Incorporating New Technology Into Emissions Mitigation Policy

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GTI Methane Connections Meeting

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Introduction – Methane Emissions

- Methane emissions from oil and gas activity is a significant source of GHG emissions in US and Canada

- Reducing methane has multiple co-benefits, in addition to climate impact
  - Improve air quality (precursor to low-level ozone)
  - Reduce product waste
  - Social license to operate near population centers

- Recent studies show significant higher emissions compared to EPA GHGI
  - 2.3% (Brandt et al. 2018) vs. 1.7% (GHG Inventory)
  - Significant upward revision in upstream production – 7.6 vs. 3.5 Tg/y
  - Aggregation of facility-level estimates

Policy Approaches to Emissions Mitigation

- Most active jurisdictions (CO, Canada) have prescriptive policies
  - ***Venting and Flaring:*** Annual limits verified through activity data and production figures
  - ***Fugitive Emissions:*** Periodic leak detection and repair (LDAR) surveys

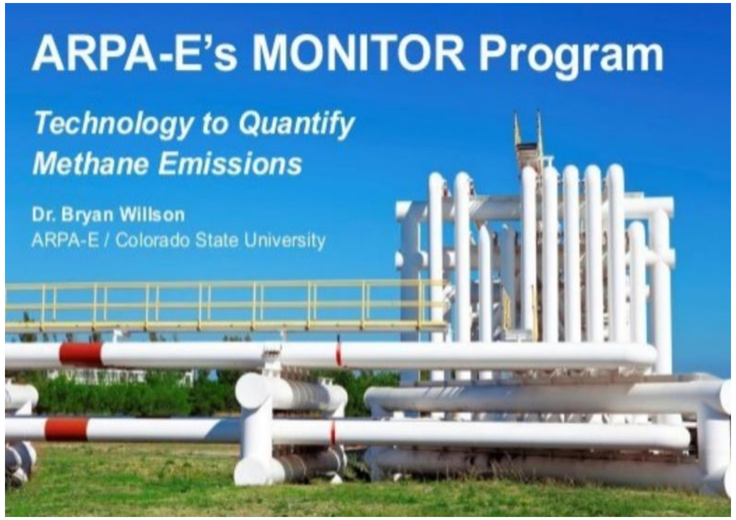
- Managing fugitive emissions or leaks
  - LDAR survey typically conducted with infrared camera technology
  - Survey frequency varies from 1/year to 12/year

- Drawbacks of camera-based surveys
  - Component-level measurements are time consuming
  - Highly susceptible to weather conditions

New Technologies and Platforms

- Truck-, drone-, and plane-based detection systems have been developed
  - Truck- and plane-based pilot studies reported in literature

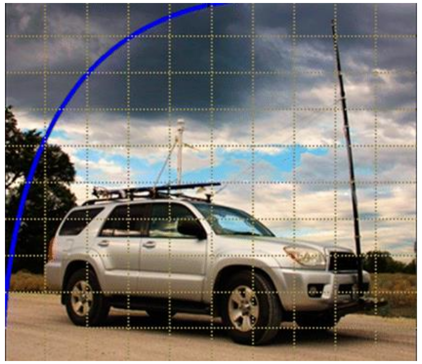
- Strong business and investor interest in testing new technologies

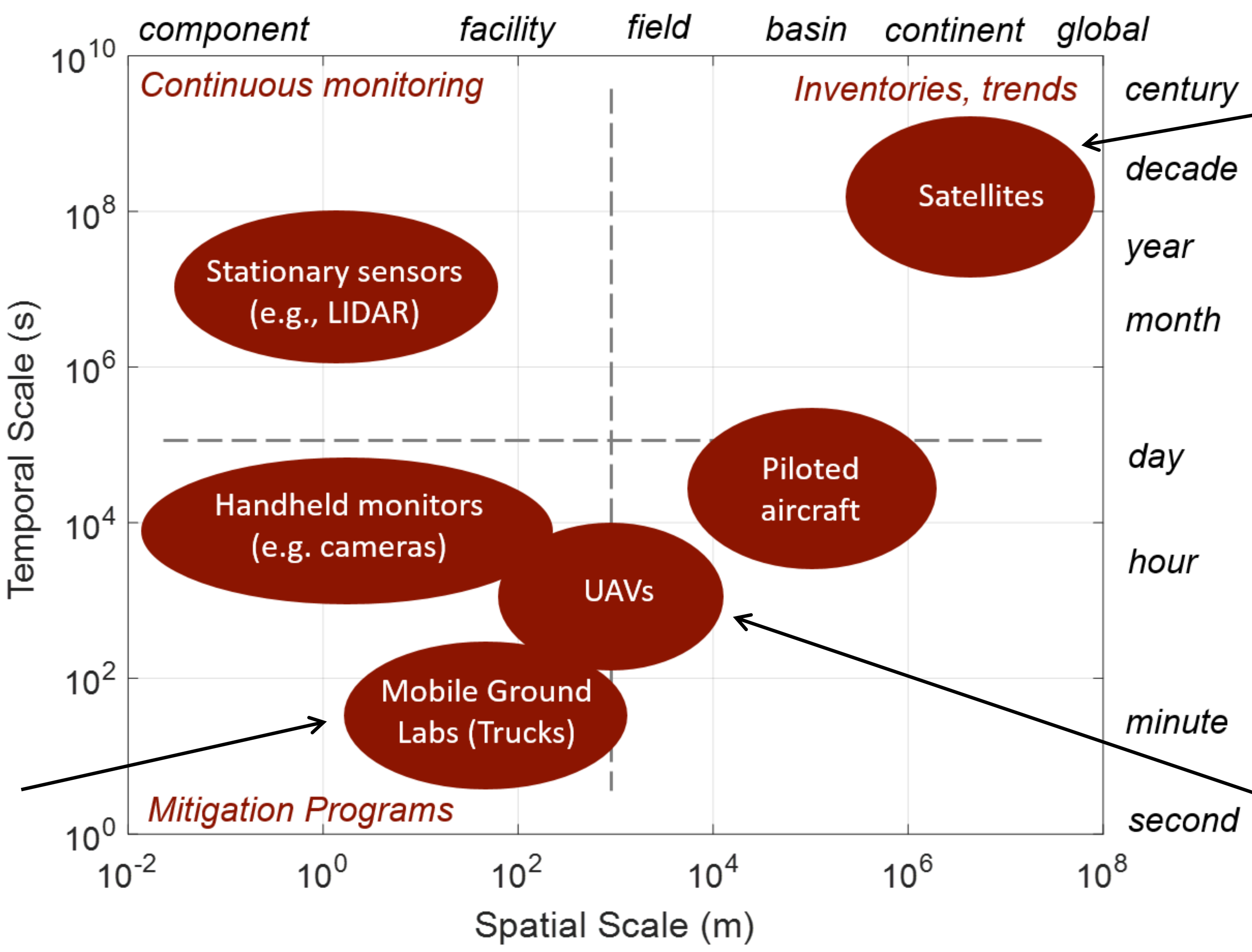


- Potential to provide more cost-effective mitigation
  - Colorado and Alberta actively studying ways to incorporate new tech

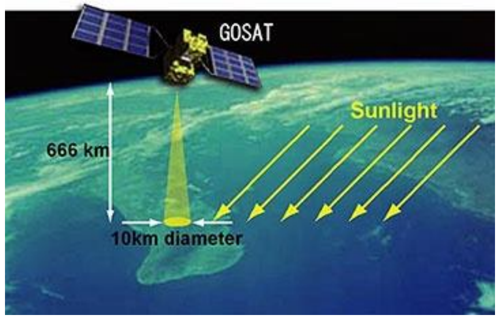
Design Space for New Technology

‘Fast screening’





Revisit time ~ 1 week



~45 min flying time

Fox et al. In review (2018)

Key Problem – Demonstrating Equivalence

- Need to demonstrate mitigation achieved using new technologies will be equivalent to existing approaches
  - Depends on how effective existing camera-based surveys are

- Recent work – controlled release experiments with cameras at METEC
  - OGI leak detection limits 10x higher than prior lab estimates

- More recent field-work with truck-based measurements in US & Canada
  - Provided facility-level instead of component-level data, but
  - Limited 'ground truth' measurements → direct comparisons difficult

Ravikumar et al. EST (2018)

Different Types of Equivalence

- **Detection Equivalence:** Technology-specific
  - Minimum detection threshold, speed, false positive rate, etc.
  - Can be identified by blind-tests (MONITOR program, Stanford/EDF Mobile Monitoring Challenge)

- **Mitigation Equivalence:** Technology + policy
  - Compare effective mitigation under specific survey protocols
  - But cannot be easily experimentally verified

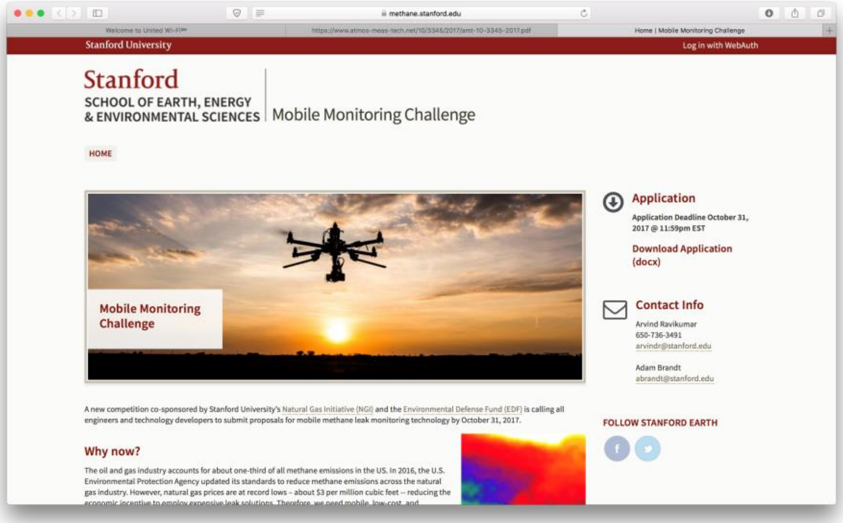
Equivalence = Technology Validation + Modeling Framework

MONITOR testing, Stanford/EDF MMC, limited field tests, etc.

FEAST-like modeling to determine long-term mitigation potential

Stanford/EDF Mobile Monitoring Challenge

- Test mobile approaches to leak detection
- Platforms – drones, trucks, and planes
- 28 applications received for the MMC call
  - 5 countries – US, Canada, Netherlands, UK, and Mexico
  - 12 technologies; 10 ultimately participated



Visit: methane.stanford.edu

Test Locations

- 2 test sites – METEC (Fort Collins, CO), Northern CA gas yard (Knights Landing, CA)
- Technologies split-up by detection sensitivities (based on detailed individual discussions with each participant)

Most Sensitive
(0 – 2 scfh)

- Heath (T)
- Picarro (D)

9 – 13 April 2018

Medium Sensitive
(5 – 10 scfh)

- Aeris (T)
- Advisian (D)
- Seek Ops (D)
- ABB/ULC (D)
- BHGE

7 – 11 May 2018

METEC (Fort Collins, CO)

Least Sensitive
(100 - 1000 scfh)

- Ball Aerospace (P)
- U Calgary (T)
- U Calgary (D)

21 – 25 May 2018

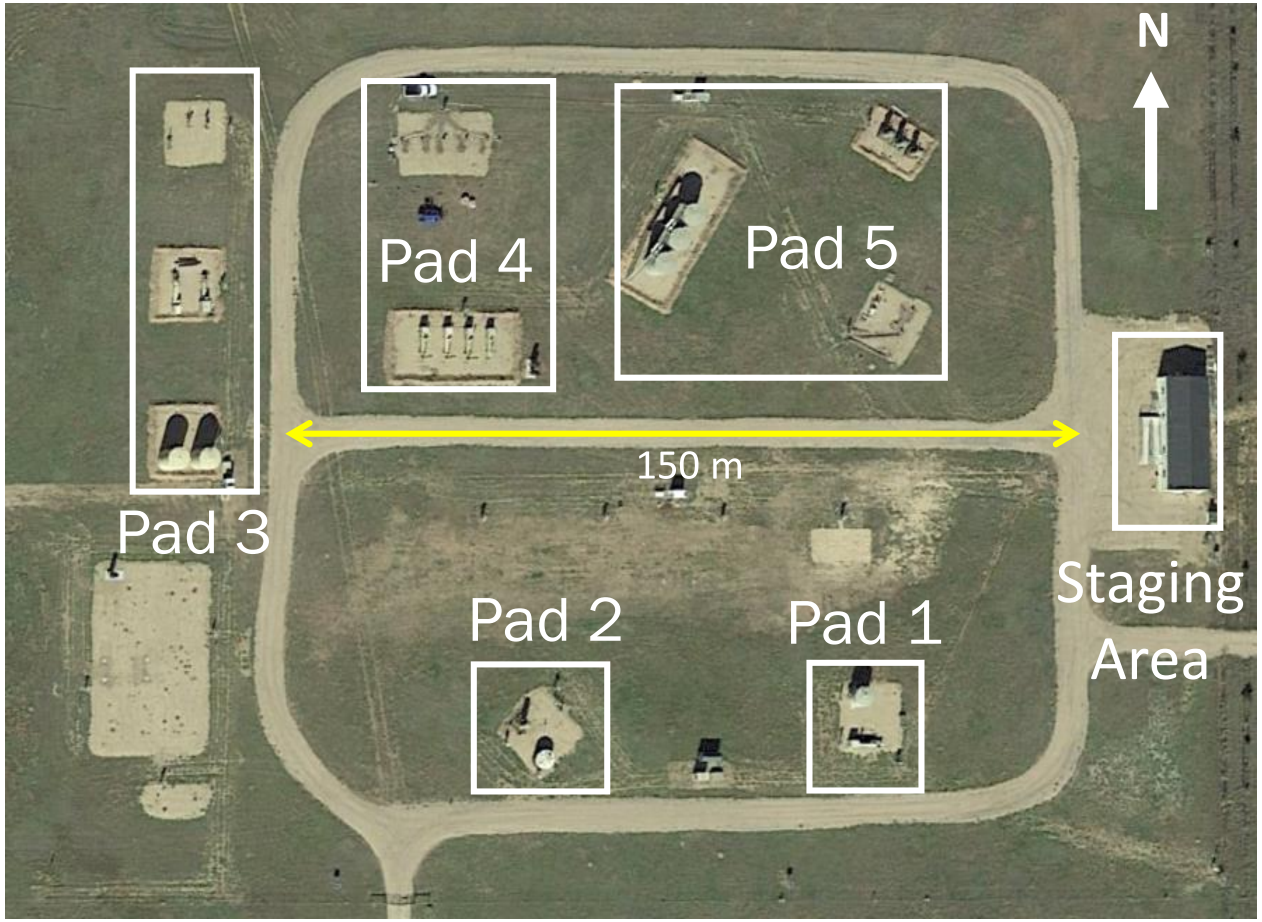
Gas Yard (Knights Landing, CA)

Test Parameters

Parameter	Description
Location identification	(a) Equipment level (both type and number), (b) Component level
Binary Yes/No detection	(a) True / False positive percentage (b) True / False negative percentage
Quantification accuracy	Parity chart of controlled leak tests
Ability to resolve leaks	(a) Small vs. large leaks close-by (b) Multiple similar leaks close-by (c) Multiple leaks on same pad

METEC Site-Layout and Field Testing

- One technology per pad (rotated periodically)
- Controlled releases were decided ‘on-the-fly’ based on wind speed and direction to avoid interference



Example Technology Testing

General Insights

- Don't believe everything a brochure says (*not their fault*)
- Most sensors efficient at detecting methane (point measurements), but…
  - Wide variety in algorithms that convert raw data to actionable info
- Quantification is a very difficult problem
  - 2 – 5x of actual leak rate is *very good* performance
  - Expectations should be at 'order-of-magnitude' level estimates
- No 'unicorn' solutions
  - Most new sensors will serve niche applications / industry segment
- Clearly distinguish 'screening' tech and 'OGI-replacement' tech

Results – Technology A

- Best-in-class performance (detection & quantification)
- Real time data including quantification (initial estimate)
- "Raw data" – no processing for winds or potential interference
  - Cross-terms affected by external weather conditions

Leak identification (overall)

Total number of leaks			63	
Number of zeros			41	
		Yes	*No*	*Total*
Leak		59	4	63
No Leak		0	41	41

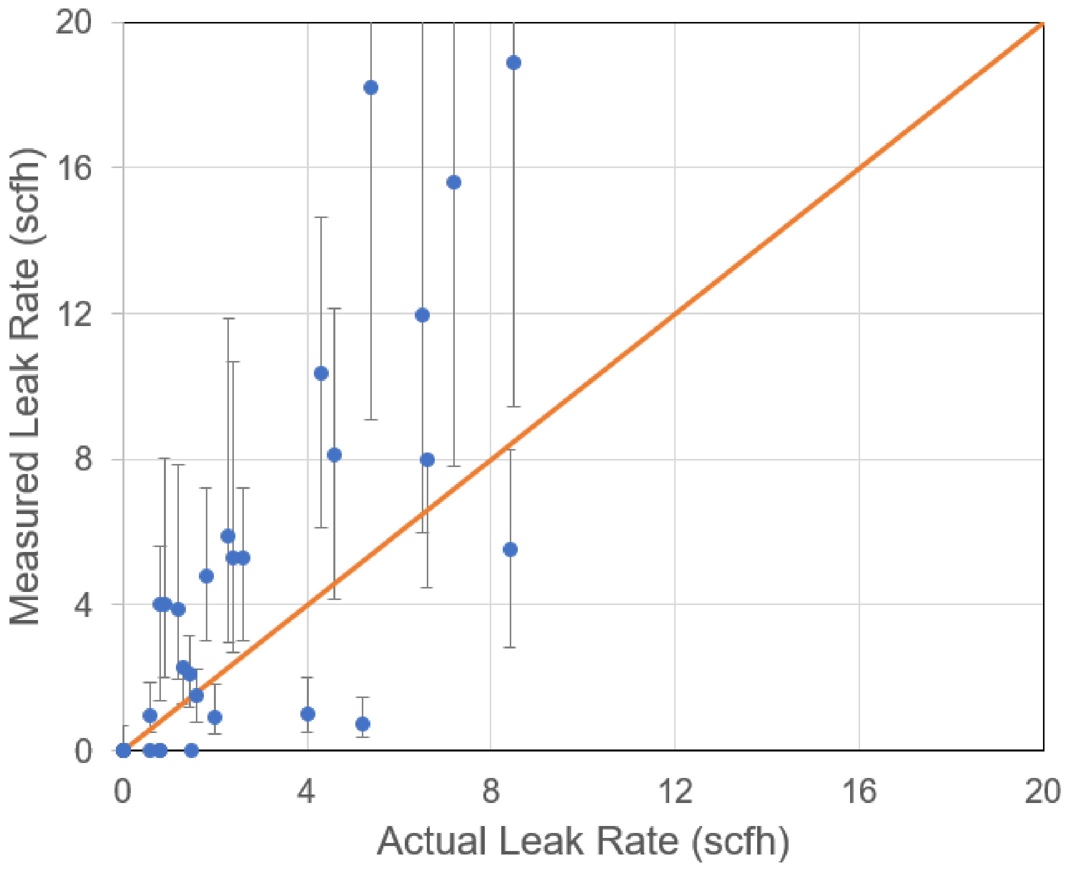
	Yes	*No*
Leak	True +	False -
No Leak	False +	True -
	0.94	**0.06**
	0.00	**1.00**

Locational Accuracy

Total number of leaks	63
Number detected	59
Number location identified	50
% location identified correctly	**0.85**

Technology A - Quantification

- Most leak estimates within 2x of actual leak rates
- (Quantification, in general, is very difficult. Within 2x is exceptional performance for sensors that don't directly measure flow rates)



Ravikumar et al. In preparation (2018)

Technology B – Detection

- Real time data on detection but not quantification
- Understand the importance of detection probabilities and limits

Leak identification (overall)

Total number of leaks				57
Number of zeros				45
		Yes	*No*	*Total*
Leak		39	18	57
No Leak		32	13	45

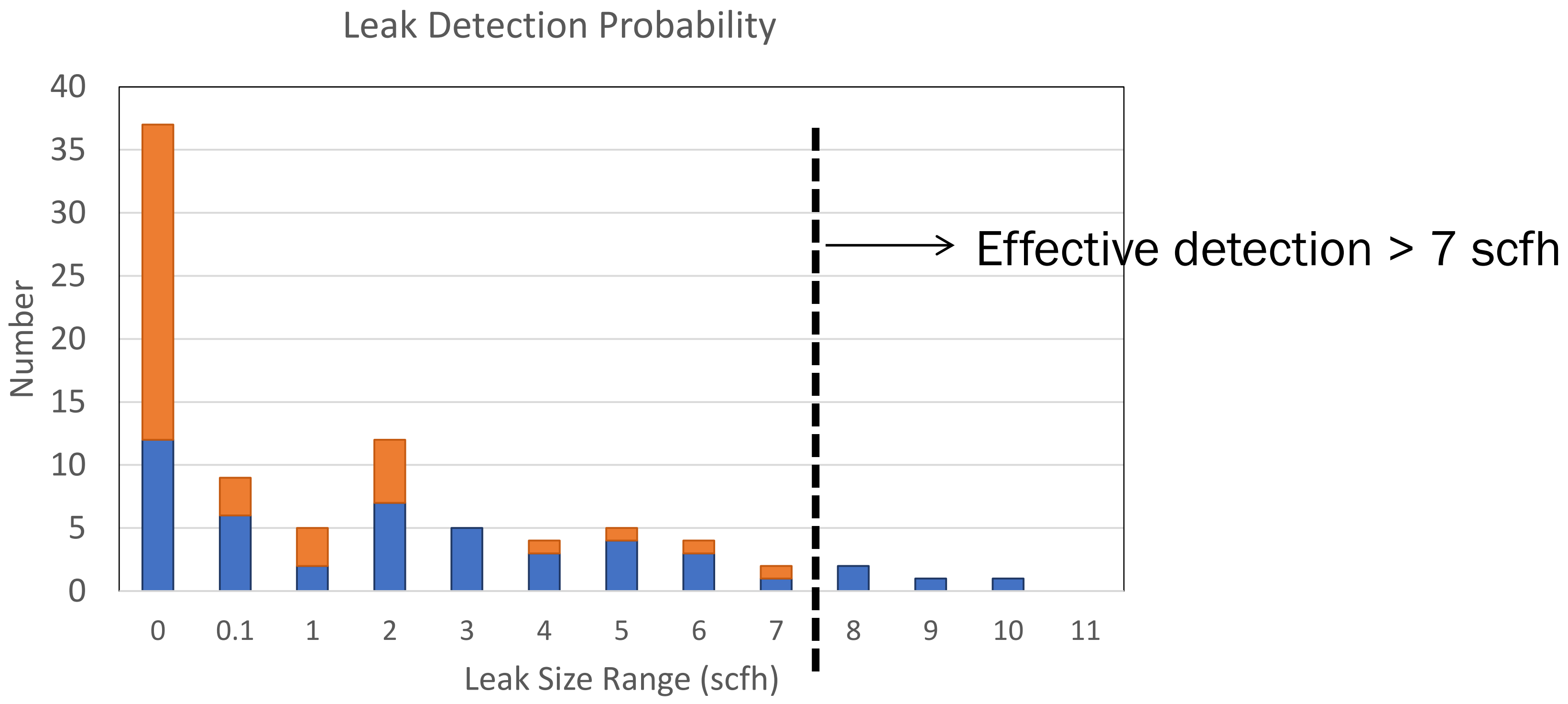
	Yes	*No*
Leak	True +	False -
No Leak	False +	True -
	0.68	0.32
	0.71	0.29

Locational Accuracy

Total number of leaks	57
Number detected	39
Number location identified	19
% location identified correctly	0.49

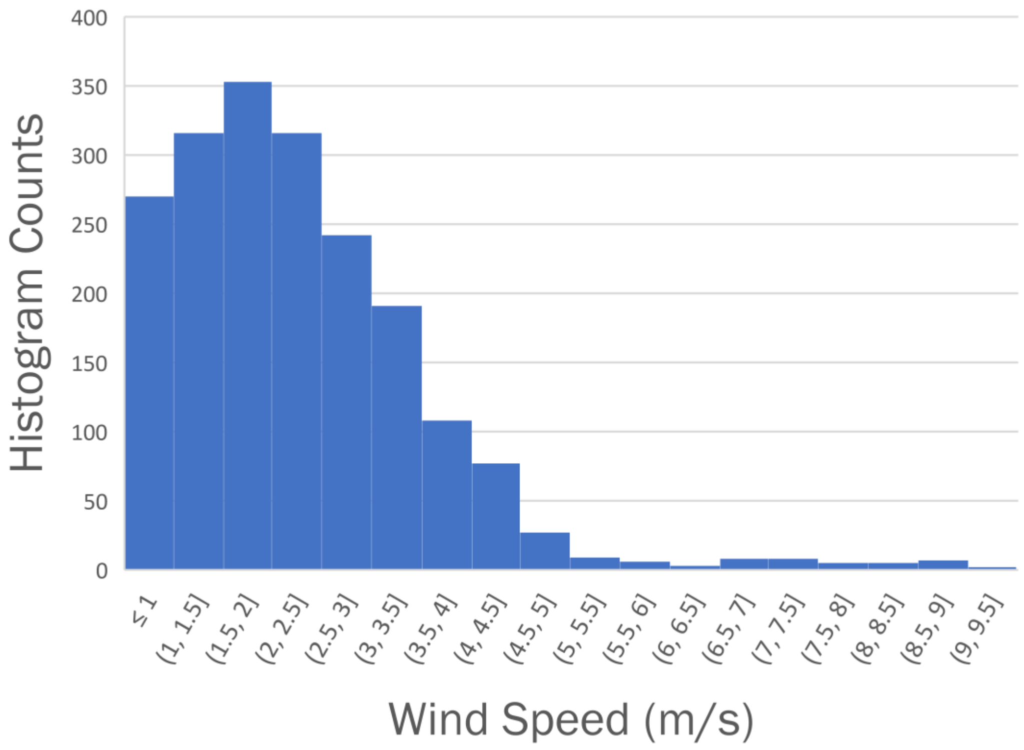
Technology B – Leak Detection Probability

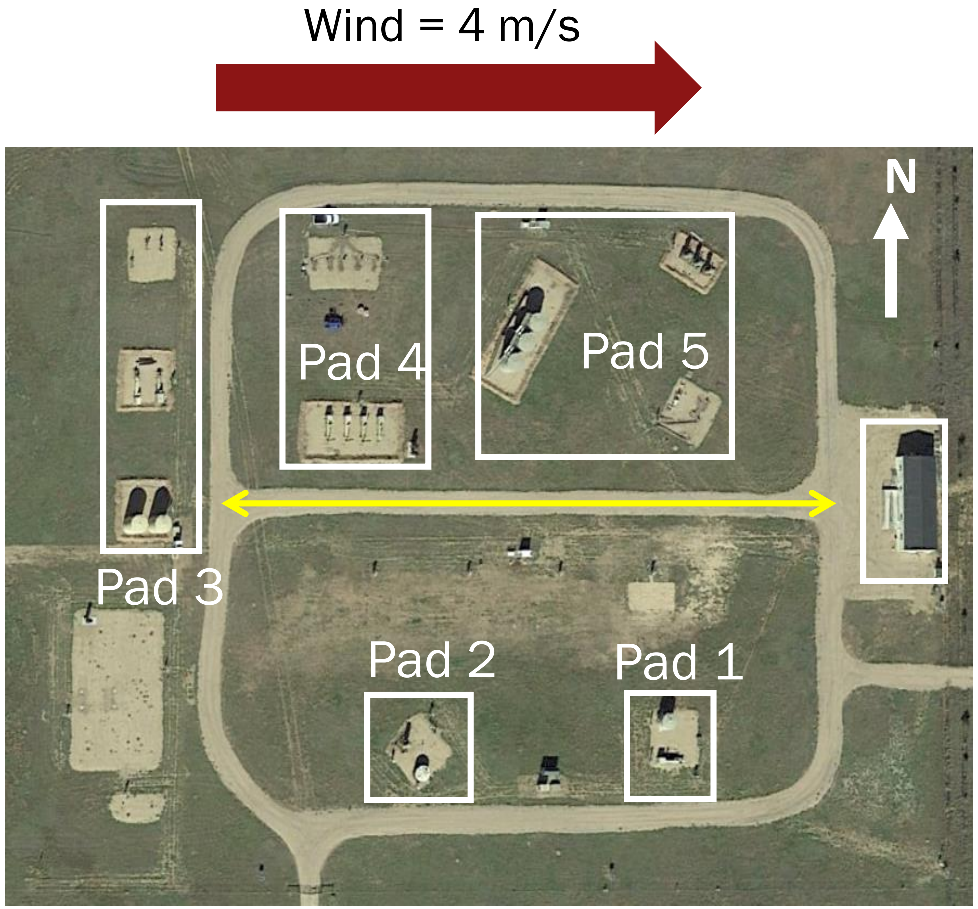
- Leak detection probability proxy by histogram of leaks detected within a given range
- Median threshold ~ 2 scfh with high false positive rate (Note: company specified 'definite detection' is 6 scfh)



Technology B – Weather Considerations

- Need to consider interference between pads (can increase false positive rate) and effect of wind speed on detection capability





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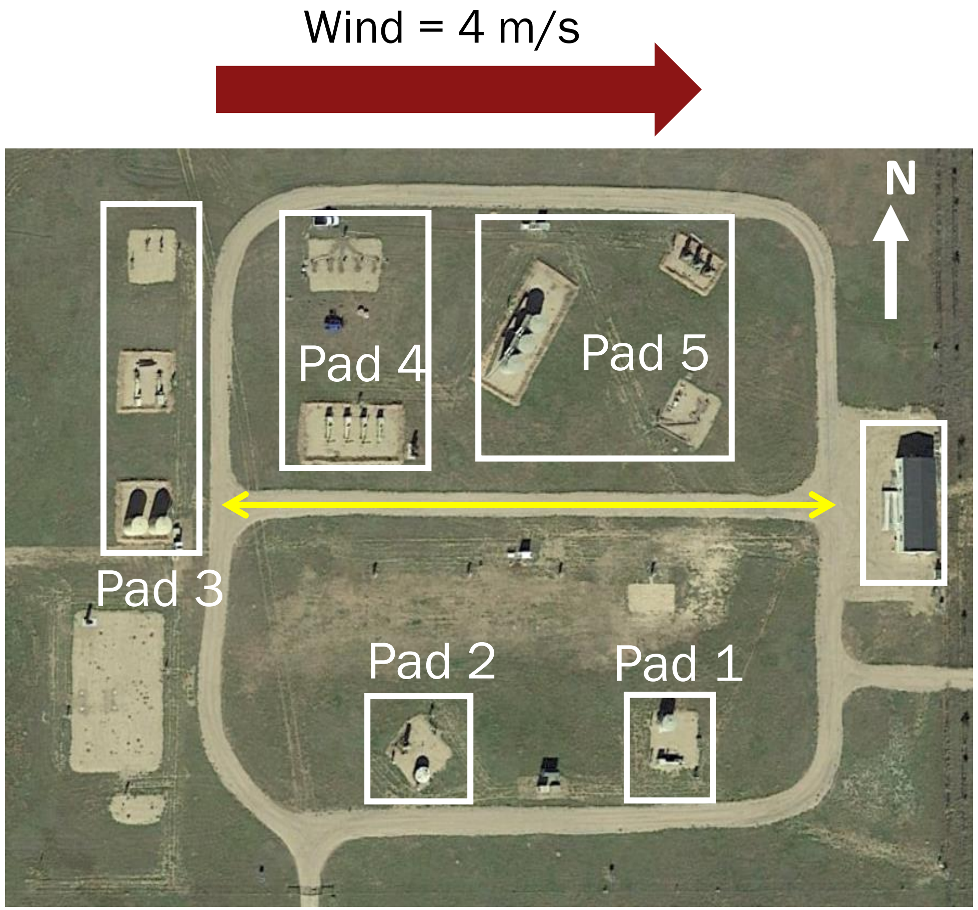


Pad 1	Pad 2	Pad 3	Pad 4	Pad 5
1	0	1	1	0

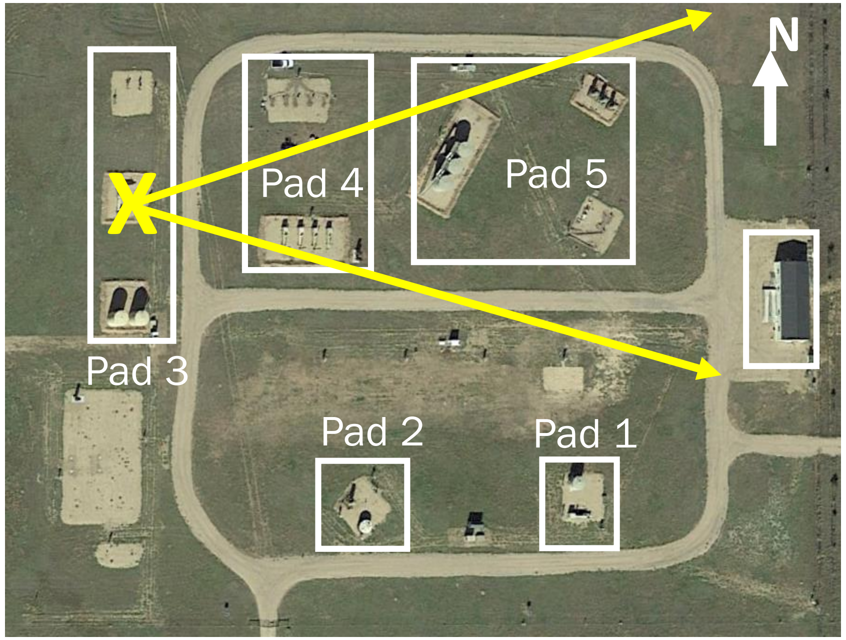
L x y

What happens on current pad?

Interference on current pad?

Pad 1	Pad 2	Pad 3	Pad 4	Pad 5
1	0	1	1	0
L10	L00	L10	L11	L01

Technology B – After Eliminating Weather Uncertainty



- ‘Cone of interference’ (40 deg) to determine influence of multiple leaks
- Mild vs. Strong interference based on wind speed parameters
  - Mild → < 2 m/s → no interference
  - Strong → > 2 m/s → cone of interference

All leaks

	Yes	No
Leak	True +	False -
No Leak	False +	True -
	0.68	0.32
	0.71	0.29

→

Mild interference

	Yes	No
Leak	True +	False -
No Leak	False +	True -
	0.68	0.32
	0.65	0.35

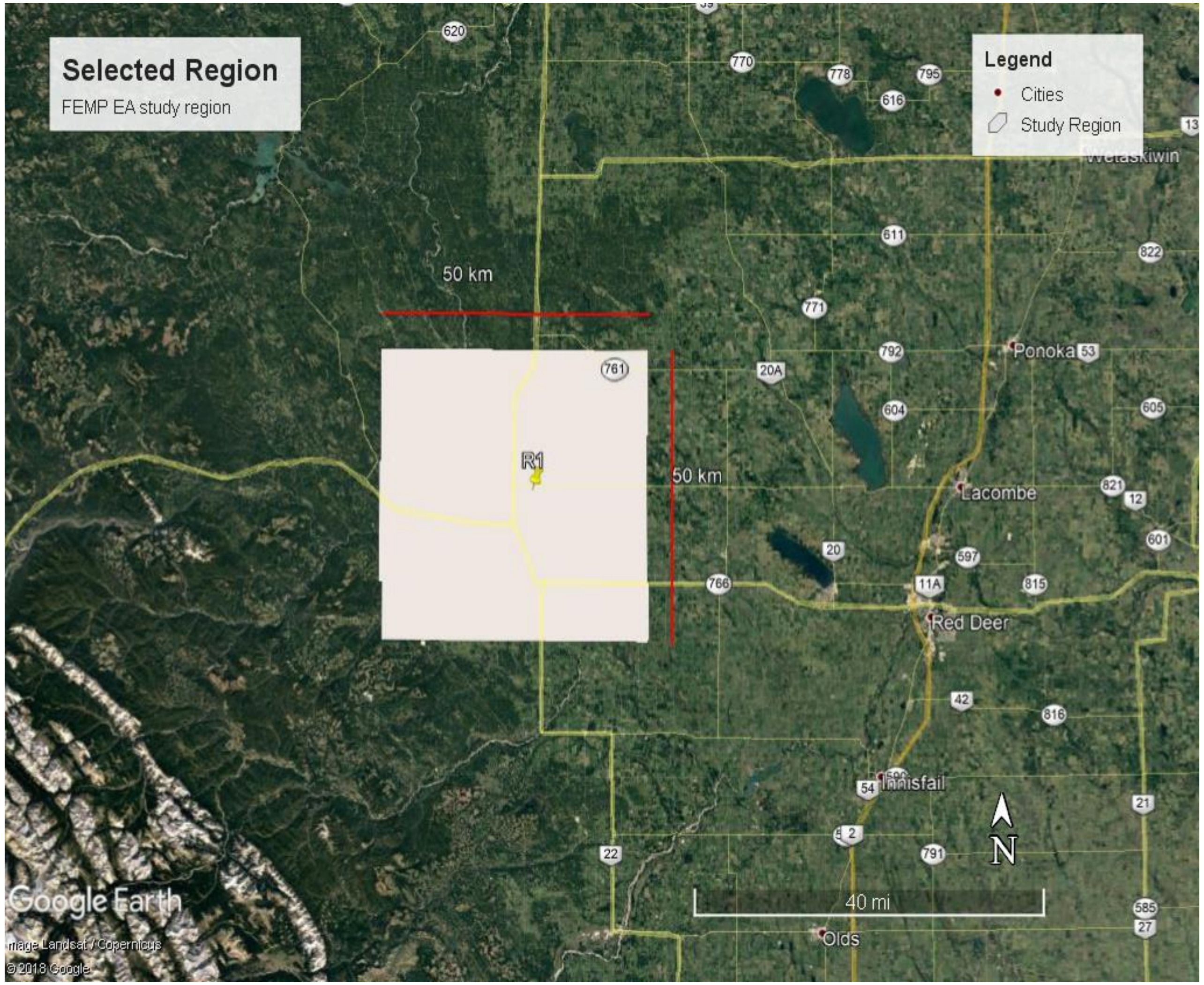
→

Strong interference

	Yes	No
Leak	True +	False -
No Leak	False +	True -
	0.65	0.35
	0.45	0.55

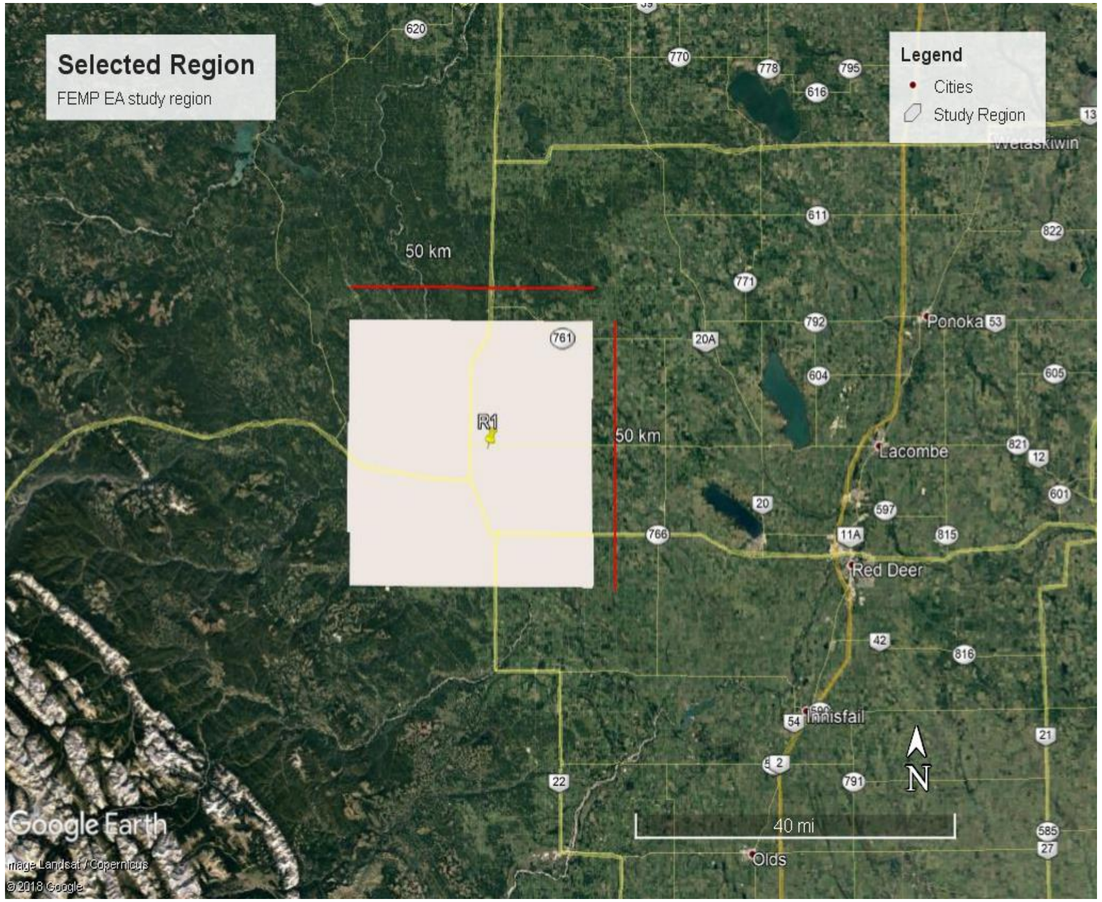
Field Campaign to Assess Policy Effectiveness (FEMP-EA)

- 50 x 50 km area NW of Calgary
- ~ 200 sites selected for leak detection and repair surveys
- 3 survey schedules (1, 2 or 3 times/year) and 1 control group
- Goals: Determine time evolution of emissions mitigation – 'sunset policy'



Field Trials of New Technology (Alt-FEMP)

- Simultaneous testing of new platforms (trucks, planes) along with OGI-based ground LDAR team
- ~1000 sites (Nov '18 – Sep '19)
- Study objectives
  - determine technology equivalence through direct field measurements
  - Study effectiveness of screening + confirmation approaches
  - Simulations to confirm mitigation equivalence



Future Work and Conclusions

- New technologies are promising alternatives for cost-effective methane emissions detection, but…

  - Technologies should be parametrized through well-designed control studies and pilot demonstrations
  - Couple data with models to estimate 'equivalent' emissions reductions and analyze long-term impact

- Policy design should allow for flexibility in mitigation practices
  - Allow for the use of 'screening' technologies
  - Re-think survey frequency rules as applicable to new technology

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