Formal Alternative Test Method

Insight M LeakSurveyor™

10 kg/hr & 15 kg/hr Deployment

SUBMITTED TO

The United States Environmental Protection Agency
Air Emission Measurement Center (EMC)

SUBMITTED BY

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1 Scope and Application

1.1 *Introduction*. This document outlines the Insight M protocol for deploying the LeakSurveyor methane spectrometer ("LeakSurveyor") for field surveys of oil and gas sites. LeakSurveyor is an airborne remote sensing instrument capable of surveying any and all onshore oil and gas infrastructure. LeakSurveyor collects reflected sunlight and measures the total concentration of methane along the complete path of the light entering the instrument. It is capable of identifying emissions to the facility level, as well as quantifying the amount of methane being emitted within a characterized range of error. Both detection and emission source rate quantification have been validated via third-party, single-blinded testing (peer-reviewed and published), numerous internal controlled release tests, and field performance in over 20 oil and gas basins.

1.2 *Scope.* This protocol outlines an alternative test method using advanced methane detection technology for periodic screening for fugitive emissions and emissions from covers and closed vent systems in lieu of the procedures set forth in 40 CFR § 60.5397b and § 60.5416b(a)(1)(ii) and (iii), (2)(ii) through (iv), and (3)(iii) and (iv).

1.3 *Instrument*. The methodologies in this protocol are specifically designed to be applied with LeakSurveyor's advanced methane detection technology. Insight M is the sole producer and operator of the LeakSurveyor system. This document outlines the protocols employed by trained Insight M personnel and its contractors when conducting a field survey for methane emissions.

1.4 *Analytes.*

Analyte	CAS No.
Methane (CH_4)	74-82-8

1.5 *Applicability.* The methodologies described in this protocol are appropriate for detecting methane emissions from onshore oil and gas infrastructure. The methodologies are broadly applicable to any and all onshore oil and gas (upstream and midstream) point sources in the United States.

1.5.1 *Proprietary application*. The LeakSurveyor technology, analytical pipelines, and accompanying methodologies described in this protocol are the intellectual property of Insight M; if you wish to deploy these methodologies, please contact info@InsightM.com for potential contracting.

1.6 *Data Quality Objectives (DQOs)*. Adherence to the requirements of this protocol will guarantee sufficient quality of reported data obtained from aerial methane surveys using LeakSurveyor, and provide a means to bring alternative technology to mandated OGI and/or

AVO monitoring of fugitive emissions components, covers, and closed vent systems without sacrificing detection and measurement rigor.

1.6.1 *Spatial Resolution*. Deploying LeakSurveyor according to this protocol characterizes emissions at a facility-level spatial resolution, meaning the method has the ability to identify emissions within the boundary of any relevant facility, including (but not limited to) a well site, centralized production facility, or compressor station.

1.6.2 *Sensitivity*. The deployment of LeakSurveyor described in this protocol will achieve a 90% probability of detection of an emission source that is emitting methane at a rate of 10 kg/hr or 15 kg/hr, depending on selected deployment.

The key difference in the method between the 15 kg/hr protocol and 10 kg/hr protocol is the deployment parameters of height above ground and wind speed, which are jointly modeled. In summary, achieving 10 kg/hr sensitivity at 90% probability of detection, requires lower altitude collection and/or slower wind speeds relative to the 15 kg/hr protocol. Sensor performance across collection altitude and wind speed have been robustly tested and characterized via controlled releases (see section 13.3 for further detail). All other data quality indicators (DQIs) and methods, including operational interferences, safety, required equipment and supplies, data inputs (including meteorological data), signal processing pipeline, quality control measures, required systems checks, etc., as well as hardware, sensor calibration, and airborne deployment platform, are identical between the Insight M 10 kg/hr and 15 kg/hr protocols.

2 Summary of Method

2.1 *Principle*. This protocol describes the application of LeakSurveyor and methodology to detect methane emissions of 10 kg/hr and 15 kg/hr or greater with a 90% probability of detection. LeakSurveyor is further described in full in the attached *Insight M LeakSurveyor Description of Technology* document.

2.2 *Pre-deployment activities.* Before deployment, flight planning identifies the facilities to be surveyed and assesses weather forecasts to estimate likely collection conditions. The goal of this effort is to facilitate survey of all target sites under meteorological conditions that ensure the target sensitivity. This method relies on aerial data collection, so on-ground site walkthroughs are not necessary and are not performed prior to deployment.

2.3 *Deployment.* The instrument is mounted on the wing strut of a fixed-wing aircraft, such as a Cessna. Standard pre-flight checks ensure that the aircraft and instrument are operational and that safety protocols are followed. Once all pre-flight checks pass, the aircraft takes off and proceeds to the collection area, which has been determined during pre-deployment flight planning. Pilots who have completed training on the LeakSurveyor technology and operations fly the aircraft and sensor over the target infrastructure. As the plane passes above target infrastructure, the LeakSurveyor system collects nadir-view spectroscopic measurements that will later be analyzed for absorption of infrared light characteristic of methane absorption (please see the *Insight M LeakSurveyor Description of Technology* document for further discussion of the scientific basis for this approach). Additionally, an optical camera located within the LeakSurveyor instrument body collects RGB imagery of the site to help determine conditions on the ground as well as more accurately locate the likely source (within the facility) of detected methane. The complete facility is surveyed, with multiple overlapping (side-lap) passes collected if necessary to obtain complete spectroscopic and optical data coverage for the entire facility and surrounding area. During aerial data collection, LeakSurveyor operation and real-time meteorological conditions are monitored to ensure data quality objectives at the target sensitivity are achieved. Once the target sites have been surveyed, the plane returns to base. Once on the ground, the LeakSurveyor system is inspected for any issues that may have occurred during the day's collection.

2.4 *Post-deployment.* After completing post-flight safety and instrument inspections, the LeakSurveyor is connected to the Internet, and data upload begins. Please see the *Insight M LeakSurveyor Description of Technology* document for more information.

3 Definitions of Method

3.1 *Controlled release* - A field test in which methane is released at well-characterized release rates and Insight M sensors are flown overhead, in order to assess instrument performance.

3.2 *Emission source rate quantification* - The measured rate of loss for a valid plume detection of an emission source, in flux units (e.g., kg/hr, etc.).

3.3 *Emission source rate quantification accuracy* - relative percent difference between true release rate and measured release rate. True release rates can be known only under controlled testing conditions.

3.4 *Facility* - An oil and gas site, such as a well site, centralized production facility, or compressor station.

3.5 *False-positive rate* - The ratio between the number of negative events wrongly categorized as positive and the total number of positive events.

3.6 *Flight path* - The planned pathways for flights designed to ensure complete LeakSurveyor coverage of target sites. Flight paths are made up of one or more flight lines over target sites, connected by turns.

3.7 *LeakSurveyor* - Patented Insight M sensor, composed of multiple subsystems designed to facilitate the collection and analysis of actionable and precise methane emissions data. LeakSurveyor is a light-aircraft-mounted methane gas imaging system that collects data to produce georeferenced methane emissions detections at onshore oil and gas sites.

3.8 *Pass* - Actual flight conducted along a planned flight line over one or more target sites. Single or multiple passes along a planned flight line may be used to collect methane data from target sites.

3.9 *Probability of detection* - the fraction of true release rates expected to be detected as a function of their release rate.

3.10 *Methane enhancement* - A cluster of pixels each containing a statistically significant level of measured methane concentration above the atmospheric background levels.

3.11 *Sensitivity* - Emission source detection rate noted in flux units (e.g. kg/hr).

3.12 *Survey* - Aerial deployment of the LeakSurveyor to collect methane emissions data from one or more specified target sites.

3.12.1 A “survey day” or “survey flight” refers to a single day or flight, respectively, of methane data collection under this protocol.

3.12.2 A “contracted survey” refers to data collection and analysis under this protocol for a scope of target sites and survey timing agreed upon between Insight M and an individual client. A contracted survey is complete when Insight M has collected data, met data quality objectives for 100% of target sites under the contract, and reported survey outcomes; contracted surveys may be completed in one or more survey days within the period specified in the contract.

3.13 *Target sensitivity* - The sensitivity at which a survey will be conducted, defined by the probability of detection at a specific rate.

3.14 *Target site* - A facility designated to be surveyed under this protocol.

3.15 Units -

3.15.1 *kg/hr* - kilograms of methane (unless otherwise specified) per hour

3.15.2 *kgh/mps* - kilograms of methane (unless otherwise specified) per hour per meter per second of wind

3.16 *Valid emission source detection* - A detected emission source, which can consist of one to multiple valid plume detections.

3.17 *Valid plume detection* - A true positive observation of a source of emitting methane. Valid plume detections consist of a cluster of pixels each containing a statistically significant level of measured methane concentration above the atmospheric background levels, which have been assessed by analysts and determined to be a true positive detection.

4 Method Interferences and Envelope of Operation

4.1 *Planning for and Mitigating Interferences.*

Insight M deploys its LeakSurveyor technology under this protocol according to a standardized operating envelope that has been defined based on well-characterized, known interferences. Our understanding of known interferences is based on controlled release testing in various locations and conditions, as well as our experience deploying this protocol in field conditions across the United States. Accordingly, deployment of Insight M’s LeakSurveyor technology under this protocol involves (a) adhering to a strict operating envelope (see Section 4.2), (b) planning in advance to work around known or expected interferences to stay within our operating envelope, (c) monitoring conditions and adapting survey plans as needed to avoid interferences, (d) training analysts to identify and filter out instances of interferences that affect a discrete area, and (e) training analysts to identify instances of interferences that affect the overall quality of a dataset and subsequently targeting those areas for re-survey. Table 1 in section 4.2, below, outlines the various operational constraints as well as how they are assessed (DQIs) and addressed before, during, or after data collection.

4.2 *LeakSurveyor Operating Envelope.*

Condition	Summary	Mitigation Plan
Sunlight	Direct sunlight is required to ensure adequate reflected signal for measurement by the imaging spectrometer.	Re/schedule flights during appropriate daytime hours.
Cloud cover	Minimal cloud cover is required to ensure adequate reflected signal for measurement by the imaging spectrometer.	Wait for conditions to improve, reschedule the flight. After collection has taken place: Remove cloud shadow contaminated data from processing and mark affected site for re-survey.
Wind speed	Wind speed directly impacts the concentration of methane plumes. Higher wind speeds disperse methane more quickly, requiring greater sensor sensitivity to detect. Conversely, slower wind speeds disperse methane more slowly, requiring less sensor sensitivity to detect. Modeling for impact of ground wind speed on LeakSurveyor probability of detection is presented in 13.3.2. Additionally, wind speed must be within safety thresholds to ensure safe airborne collection.	Wait for conditions to improve, reschedule the flight. After collection has taken place: compute the probability of detection for LeakSurveyor using the flown wind and AGL for target sites. If the target sensitivity (10 or 15 kg/hr) probability of detection falls below 90%, mark affected site for re-survey.
Altitude above ground level (AGL)	Flight altitude above ground level impacts the flown sensitivity by affecting image spatial resolution. Modeling for the impact of AGL on LeakSurveyor probability of detection is presented in 13.3.2.	Confirm flight plan target AGL is appropriate for forecast wind conditions during collection. After collection has taken place: Compute the probability of detection for LeakSurveyor using the flown wind speed and AGL for target sites. If the target sensitivity (10 or 15 kg/hr) probability of detection falls below 90%, mark affected site for re-survey.
Ground temperature	Defined as the temperature on the ground. LeakSurveyor and its sub-components are rated to operate	Wait for conditions to improve, reschedule flight. After collection has taken place: Remove data collected at incorrect

Condition	Summary	Mitigation Plan
	within a defined temperature range.	temperature from processing and mark affected site for re-survey.
Dew point spread	Defined as the difference between the ground temperature and the dew point. LeakSurveyor and its sub-components are rated to operate within a defined dew point spread.	Wait for conditions to improve, reschedule the flight.
Precipitation	Excessively wet conditions can be a safety hazard during flight and can damage the LeakSurveyor hardware.	Wait for conditions to improve, reschedule the flight.
Visibility and AQI	Clear visibility and good air quality are important for flight safety.	Wait for conditions to improve, reschedule the flight.
Topography variation	Topographical variability can introduce noise within discrete areas of collected imagery.	Plan or adjust survey flight path and timing to account for sun angle and shadows.
Aircraft turbulence	Low to moderate turbulence is important for flight safety.	Wait for conditions to improve, reschedule and re-fly survey path(s) affected by turbulence.
Aircraft groundspeed	Aircraft groundspeed is held below a speed limit to ensure flight safety and data quality.	Re-schedule and re-fly affected survey area.
Variable snow, standing water, or vegetation cover	Variable reflectivity caused by dense vegetation, standing water, or uneven snow cover can introduce noise within discrete areas of collected imagery.	Plan or adjust survey flight path and timing to account for uneven reflectivity and/or wait for conditions to improve and re-fly affected survey path(s).
Airspace restrictions	Compliance with all FAA airspace restrictions is mandatory for flight.	Ensure appropriate flight approvals and licenses are acquired; adjust AGL to meet airspace restrictions.
Instrument and hardware malfunction	LeakSurveyor function is tested prior to flight and monitored during flight for nominal operation.	Contact on-call engineer for remote troubleshooting; reschedule flight if required.

Table 1: Operational envelope summary and mitigation plan table.

4.3 *Non-Environmental Interferences.*

Non-environmental interferences include aircraft availability, pilot requirements, local air traffic, and restricted airspace. These interferences are limited by diligent program planning and scheduling. However, in any scenario, survey crews have the authority to deem flights unsafe on any given day.

4.4 *Measurement Instrument Interferences.*

Insight M personnel are trained in the proper installation of the LeakSurveyor instrumentation. After installation, an internal built-in self-test runs on the LeakSurveyor flight computer to assess a suite of metrics such as camera frame rates, storage media cleanliness, and networking configurations. Additional interferences are mitigated by pre-flight checklists and ongoing pilot monitoring of a live readout of instrument health and status during the flight. If the pilot encounters an issue with LeakSurveyor, an Insight M engineer is immediately tasked with diagnosing and resolving the in-flight issue. If the LeakSurveyor system fails and cannot be remotely troubleshooted during a flight, the pilot will land at the nearest airport for further assessment. If the LeakSurveyor system is still not operable after additional troubleshooting, Insight M will install a backup instrument system. The pilot will then conduct the remaining flight paths and resurvey any impacted paths, as necessary.

5 Safety

5.1 *Culture.*

Operational safety is the highest priority for all Insight M employees and contractors. Ensuring the safety of our employees, our flight vendors, and the general public is our top priority. We provide comprehensive training and implement strict protocols to mitigate risks and promote a secure work environment. By prioritizing safety, we strive to safeguard the well-being of every member of our team and communities.

5.2 *Training.*

All LeakSurveyor pilots undergo thorough training to prioritize safety and master equipment handling. Moreover, they are required to attain Operator Qualifications in addition to their training on Insight M's LeakSurveyor technology and protocol. Insight M has developed custom training to satisfy Veriforce CCT 728 "Aerial Leakage Survey" Operator Qualification. In addition, all Insight M analysts complete this same training to improve their ability to recognize potential emissions and assess data quality.

5.3 *Aircraft Crew and Operations Safety.*

5.3.1 Aircraft operations requirements meet FAA standards outlined in the Code of Federal Regulations Title 14.

5.3.2 Vendors undergo a quarterly safety survey to ensure the individual pilots feel safe and are able to raise concerns. The survey includes 13 questions for pilots, such as:

- whether the pilot has received training on safety protocols, including within the past year;

- whether the pilot feels adequately trained to perform their job safely;
- whether the pilot's company holds daily safety briefings;
- whether the pilot knows of their company's process(es) to report safety concerns anonymously;
- whether the pilot feels that workload or work hours may be contributing to an unsafe working condition;
- whether the pilot has experienced a safety incident or near miss in the past year; and
- how often the pilot encounters unaddressed safety hazards.

5.3.3 Pilots must complete and submit preflight and post-flight checklists to ensure the aircraft and instruments are operational and that all safety protocols are followed. Safety-related measures taken during mandatory pre-flight checklists include completing a mechanical inspection of all Insight M instrumentation and confirming proper mounting of LeakSurveyor.

5.3.4 A Flight Route Summary is created to furnish pilots with anticipated flight duration and alert them to any potential hazards along the route.

6 Equipment and Supplies

6.1 *LeakSurveyor.* LeakSurveyor consists of multiple subsystems that enable the collection of actionable and accurate data. The full system was patented on November 12, 2015, under International Patent Number WO 2015/172056 A1 and US Patent number US 10,267,729.

6.1.1 The imaging subsystem contains the infrared spectrometer and an optical (RGB) camera. The optical camera collects imagery that is used to provide a synchronous snapshot of the scene around the emission. The full instrument is discussed at length in the *Insight M LeakSurveyor Description of Technology* document.

6.1.2 The compute subsystem contains a flight computer, a GPS/INS system, and a Wi-Fi router.

6.1.3 The power subsystem contains an FAA-approved battery and network-connected power distribution electronics, which enable our flight software to control the power states of all the devices.

6.1.4 These subsystems are housed in an aviation-grade composite fairing.

6.2 *LeakSurveyor Auxiliary Equipment*. LeakSurveyor is paired with several pieces of auxiliary equipment to facilitate and monitor the safe operation of the instrument.

6.2.1 Two tablets are used to facilitate data collection and flight plan navigation. The first tablet operates proprietary software that monitors the LeakSurveyor system, providing feedback on data quality and alerting the pilot to any equipment anomalies. The second tablet aids the pilot in navigating to designated collection areas and guides them through the planned flight routes.

6.2.2 Each aircraft is equipped with supplementary equipment such as spare cables, power supplies, and additional tablets, all critical for troubleshooting and maximizing data collection.

6.2.3 At the end of each flight day, the collected data is uploaded using a dedicated computer ensuring that all information is securely backed up and available for processing and analysis.

6.3 *Aircraft*. This protocol is for an aircraft-based survey method.

6.4 *Mounting Hardware.* For the mounting of the Leak Surveyor onto aircraft, an approved FAA Supplemental Type Certificated mounting system is utilized.

7 Calibration and Testing Equipment

7.1 *Calibration and Testing Equipment.* Table 2 below summarizes the equipment needed to calibrate and test Insight M's sensors according to the protocols described in Section 10.

Process	Equipment	Specifications	Description
Laboratory calibration	Integrating Sphere	Labsphere, model USLR-D08F-NDNN-P	8" sphere
Laboratory calibration	Tungsten lamp	Labsphere, model RLH 150	150W, external
Laboratory calibration	Variable attenuator	Labsphere, model VAM-010	Manual operation
Laboratory calibration	DC power supply	Labsphere, model LPS-175-27	Programmable
Laboratory calibration	Argon lamp	Newport, model 6030	10mA lamp
Controlled release	Mass flow meter	Sierra Instruments, SmartTrak 100 Mass Flow Meter and Controller	Calibrated for 1597 SCFH, Methane (1")
Controlled release	Mass flow meter	Sierra Instruments, QuadraTherm 640i	Calibrated for 40,000 SCFH, Methane (2")
Controlled release	Weather station	Tempest WeatherFlow	3 second sampling interval at resolution of 0.04 m/s

Table 2: Summary of calibration and controlled release testing equipment.

8 Method Input Sourcing

8.1 *Internal Data Inputs.*

Instrument	Variables	Use
Spectrometer	Reflected solar radiance	Radiance data are processed to identify methane enhancements and then analyzed to identify valid plume detections and emission source rate quantification

Instrument	Variables	Use
Optical camera	RGB photography	Synchronous visible image of the scene aids in determining (a) if a methane enhancement is a valid plume detection and (b) source attribution to oil and gas infrastructure
GPS/INS unit	Latitude, Longitude, Altitude, Roll, Pitch, Yaw, Groundspeed	Orthorectification of calibrated radiance data on a per-pixel basis.
Flight Computer	System operation	Runs all the embedded flight software, which controls both cameras and the GPS/INS unit.
Wi-Fi Router	System connectivity	Allows the pilot to operate and monitor the system remotely.

Table 3: Summary of internal data inputs utilized in this ATM protocol.

8.2 *External Data Inputs.*

External Data Type	Variable used	Use(s)	Source
Meteorological data	Cloud cover (%), temperature (°C), precipitation (mm/hr), dew point	Flight planning; Day of DQI confirmation	Weather forecasts and weather station reports (METAR)
Meteorological data	Wind speed at 10m (m/s; 1 hour resolution)	Flight planning; Confirming deployed sensitivity; Emission source rate quantification	Third-party API (proprietary)
Solar data	Solar zenith angle (deg)	Flight planning	Government data sources (NOAA)
Aviation safety and traffic reports	All appropriate data	Restricted areas alerts; obstacles/ traffic alerts; hazardous weather events	Government data sources via approved electronic flight bags
Topographical data	Terrain/elevation (m)	Flight planning	Third-party digital elevation model (proprietary)
Customer data	Target site locations (lat/long)	Flight planning	Customer

Table 4: Summary of external data inputs utilized in this ATM protocol.

8.3 *Protocol for assessing new third party wind data sources.*

New third-party meteorological data sources are evaluated for use based on the following criteria in Table 5.

Criteria	Definition	Requirement
Accurate wind estimates	The wind data variable from the meteorological dataset must show good accuracy relative to ground truth.	Mean Average Error is comparable (or better) to data sources used in validated system
Coverage	The meteorological data must have comprehensive spatial coverage, such that all potential flight areas can be included.	Spatial gaps not present over target basins/sites
Temporal Resolution	The meteorological data must have good temporal resolution to properly characterize local conditions at the time of survey.	Model produces a 1 hour or better resolution
Recency	The wind data variable must be available instantaneously to ensure timely reporting of quantified emission rates.	Model produces queryable, near real-time (<2 hour delay) estimates
Historical wind availability	Historical data must be available (required for R&D purposes.)	Historical data is available within an appropriate window, or the provider allows Insight M to archive historical data in collection areas

Table 5: Summary of criteria for evaluating new third-party wind data sources for use in connection with this ATM protocol.

9 Quality Control

9.1 *Integrated Quality Controls.* As part of this protocol, Insight M applies standard quality controls at every step to ensure we meet DQOs, including during flight planning, before and during data collection, and during data processing and analysis. An outline of these controls, and defined corrective action, are provided in Table 6 below. Additional description of each condition can be found in section 4.2.

Condition	Acceptance Criteria	DQI Assessment
Sunlight	Sun angle >=25 degrees above the horizon	Pre-flight: Deploy in appropriate time window Data processing: Validate time of collection
Cloud cover	Clear or mostly clear days with moderate cloud cover	Pre-flight/in-flight: Consult weather forecasts Monitor instrument exposure data Data processing: Cloud shadow automatically excluded by algorithm Visual assessment for additional cloud shadow contamination
Wind speed	<= 20 mph for data quality	Pre-flight/in-flight: Consult weather forecasts and weather station reports (METAR) Data processing: Evaluate API wind data to ensure collection is within limits
Ground Temperature	> 4°C and < 40°C The LeakSurveyor can operate at temperatures down to -5°C, but Insight M operates within a narrower ground temperature range to ensure DQOs are met.	Pre-flight/in-flight: Consult weather forecasts Monitor instrument temperature Data processing: Evaluate flight data to ensure collection is within limits
Dew point spread	Ground temperature >= 1.5°C higher than the dew point We generally apply a more conservative dew spread constraint of at least 4.5°C. But we are able to collect data that meet DQOs at lower dew spread values when flying at lower altitudes above ground levels (AGL)	Pre-flight/in-flight: Consult weather forecasts and weather station reports (METAR)
Precipitation	< 1 mm/hour	Pre-flight/in-flight: Consult hourly precipitation forecast and visual reports from pilots

Condition	Acceptance Criteria	DQI Assessment
Visibility and AQI	Safety Thresholds: VFR at the base airport and airports near the area of the survey Visibility >= 5 nautical miles for flight safety Air Quality Indicator (AQI) <= 150 at the base airport or within the planned survey area.	N/a (not a data quality indicator)
Topography variation	Topographical variability can introduce noise within discrete areas of collected imagery	Pre-flight/in-flight: Deploy in appropriate time window Data Processing: Areas with inadequate signal (<20% of sensor well depth) or saturated (>98% of sensor well depth) signal automatically excluded by algorithm.
Aircraft turbulence	No turbulence to moderate turbulence	Pre-flight/in-flight: Consult weather station reports (METAR)
Aircraft groundspeed	Median speed of pass is at or below 150 kts	Pre-flight/in-flight: Design flight plan with target speed Data processing: Evaluate groundspeed data and discard passes collected above threshold
Variable snow, standing water, or vegetation cover	Variable reflectivity caused by dense vegetation, standing water, or uneven snow cover can introduce noise within discrete areas of collected imagery	Pre-flight/in-flight: Deploy in appropriate time window Data processing: Areas with inadequate signal (<20% of sensor well depth) or saturated (>98% of sensor well depth) signal automatically excluded by algorithm.
Airspace restrictions	Compliance with all FAA airspace restrictions	N/a (not a data quality indicator)

Condition	Acceptance Criteria	DQI Assessment
Instrument and hardware malfunction	In-cabin monitoring system of instrument operation and collected data quality indicates nominal operation.	Pre-flight/in-flight: Collect and error-check 1 minute of data to confirm nominal instrument function; Monitor in-cabin system to confirm nominal operation during flight. Data processing: Investigate flags indicating rare/anomalous cases related to possible sensor or processing pipeline malfunction (e.g., Null data; Anomalies in IMU; Data corruption during copy/processing)
Site Coverage	Asset is 100% covered by collected imagery.	Pre-flight/in-flight: Design flight plans to cover all assets, including flightline overlap to ensure no gaps between flightlines. Monitor in-cabin system to ensure flight waypoints are met. Data processing: Visual assessment of asset coverage.

Table 6: Summary of integrated quality controls.

10 Calibration and Standardization

10.1 *New sensor acceptance testing for standardized performance.*

Every new sensor in Insight M's fleet goes through rigorous laboratory acceptance testing to ensure standardized performance. Each instrument must meet specific criteria to be deployed to the field, as described in Table 7, below.

Feature assessed	Time of assessment	Assessment approach	Acceptance criteria
Sensor noise	New sensor laboratory acceptance testing	Measure the relationship between signal and noise over the dynamic range of the sensor.	Within sensor manufacturer specifications
Stray light	New sensor laboratory acceptance testing	Illuminate a single spot on the sensor and look for signal in the dark regions of the sensor plane.	No stray light detected
Spatial focus	New sensor laboratory acceptance testing	Focus spatial optics on a point source that is very far away.	>95% of point source light contained within one pixel
Spectral	New sensor	Image spectral calibration lamp to	Within defined family

Feature assessed	Time of assessment	Assessment approach	Acceptance criteria
focus	laboratory acceptance testing	produce well-characterized spectral features.	baseline
Per-pixel noise	New sensor laboratory acceptance testing	Individual pixel temporal and spatial noise is within 350% of the surrounding field (pixels not meeting this criterion will be masked).	Within sensor manufacturer specifications
Dark current	New sensor laboratory acceptance testing	Collect light-free imagery to measure sensor dark current.	Within manufacturer specifications
Deployment test	After laboratory acceptance testing and before deployment	Flight test of new, calibrated instrument to confirm all components of the sensor function within specification in a typical flight environment	Technician exam of sensor confirms nominal performance; Evaluation of data confirms nominal performance

Table 7: Summary of new sensor calibration and acceptance testing.

10.2 *Calibration Standard Protocol.*

After sensors pass new sensor acceptance testing and are moved into use in production, Insight M tests the sensor calibration on both an annual and ongoing basis. Table 8 below outlines all calibration procedures and standards for this method.

Calibration Target	Action	DQI	Minimum frequency
Camera response and alignment	Check and recalibrate if necessary	Change from baseline sensor calibration > 1%; or existing calibration data is > 2 years old	Annual
Spectrometer response & alignment	Check and recalibrate if necessary	Change from baseline sensor calibration > 1%; or existing calibration data is > 2 years old	Annual (can also be calibrated as needed on an ongoing basis)
Per-pixel noise	Investigate flagged pixels (algorithm)	Update calibrations remotely	Ongoing

Table 8: Summary of hardware calibration tests conducted on an annual or ongoing basis.

10.3 *Ongoing maintenance.*

In addition to calibration testing, ongoing and routine maintenance is conducted for each sensor at least annually. Table 9 below outlines all hardware maintenance procedures and standards for this method.

Evaluated Components	Action	DQI	Minimum frequency
Wiring connections	Check and repair if necessary	Technician examination	Annual
Fittings	Check and repair if necessary	Technician examination	Annual
Physical damage	Check and repair if necessary	Technician examination	Annual (field inspections also conducted on an ongoing basis)
Sensor cleanliness	All components cleaned	Technician examination	Annual (external components cleaned on an ongoing basis or as needed)

Table 9: Summary of hardware maintenance checks.

10.3.1 *Field data quality assessment.* In certain instances, if collected field data is determined to be unusual or degraded, or if damage is reported in the field, the instrument may be returned to the lab early for inspection, repair, and/or updated calibration if necessary. See sections 9.1 and 9.2 for additional discussion of data quality assessment and Section 7 for a discussion of calibration testing and recalibration protocols.

10.4 *Hardware Lifecycle, Inventory Tracking, and Documentation.*

All production hardware components follow the following standard lifecycle:

- The item is purchased.
- The item is received.
- Our digital inventory is updated along with the associated purchasing paperwork.
- The item is placed in our physical inventory.
- The item is physically installed in a LeakSurveyor system, and the digital inventory system is updated.
- The item is physically uninstalled from a LeakSurveyor system, and the digital inventory system is updated.

By following this standard process, Insight M maintains traceability between each hardware item and the LeakSurveyor assembly in which it is installed. The installation and uninstallation steps commonly occur during periods of routine maintenance (described in Section 10.1.3). In this way, upgrades to our hardware systems are rolled out to the entire fleet and assemblies are kept constantly up to date in terms of hardware and software versions. Every new hardware installation is accompanied by supporting documentation that enables our technician team to carry out the installation process across every LeakSurveyor in a consistent manner.

11 Data Collection Procedure

11.1 *Flight Planning and Routing.*

11.1.1 *Flight Planning*. All surveys begin with flight planning for the target sites to be surveyed by LeakSurveyor. Flight planning begins with the generation of safe and efficient flight lines. These lines, when flown at a designated altitude in straight, level flight, are designed to achieve comprehensive coverage at target sensitivity of designated operator facilities while maintaining operational safety, complying with aviation regulations, and maximizing flight efficiency. To achieve these goals, Insight M operations engineers take into account various factors, including terrain, airspace restrictions, ground features, and seasonal weather trends. Additionally, flight plans are designed to be flexible, allowing for adjustments in flight orientation and altitude above ground level to accommodate changing conditions and adhere to specific regulatory requirements and data quality objectives. To ensure surveys meet the desired sensitivity for sites under varying conditions, operations engineers leverage terrain analysis of a digital elevation model (DEM) to calculate the optimal target altitude above mean sea level (MSL) for the flight.

11.1.2 *Flight Routing*. After flight plans are generated, Insight M flight coordinators begin planning daily flight routes. Flight routing takes into account forecasted weather conditions and various aviation considerations for all collection areas. By evaluating areas and days with favorable weather conditions, Insight M flight coordinators determine the most efficient and effective paths for aircraft to collect accurate, high-quality data that meet the data quality objectives of this protocol on any given day. This iterative process continues up to and throughout the day of deployment, with ongoing analysis of weather conditions and continuous flight tracking. This dynamic approach enables flight coordinators to promptly communicate real-time reroutings to pilots, facilitating flexible operations and enhancing the quality and efficiency of data collection.

11.2 *Pre-flight Checklist and Day of Flight.*

After determining that current field conditions are within the instrument's operating envelope, flight operations personnel mount the instrument to the wing strut of the aircraft (if it is not already mounted). Flight personnel complete required safety, operational, and aviation checklists before a flight can be cleared for takeoff and data collection.

The aircraft flies to the designated survey area (flight box) and target altitude AGL. The aircraft will completely cover all designated operator assets (target sites) in each flight box. Multiple flight boxes, representing multiple clusters of contracted assets, may be surveyed by an aircraft over the course of one flight day.

Upon landing, flight personnel complete post-flight checklists to ensure that all required safety inspections are complete.

12 Data Analysis and Calculations

12.1 *Summary*. Transforming raw data into geolocated methane plumes is done via the Insight M proprietary pipeline, which includes both automated and supervised analyses. The general procedure is summarized in the following processing steps:

1) Raw methane data is automatically saved into a spatially aware data structure and transformed into an estimate of methane enhancement.
2) Methane enhancements, defined as a cluster of pixels each containing a statistically significant level of measured methane concentration above the atmospheric background levels, are assessed by analysts and flagged if determined to be valid plumes. Note that methane enhancements identified through Insight M's automated processing pipeline are not considered methane plume detections; because environmental factors can contribute to elevated methane signal, not all areas with methane enhancement ultimately indicate an emission source. Insight M reports all valid methane detections confirmed through its full analytical procedure and does not report intermediate data such as methane enhancements.
3) The source rate is automatically quantified for all valid plume detections.
    a) Note that partially imaged plumes (cut off by the edge of the pass) determined by analysts to be a true positive detection are considered valid plume detections. These will be reported, along with a low-confidence quantified emission rate.
4) Valid plume detections are associated to their source. Multiple valid plume detections of a single source (resulting in cases where the source location has been surveyed via multiple overflights) are grouped together into a single emission source detection. In other words, these are handled as multiple "looks" at a single emission source.

12.2 *Requirements for reporting detected emissions.* Insight M is a detection-first methodology. This means that all confirmed methane detections associated with the designated operator's assets will be reported to the operator and are not subject to filtering by emission source rate or any other attribute. Emission source rate quantification, calculated after a methane detection has been confirmed, is reported for each detection. In cases where Insight M has lower confidence in emission source rate quantification, e.g., due to capturing only part of a plume in an aerial overpass, the detection is reported to the customer with additional descriptive annotation describing lower confidence in the estimated emission source rate quantification.

13 Method Performance

13.1 *Method for Determining Performance.*

Insight M relies on controlled release testing to validate system performance and ensure that expected methane detection thresholds are maintained in the field across expected environmental variability. We routinely participate in externally and internally conducted controlled release tests with the aim of generating datasets to assess detection sensitivity and noise across a variety of environmental conditions and deployment configurations. Controlled releases are conducted with one or multiple of our LeakSurveyor systems, which have identical hardware and onboard software and have been calibrated in the lab before deployment (see section 10.1).

13.1.1 *Controlled release methodology*. The generalized approach for conducting a controlled release has been described in detail in Sherwin et al. (2021) and is briefly described here. The controlled release procedure requires methane to be released at known rates while the sensor surveys the release area. Typical survey patterns are alternating direction passes along a single flight line. Methane flow rates are measured with 'in-line' flow meters which record the flow rate as well as the temperature of the gas as it is released with high precision. The site is also instrumented with an anemometer (wind gauge) which records local wind data with high granularity. Recorded flow rate data (including null passes where no methane is released) is compared against both detections and leak rates calculated from LeakSurveyor measurements processed through the Insight M analytical pipeline. Through this analysis, emission source rate quantification accuracy, sensitivity, and false-positive rates can be calculated for a given sensor.

During a controlled release, LeakSurveyor is mounted aboard fixed-wing aircraft and deployed as it would be in the field. Prior to the start of the controlled release, a release plan is created that is designed to test the instruments' sensitivity, emission source rate quantification accuracy, and false positive rate. Prior to the start of a pass, a specific release rate is chosen based on the recommended release rate from the release plan and current wind conditions. One minute prior to the plane's overhead pass, the flow rate is held constant in order to obtain a steady state flow downwind of the release point. Once the plane is overhead, the release rate, wind data, and any relevant notes are recorded by the ground crew. This process is repeated multiple times throughout the test to gather a range of representative data.

13.2 *Third-Party, Single-Blind Assessment via Controlled Release.*

In the fall of 2022, Stanford University conducted a single-blind controlled methane release study of Insight M's LeakSurveyor technology. Testing took place over 5 days, from October 24th through October 28th (El Abbadi et al., 2024).

13.2.1 *Single-blind experimental design.* The Insight M test was part of a larger controlled release campaign assessing multiple airborne technologies, conducted by Stanford University researchers in October and November 2022 in Casa Grande, Arizona. Researchers followed a peer-reviewed testing protocol (Sherwin et al., 2021; Rutherford et al., 2022). In summary, the ground team (consisting only of Stanford researchers) conducted a series of methane releases at a variety of controlled rates while aircraft and satellites passed over and collected measurements. Strict blinding protocols were maintained– prior to and during testing operators were provided with no information about activities on the ground, including ground conditions, the rate of release, and whether or not methane was being released. Detections resulting from data collected by the Insight M LeakSurveyor were assessed by Stanford researchers for sensitivity, false positive rate, and emission source rate quantification accuracy.

13.2.2 *Data reporting*. Insight M elected to participate in a multi-stage unblinding of data to better evaluate technology performance. Stage 1 represents the closest approximation of true field conditions, where no ground wind measurements or release rate data was provided. We report these results in the next section.

13.2.3 *Summary of Insight M performance*. Over the 5 days of testing, a total of 191 valid controlled releases of varying emission rates were conducted. The tested rates ranged from 0.64 to 1,110 kg/hr, with 107 releases below 15 kg/hr. An additional 18 were null releases, where no methane was released to quantify the technology false positive rate. The full results of this test are published in El Abbadi et al. (2024). In summary:

- **Sensitivity**: The study reports that the largest missed detection was 10.47 kg/hr (representing the only missed detection above 10 kg/hr). The smallest valid plume detection was 3.40 kg/hr. A logistic regression fit to the data collected by the study demonstrates a 90% probability of detection of 8.9 kg/hr under testing conditions (see Figure 1 below).
- **False positive rate**: LeakSurveyor demonstrated a false detection rate of 0%.
- **Emission source rate quantification**: Quantification accuracy was assessed with an r^2=0.87, with 38% of quantified rates falling within +/- 25% of the true flow rate, and 73% falling within +/- 50%. This is similar to performance demonstrated in the previous blinded testing of Insight M technology (Sherwin et al., 2021) which observed quantification error of approximately 40% (1 sigma).

The final published manuscript can be found in the Supporting Documentation submitted with this application.

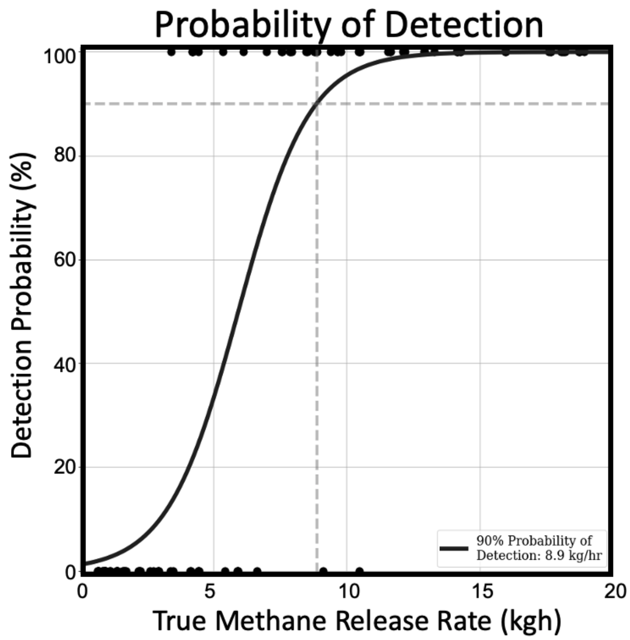

Figure 1: Probability of detection of the Insight M LeakSurveyor, calculated as the logistic regression fit to the data collected during single-blind testing by El Abbadi et al. (2024).

13.3 *Internal Assessment via Controlled Release.*

Controlled release datasets have been produced by Insight M scientists and engineers using the methodology described in Section 13.1.1 (as well as in the *Insight M LeakSurveyor Description of Technology* document). Controlled releases are designed to quantify performance across different axes of variability, including environmental conditions and deployment configurations.

As a remote sensing instrument, the two variables with the most significant impact on LeakSurveyor sensitivity are sensor height above ground and wind speed (Sherwin et al., 2021; Conrad et al., 2023). Additionally, different environments may impact sensitivity differently. The most important of these are related to overall moisture and reflectivity of the ground, where environments with green vegetation or moist conditions are less reflective than bright, dry environments. In the following sections, we describe characterized LeakSurveyor performance across these key variables.

13.3.1 *Description of the controlled release dataset.* The current controlled release dataset consists of 595 total flyovers collected at altitudes ranging from 983 to 6166 ft altitude AGL, testing release rates ranging from 0 kg/hr (representing null releases) to 1201 kg/hr. Wind speeds during testing range from 0.01 to 18.8 mph, while testing conditions have been constrained to periods where solar elevation is >25 degrees and ground temperature is within 4 to 40°C. Controlled releases in this dataset have been conducted within two "endmember" environments encompassing a range of environmental conditions: a dry, desert environment (Arizona) with low, senesced vegetation and generally representative of dry basins; and a wet (irrigated) agricultural area (California) with moist soils and thick vegetation, generally representative of well-watered basins. Each of the 595 collected passes was processed through the commercially deployed Insight M analytical pipeline (05/2024), and analyzed for detections using standard analysis procedures. Resulting detections are recorded, along with the quantified rate. This section evaluates the resulting dataset to characterize sensor sensitivity across different conditions.

Note that any future improvements made to Insight M data processing software that could change sensitivity will be assessed against this static dataset, and the modeling approach presented in 13.3.2, below, will be used to update the Insight M instrument fleet's sensitivity profile.

Locations	California; Arizona
Scene Condition Variation	Wet, agricultural, green vegetation; Dry, desert, senesced vegetation
Collection altitude AGL range	983-6166'
Total number of passes/releases	595
Wind speed range	0.01–18.8 mph
Solar elevation	> 25 degrees
Ground temperature range	within 4 to 40°C

Table 10: Summary of current controlled release baseline dataset.

13.3.2 *Sensitivity as a function of sensor height and wind speed.* Insight M uses an empirical model of LeakSurveyor sensitivity as a function of sensor altitude AGL and local wind speed, following the methodology described by Conrad et al. (2023) and fit to the controlled release dataset described in Section 13.3.1, to characterize sensor sensitivity. This function underlies our operational capability to ensure target sensitivity at 90% probability of detection when collecting in a range of wind speeds.

13.3.2.1 Model validation. Various statistical tests were performed using a "hold-out" cross-validation approach, where different sensor altitudes and wind speed regimes were excluded from the model fitting process. The resulting fitted models, both with and without these holdouts, showed no statistical differences, reinforcing the generalizability of this approach for characterizing the operational sensitivity of the Insight M instrument fleet.

13.3.2.2 Model use in method. The validated model is employed to verify that the sensitivity requirements defined in 1.6.2 are consistently met during operational surveys. For the surveyed target sites during a flight, the model calculates the probability of detection using the wind speeds (see Table 4, section 8.2) and flown sensor altitude above ground level (see Table 3, section 8.1) during data collection. Surveyed target sites where the calculated probability of detection falls below the threshold of 90% are automatically flagged for re-flights to ensure compliance with the performance requirements defined in 1.6.2.

13.3.3 *Sensitivity comparison between desert and green vegetation environments.* To understand the possible impact of scene variability on sensitivity, we compared the results of two days of controlled releases from the controlled release dataset described in section 13.3.1. One day of testing was conducted in Arizona (dry desert) and the other in California (wet vegetated). A comparison of the two datasets is provided in Table 11, below:

Location	California	Arizona
Date of collection	Sept 30, 2022	October 24, 2022
Scene conditions	Wet, agricultural, green vegetation	Dry, desert, senesced vegetation
Collection altitude AGL (avg)	1417’	1334’
Number of passes	40	43
Wind speed range during testing	5-12 mph	5-15 mph

Table 11: Comparison of two days of LeakSurveyor controlled release collection conditions.

Assessment of the results of these two datasets reveals a wind-independent 90% probability of detection of 2.93 kgh/mps in the California test, and 2.85 kgh/mps in the Arizona test. Statistical testing reveals no difference between the results of the two tests, indicating that LeakSurveyor sensitivity remains consistent across significant scene variability when deployed within its standard operating envelope (defined in Section 4.2).

13.4 *Operator Validation of Performance from Field Deployments.*

Insight M has deployed LeakSurveyor to all major onshore basins in the United States and has received operator feedback that validates reported detections in 19 basins, provided in Table 12 below. While this feedback does not represent a formal controlled release, it does demonstrate successful operation across a larger geographic scale than would be possible to test, supporting the conclusions in section 13.3. Surveys of these areas are conducted within the same operating envelope, including solar angle > 25 degrees, ground temperature within 4 to 40°C, and adherence to wind limits, ensuring that the performance characterized in our controlled testing is also applicable to these field collections.

Anadarko	Piceance
Appalachian	Powder River
Ardmore	San Joaquin
Arkoma	San Juan
Denver	TX-LA-MS Salt
Fort Worth	Uinta
Greater Green River	Ventura
Illinois	Western Gulf
Marietta	Williston
Permian	

Table 12: United States onshore oil and gas basins in which Insight M has deployed the LeakSurveyor technology and received client feedback validating reported detections.

Insight M also has operator-validated detections from international deployments, including in the Neuquén Basin in Argentina and multiple basins in Colombia.

13.5 *Assessment of Operating Envelope Conditions across Major Oil and Gas Basins in the United States.*

Insight M has reviewed meteorological data and confirmed that all environmental operating envelope DQIs (as outlined in Section 9.1) are met in all major oil and gas basins in the United States. We reviewed hourly cloud cover, dew spread, precipitation, solar elevation, temperature, and wind speed data from a third-party commercial dataset for every United States county with at least 50 active producing oil and gas wells in Enverus Prism. For each county, we reviewed hourly meteorological data for every day from 2018-2023 using the centroid of the county based on 2023 TIGER/Line® data.

For each hour and county in the dataset, we annotated whether each operating envelope requirement was met individually and whether all operating envelope requirements were met simultaneously. Note that we selected a conservative ground-level dew point spread value for this analysis–this operational constraint varies by the altitude of the aircraft so there are cases where safe and effective collection at a smaller ground-level dew point spread is possible. We aggregated the six years of data to analyze local operating envelope variables for each county. We then reviewed individual county and basin-aggregated data to confirm that all six core meteorological operating envelope requirements are met, individually and collectively, across all major US oil and gas basins. The results of this analysis are summarized in Table 13 and Figure 2, below.

Basin	Cloud Cover <= 25%	Dew Spread >= 4.5°C	Precipitation <= 1mm	Solar Elevation >= 25deg	Ground Temperature >= 4°C and <= 40°C	Wind Speed within limit for 90% POD at 10 and 15 kg/hr	Validation of Overlapping Conditions
Anadarko	✓	✓	✓	✓	✓	✓	✓
Appalachian	✓	✓	✓	✓	✓	✓	✓
Arkoma	✓	✓	✓	✓	✓	✓	✓
Bighorn	✓	✓	✓	✓	✓	✓	✓
Black Warrior	✓	✓	✓	✓	✓	✓	✓
Cherokee Platform	✓	✓	✓	✓	✓	✓	✓
Denver	✓	✓	✓	✓	✓	✓	✓
Forest City	✓	✓	✓	✓	✓	✓	✓
Fort Worth	✓	✓	✓	✓	✓	✓	✓
Greater Green River	✓	✓	✓	✓	✓	✓	✓
Illinois	✓	✓	✓	✓	✓	✓	✓
Los Angeles	✓	✓	✓	✓	✓	✓	✓
Marfa	✓	✓	✓	✓	✓	✓	✓
Michigan	✓	✓	✓	✓	✓	✓	✓
Montana Thrust Belt	✓	✓	✓	✓	✓	✓	✓
North Park	✓	✓	✓	✓	✓	✓	✓
Palo Duro	✓	✓	✓	✓	✓	✓	✓
Paradox	✓	✓	✓	✓	✓	✓	✓
Permian	✓	✓	✓	✓	✓	✓	✓
Powder River	✓	✓	✓	✓	✓	✓	✓
Raton	✓	✓	✓	✓	✓	✓	✓
San Joaquin	✓	✓	✓	✓	✓	✓	✓
San Juan	✓	✓	✓	✓	✓	✓	✓
Santa Maria	✓	✓	✓	✓	✓	✓	✓
TX-LA-MS Salt	✓	✓	✓	✓	✓	✓	✓
Uinta-Piceance	✓	✓	✓	✓	✓	✓	✓
Valley and Ridge	✓	✓	✓	✓	✓	✓	✓
Ventura	✓	✓	✓	✓	✓	✓	✓
Western Gulf	✓	✓	✓	✓	✓	✓	✓
Williston	✓	✓	✓	✓	✓	✓	✓

Table 13: LeakSurveyor Operating Envelope DQIs in U.S. Oil and Gas Basins. For each United States onshore oil and gas basin, this table depicts whether each operating envelope requirement under this protocol is met, as indicated by a checkmark (✓). The final column

"Validation of Overlapping Conditions" indicates whether all operating requirements, taken together, are met simultaneously.

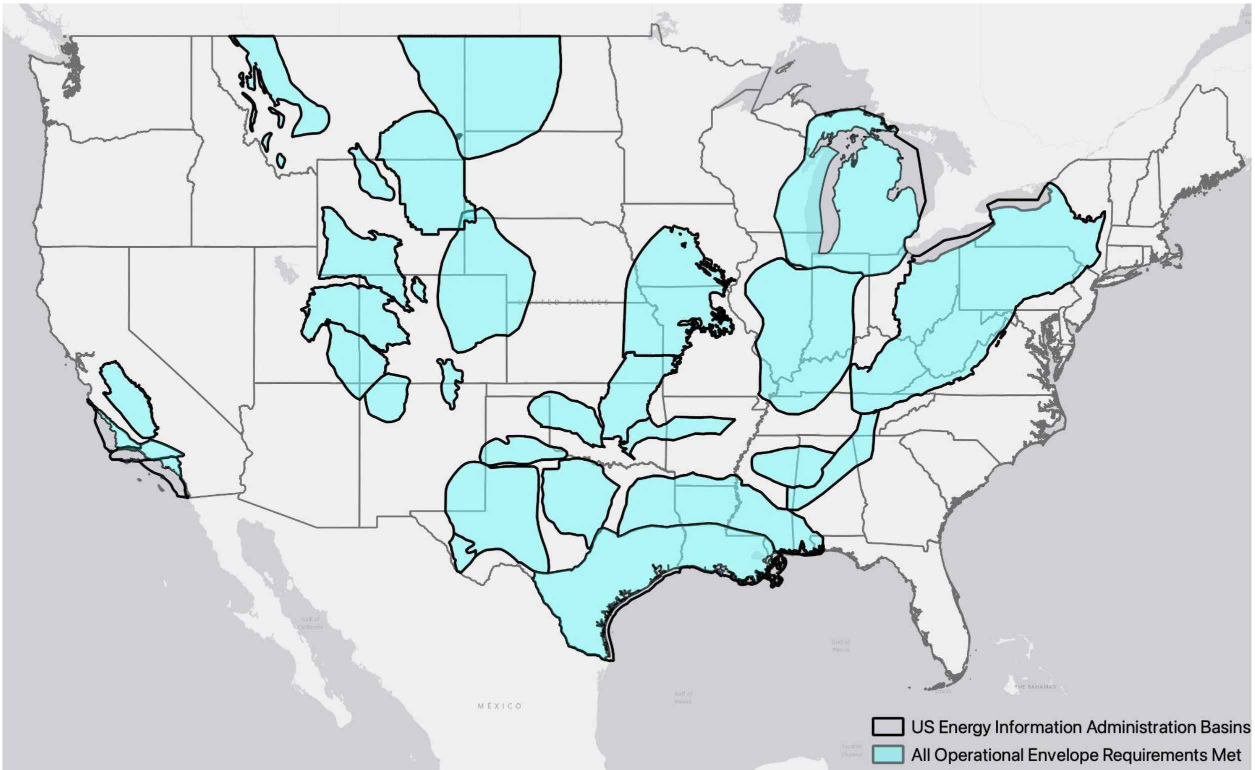

Figure 2. Map of United States Onshore Oil and Gas Basins and Validation of Operating Envelope Requirements under This Protocol. Sources: U.S. Energy Information Administration (basin geographies); Third part commercial dataset (meteorological data tested for validating operating envelope conditions).

14 Pollution Prevention

Pollution is generated by aircraft during flight. Flight plans are drawn to ensure the most efficient paths of collection possible in order to reduce excess flight hours.

15 Data Management

15.1 *Data Management, Processing, and Storage.*

All collected data are stored onboard the LeakSurveyor instrument for the duration of the survey flight. When an aerial survey flight is complete, collected data are transferred from the LeakSurveyor to a dedicated standalone computer located in or near the hangar. During this copy, an initial quality assurance and data verification step confirms data validity before uploading all relevant data to our secure cloud-based processing platform. Data are simultaneously copied to a local backup drive with a consistent, independent cloud backup process. Insight M retains two full backups of the raw data for a minimum of 5 years. All data on the local standalone computer and LeakSurveyor are erased only after both the local and cloud backup copies of the raw data are validated as complete and accurate copies of all valid data from the LeakSurveyor instrument.

On completion of the upload, our processing pipeline validates and refines the spectrometer measurements and runs a series of processing steps including (a) georectification of all collected data based on recorded GPS and IMU data and (b) the processing of spectroscopic measurements into methane plume imagery. This pipeline additionally produces time-of-survey orthorectified georegistered optical aerial imagery aligned with the processed methane imagery to build a complete dataset representative of the time of any identified leaks. Both raw and processed imagery are retained in our cloud storage for at least 5 years.

15.2 *Software System Controls.*

Insight M uses industry-standard software engineering best practices to ensure our data processing, data analysis, and report generation systems are accurate, reliable, and free of defects.

15.2.1 *Software Version Control*. All of our system code and configuration parameters are tracked in a version control system which lets us review, add, and remove changes in a well-defined and auditable manner.

15.2.2 *Code Reviews*. All software changes are peer-reviewed for functional correctness before being incorporated into our code base.

15.2.3 *Automated Tests*. In addition to code reviews, all software changes must pass an automated test suite which includes end-to-end, unit, and integration tests.

15.2.4 *Logging and Alerting*. Key application events and system-level metrics are captured by logging tools, and used to generate automated alerts which let us know in real-time if core functionality deviates from what is expected.

15.3 *Emissions Reporting to Oil & Gas Clients.*

15.3.1 *Emissions data provided to the end-user.* Insight M provides operators with data for all validated methane plume detections. For each validated emission source detection, the data provided include, but are not limited to, the data in Table 14 below.

Data Type	Description	Delivery Timeline
Detection Time	The date and time of detection	Within 1-5 calendar days after the date of the aerial survey
Emission ID	A unique identifier for the emission that allows for comparison with past and future reports	Within 1-5 calendar days after the date of the aerial survey

Data Type	Description	Delivery Timeline
Associated Facility	The name and/or ID of the facility where the emission was observed, as provided by the operator	Within 1-5 calendar days after the date of the aerial survey
Location	The estimated emission location, based on the shape and extent of observed methane (reported as a latitude/longitude coordinate)	Within 1-5 calendar days after the date of the aerial survey
Emission Rate	The best estimate of emission rate from the source, in kg/hr or MCF/day, along with an error range of +/-40% as characterized by El Abbadi et al., 2024. If multiple valid plumes are confirmed for the same reported emission source, Insight M reports (a) rate estimates, with error ranges, for each valid plume detection and (b) an emission rate for the source, reported as the average of the rates of all valid, non-cutoff plume detections for the source	Within 1-5 calendar days after the date of the aerial survey
Plume Image & Optical Image	Geolocated methane plume images superimposed on a geolocated optical image to guide close-range follow-up surveys; if multiple valid plumes are confirmed for the same reported emission source, all plume images are reported	Within 1-5 calendar days after the date of the aerial survey
Notes (if applicable)	If applicable, notes regarding the emission, such as suspected intermittency, notification of liquids leaks, observed maintenance events, etc.	Within 1-5 calendar days after the date of the aerial survey
Additional guidance for use of reported data	The following guidance is currently provided with each report: "Detected emission levels in this report represent observations of suspected elevated concentrations in methane at the time of survey. A reported detection level does not in itself constitute a confirmed discovery of fugitive emissions, nor does it constitute evidence of any failure to comply with applicable environmental laws. Insight M recommends each reported detection be evaluated by qualified ground-based technicians to confirm the source of the detection, for root cause analysis, quantification, and follow-up action." Reports	Within 1-5 calendar days after the date of the aerial survey

Data Type	Description	Delivery Timeline
	may contain additional or slightly modified language as required or recommended by EPA to clarify compliance requirements.	
Date of Delivery	Date that emission result is made available to the operator	Within 1-5 calendar days after the date of the aerial survey

Table 14: Summary of emissions data provided to customers under this test method.

15.3.2 *Other survey data*. For each contracted survey, Insight M provides additional coverage data to the client, including for surveys that yielded no confirmed emissions. The survey data provided include, but are not limited to:

- Confirmation that the alternative test method described in this protocol was the test method deployed by Insight M for the complete survey.
- Confirmation of the facility-level spatial resolution of the survey and the validated sensitivity of the deployment.
- Survey coverage results for each target site, provided as a cumulative list of coverage datetimes. Coverage results are provided for all target sites in a contracted survey, whether or not any emission was detected at the site. These reported results include only the coverage datetimes for target site coverage that meet all DQOs. Insight M will continue reflights over a target site until the target site has at least one coverage event meeting all DQOs in the survey period.

15.3.3 *Data delivery.* Data is delivered in the digital format(s) and at the cadence(s) agreed upon with each individual customer. Final analyzed and validated detection data, including the attribute data listed in 15.2.1, above, are available within 1-5 calendar days after the date of the survey and delivered to the customer no later than 5 calendar days after the survey. Survey data described in 15.4.2, above, are provided at the end of a contracted survey or at another cadence agreed upon with the individual customer.

15.3.4 *Data storage.* Reported emissions and survey coverage data are saved in our cloud database for at least 5 years.

16 References

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