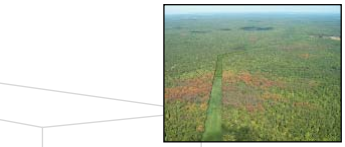
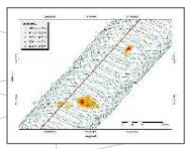
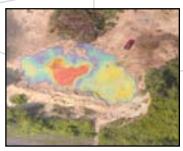
Methane to Markets

Oil and Natural Gas Technology Transfer Workshop

Detection and Measurement of Fugitive Emissions Using Airborne Differential Absorption Lidar (DIAL)

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25 April 2006

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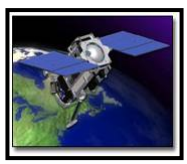
ITT – Corporate Overview

ITT: ~$7.0 Billion (annual revenue)

- **ITT Defense:** ~$3.0 Billion (annual revenue)
  - Supplier of sophisticated military defense systems and provider of advanced technical and operational services to government customers.
- **ITT Space Systems Division**
  - Over 50 years as a national leader providing innovation and quality in the design, production and development of Remote Sensing, Meteorological, and Navigation satellite systems.



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Evolution of Pipeline Leak Survey Technology

1970 1980 1990 2000 2001 2002 2003 2004 2005 2006

Flame Ionization Spectroscopy
- Hand-held device
- Slow – 1 mph
- Need to come in contact with the plume
- Difficult terrain and property issues
- Industry standard equipment

Pass-through Optical Sensors
- Truck mounted sensor
- Slow – 5 mph
- Need to come in contact with the plume
- Difficult terrain and property issues
- Easily damaged

Airborne Remote Sensing
- Airborne DIAL Sensor
- High sensitivity
- Detects and quantifies emissions
- Broad area scan pattern
- Fast – 150 mph
- Operates over difficult terrain and environmentally sensitive areas
- GIS-ready results

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Hydrocarbon Gas Detection: Active Remote Sensing

Definition
– A remote sensing system that can emit its own electromagnetic energy at a target and then records the interaction between the energy and the target.

Application
– DIAL (Differential Absorption Lidar) is an example of an active remote sensing technology. A DIAL system sends out controlled pulses of laser energy and then measures the interaction between the laser energy and the target.

Advantages
– The ability to obtain direct measurements of specific gases, regardless of the time of day or season. Ability to accurately locate and quantify area emissions. The ability to control target illumination. Active systems are particularly advantaged when the desired wavelengths are not sufficiently provided by the sun, such as portions of the mid-wave infrared (IR).

Disadvantages
– A large amount of generated energy is required to adequately illuminate the target. Other disadvantages include complex system designs, components, integration, and data analysis.

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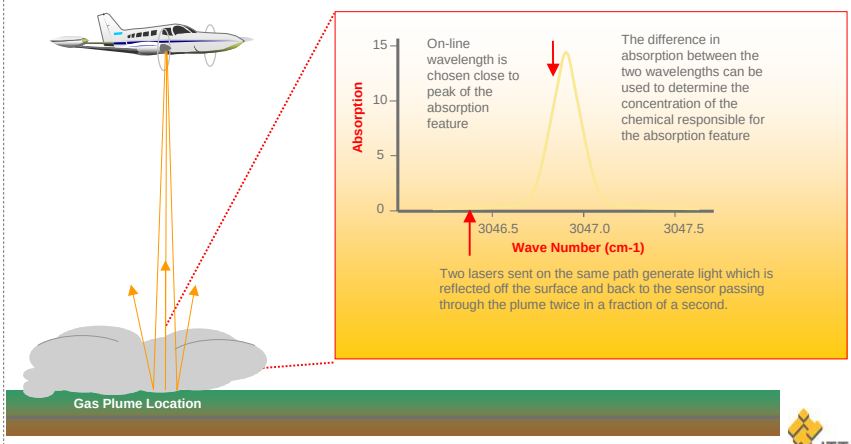
Hydrocarbon Gas Detection: Active Remote Sensing

Differential Absorption LIDAR



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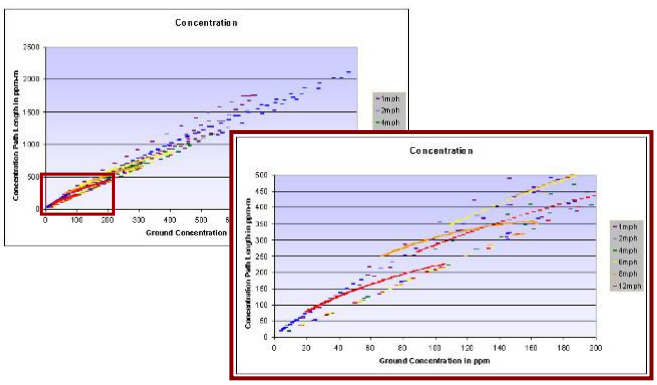
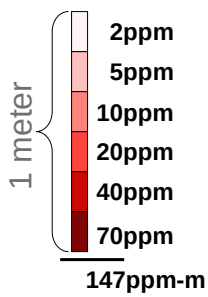
Emission Measurements: Linear trend between Concentration (*PPM)* and Concentration-Path-Length (*PPM-m)*

Depending on conditions, a 150ppm-m CPL will have a ground level concentration ranging from 45ppm to 70ppm.





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ITT Airborne Natural Gas Emission Lidar (ANGEL) Service Aircraft:
DIAL Sensor System and Supporting Hardware

DIAL Sensor

Digital Video Camera

High Resolution Mapping Camera

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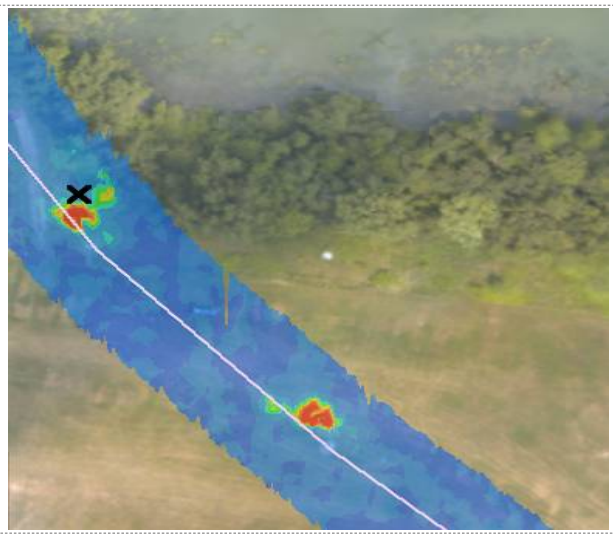
ITT Airborne Natural Gas Emission Lidar (ANGEL) Service Aircraft:
Computer controlled pointing, scanning and tracking system



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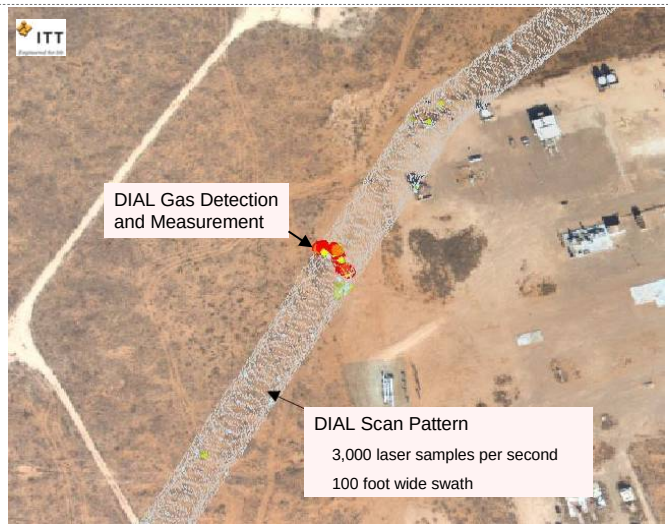
DIAL Detection and Measurement of Hydrocarbon Gases

Example #1: Pipeline Route – Texas



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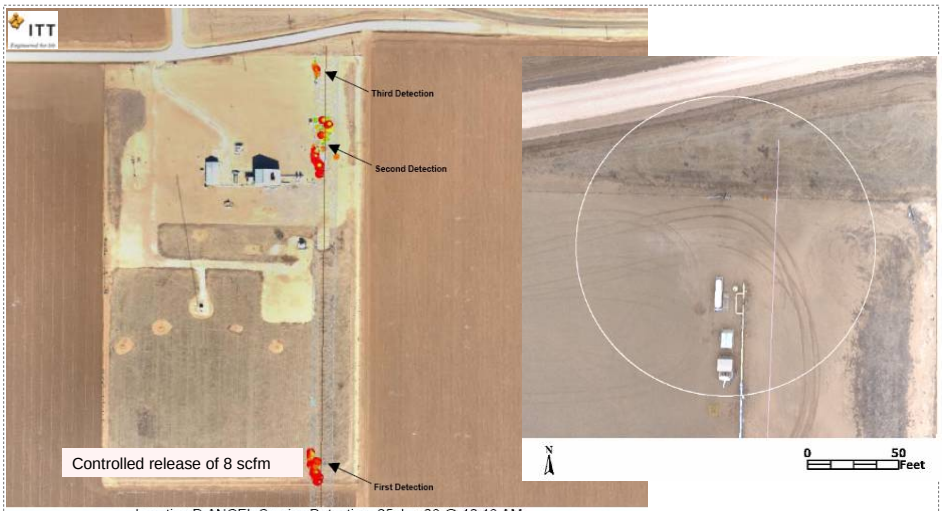
DIAL Detection and Measurement of Hydrocarbon Gases

Example #2: Pipeline Route – Texas



Location D ANGEL Service Detection, 25 Jan 06 @ 10:16 AM

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DIAL Detection and Measurement of Hydrocarbon Gases
Example #3: Light Crude Tank Farm

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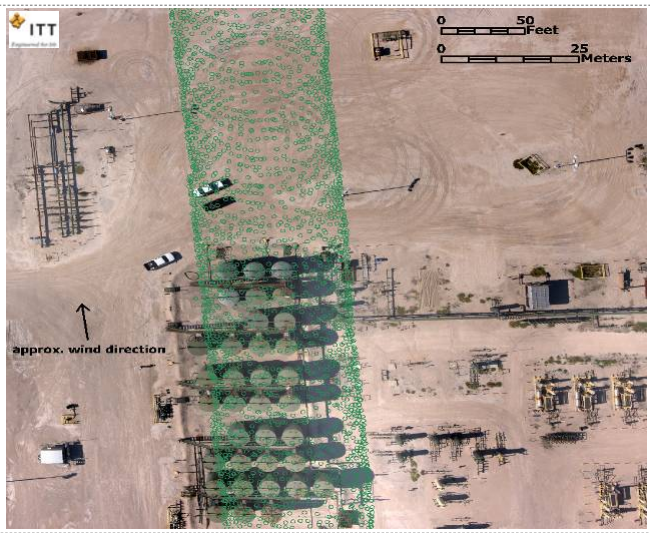
DIAL Detection and Measurement of Hydrocarbon Gases
Less than 3 seconds of collection from 1,000' altitude

DIAL Scan Pattern



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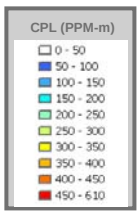
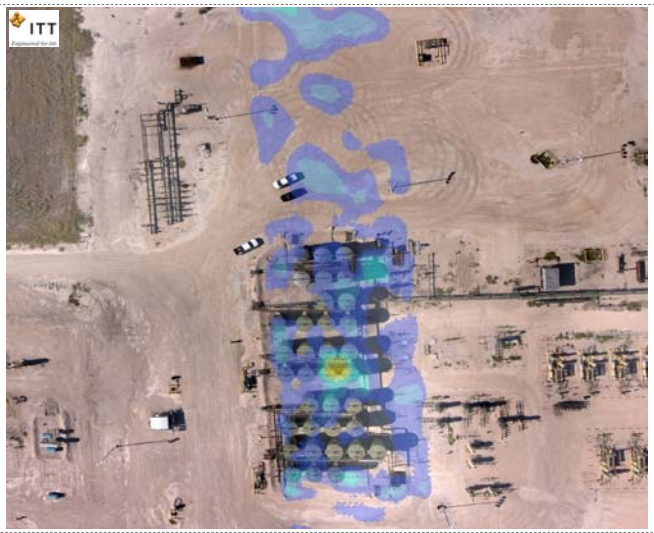
DIAL Detection and Measurement of Hydrocarbon Gases
Example #3: Light Crude Tank Farm

Hatches CLOSED





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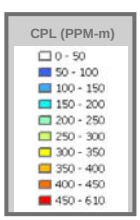
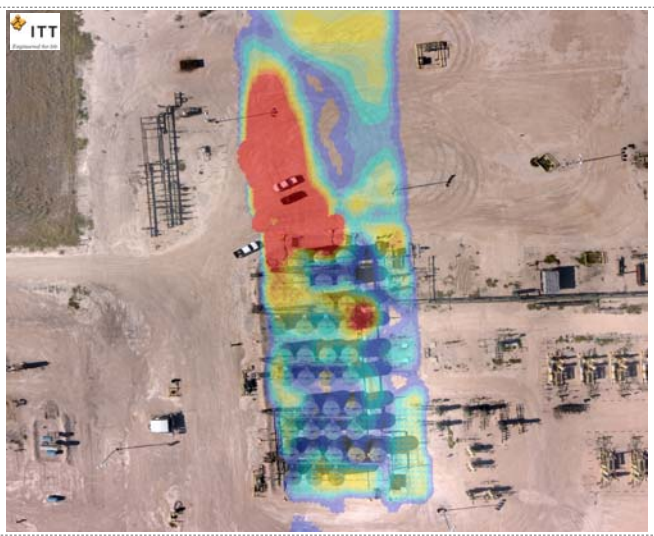
DIAL Detection and Measurement of Hydrocarbon Gases
Example #3: Light Crude Tank Farm

Hatches OPEN





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DIAL Detection and Measurement of Hydrocarbon Gases
Example #4: Detection over grass – Open field.

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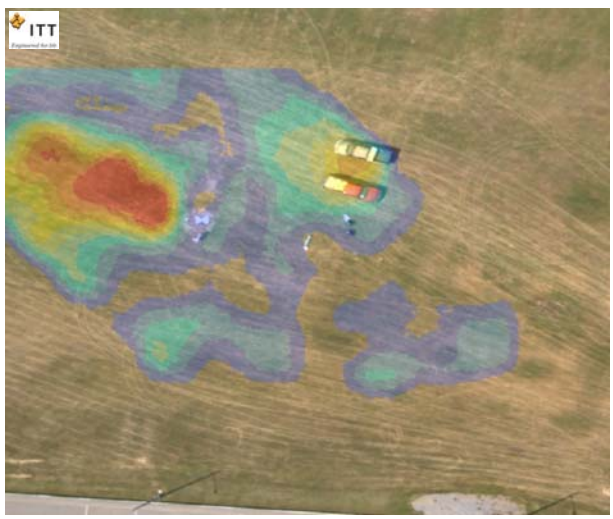
DIAL Detection and Measurement of Hydrocarbon Gases
Less than 3 seconds of collection from 1,000' altitude

DIAL results



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DIAL Detection and Measurement of Hydrocarbon Gases
Example #5: Detection over sand/dirt

Embankment release

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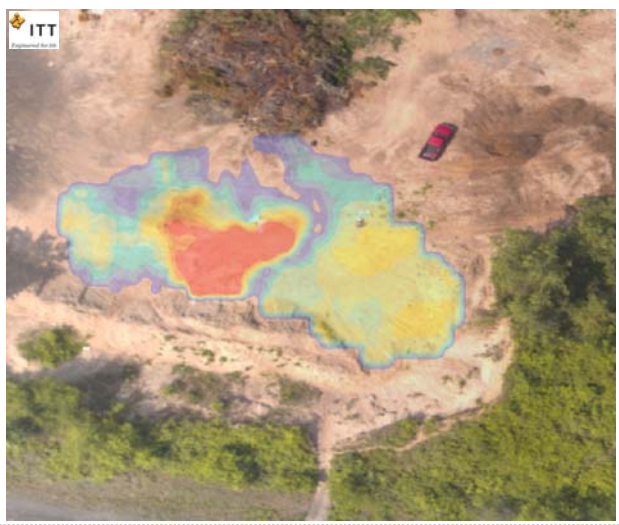
DIAL Detection and Measurement of Hydrocarbon Gases
Less than 3 seconds of collection from 1,000' altitude

DIAL results



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Conclusions — Airborne DIAL can detect and measure fugitive gas emissions

- ✓ Airborne DIAL can provide a unique, comprehensive, and unobstructed view of area emissions.
- ✓ Airborne DIAL can detect specific hydrocarbon gases/vapors (i.e. methane, ethane, propane, gasoline, condensates, etc.).
- ✓ Airborne DIAL can quantify area emissions and provide quantitative information on a plume's size and shape.
- ✓ Airborne DIAL can directly measure the various concentration-path-lengths (ppm-m) within area emissions.
- ✓ Airborne DIAL can operate day or night, and when integrated into a fixed wing aircraft can survey up to 1,000 pipeline miles per day.

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Acknowledgements — Funding, Field Research, Facilities

- US Department of Energy – National Energy Technology Laboratory (DOE/NETL)
- US Department of Transportation – Pipeline and Hazardous Materials Safety Administration (DOT/PHMSA)
- Texas A&M University – Corpus Christi, Pollution Prevention Partnership
- BP America, Inc.
- El Paso Production
- National Fuel Gas Company
- Northern Natural Gas

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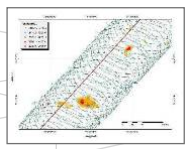
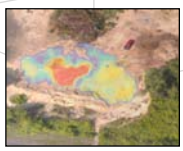
Questions and Answers

Thank you for your time and interest.





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