Detection of Unauthorized Construction Equipment in Pipeline-of-Ways
&
Real-Time Acoustic Monitoring of Contact to Pipelines

> **Presented to:**

Pipeline Research and Development Forum
Prevention Track

by
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December 11, 2003

Outline of Presentation

- The need for 3rd-party damage detection
- Two solutions under development:
  - Use an optical fiber to detect encroachment in the right-of-way
  - Detect acoustic signal generated when pipeline is hit
- Brief overview of each technology & deliverables

Prevention of 3rd-Party Damage is a Industry Concern

- Third-party damage on HP pipelines can be extremely costly and disruptive
- DOT statistics on transmission lines from 1994-2002 give:
  - 237 third-party incidents
  - 8 deaths
  - 36 injuries
  - $168 million in property damage
- One incident cost ~$25 million
- True cost 2 to 5 times greater

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Optical Fiber Sensor for Detection of Unauthorized Construction Equipment in Pipeline Right-of-ways BEFORE the Pipe Is Hit

- Sponsored by
  - DOE NETL
  - GRI
  - OTD
  - Test site at ANR Pipeline
- Proof-of-Concept Phase

Optical Fiber Sensor: Objective

> Develop a system that can detect hazardous encroachment with minimum false positives
  - System must be automatic, 24 hours per day/ 7 days a week
  - Effective
  - Reliable
  - Economical

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An Optical Fiber is the Sensor

> Optical fiber buried along pipeline

> Compression of soil and vibrations change light transmission properties of the fiber

> Light pulses and an OTDR* detect these changes

> After disturbance, fiber returns to original condition (fiber is not broken)

*** OTDR = Optical Time Domain Reflectometer**

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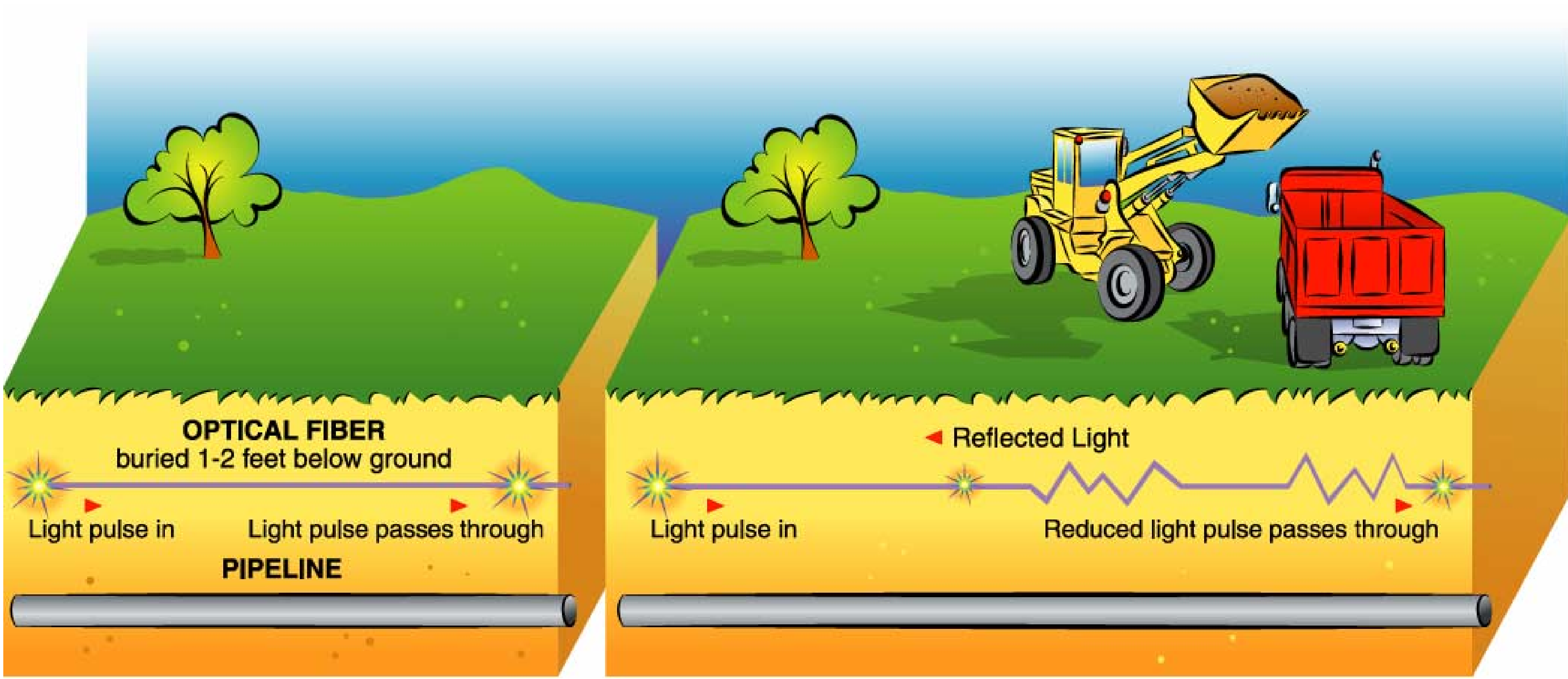
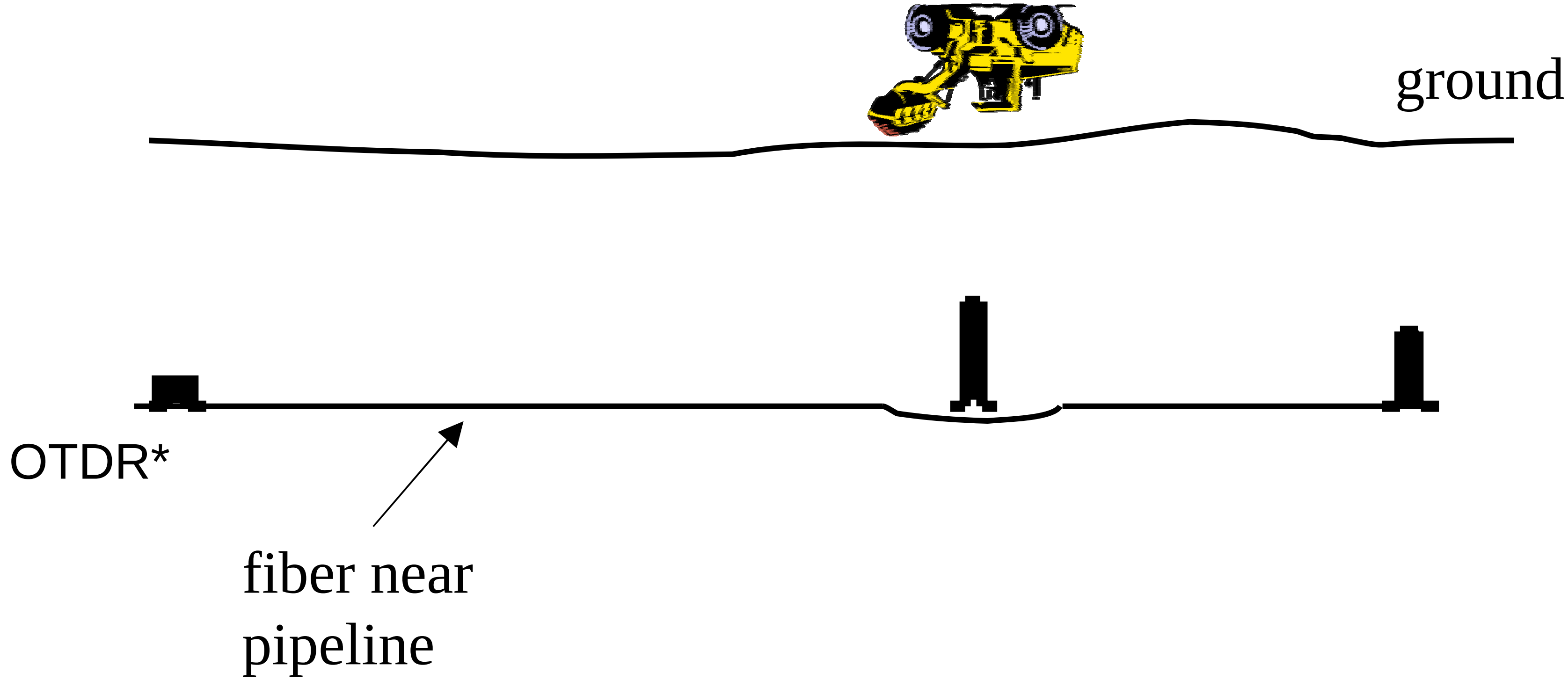
OTDR Technique Can Discriminate Simultaneously Occurring Events



Round trip travel time of a light pulse locates encroachment.

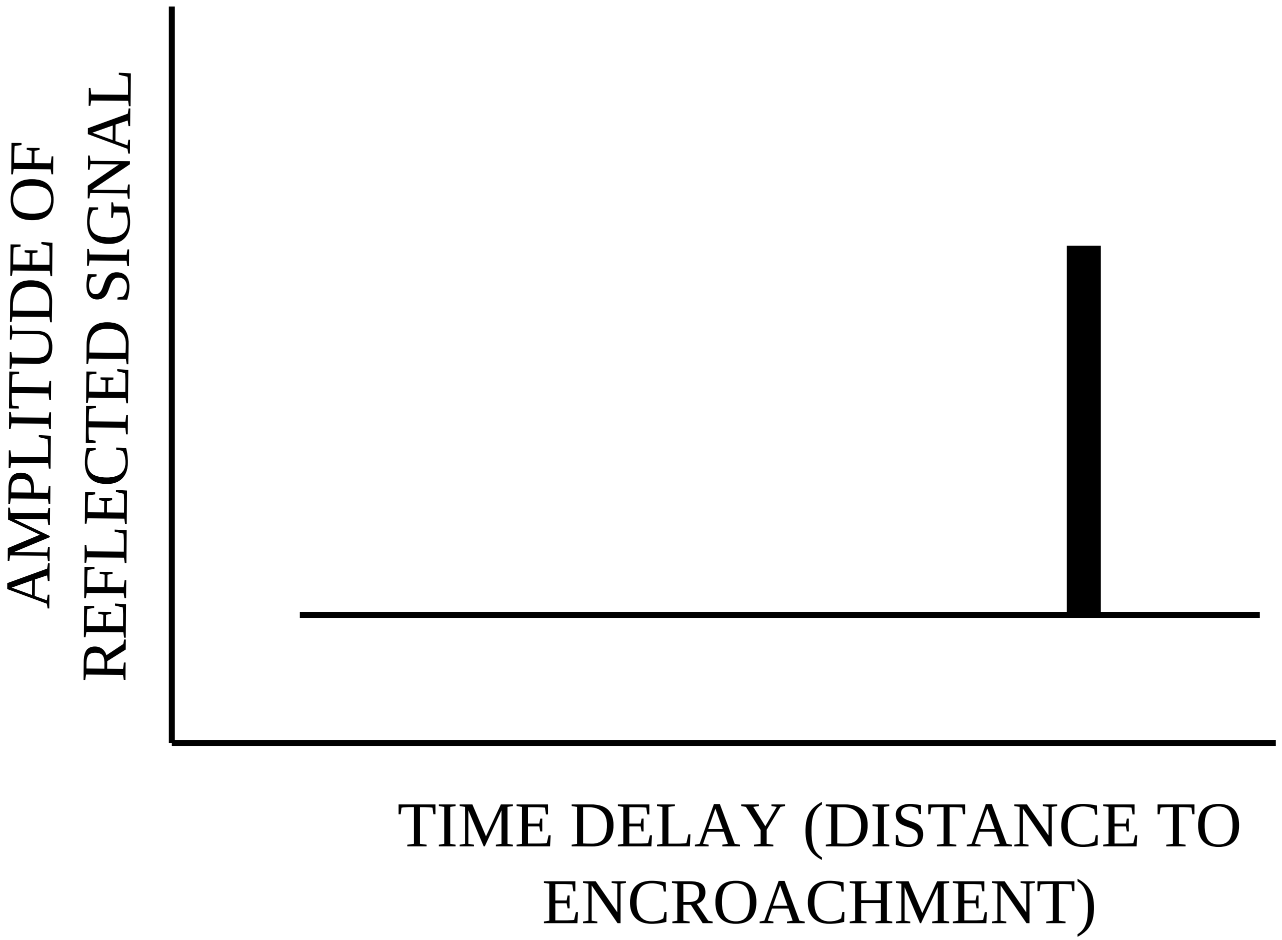
Variations in amplitude identify type of encroachment.

Optical Fiber Sensor: Disturbances to the Fiber Will Reflect Part of a Light Pulse

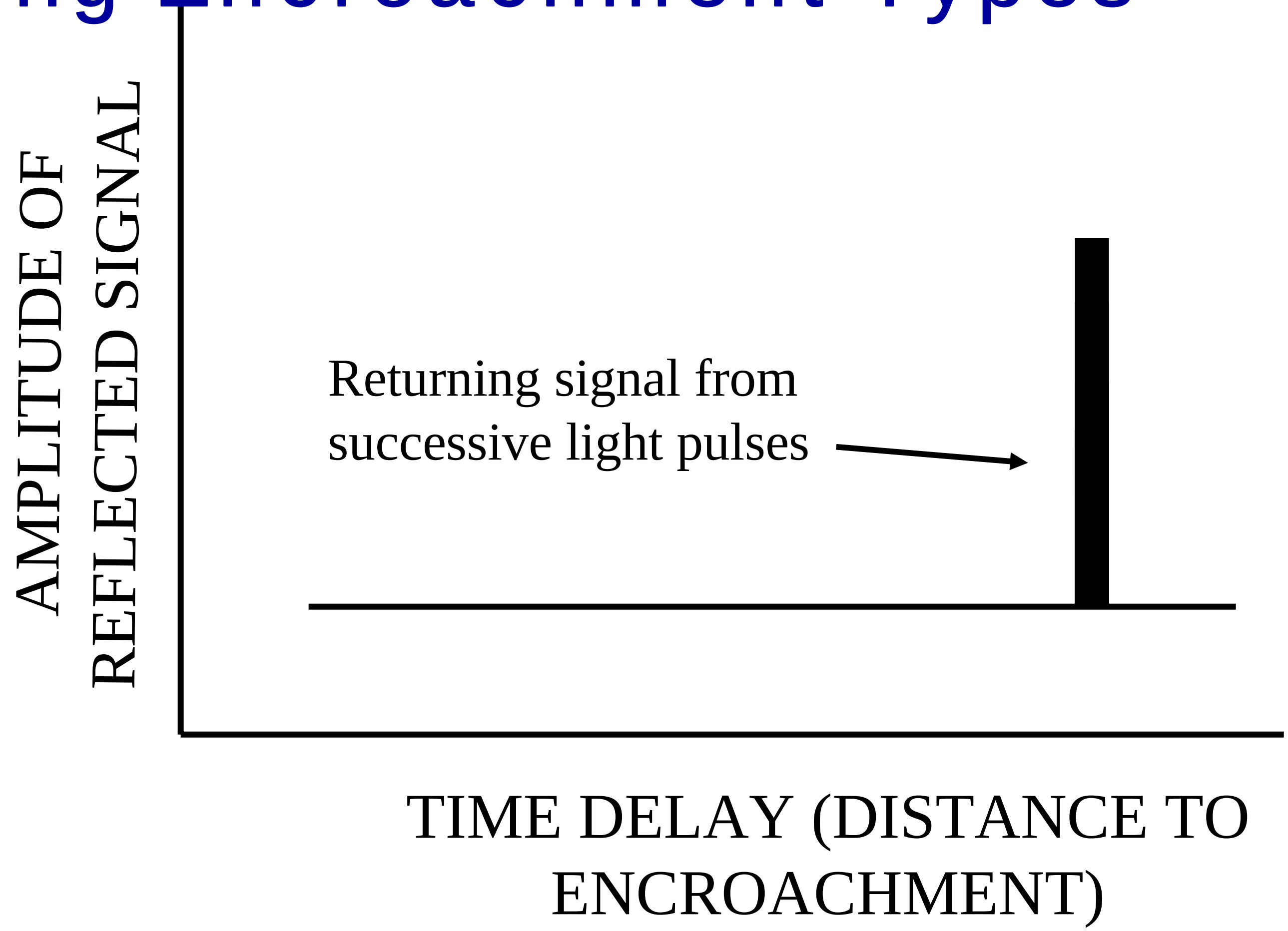


***OTDR = optical time domain reflectometer**

Optical Fiber Sensor: When Displayed on a Scope, the Position of the Signal Is Proportional to Distance to the Encroachment



Optical Fiber Sensor: The Variation in Signal Strength Used to Discriminate Among Encroachment Types



Minimizing False Positives and "Masked Events" Is Critical for Industry Acceptance

- > Encroachment is common, 3rd-party damage is rare
- > Economics requires monitoring long distances from one location
- > Pipelines in noisy areas will have "events" occurring simultaneously
- > Thus, being able to detect and distinguish simultaneous events at different locations is important
- > Also critical to identify what is causing encroachment

Optical Fiber Sensor

Key technical issues:

> Demonstrate the ability to detect encroachment

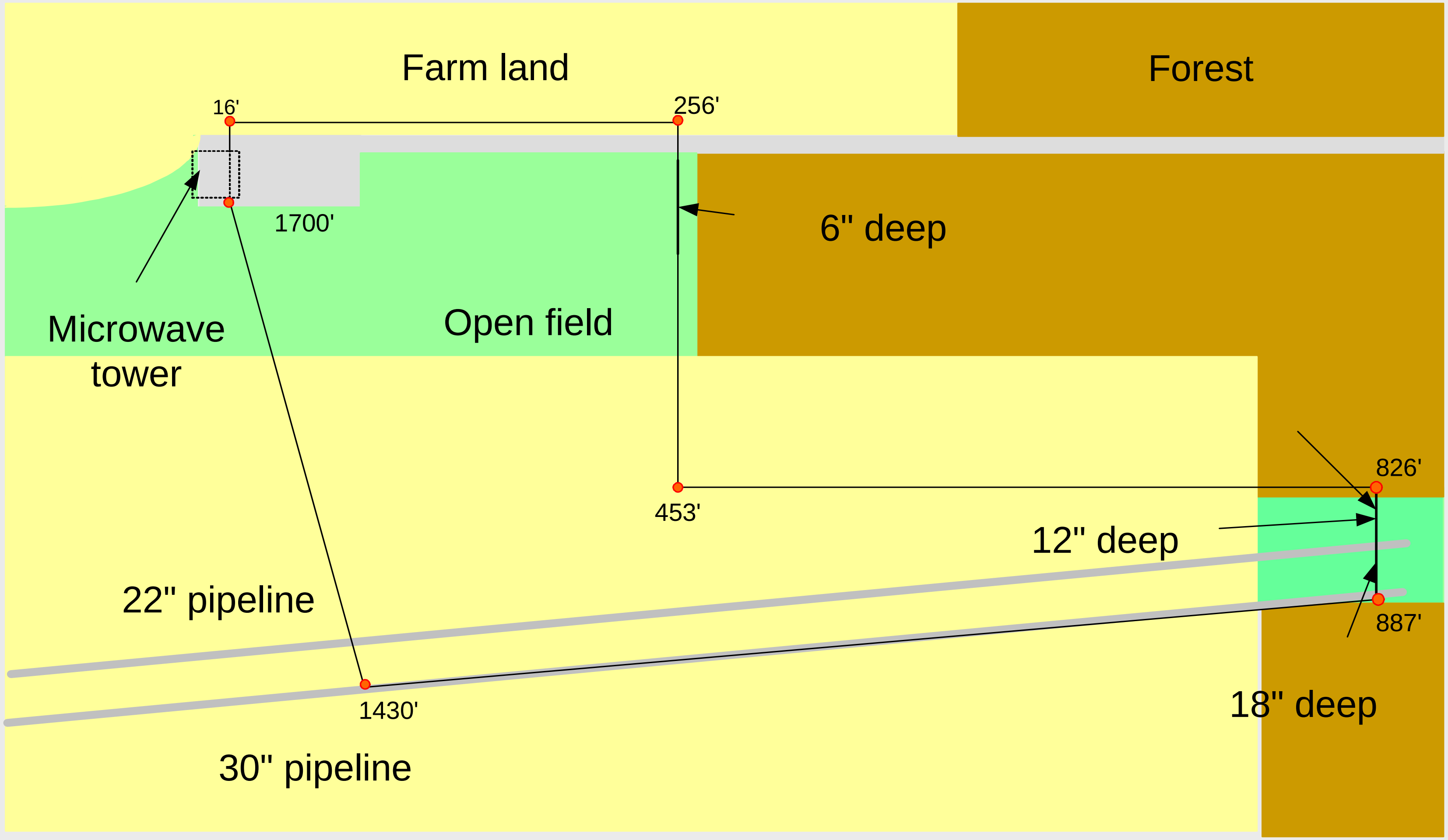
> Develop methods to discriminate between potentially hazardous and benign encroachments

Optical Fiber Sensor: Project Deliverables

> Design and build custom OTDR
> Select, install and test optical fibers
> Collect data characterizing right-of-way encroachment types
> Develop techniques to distinguish potentially harmful from harmless encroachment
> Demonstrate sensitivity and discrimination capabilities

Optical Fiber Sensor: Custom OTDR

Optical Fiber Sensor: Field Site



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Real-Time Monitoring of Contact to Pipelines Detects Impacts

- Sponsored by
  - GRI
  - PRCI
  - PSE&G
  - Questar
  - NGA (NYGAS)
  - GTI's SMP
  - Duke Energy
  - SoCalGas
- Phase 7 Battelle is subcontractor

Acoustic Monitoring: Detect the Impact Signal

> When construction equipment strikes a pipeline, it creates an acoustic signal that propagates in the gas stream

> Sensors on the outside of the pipe can detect these impact signals and be used to send an alarm

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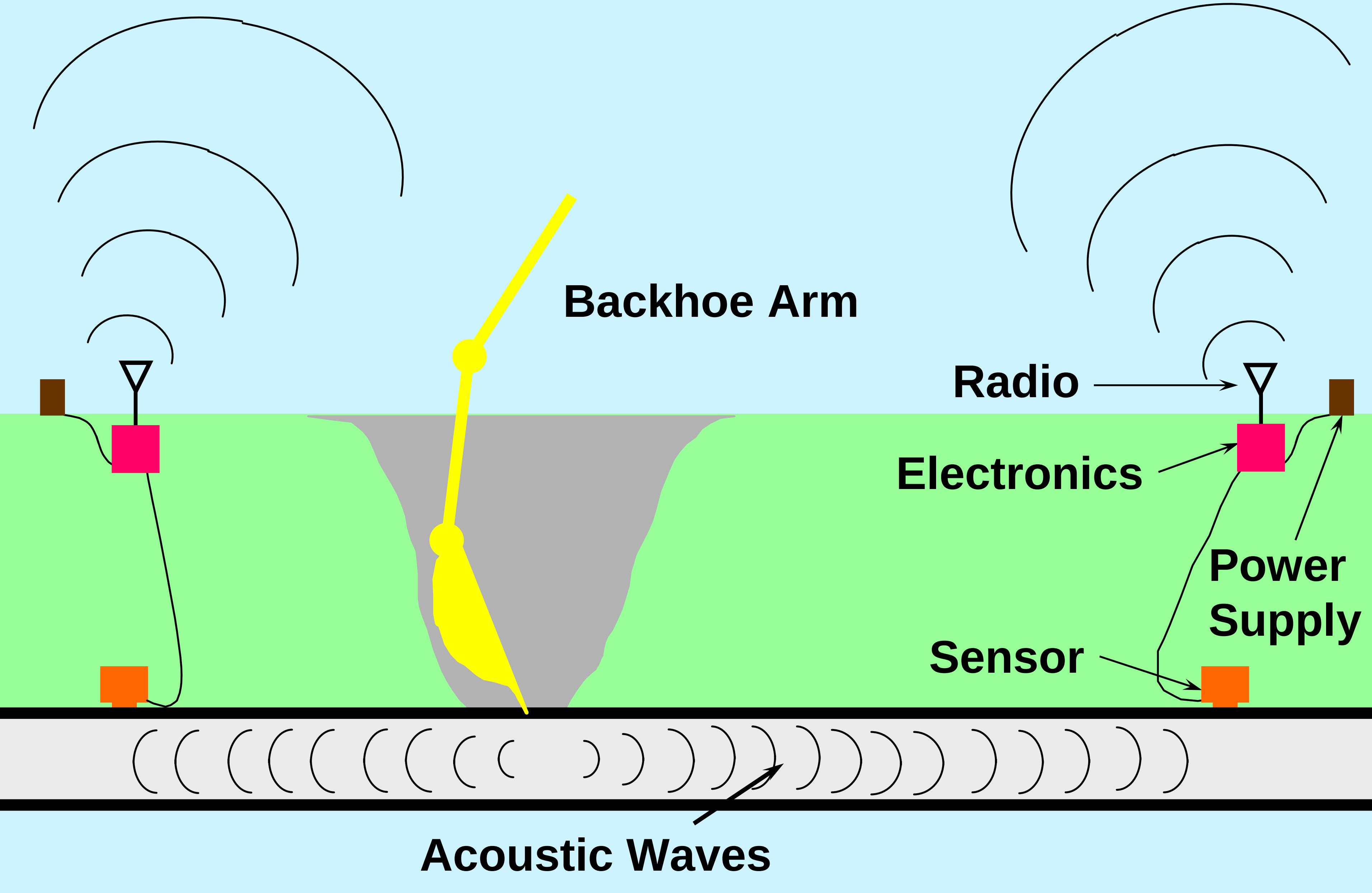
3rd-PARTY DAMAGE DETECTOR



Acoustic Monitoring: Overall Objectives

> Continue development by designing & constructing new hardware and incorporating background noise management

> Design equipment to accelerate bringing a real-time monitoring system to market

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Acoustic Monitoring: Two Applications

> Permanent installation on critical pipeline segments

> Temporary monitoring at construction sites with hardware moved to the next site when construction is complete

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Acoustic Monitoring: Previous Phases

- Developed understanding of acoustic signal propagation in pipelines
- Developed understanding of signal characteristics created by contact with the pipe
- Detected simulated impact at up to 3 miles in low-noise areas
- Built catalog of impact signals
- Investigated noise discrimination techniques
- Demonstrated technique in field trials in rural areas

Acoustic Monitoring

Key technical issues:

> Main issue is economics: cost per mile of system

> Sensor spacing and noise management are critical

Acoustic Monitoring: Development Approach

- Develop rugged, practical hardware
- Install equipment at utilities ~ 1 year after start of project
- Conduct field trials and analyze data for ~ 1 year
- Use real-world data to develop noise management

Acoustic Monitoring: Project Deliverables

- Plan for selecting test sites
- System architecture & hardware design
- Six to ten sets of hardware
- Installation of units at participating utilities
- Results of the reliability testing
- Library of background noises
- A suite of noise management techniques

Summary

- 3rd-party damage is a major gas industry concern
- 24/7 coverage needed
- A minimum of false positives is critical
- Complementary approaches
  - Optical fiber sensor for detecting equipment in right-of-ways BEFORE the pipe is hit
  - Real-time acoustic monitoring for alerting on impact
- Practical systems need to be developed and demonstrated

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