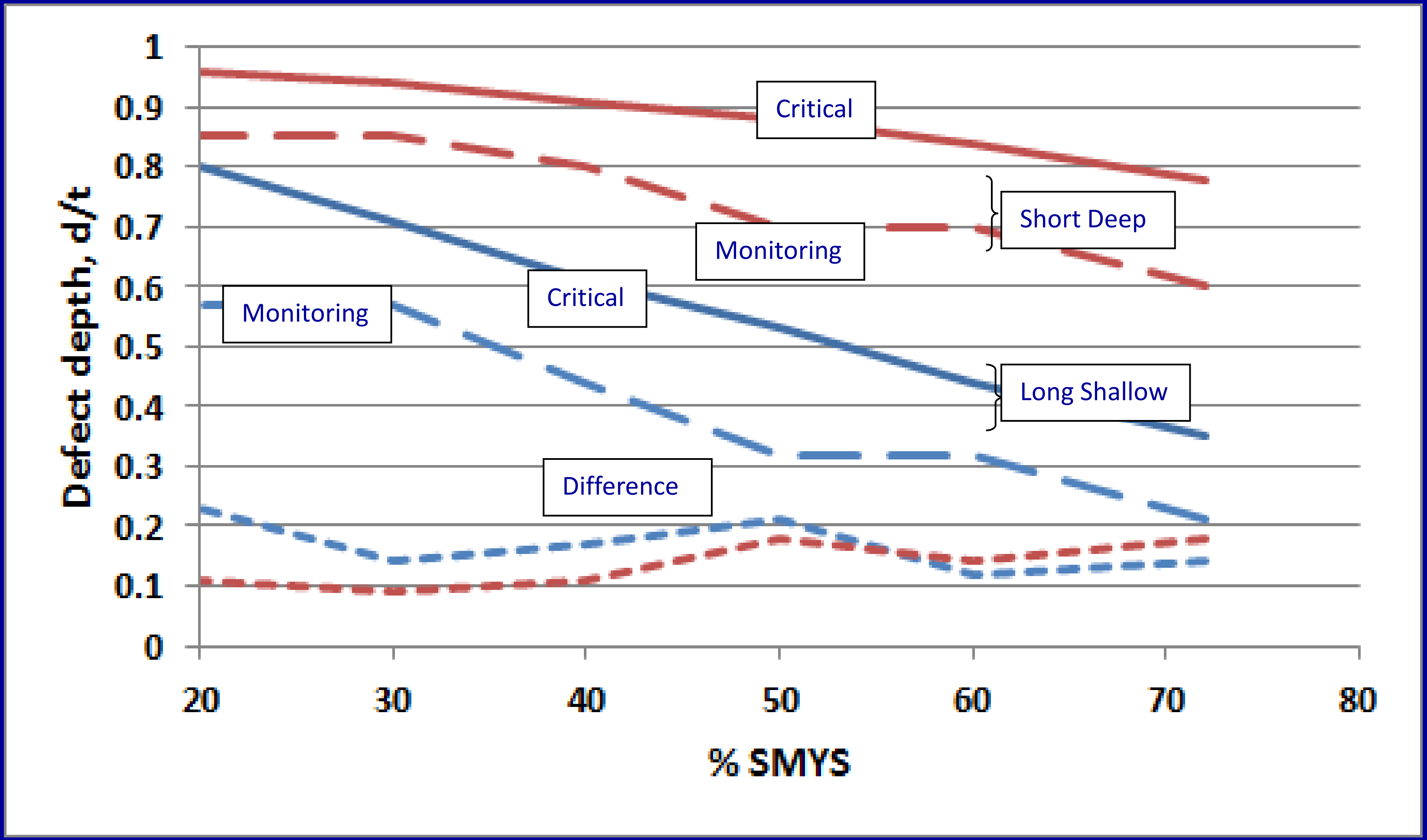
Minimum Longitudinal Crack Detection Requirements of Class 4 Pipelines

(all materials, moderate toughness and high toughness)

Critical vs. Monitored Longitudinal Defect

Long flaws – remaining wall thickness

Short flaws – deeper w/o rupture



Trend of difference between “monitoring” and “critical” defects for Grades A, B, X42

STUDY CONCLUSION

- There is not one crack defect detection size and depth target
- Varies with application by:
  - Yield Stress and stress level
  - Pipe Size
  - Material property variability
  - Tool measurement error
  - Inspection reassessment interval
- Low strength & moderate toughness within many ILI detection capabilities
- Higher strength, lower toughness, short or deep development challenge for ILI crack detection

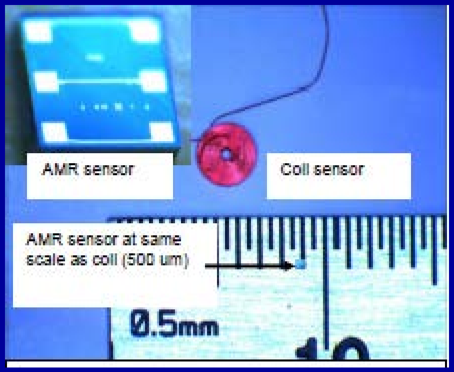
Crack Sensors

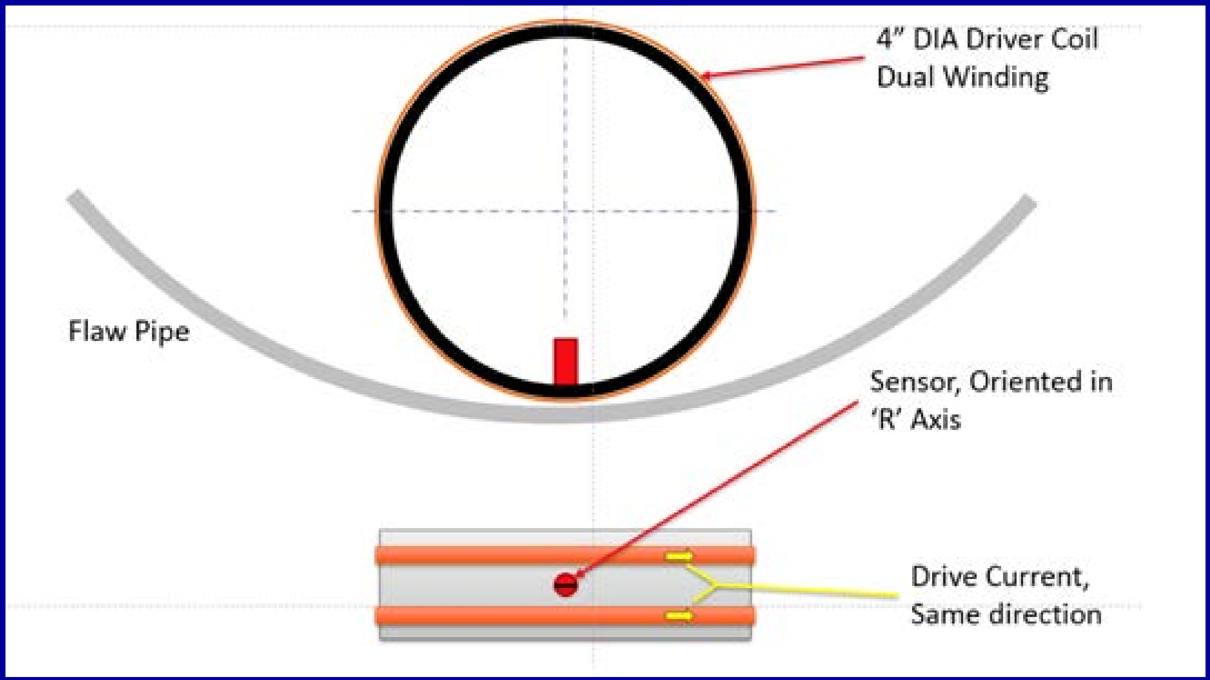
- Two parallel efforts; prototypes for Explorer 20/26
  - Combination TMFL and EMAT sensor
    - Cofunded by PHMSA
    - In field demonstration stage
    - Commercially available in early 2015
  - Advanced Eddy Current sensor
    - Initially developed for aerospace applications
    - Feasibility study; promising results

Advanced Eddy Current Sensor

- Developed by Radiation Monitoring Devices, Inc. (RMD) for heat exchanger applications
- Feasibility study to determine ability to detect cracks in gas pipelines
- Solid State Anisotropic MagnetoResistive (AMR) sensors; they replace traditional coil sensors
  - Solid state AMR sensors offer superior performance
  - Can be fabricated using photolithography in linear arrays on flexible sheets

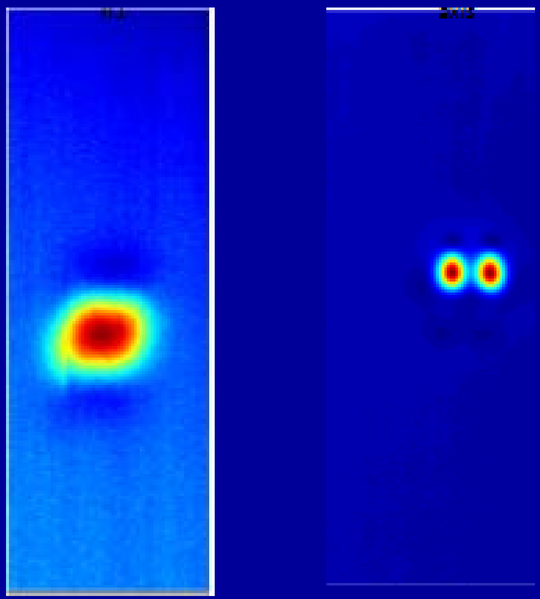
Advanced Eddy Current Sensor (continued)





Traditional coil sensor

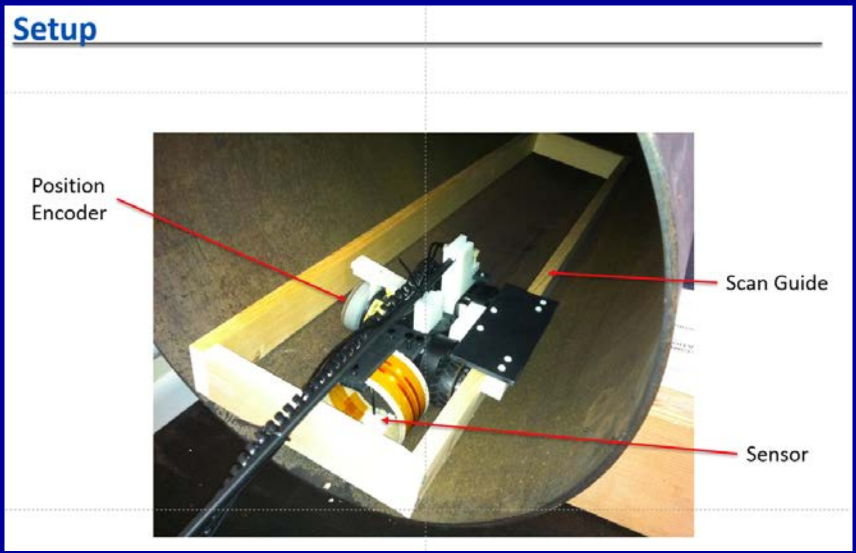
AMR sensor

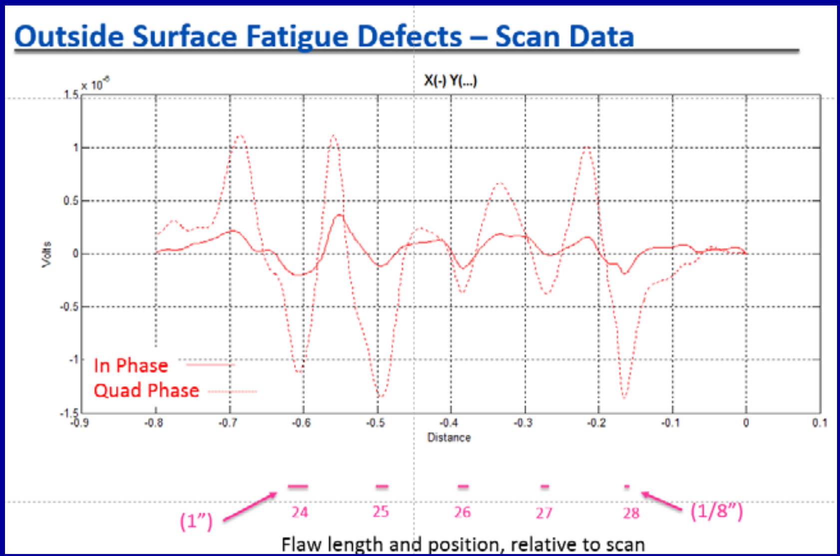


defects are 5 mils long, 105 mils separation

Advanced Eddy Current Sensor (continued)

- Testing being carried out on EFW gas pipe with actual crack defects (not machined defects)
  - 25% to 50% WT depth; .125” to 1” long
  - Cracks in seam weld and base material; inner & outer surface
  - Able to detect all of them

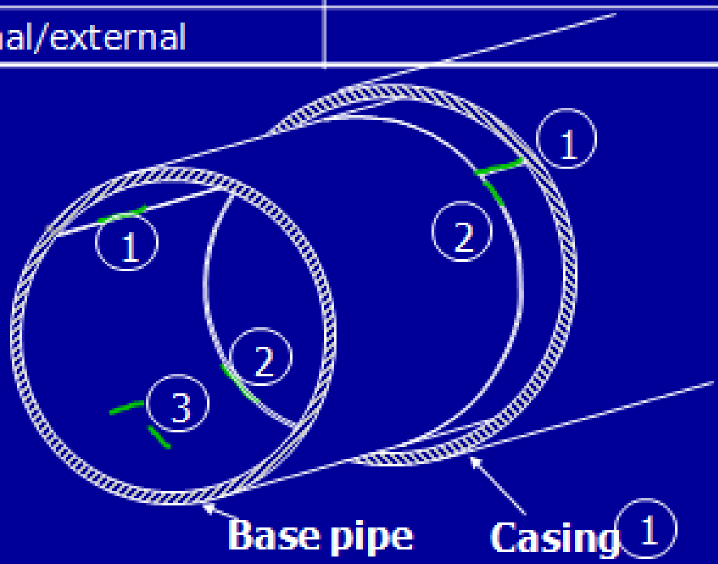




TMFL/EMAT Sensor

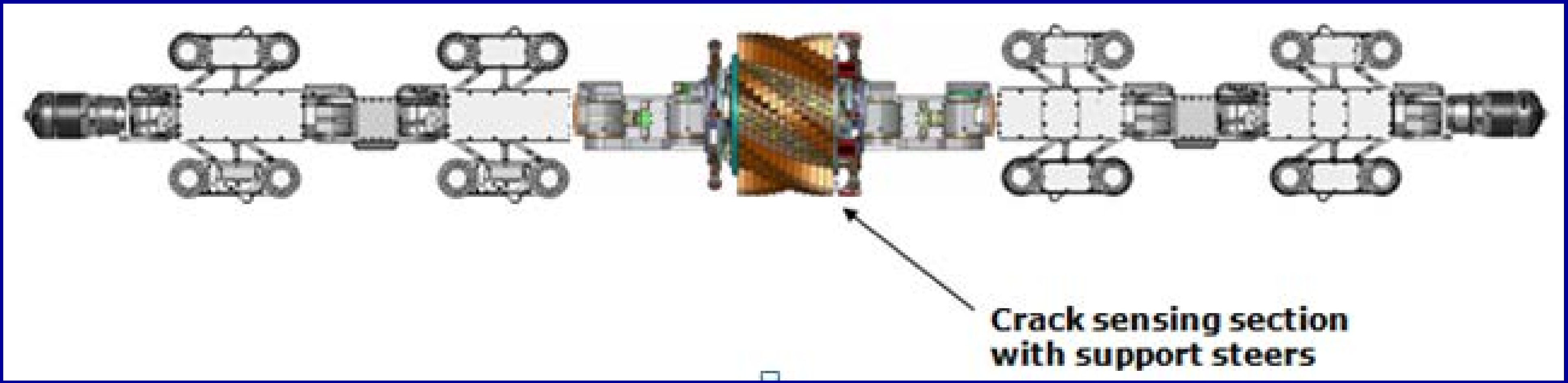
- Combination TMFL and EMAT sensor

Priority 1 (1)	Priority 2 (2)	Priority 3 (3)
Seam weld cracks	Girth weld cracks	Base material cracks
Large flaws (lack of penetration, lack of fusion, mill flaws)	Tight cracks	
Pipes within casings		
Corrosion		
Internal/external		



TMFL/EMAT Sensor (continued)

- One-pass inspection
- Single sensor module
- Collapsibility and/or feature negotiation
- Heavier and more power consuming than axial MFL sensor



TMFL/EMAT Sensor (continued)

- Full array TMFL provides detection mainly in base material
- EMAT provides detection mainly in seam welds
  - Number of transceivers and receivers optimized
- Crack sensor interchangeable with axial MFL sensor

TMFL/EMAT Sensor (continued)

- Initial testing carried out on gas pipe with actual crack defects (not machined defects)
- First field demo carried out in May '14 (EMAT only in order to optimize its design)
- Second field demo carried out in July '14 (combined TMFL & EMAT)
- Additional three field demos planned over the next 6 months
- Should be commercially available through Pipetel Technologies in early 2015

THANK YOU

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