Webinars

Welcome!

The program will begin soon.

You will not hear audio until we begin.

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Webinars

Methane Detection and Monitoring-Tackling the Challenge

2023 August 9

Panelists: Ryan Streams, Jennifer Blackledge, Meghan Cornwall

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Webinars

Methane Detection and Monitoring Tackling the Challenge

Audrey Mascarenhas

President and CEO – Questor Technology Inc

2023 August 9

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Why Methane?

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- Methane is ***more than 84-86 times*** more potent than CO_2 over a 20-year time horizon.
- Methane's lifespan is ***9 to 12 years*** so cutting methane emissions yields an immediate reduction in the rate of warming, while also delivering air quality benefits.
- ***25%*** of today's global warming is driven by methane from industry
- Cutting methane emissions by ***45 per cent*** by 2030 could help us meet the Paris Agreement's goal of limiting global warming 1.5°C.

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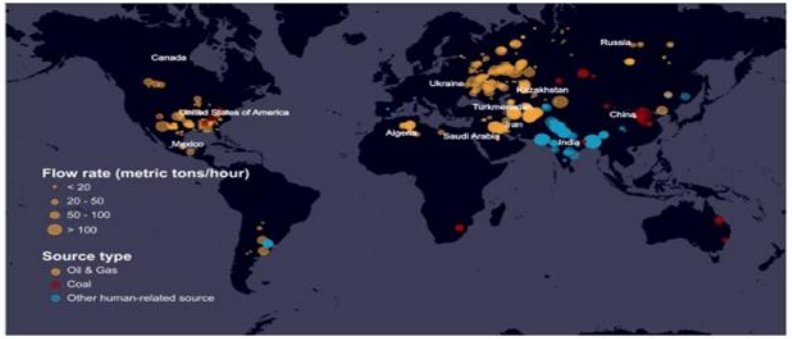
The Magnitude?

Satellite-detected methane leaks from human activities, 2021



Source: Kayrros analysis based on modified Copernicus data.

- Greater than 40% of methane emissions is unaccounted for
- The oil & gas industry alone globally flares over 14.5 billion standard cubic feet per day[1] of associated gas
- Kayrros[2] estimates from satellite imagery that over 1Gt CO_2e annually comes from non-routine flaring
- The IEA[3] estimates annually over 79 million Tonnes of methane is emitted, equivalent to more than 2 billion Tonnes of CO_2e from routine flaring

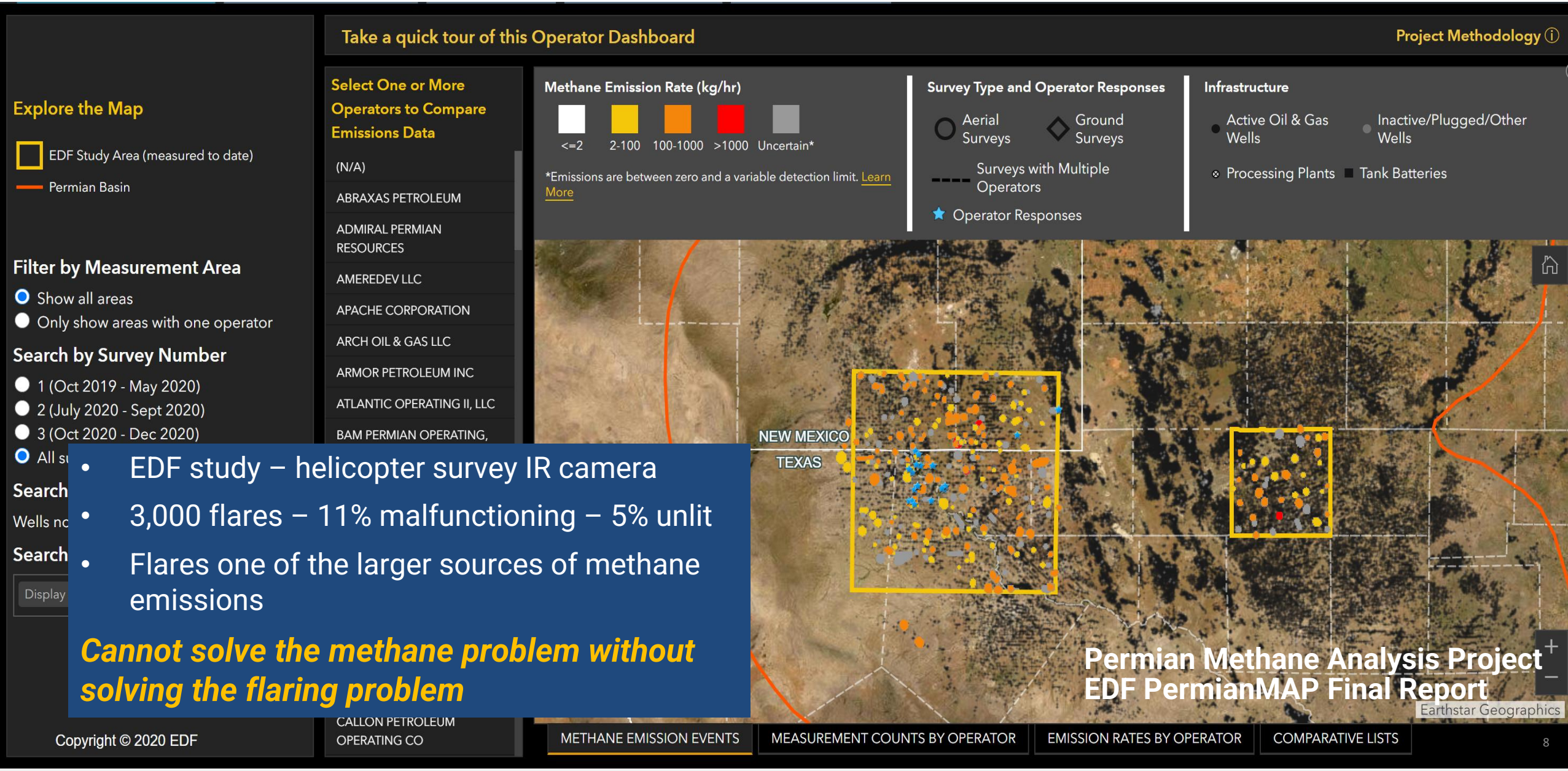
1. Global Gas Flaring Tracker Report, GGFR, The World Bank, July 2020
2. Kayrros flaring report
3. IEA 2022 Global Methane Tracker report,

From Well to Wheel

Webinars

- Emission profiles are different at each stage of the oil and gas value chain
- Wellsite is different from a oil battery which is different from a compressor station
- We cannot lump them all together and use emission factors thinking our job is done.
- Proactive approach along the whole value chain recognizing the uniqueness of each stage and designing to reduce the fugitives, flaring and venting

Satellites, Airplanes, Drones, Sensors, Handhelds….



- EDF study – helicopter survey IR camera
- 3,000 flares – 11% malfunctioning – 5% unlit
- Flares one of the larger sources of methane emissions

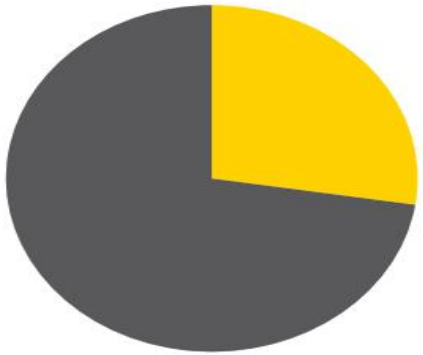
Cannot solve the methane problem without solving the flaring problem

FLARING INSIGHTS

8

Total surveys

1,320 Emission sources detected



- 362 Malfunctioning Flares
- 958 Other sources (Tanks, vents, valves)

50%

of super emitters come from midstream operations.

Super emitters are sites that produce a disproportionate amount of methane pollution, releasing 10 kilograms of methane an hour or more.

- Gathering and boosting
- Transmission and storage
- Pipelines and compressors

Mobile laboratory measurements indicate low-producing "marginal wells" are responsible for half of the Permian Basin's well pad emissions. More than 75% of these are owned by major corporations.

"I knew we would find a lot of pollution, but I had no idea flaring emissions would be this bad."

David Lyon
Senior Scientist
Environmental Defense Fund

The Elephant In The Room

- Assumption that a flare is 98% efficient
- Non-routine flaring and venting ignored
- Maintenance, equipment failure and well unloading emissions not accounted for

3X HIGHER

Over the course of the project, aircraft measurements have revealed Permian emissions are **2-3 times higher** than what the Environmental Protection Agency estimates in their inventory of greenhouse gas emissions.

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Methane Detection and Monitoring-Tackling the Challenge

Ryan Streams
Vice President of External Affairs
Kairos Aerospace
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Our Understanding of Methane Emissions is Transforming Before our Eyes

- **Emission factors** are wrong. **Direct measurement** is becoming the new paradigm for industry and regulators.

- We're seeing regulators rapidly shift to the direct measurement paradigm, but **this change is uneven today.**

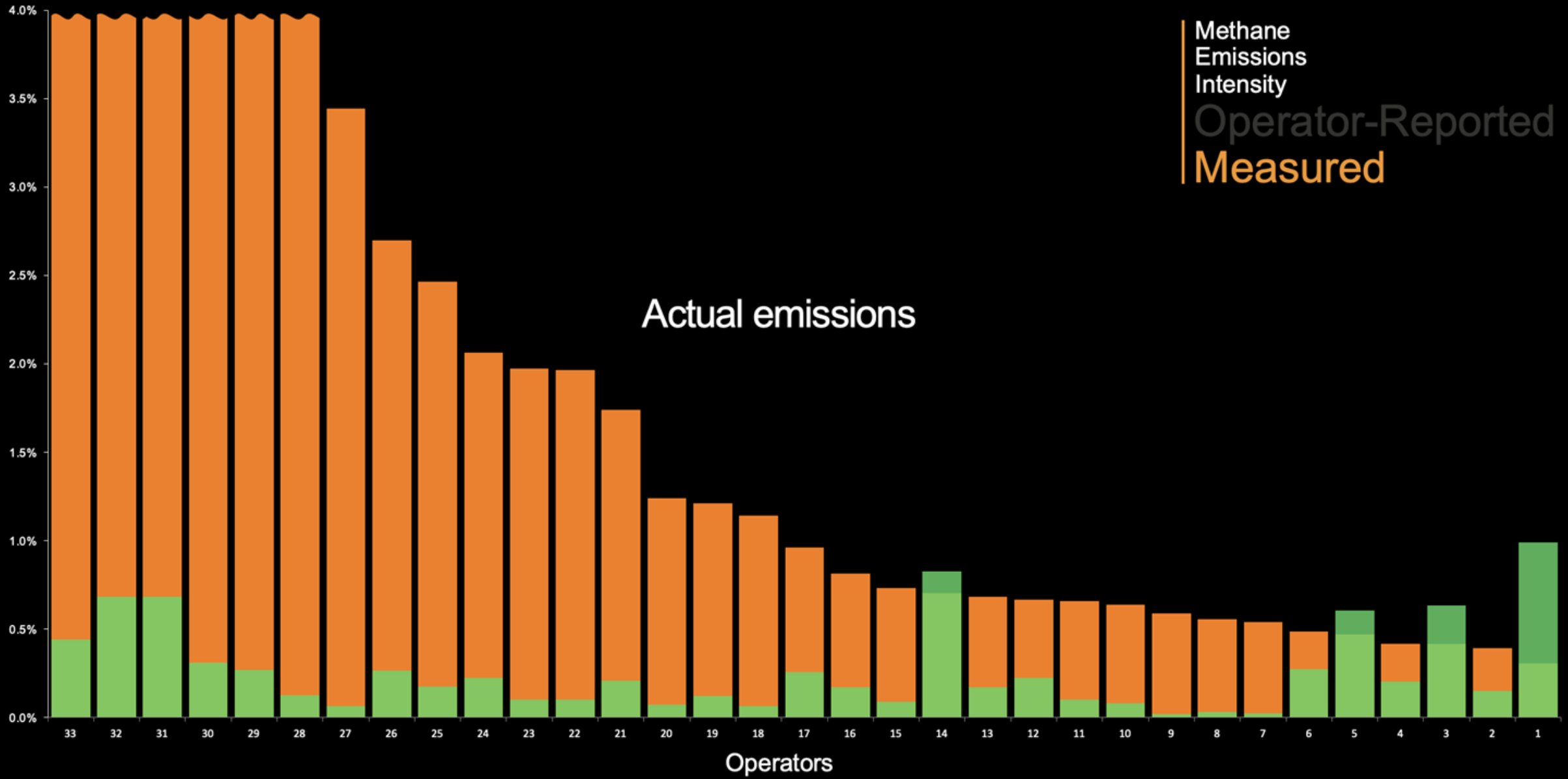
KAIROS AEROSPACE

Methane Emissions Intensity

Operator-Reported

Emissions reported per the EPA's existing guidance

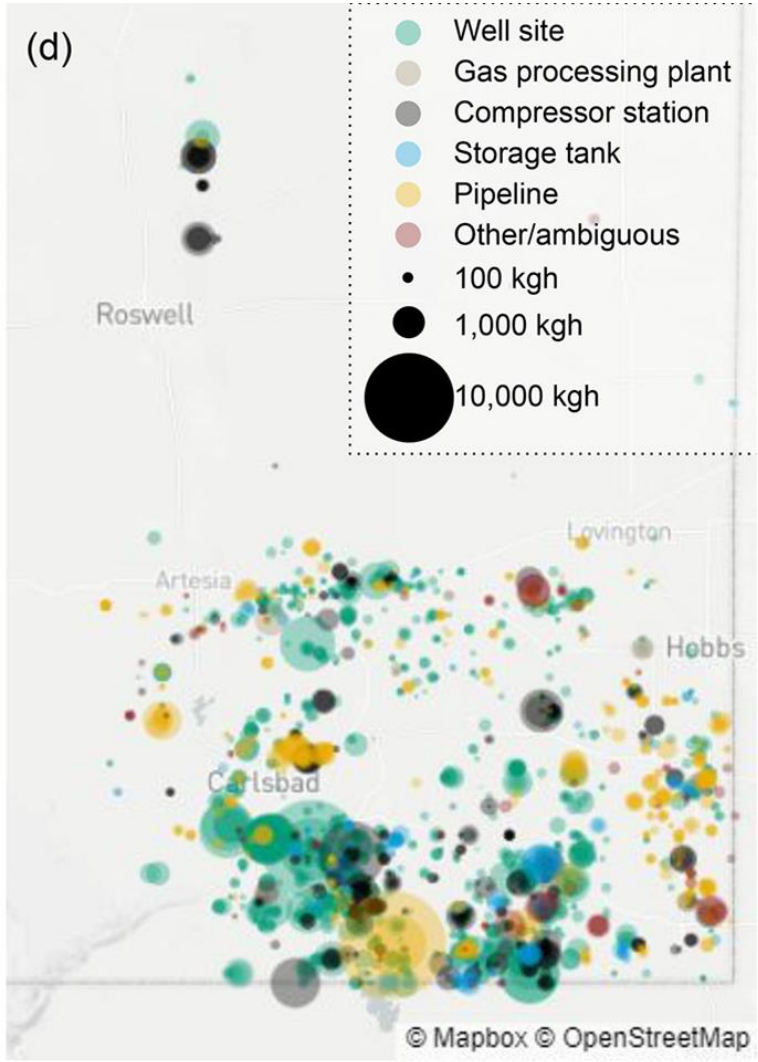
KAIROS AEROSPACE



Measurement Reveals Strong Discrepancies Between Measured vs. Calculated Emissions

Permian Basin – 2019

- The study encompassed 26,292 active wells, 91% of New Mexico's Permian footprint
- Stanford University scientists calculate methane emissions are **6.5x higher** than EPA Greenhouse Gas Inventory estimates
- The survey found 2,874 methane plumes above 100 kg/hr, all of which would be "Super Emitters" under new EPA rules
- Half of all measured emissions were from sources >308 kg/hr (385 MCF/day)



Measurement Reveals Strong Discrepancies Between Measured vs. Calculated Emissions

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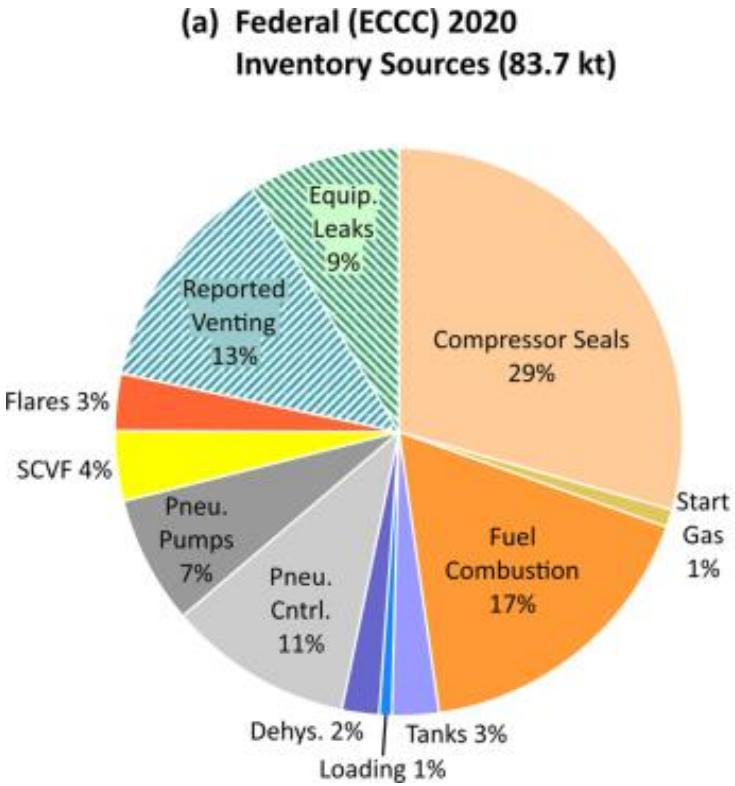
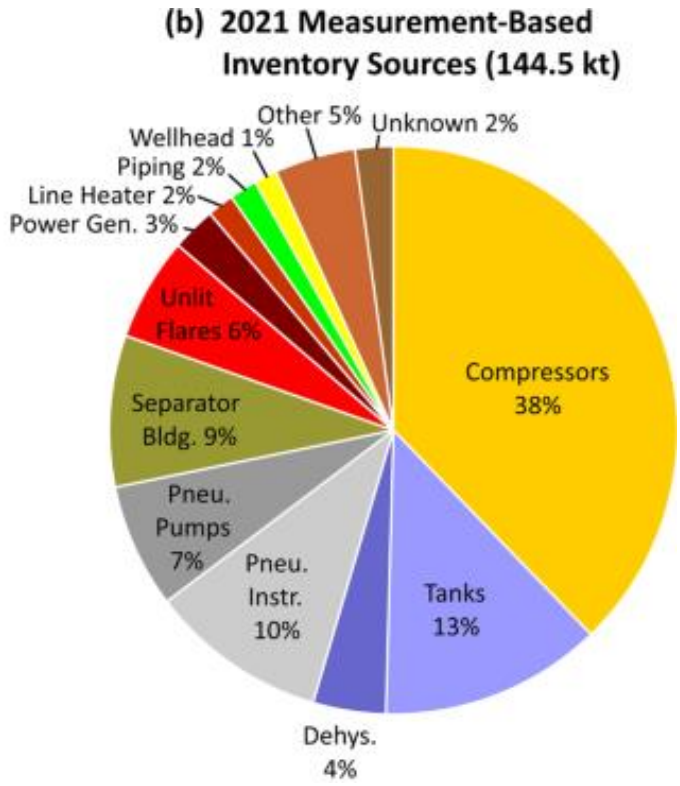
British Columbia - 2021

- Carleton University scientists reported **measured emissions are double** official GHG inventory estimates
- The sources responsible for the measured emissions did not reflect the GHG inventory either
- Study concludes that a “hybrid inventory” that includes measured emissions and calculation-based emission factors is a comprehensive approach





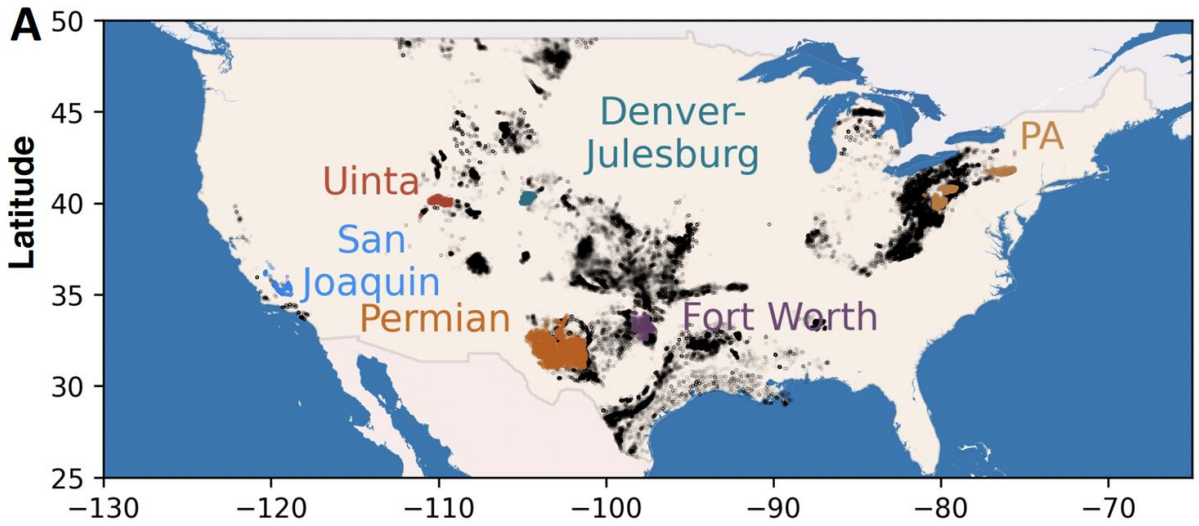
Measurement Reveals Strong Discrepancies Between Measured vs. Calculated Emissions

Continental U.S. – 2023

- Stanford scientists (paper in revision) examined whether this is a **Permian phenomenon** by evaluating fifteen measurement campaigns across six basins

- Basin-level methane loss rates vary significantly, but **all campaigns** with greater than 80% basin coverage (n=11) **quantified a loss rate greater than the EPA GHG inventory** estimated loss rate.

- Surveyed regions in this study contribute an estimated **6.3 million tonnes/yr of methane emissions**, equivalent to total greenhouse gas emissions from France



How Are Regulators Addressing the Inventory Gap?

Colorado

- Colorado already has some of the most stringent air quality regulations in the nation
- State has set an ambitious **emission intensity target** for its oil and gas industry
- But if inventories don't accurately reflect reality, how do we **measure progress**?
- Enter the Greenhouse Gas Intensity Verification Rule

How is Colorado Addressing the Inventory Gap?

Colorado

- The State's goal is to use **basin-scale measurement** to determine how much its inventory is undercounting emissions
- Creating a measurement-informed "**default**" measurement factor
- Providing operators pathways to **report their own methane intensity results** based on their advanced technology measurement campaigns
- Now, the state will be able to measure progress against its methane intensity targets that better reflect reality

EPA's Multi-Pronged Approach

- OOOOb/c methane rules to **find** methane
- Greenhouse Gas Reporting Program changes to **track** methane
- IRA methane fees to **increase accountability**

How is EPA Addressing the Inventory Gap?

US EPA – *OOOOb/c to Find and Eliminate Methane*

- Proposed **OOOOb** and **OOOOc** rules dramatically increase leak detection requirements and embrace methane quantification technologies
- Massive increase in leak detection – both in sites covered and in frequency of surveys
- Most technology-forward regulations we've seen to date
- Major changes to important sources like **tanks, pneumatics, liquids unloading**

How is EPA Addressing the Inventory Gap?

US EPA – *Improving the Greenhouse Gas Inventory*

- Proposed **Greenhouse Gas Reporting Program** changes incorporate these methane quantification techniques directly into the GHG inventory for more accurate information
- Moving away from emission factors and towards measurement in many places
- New reporting category – “Other Large Release Events” will track and quantify **super emitters** for the first time
- 100 kg/hr leaks and/or 500 MCF cumulative release events will now be reported in the GHG inventory

How is EPA Addressing the Inventory Gap?

US EPA – *Driving Accountability with the IRA*

Inflation Reduction Act (IRA) marries the two into **fee-based incentives** to eliminate methane emissions

- Establishes Methane Emissions Reduction Program by creating Section 136 of the Clean Air Act - Managed by EPA
- Establishes $1.55B financial and technical assistance for methane reductions **($350M available to states!)**
- Establishes methane waste fee
  - Fee is based on EPA GHG Inventory reported emissions
  - Fee is calculated per ton of methane
  - When OOOOb/c are finalized, companies can use compliance to avoid fees
    - Until rules are finalized, they are stuck paying fees
    - Pipelines do not have an off-ramp from fees

OOOOb to **measure**, GHGRP to **track**, Inflation Reduction Act methane fees to **increase accountability**

Where Do We Go From Here?

Regulations must align with **measurement** to be cost-effective

Intense focus on “traditional” emission sources like pneumatics may **completely miss reality** of what’s driving emissions in certain basins

- **Step One:** More, better measurement
- **Step Two:** Proper incentive structures in regulation
- **Step Three:** Implementation and continuous improvement through reviewing measurement data

Appendix

- Chen et al. 2022 "*Quantifying Regional Methane Emissions in the New Mexico Permian Basin with a Comprehensive Aerial Survey*" https://pubs.acs.org/doi/10.1021/acs.est.1c06458
- Johnson et al. 2023 "*Creating measurement-based oil and gas sector methane inventories using source-resolved aerial surveys*" https://www.nature.com/articles/s43247-023-00769-7
- Sherwin et al. In revision "*Quantifying oil and natural gas system emissions using one million aerial site measurements*" https://www.researchsquare.com/article/rs-2406848/v1

Webinars

Methane Emission Monitoring Solutions - From Super Emitter to 1ppm

Meghan Cornwall
Customer Success Manager
ChampionX Emissions Technologies
2023 August 9

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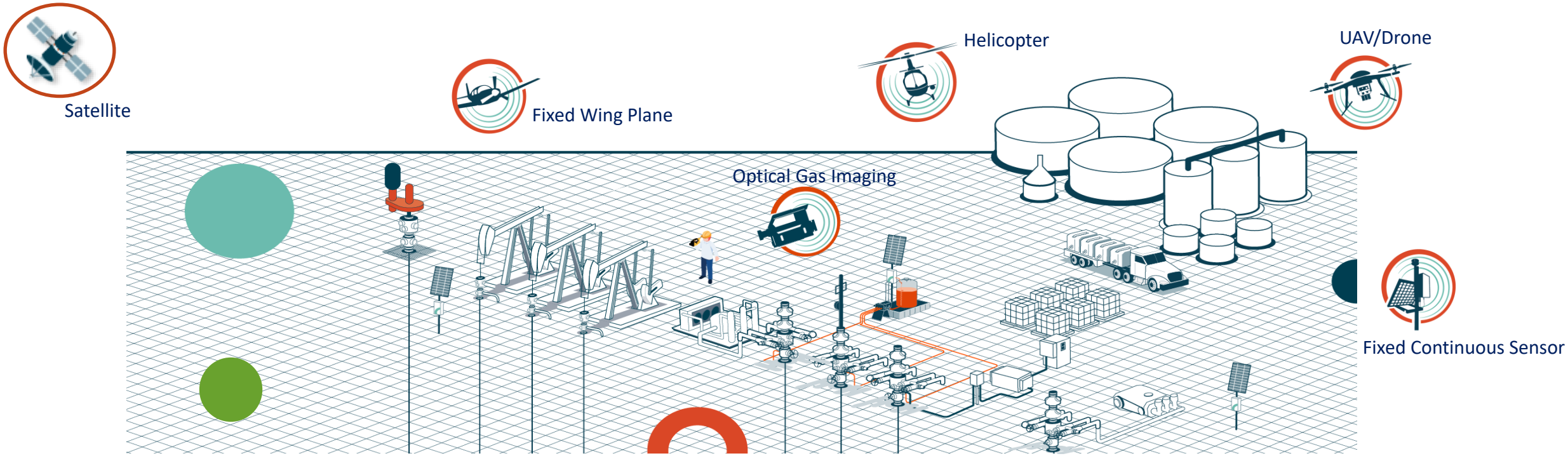
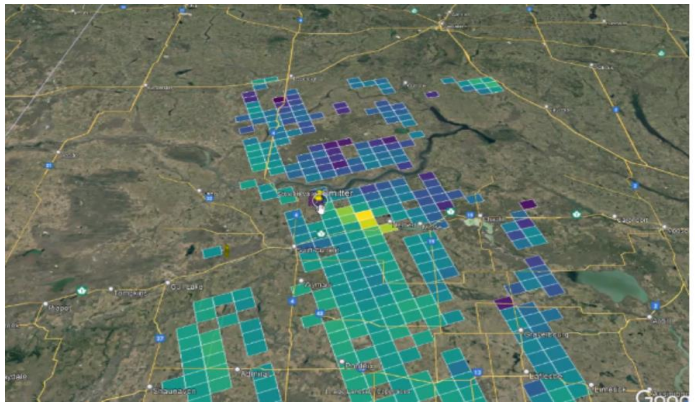
Spectrum of Solutions



Your Solution: Satellite



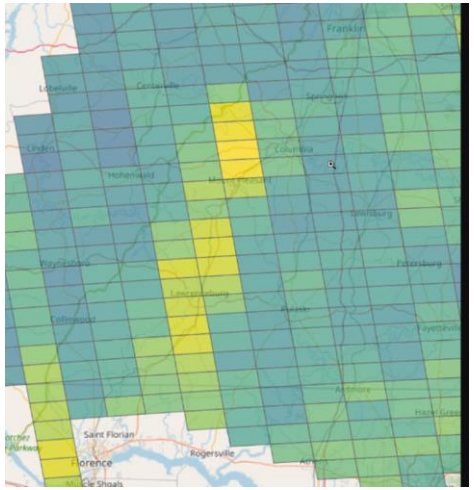
Advantages

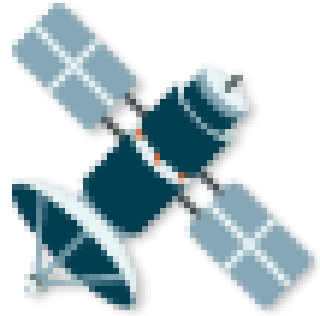
Large survey coverage area (basin or larger)
Can detect super emitter events with quantification ability
Uses remote sensing data to detect methane

Disadvantages

Point in Time Detection
Temporal Resolution –ideally around noon to provide sufficient light for remote sensing
Large Resolution

Minimum Leak Rate Detection Limit: 100kg/hr





Your Solution: Fixed Wing Plane

Advantages

Large survey coverage area (300-800 square miles a day)

Can detect super emitter events with quantification ability

Measure where ground access is difficult

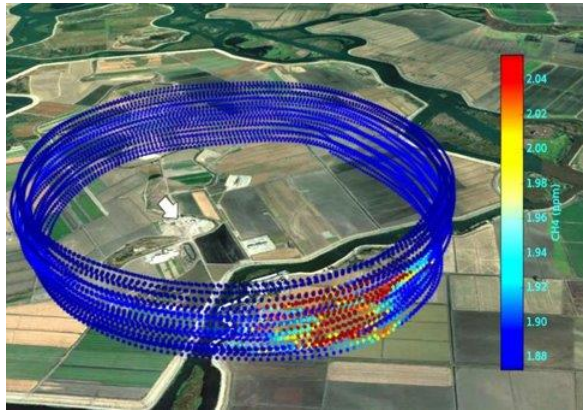
Disadvantages

Point in Time Detection

Need clear and safe weather conditions for flights

Resource Intensive

Minimum Leak Rate Detection Limit: 10kg/hr



Your Solution: Aerial OGI

Advantages

Site Based- compressor stations, pipelines etc.

Can detect small methane leaks

Can get to sites that are hard to access

Combine with on the ground leak repair

Disadvantages

Point in Time Detection

Need clear and safe weather conditions for flights

Resource Intensive

Minimum Leak Rate Detection Limit: Not able to quantify

Your Solution: UAV/Drone

Advantages

Site Based- compressor stations, pipelines etc.

Most accurate individual site quantification

Combine with on the ground leak repair

Takes less time to survey a site than with OGI camera

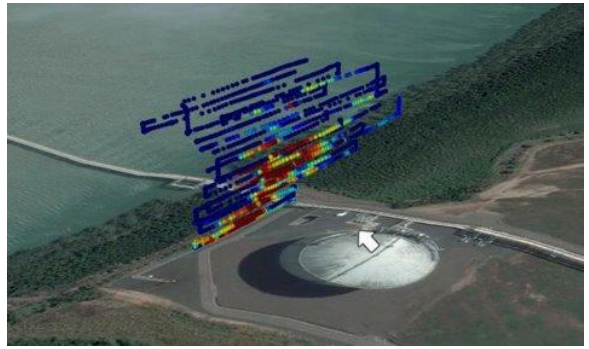
Disadvantages

Point in Time Detection

Need clear and safe weather conditions for flights

Need accurate wind data

Resource Intensive



Minimum Leak Rate Detection Limit: 1 kg/hr

Your Solution: Fixed Continuous Sensor

Advantages

On Site 24 hours a day

Rapid Identification of super-emitters and persistent leaks

Data is in real time

Insights about total emissions on a site

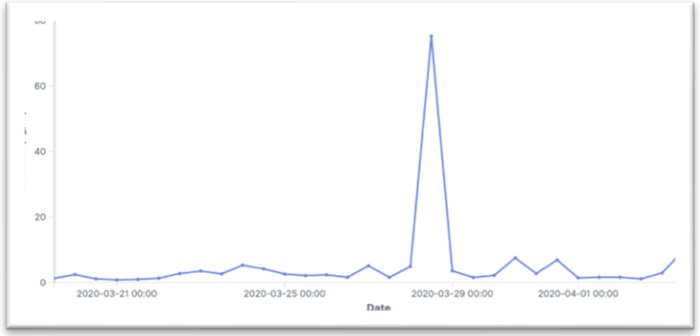
Disadvantages

Need accurate wind data

Provides general location of leak

Generally need more than one per site

Potential for false alerts or event is over when a technician is out



Minimum Leak Rate Detection Limit: less than 1kg/hr

Your Solution: Optical Gas Imaging

Advantages

Drives regulatory compliance

Identifies exact location of leak

Drive repair of site leaks

Disadvantages

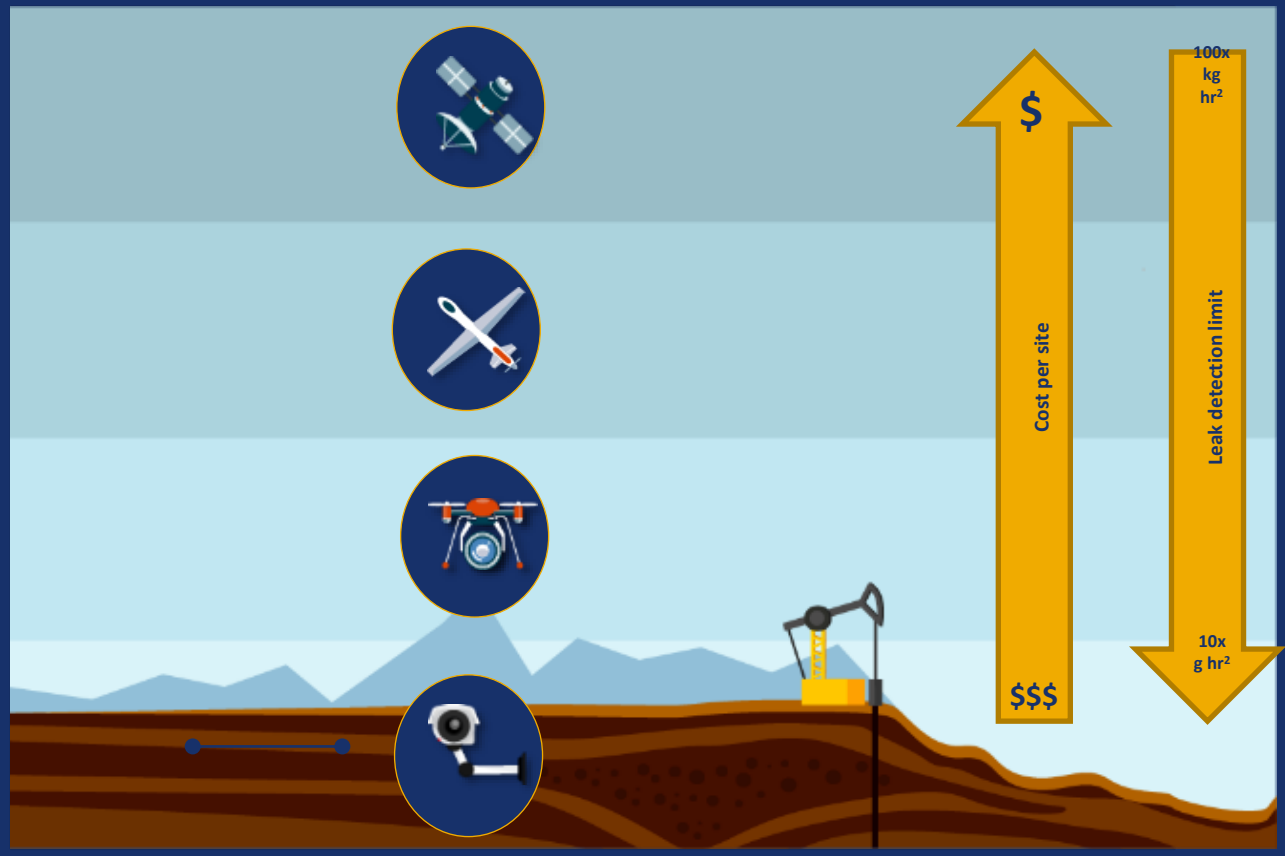
Point in Time

Can only be done in daylight

Resource Intensive

Minimum Leak Rate Detection Limit: not able to quantify

Cost vs Resolution



What is the Best Solution?

It depends on…

Your Assets
- Density
- Geography
- Operational

AND

Your Goals
- Satisfy Regulations
- Internal
- Cost Effectiveness

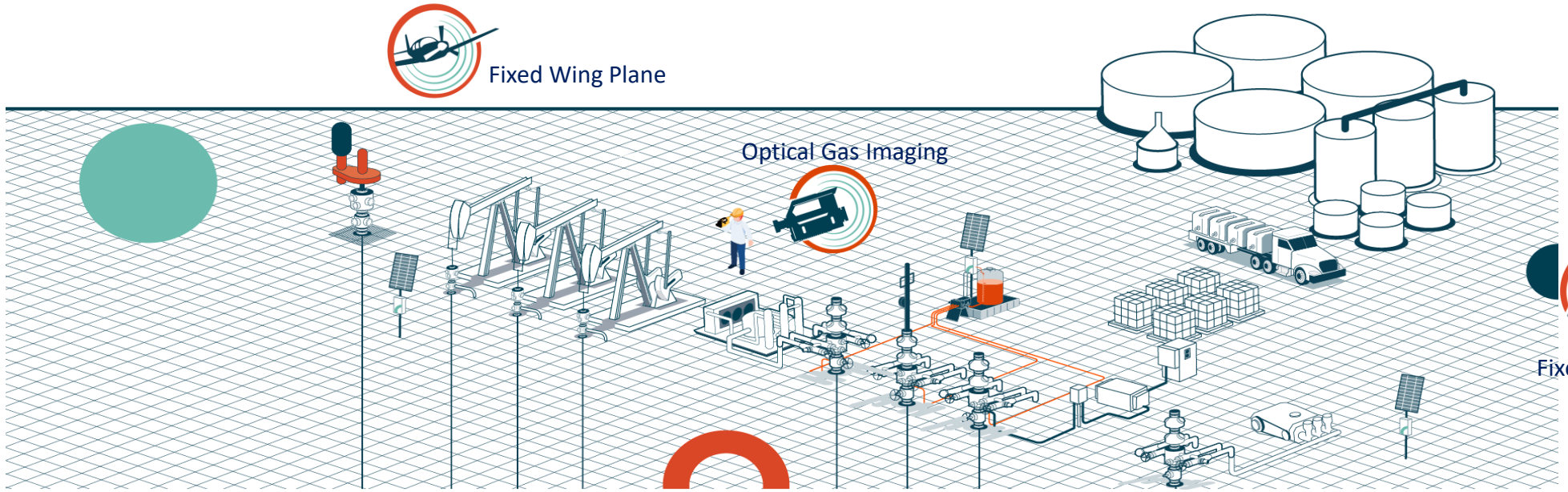
AND

Your Methane Event Focus
- Super Emitter
- Intermittent Leaks
- Persistent Leaks

What Should I Use?

Objective	Best Tool
Survey basin or region	Satellite
Reduce total emission from a site	Continuous monitoring.
Rapidly survey large number of facilities	Manned aircraft
Calculate methane intensity	UAV is the most accurate tool to measure total site emission
Identify and repair small sources (~ < 250 scf/hr)	AOGI and OGI still reigns supreme for pinpointing sources and reliability detecting small emissions

There is no silver bullet!



Webinars

Methane Emission Monitoring Technologies for EPA Proposed Regulations

Jennifer Blackledge,

Business Development Manager – ChampionX Emissions Technologies

2023 August 9

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New Proposed Regulation Requirements

Increased Leak Monitoring

OOOO b and c require more frequent LDAR monitoring – Do we have the manpower to accommodate the demand?

Flaring & Venting Restrictions

Strict limits on venting and flaring. Equipment plans and upgrades need to be implemented.

Super-Emitter Enforcement

EPA & third parties detect leaks with aerial surveillance technology. (satellite, planes & helicopter)

*Avoid penalties with continuous monitoring and alerting notifications.

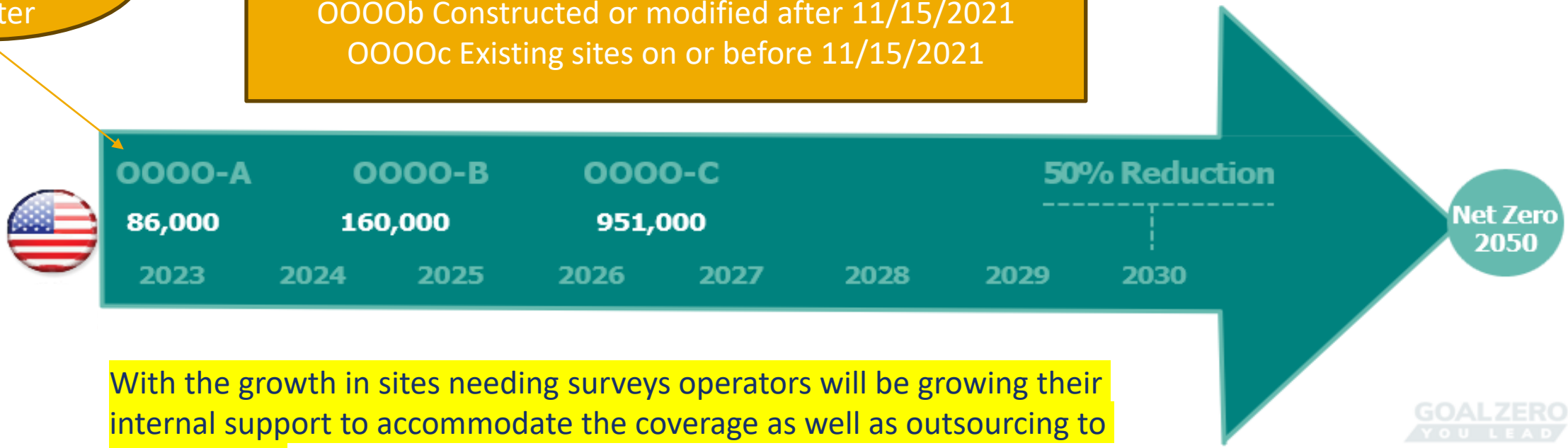
Compliance Incentive & ROI

Reduce upstream facilities' emissions below 0.2% methane intensity or comply with OOOO rules to avoid methane fees under Inflation Reduction Act.

Impact on Resources/ Workforce

of sites surveyed per quarter

OOOO Constructed or modified 8/23/2011 to 9/18/2015
OOOOa Constructed or modified after 9/18/2015
OOOOb Constructed or modified after 11/15/2021
OOOOc Existing sites on or before 11/15/2021



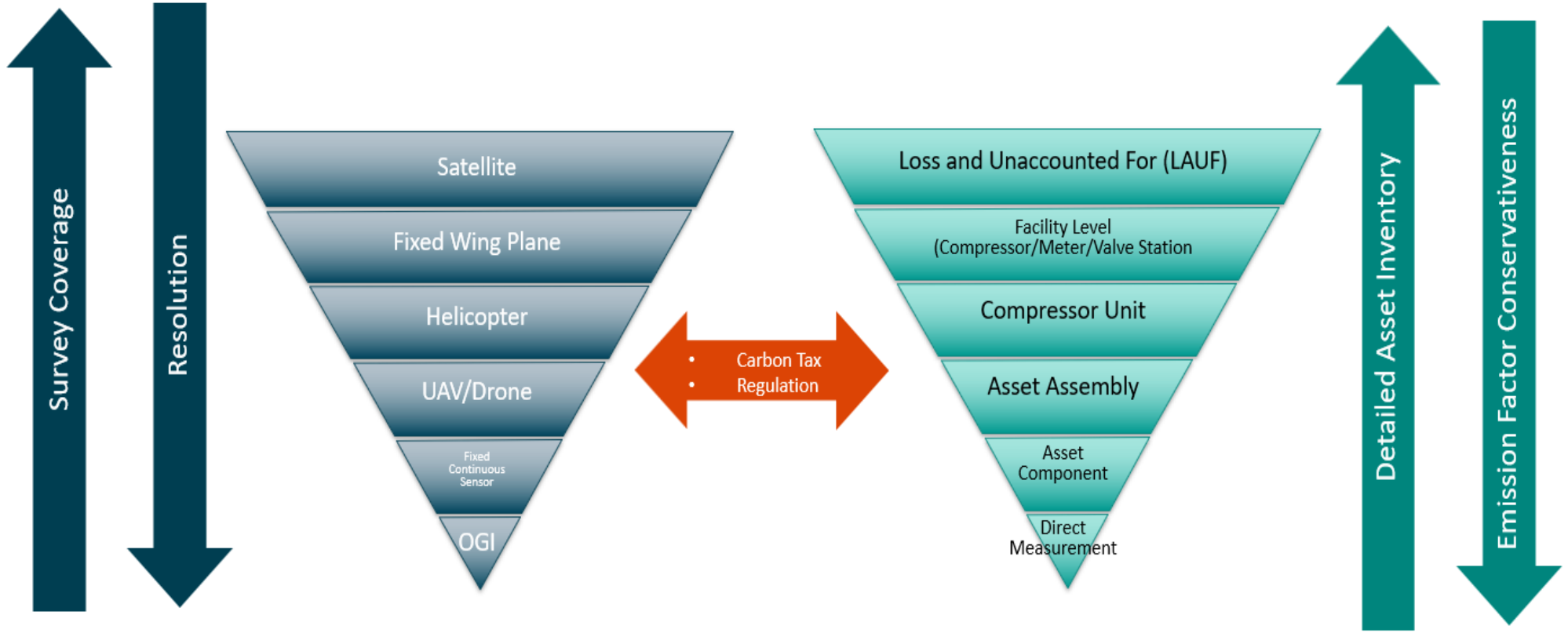
With the growth in sites needing surveys operators will be growing their internal support to accommodate the coverage as well as outsourcing to third parties.

How are decisions made?

Webinars

Overview of tech with the critical focus on different platforms or combinations of tools that are used to tackle varying asset configurations based on:

- Geographical spread
- Asset density
- Safety (Elevated sourced)
- Level of detection resolution or detail required to drive actionable insights
- Equipment for the "Find and Fix Team" and how they can pinpoint, and equipment required



Canada

- Regulatory Requirements – OGI 3X Surveys at Compressor and Meter StationS

Potential addition of Valve Sites in LDAR

Alternative Leak Detection and Repair

USA

- Regulatory Requirements – Only at Compressor Stations
  - Potential requirement to track all emissions in discussion

Mexico

- Regulatory Requirements – Stationary combustion focused, phased in LDAR in 2023
  - Similar regulation to Canada, late using Gas Detectors

Carbon Tax Regulation

- **Evolving reporting requirements**
- **Variable compliance mechanisms**
- **Increased focus on detailed reporting**

Canada GHGRP
- >10,000t/a

British Columbia GHGRP
- Highly prescriptive venting and pneumatics
- Greater focus on reporting than compliance
- $C (2021) - $45 (Consumption)

Alberta TIER
- One of the earliest jurisdictions to regulate, but very politicized
- 3 regulations in 3 years
- Methodologies under review
- $C (2021) - $40 – applied to compliance

Saskatchewan and Manitoba >CA OBPS
- Very basic
- Focuses on stationary combustion
- New
- Adopted by provinces without adequate programs
- $C (2021) - $40

Ontario GGPPA
- Tends to revise requirements and regulations frequently
- $C (2021) - $40

Quebec RODECCA
- Cap and Trade
- Significant updates in progress
- CA-Linked
- Very prescriptive and additional categories
- Still use IPCC 2nd Assessment (GWP CH4 = 21
- $C + C&T allowances = $23

US Federal
- Static regulation
- Reporting only – no compliance mechanisms, verification or reduction targets
- No carbon pricing at a federal level

California
- Cap and Trade Program
- Very prescriptive reporting, methodologies and requirements
- $C (2020) - $21 CDN

Colorado
- Highly prescriptive with stringent Emission Inventory and measurement requirements for quantification
- Restricted flaring and venting activities enforcing destruction and mitigation technologies

Oregon
- Quaint methodologies tied to Fed EPA
- Requires additional state-level submissions
- $C – In discussion

Washington
- Quaint methodologies tied to Fed EPA
- Requires additional state-level submissions
- $C – Cap & Trade - 2023

Relevant Complexity (Stringency + Prescriptiveness)	
	1 California / Colorado
	2 AB/BC
	3 QC/ON
	4 OBPS (Can Fed) – SK, MB
	5 US EPA (all other states)

Mexico
- 2019 – basic reporting requirements, limited prescriptiveness
- Verification 3 year
- Evolving federal, state and municipal requirements
- $C - $2.19 CDN (Mx 46.67)

Mexican states have evolving and increasingly stringent reporting requirements.

Current Approved Leak Detection Technologies

AVO –Audio, Visual, and Olfactory observations
Careful inspection of air pollution controls and equipment Documentation of malfunctions and potential leaks.

OGI –Optical Gas Imaging
Detects fugitive emissions using infrared cameras; certified operators gather and report survey data.

EPA Method 21Quantitative VOC leak identification

Portable detectors, such as flame ionization, catalytic oxidation, infrared absorption, or photoionization used to locate and classify leaks by VOC concentration.

What will fit in the proposed box?

Webinars

Technology	0000'B	0000'C	Super Emitter Program	Methane Reduction Tax
Satellite				
Aerial Detection/quantification Survey (planes, drones & helicopters)				
Continuous monitoring (leak rate detection)				
OGI surveys				

Incentive to comply with OOOO b & c.

QUESTIONS / DISCUSSION