From Leak Detection to Network Intelligence

Using data analytics to extract more value from Advanced Leak Detection

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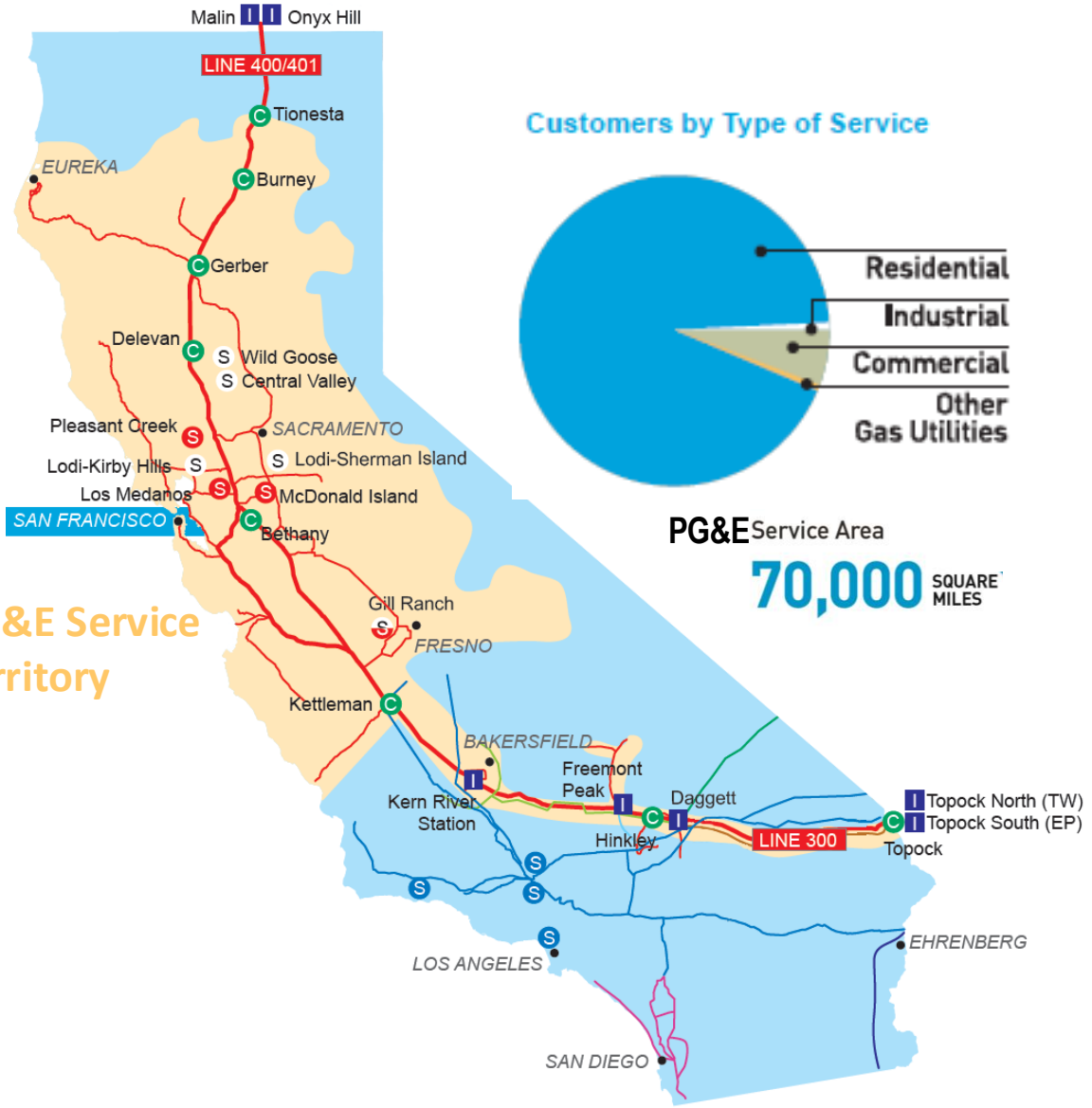
August 14, 2025

PG&E Gas Overview



PG&E Service Area

70,000 SQUARE MILES

One of the Largest Combined Gas & Electric Utilities in the United States	
Transmission Miles Distribution Miles	~5,650 ~44,300
Facilities	9 Compressor Stations 3 Storage Facilities 450 Regulation/Metering Stations
Customer Base	4.7 Million customer meters served in Northern & Central CA

~44,300 miles of gas distribution main

~34,200 miles of gas distribution services

~78,500 miles of gas distribution pipe

Enough pipe to wrap around the circumference of the Earth 3-times!

~3.4 million services

~6,300 cathodic protection areas

~7,700 active emergency valves

~4,000 rectifiers

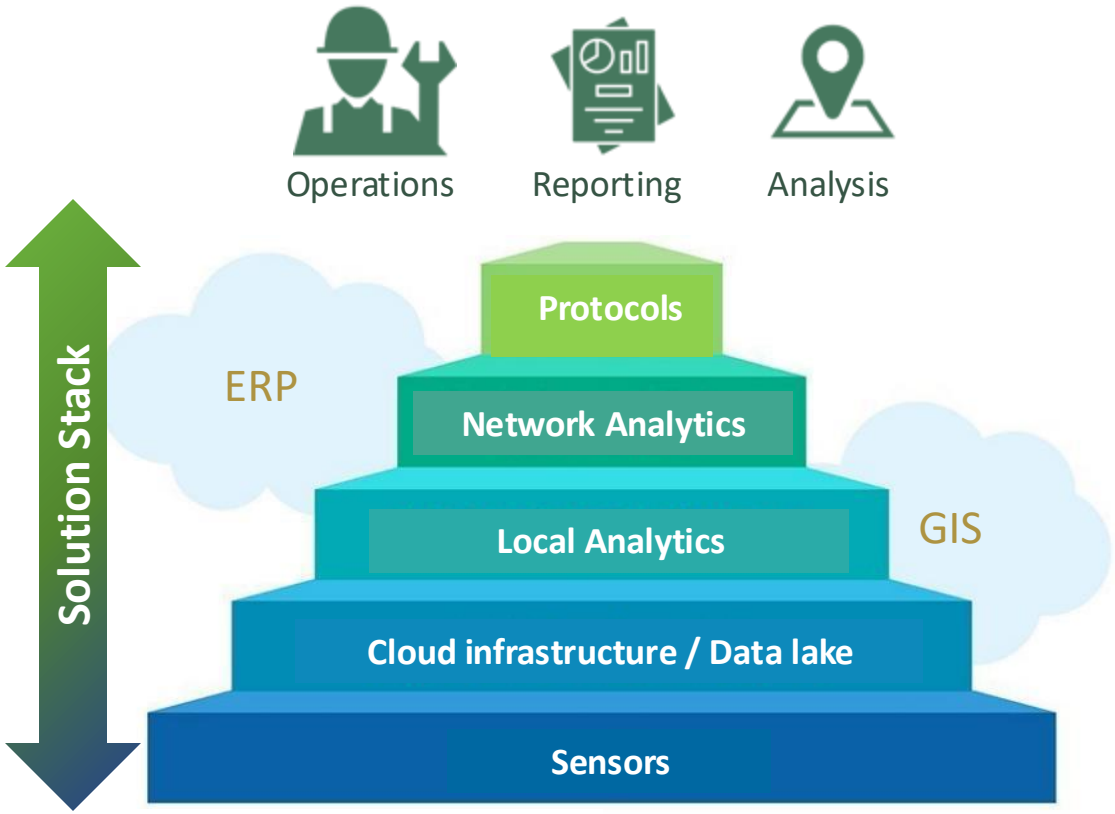
Public

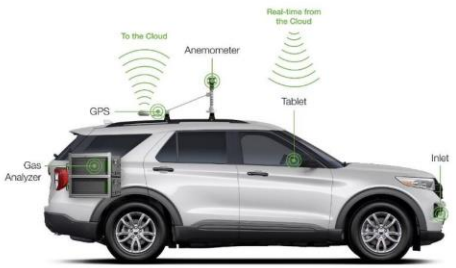
Traditional Leak Survey (before AMLD)

- Key purposes of Traditional Method
  - Compliance
  - Prioritizing Repair schedules
  - Minimal Risk Assessment
- Data Collection Process
  - 5 Year leak survey with crews walking lines
  - Paper Maps and paper leak forms used
  - Originally stored in paper then into basic databases
  - Leak indications and methane volumes were not recorded
  - Repair data collected

Advanced Mobile Leak Detection and Picarro Overview

- Picarro is the world leader in AMLD
  - 50+ gas operators worldwide
  - 1M+ miles of mains covered since 2012
  - 4M+ detections found



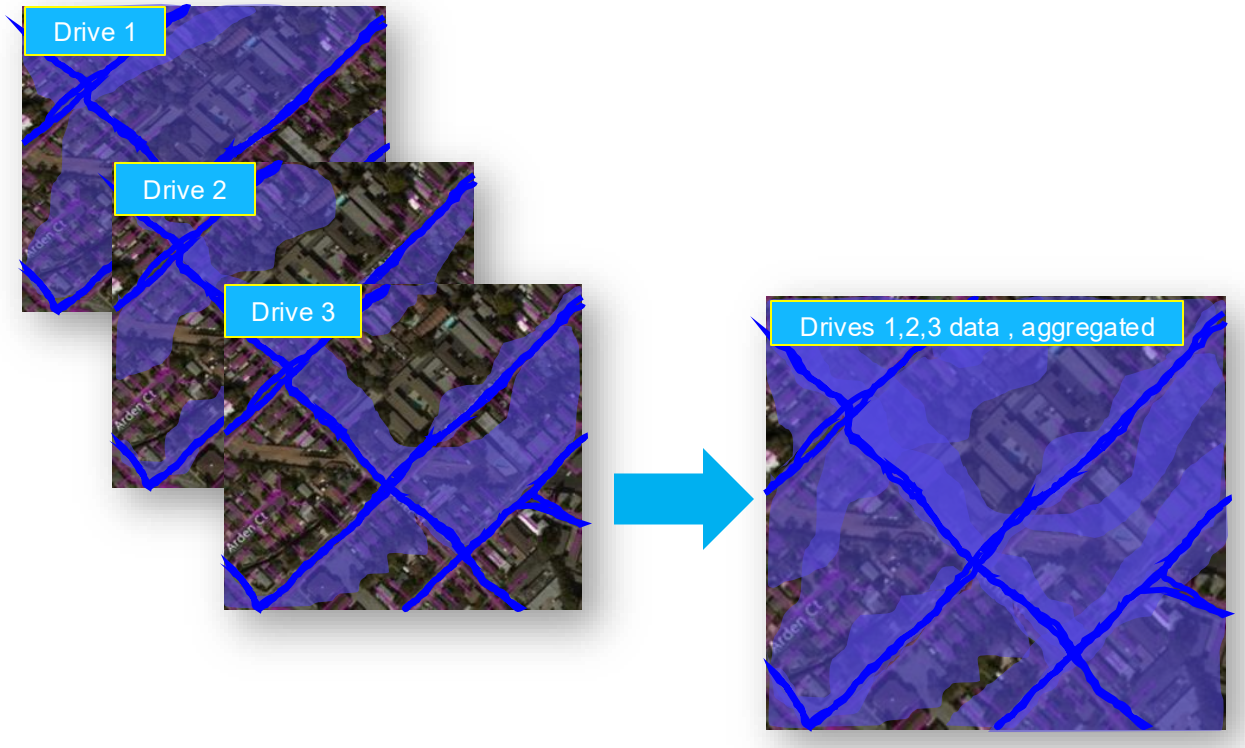


AMLD to support leak survey process but also to generate data for more value

- Principle of AMLD

Finding leaks

- Field of View through data analytics

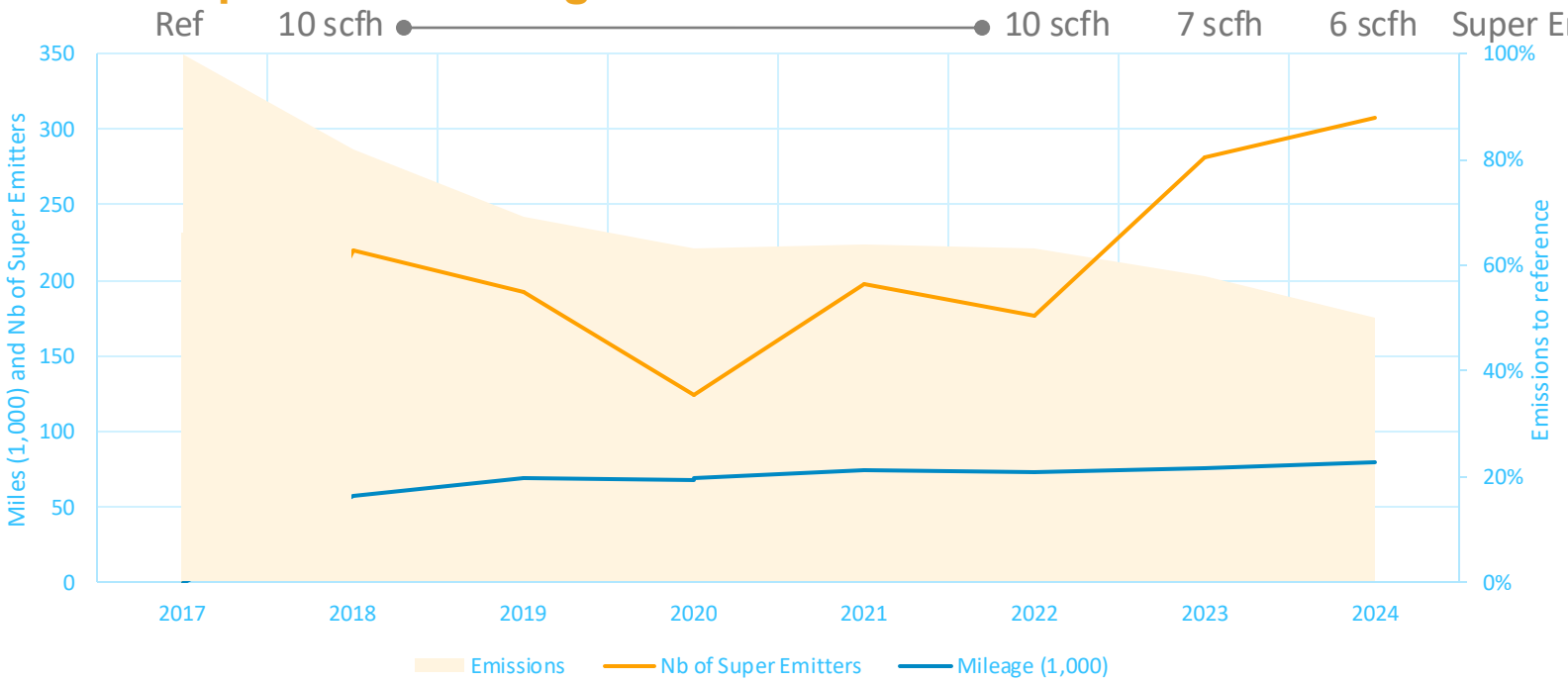


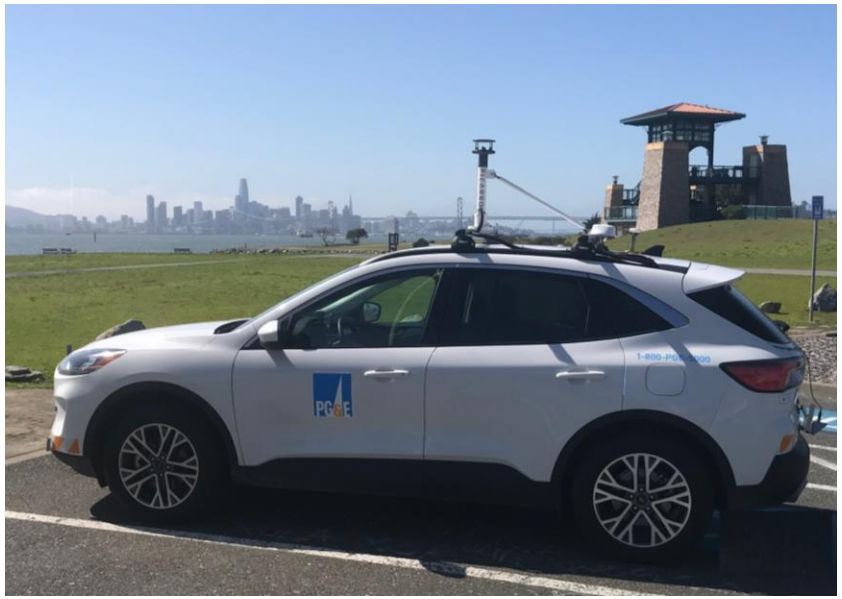
Assessing what assets were covered

PG&E's Super Emitter Program

- Progress in data analysis unlocked estimation of leak flow rate in 2017.
- Starting in 2018, we drove entire distribution system every year rather than 3 years for compliance surveys and only investigate and repair detections greater than a certain threshold
- In 2023, we decreased the Super Emitter Threshold from 10 to 7 standard cubic feet per hour (scfh)
- In 2024, we decreased it to 6 standard cubic feet per hour (scfh)

PG&E Super Emitter Program Results

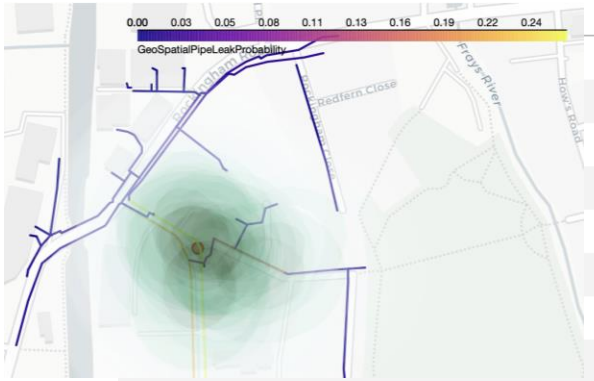




Prioritizing Detections based on the associated risk

- Leak detections do not carry the same risk depending on their location, their environment, their size, the assets around them, etc.
- Risk can be assessed for every detection as a function of asset and environment attributes supplemented with data collected by Picarro.

Detection



RoF_COR	RoF_EF	RoF_MF	Pipe Probability
0.000115	0.000002	0.000001	0.20
0.000115	0.000002	0.000001	0.19
0.000000	0.000001	0.000028	0.11
0.000000	0.000001	0.000008	0.11
0.000053	0.000001	0.000001	0.05
0.000053	0.000001	0.000001	0.04
0.000053	0.000001	0.000001	0.03
0.000000	0.000001	0.000008	0.03

ROF: Risk of Failure
CORR: Corrosion
EF: Equipment Failure
MF: Mechanical Failure
COF: Consequence Of Failure
LOF: Likely Of Failure

Flow Rate × COF × [Persistence (peaks/passes) + LOF] = Risk Score

- This representation is fully auditable and represented by a combination of additive and multiplicative terms.

Injecting DIMP data

Asset risk is modeled using several datasets of frequency and consequence

- **Frequency** of leaks (excludes non-leaking scenarios)
- **Safety consequence** (excludes gas reliability or other consequences)
- **8** code-required threats split into **33** sub-threats:

Corrosion	Excavation	Material, Weld, or Joint Failure	Incorrect Operation	Natural Force	Other Outside Force	Equipment Failure	Other
• Internal • External • Atmospheric	• Excavation Damage	• Longitudinal Weld Failure • Metallic Material Failure • Plastic Material Failure, Body of Pipe • Plastic Material Failure Fitting • Compression Coupling • Plastic Tee Cap, Material Failure	• Crossbore • Fusion Failure • Other Weld Failure • Girth Weld Failure • Incorrect Operation • Construction Defect	• Earthquake • Earth Movement • Flood • Lightning • Root Damage • Tsunami • Other Natural Forces	• Fire/explosion • Rodent • Previously Damaged • Electrical Facilities • Third Party • Vandalism • Vehicle	• Seal Failure • Miscellaneous	• Other

Injecting DIMP data - General Risk Equation

Risk of Failure (RoF) Serious Injuries & Fatalities (SIFs) / 100,000 years per segment

$LoF_{SubThreat}$ × CoF = $RoF_{SubThreat}$

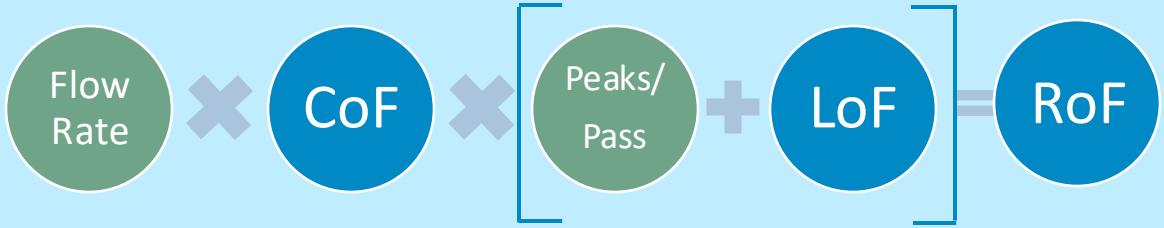
(leaks / year) × (SIFs / 100,00 leaks) = (SIFs / 100,000 years)

- {Historical leak rate for district or plat (leaks/mile-year)
  +
  Projected leak rate for specific characteristics of asset or operating environment (leaks/mile-year)}
  x
  segment mileage
  =
  leaks / year

- PHMSA nationwide SIFs per leak (SIFs/100,000 leaks)
  x
- unitless modifiers:
  - Migration
  - Pressure
  - Population Density
  - Excess Flow Valve (service assets only)

Applying Risk Data to Leak Detection

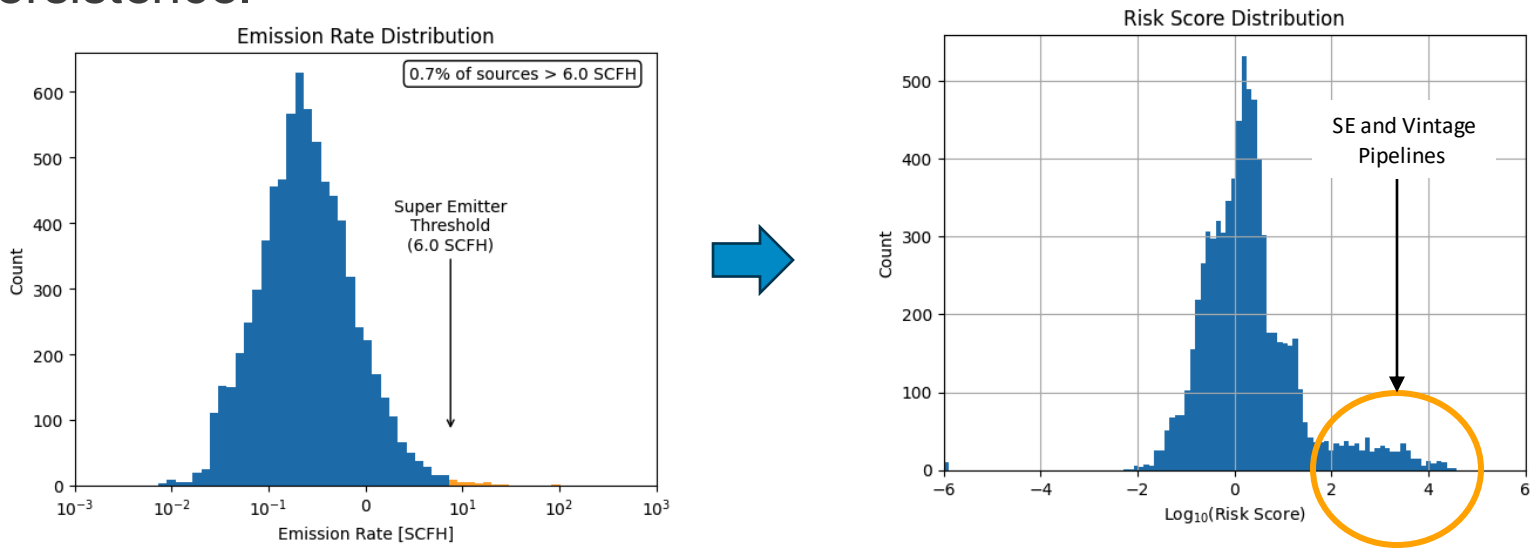
- Risk can be assessed for every leak detection as a function of asset and environment attributes supplemented with flow data. i.e. high flow rates



- With increasing data collection, a new view on asset risk and investment alternatives becomes possible.

First Application: accelerated surveys of vintage pipelines

- Accelerated survey (annual) of higher leak density vintage steel (pre-1940) and Aldyl-A (pre-1975) pipelines
- Used the risk-informed prioritization by adding pipeline material and vintage to flow rate and persistence.

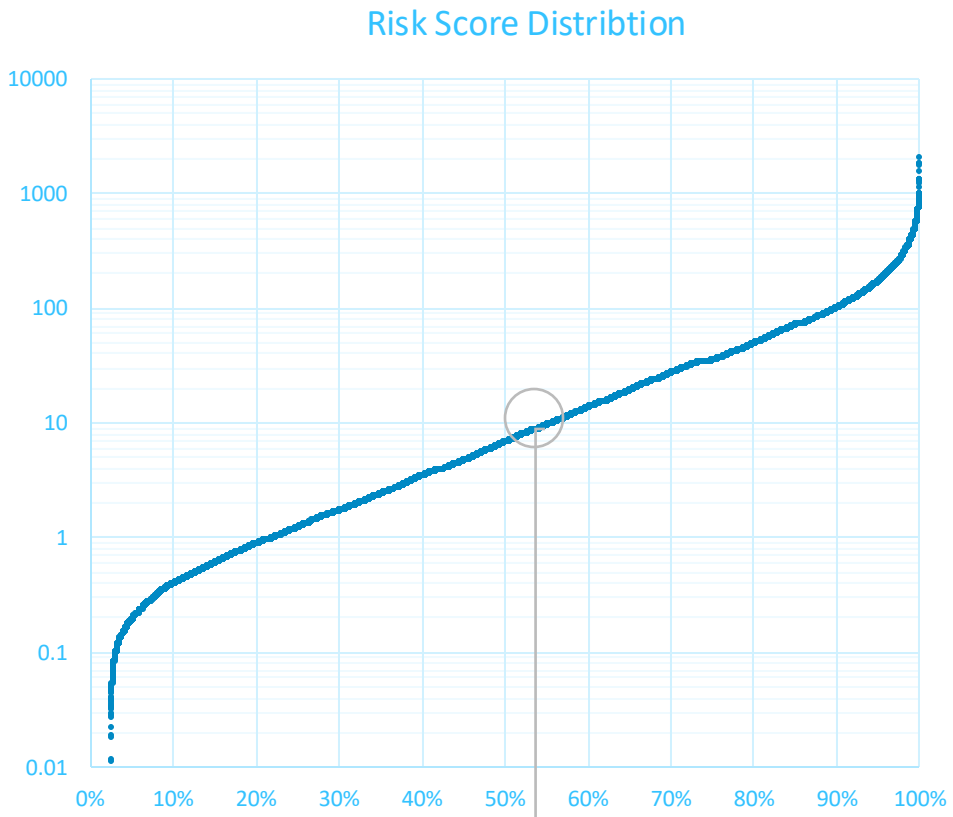


- Same data set as for Super Emitter Program but added a material-based prioritization factor to extend to vintage pipelines.
- Risk–informed model provides flexibility for gas operators to leverage the data to different programs extracting more value from the surveys.

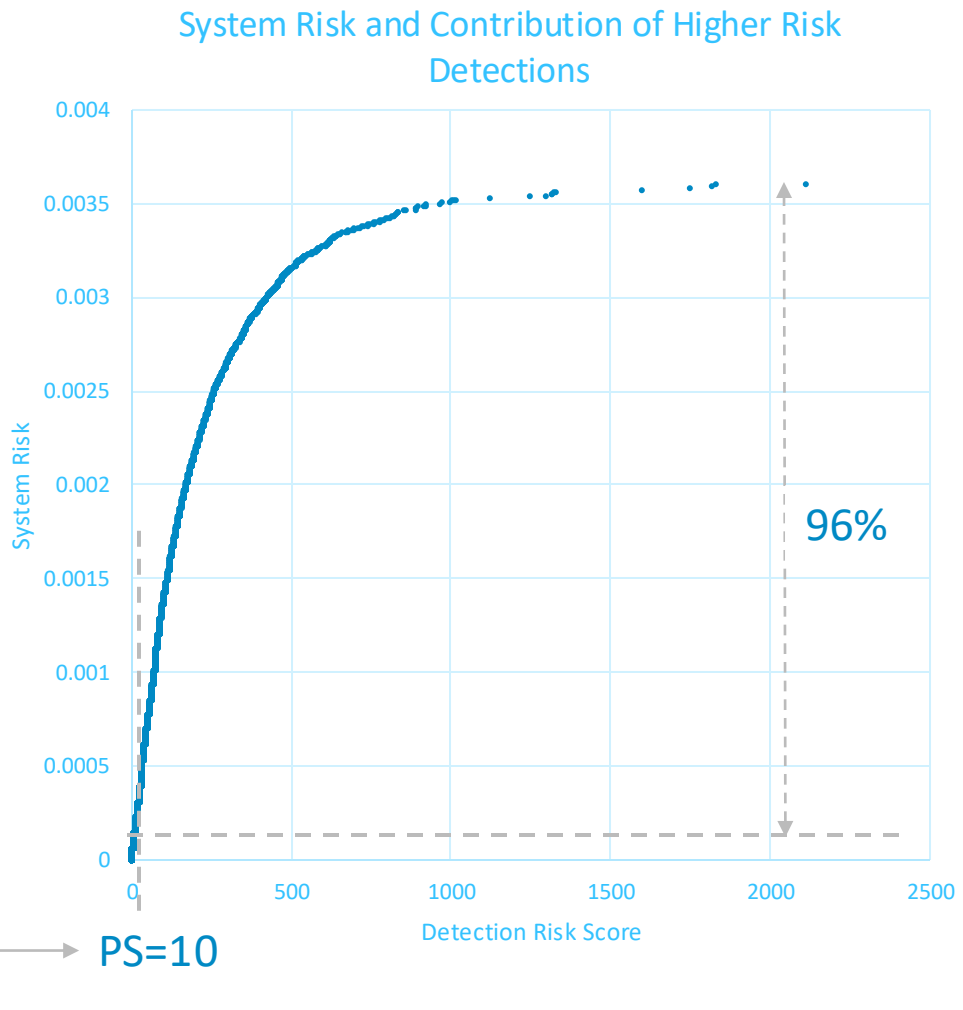
Extension to risk-informed leak management

Each detection is assigned a risk as defined earlier. They are aggregated to represent the risk at the system level

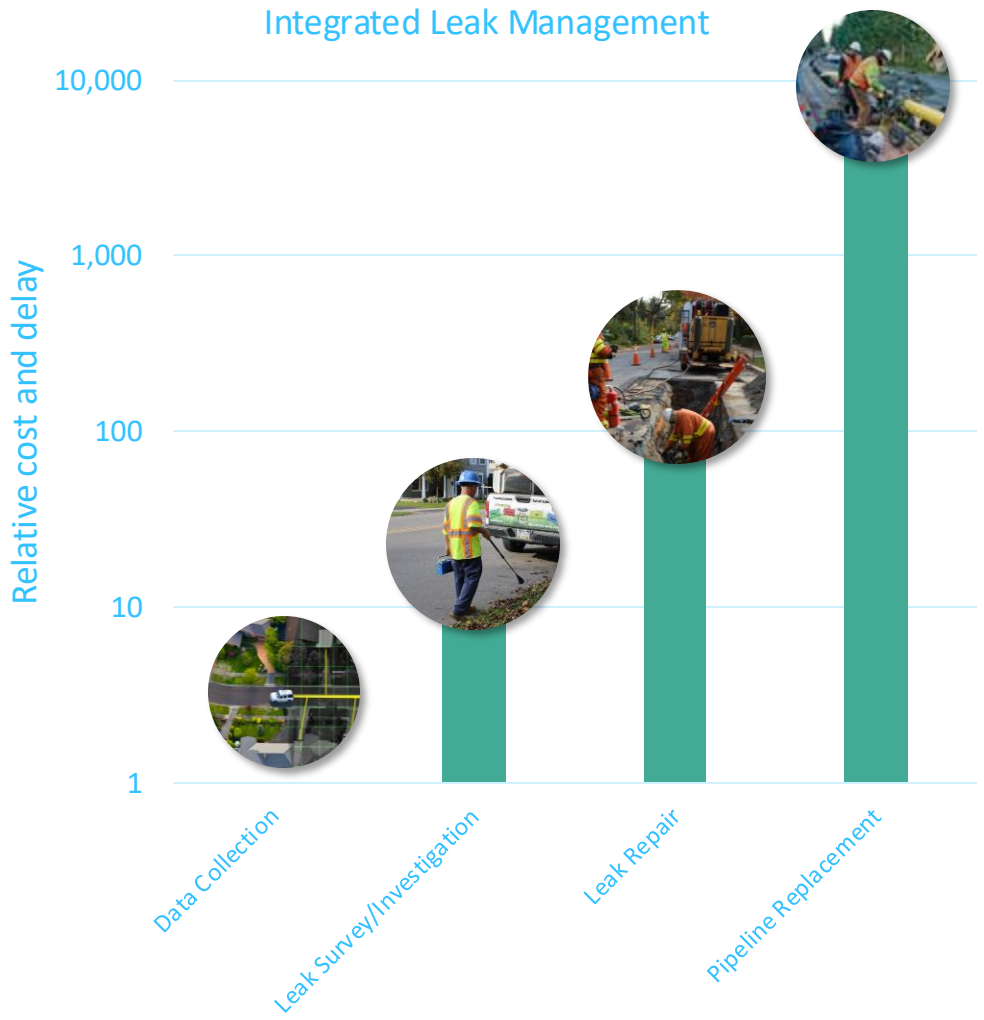
- Detection Risk Scores span over more than 4 orders of magnitude



$$1 - P^{sys} = \prod_i (1 - P_i)$$



Minimization of System Risk



- Comparing 5 year survey and repairing everything to Annual Data Collection and repairing PS>10

5 years survey

	All Leaks	PS<10	PS>10
area1	0.04%	0.00%	0.03%
area2	0.14%	0.01%	0.14%
area3	0.32%	0.01%	0.31%
area4	0.58%	0.02%	0.55%
area5	0.90%	0.03%	0.87%
All areas	**1.97%**	0.07%	1.89%

Annual survey

	All Leaks	PS<10	PS>10
area1	0.04%	0.00%	0.03%
area2	0.04%	0.01%	0.03%
area3	0.05%	0.01%	0.03%
area4	0.06%	0.02%	0.03%
area5	0.07%	0.03%	0.03%
All areas	**0.25%**	0.07%	0.17%

Increasing System Safety by a factor of 8 while reducing repair cost by 2

Conclusion

- Data Analytics leverage AMLD for much more than leak detection
- The same survey can then feed several programs
  - Emissions, pipeline replacement, risk reduction, etc.
- Risk at the system level optimizes the use of utility's resources (leak survey, repair, pipeline replacement, operation, etc.)
- Reduce O&M expenses by leveraging the system intelligence
- AMLD associated with data analytics unlocks new opportunities for utilities to integrate leak management to minimize risk.
- For operator risk, emission, and cost reduction: convergence of interests between regulators, operators, customers

Public

Thank You

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