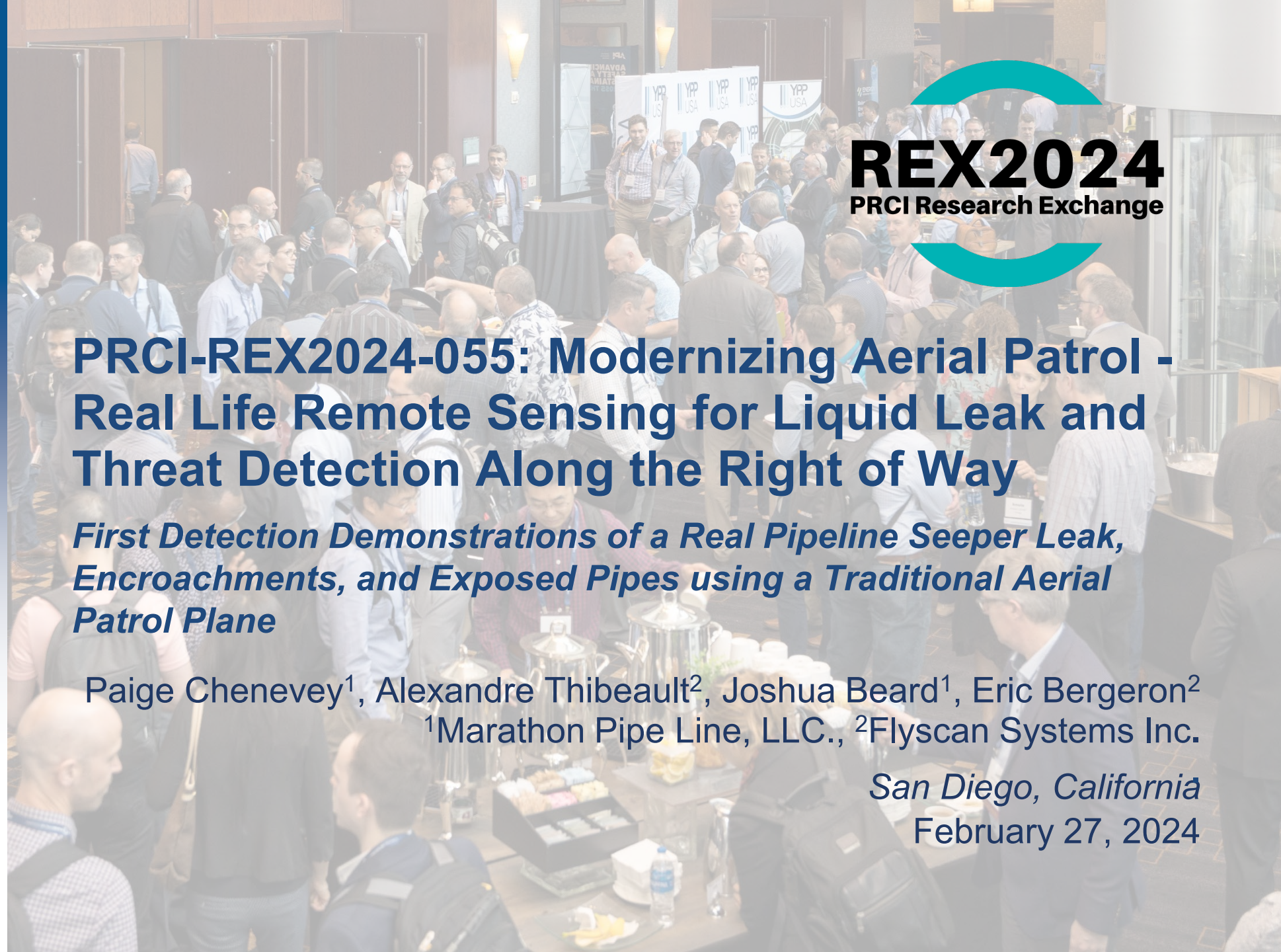

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PRCI-REX2024-055: Modernizing Aerial Patrol - Real Life Remote Sensing for Liquid Leak and Threat Detection Along the Right of Way

First Detection Demonstrations of a Real Pipeline Seeper Leak, Encroachments, and Exposed Pipes using a Traditional Aerial Patrol Plane

Paige Chenevey[1], Alexandre Thibeault[2], Joshua Beard[1], Eric Bergeron[2]
[1]Marathon Pipe Line, LLC., [2]Flyscan Systems Inc.

San Diego, California
February 27, 2024

PRCI LEADING PIPELINE RESEARCH
Pipeline Research Council International

Agenda

- Company Backgrounds
- Pilot Objective
- Description of the technology
- Real results from the field trial
- Summary and next steps

Flyscan Systems at a Glance

Founded 2015 – 27 employees – First Mover in Liquid Leak Detection

Raised over $10 million USD to date

Equity Investments from Enbridge, Hatch, Marathon, BDC and Adlares

Over 50,000 miles of ROW flown in North America

ENBRIDGE

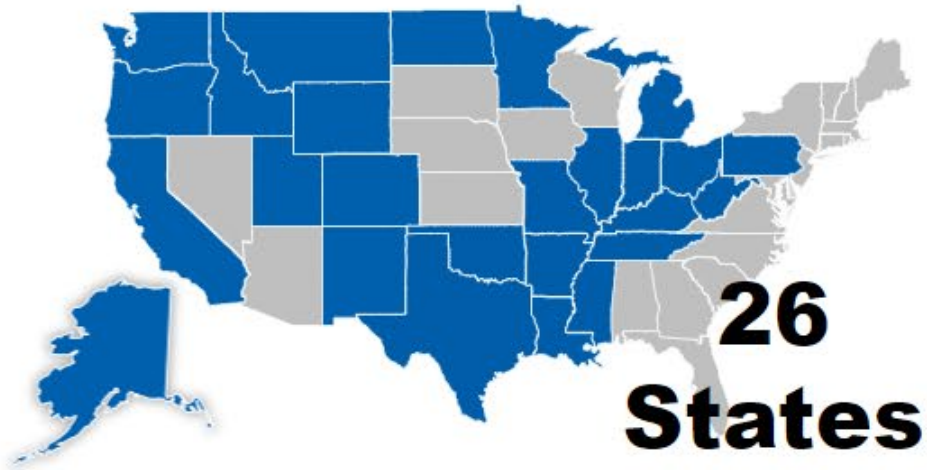
HATCH

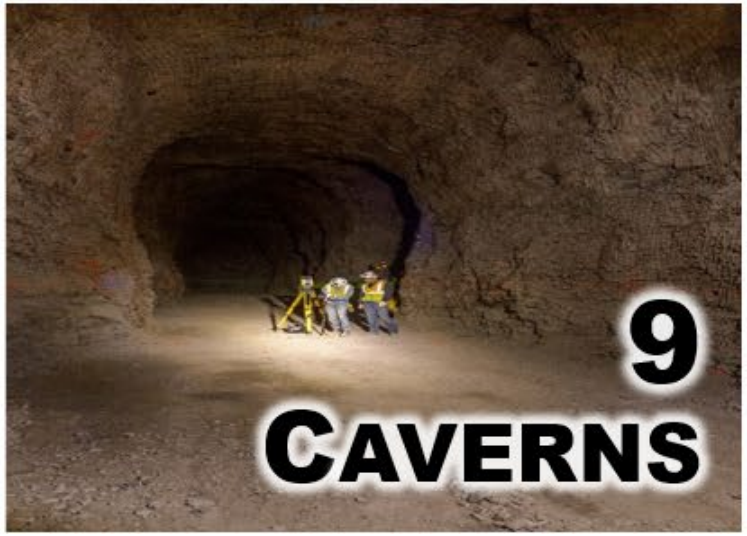
MARATHON

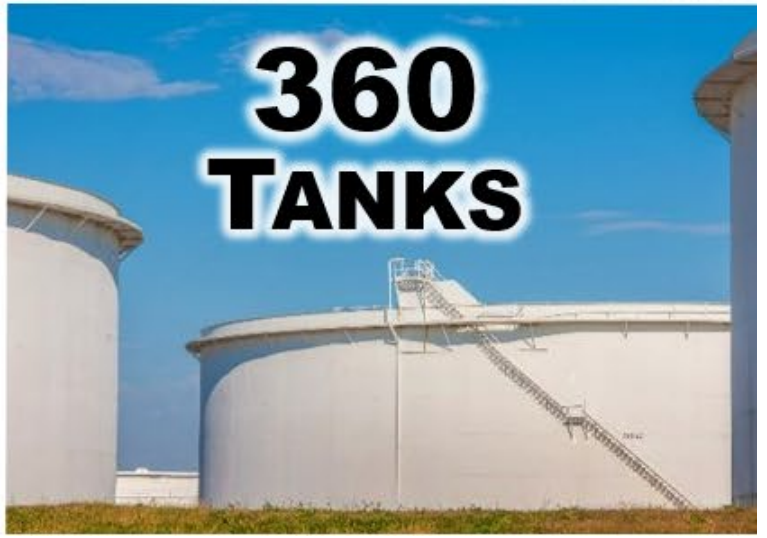
bdc

ADLARES

About Marathon Pipe Line (MPL)







MPL's Mission

Our **MISSION** is to safely and reliably operate our pipelines and grow the business.

Our **VISION** is to be a premier pipeline operator known for the strength of our people, our culture, and exceptional performance.

MPL's Strategic Goals

Zero Mainline Releases

Prevent people from hitting our pipelines.

Understand and manage all threats to our pipelines.

Protect the Public and Earn their Trust

Keep the public informed and safe.

Improve the effectiveness of our earning your trust program.

Develop and advance new technologies to mitigate risk and enhance efficiency

Pipeline Right-of-Way Inspection

- § 195.412 - Each operator shall, at intervals not exceeding 3 weeks, but at least 26 times each calendar year, inspect the surface conditions on or adjacent to each pipeline right-of-way. Methods of inspection include walking, driving, flying or other appropriate means of traversing the right-of-way.

- MPL typically utilizes bi-weekly inspections by fixed wing aircraft

- Pilots are trained to identify potentials threats:
  - Evidence of leaks – surface staining, sheen on water, dead vegetation
  - Third-Party Activity – construction, excavation
  - Natural Forces – washouts, erosion, land slips, sink holes
  - Encroachments – sheds, decks, structures

Advanced Right-of-Way Inspection Initiative

- Traditional patrol has a 67% effectiveness identifying 3rd party conflicts
  (PRCI Study SM-403-148100, Price, Yoel, & Asari, 2016)

- Project Scope: Partner with Flyscan on a one-year pilot to evaluate automated threat detection leveraging artificial intelligence and advanced imaging as potential replacement for traditional aerial patrol.

- Goals:
  - Improve the overall effectiveness of the aerial patrol process
  - Expand capability to detect previously undetectable hazards that could lead to larger issues
  - Supplement more costly data collection such as LiDAR and ground survey

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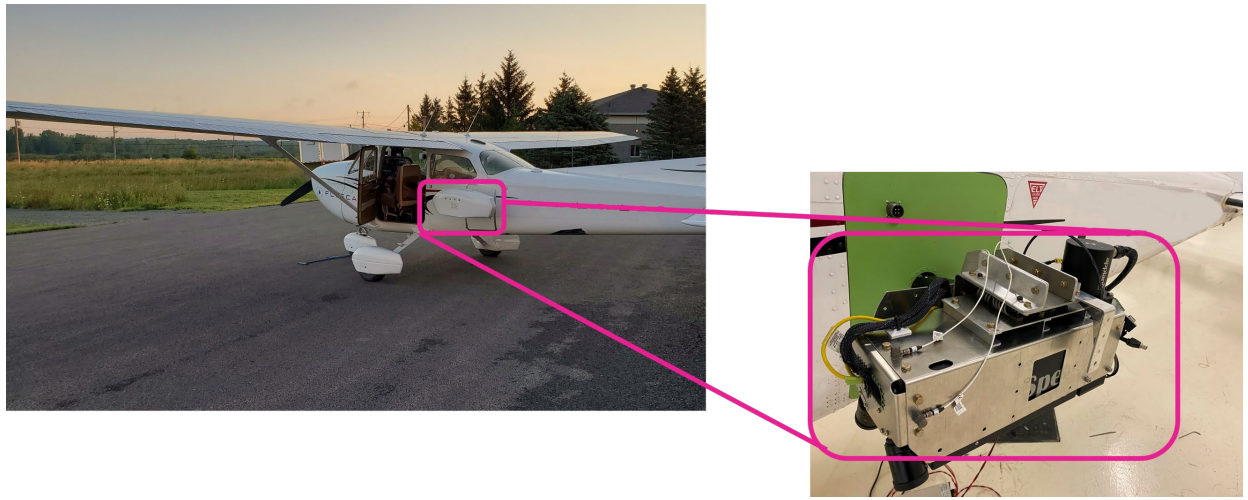
Flyscan Technology Overview

Sensor Pods

Generation 1 Pod



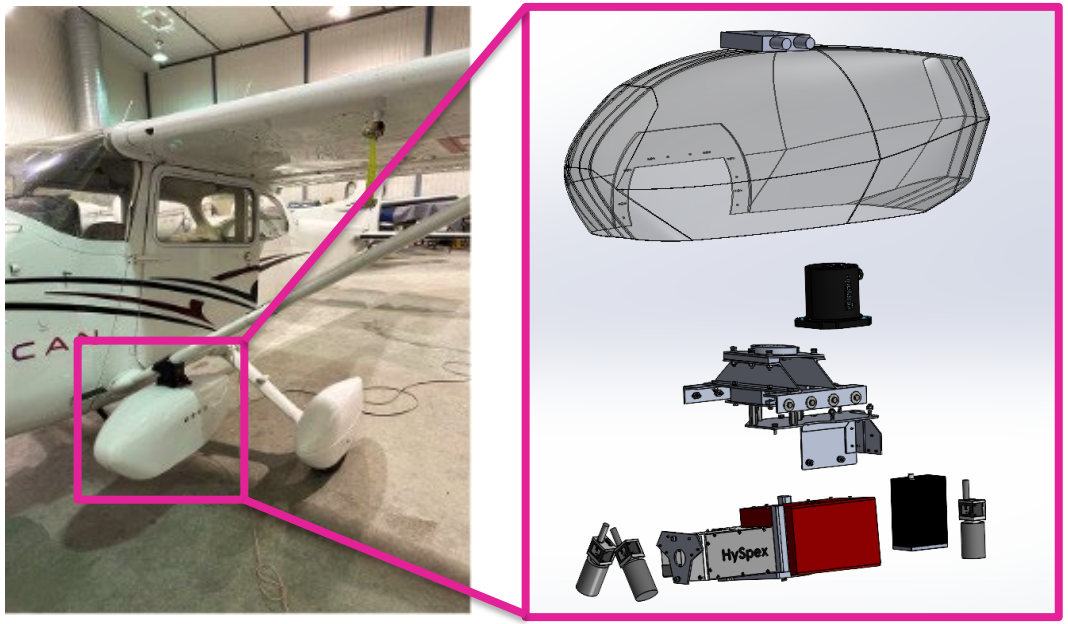
- External pod - remote sensing cameras
- Internal rack - computers, navigation, communication and pilot user interface
- Designed for single pilot-operator
- Designed to piggy-back on planes doing ROW patrols

Generation 2 Pod

Compatible with:

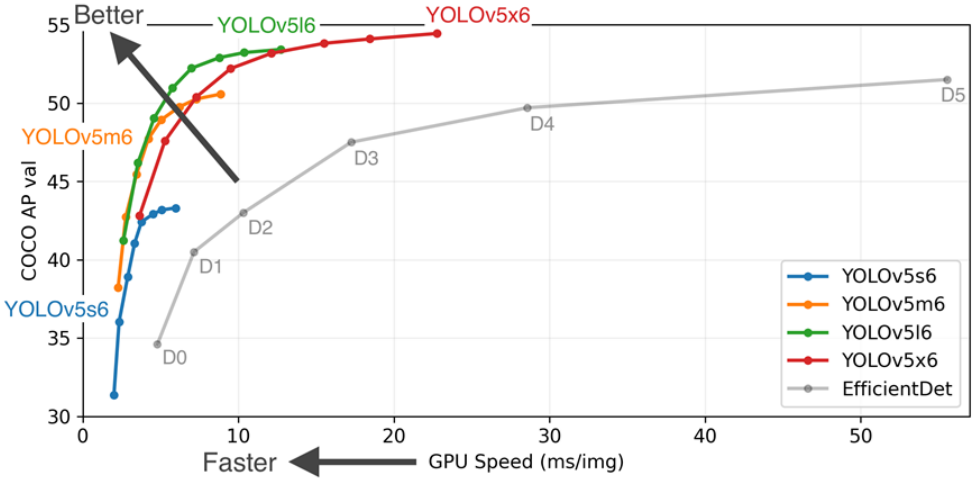
- ✓ Cessna C172K to C172P
- ✓ Robinson helicopters
- ✓ Cessna 182
- ✓ Cessna 206
- ✓ Cessna 208

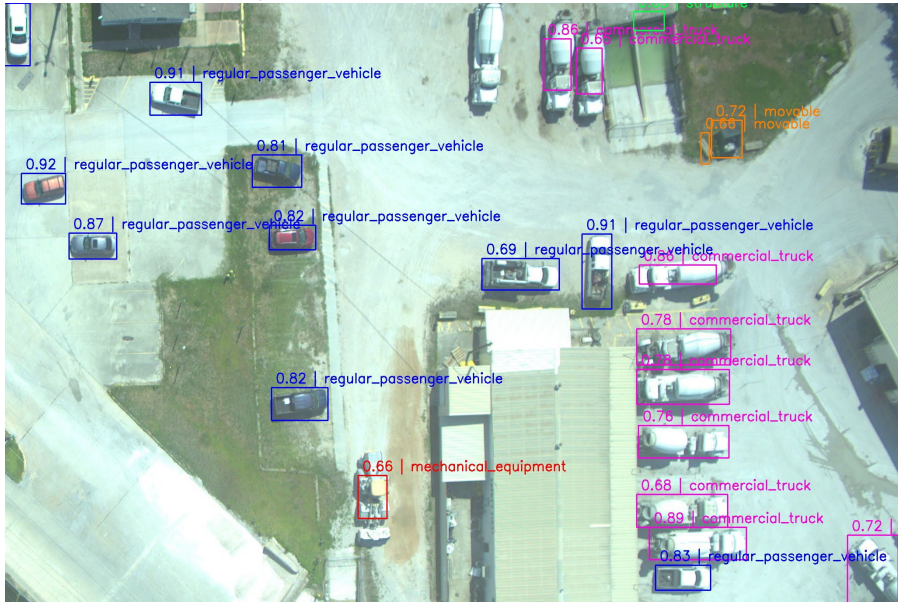
Meeker mount



The *"How"*: Threat detection

- Machine learning object detection
  - i.e. training the computer to recognise potential treats in images
- Thousands of examples are used to train an algorithm
- Each images is manually annotated to identify the objects of interest
  - The model is in a constant state of improvement as it can be continually fed data to increase its accuracy
- 3 images are processed per second
  - Each image is processed in real time to give the pilot the information he needs at that moment in flight
  - Custom pre-processing and post-processing modules have been developed to handle large resolution aerial images as such large images cannot directly be fed to the model.





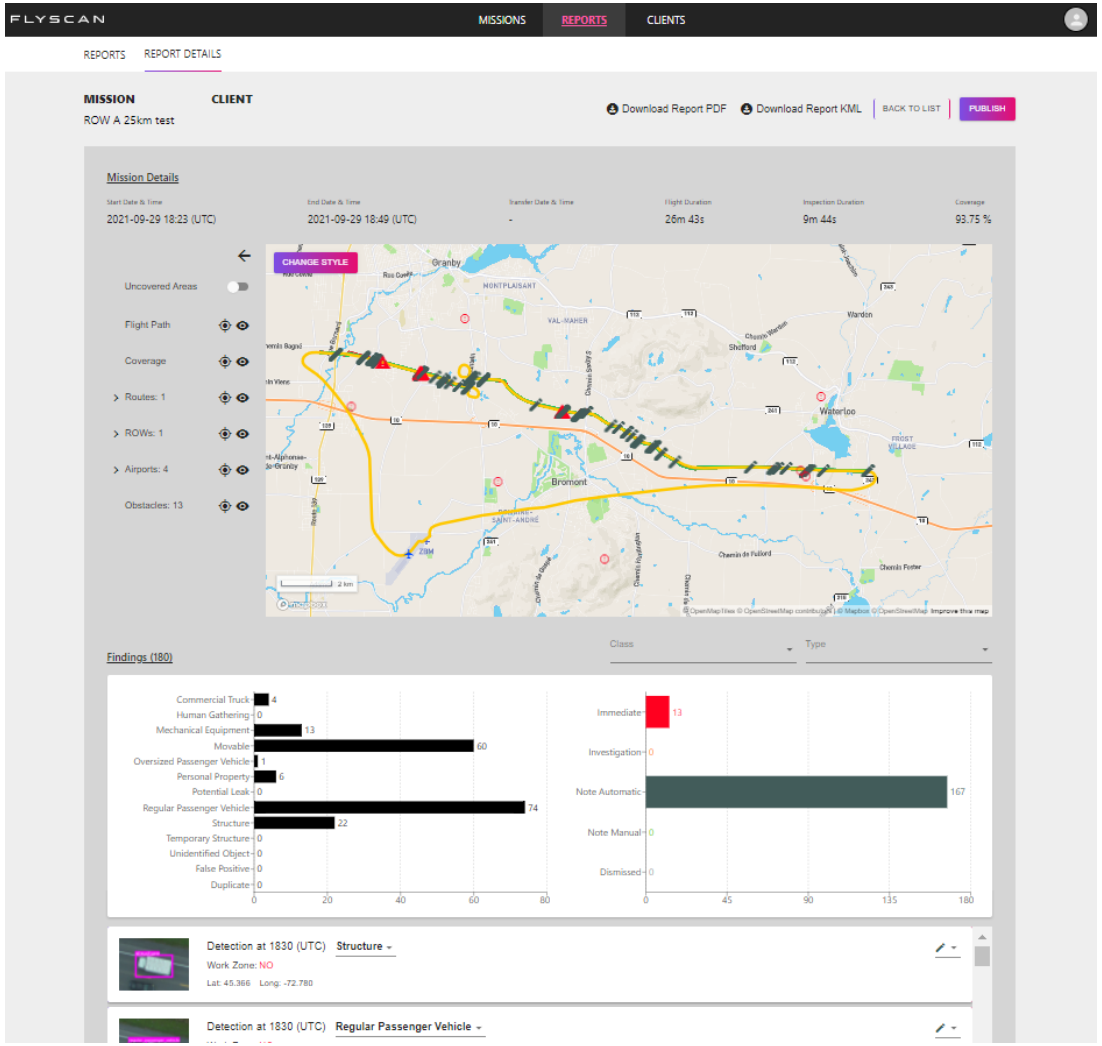
Automated Threat Detection Details

Initial Release 4Q21:

1. Regular Passenger Vehicles
2. Oversized Passenger Vehicles
3. Commercial Truck
4. Mechanical Equipment
5. Movable
6. Structure
7. Personal Property
8. Recreational off road vehicles
9. Customer specific vehicles

New classes to be released 2Q24:

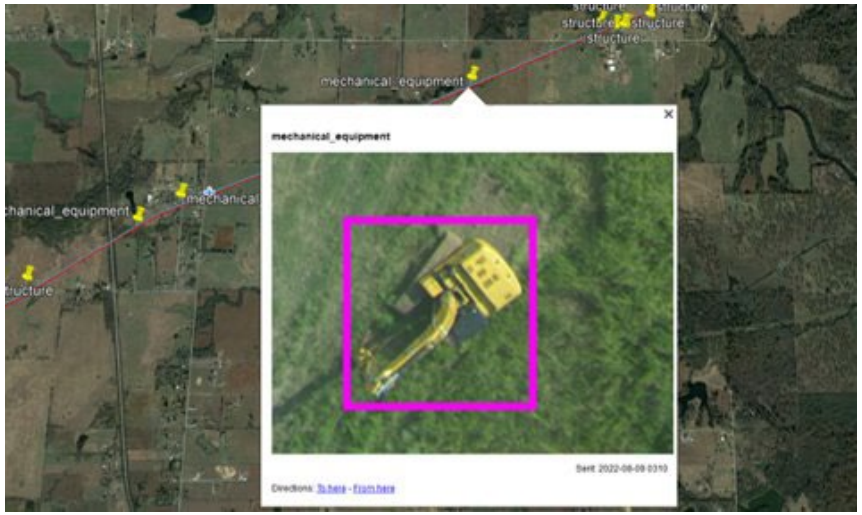
1. Drainage tile detection
2. Erosion indicators
3. Exposed pipe

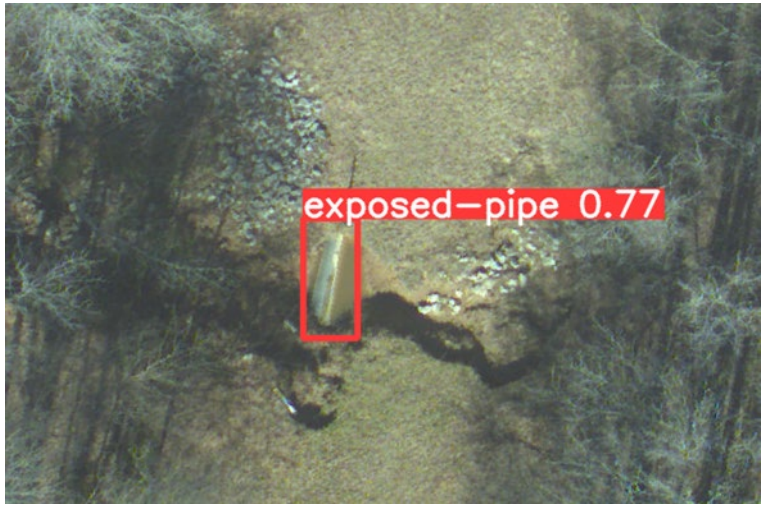


Automated Threat Detection Details

Expanding the capabilities of pipeline patrol with automation

- **Third-Party Threats:**
  - Mechanical Equipment
  - Vehicles (commercial, passenger, recreational, customer specific)
- **Encroachments:**
  - Structures
  - Movable Objects
  - Personal Property
- **Potential Leaks**





New capabilities coming in Q2 2024:

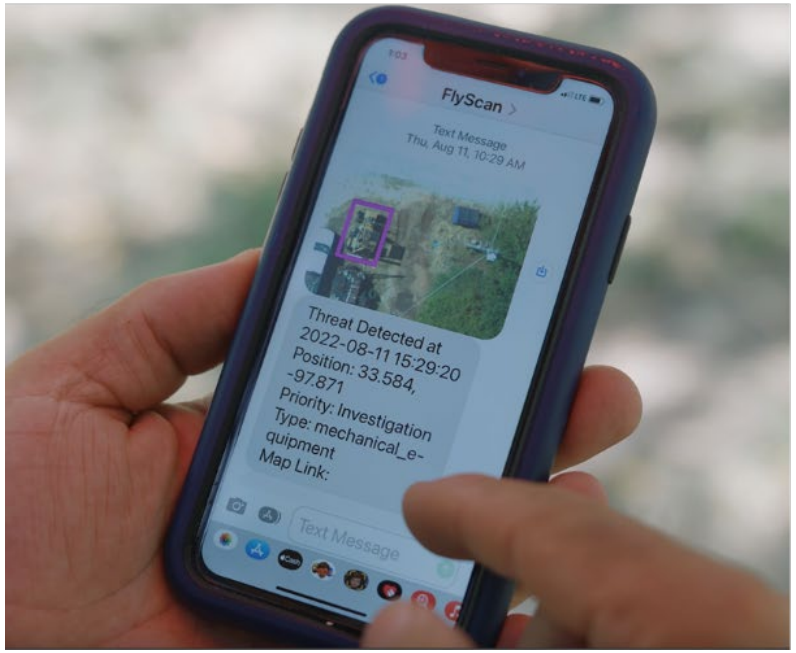
- Operational Threats (Exposed Pipe)
- Additional Third-Party Threats (Drainage Tile, Agricultural Activity)
- Natural Force Threats (Geohazard Indicators)

Automated Exposed Pipeline Detection

Real-time Notifications During Flight

Notifications via text, email and/or integration with ticket applications

Threat description, GPS and Photo included



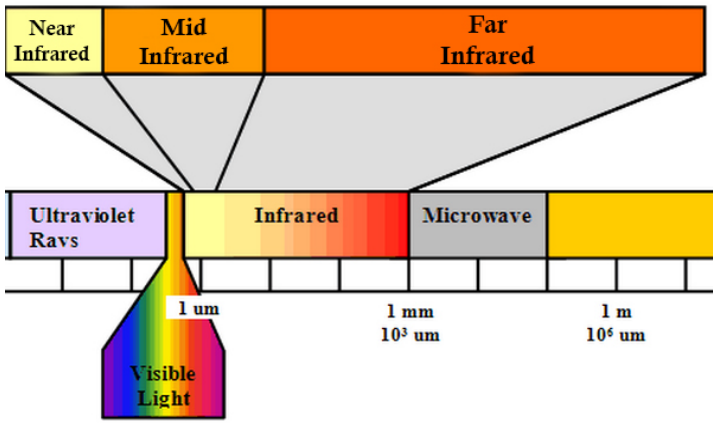
Real-time notification example

Real “encroachment” detected

Hyperspectral Liquid Leak Detection Solution - Principle

1. This passive system uses the sun's power

3. This signature is detected using sophisticated algorithms to detect



2. As the light rays bounce from the ground they get imprinted with the spectral signature of the material

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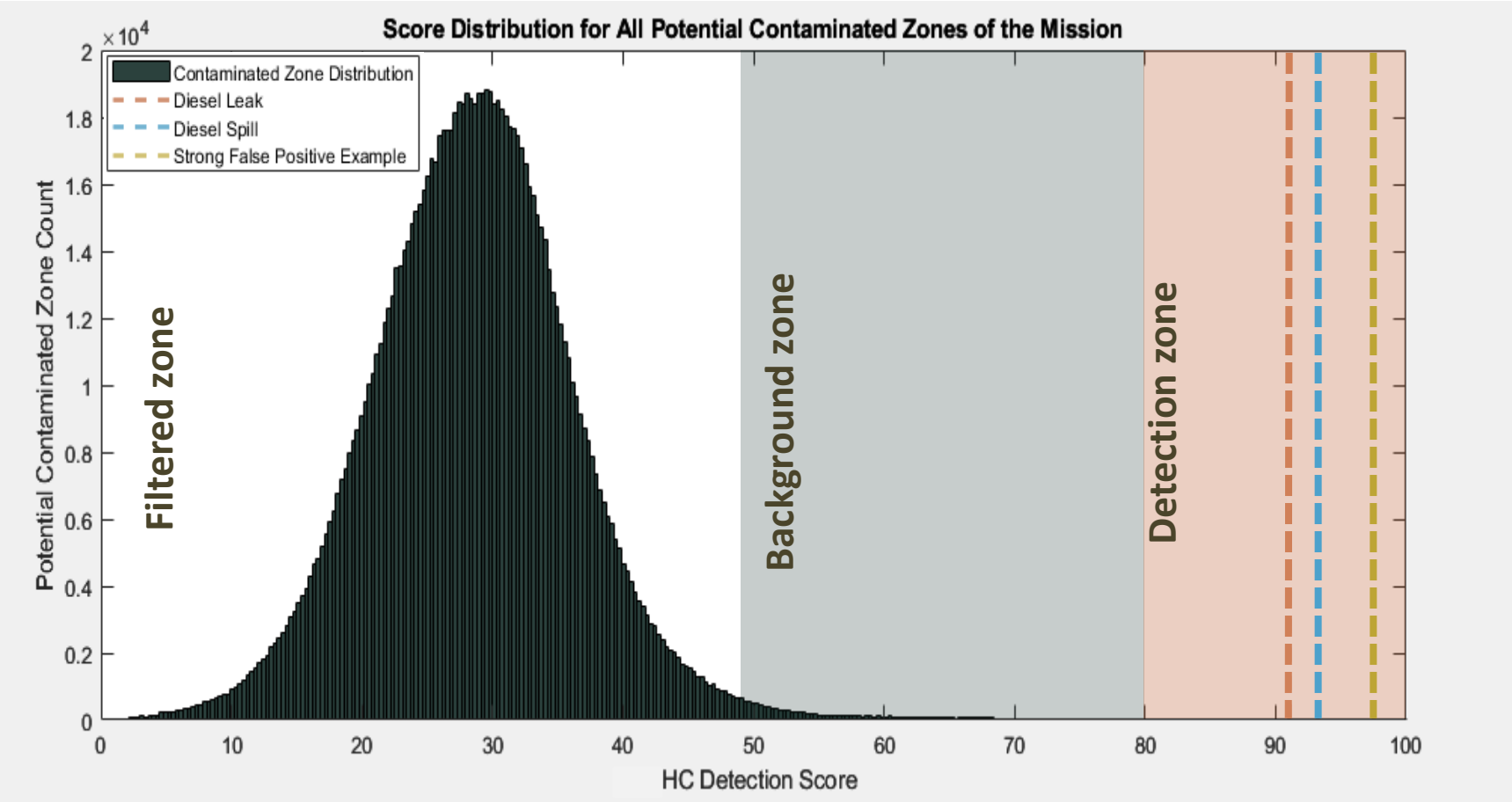
Results From Regular Patrols Using the Technology

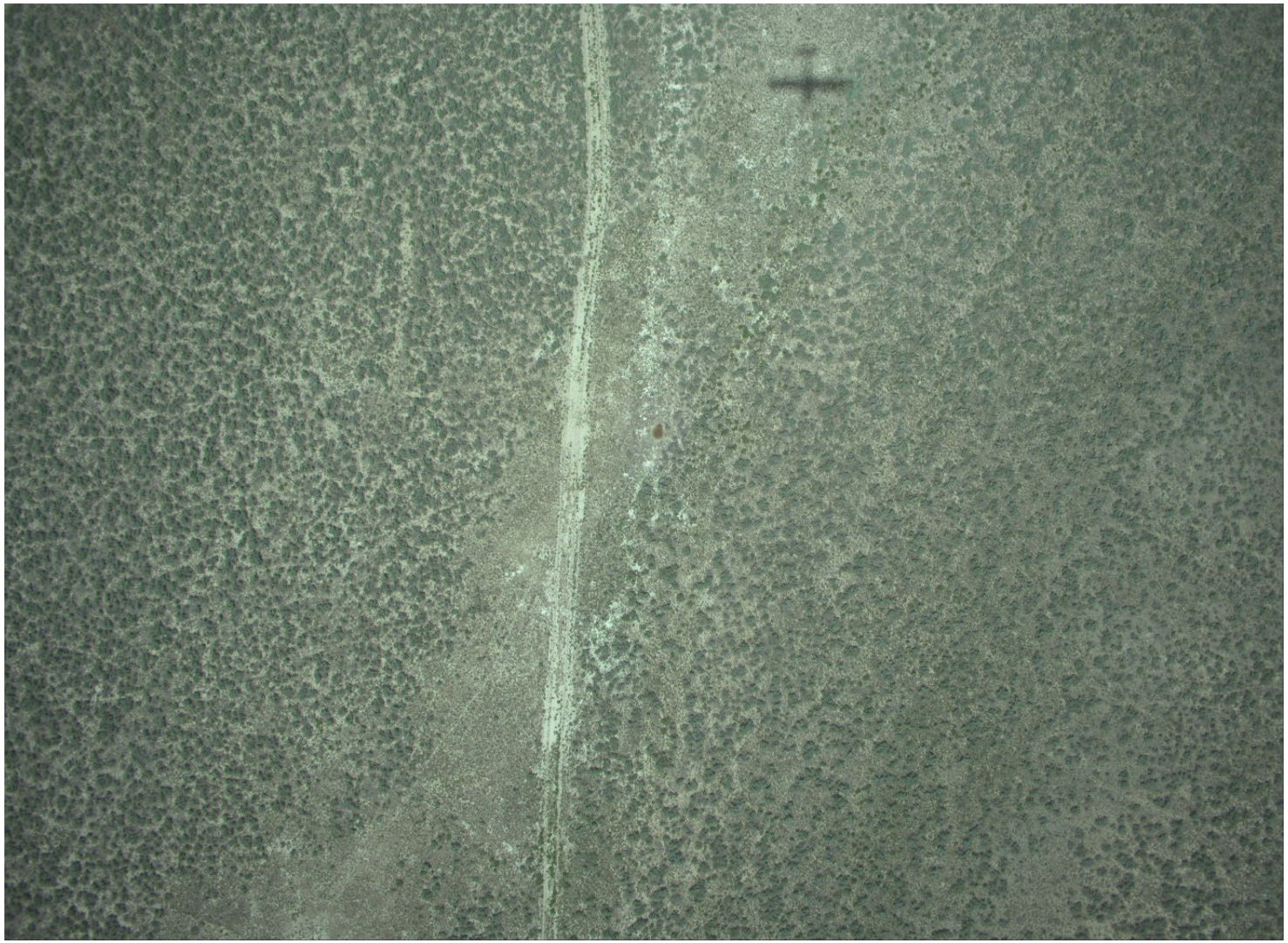
Actionable insights

Seeper Leak and Diesel Spill Detection Score



Liquid hydrocarbon detection algorithm distribution

Real Seeper Leak Detection - Diesel Pipeline

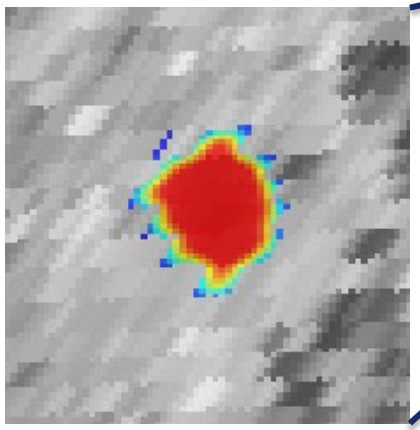


- Picture shows pilot's view at 550 feet
- No visible sign of diesel at the surface
- Leak probably ongoing for months
- Regular air patrol never reported anything

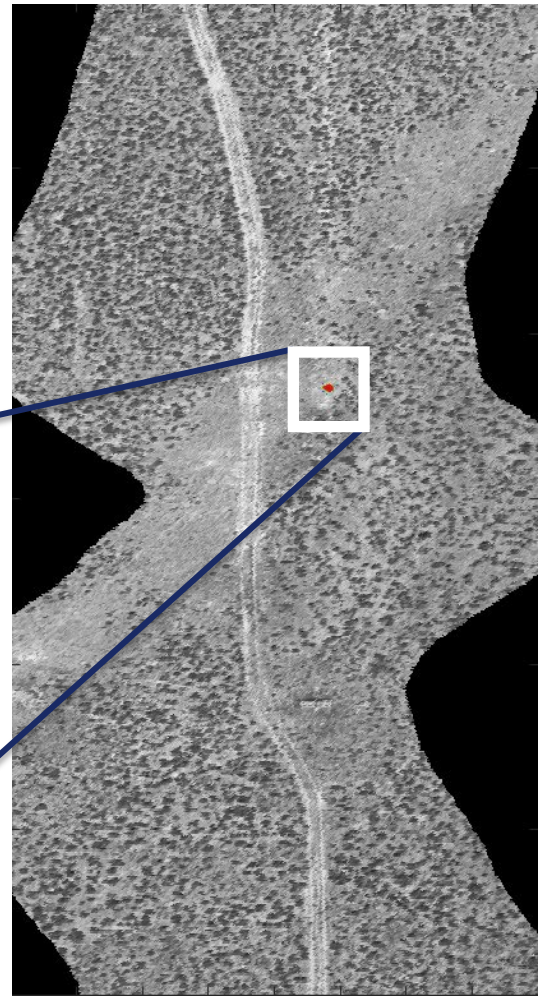
Real Seeper Leak Detection – Diesel Pipeline

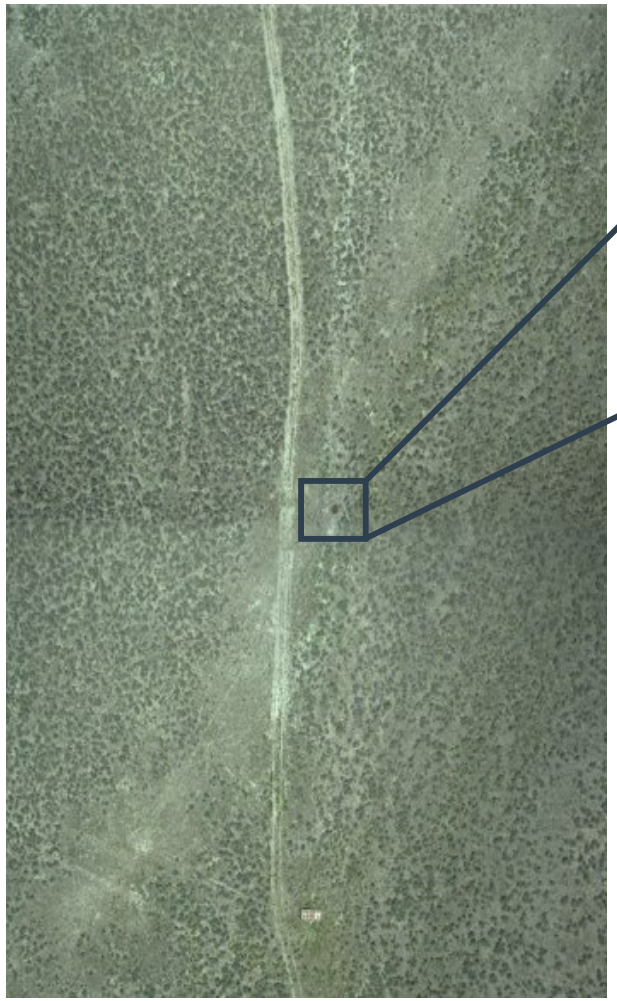
Size:	2.2 m^2
Detection score:	93.25
Estimated volume:	54 bbls*
Estimated leak rate:	<0.1 BPH
Possible cause:	Corrosion

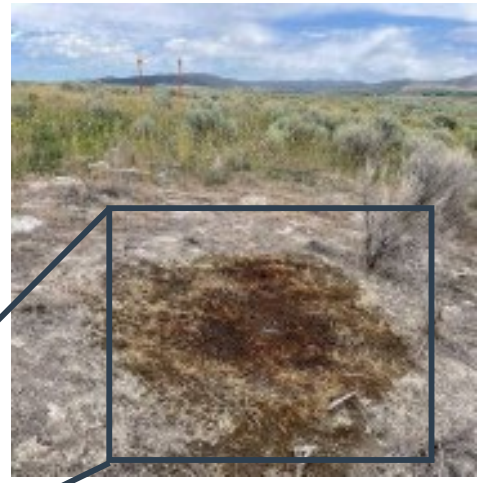
Slow leak over several months well below CPM sensitivity



Hyperspectral Detection

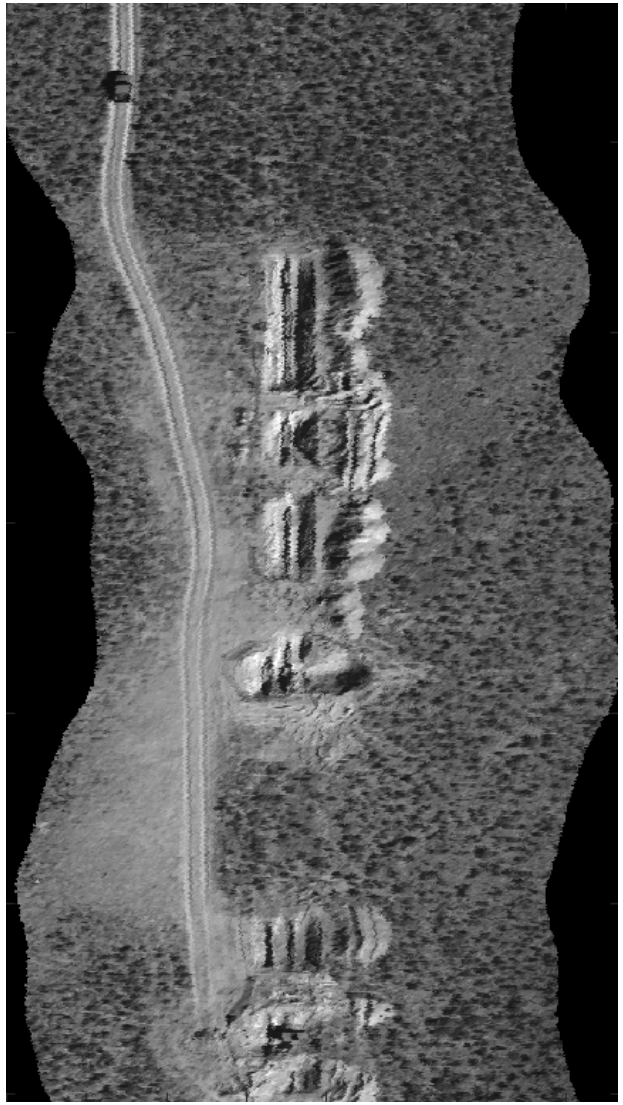






As Seen On the Ground – Diesel Seeper Leak

Repair and Clean-up Documentation



After site clean-up, no hyperspectral detection of liquid hydrocarbons

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Other Reported Detection Examples NOT caused by leaks

Examples of ground-validated detection during commercial operations on the ROW and within facilities

Diesel Contamination NOT caused by the pipeline

Picture shows pilot's view at 550 feet

No visible sign of diesel at the surface

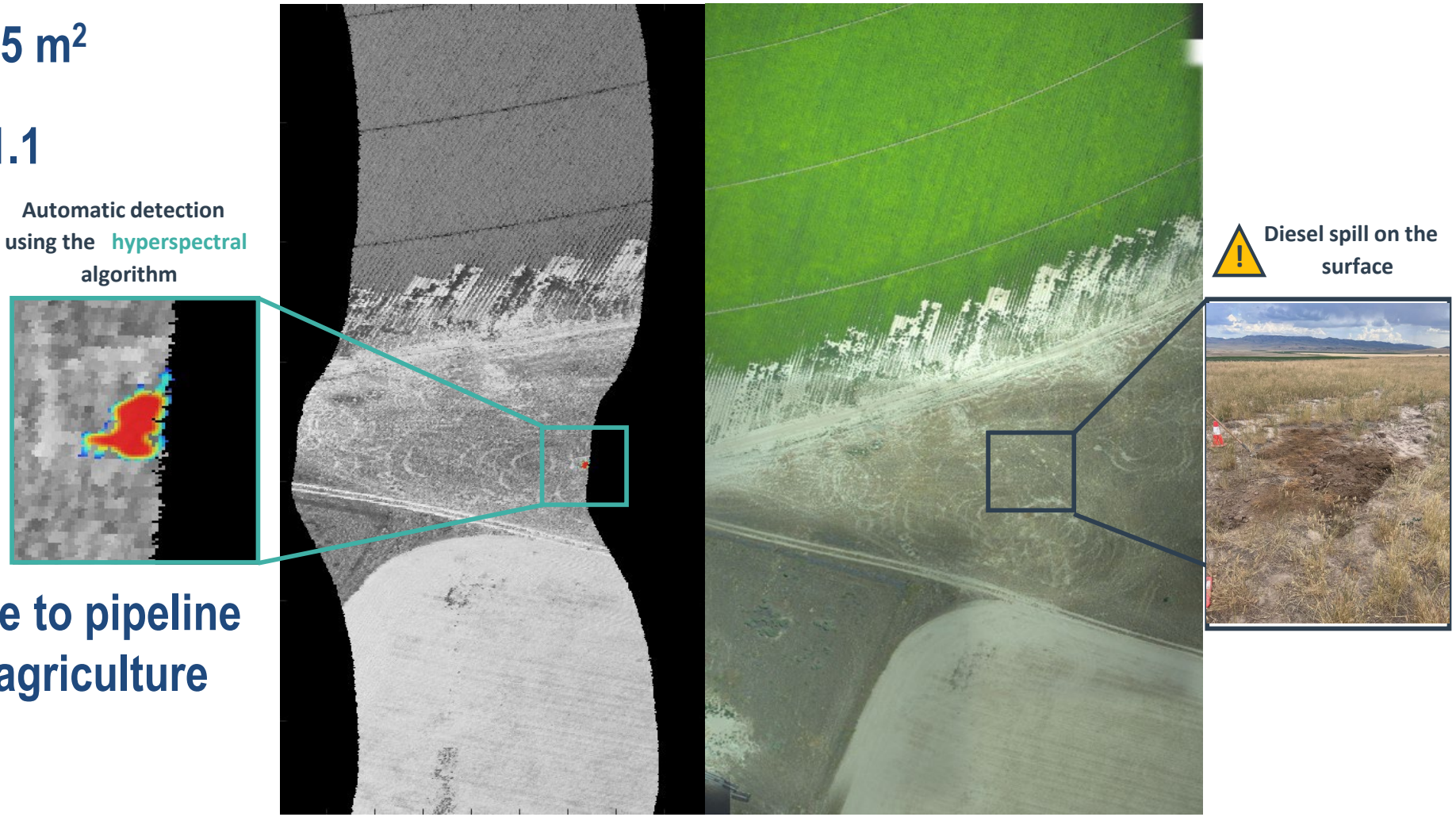
Observation affected by:

- Speed of flight
- Navigation
- Communications
- Fatigue

Diesel Spill – Picked-up by Hyperspectral Algorithm

Size: 3.5 m^2

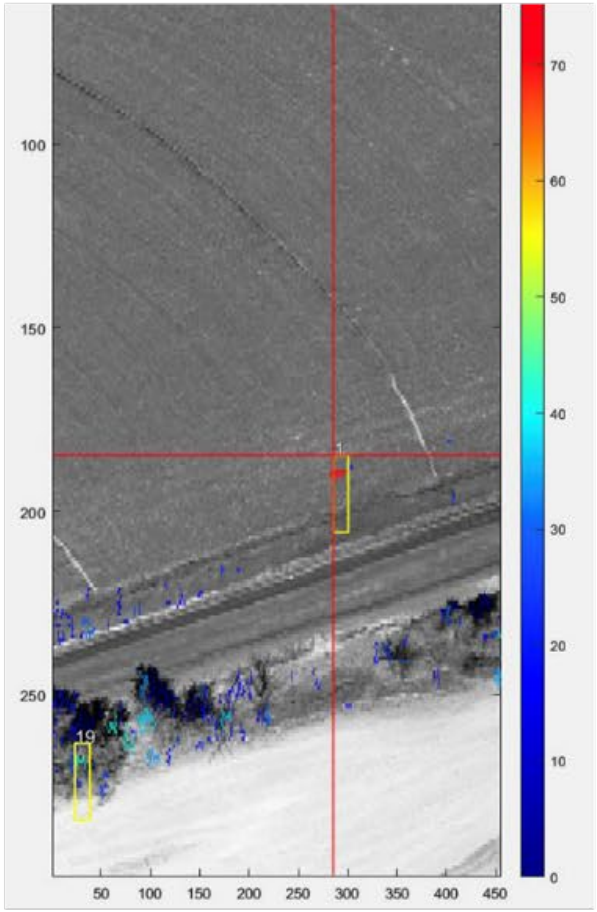
Detection score: 91.1



- Spill occured close to pipeline
- Probable source: agriculture equipment

Diesel Contaminated Vegetation

As seen from the plane



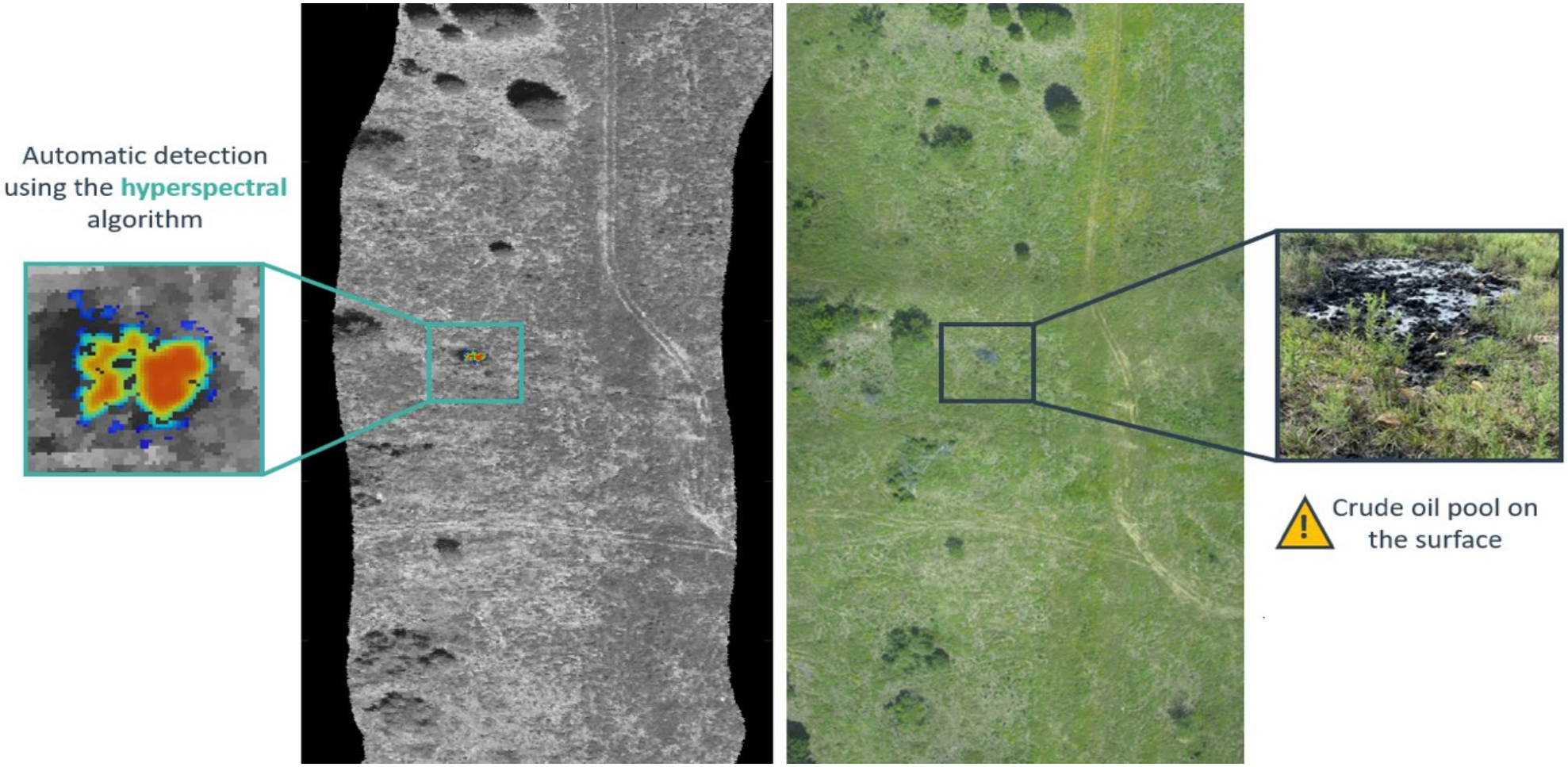
Hyperspectral

At the surface

Crude Oil Pool Detected

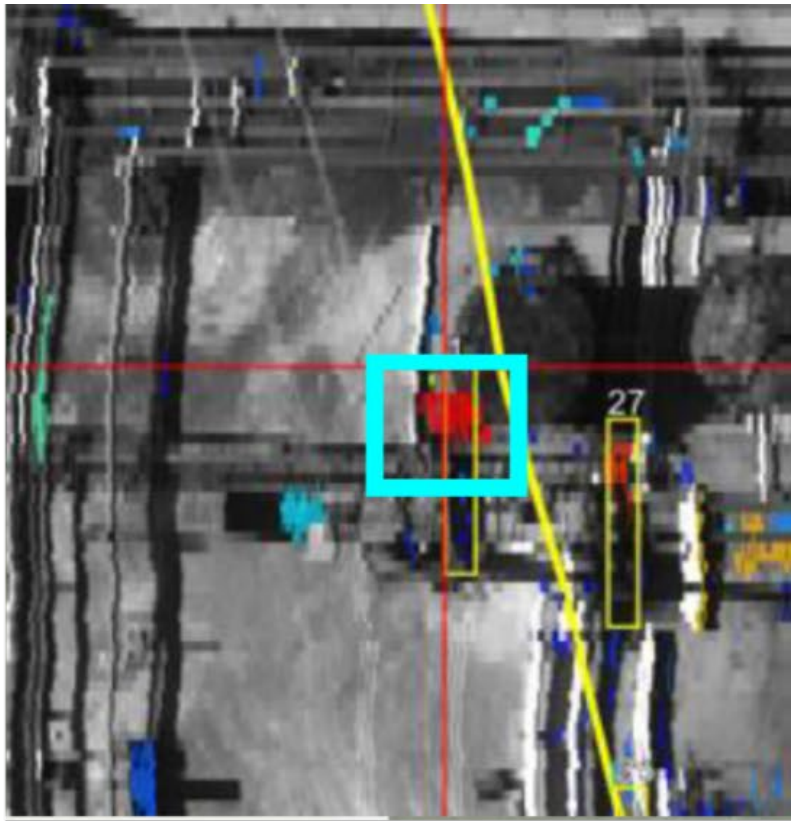
- Picture shows pilot's view at 550 feet
- No visible sign of crude at the surface

Crude Oil Pool Detected



Contamination Detected Within Facilities

Aerial zoomed-in image

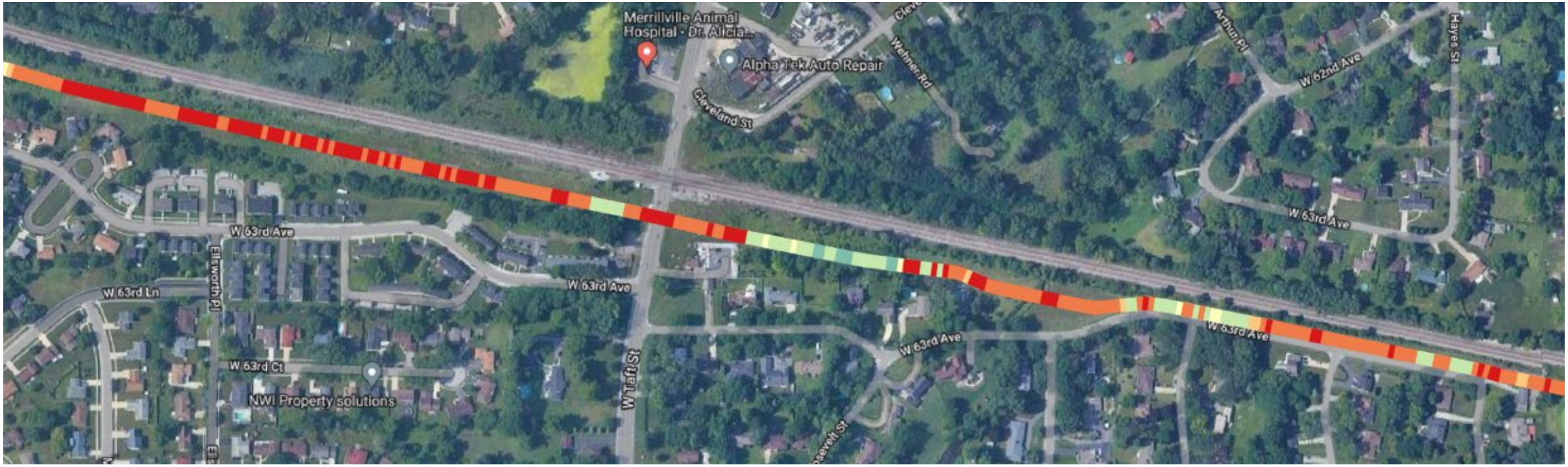


Hyperspectral

2D Orthomosaics and 3D Rendering

Landslide reconstructed with a high resolution orthophoto mosaic overlaid on its corresponding DSM

Depth of Cover Analysis – Under Development

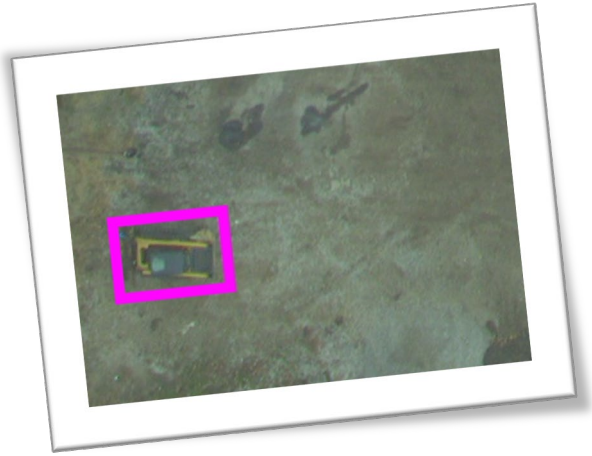


Roadmap – New features to be implemented in 2024

1. Liquid leak detection for gathering lines, including produced water
2. Shared ROW multi-operator inspection
3. Methane (CH4) leak detection on gathering and transmission lines
4. Geo-hazards alerts (land slippage, erosion)
5. Post-extreme weather and natural disaster analysis (§ 195.414)
6. Vegetation management tools
7. Early leak detection through stressed vegetation analysis

MPL Pilot Summary

- Pilot successfully conducted from November 2022 to December 2023
- Over 42,000 miles of pipe inspected - 7.5 million images collected
- Automated threat detection:
  - No known misses of staged or known ROW activity
  - Averaged 4 new conflicts beyond traditional patrol per 1000 miles inspected
- Passive leak detection:
  - Detection of a real pipeline seeper release
  - Multiple positive detections of saturated soil
- Proof-of-Concepts:
  - Exposed Pipe Detection – 32 previously unknown
  - Vegetation Management



Traditional Patrol

Flyscan Inspection

thank you

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