



Alternative Technologies for Leak Detection
Enhancement of Pipeline Integrity

Natural Gas STAR
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ROW



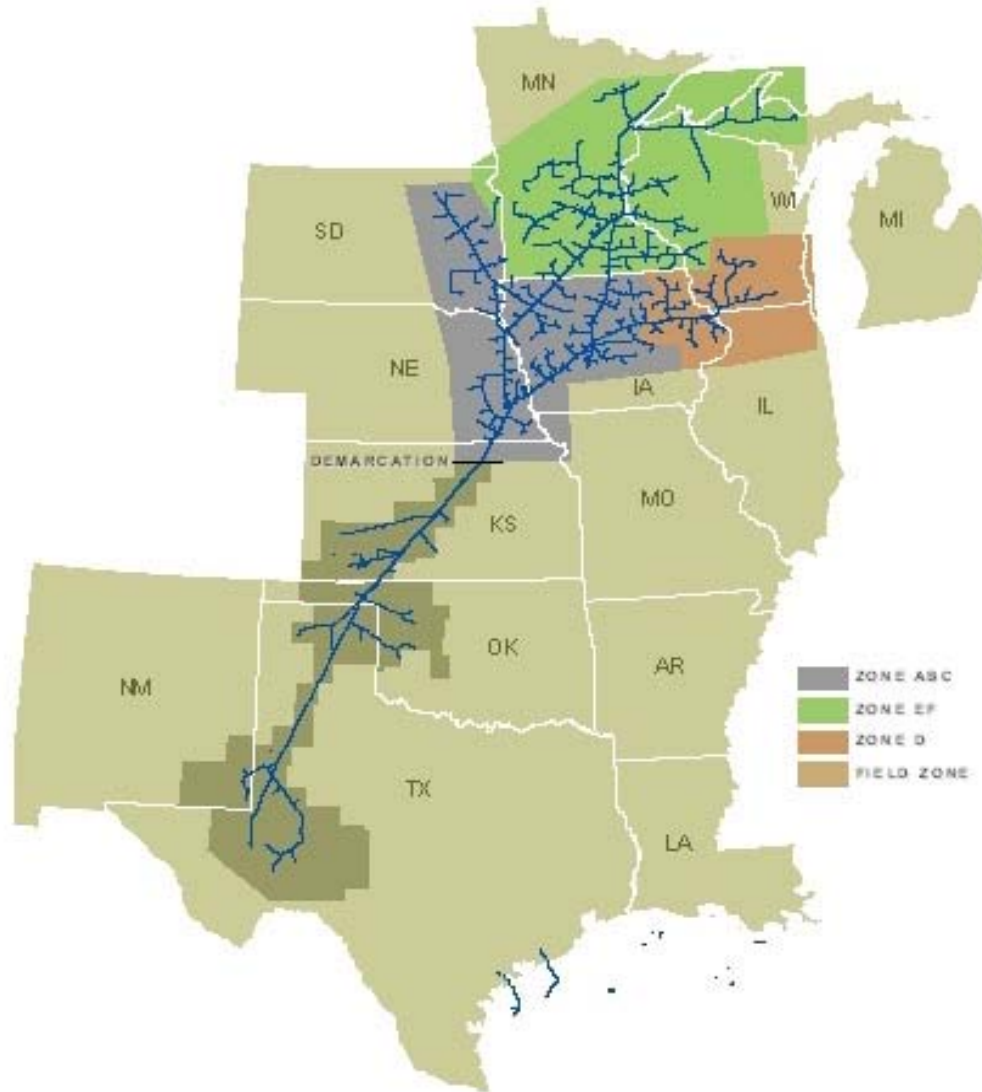
Northern Natural Gas Overview

Northern's Pipeline System:

- 1. Approximately 15,700 miles of high pressure, natural gas transmission pipeline operating in portions of eleven Midwestern states.*
- 2. Steel pipe sizes range from 2" to 36" in diameter*
- 3. Maximum operating pressure ranges from 50 to 1,600 psig*



Northern's Pipeline System



Northern's Pipeline System

Northern's system dates back to 1930

Initially pipeline was almost all in rural sparsely populated areas

94.9% of Northern's pipeline system is Class 1

3.02% of Northern's pipeline system is Class 2

2.08% of Northern's pipeline system is Class 3

Current Requirements for Patrolling, Leak Surveys and Continuing Surveillance

Northern Natural Gas Procedures

⊕ **GAS LEAK DETECTION SURVEY FREQUENCY TABLE FOR NON-ODORIZED GAS**

Feature	Gas Leak Detection Survey Interval			
	Class 1 Location	Class 2 Location	Class 3 Location	Class 4 Location
Pipeline -				
Coated cathodically protected	n/r	10y	6m	3m
Bare cathodically protected	10y	5y	6m	3m
Bare unprotected/hot spot protected	3y	3y	6m	3m
Uncased road and railroad crossings -				
Coated cathodically protected pipe	10y	5y	6m	3m
Bare cathodically protected pipe	5y	3y	6m	3m
Bare unprotected/hot spot protected pipe	3y	3y	6m	3m
Cased road and railroad crossings -				
Casing not shorted to bare or coated pipe	1y	1y	6m	3m
Casing shorted to bare or coated pipe	6m	6m	3m	3m
Plant Yard Piping -				
A plant in this instance means a facility such as a compressor station, dehydration plant, liquid extraction plant, or gas treating plant that is manned or is considered operationally significant by the location Team.	1y			
Other Facilities -				
At town border stations, interconnect meter stations, and similar facilities, the leak detection survey frequency should be the same as the pipeline coming into the facility.	n/r	10y	6m	3m
High Consequence Area (HCA)				
High consequence areas regardless of class location.	6m			

Note 1 - When an interval is stated in years, One year means each calendar year not to exceed fifteen months. Two or more years means the equivalent time in months not to exceed that time plus six months. When the interval is stated in months, it means that number of months not to exceed that time plus one and one-half months.

Leak Detection and Monitoring Alternatives

Part 192- Natural Gas Transmission

Conventional Patrolling – Visual Observation

Gas Leak Detection Using Instrument –

- n Walk ROW or drive using ATV with LEL or PPM Flame Ionization Detector or PID
Common Practice

Flow Based Leak Detection Applications

Computational Pipeline Monitoring Systems

Acoustic Based Leak Detection

Infrared Light and Laser Based

- n Land based and airborne equipment
- n Flow through Instrumentation
- n Lidar- DIAL
 - Airborne Natural Gas Emission Lidar (Angel)

LIDAR Technology as Used by ITT-ANGEL

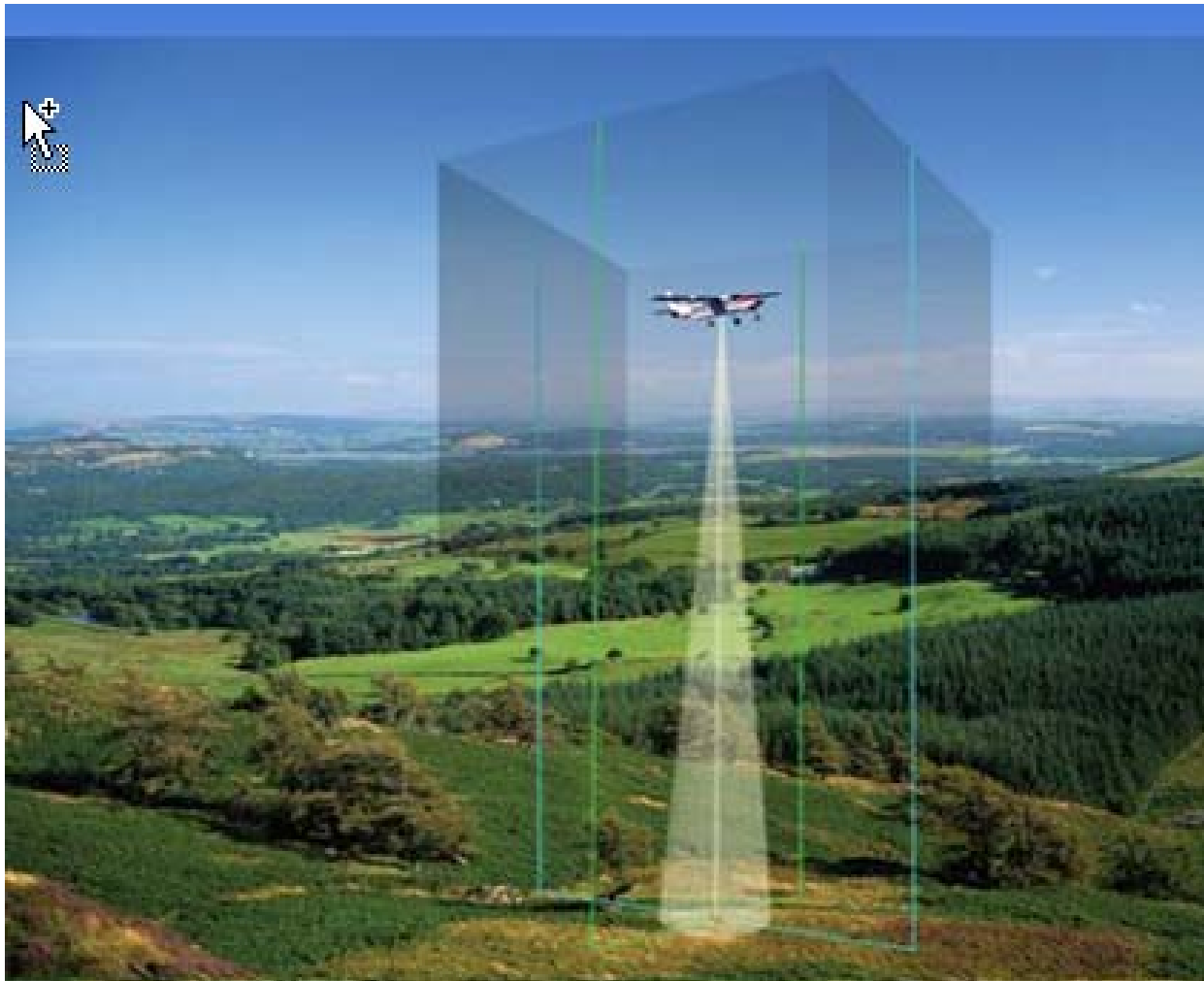
–Components

- ◆ LIDAR-Differential Absorption Lidar (DIAL) System
- ◆ Digital Mapping Camera
- ◆ Geo-referenced Color Digital Video System
- ◆ Optical Guidance System to keep DIAL Lasers Pointed at Center Line of Pipeline
- ◆ Cessna Caravan 208B
 - » Flight Speed 100-125 mph
 - » Altitude of 750-1500 feet above ROW

–Process

- ◆ While Plane Follows Pipeline Path, DIAL Emits about 3000 Laser Pulses Per Second
- ◆ Spiral Pattern Over the Pipeline ROW
- ◆ LIDAR Measures Time of Laser Pulse Return
- ◆ DIAL Measures Amount of Calibrated Laser Light Returned
- ◆ More Methane and Ethane Present- Less Light Returned to Onboard Detectors

ITT ANGEL- LIDAR Technology



Benefits of Enhanced Leak Detection Options

- *Reduction of Lost-Unaccounted for Gas*
 - *Cost savings*
 - *Environmental Benefits-*
 - *Green House Gas Program*
 - *EPA Gas STAR Program*
 - *Fall 2004 Partner Update*
 - *Gas STAR Implementation Workshop October 2005*
 - *2005 Implementation Workshop –Gas STAR –Aerial Infrared Imagery*
- *Pipeline Integrity Program*
 - *Increased leak detection accuracy*
 - *Faster completion*
 - *Possibly detect anomalies, small leaks before expansion*

Challenges with Enhanced Leak Detection Options



- *Industry and regulatory acceptance*
 - *PHMSA acceptance*
 - *State agents*
- *Operator Qualifications*
 - *Patrolling and gas leak detection is a covered tasks if done to meet 192.705, 706 requirements*
- *Be prepared to address findings*
 - *Outage requirements*
 - *Repair crew availability*
 - *Seasonality and weather conditions*



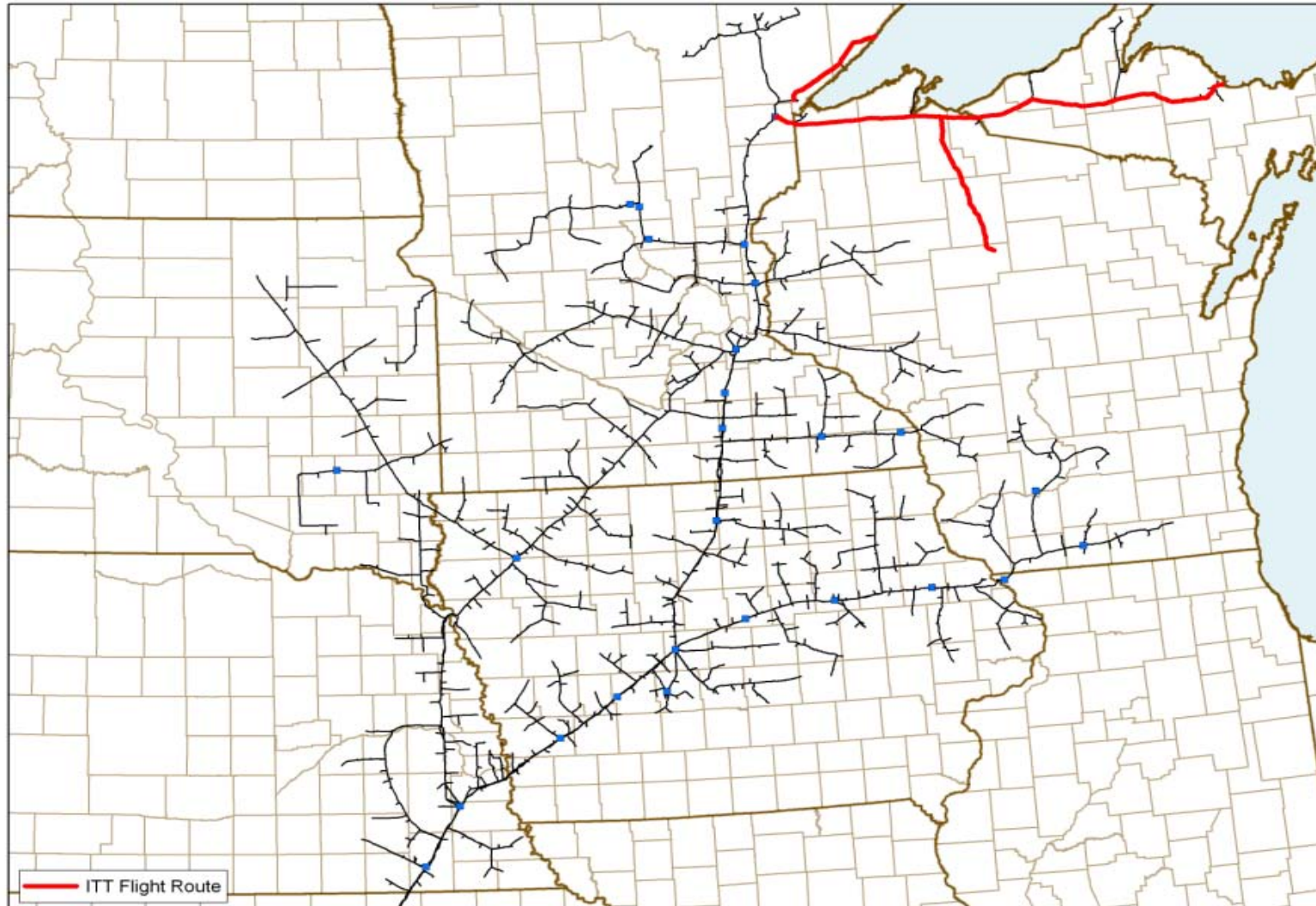
Northern Minnesota Branch Line

- The line was noted to have dents and coating holidays resulting from past (pre 1970s) construction practices coupled with challenges of shallow bedrock and generally rocky terrain with hills and buttes
- Northern had already met 192.705, 706 requirements for pipeline patrolling and gas leak detection
- Northern continues to review additional options to monitor the integrity of this line.
- In May 2008, Northern contracted with ITT-Angel to fly and conduct leak survey of an approximate 425 mile length of pipelines in Minnesota, Wisconsin and Michigan. This included three branch lines
- The survey detected one leak indication on the branch line in Lake County, Minnesota



Pipeline LIDAR Leak Detection Survey Route

425 mile route





Leak Indication - Northern Minnesota

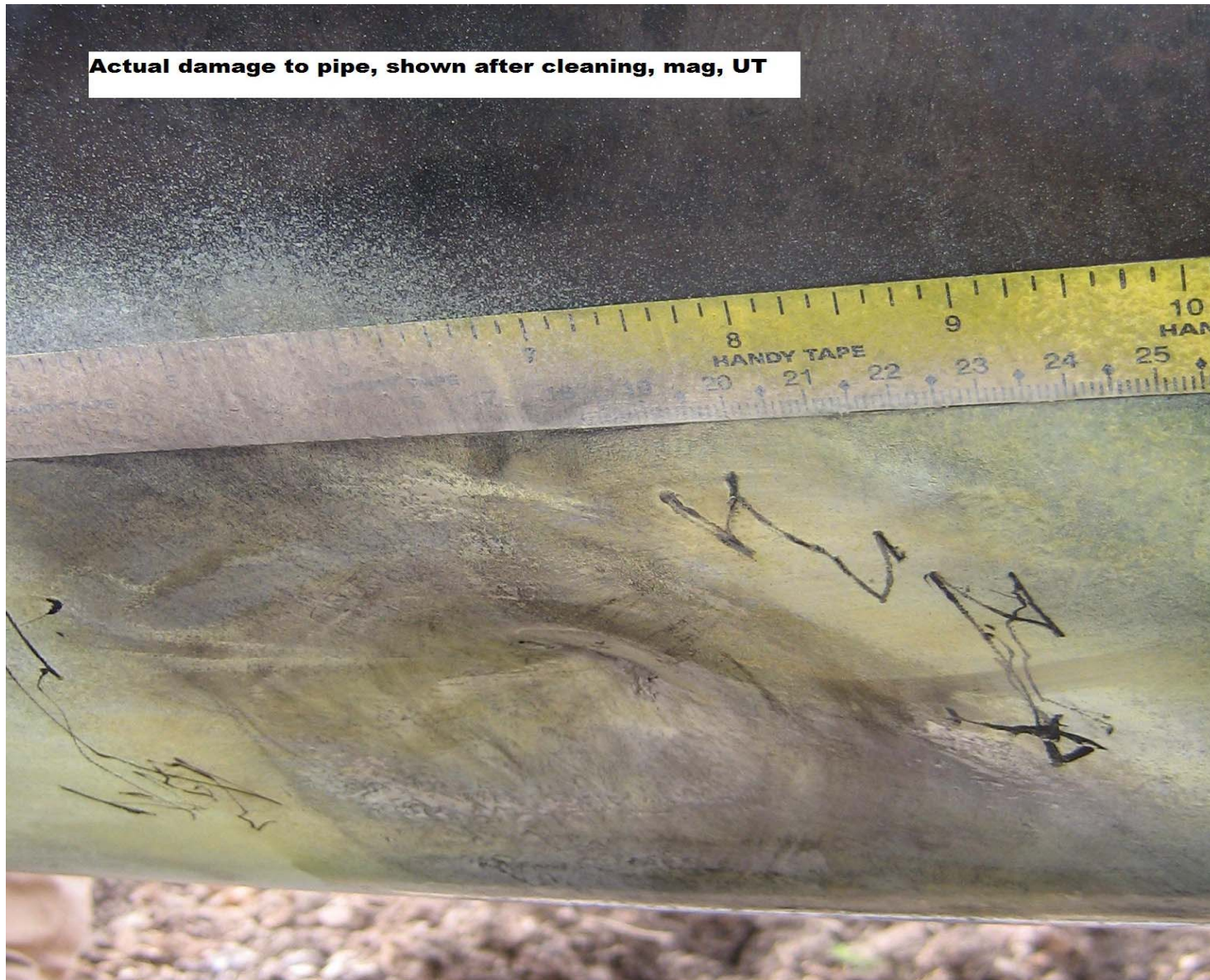




Leak Resulting From Rock Dent



Leak Resulting From Rock Dent





Leak Resulting from Rock Dent



Example: Infrastructure Leak in Populated Area

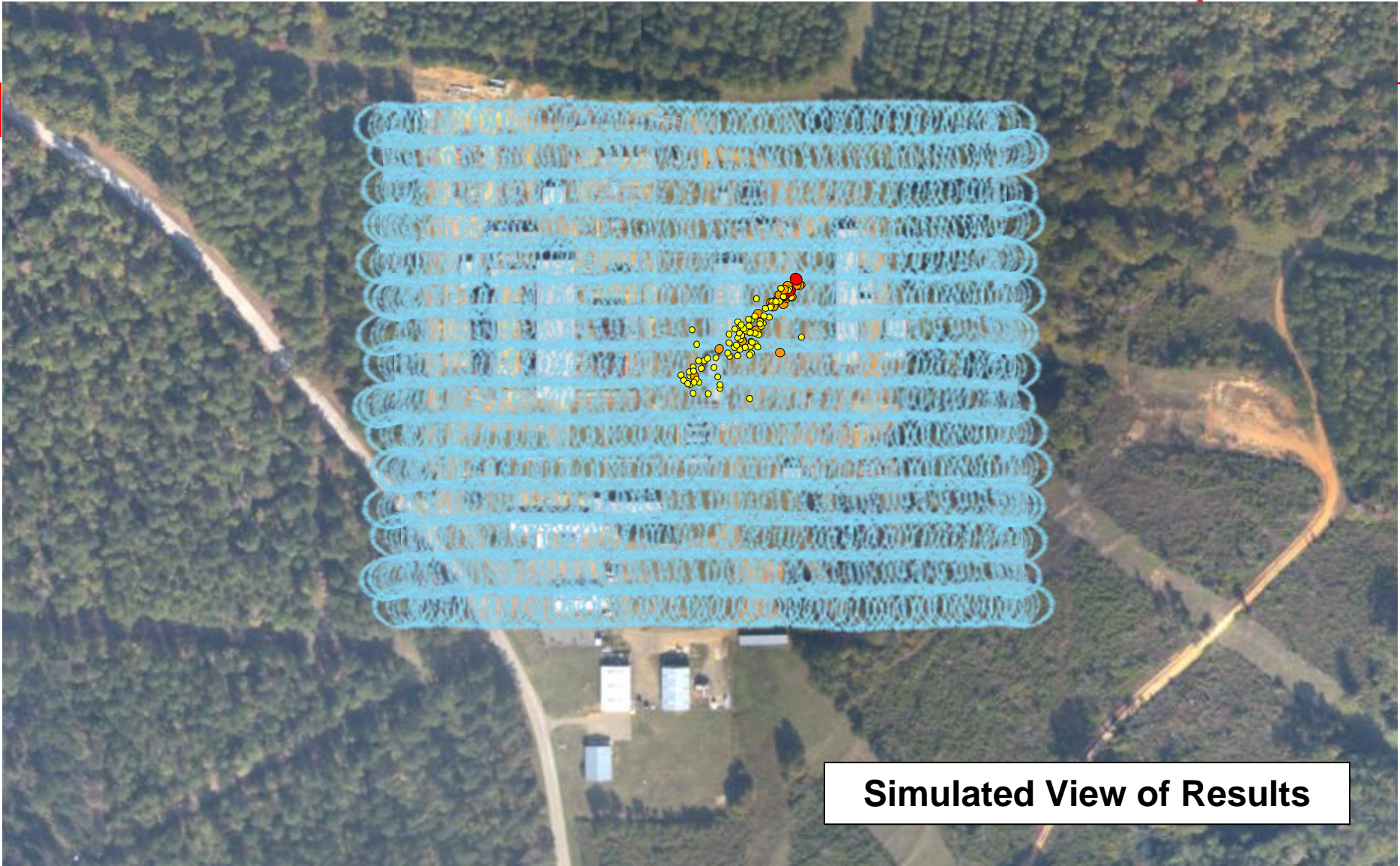


Leak found within 50 yards of highway and rail yard.

Broad Area Coverage – Facility Example



Broad Area Coverage – Facility Example



Similar process applied to exploration projects.



Alternative Leak Detection Methods

Conclusions

- New technologies are providing additional opportunity for enhanced pipeline safety and integrity
- Lidar and Differential Absorption Lidar has provided good results and detection of low level leaks and releases when used on Northern Natural Gas facilities