Methane Emissions from the U.S. Natural Gas Industry and Leak Detection and Measurement Equipment

March 29, 2012

Roger Fernandez
U.S. EPA

Overview

- U.S. GHG Emissions by Gas
- Natural Gas STAR Overview
- Natural Gas in the GHG Inventory
- Updates to Natural Gas Estimates (1990-2009 Inventory)
- Leak Survey Methods
  - Leak detection tools
  - Leak measurement tools
- Contact and Further Information

Why Focus on Methane?

- A potent greenhouse gas (GHG) with 100-year global warming potential of 25; atmospheric lifetime of ~12 years
- The 2nd most important GHG accounting for ~18% of total climate forcing
- A primary component of natural gas and a valuable, clean-burning energy source
  - Proven, viable technologies and practices exist to reduce methane emissions cost-effectively
- Oil and natural gas operations are a significant source of total U.S. (23%) and global (18%) human-made methane emissions.
- Methane emissions in the oil and gas industry comprise over 70% of total U.S. Natural Gas industry GHG emissions on a 20 year global warming potential basis.

Natural Gas STAR Program

The Natural Gas STAR Program is a *flexible*, *voluntary partnership* between EPA and the oil and natural gas industry designed to *cost-effectively* reduce methane emissions from natural gas operations.

- Over 120 partners and endorsers comprising over 50% of U.S. oil and gas industry from well head to burner tip

Natural Gas STAR Key Components

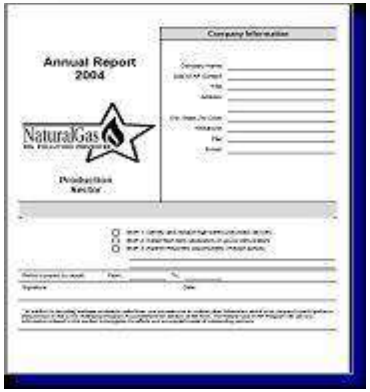
- **Guidance on new technologies and practices**
  - Technical documents on more than 80 **cost-effective** technologies and practices
  - Free Technology Transfer workshops
  - One-on-one technical assistance to identify and prioritize cost-effective methane emission reduction opportunities

- **Annual record of partner voluntary actions and methane savings**

Technical Information

Project Demonstrations

Workshops



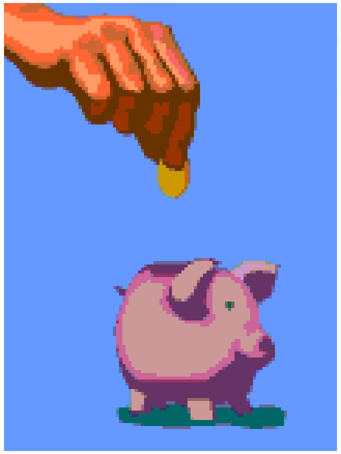
Annual Reports

What is Cost Effective?

The simple payback is the number of years it takes to pay back the capital cost of a project (based on $3/Mcf)

- Payback within 10 years 87%
- Payback within 3 years 77%
- Payback within 12 months 47%
- Immediate payback 1%

Percentage of over 80 Gas STAR Recommended Technologies and practices at each payback level



Yet billions of dollars in losses through fugitive and vented emissions each year.

Cost-Effective Methane Mitigation Opportunities

Oil Production

Route casinghead gas to VRU or compressor for Recovery & Use or Sale

Install VRUs on crude oil storage tanks

Natural Gas Production & Processing

Reduced emission well completions

Economic replacement of reciprocating compressor rod packing

Install flash tank separators on dehydrators

Identify, measure & fix leaks in processing plants

Gas Transmission

Use pipeline pumpdown

Composite Wrap for Non-Leaking Pipeline Defects

Identify, measure & fix leaks in compressor stations & pipelines

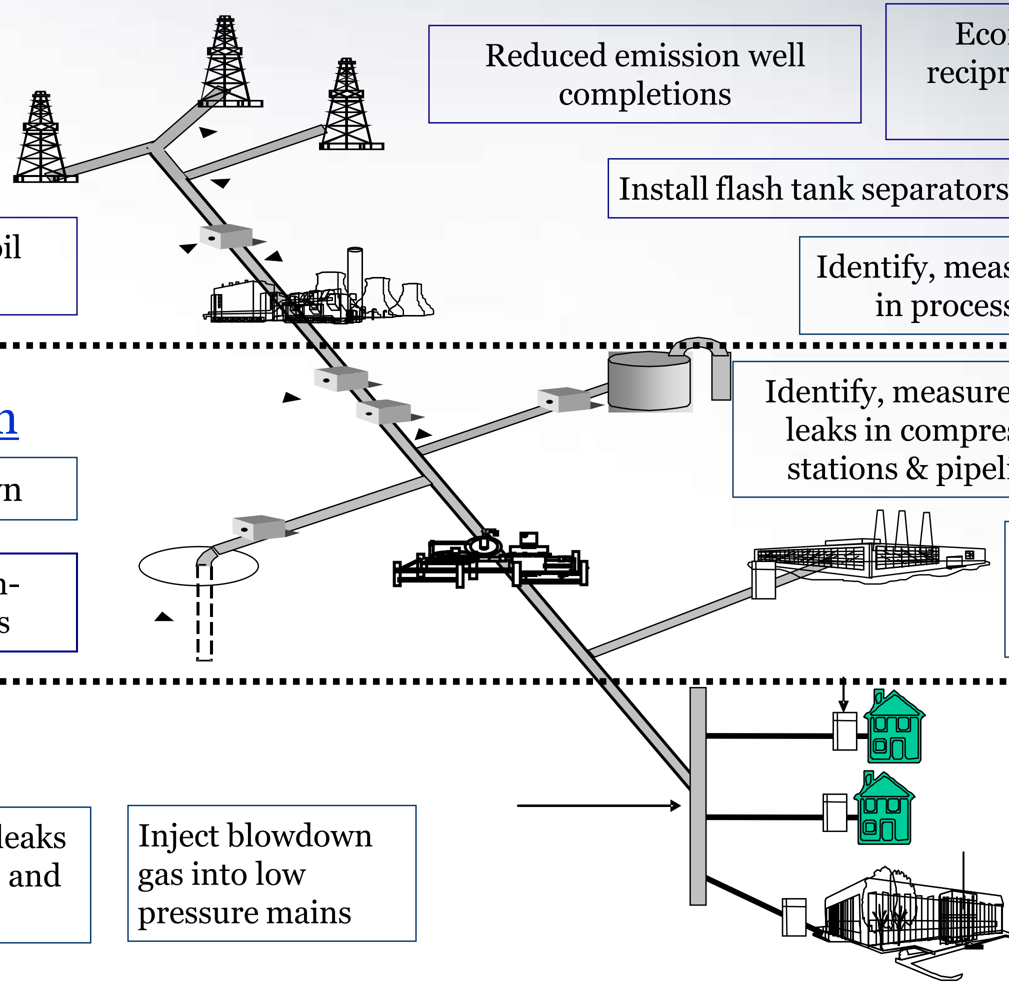
Re-route gas to fuel system or sales line or flare

Replace wet seals with dry in centrifugal compressors

Gas Distribution

Identify, measure & fix leaks in pipelines & metering and regulating stations

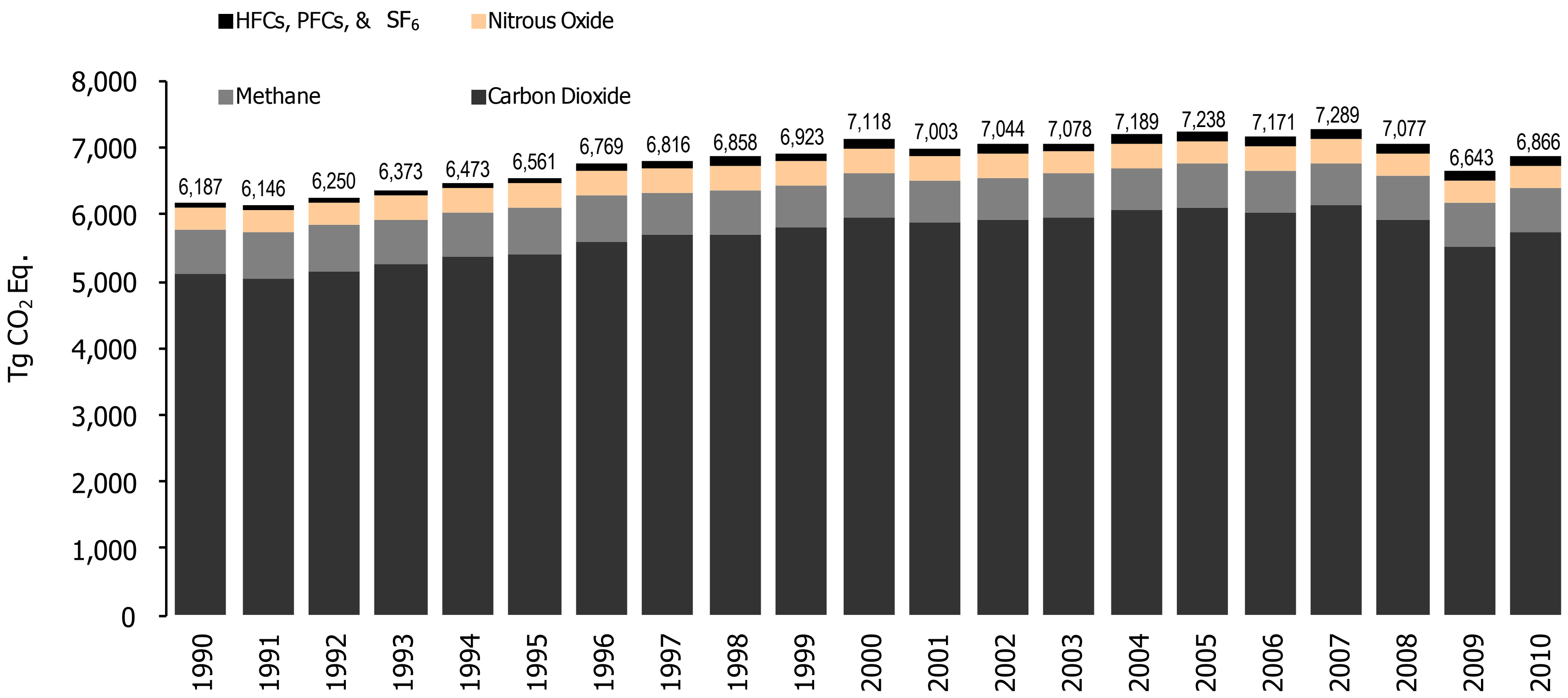
Inject blowdown gas into low pressure mains



Picture courtesy of American Gas Association

U.S. GHG Emissions by Gas

In total, emissions increased by 11% from 1990 to 2010.



Source: *Draft* Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2010 (Feb. 2012). epa.gov/climatechange/emissions/usinventoryreport.html.

Natural Gas in the GHG Inventory

- EPA's annual GHG inventory includes estimates for oil and gas production, processing, transmission and storage, and distribution
- 30.9 MMTCO2e total CH4 emissions from petroleum systems
- 221.2 MMTCO2e total CH4 emissions from natural gas systems
  - 130.3 field production (includes wells, gathering pipelines, and well-site gas treatment facilities such as dehydrators and separators)
  - 17.5 processing (includes compressors and acid gas removal plants)
  - 44.4 transmission and storage (includes compressor stations and storage tanks)
  - 29.0 distribution (includes pipelines and gate stations)
- CH4 emissions from natural gas systems increased 31.4 MMTCO2e, or 17%, from 1990-2009
  - Key driver of increase is increased production
- 32.2 MMTCO2 non-combustion CO2 estimates from natural gas systems
  - 10.9 field production, 21.2 processing, 0.1 transmission and storage
- 0.5 MMTCO2 total CO2 emissions from petroleum systems

Source: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009 (Apr. 2011). epa.gov/climatechange/emissions/usgginv_archive.html.

Updates to Natural Gas Estimates (1990-2009 Inventory)

- EPA did not make changes to the 1990-2010 Inventory
  - Same methodologies, emission factors, sources of activity data as 1990-2009
  - Ongoing review of information and data received
- Several changes made in 1990-2009 Inventory published last year
  - Increased calculated emissions to 120% of the previous Inventory
  - Main contributors to increase were improvements to estimates for gas well clean ups, condensate storage tanks, and centrifugal compressor seals
- Included emissions from gas wells with hydraulic fracturing for the first time
  - Used emission factor first published in the GHG Reporting Program, Subpart W TSD (April 2010)
  - New factor based on four recent data sources containing over 1,000 data points
    - Includes direct industry estimates of emissions captured with reduced emission completions.
    - Data is set representative, including both low (e.g., CBM) and higher pressure wells
  - Previous inventories based on assumptions used in the EPA-GRI study (based on data from 1992) when hydraulically fractured gas wells were not as common

Leak Survey Methods

- Leak detection tools
  - – Infrared cameras
  - – Catalytic oxidation/thermal conductivity detector
- Leak measurement tools
  - – Acoustic leak detector and quantifier
  - – Hi Flow Sampler
  - – Calibrated vent bag
  - – Vane/hot wire anemometers
  - – Ultrasonic flow meter
  - – Turbine meter

The technologies mentioned in this presentation are those that Natural Gas STAR Partners have reported using from own projects and experience. EPA is not endorsing a particular technology or brand.

Leak Detection and Measurement Tools

- <u>Catalytic oxidation/thermal conductivity detector:</u> combines *catalytic detection* with *thermal conductivity* to provide accuracy and sensitivity over the entire concentration range (0 to 100 percent) of gas
- <u>Acoustic leak detector and quantifier:</u> detects leakage across a closed valve by detecting the level of sound (in decibels) of leaking gas as it expands across the leak
- <u>Hi Flow Sampler:</u> Variable flow rate sampling system that provides total capture of the emissions from a leaking component

Leak Measurement Tools

- <u>Calibrated vent bag:</u> bag of known volume (e.g., 3 ft^3), made from antistatic plastic with a neck shaped for easy sealing around the vent
- <u>Vane anemometer:</u> channels emissions over a rotating vane that in turn rotates a fan to measure velocity of emissions
- <u>Hot wire anemometer:</u> measures emissions velocity by noting the heat conducted away by the emissions

Leak Measurement Tools

- Ultrasonic flow meter: consists of two transducers: both are ultrasonic signal generators and receivers
- Turbine meter: used on hydrocarbon emissions exceeding 10 standard ft3/minute
  - Allows continuous and automated measurement with a recording device

Infrared Cameras

Opgal EYE-C-GAS

FLIR GF320

Infrared Cameras

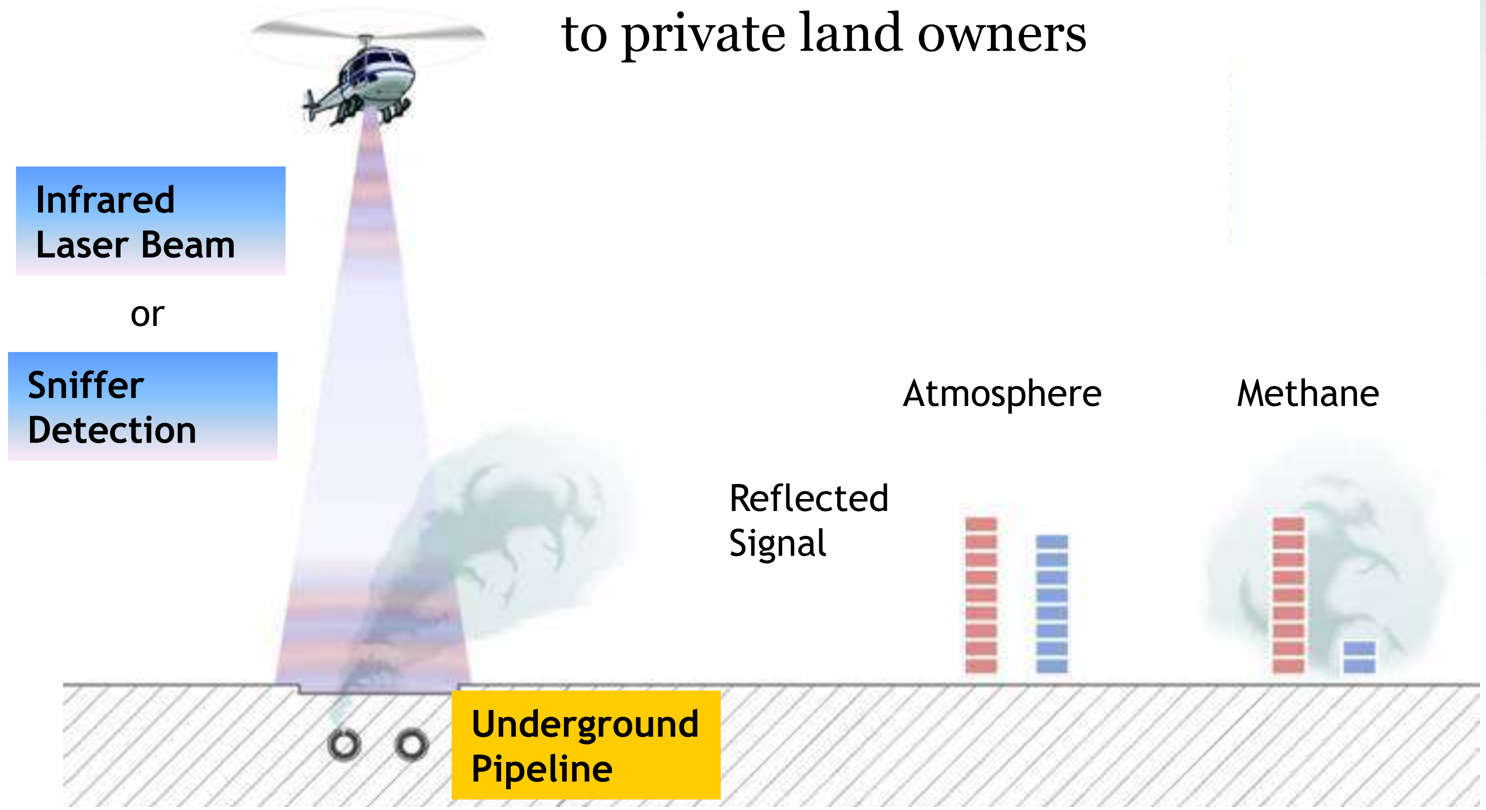
Compressor Station Blowdown

Storage Tank Emissions

- Can see methane leaks and volatile organic compounds
- Displays real-time visual image, allowing quicker identification and repair of leaks
- Allows for screening hundreds of components an hour
- Can screen inaccessible areas:
  - Vent stacks
  - Blowdown systems
- “Wish” – to have a camera that can measure emissions as well.

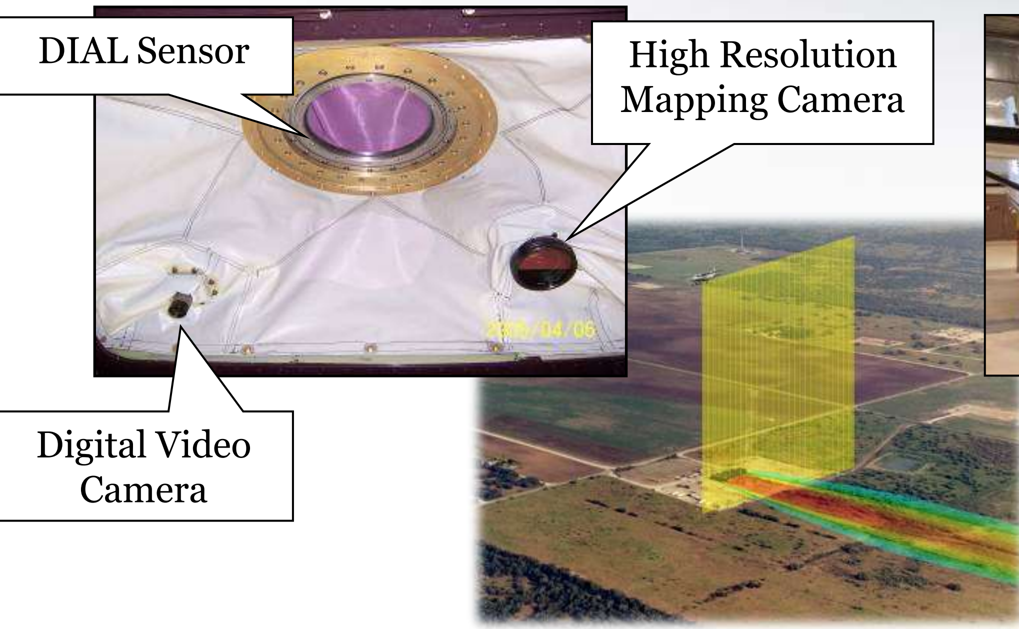
Aerial Pipeline Leak Surveys

- Over 10 times faster than ground surveys
- Full coverage of the right-of-way
- Easy access to rough terrain and non-disruptive to private land owners



ITT's Airborne Natural Gas Emission Lidar (ANGEL) Service

- Airborne Differential Absorption Lidar (DIAL)



- Example emissions rate quantification:
  - Consider a "fenceline" 100-ft high by 100-ft wide (10,000 ft^2)
  - At a wind speed of 2 mph = 10,560 ft/hour, 1.056×10^8 standard ft^3/hour (SCFH) of airflow across that fenceline under standard conditions
  - If the air contains 1,000 ppm of methane on average (0.1%), then the methane flow is approximately 105,600 SCFH = 2,545 thousand standard ft^3/day (MSCF/day)

Source: ANGEL, Aerial image

Apogee Leak Detection System (LDS) and Chesapeake Energy

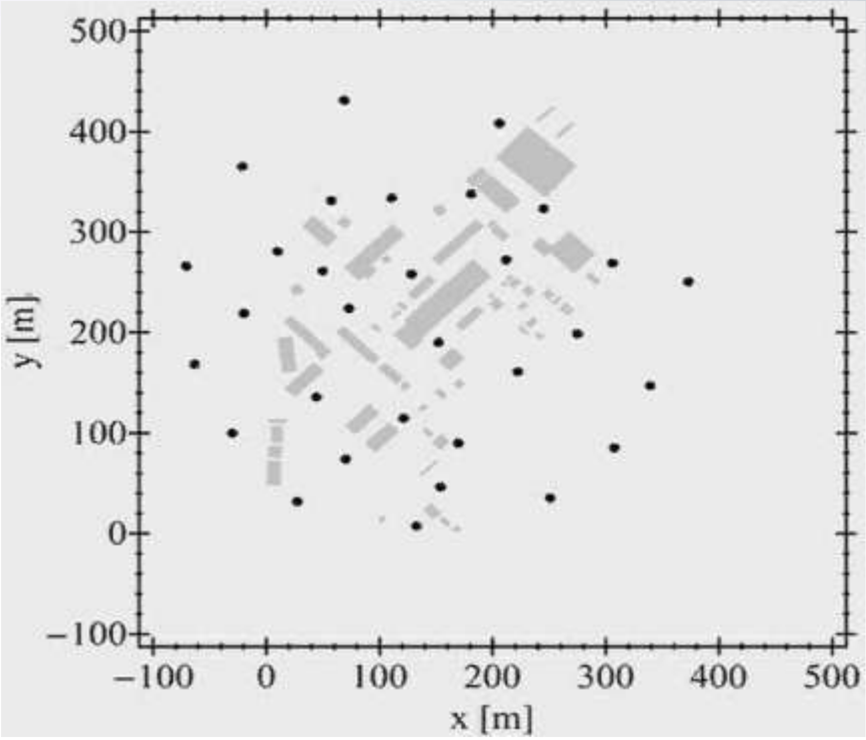
- Apogee LDS: an infrared-based method for detecting leaks from hydrocarbon liquids and gas pipelines, production and storage facilities, landfills, and coal-seam seeps
- Chesapeake's Eastern Division has successfully used the Apogee LDS to survey gathering lines in several operating areas within the Appalachian Basin
- Sept. 2008 flight covered 616 miles
- To cover the same area with ground patrol:
  - 4 men: 2 men on 2 crews, 2 vehicles, and fuel
  - 6 hours/day; 6 miles/day
  - Result: 100 days, 3,200 man hours, 5 months of detection
- Flight time was 65 hours
- Real savings in man hours, time, and vehicle fuel

Leak Surveys Inc. (LSI) and Enbridge

- After becoming a Natural Gas STAR Partner, Enbridge was interested in aerial infrared imaging to identify pipeline leaks
- Worked with LSI on a pilot project to survey 160 miles of pipeline, discovering 22 leaks that would have otherwise been undetected
- Immediately repaired all leaks, allowing Enbridge to reduce methane emissions by 1.38 million cubic feet (MMcf) per day
- Enbridge agreed the pilot project was a success and contracted LSI for three additional surveys—totaling more than 443 miles of pipeline surveyed
  - Total of 30 leaks discovered and repaired through the three efforts

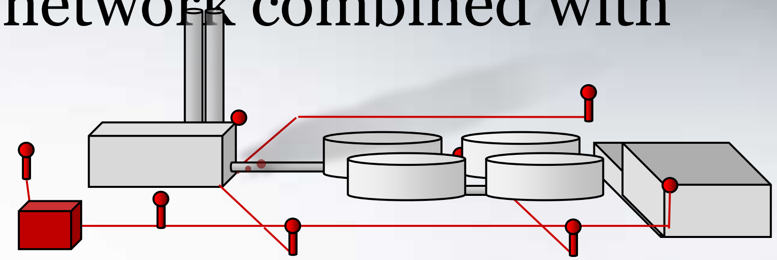
Inverse / Sensor Oriented Analysis

- Starting from measureable sensor data, what source(s) would reproduce observations?
  - Sensor data contains information about upwind concentrations
- Similar approaches used on continental scale since <1980s
- We are considering two classes of methods:
  - Statistical (trajectory based)
  - Adjoint (gradient optimization based)



What is the vision?

- Permanent concentration sensor network combined with wind direction and speed
  - Quasi-continuous operation
  - Directed maintenance to new leaks as they appear
  - Reduced costs and reduced emissions



- Current research focus:
  1. Detection system design
  2. Numerical testing and development of statistical source location algorithms
  3. Simulation and development of advanced, gradient adjoint based, quantification algorithms

- Detailed proof of concept simulations show ability to locate synthetic emission sources, within in a complex geometry, under a range of conditions
  - Adjoint approach shows potential to ultimately quantify sources, but still in very early phases of development

- Steady progress continues on developing field-ready sensors and strategies to efficiently implement source location algorithms
  - Next steps would include controlled release experiments

Matthew Johnson, *Canada Research Chair in Energy & Combustion Generated Pollutant Emissions, Associate Prof., Carleton University*

Future Wish List

Remote sensing equipment that MEASURES emissions

Companies are working on this but equipment completion date is unknown

Contact and Further Information

Roger Fernandez

Team Leader, U.S. EPA

Global Methane Initiative - Oil & Gas

Natural Gas STAR International

202-343-9386

fernandez.roger@epa.gov

Global Methane Initiative:

globalmethane.org

Natural Gas STAR:

epa.gov/gasstar