



Natural Gas Leakage Technology Forum

Mobile Monitoring for Rapid, Selective Natural Gas Leak Detection

Outline

- **Company Overview**
- **LGR's Solution**
 - Methane/Ethane analyzer
 - Leak Detection and Mapping Software
- **Sample Dataset**
- **Ongoing Development**
- **Commercial Details**

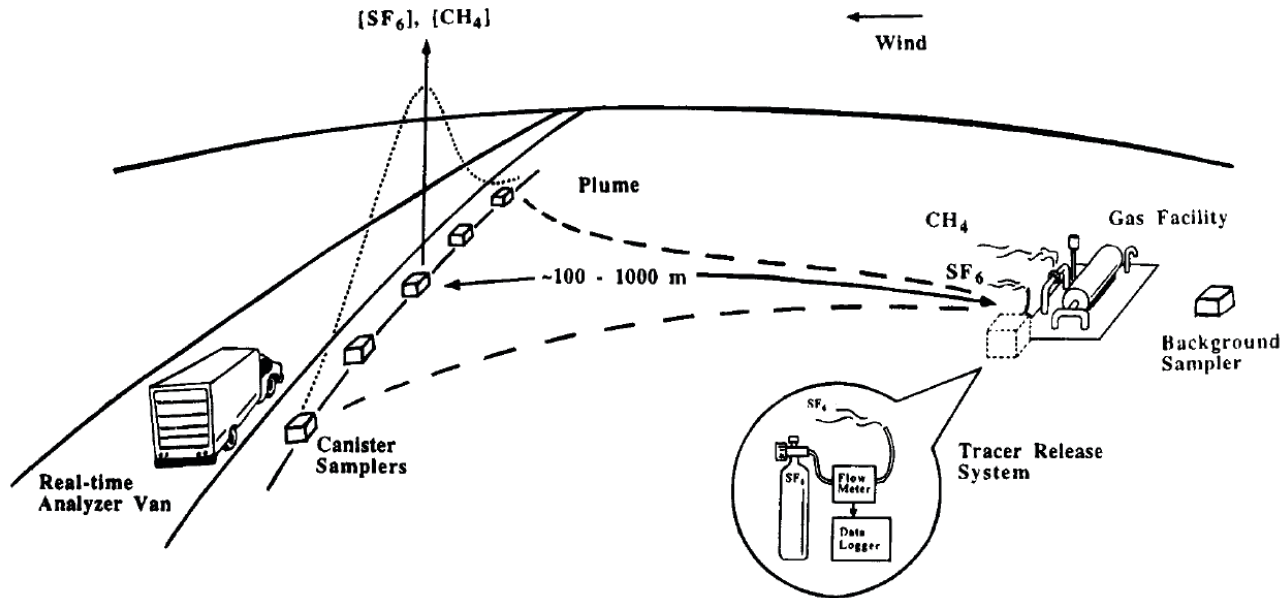
Company Overview



- **Founded in 1994, acquired by ABB in October 2013**
- **Located in Mountain View, California (Silicon Valley)**
- **Pioneer and world-leader in laser-based gas sensing**
- **Pioneers in "cavity enhanced absorption spectroscopy" (CRDS, Off-axis ICOS)**
- **Numerous patents granted for analytical methods**
- **Hundreds of publications in peer-review journals**
- **Target markets: industrial, environmental, research, medical**
- **Sold >1200 instruments on all 7 continents**

LGR Solution

Mobile Monitoring Requirements



¹Lamb, Brian K., et al. "Development of atmospheric tracer methods to measure methane emissions from natural gas facilities and urban areas." *Environmental science & technology* 29.6 (1995): 1468-1479.

- Vehicle-mounted sensors have a long history and have been extensively vetted
- Allows for cost-effective surveys of large areas at a rapid pace
- Requires:
 - Manufacturable, easy-to-use gas sensors that do not require researchers
 - Complete sensor suite - sensor, GPS, anemometer, gas inlet...
 - Data aggregation, analysis and interpretation - leak detection software
 - Data presentation - HMI

LGR Solution Overview



Off-Axis ICOS Analyzer
(Methane/Ethane)



GPS
(Location)



Sonic Anemometer
(Wind Speed/Direction)

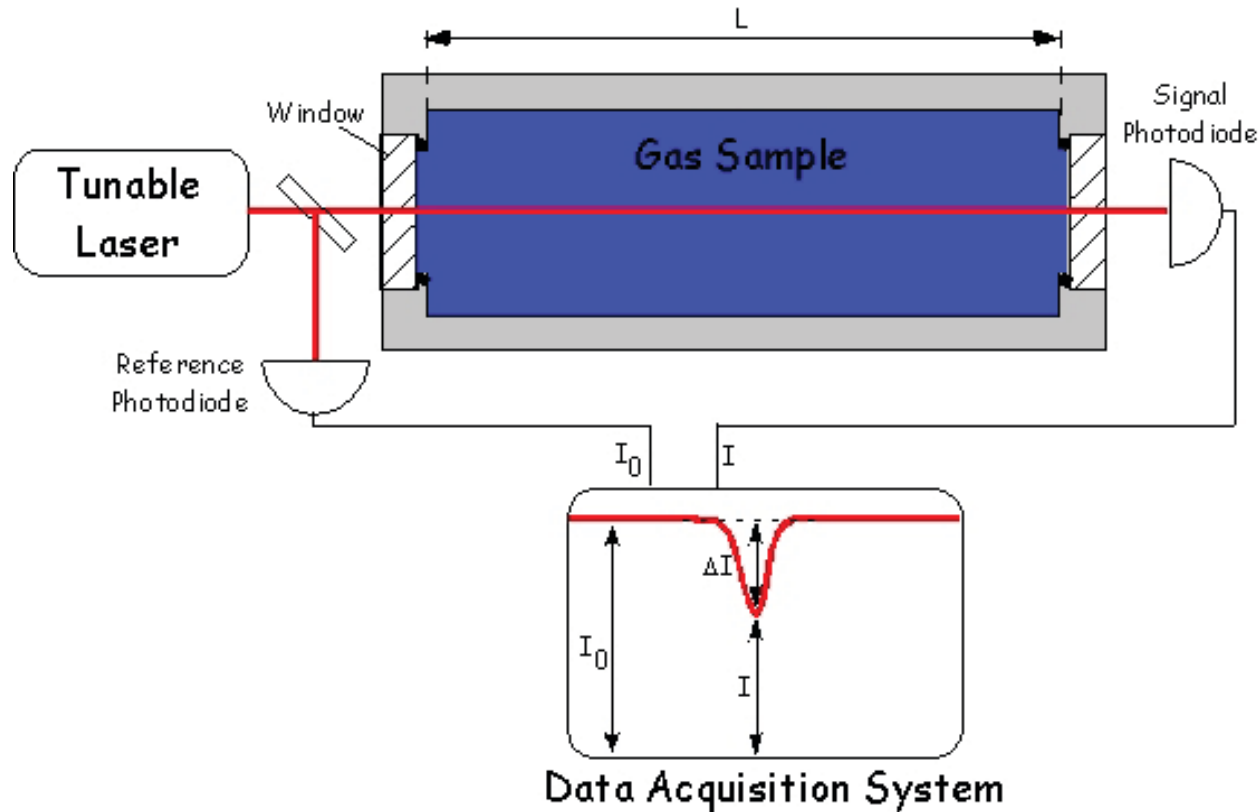


Computing
(HMI/Leak Detection Software)

Enables rapid identification of the size and location of natural gas leakage with high selectivity

LGR Solution

Methane/Ethane Analyzer – Conventional TDLAS



- **First-Principles Measurement** → little to no calibration required
- **Highly Selective** → only target molecule absorbs at probe wavelengths
- **Fast** → measure spectra at > 1 kHz
- **Robust** → utilizes solid-state telecommunications-grade lasers and detectors
- **Insufficient Sensitivity** → cannot measure low levels of methane and ethane

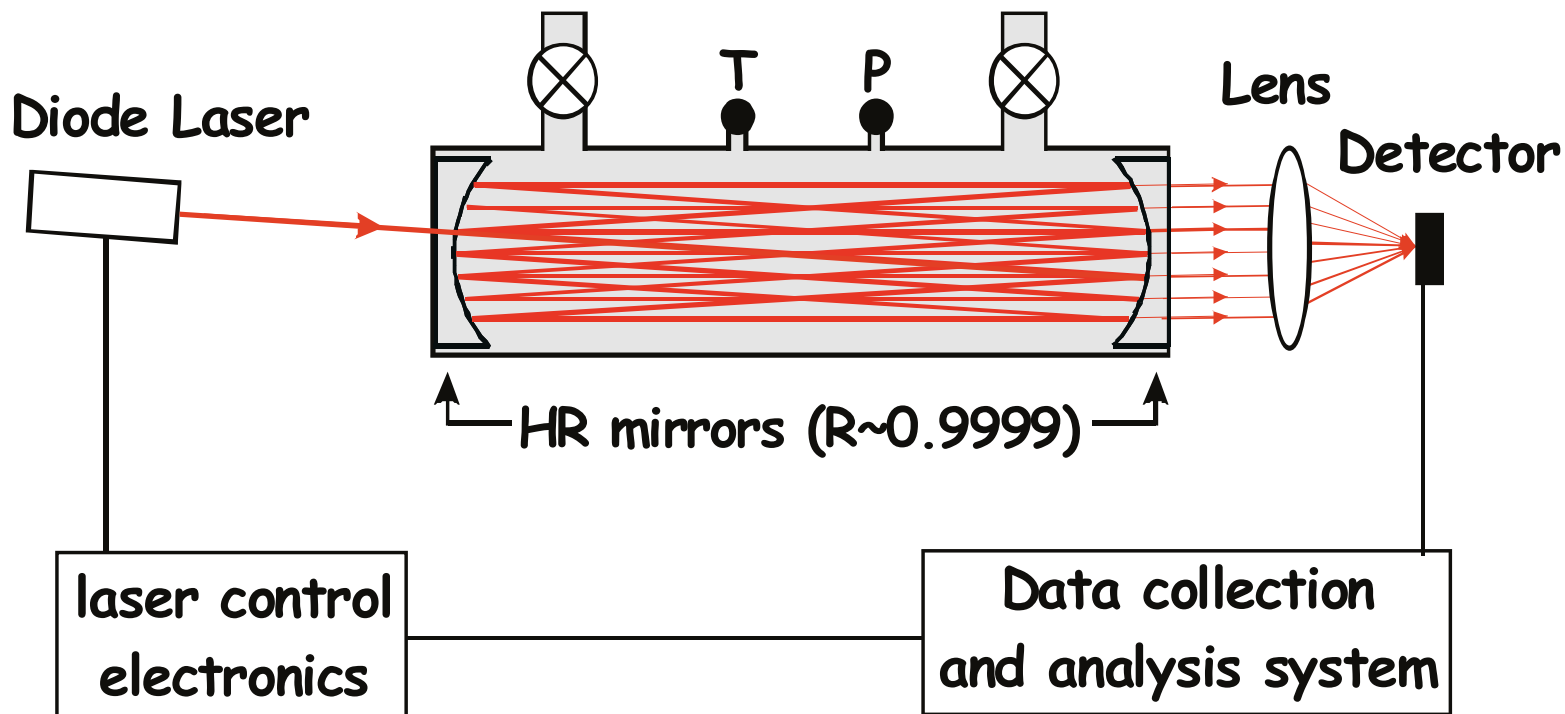
LGR Solution

Methane/Ethane Analyzer – Off-Axis ICOS

Gas Inlet

Gas Outlet

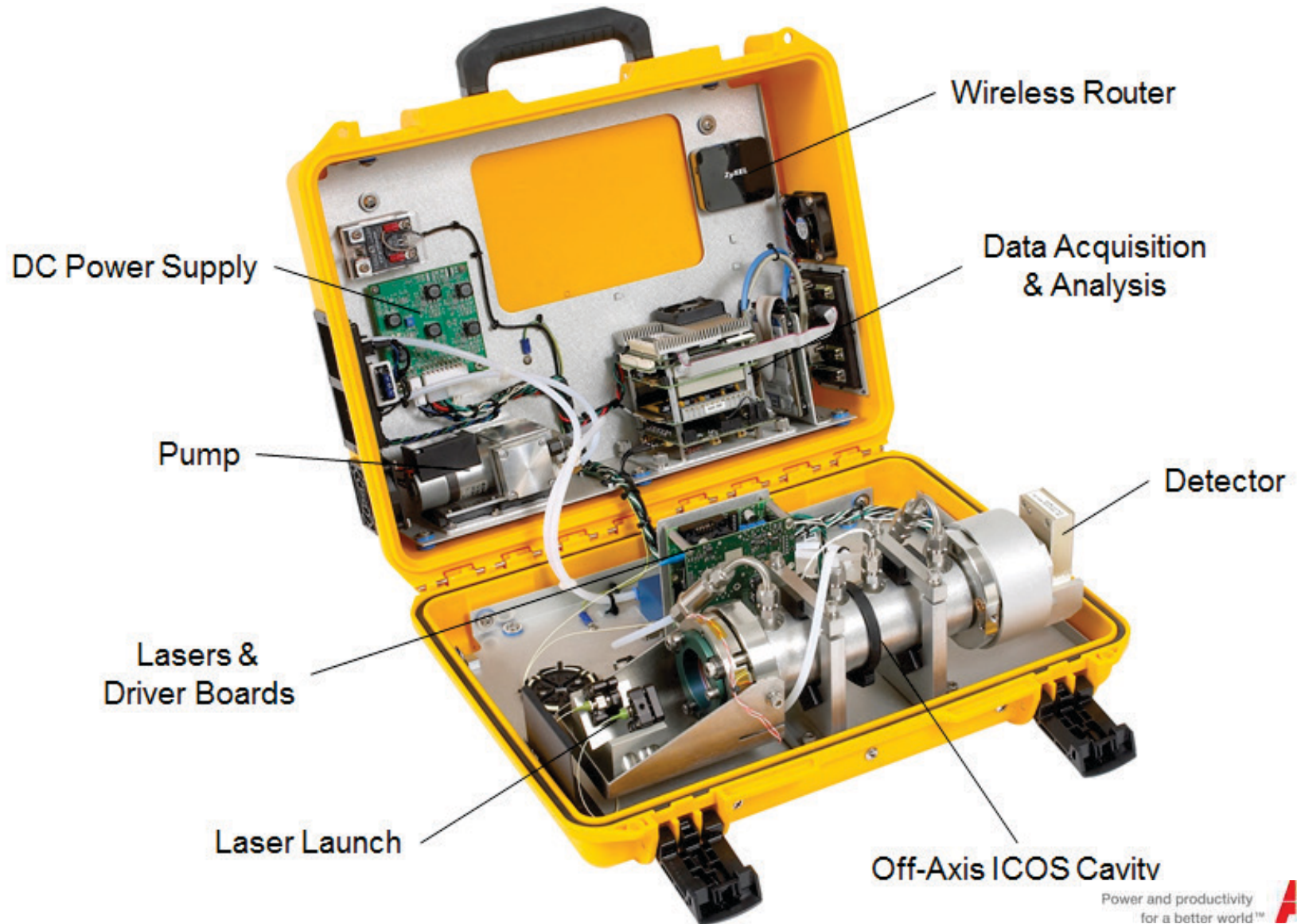
(to vacuum pump)



- Optical cavity provides effective pathlength of 1 - 100 km
- Increased dynamic range of 1,000 - 10,000
- Very robust - exact alignment is not critical, enabling mobile monitoring
- All advantages of conventional TDLAS, with increased sensitivity and dynamic range

LGR Solution

Methane/Ethane Analyzer - Instrument



LGR Solution

Methane/Ethane Analyzer - Performance

Feature	Specification	Advantage
Highly Sensitive	Methane: 2 ppb Ethane: 10 ppb	Observe and attribute small leaks from large distances
Fast Response	Response time of up to 5 Hz	Allows for driving speeds in excess of 40 mph
Highly Selective	No interferences from ambient compounds or higher hydrocarbons	No false positives
Calibration-Free	Utilizes Off-Axis ICOS – a first principles measurement technique	No need to calibrate the analyzer
Large Dynamic Range	Methane: 1 – 100,000 ppm Ethane: 0 – 100 ppm	Accurately quantify leaks independent of distance and size
Fast Warm-Up Time	Less than 2 minutes from power on to data collection	Improves uptime and efficiency
Low Power	Analyzer and pump only require 100 W	Can power from a standard car battery power point
Wide temperature range	Operates from -5 to +50 °C	Can be deployed in a wide array of environments

LGR Solution

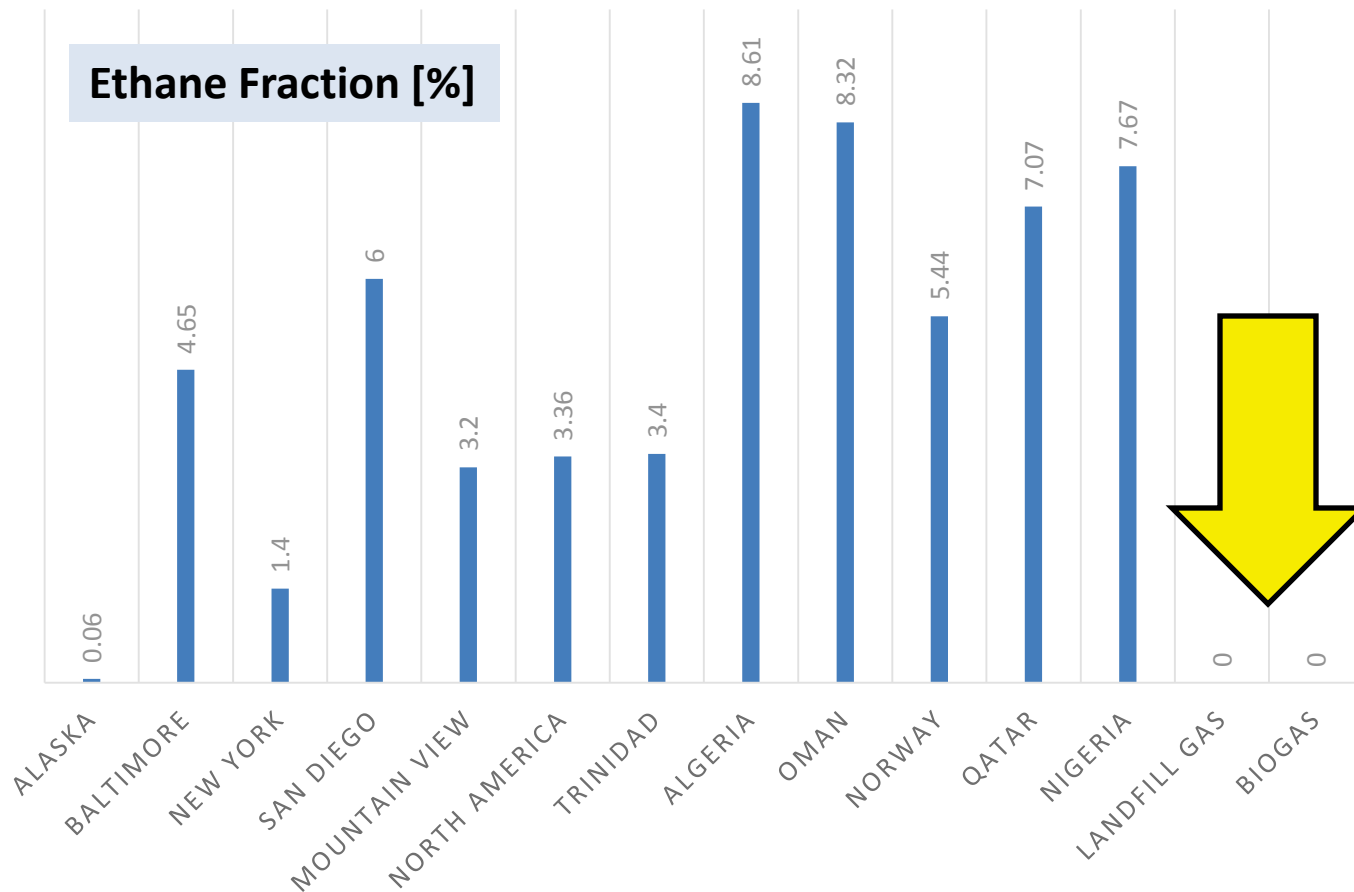
Methane/Ethane Analyzer - Robustness



- No temperature control required → fast warm-up
- No vibrational damping required → easy to mount
- Mirrors can be cleaned in the field → field serviceable
- Has been successfully deployed in harsh conditions on all 7 continents

LGR Solution

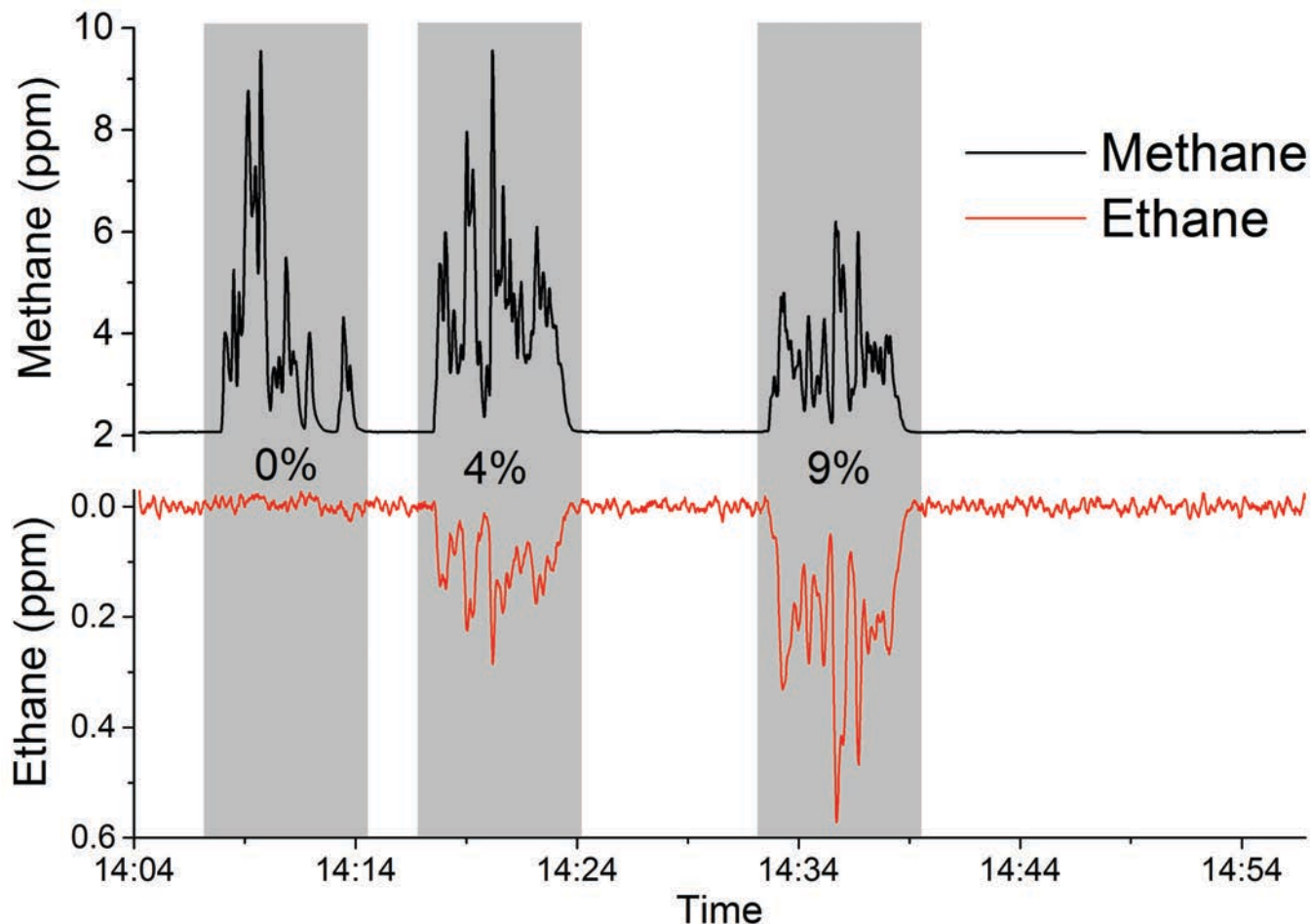
Methane/Ethane Analyzer – Why Measure Ethane?



- Ethane is a fingerprint of natural gas leakage not found in biogas
- Methane isotopes are not unique and ratios may change with soil migration
- In ethane-poor regions, system can operate in methane-only mode

LGR Solution

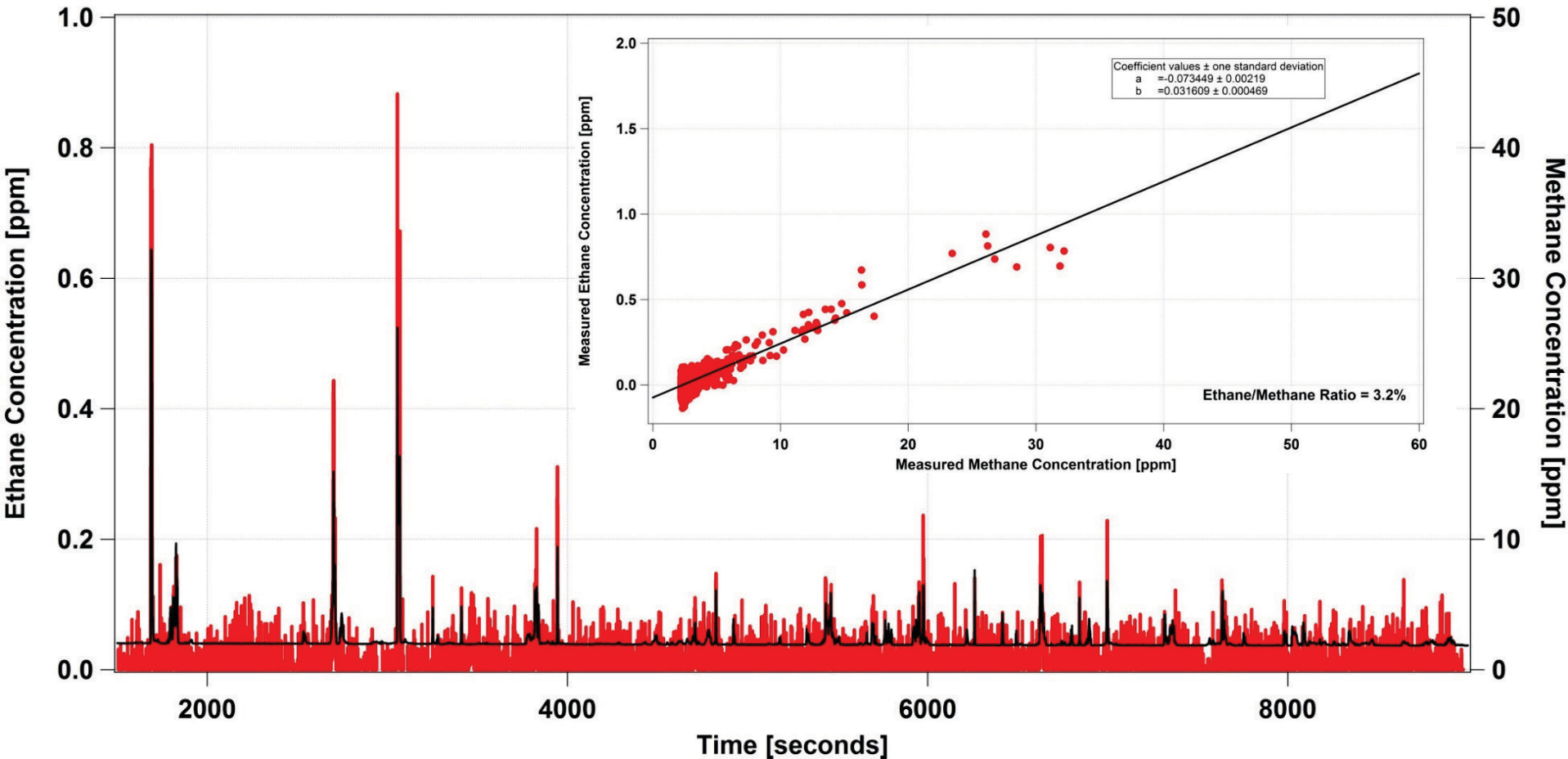
Methane/Ethane Analyzer – Controlled Release



- Controlled release of pure methane, 4% ethane/methane, and 9% ethane/methane
- Analyzer can readily detect ethane and quantify ethane/methane fraction

LGR Solution

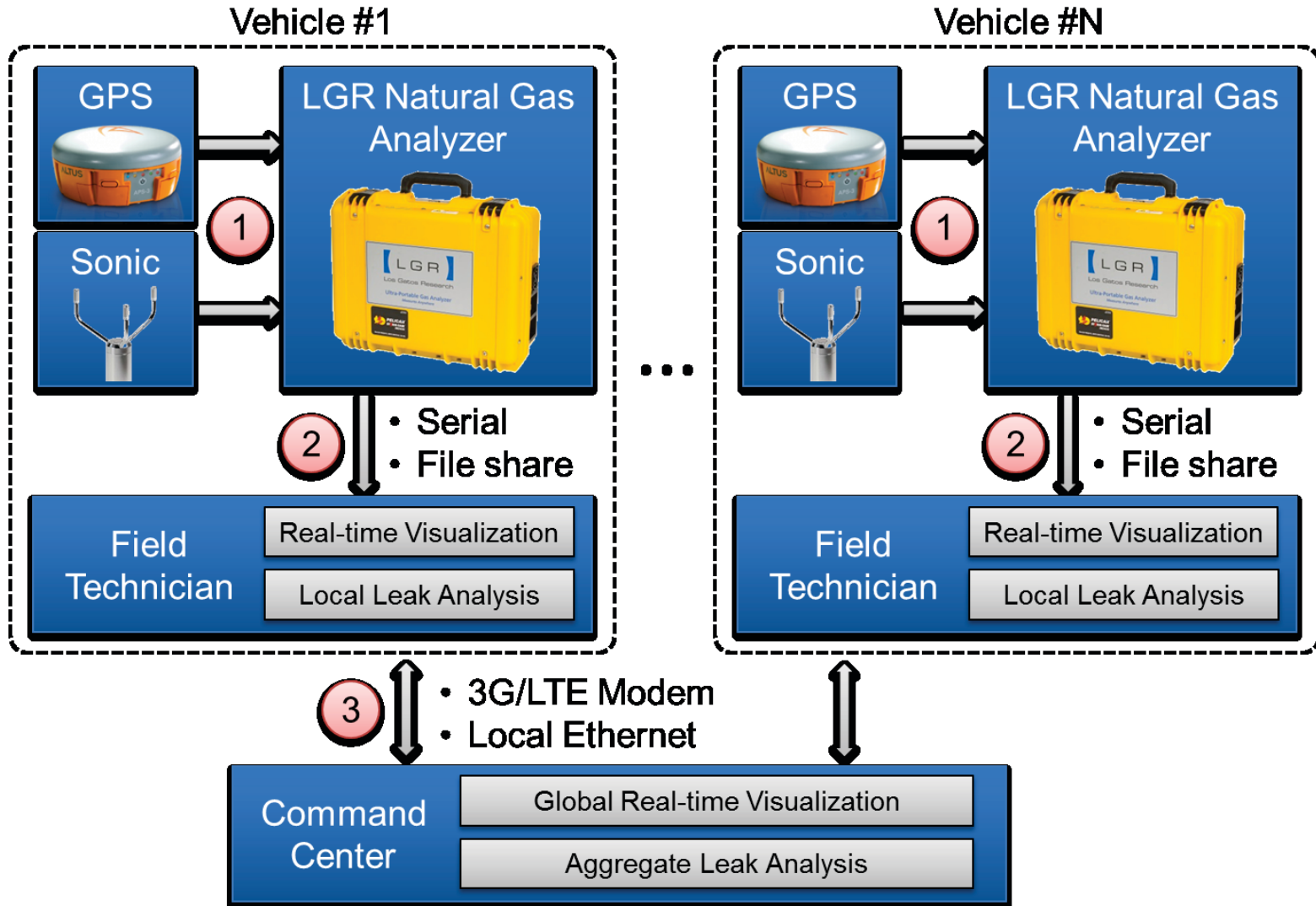
Methane/Ethane Analyzer – Preliminary Data



- Preliminary demonstration at PG&E training facility in Livermore, California
- Ethane vs. methane slope = 3.2%, matches PG&E natural gas composition

LGR Solution

Leak Detection Software – Overview



LGR Solution

Leak Detection Software – Administrative Screens

The screenshot shows the 'Data Management' screen in the LGR software. It features a sidebar with navigation options: DATA MANAGEMENT, USER MANAGEMENT, MILLHOUSE SETTINGS, ALARM, and CONFIGURATION. The main area displays a table of files for download from instruments. The table has columns for Filename, Instrument Id, Date, and Size. Below the table is an 'Import' button. At the bottom, there are status indicators: 'Real Time Stream disconnected', 'Notification: Millhouse execution triggered due to threshold violation of ch4', and 'Millhouse Execution'.

Filename	Instrument Id	Date	Size
sgp4r1911002_lgr-13-0204_2015-04-02_4599.zip	lgr-13-0204	Apr 8, 2015 1:30:53 AM	723kb
sgp4r425_lgr-13-0204_2015-04-01_0113.zip	lgr-13-0204	Apr 8, 2015 1:30:36 AM	3619kb
sgps_lgr-13-0204_2015-02-23_8000.zip	lgr-13-0204	Mar 5, 2015 3:00:07 AM	4423kb
sgps_lgr-13-0204_2015-02-24_8000.zip	lgr-13-0204	Mar 5, 2015 2:56:20 AM	4423kb
sgps_lgr-13-0204_2015-02-17_8000.zip	lgr-13-0204	Feb 26, 2015 4:32:19 PM	4423kb
sgps_lgr-13-0204_2015-02-18_8000.zip	lgr-13-0204	Feb 26, 2015 4:32:11 PM	4383kb
sgps_lgr-13-0204_2015-02-19_8000.zip	lgr-13-0204	Feb 26, 2015 4:32:04 PM	4423kb
sgps_lgr-13-0204_2015-02-20_8000.zip	lgr-13-0204	Feb 26, 2015 4:31:57 PM	4423kb
sgps_lgr-13-0204_2015-02-21_8000.zip	lgr-13-0204	Feb 26, 2015 4:31:52 PM	4443kb
sgps_lgr-13-0204_2015-02-22_8000.zip	lgr-13-0204	Feb 26, 2015 4:31:43 PM	4513kb
sgps_lgr-13-0204_2015-02-23_8000.zip	lgr-13-0204	Feb 26, 2015 4:31:31 PM	4423kb
sgps_lgr-13-0204_2015-02-24_8000.zip	lgr-13-0204	Feb 26, 2015 4:31:28 PM	4453kb
sgps_lgr-13-0204_2015-02-25_8000.zip	lgr-13-0204	Feb 26, 2015 4:30:58 PM	4451kb
1004_04012015_0002_ahack6d46	04810315	Feb 25, 2015 10:43:26 AM	3324kb

The screenshot shows the 'Alarm' screen in the LGR software. It features a sidebar with navigation options: DATA MANAGEMENT, USER MANAGEMENT, MILLHOUSE SETTINGS, ALARM, and CONFIGURATION. The main area displays a table of alarm events. A red banner at the top indicates 'Gas thresholds and system alarms occurred. Immediately estimate the severity of the problem'. The table has columns for Date - Time, Alarm Type, Value, and Threshold. Below the table, there is a status indicator: 'Connected to Instrument'.

Date - Time	Alarm Type	Value	Threshold
12/24/2014 - 14:30	CO ₂	2.125	2.4
12/24/2014 - 15:50	Pressure	140.045	144

The screenshot shows the 'Millhouse Settings' screen in the LGR software. It features a sidebar with navigation options: DATA MANAGEMENT, USER MANAGEMENT, MILLHOUSE SETTINGS, ALARM, and CONFIGURATION. The main area displays configuration options for the leak detection algorithm. The 'Select Algorithm' dropdown is set to 'LD'. The 'Auto-Trigger Calculation' is checked. The 'Auto Calculate every' field is set to '100' min. The 'Threshold' is set to 'Ch4 (3 ppm)'. The 'Data Source' is set to 'Real Time'. The 'Machine Name' is 'Machine1'. The 'Archival Data Source' is set to 'lgr-13-0204'. The 'Data Filters' section shows 'Start time' as '04/01/2015 10:30:23.698' and 'End time' as '05/30/2015 10:36:31.842'. The 'Time of Day' filter is set to '0.24' hrs. The 'Concentration Filter' is set to 'Ch4 (2 ppm - 100 ppm) Gas Pressure (130 Torr - 260 Torr)'. The 'Wind Speed' filter is set to '0.0 100.0' mph. There are 'Save' and 'Cancel' buttons at the bottom.

- Login screen with access levels
- Data management
- Alarm setpoints and readouts
- Leak detection settings

LGR Solution

Leak Detection Software – Measured Time Series

LGR

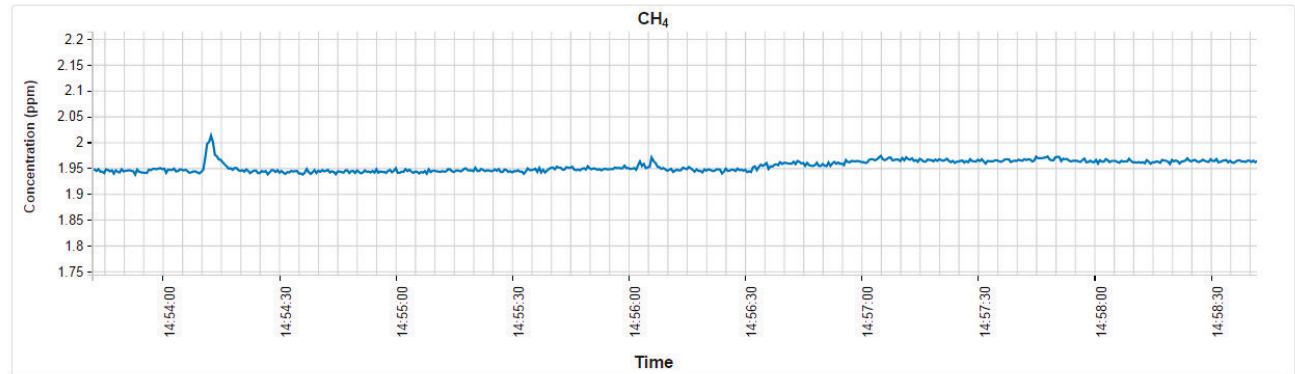
System Gas  

TIME SERIES MAP SETTINGS

Select to draw graphs

- CH₄
- H₂O
- CO₂
- CH₄ Dry
- CO₂ Dry
- Gas Pressure
- Gas Temperature
- Ambient Temperature
- Wind Speed

Time Series



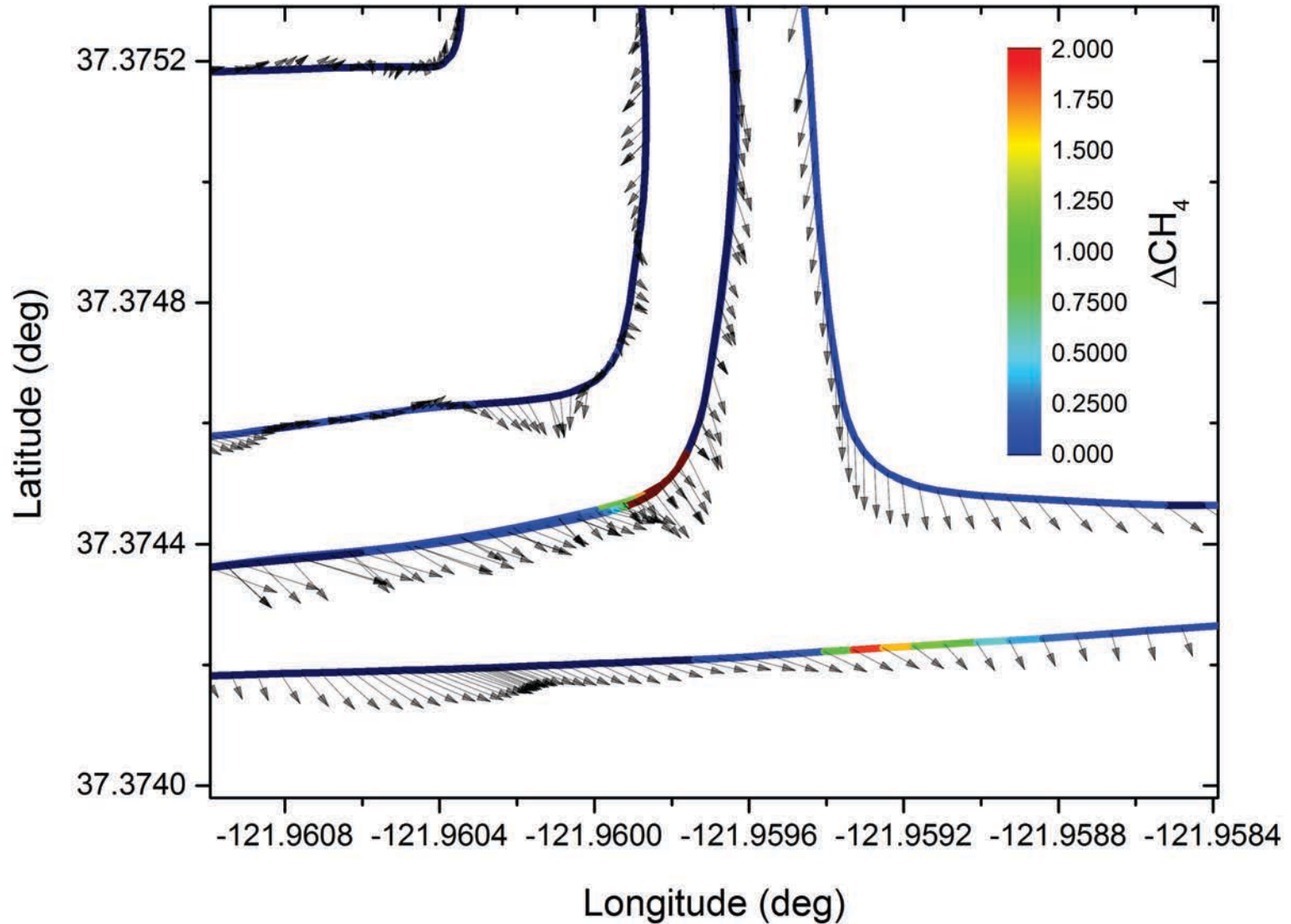
 Real Time Stream disconnected

Notification: Millhouse execution triggered due to threshold violation of ch4_dry

Millhouse Execution 

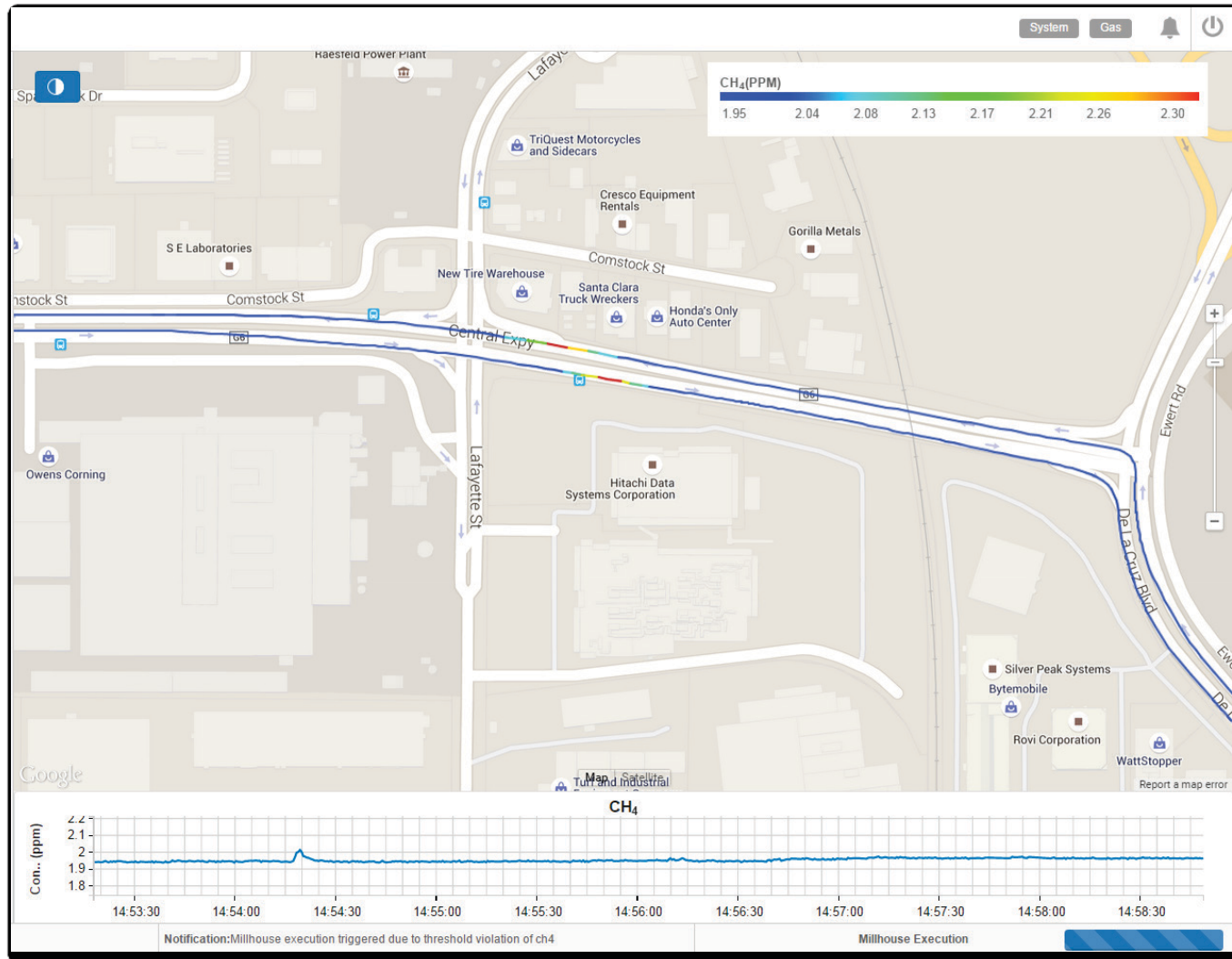
LGR Solution

Leak Detection Software – Raw Measured Data



LGR Solution

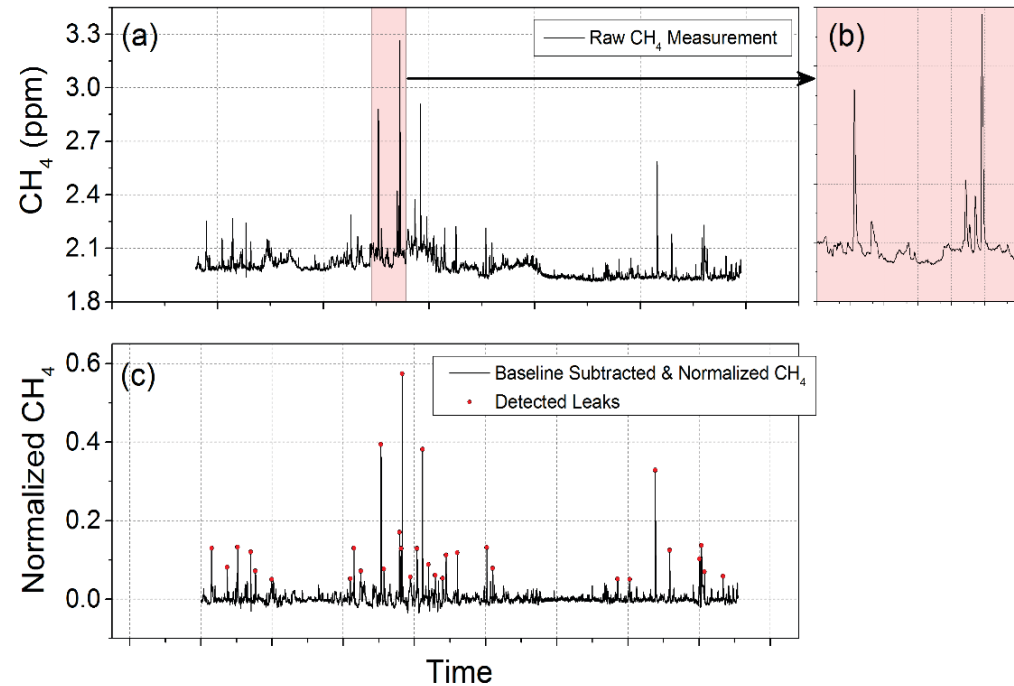
Leak Detection Software – Map View



- Wind vectors removed for clarity
- User selectable display variables

LGR Solution

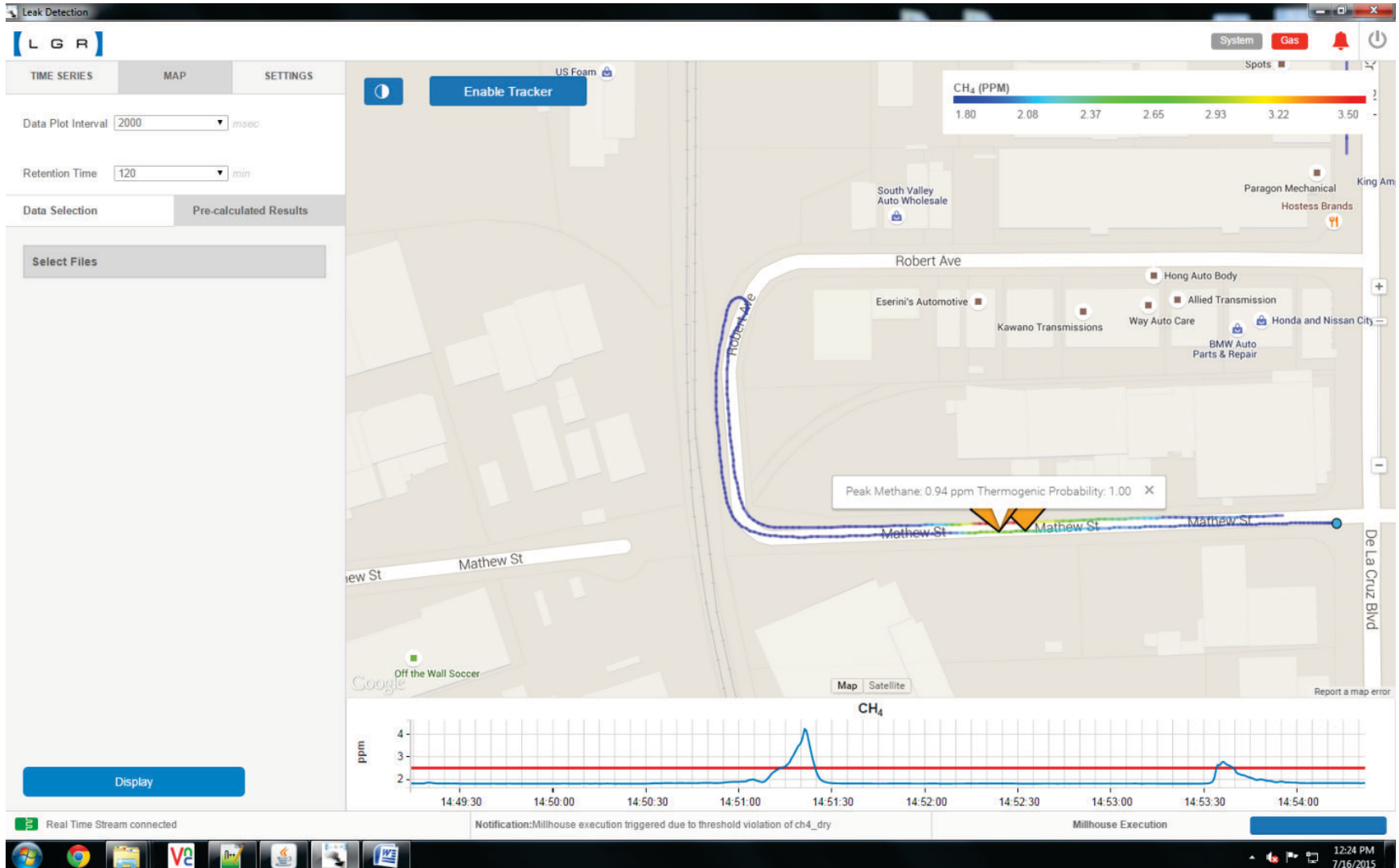
Leak Detection Software – Simplest Leak Identifier



- Remove slowly varying background changes in methane
- Identify significant methane peaks (user determined)
- Mark peaks by location and amplitude
- Not using wind vector information

LGR Solution

Leak Detection Software – Leak Representation



LGR Solution

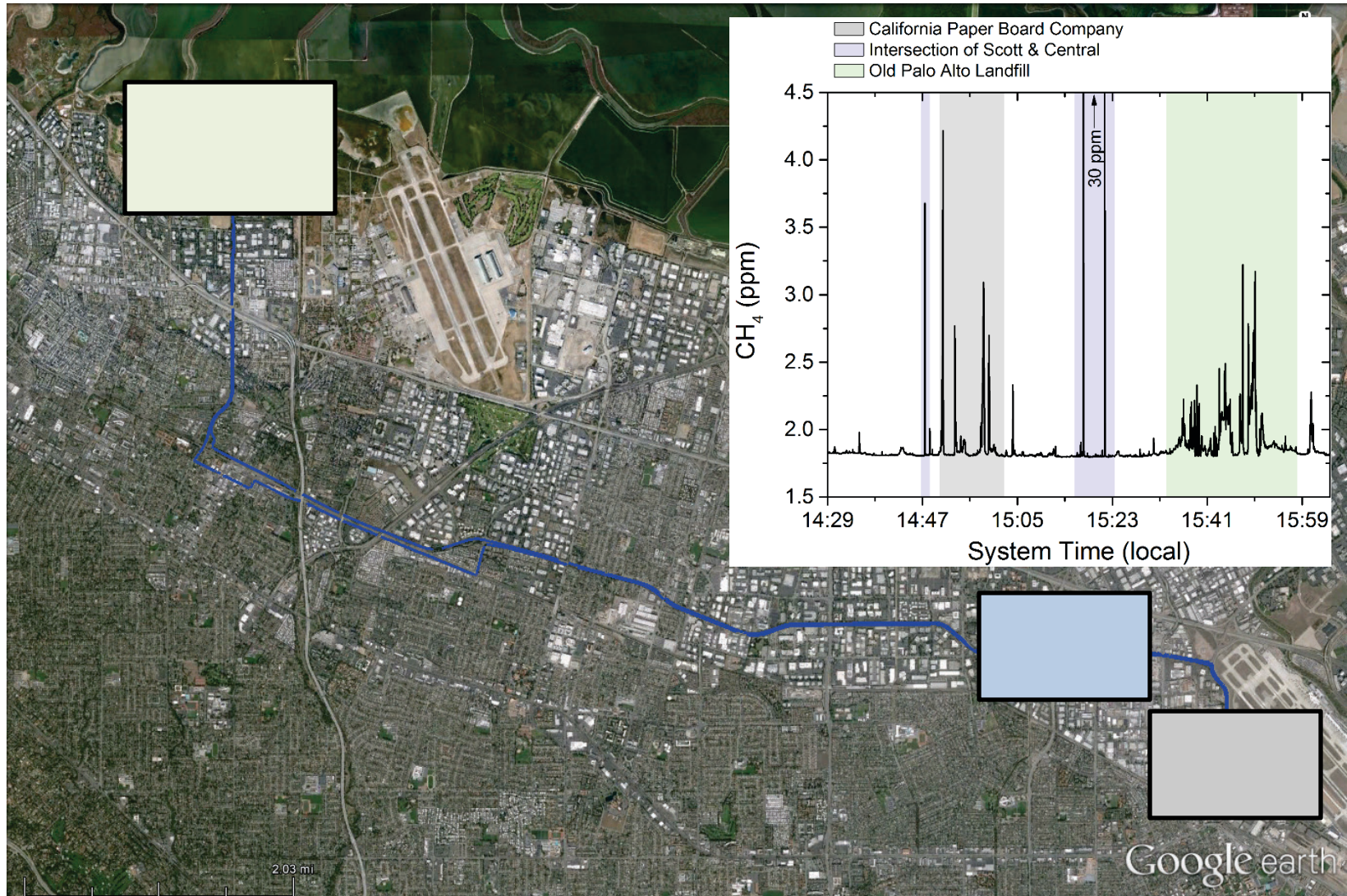
Leak Detection Software – Report Generation

Identification #	Longitude	Latitude	DCH4	P(Ethane!=0)	Wind Direction	Wind Dir Error
1	-121.9592	37.3742	1.1959	0.1707	323.3522	20.9102
2	-121.9437	37.3634	2.4051	1.0000	350.7418	17.8192
3	-121.9437	37.3634	0.9446	0.9996	352.7219	22.3281
4	-121.9436	37.3634	1.2156	1.0000	355.8145	12.8568
5	-121.9431	37.3634	0.5092	0.9968	13.1709	20.9858
6	-121.9597	37.3746	27.8146	1.0000	312.0846	19.9007
7	-121.9598	37.3745	9.6297	1.0000	304.5190	23.7575
8	-122.0707	37.4283	1.3830	0.5725	294.4153	5.3405
9	-122.0707	37.4283	0.9000	0.3775	266.0482	13.7702
10	-122.0706	37.4284	0.6802	0.2359	294.2117	8.2749
11	-122.0706	37.4284	0.8830	0.7481	275.8201	6.3103
12	-122.0709	37.4283	1.2796	0.5062	279.1875	5.0638

- Raw Measurement output - GPS, methane levels, ethane levels, wind direction, wind speed, diagnostics information
- Processed text output - analysis settings, driver info, time/date, system info, leak position, leak amplitude
- Custom User Interface - interactive maps and printable maps with GPS coordinates
- High degree of report configurability

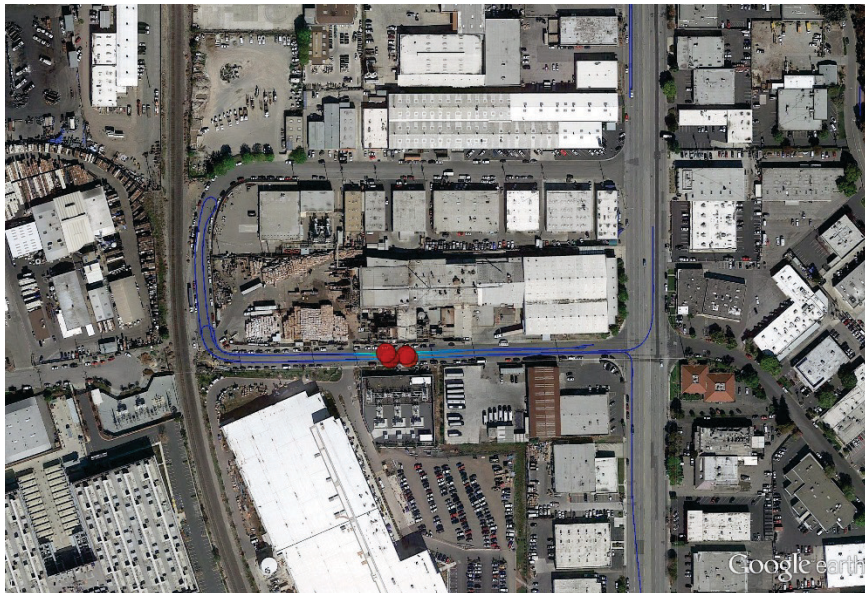
Sample Dataset

Drive with 3 Leak Locations



Sample Dataset

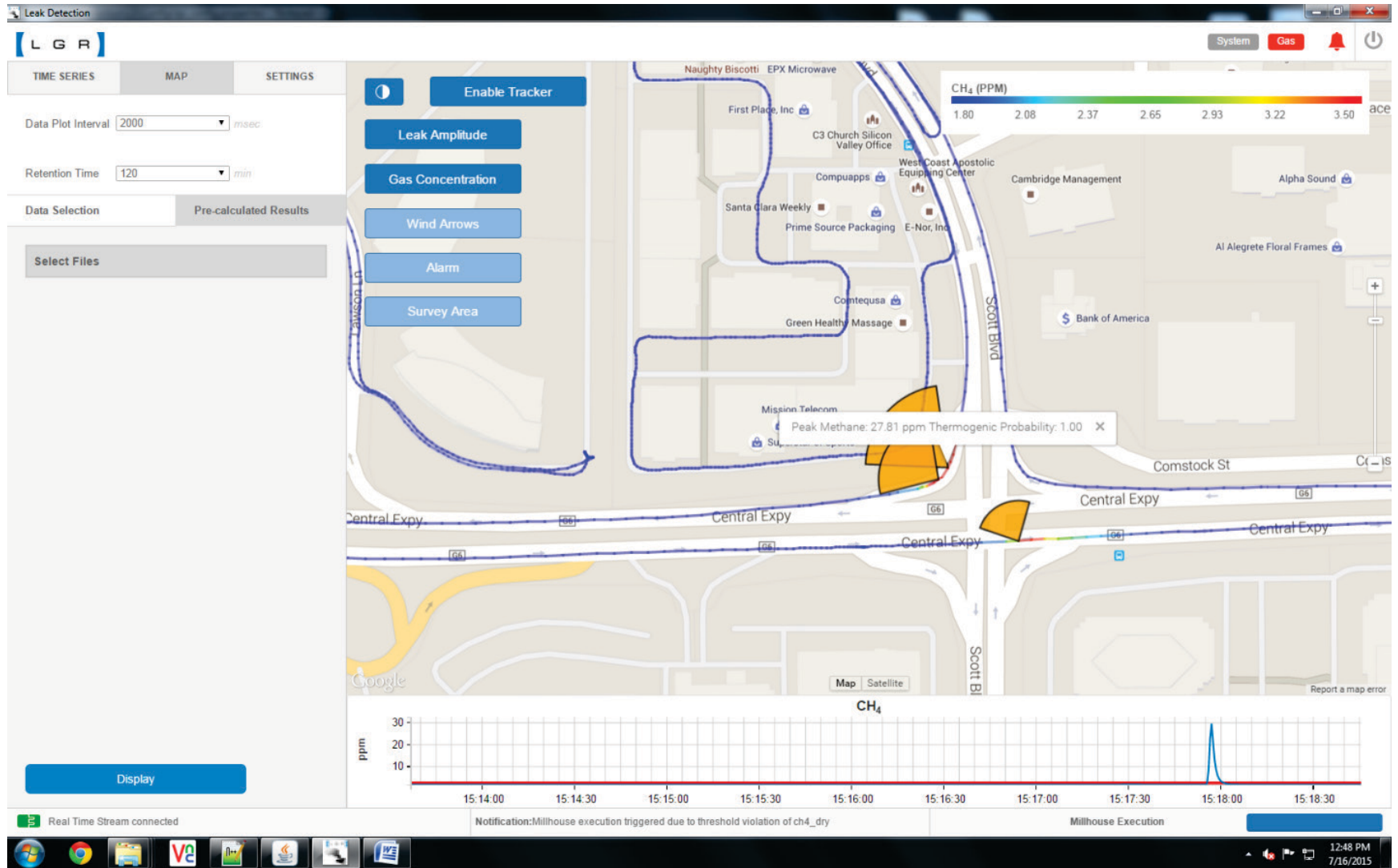
Expanded View of Leak Locations



- 3 distinct methane leak locations
- Simplified leak detection algorithm
- Use ethane measurements to identify natural gas leaks

Sample Dataset

Leak Location Identification



Ongoing Development

- **Improved natural gas diffusion models**
 - Estimate leak distance
 - Account for gas diffusion under real-world conditions
- **Continue to improve user interface based on customer feedback**
- **Further improve ethane detection sensitivity**
 - Attribute small methane peaks
- **Integration with GIS**
 - Pipeline data

Commercial Details

- **Cost-Competitive**

 - Cost per identified leak is very low

 - Minimized false-positives due to simultaneous methane/ethane measurements

 - Highly cost-competitive versus other mobile technologies

- **Demonstration field tests are welcome**

- **Data is owned by the customer**

 - LGR provides complete hardware solution

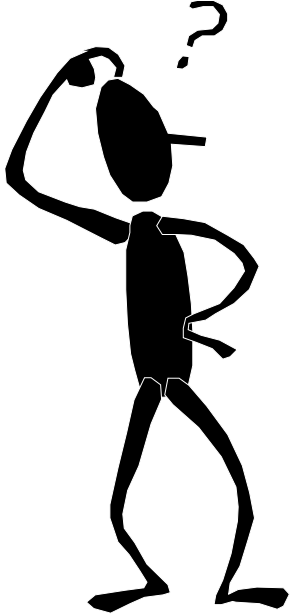
 - Data is acquired, held, and owned by the customer

 - LGR offers software solutions to analyze the data and identify leak locations

- **LGR solution can be tailored to customer need**

 - Optional components include sonic anemometer, vehicle communication, and networked data center

Questions?



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