Pipeline Research Council International, Inc.

Damage Prevention & Right of Way Monitoring for Operating Pipeline Systems

Confronting the Challenges through Research Programs

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LEADING PIPELINE RESEARCH

Presentation Topics and Overview

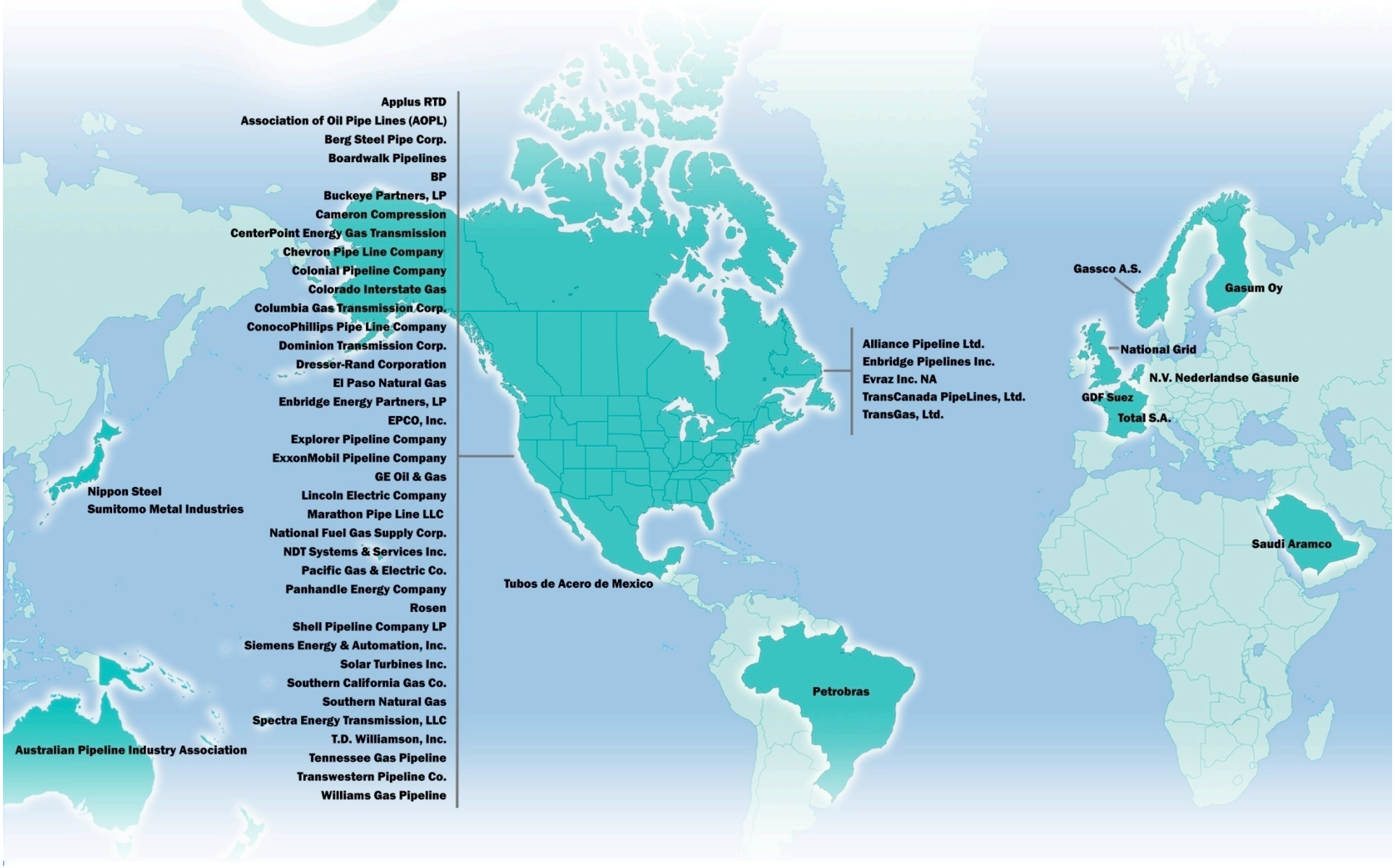
- Damage Prevention – Drivers & Challenges
- Successes of Current Research Programs
- Building on the Successes & Addressing the Next Series of Challenges for the R&D Community

PRCI Membership Drives Research

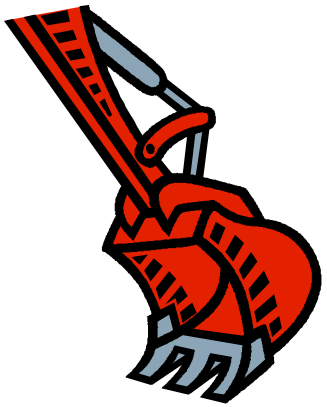
- **38 Energy Pipeline Operating Companies**
  - *25 Natural Gas Transmission; 11 Liquid*
  - *2 Operators - both Liquid and Natural Gas Transmission*
- **World-wide Research Organization**
  - *26 U.S. Companies*
  - *12 Non-U.S. (Brazil, Canada, Europe, Saudi Arabia)*
- **14 Associate Members**
  - *U.S.; Canada; Mexico; Japan*
- **Total mileage represented ~355,000 miles**

PRCI™

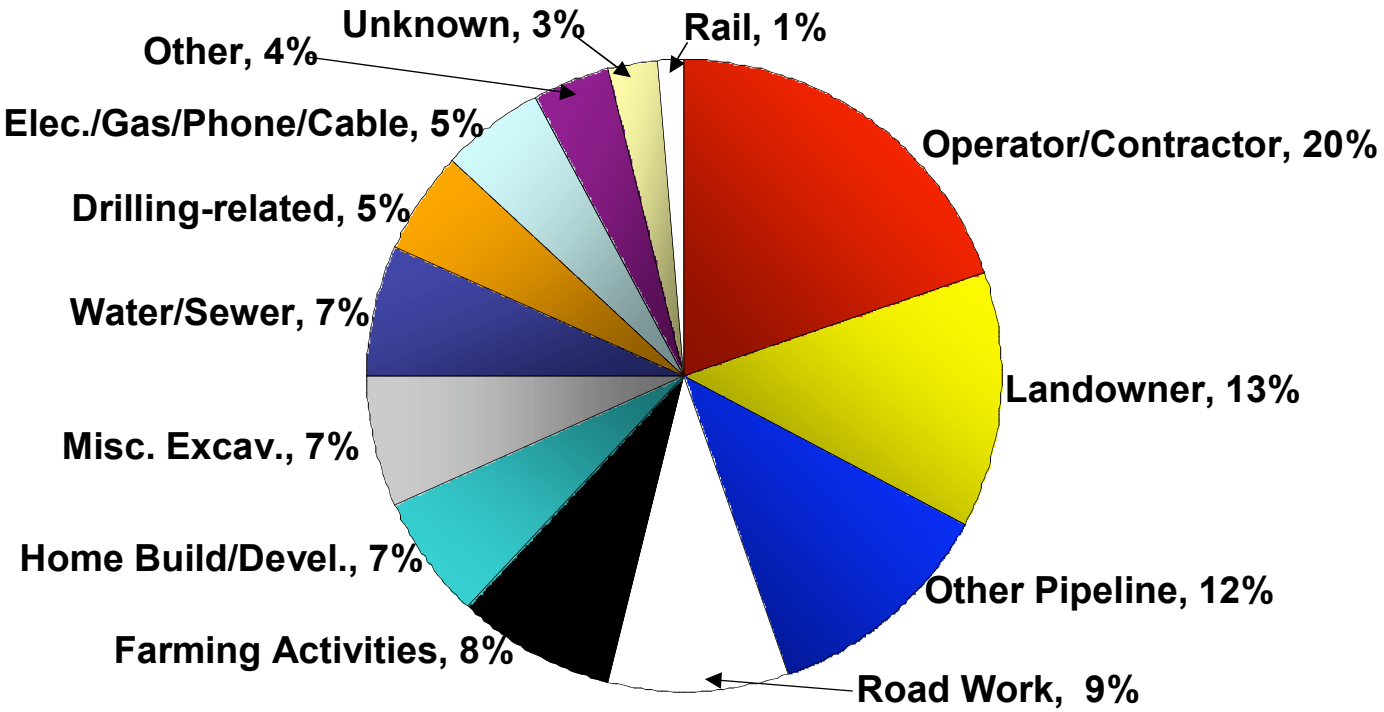
LEADING PIPELINE RESEARCH WORLDWIDE



Damage Prevention & ROW Monitoring
Drivers & Challenges



Causes of Damage to Pipelines



Excavation damage, 2002-03

(OPS data, from GRI 8747)

Outside force damage is the single greatest cause of pipeline failures

Mechanical Damage is single largest cause of on-shore pipeline damage

>90% of all incidents occur immediately

>70% occur without One Call being made

(source Visitless Integrity Assessment Ltd., 2009)

Impacts of Damage to Pipeline Systems

- **Safety - Toxic & Heat Injury; staff, contractors, landowners, public**

- **Environmental Performance**
  - *Contamination - soil, ground water, and air*
  - *Liability for natural resource impacts and damages*
  - *LAUFE – emphasis on greenhouse gas releases*

- **Financial & Economic Considerations**
  - *Keeping product in the pipe and delivery to market – revenue impacts*
  - *Paying for environmental liabilities - remediation, NRD, 3rd party claims*
  - *Pipeline and facilities repair costs*

- **Public Perception & Corporate Citizenship**
  - *Reputation – public and stockholders*
  - *Enhanced awareness*
  - *License to operate*

Damage Prevention – Why is This so Challenging?

- Substantial mileage of SYSTEMS - transmission and distribution
- Varying needs based on unique conditions for each operator
- No single technology can address all pipeline issues – tiered approach, multiple technologies
- Monitoring Frequency and timing
- Resource limitations
- Accuracy and reliability of databases (upkeep)
- Sensitivity of Measurement systems
- Effective communication with multiple stakeholders, and existing databases – DIRT, One Call, etc.
- "If You Build it They Will Come" – Increasing Encroachment

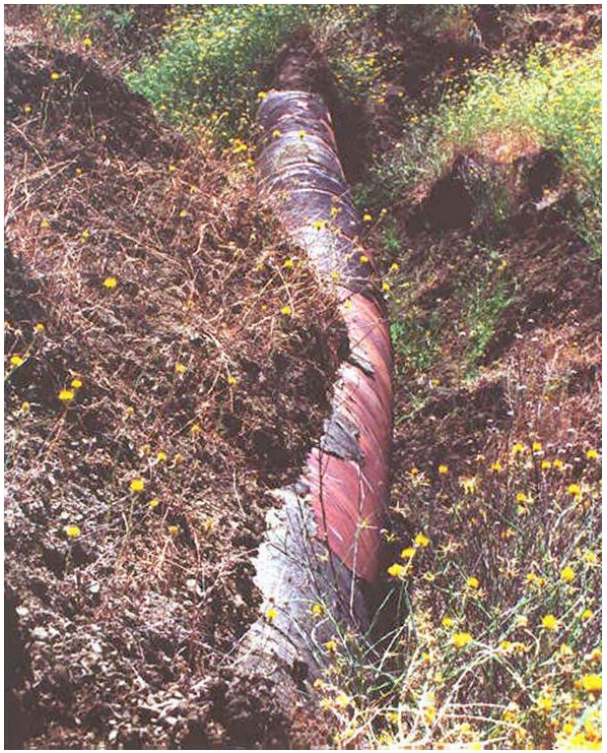
When Prevention Fails – Mechanical Damage Due to Contact

- Coating damage, removal
- Dent (re-rounded), pipe ovalization
- Stress, strain concentration
- Metal removal, ploughing, gouge
- Surface & sub-surface cracking
- Sub-surface deformation
- Time-dependent cracking
- Nearby weld, corrosion
- Leak vs. Rupture; Time-delayed Failure
  - *Tracks 2, 3 & 4*

When Prevention Fails – Damage From Natural Forces

Monitoring and Detection of Change

- Landslides
- Faults, Earthquakes
- Subsidence & sinkholes
- Erosion
- Flooding

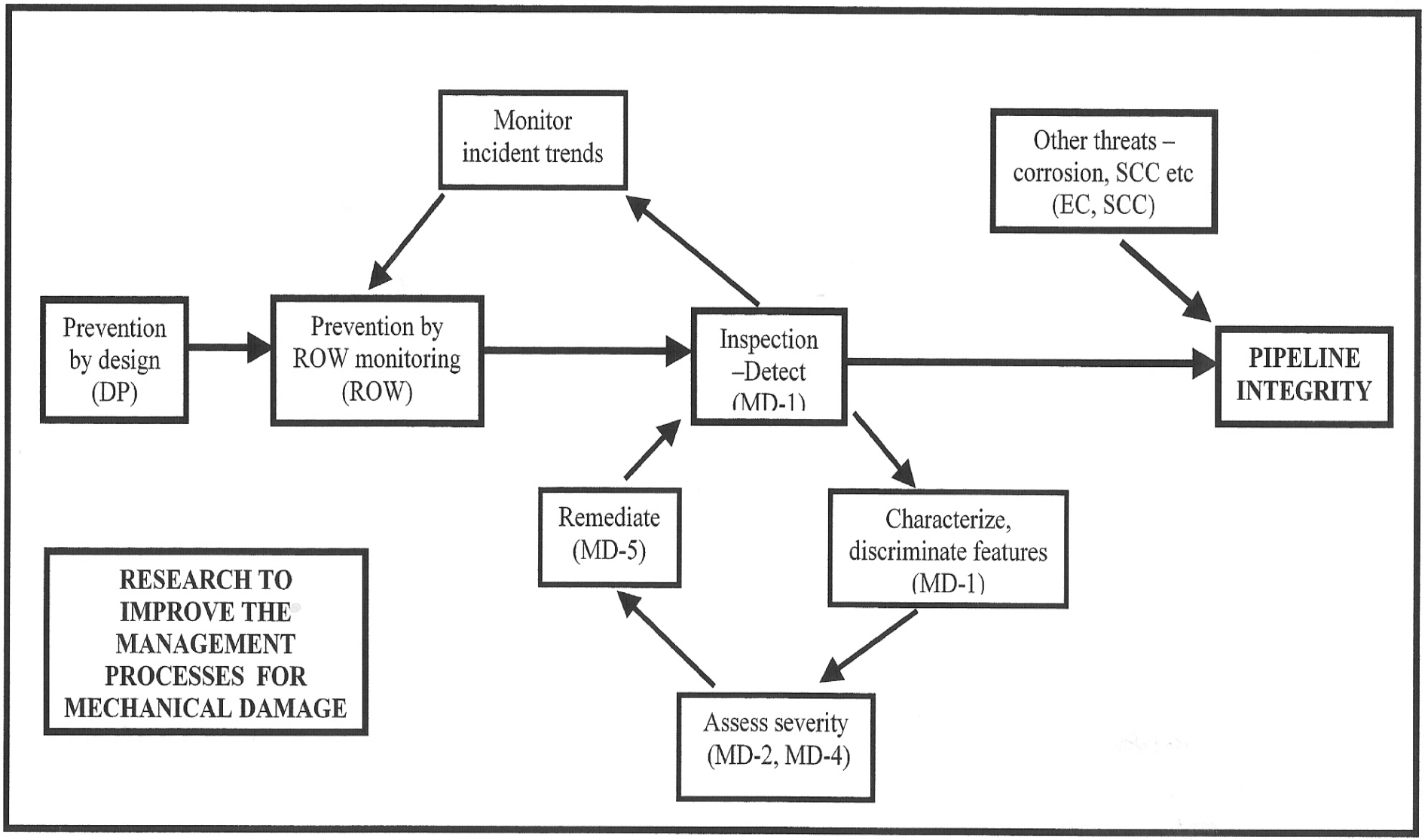


PRCI Roadmap – Damage Prevention

- Developing the means to detect, assess, and prevent the damage to pipelines caused by outside forces such as excavation equipment and ground movement;
- Better understanding of current situation – successes and failures – identify 'menu' of good practice for each pipeline location
- Identify gaps and weaknesses in current practice – techniques, procedures, human factors – and develop solutions
- Explore opportunities for 'next generation' solutions, incorporating technologies from other industries
- Assessing the human factors influences and impacts in pipeline operations control centers and the development of protocols for normal and abnormal operating conditions

our goal ….. zero hits

Research to Improve IM processes



PRCI Research Focus

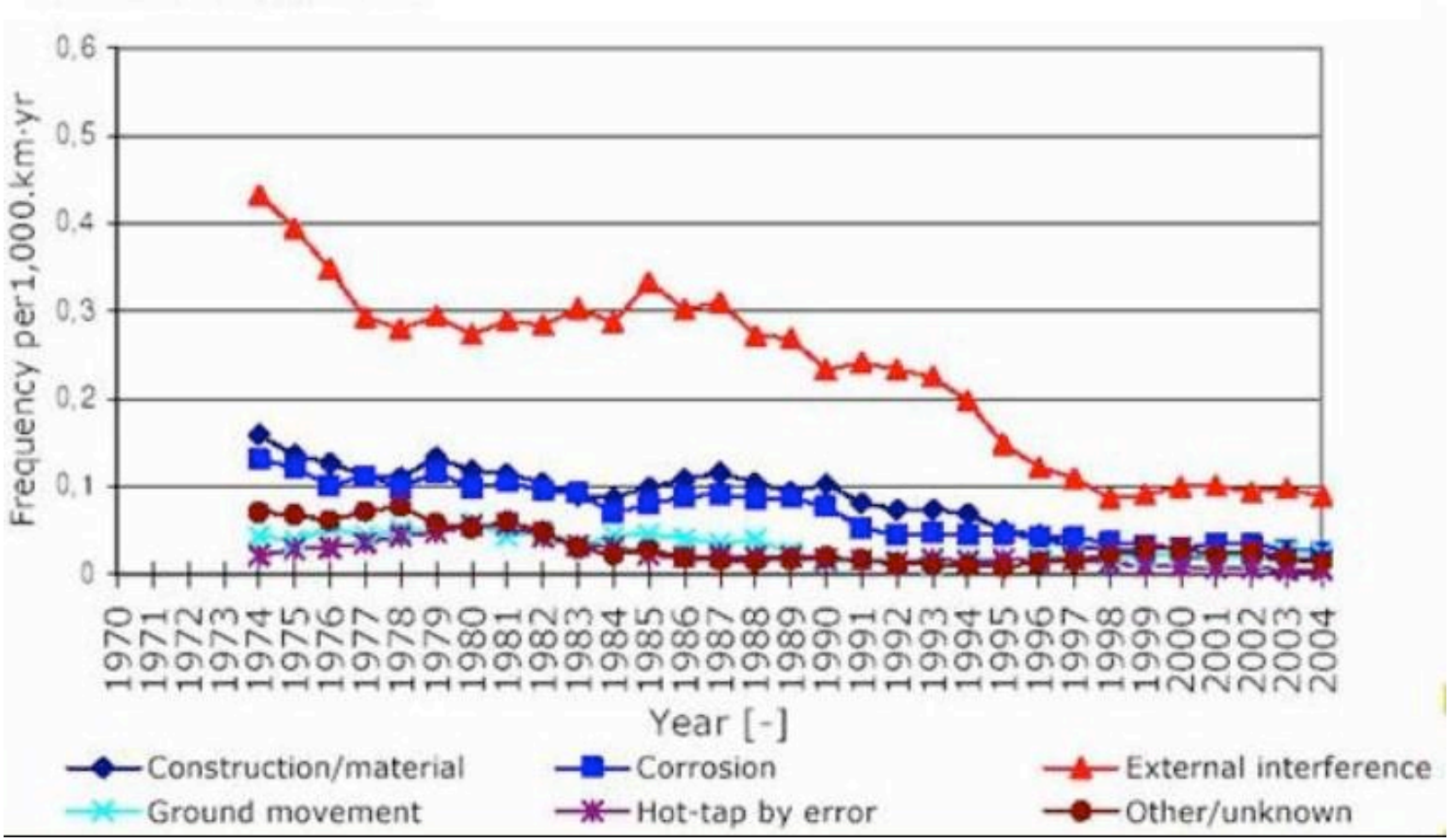
- **Right-of-Way Monitoring & Management**
  - *Best practices to prevent mechanical damage to pipelines*
  - *Technologies to accurately and cost-effectively detect and identify unauthorized activity near pipelines*
  - *Measuring the effectiveness of current ROW monitoring techniques/practices*
  - *Development of Pipeline Encroachment Prediction Models*
  - *Analysis and development of acoustic monitoring technology*
  - *Right of Way Automated Monitoring*

- **Damage Prevention Technologies & Human Factors**
  - *Survey of good operator practice (DP1-1)*
  - *Utilization of a ground positioning satellite device in conjunction with a current one-call system (DP 1-4)*
  - *DP-3 - Human Factors Analysis of Pipeline Monitoring & Control Operations*
  - *DP 3-2 - Influence of Human Factors on Pipeline Damage Prevention*
  - *Acoustic monitoring technology*

Expected Outcomes – Damage Prevention

- A benchmark of current mechanical damage prevention practices/measures and their effectiveness
- A 'menu' of good damage prevention practices and technologies, taking into account individual pipeline locations, attributes and operational circumstances
- Improved public awareness guidance and behavioral compliance measures for controlling ROW activity
- Identified opportunities for developing and demonstrating 'next generation' technologies for ROW monitoring and pipe/facility location – RAM Presentation

Damage Prevention Metrics



(**European Gas Industry Data Group 6th report**)

Getting better, but room for further improvements

Key Industry Challenges and R&D Needs

- Improve understanding of current system performance and capabilities – POI, POD, POFC; aerial patrol, ground surveillance, satellite, etc.
- Improved integration of industry-government databases; mining existing information and extracting the value – Predictive Modeling
- Developing new technologies that can be integrated into existing platforms
- Application of emerging technologies - new constellation of satellites, UASs
- Advanced algorithms and sensors –spatial & spectral resolution
- Standard/guidelines supporting selection of appropriate monitoring method – PFD or decision-tree diagrams
- Real time processing, communication, and reporting
- Continued focus on public awareness and Best Practices