Mechanical Damage Detection & Characterization

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Mechanical Damage – An Example

Detection & Characterization – Colonial Experience

- ILI
  - MFL - High & Low Resolution
  - Geometry tool
  - Wheel Coupled UT
  - Liquid Coupled UT (Compression and Shear Wave)
  - ILI w/ TFI
  - Over 25,000 miles of ILI performed
- Direct Examination
  - Visual examination
  - Magnetic particle inspection
  - Ultrasonic inspection
  - Defect modeling
  - Over 30,000 excavations

Detection & Characterization

In-line Inspection


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Detection & Characterization – In-line Inspection

- Detailed data integration / risk based dig planning is key
  - Discrimination of indications is challenging (i.e. dent with cracking versus plain dent)
  - Efficient and accurate critical assessment of ILI data is difficult (localized strain, stress)
- ILI data alone is not sufficient for such a complex threat

Detection & Characterization – In-line Inspection

- Threat is dependent on many factors
  - The damage – Type, strain, stress, shape, position, orientation
  - Stress Risers?
  - Pipe design - WT, D/T, toughness
  - Operations – Product, significant cycles
  - Environment – Activity, stability
  - Others?
- No single dominant driver, however…

ILI - Current Paradigm

- Current regs focus on depth and lead to excavation of large population of indications
- Discovery of small number of integrity threatening defects
- Benefits
  - Finds many of the potentially threatening defects
- Negatives
  - Unnecessary excavations (safety & damage potential)
  - Misguided resources
  - Can overlook potentially threatening defects
- Teaches us that a simple criteria is not most effective

…but when we dig…

Detection & Characterization

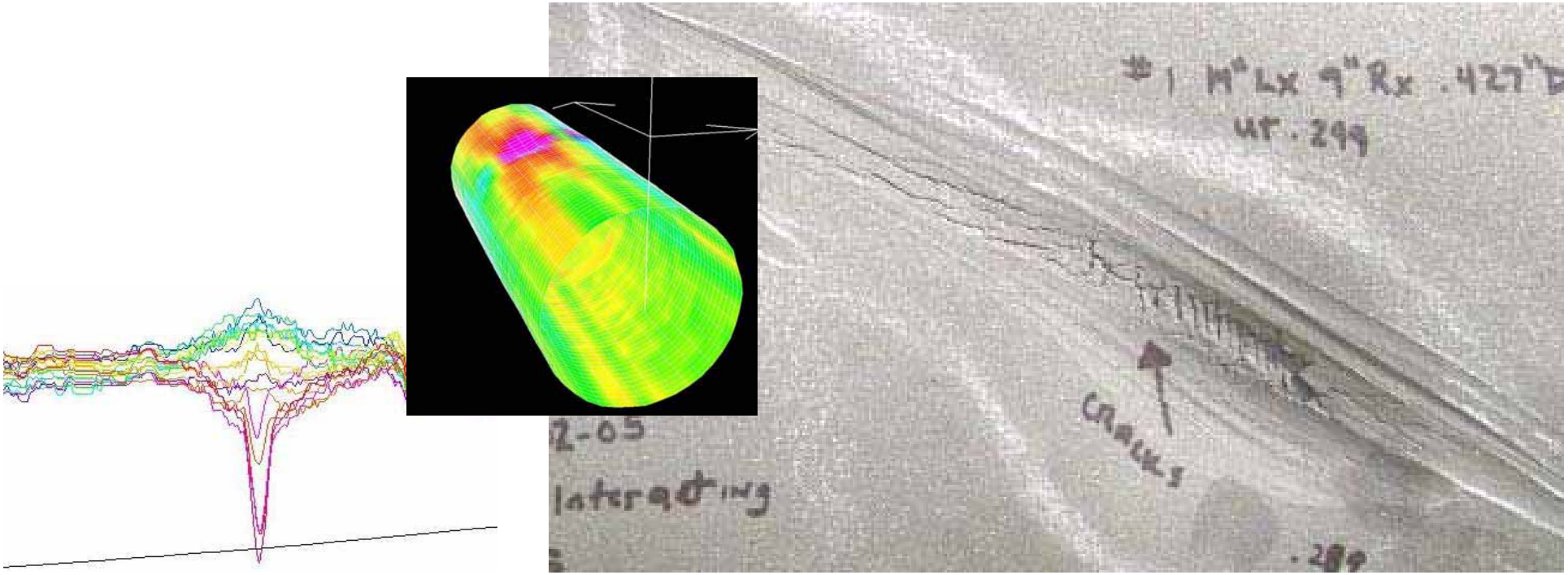
Direct Examination

Detection & Characterization – Direct Examination

- Visual inspection – important, but alone can miss anomaly features
- Magnetic particle inspection – effective at exposing anomaly features
- A simple repair criterion (i.e. depth) – efficient but overly conservative, but…
- Often times, by the time an anomaly is exposed, the decision to repair often has relatively low impact

Detection & Characterization – Direct Examination

- Goal: know what you've got before it is exposed (ex.)
- Data feedback is critical to improve ILI detection and characterization (move further up the chain)



Detection & Characterization

- Observations
  - Growth of latent damage is rare (<1%)
  - Fatigue growth is rare but exists in some liquid lines
  - Heavily dependent on line conditions (D/T, cycles)
  - Apply technology, science and resources proportionate to risk (move further up the chain)

Detection & Characterization

Summary

Detection & Characterization - Conclusions

- Optimized detection & characterization process:

1) Use risk mgmt to focus where threat is significant
2) Advanced indirect detection, characterization and data integration to dig the right indications
3) Accurate examination & feedback to mitigate and learn

Detection & Characterization - Conclusions

- There is no one size fits all detection technology
- Simple dig criteria (i.e. depth) is not the most effective method
- Mechanical damage is complex and damage behavior is variable dependent on line conditions and environmental factors
- Often find things in the field that were not identified during ILI
- Currently employing a sledgehammer when a scalpel is needed

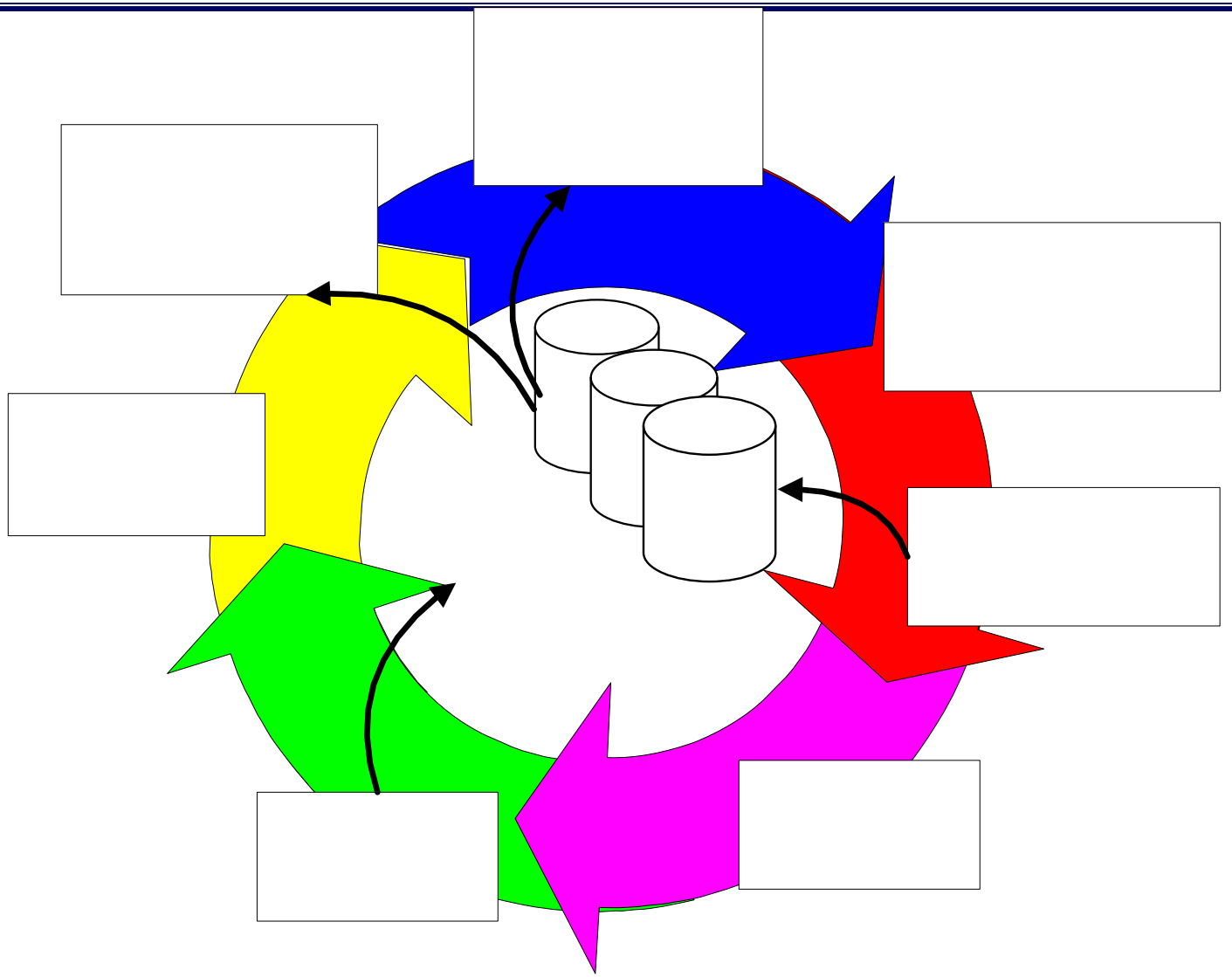
Detection & Characterization - Conclusions

- Courses of Action
  - Continued focus on prevention
  - Fit for purpose tool selection based on risk assessment
  - Analyze damage characteristics and line properties / conditions to develop a profile of pipelines susceptible to latent damage growth (growth likely not random)
  - Risk assessment enhancements, data integration guidelines and reliable engineered dig selection methodologies

Detection & Characterization - Conclusions

- Courses of Action cont.
  - Efficient advanced critical assessment of ILI data
  - Prioritization of dents with metal loss / stress risers
  - Technical definition of stress risers
  - Appropriate scheduling or monitoring of other damage
  - Standardized strain based criteria for liquid lines that incorporates fatigue consideration
  - **Regulations that enable and promote an engineered approach versus one size fits all criteria**

Detection & Characterization - FOCUS



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