Methane Airborne Detection Solution

Introduction

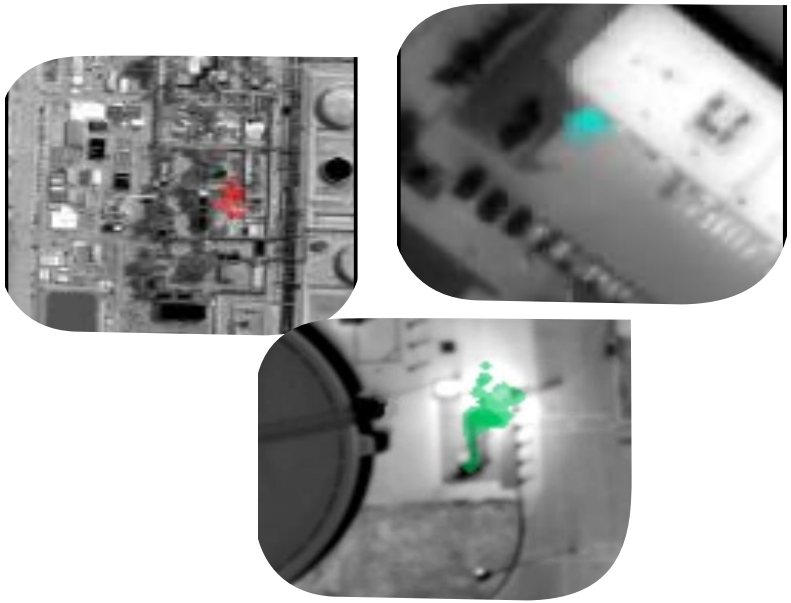
Operators have testified to EPA that fugitive emissions can be reduced at a given site by 80-90% using advanced screening methods

https://business.edf.org/wp-content/blogs.dir/90/files/Investor-Guide-to-Commenting-on-EPA-Methane-Rule-Proposal.pdf

Telops
Exosens Group

- Telops was started in 2000 in Quebec City (Canada), and now employs over 90 people (Ph.D., M.Sc., Eng.).
- It has established itself as a world leader in thermal infrared imaging solutions.
  - 2005: Development of the first hyperspectral infrared camera
  - 2008: Launch of the airborne version
  - 2010: Development of the gas detection and identification software
  - 2021: Launch of the Hyper-Cam Airborne Mini

It now offers innovative solutions for aerial methane leak detection and quantification.



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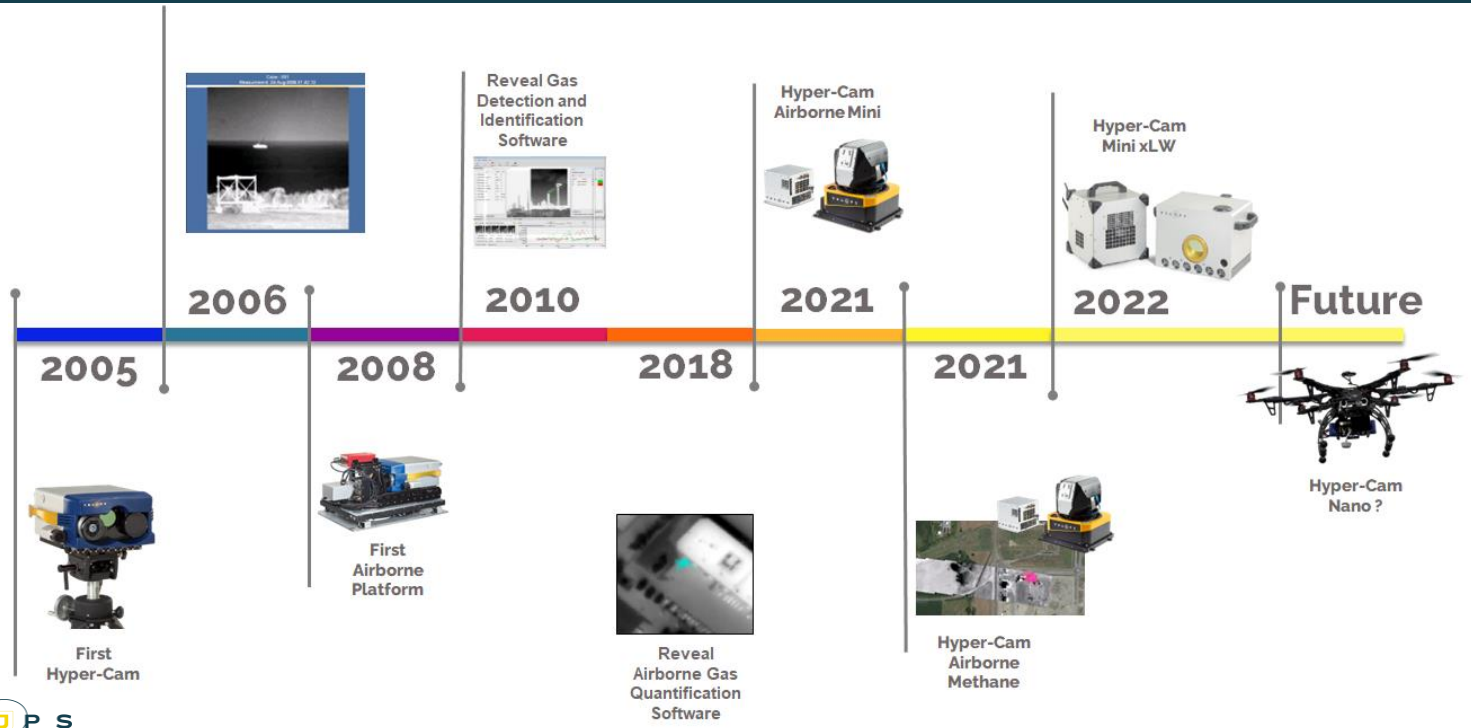
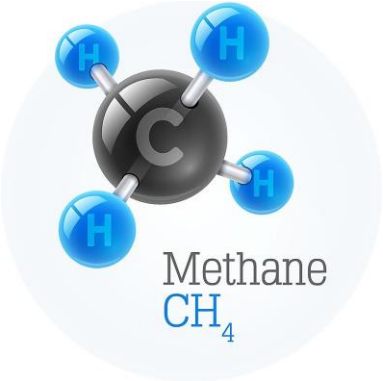


Methane

Natural Gas

- Powerful greenhouse gas with a warming impact 86 times stronger than CO2 per unit of mass over a 20-year period
- Atmospheric lifespan of around 12 years.
- Reducing methane emissions can slow the rate of warming and have positive impacts in our lifetime.



Measurement Techniques

- Optical gas imagers (OGIs)
  - Strong gas detection capabilities.
  - Limited in their ability to accurately identify type of gas.
  - Not suited to survey multiple assets rapidly and cost effectively.
  - Approved method for detecting fugitive methane emissions from equipment.
- Aerial surveys
  - Detection of more important leaks.
  - Monitor difficult to access areas.
  - Well adapted to survey multiple assets in a cost-effective manner.

The Hyper-Cam Airborne Mini

A Passive Hyperspectral Camera for the **D**etection, **I**dentification and **Q**uantification of Methane Fugitive Emissions

Hyper-Cam Airborne Mini

Passive Hyperspectral Camera

- Robust, flexible, high performance Passive Hyperspectral Camera based on proven design.
- Automatically adapts operational parameters to flight conditions to ensure 100% area coverage

  [▫] Streamlined Automation: The system's streamlined automation ensures smooth operation without constant manual input.
- Real-time gas detection & identification

  Quantification to leak rate in post-processing.
- Excellent detection performance over snow, water, day and night.
- Integrated 4096 × 3000 pixels visible camera
- Detects many other gaseous hydrocarbons and VOCs.

Hyper-Cam Airborne Mini

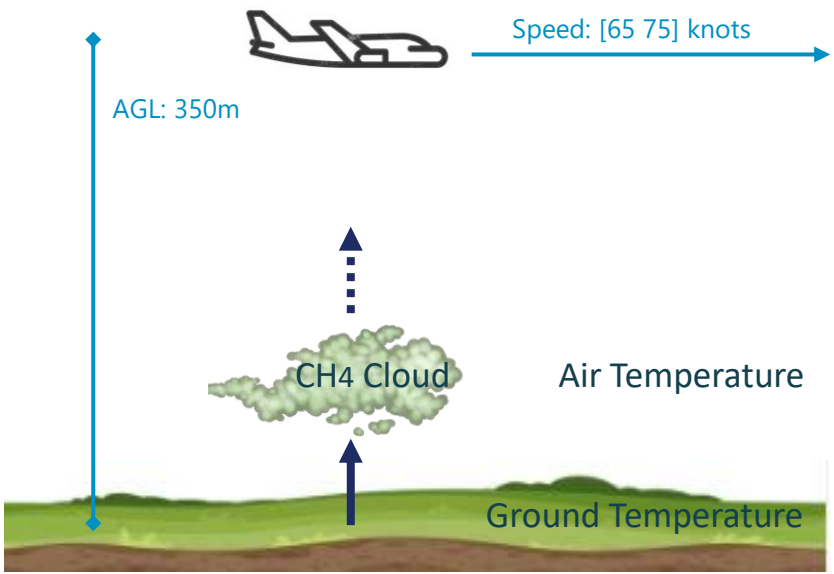
Multi-Platform

Hyper-Cam Airborne Mini

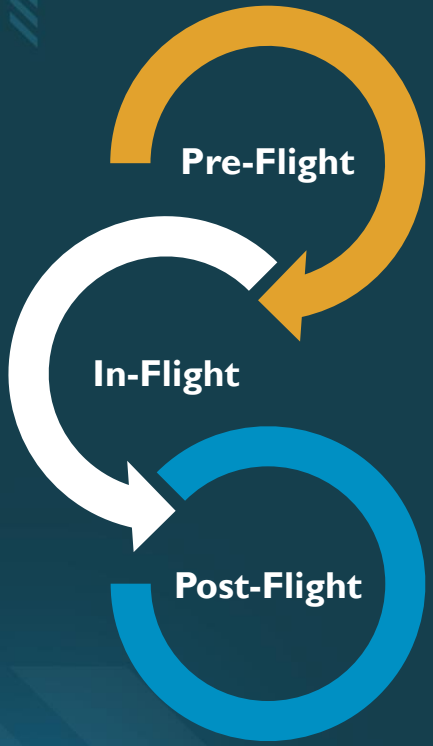
Passive Thermal Infrared Camera

- Passive infrared hyperspectral camera:
  - Collects infrared light emitted/reflected by objects in the scene.
  - Decomposes the light into a multitude of contiguous spectral bands. A spectrum per pixel.
  - No laser light emitted.
- Signal is produced by thermal contrast between temperature of the background and the one of the gas plume.
- Signal is proportional to
  - (Gas Quantity [ppm*m]) * (Gas Plume Temperature – Ground Temperature)
- Excellent detection performance over a wide range of conditions including over snow, water during both day and night.

Typical flight conditions



Pixel size on the ground : 25cm
Swath: 30m



Methane Airborne Detection Solution

Officially documented as an emission detection technology by AMEP to be included in an Alternative Fugitive Emissions Management Program.

Submitted its application for approval as an oil and gas alternative test method to the U.S. Environmental Protection Agency (EPA).

Methane Airborne Detection Solution

A strong partnership with experienced geospatial survey companies

Team effort!

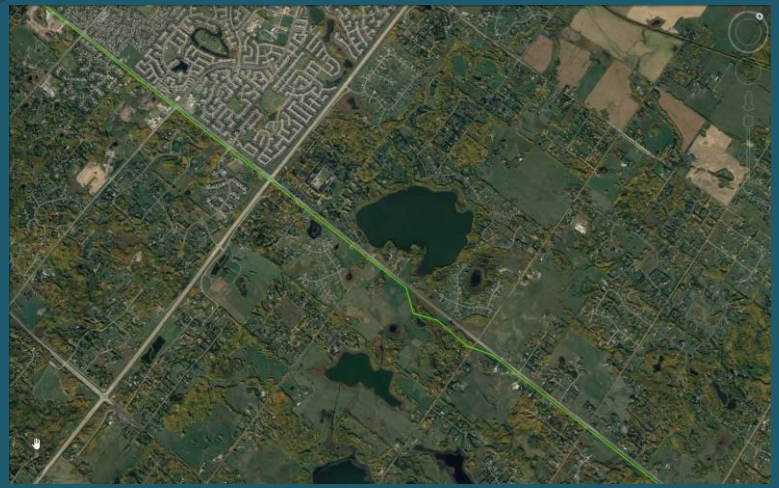
LiDAR Services International (LSI).
Calgary, Alberta , CA

SkyCam Aviation, Inc.
California, USA

BARR GeoSpatial
Texas, United States
Calgary, Alberta, CA

General Overview

Methane Airborne Detection Solution



Pipeline track

Inspection corridor

Aircraft track

Measurement

Preflight

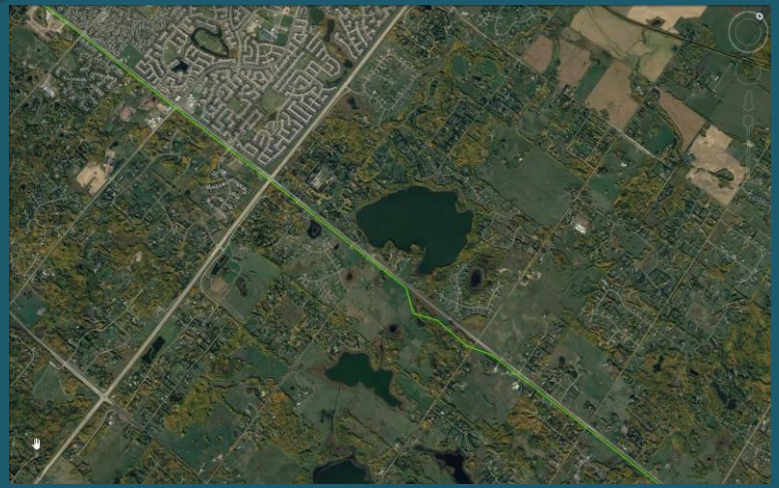
- Provide geographic information (GIS) to our team.
- Our team will create the optimal flight plan.
- Discuss flight plan, schedule and goals.
- Our team handles all aspects of flight and survey logistics.

Flight

- Our team will execute the mission.
- Real-time notifications for important leaks are provided to the operator in the aircraft.

General Overview

Methane Airborne Detection Solution



Pipeline track

Inspection corridor

Aircraft track

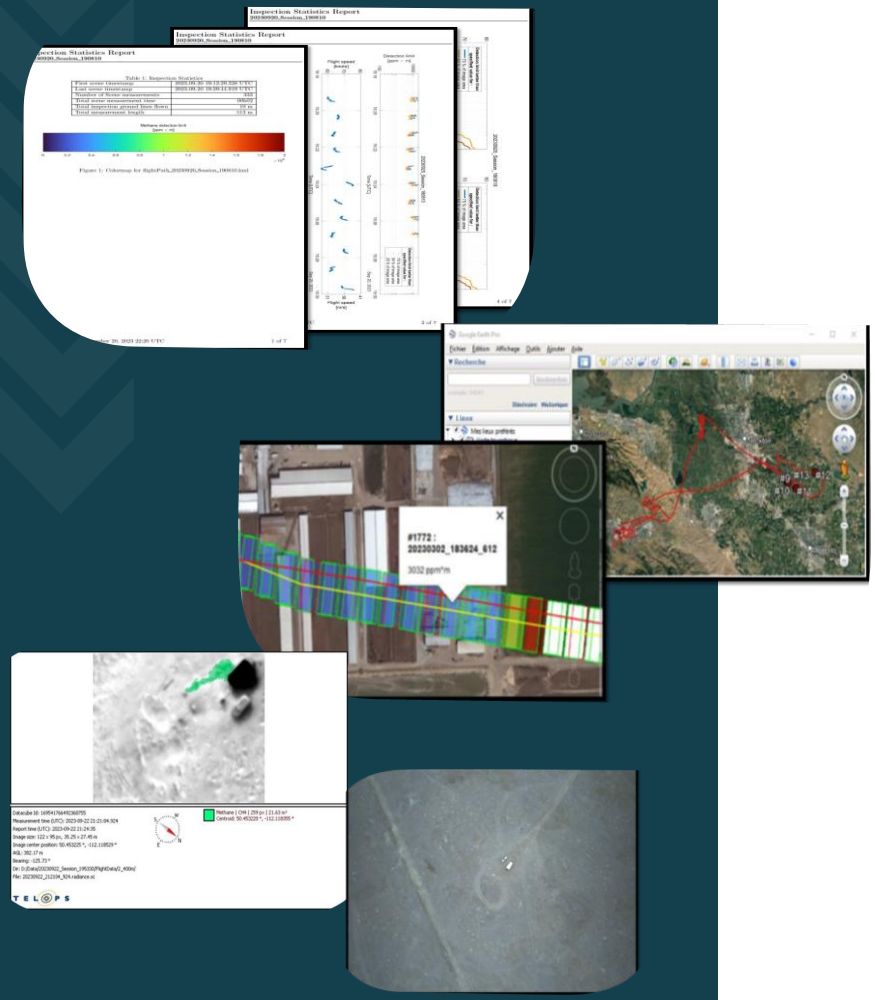
Measurement

- Post-Flight

  - **P1 -** Immediately following a flight: detailed flight inspection report

  - **P2 -** 24h after the flight: complete set of geoTiff images

  - **P3 -** 10-14 days after flight: Final list of the positive detections



Package #1

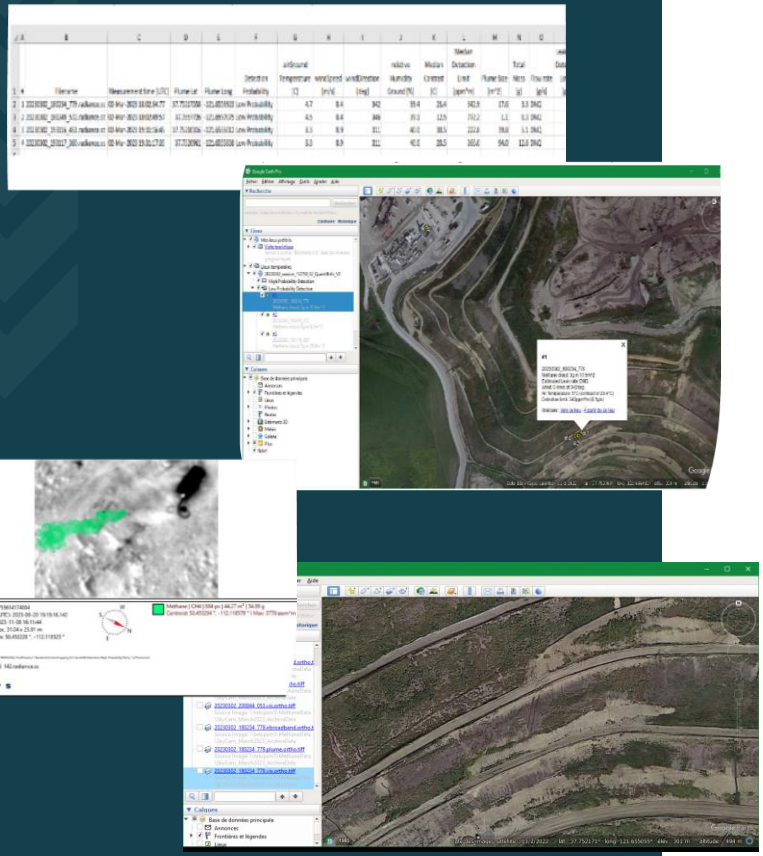
Detailed flight inspection report

- The following parameters are provided for the entire flight:
  - [ ] Estimated detection limit (in ppm*m and in g/s)
  - [ ] Flight speed (ground speed)
  - [ ] Flight altitude in AGL (above ground level)
  - [ ] Thermal contrast
  - [ ] Ground level air temperature ground brightness temperature
  - [ ] Ground-level wind speed
- The flight path to verify the quality of the inspection flight.
- Detection Reports and high resolution visible imagery.

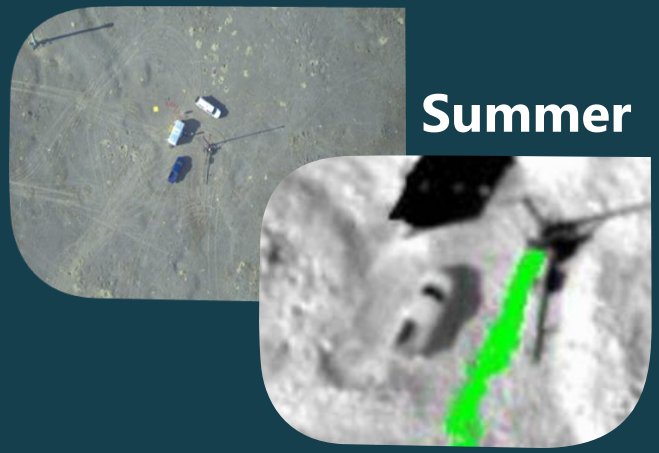
Package #2
GeoTiff Images

- Telops prepares and send 2 geoTiff images for each measured scene
  - The broadband thermal image
  - The visible image
- The image files are grouped by segment (1 folder per segment per session)
- These image files can be imported in Google Earth and will be shown at the proper geolocation

Package #3
General Overview



- The final list of the positive detections is delivered at the end of the Telops' D&I post processing stage
  - The list of the **positive detections** is compiled in an Excel spreadsheet
  - A **kml file** intended to be explored in Google Earth containing the same list of positive detections
  - Each positive detection has a **detection report** file in the form of an image.
    - the individual **detection reports** (1 jpg file per positive detection)
    - 4 **images** (2 visibles , 1 infrared and 1 detected plume) for each positive detection



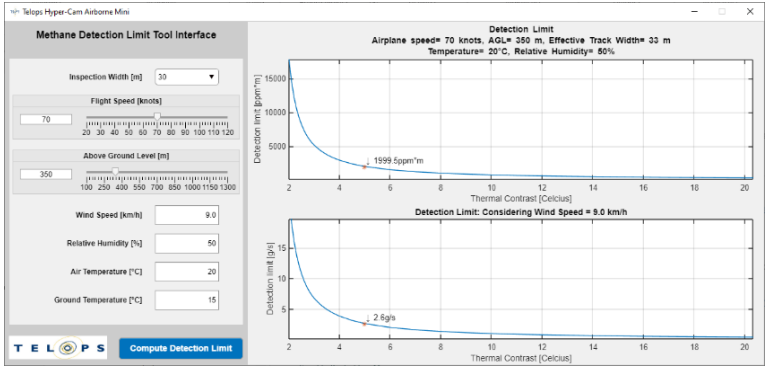
Technical Considerations and Recent Results

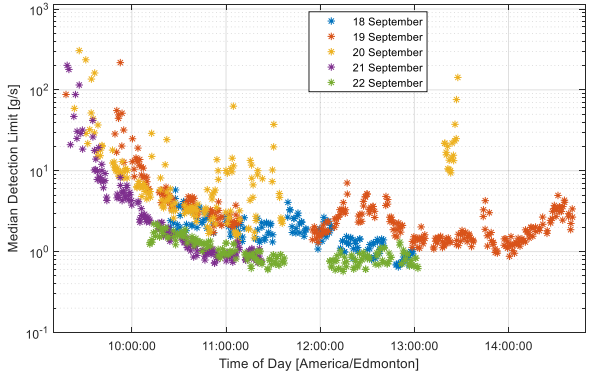
Detection Limit
Predicted and Calculated

- The system sensitivity (expressed as the methane detection limit) depends on various variables:
  - Flight parameters (speed & AGL)
  - Instrument settings (image width)
  - Environmental conditions (Thermal contrast, Wind speed and RH)

- Pre-flight: Telops developed a tool to estimate the detection limit in leak rate units [g/s].
  - Facilitates decision making
    - Select flight parameters
    - Select camera settings
    - Select when to fly

- Detection limit is also calculated after a flight to provide the actual inspection performance.





AMEP Test Campaign

Release Locations, Test Parameters and Conditions

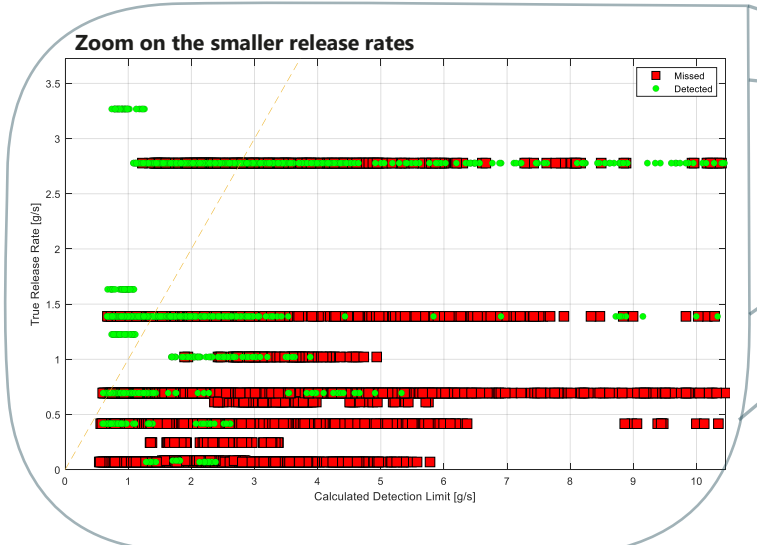
- Methane release rates varied from 0.07 to 22.2 g/s (0,2 to 80 kg/h) including also “No Release” conditions
- Wind speeds varied from 1.7 to 4.1 m/s (6.1 to 14.8 km/h)
- Flight speed varied from 46 to 90 knots
  - Telops recommends 70 knots
- Flight AGL varied from 250 to 410 m (820 to 1345 ft)
  - Telops recommends 350 meters (1150 ft)
- Thermal contrasts varied from 0 to 15°C
  - Summer conditions can bring higher thermal contrasts (> 25°C) providing lower detection limits.

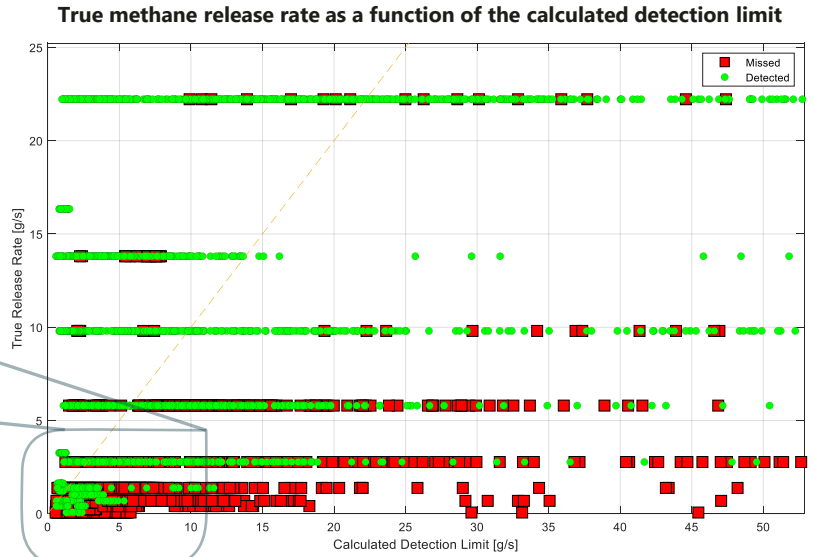
View of the 2 release sites from the air.

2 release sites. Left: West site. Right: East site

Detection Performance

- Detection performance for all measurements during the campaign:
  - Missed detection
  - Detected
- Some of the 0.07 g/s (0.24 kg/h) releases were detected.





Detection Performance

Probability of Detection (PoD)

- Using only the data from methane releases where the true leak rate is above the detection limit, we get a PoD of 93%.

		Truth	
		True Release	**No Release**
Telops	**Positive Detection**	5357 True Positive	0 False Positive
	No Detection	422 False Negaitive	901 True Negative

- Accuracy: 94%
- Precision: 100%
- Sensitivity (PoD): 93%
- Specificity: 100%
- F-Score: 96%

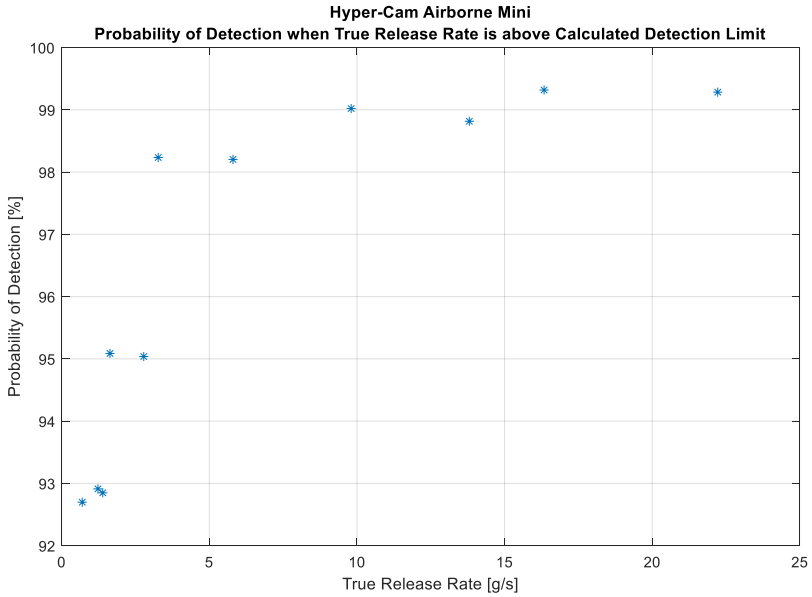
$$ACC = \frac{TP + TN}{TP + TN + FP + FN}$$

$$P = \frac{TP}{TP + FP}$$

$$Sn = \frac{TP}{TP + FN}$$

$$Sp = \frac{TN}{TN + FP}$$

$$F - score = 2 \times \frac{P \times Sn}{P + Sn}$$

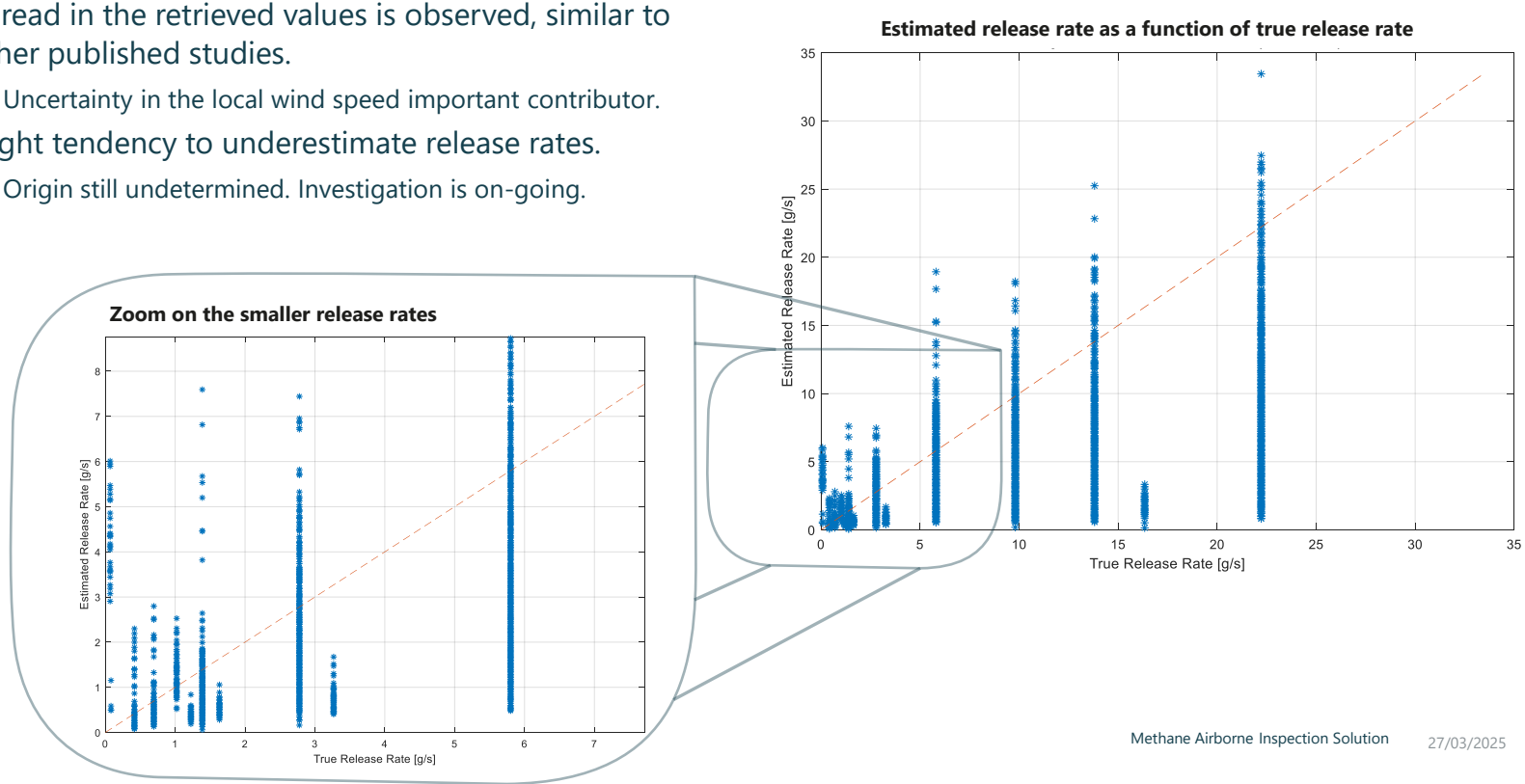


- For higher release rates, the Probability of Detection (PoD) increases.
  - 98% for release rates above 5 g/s (18 kg/h)

Quantification Performance

Retrieving the estimated methane release rate from the collected imagery

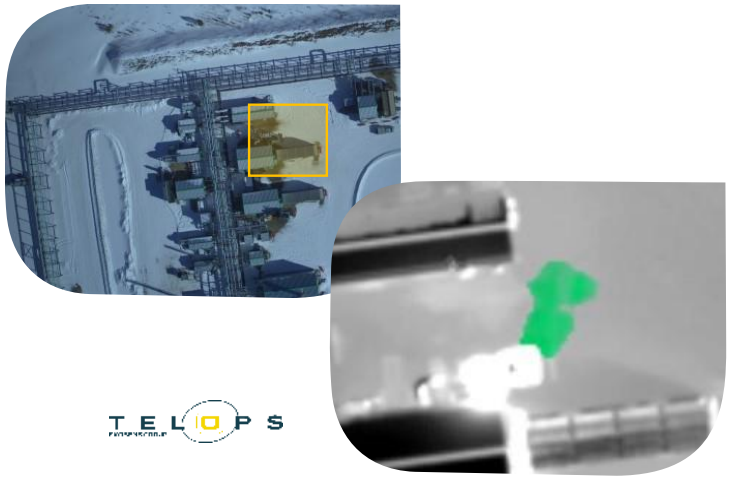
- Spread in the retrieved values is observed, similar to other published studies.
  - Uncertainty in the local wind speed important contributor.
- Slight tendency to underestimate release rates.
  - Origin still undetermined. Investigation is on-going.

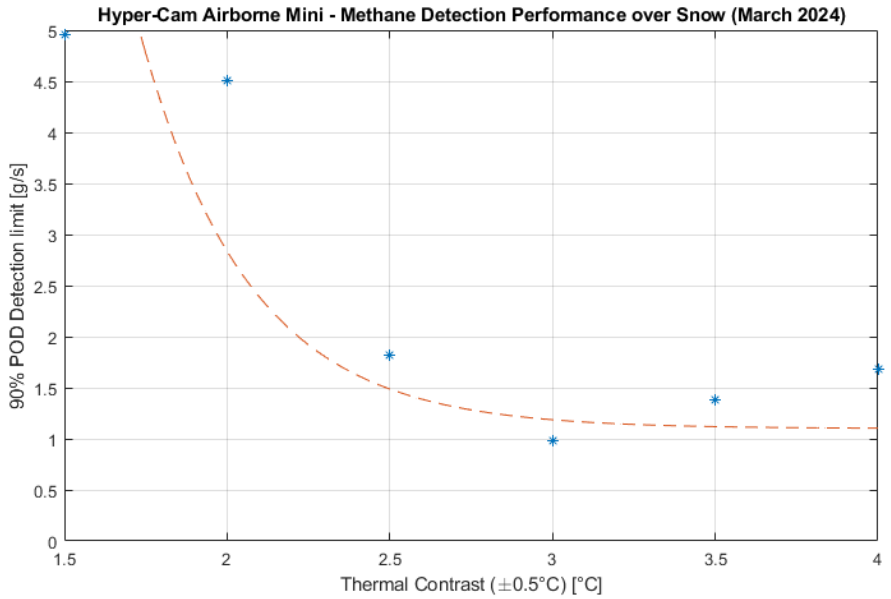


Winter (Snow Covered) Detection Performance

Probability of Detection (PoD)

- A 90% PoD for methane leak rates of 1.2 g/s or higher for thermal contrasts of 3°C and higher.
- Good thermal contrasts are obtained in the winter despite snow covered ground.





Key Takeaways

- Cost effective solution: manage emission related decision making, reduce risks and confirm compliance.
- Reporting: Real-time, clear and actionable reports.
- Our unique system:
  - Adapts autonomously
  - Automatic and real-time reporting
  - Multi-platform
  - Multi-mission
- Detects many other gaseous hydrocarbons and VOCs.
- Multiple blind test release missions over various release sites under various conditions in the last two years.
  - Good confidence in the inspection results using the Telops' Hyper-Cam Airborne Mini since the system calculates its detection limits on every measured scene.
  - The Telops' solution can be used all year long for methane release inspection, since the performance is not impacted by the presence of snow.
    - **90% PoD for methane leak rates of 1.2 g/s or higher**
  - Good thermal contrasts are obtained for both summer and winter conditions with the ground covered by snow