Trusted Partner of Utilities Everywhere

Emerging Advanced Leak Detection and Emission Technologies – Best Fit for LDC's

Presentation to:

14th Annual KGA EXPO

Alnoor Ebrahim
Director Products and Technology

Agenda

Introduction

- Regulatory and Industry Challenges
- Definition – What is Advanced Technology?
- Landscape Today
- Emerging Technologies for Leak Detection and EQ
- Technical and Workflow / Survey Considerations

AMLD Platform Overview – Good Choice for LDC

- AMLD Platform and Analytics
- Methodology and Survey Process
- Leak Survey
- Emissions Quantification

AMLD Operational Insights – What to Expect

- Planning the Leak Survey and EQ Process
- Lessons Learnt

SPARUS

Southern Cross

Southern Cross is a well-known field services organization with a 75-year history in the utility industry. Headquartered in Peachtree Corners, GA, Southern Cross works throughout the nation providing traditional inspection, utility locating, and meter services to gas, electric, and water utilities.

Spear Group

The Spear Group is a professional services organization that provides capital project execution services. The Spear Group has partnered with companies in a variety of industries, including gas and electric utilities pharmaceuticals, and various other industrial organizations.

NAFS

North American Field Services (NAFS) is a union workforce that complements your projects large and small with all necessary positions. NAFs provides field services from leak survey, locate and mark, pipeline integrity, demand response, stray voltage, and many others.

OneVision

OneVision Utility Services has been a top tier Damage Prevention and Locating service provider for many years. Founded in Atlanta, GA, OneVision continues to expand their footprint throughout the Southeast.

ULS

United Locating Services (ULS) is an industry leader in underground utility locating and damage prevention services. Headquartered in Missoula, ULS' highly skilled workforce operates across multiple states

TruCheck

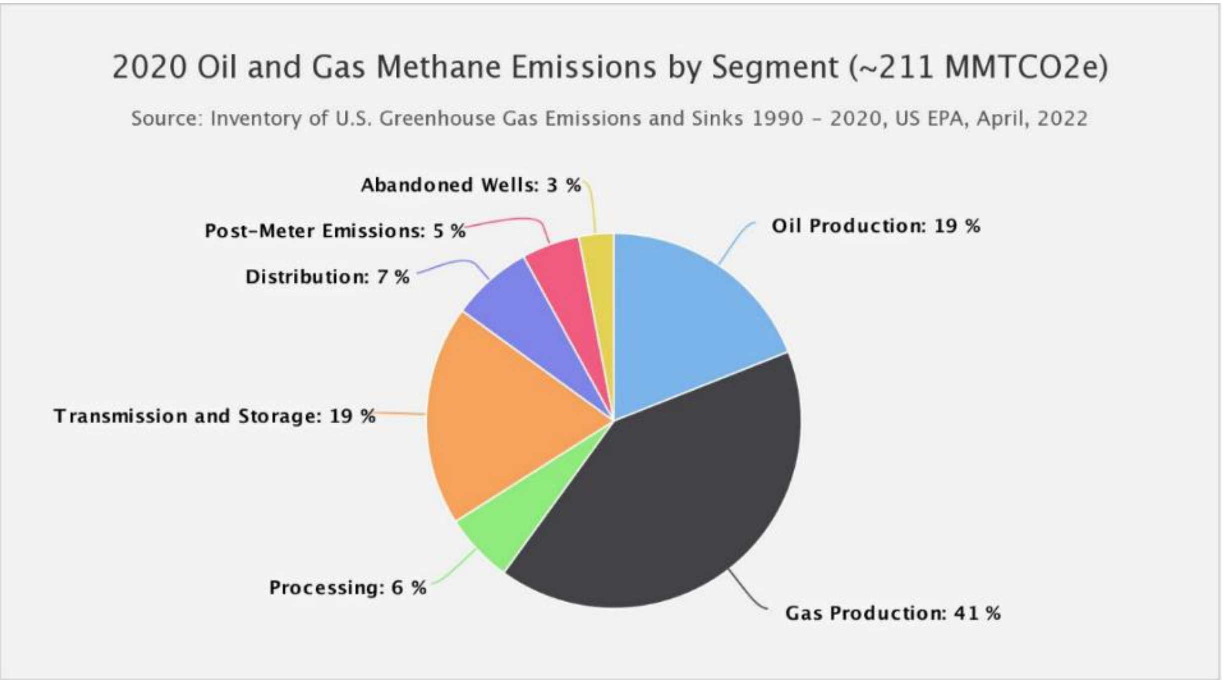
TruCheck is a national contract services organization based out of Somerset, KY, is a provider of meter installation, meter reading, and related field services to municipal, investor-owned, and cooperative utilities.

Allegiant

Allegiant Utility Services is based out of Manor, TX and has been providing meter services to rural electric cooperatives and municipalities for 25 years. They specialize in installation, network deployment, electric meter renewing, demand response, testing, inspection, configuration services, and more.

Introduction - Why Worry about Methane?

- Methane is a major component of natural gas -- about 95%.
- Methane (CH_4) is a potent greenhouse gas (GHG) and represents about 10% percent of all anthropogenic GHG emissions.
- Methane has the capability to trap about 86 times more heat in the atmosphere more immediately over the first 20 years than carbon dioxide (CO_2).



Methane Emissions placed in a Center Stage – Reducing Emissions:

- Easiest and fastest way to reducing overall GHG emissions in the short term
- Provides pipeline and gas infrastructure safety
- Protects people and property
- Enables environmental stewardship

Public Focus on Methane Reduction Initiatives

COP26 Global Pledges

- **Over 100 countries** representing more than 85% of the world's forests committed to halting and reversing deforestation and land degradation by 2030.
- **105 world leaders signed** onto the Global Methane Pledge, a U.S. and EU joint initiative to cut methane emissions by 30% by 2030.

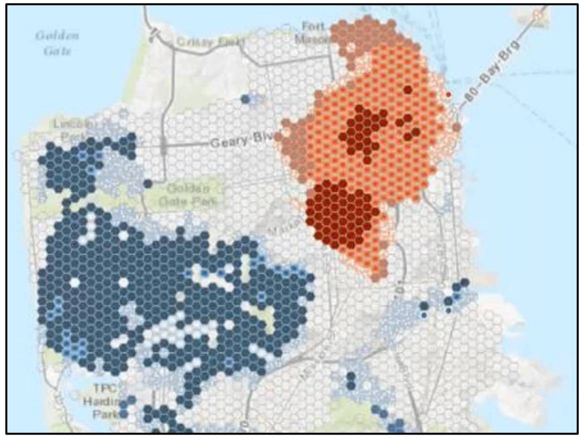
Department of Energy

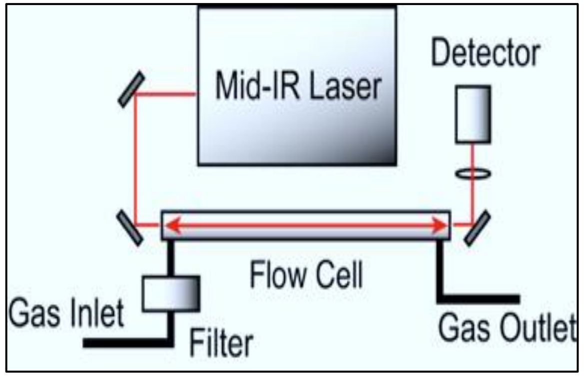
DOE Awards $35 Million for Technologies to Reduce Methane Emissions

DECEMBER 2, 2021

Definition – Advanced LDAR and EQ Platforms

1. **SURVEY METHODS:** Different Survey Methodologies compared to traditional walking methods – e.g., AMLD does multiple passes over three nights indicating presence or absence of gas
2. **SENSORS:** High sensitivity, measures in parts per billion (methane/ethane) – many different types.
3. **PLATFORMS:** Non-traditional platforms – UAV, Vehicles, Airplanes, Helicopter and Satellites etc.
4. **COVERAGE:** Ability to sense from a distance and survey large swaths of network
5. **DATA STORAGE:** A secured Database to house survey data for multiple post survey analysis
6. **AI-POWERED:** Software Analytics to compute spatial analysis, leak indications, ranking, other statistical criteria and emissions quantification. Incorporates aspects of Machine Learning and AI for predictive analysis





Challenges

- **Gas utilities are being challenged to reduce methane emissions**
  - Pipes Act 2020 – explore ALD technologies
  - ESG Objectives (net-zero at some point) – decarbonized economy
  - COP27 – 105 countries pledge to cut methane emissions by 30%
  - Voluntary Consortiums – OGMP, GMI, OGCI etc.,

- **Cost can be a major impediment.**
  - Procuring these newer technology platforms and skilled personnel can present a financial challenge – especially for organizations with limited budgets.

- **Lack of standardized methodologies can be a barrier**
  - Many new technologies and methods – last decade has seen rapid growth of LDAR and EQ technologies.
  - Different Survey Methods and EQ estimates approach
  - Many units of measurements e.g. scfh, Mscfd, kg/hr, m^3/d, l/m

- **Data Intensive Environment - New Skill Sets Required**
  - Can't measure it – can't manage it
  - Spatial analytics Needed (environmental, GPS etc data)
  - AI and Machine Learning

Landscape Today

1. **HUGE INNOVATIONS:** The last decade has seen many new technology innovations in sensors, platforms and analytics for LDAR and Emissions Quantification. These include laser-based handhelds, AMLD, UAVs, Airborne and Satellite Platforms and Continuous Monitoring Systems. We expect this trend to continue going forward.

2. **RAPID ADOPTION:** Many of these technology platforms are seeing rapid adoption across the supply chain. e.g., AMLD now approved for compliance survey in 15+ states. ***Airborne and Satellite detection platforms are beginning to be used commercially – despite lack of regulations proving value of the technology***

3. **TIERED APPROACH:** Multiple technologies (tiered approach) are also being used in many cases. e.g., AMLD plus ground crew or Satellite/AMLD/Ground crew. Different sections/segments of the supply chain will require different type of technologies platforms – no one size fits all scenario.

Much Work Still Needs to Be Done to Standardize these Technologies

Southern Cross

Example – Southern Cross Approach (Leak Detection Solution Set)

SC Preferred Equipment

- Irwin laser based handheld leak survey unit
- Multi-Gas and personal safety handheld units
- Partner solutions
- Mobile survey unit fitted with preferred equipment



Client-Required Equipment

- Remote laser solutions
- Other approved survey equipment (Airborne platforms)
- Client Software

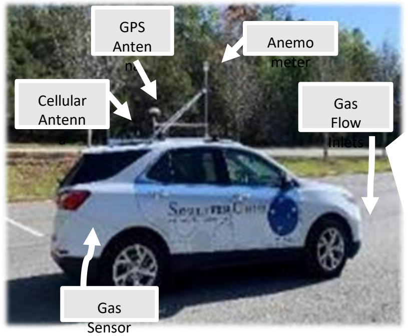



AMLD Solutions (Advanced Mobile Leak Detection and EQ Platform)

- Extended range high sensitivity sensors combined with data analytics
- Additional investigation for pinpointing
- Emissions Quantification
- Quality assurance

SC Software

- Tracking of workforce
- Validated performance against GIS data
- Leak tracking and quantification

Technologies Today – Methane Detection and EQ

Top Down

Country-wide, Global

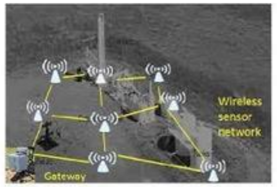


Figure 2. Wireless sensor network forming a mesh network on a well

Continuous Monitoring Fixed Network

Satellite
(High Minimum Detection Threshold)

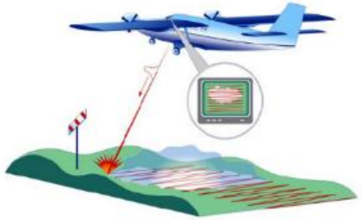
Satellite Based Systems

Large Areas, Regional

UAV

Helicopter

Airplanes



Airborne Based Systems

Large Areas, Regional

AMLD (Vehicle Based)

Vehicular Based Systems

Single Source

OGI Camera

Ultrasound

Laser

Hi-Flow Samplers

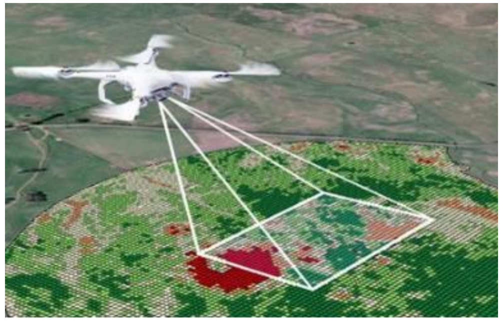
RMLD

Ground Based Systems

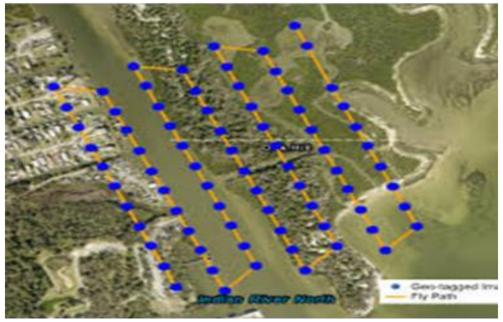
Bottom Up

Technology and Workflow/Survey Consideration

- **Survey Methodology and Operational Conditions:** Different types of technologies use different survey methodologies and work practices. Hence leak indications, flow rates, underground leaks versus meter set leaks and costs can vary widely.
  - Number of passes per asset point and time to survey
  - Day/night data capture
  - Coverage area and Gaps
  - Platform speed and height
  - Cloud Coverage, Wind speeds, Rain, Snow
  - Leak Pinpoint Accuracy (Leak Indications – how close to the source)



- **Detector Sensitivity:** Each technology operates using different types of sensing mechanisms – Laser Spectroscopy, LiDAR, imaging spectrometry, Hyperspectral Camera, Optical Imaging etc.
  - Detection Sensitivity – size of leak that can be detected by a technology
  - Minimum Detection Level (MDL) of a leak or Detection Sensitivity
  - Probability of Detection - PoD (per detection sensitivity)
  - Source Attribution - Probability of Natural Gas versus swamp Gas (Methane / Ethane Ratios)



- **Analytics and Software Algorithms:** Each type of technology uses different types of analytics for generating leak indications and estimating methane flow rates. Some capture environmental data such as wind speeds and directions, others do not. Hence wide differences in estimation errors, spatial resolution.

- **Emissions Quantification** - Same Survey Data for both LDAR and EQ ? – Different Analytics and Algorithms and approaches can produce different results.

SOUTHERN CROSS

Careful Considerations Must be Given to Various Technologies

One Good Choice – Vehicle Mounted Sensors + Analytics

1. Using parts per billion sensor technology gives us the ability to detect the smallest of all leaks. Minimum Detection Threshold – Many other technologies don't have a low detection level; cannot see a large number of the smaller leaks

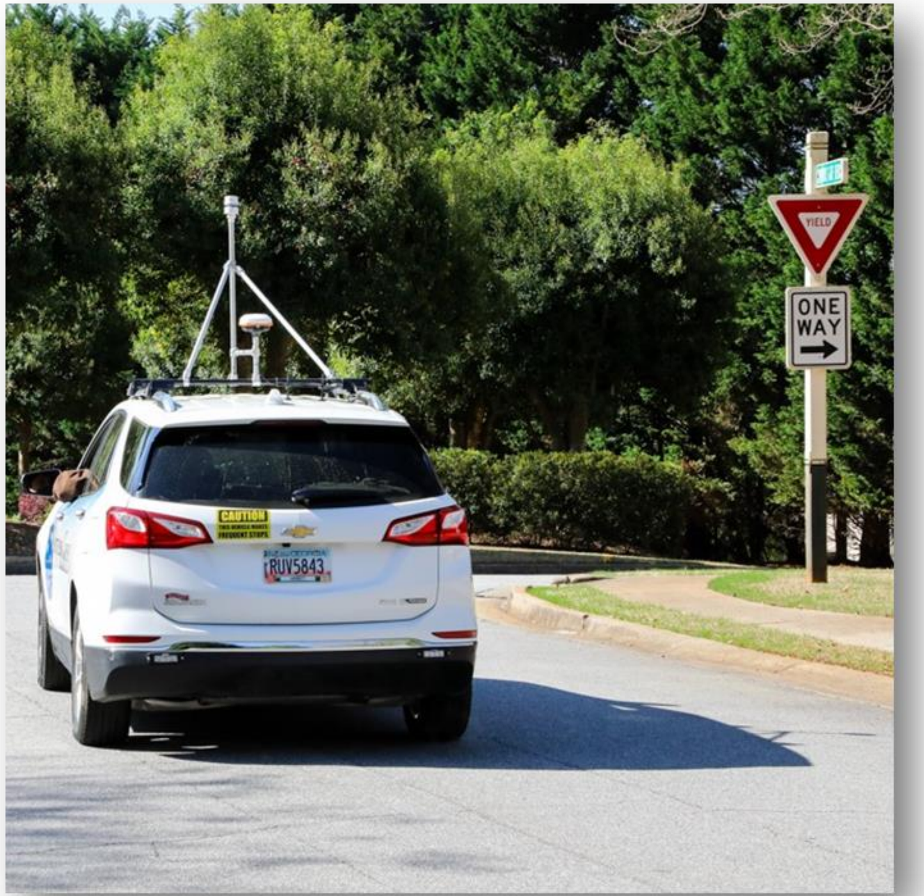
2. The data collection methodology of multiple drives and at least six passes past any asset point gives a very highest probability of not missing any leaks.

3. Closer to the source of the leak: the AMLD systems will always be closer to the source of the leaks than any other technology platform.

4. More cost effective that air-borne or space-borne systems

5. Fast surveys, Scalable and cost-efficient platform to survey large swaths of the network.

6. Ability to use Survey data for Leak survey, Emissions Quantification and supplementary recent data for pipeline replacement program.



AMLD & EQ Platform

Gas Sensor
- Ethane/Methane detection
- Parts-per-billion (ppb) sensitivity

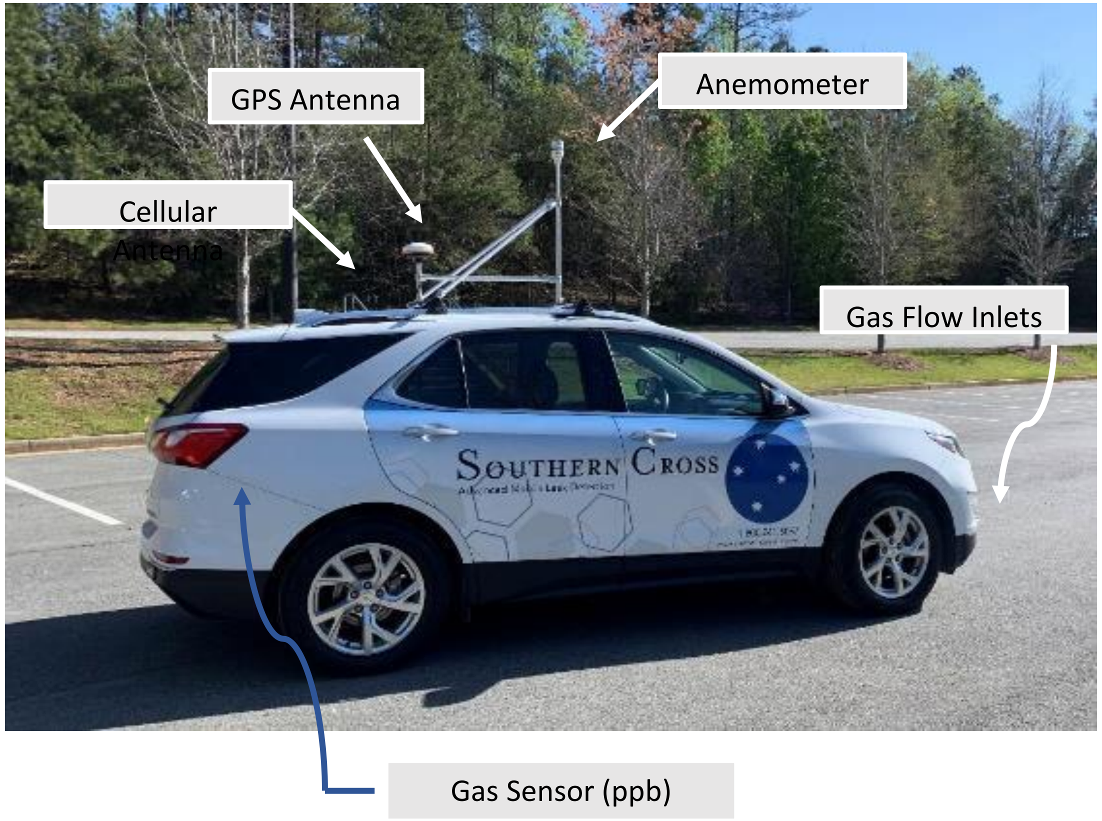
Wind Sensor
- Sonic Anemometer

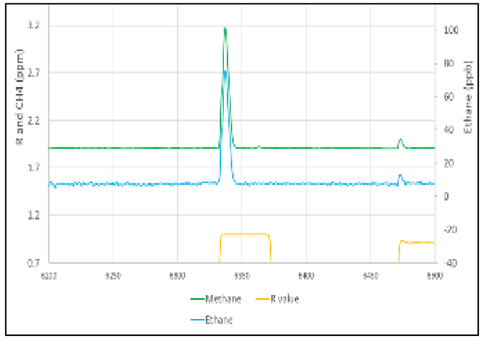
GPS Sensor
- High-precision location information embedded to all data

Auxiliary Systems
- Wireless modem for prompt data upload to the cloud
- In-car Driver tablet

Analytics
- Combine data from multiple drives
- Generate Gas Indications with GPS Coordinates
- Technician dispatching system for further investigation

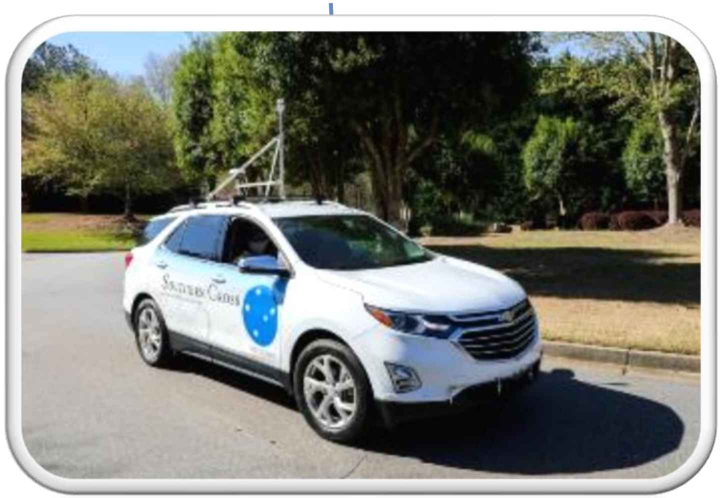
Outputs can be prioritized by:
- Magnitude of gas, Frequency of detection, etc.
- Probability of Natural Gas (source discrimination)
- Confidence score
- Emissions Quantification and Ranking





AMLD Methodology

DATA CAPTURE



First, driving survey data is collected.
Driving is the most efficient means of data collection
(CH_4 levels, GPS, Wind Speed/Direction)

DATA ANALYTICS

Raw data from multiple drives are analyzed and consolidated using algorithms and data analytics.
Source identification is derived
Actionable Insights generated

DECISION & EXECUTION

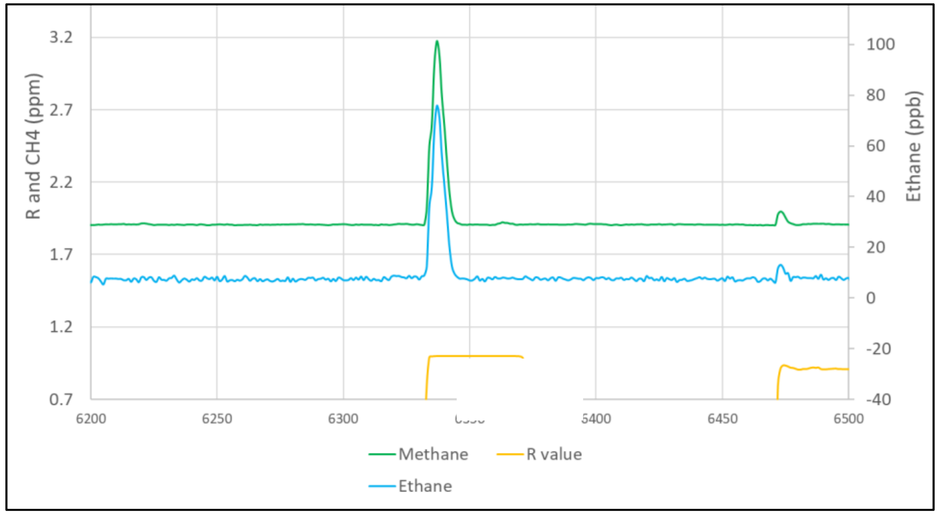
Work Orders are then generated embedded with information such as location of the detected emission, gas amplitude, gaps in coverage, etc
Data and insights used for multiple purposes

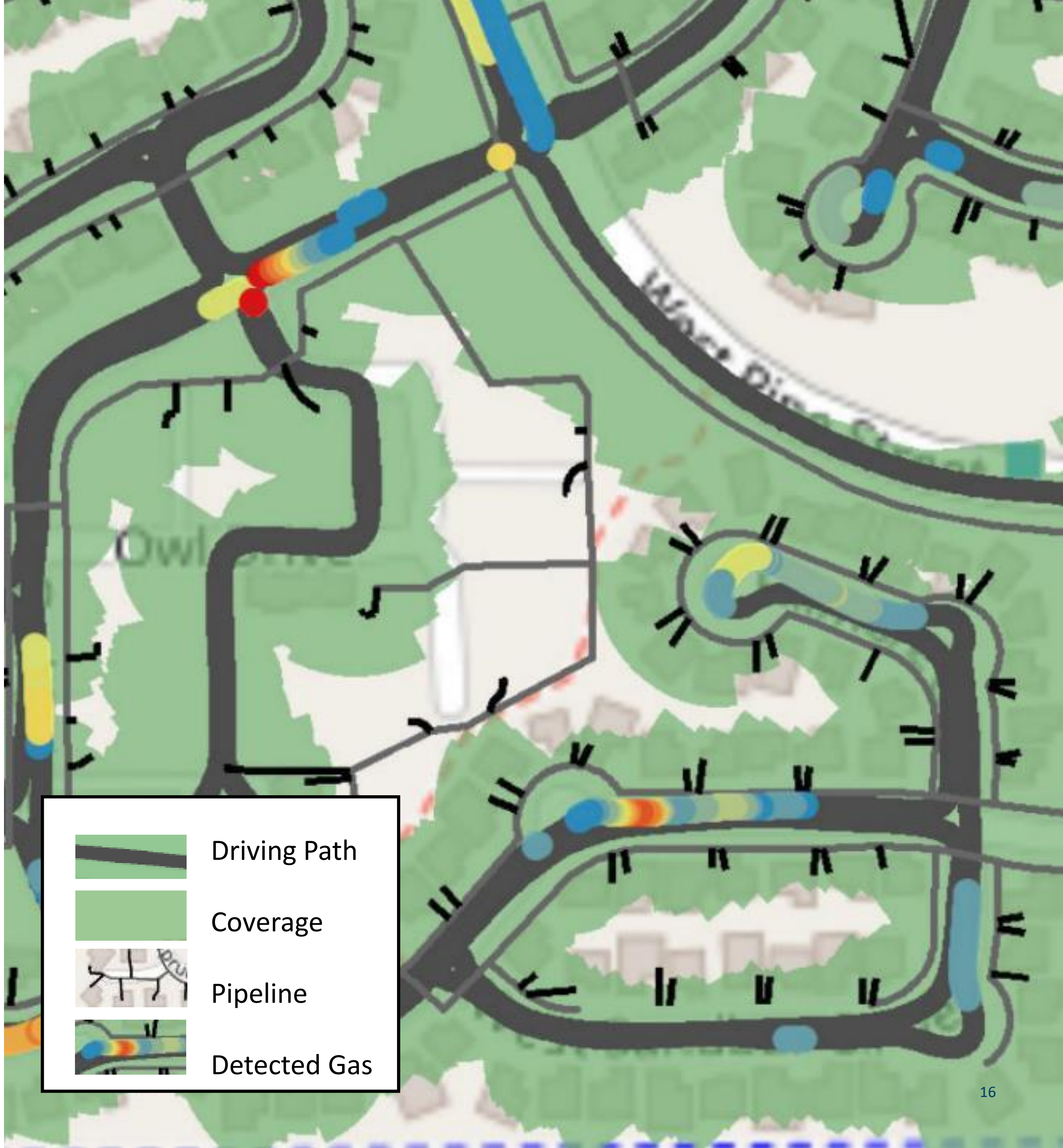
Driving and Data Collection

- Vehicle drives all roads in the area with assets
- Via the wind, the vehicle is able to detect leaks some distance off the road
- Detection limited only by access to leak and wind behavior
- Vehicle makes **Multiple passes** over multiple days
- *Strength:* via multiple passes, the survey increases the likelihood of detection
- Driving performed at night

Data Analytics

- Gas sensor data is analyzed for elevations in Natural Gas against background methane.
- Analysis considers environmental data
- Natural Gas versus ‘Swamp Gas’
- Key outputs:
  - Leak Indications Search Areas (Lat/Lon)
  - Covered Assets with no gas found
  - Coverage
  - Gaps





1 - Coverage with No Gas Found

- Analytics confirms the **absence** of gas
- These areas do not need any further investigation activities
- Assets can be marked – “No Gas Found”
- Typically, 85% to 90+ % of area is covered

2 - Coverage with Leak Indications – Gas found

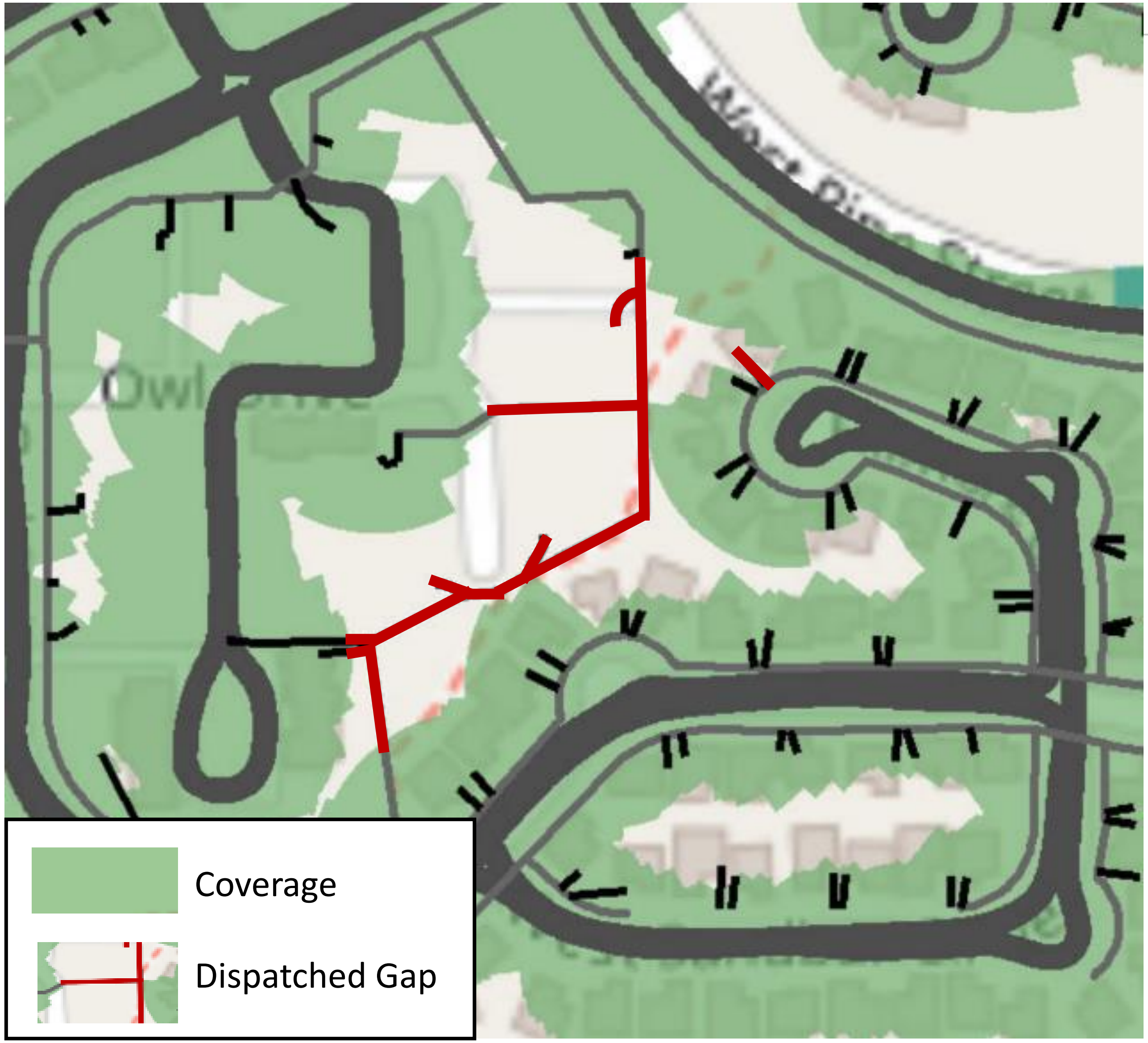
- Individual clusters of gas are dispatched as Indications
- Technician dispatched for further investigation and confirm presence of leak and grade the leak
- Indications can be prioritized by
    - Magnitude of gas,
    - Frequency of detection, etc.
    - Probability of Natural Gas (source discrimination)
    - Confidence score
    - Emissions Quantification
    - Ranking

3 - Coverage and Gaps

- Gaps - Any assets or portions or the target area not covered by AMLD

- Gaps
  - not able to drive in the area-private road/construction or road closures
  - unfavorable environmental conditions such as wind speed and direction
  - Terrain

- Any assets or portions or the target area not covered by the vehicle are dispatched for traditional investigation as a <u>Gaps</u>



Three Basic Outputs

1. Coverage – No Gas found

- No further activities in this area
- Typically, 85% to 90% of area is covered

2. Coverage with Leak Indications – Gas found

- Technician dispatched to investigate and confirm the leaks

3. Not Covered – Gaps

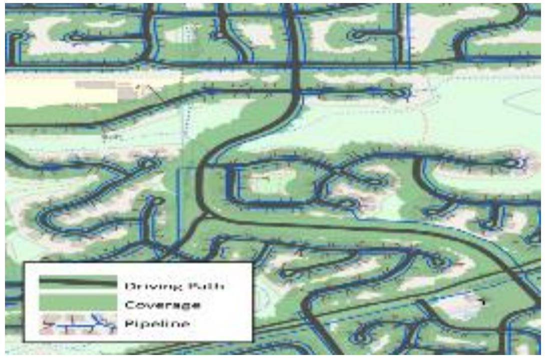
- Technician dispatched to survey the area
- Typically, 10% to 15% of the area depends

Field work consists of:

- Investigating the gas indications - Dispatching technician to investigating the natural gas Indications, confirming presence of leaks, grading the leaks and measuring flow rates

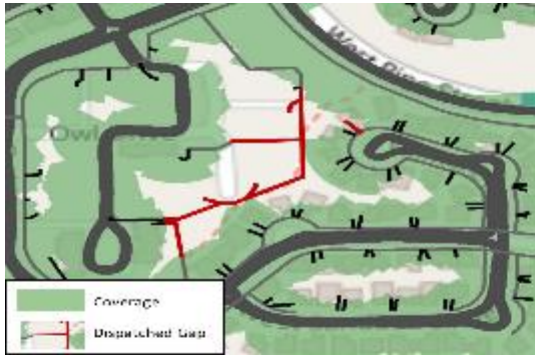
- Surveying the Gaps for any leaks, grading the leaks and measuring flow rates

1



2

3



Many Applications and uses of AMLD Technology

Southern Cross Experience

Regulatory Compliance Survey

Pre-Event & Public Safety Audits

DIMP Assessment Management

Disaster Recover Surveys

Environmental & Emissions Reduction programs

Frost Patrol

Pre & Post Quality Construction Audits

Auditing Traditional Leak Survey

Satellite Tiered System Leak Survey

Emissions Quantification

Emissions Quantification Methods

1. **Engineering Calculations**
   Data from engineering specifications, flaring models and other simulation modes are used to calculate the flow rates.

2. **Emission Factors**
   Standard Emissions factors for various components are used and results extrapolated for remainder of the network.

3. **Direct Empirical Measurement**
   - **Bottom Up** - Traditional methods of measuring and quantifying emissions utilize chamber methods, bagging individual components, or require the release of a tracer gas. The most accurate way to measure emission flow rates is to use a flow meter directly over the leak source . Extrapolate across the networks.

   - **Top down -** measure the atmospheric concentration of methane at locations downwind of the actual leak source and then use these measurements to obtain a reasonable estimate of the methane emission flow rates using one of the several plume modelling algorithms. (AMLD, Satellites, UAV, Airplanes etc.,)

4. **Uncertainties in Estimates -** In any case, it is important to realize that all these quantification algorithms will only give estimates of the methane flow rate. There will always be some uncertainties in the calculations due to several factors – frequency of measurements, abnormal conditions, intermittent leaks etc.,

AMLD - Plays well for Leak Survey and both EQ

Data Collection

- Methane / Ethane level,
- GPS
- Wind Speed/Direction
- Atmospheric Stability

Cloud Storage And Analytics

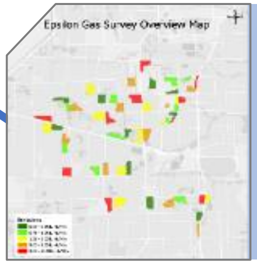
- Raw data from multiple drives analyzed
- Source identification is derived
- Actionable Insights generated

Compliance Survey (end-to-end)

- Indications (shapefiles / Tables)
- Coverage
- Gaps
- Leak grading summary
- Other Statistical Metrics

Compliance Survey (Driving Only)

- Indications (shapefiles / Tables)
- Coverage
- Gaps
- Other Statistical Metrics



Emissions Quantification

- Indications/Coverage/Gaps
- EQ Flow rates by Polygon/Grids
- Number of Sources / Polygon
- Other Statistical Metrics

"High" Emitters Program

- Indication above Threshold
- Coverage
- Gaps
- Other Statistical Metrics

Leak Detection and Emission Quantification Workflow

1. **Collect Data:**
   This can be accomplished in any number or combination of the technologies available today. The Mobile Vehicle Based Leak Detection and Emission Quantification platform (AMLD) lends itself quite well for this data collection stage.

2. **Source Identification:**
   Identify the location of the leaks from the data collected. Analysis becomes much easier if the area under consideration is divided into small grids or polygons – say one mile by one mile.

3. **Estimations:**
   Estimate the emission of methane by individual Natural Gas Indication (or grids / polygons for EQ).

4. **Ranking and Risk Mitigation:**
   Rank by polygon and then rank by leak size within the polygon

5. **Actionable Fixes:**
   Fix the “cost effective” significant leaks by certain payback criteria such as value of lost gas versus repair costs or other suitable payback criteria.

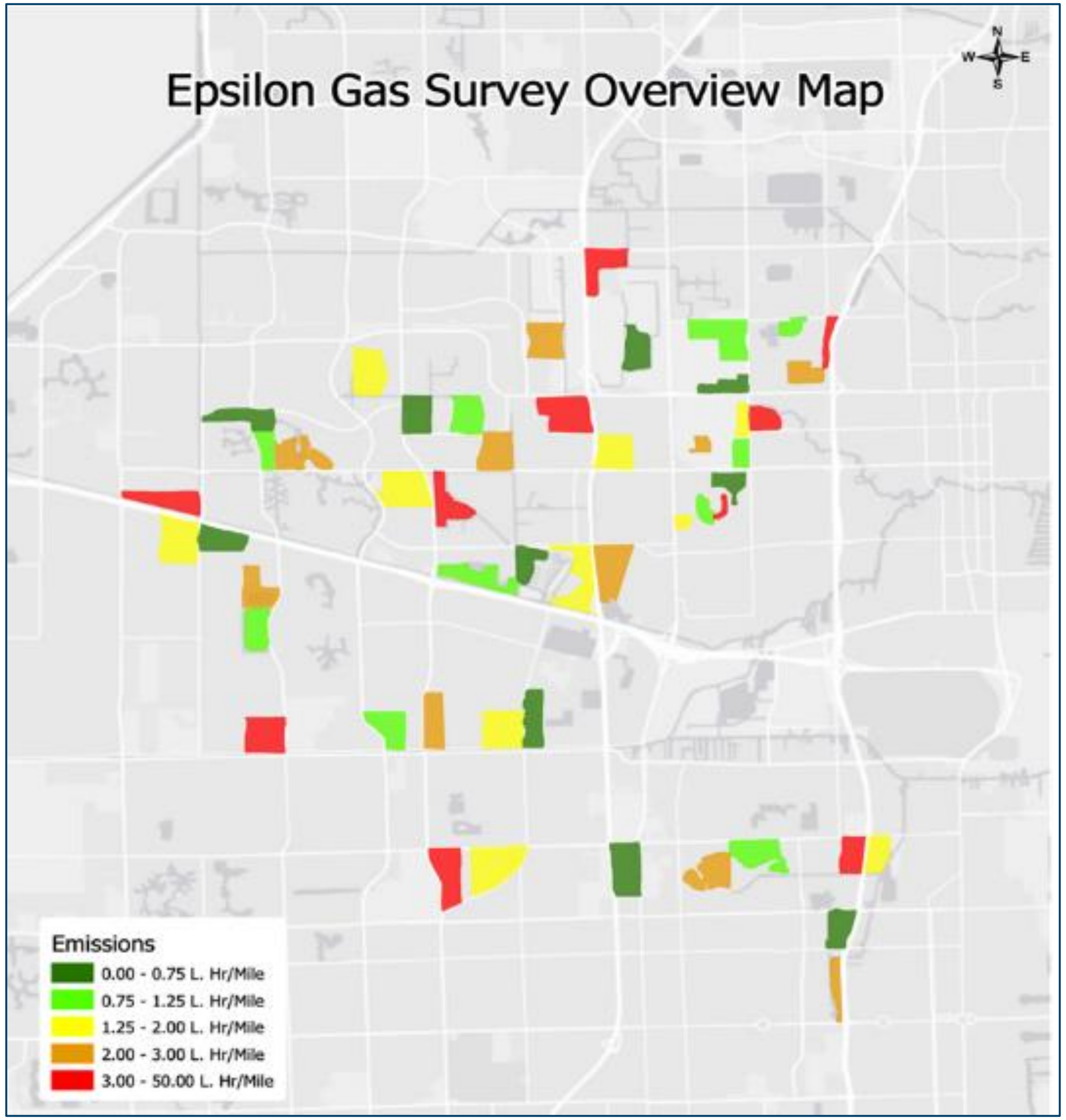
Sample Metrics Table

From the survey data, Southern Cross was able to analyze and provide our client with the following metrics:

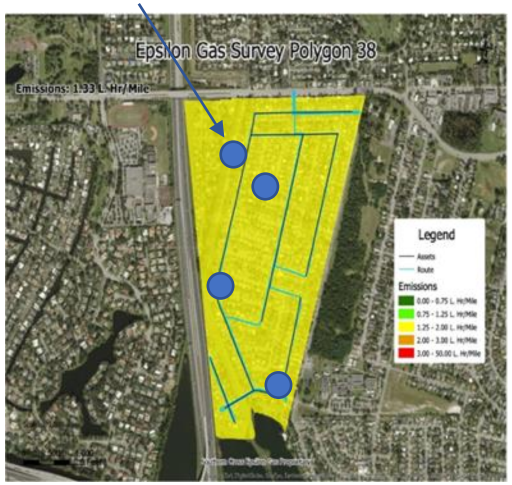
- Estimated Total Emissions Flow Rate (L/Min)
- Estimated Emissions Flow Rate per Mile (L/Min/Mile)
- Rank by Estimated Emissions Flow Rate per Mile (L/Min/Mile)

Polygon	Estimated Total Emissions Flow Rate (L/Min)	Main Length (miles)	Estimated Emissions Flow Rate per Mile (L/Min/Mile)	Rank by Estimated Emissions Flow Rate per Mile (L/Min/Mile)
1	2.10	4.12	0.51	14
2	4.40	5.31	0.83	9
3	3.90	6.86	0.57	13
4	6.99	7.52	0.93	8
5	8.77	8.20	1.07	7
6	5.67	2.06	2.75	4
7	9.20	1.40	6.57	1
8	2.33	3.76	0.62	12
9	4.51	5.45	0.83	10
10	5.34	4.05	1.32	5
11	16.70	2.56	6.52	2
12	12.71	4.32	2.94	3
13	7.65	6.54	1.17	6
14	3.86	4.92	0.78	11

Example: Emissions Quantification – Heat Maps



*Verified Leak Indication



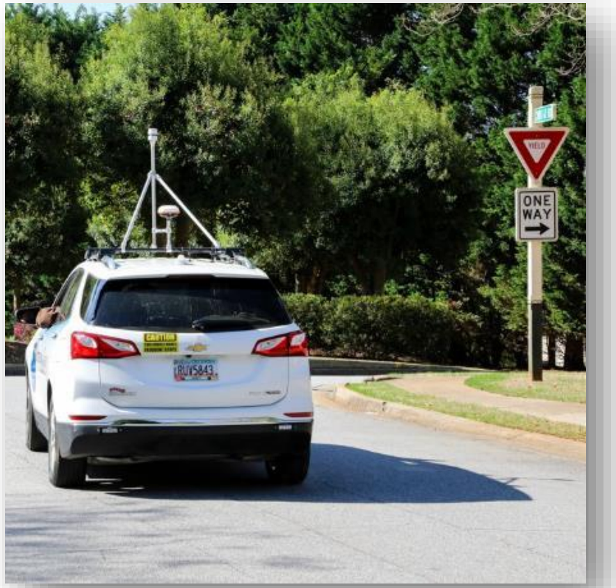
*"Super Emitter" Scenario

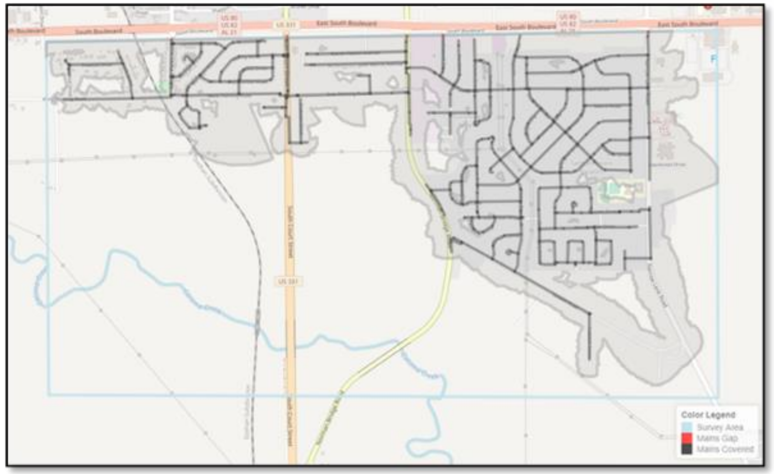
AMLD Operational Planning and Insights

1. Planning
2. Lessons Learnt

Operational Planning

1. Define the survey purpose - Compliance leak survey, special survey, disaster recovery, environmental / emissions, etc.
2. Prepare for potential of increased leak identification in the first years
3. Obtain regulatory approvals (if needed) and inform law enforcement authorities
4. Develop processes for prioritizing & responding to leak indications
5. Understand GIS accuracy and project impact
6. Determine areas to be surveyed – divide into grids or polygons
7. Develop coverage targets – plan resources to investigate gaps
8. Schedule / Timing
9. Logistical planning - Road closures, gated neighborhoods, etc.





Lessons Learnt

1. **COVERAGE:** You will probably never get 100 coverage of the network – you will always have some gaps that need to be investigated the traditional way. Typical coverage we have seen ranges from 70 % to 90+ %
    a. Mains 90+ %
    b. Service lines 70% - 95%
    c. Intercity -better than rural due to shorter proximity of assets to vehicle

2. **MORE LEAKS:** You will find more leaks in the first year due to the high sensitivity of the AMLD platform – Plan your resources accordingly. Human being versus technology.
    a. Investigation process is different than tradition.
    b. more diligence and persistence
    c. inspect venting locations.
    d. need to be more thorough.
    e. bar hole where it makes senses at the T-joint

3. **LEAKS PER INDICATION:** You will probably find multiple leaks per indication. On average we have seen a 1.5 – 2.0 number of leaks per indication – but this is network dependent and can vary. Could be more sometimes. Leaks closer together within the search area. Smaller or intermittent leaks on meter sets that car did not pickup.

4. **STABILIZING LEAKS:** After the first year, the number of leaks will gradually stabilize or even decrease where you can now plan your resources in a manageable way. (assuming that you are fixing many of the leaks)

5. **IGNORING VERY SMALL LEAKS:** You can probably adjust the outputs to disregard the very small leaks that you might classify as ungradable.
    a. Technically possible but not advisable for compliance survey because you don't know what the actual leak is at the source.

6. **GIS ASSETS RECORDS:** Accurate GIS records are critical to ensure the AMLD vehicle drives past all the asset points and does not miss any.

7. **NUMBER OF PASSES:** After a couple of years of experience on the network, you may decide to drive two nights (4 passes) instead of three nights (six passes).

8. **DAYTIME VERSUS NIGHTIME DRIVING:** If you decide to drive during the day, you may get more false positives and miss some leaks due to several factors –
    a. eddy in the air,
    b. propane/natural gas fleets,
    c. dispersion from large parking lots etc., etc.

    Mains might be ok during the day, but meter set/services lines might need night-time driving.

9. **LEAK FIND RATES:** Your leak find rates will vary from technician to technician. The good and diligent ones will have high find rates and the new technician with little experience will have low find rates. There are also other reasons you may not find some leaks such as:
    a. Rain the day before can't see gas then
    b. Wind conditions on that day
    c. Wrong asset maps
    d. Debris - leaves, wood after the survey

You got to be skilled in how gas reacts – you have to be diligent

Conclusion

The future for methane detection and emissions quantification looks extremely bright. Lots of investment in new advanced technology.

All technology platforms are evolving and getting better and better and adoption rates are accelerating – many technology options from the toolbox to deploy.

Public opinions, gov't commitments and regulations will become a pressing issue for oil and gas operators to accelerate adoption of advanced LDAR and Emission Quantification technologies.

Machine Learning software and advanced prediction analytics will continue to evolve and play a large role in methane detection and emission quantification systems

Thank You !