Alternative Test Method (MATM-14): Percepto – Air Max UAS

09/10/2025

1.0 Scope and Application

1.1 Scope

This method is applicable for demonstrating compliance with the procedures in 40 CFR § 60.5398b for fugitive emissions components at affected facilities, as well as for the required inspection and monitoring of covers and closed vent systems. It is designed specifically for demonstrating compliance through periodic screening, as detailed in 40 CFR § 60.5398b(b), and is submitted for approval by the Administrator under the provisions of 40 CFR § 60.5398b(d). The scope of this method covers a wide range of affected facilities, which could include, but are not limited to, single wellhead only sites, small well sites, multi-wellhead sites, well sites with major production and processing equipment, centralized production facilities, and compressor stations.

1.2 Application

This test method is applicable to the detection of methane (CH_4, CAS No. 74-82-emissions originating from fugitive components within the oil and gas sector. The technology employed is classified as an airborne mobile remote sensor. Specifically, the method utilizes the Percepto Air Max OGI, an autonomous unmanned aerial system (UAS) which is integrated with a high-sensitivity optical gas imaging (OGI) camera, specifically the Sierra-Olympia Ventus OGI™, to perform its detection and monitoring functions. Note: While applicable to detection of methane, the OGI camera detects volatile organic compounds (VOCs) that absorb in the wavelength where the OGI operates. This method is broadly applicable across the oil and gas sector for operators electing to use periodic screening as their compliance approach. As approved by the Administrator, this method can be used in lieu of the fugitive monitoring requirements outlined in § 60.5397b and the inspection and monitoring protocols for covers and closed vent systems in § 60.5416b. Furthermore, this test method may be used to satisfy the fugitive monitoring requirements in § 60.5397c and the monitoring of covers and closed vent systems under § 60.5416c when a state, local, or tribal authority incorporates the model rule (i.e., OOOOc) as part of their State Implementation Plan (SIP) or where it is otherwise approved as applicable.

1.3 Method Sensitivity

This sensitivity of the outlined method is below 1 kg/hr as applied to Tables 1 and 2 Subpart OOOOb of Part 60, Title 40. This method has a field-verified method sensitivity to reliably detect fugitive methane emissions of 0.1 kg/hr with a 90% probability of detection under a variety of real-world operational conditions, including variable wind speeds up to 20 kph and at standoff detection distances ranging from 20 to 140 feet. The method provides component-level spatial resolution, as defined in § 60.5398b(b)(5), which dictates the required specificity and focus of follow-up ground surveys after a detection is confirmed.

1.4 Data Quality Objectives

Adherence to the requirements, quality control procedures, and operational protocols detailed within this method will ensure that the data collected is accurate, defensible, and of a known quality sufficient to meet the technology's primary objective. The method's objective is to screen for fugitive emissions from applicable oil and gas facilities on a repeated basis for emission events that equal or exceed 1.0 kg/hr. Upon detection of such an event, the system is designed to provide a clear and timely alert to the site operator, which serves to trigger the required leak detection, localization, and repair response actions. This minimum screening frequency is directly linked to the technology's demonstrated detection threshold, consistent with the requirements specified in Tables 1 and 2 of 40 CFR Part 60, Subpart OOOOb.

2.0 Summary of Method

2.1 Method for Methane Emission Detection.

The method leverages the Air Max OGI UAS, equipped with a Sierra-Olympia Ventus OGI™ 25 mm camera and Percepto AIM cloud-based software[1]. This OGI payload, a high-resolution mid-wave infrared camera mounted on an unmanned aerial vehicle (UAV), enables efficient and accurate methane emissions detection by leveraging advanced thermography principles. The method captures high-resolution imagery to locate the exact source of emissions with component-level precision.

2.2 Deployment

The Air Max OGI UAS is deployed via a ruggedized, weather-proof solution permanently installed in close proximity to the equipment to be surveyed, enabling unmanned operations of multiple assets. A detailed site map is created, outlining critical infrastructure and equipment which could be inspected. A flight plan is then designed, pinpointing specific Points of Interest (POIs) for inspection. Each POI can be configured with various parameters, including distance, angle, camera mode, and observation time (default of 10 seconds). This flexibility allows for tailored inspections and reduces the risk of missing potential leaks due to adverse weather conditions.

2.3 Autonomous and Manual Flight Operations

The operation of this method is contingent on Percepto operating in compliance with a waiver from the Federal Aviation Administration ("FAA").[2] An FAA-certified pilot (pilot) must oversee the autonomous flight, executing the pre-programmed flight plan. The FAA waiver enables a single pilot to remotely operate up to 30 UAVs simultaneously.[3] Although programmed to be an autonomous flight, during the flight, the pilot can perform manual operations as follows:

- Pause and Reposition: Manually pause the autonomous flight and reposition the UAS for a closer inspection of a specific area. For example, if the pilot sees a possible leak, the pilot may reinspect the specific component or POI to obtain additional data for subsequent review by the OGI inspector.
- Assume Full Manual Control: Assume full manual control of the UAS to conduct a more detailed inspection of a POI, potentially extending the observation time beyond the default 10 seconds.

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[1] The camera has met the EPA's performance specification requirements.
[2] See Percepto waiver on the FAA website
[3] Percepto employs UAS operators; however the Site Owner/Operator can operate the UAS if they use FAA-certified pilots and otherwise adhere to all applicable regulations.

2.4 OGI Inspections

In addition, a certified OGI inspector can review the data captured by the UAS in two ways:

- Monitor Live Video Feed: Observe the live video feed during the flight to identify potential methane plumes and provide real-time guidance to the pilot.
- Review Post-Flight Video: Analyze the recorded video footage after the flight to confirm the presence of any detected methane emissions. 3 Percepto employs UAS operators; however the Site Owner/Operator can operate the UAS if they use FAA-certified pilots and otherwise adhere to all applicable regulations. 2 See Percepto waiver on the FAA website.

2.5 Post-Flight Analysis and Reporting

If a leak is identified, after the mission is completed, Percepto sends a notification to the Site Owner/Operator that identifies the specific time in the video footage of the mission when the leak occurred. A comprehensive mission documentation must be generated that details the location and severity of leaks, video clips with relevant bookmarks at points when leaks occurred, flight path information, meteorological data, and timestamps.

3.0 Definitions of Method

3.1 Definitions

3.1.1. *Autonomous Inspection & Monitoring or AIM* means the software through which the Site Owner/Operator can interact with the UAS, execute flights, and view and retrieve collected data.

3.1.2. *Air Max OGI means* a Percepto-manufactured autonomous UAS equipped with a mounted OGI camera.

3.1.3. *Deployment Acceptance Test Procedures or DATP* means a series of tests conducted to verify that a system, software, or update has been correctly deployed to its target environment (e.g., production servers, user devices) and functions as expected. These procedures confirm that all components are properly installed, configured, and integrated, ensuring a smooth transition and minimal disruption to users or operations.

3.1.4. *Delta T* means Temperature difference between the objects in the field of view of the camera and gas detected.

3.1.5. *Flight Acceptance Test Procedures or FATP* means are a series of ground and flight tests performed on newly manufactured, modified, or overhauled aircraft to verify their compliance with all safety, performance, and operational requirements. These procedures ensure the aircraft meets stringent standards and contractual obligations before being delivered to an owner/operator or entering service.

3.1.6. *Ground Acceptance Test Procedures or GATP means* are a set of ground-based tests conducted on aircraft, systems, or components after manufacturing, modification, or major maintenance, focusing on verifying functionality without flight. These procedures confirm that all systems, such as engines, hydraulics, avionics, and electrical components, operate correctly and meet specified performance criteria on the ground.

3.1.7. *Optical Gas Imaging or OGI* means a mid-wave infrared camera tuned for the detection of methane and/or VOC emissions.

3.1.8. *Percepto* means the entity that operates the UAS and provides the AIM software and services.

3.1.9. *Pilot* means an FAA-certified individual who oversees and can manually control the UAS flight operations.

3.1.10. *Point of Interest or POI* means a specific location the drone is configured to inspect.

3.1.11.*UAS* means Unmanned Aerial

3.1.12. *UAV* means Unmanned Aerial Vehicle

3.2 Abbreviations

ADS-B: Automatic Dependent Surveillance-Broadcast

API: Application Programming Interface

AWS: Amazon Web Services

EPA: Environmental Protection Agency

FAA: Federal Aviation Administration

FAI: First Article Inspection

GEM: Gas Enhancement Mode

kg/hr: Kilograms per Hour km/hr

Kilometer per Hour

METEC: Methane Emissions Technology Evaluation Center

mm: Millimeter

mph: Miles Per Hour

MWIR: Mid-wave infrared

PCB: Printed Circuit Board

PTZ: Pan-Tilt-Zoom

QA/QC: Quality Assurance / Quality Control

RGB: Red, green, blue s

UAS: small Unmanned Aircraft System

4.0 Interferences for Method's Operating Envelope

Table 4-1. Potential Interferences

Condition	Summary	Mitigation
Winds	In aerial winds above 45 km/hr (28 mph) and gusts higher than 30 km/hr (18.6 mph) the system cannot reliably detect emissions	AIM software prevents the UAS from taking off if wind speed or gusts exceed these parameters
Winds	Higher wind speeds and stronger wind gusts reduce the ability to identify the exact emission source because the wind spreads emissions over a larger area, diluting concentration and reducing visibility	The UAS can maneuver closer to the POI to reduce the effect of the wind.
Temperatures	At ambient temperatures above 42 degrees Celsius (107.6 °F)and below -10 Celsius (-14°F) the system cannot safely fly	AIM software prevents the UAS from taking off if ambient temperature exceeds these parameters.
Precipitation	Precipitation that is stronger than 6 mm/hr can interfere with system operations.	AIM software prevents the UAS from taking off if precipitation exceeds this parameter
Icing	Ice can interfere with system operations.	No flight into known icing
Lightning	Lightning can interfere with system operations.	No flights during lightning.
Solar glint	Solar reflections can be detected by cameras and mistaken for a hot spot or thermal anomaly. This occurs because the camera's wavelength is subject to peak radiation from the sun.	The UAS can orbit the point of interest to view it from different angles. If the anomaly moves with the camera, it is glint. Flights can also be conducted at night or on cloudy days.
Distance (horizontal and vertical)	The further the camera is from the component, the lower the resolution and sensitivity, making it difficult to distinguish between the plume and the background. Atmospheric conditions such as humidity, dust, and other particles can interfere with the infrared signal, and the degree of interference is affected by the distance of the OGI camera from the source of emission.	The UAS can safely maneuver to within 20 horizontal feet of a POI and to within 40 vertical feet of a POI;[4] at this proximity the system can achieve a 90% probability of emission detection.
Maintenance	Battery or rotor replacement can impose temporary downtime of the UAS.	Strict guidelines for scheduled maintenance reduce downtime and allow for more predictable periods when the UAS is out of service. [5]

[4] Chapter 13 details the maximum detection distances per leak size for a 90% probability

[5] Percepto complies with the manufacturers' maintenance schedules.

Condition	Summary	Mitigation
Winds	In aerial winds above 45 km/hr (28 mph) and gusts higher than 30 km/hr (18.6 mph) the system cannot reliably detect emissions	AIM software prevents the UAS from taking off if wind speed or gusts exceed these parameters
External Factor	High temperatures from emission flares can affect image quality.	The UAS maneuvers to a distance and angle where interference is lower; each leak point is then inspected from different angles per the pre-built automated flight. If the operator sees the OGI camera is not collecting quality data, they will take over in manual flight to inspect from an optimum angle.

5.0 Safety

The safety of the UAS pilots, facility employees, and any other people who may be on-site at a facility are Percepto's highest priority. Percepto ensures safety by undertaking the following:

5.1 Equipment Functionality

To ensure optimal performance and safety, Percepto monitors various parameters of the Air Max OGI UAS throughout its lifecycle during assembly, operation, and maintenance:

a) Each component of the Air Max OGI UAS is meticulously examined upon receipt and before UAV assembly.

b) Percepto personnel conduct preflight checkups, which include a review of UAS charging rate and base station operation.

c) During the flight, an over-heating component or a connectivity problem prompts the UAS to safely return to base. In case of emergency, the UAS is also equipped with a parachute, preventing it from an accelerated fall on people or property.

d) Additional post-flight measures are discussed in Section 11 of this method.

e) Percepto has a thorough periodic maintenance procedure which is covered in the maintenance manual,[6] and incorporates component manufacturer recommendations.

5.2 Adverse Weather Conditions

Weather is constantly monitored remotely by the UAS pilot through a weather station that is installed on the base station. In case of severe weather conditions, the UAS cannot take off. Weather is re-evaluated every few seconds.

[6] See ATP & routine maintenance document in supporting documents.

5.3 Obstacles

Certain equipment or other air traffic may interfere with sight lines. Software enhances operational safety by actively identifying and navigating around potential obstacles or conflicting air traffic.

6.0 Equipment and Supplies

The method utilizes several pieces of equipment.

6.1 Air Max OGI

Is the main component of the alternative method for detecting emissions. The Air Max OGI UAS is a UAS equipped with an OGI camera, a day camera, and a landing camera. The Air Max OGI UAS is equipped with a flight controller, a telemetry communication system, and a GPU processor.

6.2 Gimbal

A 3-axis gyro-stabilized mechanical assembly. Its primary function is to maintain the orientation of the sensor payload, isolating it from the drone's motion and vibrations across the pitch, roll, and yaw axes. This ensures a stable line-of-sight for consistent data collection. The gimbal integrates a payload of three cameras: a high-resolution RGB camera for standard visual data capture, an Optical Gas Imaging (OGI) camera which is a cooled midwave-infrared detector for identifying hydrocarbon gas signatures, and a fixed, downward-facing landing camera used for terminal guidance during the autonomous landing sequence.

6.3 Sierra-Olympia Ventus OGI™ camera mounted onto a 2-axis gimbal on the UAS

The Ventus OGITM camera is a 640 x 512 resolution MWIR camera with a 25mm lens. The Ventus OGITM is designed to detect and visualize hydrocarbon gases, and can recognize a number of gases, including methane, propane, and butane.[7][8] The Ventus OGITM GEM colorizes gas leaks to enhance visibility of leaks from equipment subject to fugitive monitoring or inspection of covers and closed vent systems.

6.4 Percepto Base

Is an industrial grade weatherproof shelter which protects the UAS from weather and hazards. It has a take-off and landing zone for the UAS. The base station is equipped with a charging dock to enable continuous operations and an air conditioning unit to preserve the durability of the UAS.

6.5 Davis Vantage Pro2 weather station

A Weather station Installed on the base station, which provides real-time meteorological information with wind speed, temperature and precipitation sensors. The instrumentation meets the following manufacturer-specified precision and accuracy standards:

a) Wind Speed Accuracy: The greater of ±2 mph (±3 km/h) or ±5%.

b) Temperature Accuracy: ±0.5°F (±0.3°C).

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[7] *See* System Description – Air Max OGI (Aug. 22, 2024) for a full description of the UAS and its systems in supporting documents

[8] See Sierra Olympia Technologies Inc., "Ventus OGITM EPA Appendix K Test Report".

c) Precipitation Resolution: 0.01" (0.2 mm)."

6.6 Percepto AIM software

Is a cloud-based solution that acts as a control system for the UAS and manages and analyzes data collected. The software enables 24/7 monitoring, inspection planning, control, management of the UAS. Additionally, users can customize flight missions, watch real-time footage, and analyze data collected by the Air Max OGI UAS. A user can also conduct their own analysis within AIM by viewing images in several modes and leveraging image analytic tools, including RGB, thermal, and GEM, and by viewing maps and 3D models of the site. The user can mark issues—such as emissions or potential leaks—on specific objects and share these findings with personnel at the owner/operator site.

7.0 Reagents and Standards

This method does not require chemical reagents or standard gases for its primary operation. However, a non-consumptive standard is used to verify the functionality of the optical system during routine maintenance and the Acceptance Test Procedure (ATP). This standard consists of Ventus OGITM performing several self-checks during its startup procedure to ensure the camera is properly calibrated and fully operational. If any of these checks fail, the UAV will not proceed with the flight. The camera system's functionality is verified by confirming its ability to detect this standard under controlled conditions, ensuring the system is operating correctly prior to field deployment.

8.0 Data Collection and Method Input Sourcing

This section details the comprehensive framework for data collection, input sourcing, and management to ensure compliance and operational efficiency. The solution integrates data from the Air Max Optical Gas Imaging (OGI) UAS, a co-located ground-based weather station, and external data services. The operation of the technology is dependent on adherence to the method, the following of proprietary SOPs, and meeting the data objectives.

Table 8-1. Data Inputs collected for this method

Instruments/Source	Variables	Use in Method
Air Max OGI UAS	High-Definition Footage (RGB/OGI video and still images)	Primary data source used by certified OGI analysts to detect, identify, and document fugitive methane emissions.
Air Max OGI UAS	UAS Telemetry (position, velocity, altitude, yaw, gimbal parameters, battery status, GPS, IMU)	Provides precise location and orientation data for geotagging all collected imagery. Ensures flight stability and provides real-time monitoring of the UAS's operational health.
Air Max OGI UAS	Mission & System Logs	Creates a detailed, auditable record of the entire flight operation, used for diagnostics and mission verification.
Percepto Base Station	Base Status & Operation Logs	Monitors the health and operational status of the ground support equipment, including the autonomous charging and weatherproof housing systems.

Instruments/Source	Variables	Use in Method
On-Site Weather Station	Meteorological Data (wind speed, wind direction, temperature, humidity)	Provides real-time, localized weather data used for automated pre-flight safety checks and to contextualize OGI data during post-flight analysis.
External Web API	Weather Forecast Data & ADS-B Flight Data	Provides predictive weather information for mission planning and real-time positional data for manned aircraft to ensure airspace deconfliction.
AIM Cloud System	User Interactions & Inputs (Site Maps, Points of Interest)	Defines the survey area, critical infrastructure for inspection, and specific parameters for the autonomous flight path. Logs all user commands and interactions for audit purposes.

8.1 Foundational QC for Data Collection

Prior to deployment, all critical system components undergo initial quality control (QC) checks to ensure they meet performance specifications for valid data acquisition. The complete QC procedures, including detailed acceptance criteria and corrective actions, are provided in Section 9.

8.2 Aerial Survey Procedures

The following subsections provide a detailed, chronological description of the procedures for conducting an aerial survey mission. This approach increases the efficiency and coverage of methane emission monitoring, allowing for more frequent, consistent, and safe surveillance of the entire site, including hard-to-reach areas.

8.2.1 Pre-Flight Procedures

A pre-flight sequence must be performed to ensure that a mission is planned effectively and executed safely, with full system and environmental readiness.

8.2.1.1 Mission Planning and Design

Each survey is initiated within the cloud-based AIM software platform. Percepto personnel create a detailed site map that includes the locations of all relevant fugitive emission components such as compressors, tanks, hatches, pipelines, and additional Points of Interest (POIs). Based on this map, an optimized, autonomous flight path is designed. Each POI along the path is configured with specific observation parameters, including distance from the POI, camera angle, camera mode (including GEM mode), and a default observation time of 10 seconds to ensure standardized and repeatable data collection. To accommodate dynamic site changes, such as the temporary presence of equipment, temporary no-fly zones can be created within the flight path.

8.2.1.2 Automated System Health Checks

Prior to an authorized flight, the UAS conducts a comprehensive, automated self-diagnostic sequence. This procedure verifies the airworthiness of the aircraft, including the structural integrity of the airframe, motor function, propeller condition, and the status of all flight-critical systems. It also confirms the operational readiness of the OGI and RGB imaging payload. Any detected anomaly results in an automatic flight cancellation.

8.2.1.3 Automated Environmental and Safety Checks

The system autonomously checks environmental conditions against the method's validated envelope of operation. Real-time data from the on-site weather station is analyzed, and external APIs are queried for weather forecasts and ADS-B data for nearby manned aircraft. The flight should be postponed if precipitation, high winds, or other adverse weather conditions are present, or if a potential conflict with other air traffic exists. The FAA-certified remote pilot must review and provide final confirmation of all automated pre-flight checks before the mission can commence.

8.2.2 In-Flight Procedures

When the criteria in Section 8.2.1 are satisfied, The survey mission is executed autonomously. Each survey must be operated with continuous oversight and the capability for manual intervention by a remote pilot.

8.2.2.1 Autonomous Survey

The UAS will autonomously launch from the Percepto Base and execute the pre-programmed flight plan developed as part of the mission planning and design. The UAS will navigate between the established POIs, capturing continuous high-definition OGI/RGB video of the flight path and high-resolution still images at each designated inspection point.

Note: A single FAA-certified remote pilot, operating from a centralized control room, can securely monitor and manage up to 30 autonomous missions simultaneously.

8.2.2.2 Real-Time Monitoring and Data Streaming

Throughout the survey, a continuous stream of telemetry data including UAS position, altitude, velocity, and system health is transmitted to the AIM platform. The remote pilot, who is trained to identify potential emissions, monitors the live video feeds. If a potential methane leak is detected, the operator analyzes the video in real-time and places a digital bookmark at the specific time point for quick reference and post-flight analysis. This allows the pilot to maintain complete situational awareness of the mission's status and UAS performance.

8.2.2.3 Manual Pilot Intervention

The trained remote pilot retains the ability to intervene at any point to ensure critical information is not missed. The pilot can pause the automated mission to take manual control and conduct a more detailed ad-hoc inspection of a suspected emission source. This may involve repositioning the UAS or adjusting the camera angle to get a closer look at a potential leak before seamlessly resuming the automated survey.

8.2.3 Post-Flight Procedures

Upon mission completion, all collected data is securely and automatically handled to ensure data integrity and prepare it for analysis and reporting.

8.2.3.1 Autonomous Landing and Data Offload

After the survey is complete, the UAS will return to the Percepto Base, land, and position itself for charging and data transfer. All collected data, including OGI/RGB video, still images, bookmarked events, and drone mission logs are automatically and securely uploaded to the centralized AIM cloud server.

8.2.3.2 Data Processing

The raw data is processed and archived. All video and still imagery is timestamped and geotagged with precise location data from the UAS's GPS and IMU. The data are organized and linked to the specific assets and components defined in the site map, creating a complete and verifiable record of the inspection. These structured data are then made available for the analytical procedures.[9]

8.2.3.3 Notification of Potential Emissions

When a potential methane leak is bookmarked by the operator, the Site Owner/Operator is notified via API or email with information regarding the location of the potential leak.

8.2.4 Data Management and Storage

All data generated and collected by the system are sent to a centralized server. The server infrastructure uses different databases to store different data types. UAS-related data, including footage, parameters, and logs, are collected during missions or while the UAS is active and stored in cloud storage. Base station data, such as status and logs, is similarly collected and stored. Weather information is acquired from both the on-site station and a web API, with both datasets stored in a cloud database. User interactions with the system are also recorded. Lastly, ADS-B flight data is pulled from a web API during UAS missions and stored in the cloud database. Percepto maintains the data in a format that is readily accessible to the Site Owner/Operator for at least one year and in a "cold storage" format for longer periods of time to meet regulatory requirements.

9.0 Quality Control

Table 9-1. Quality control acceptance criteria and corrective actions for this method

Test Specifications	Acceptance Criteria	Frequency of QC Procedure	Corrective Actions
Component Incoming Inspection: First Article Inspection (FAI)[10]	New or fi rst-time parts meet all specifications and standards before mass production.	On the entire order for new or first-time parts.	Prevents non-conforming parts from entering mass production.
Component Incoming Inspection: PCB & Shipping Protocol Checks	Printed Circuit Board (PCB) functionality is confirmed; adherence to shipping protocols ensures sensitive electronics are adequately protected during transit.	Upon receipt of new components.	Minimizes the risk of damage that could affect performance and reliability. Rejected parts are segregated and discarded.

[9] See Section 17 for a detailed table of each data source, its type, when it is collected and where it is stored.

[10] See Incoming Inspection Report and Supplier Quality Audit Report in supporting documents

Test Specifications	Acceptance Criteria	Frequency of QC Procedure	Corrective Actions
Supplier/Subcontractor Audits	Suppliers and subcontractors comply with integration standards.	Systematically, with a heightened frequency for key partners.	Reduces the likelihood of incidents leading to equipment damage or delivery delays.
Quality Issue Identification & Tracking	Identification of visual defects (cracks, tears), functional problems (assembly difficulties, electrical issues), or deviations from assembly protocols.	Upon identification of a defect or non-conformance.	Rejected parts are segregated and discarded. Non-conformance reports are issued to the supplier.
Quality Issue Investigation	A structured process is initiated via quality tickets to investigate issues.	When a quality issue is identified.	Segregate suspected faulty parts and conduct inventory checks to rule out discrepancies.
Quality Issue Resolution	Root cause is determined, and appropriate corrective actions are decided.	Following investigation and root cause determination.	Actions are decided in collaboration with Engineering, R&D, and Supply Chain teams, including repair, scrapping, redesigning, or a software patch.
Mechanical Assembly Inspection[11]	Mechanical subassemblies (e.g., gimbal, other external parts) meet all required specifications and quality standards.	After a subassembly is fully assembled.	Ensures subassembly meets quality standards before integration into the fi nal system.
GATP – Ground Acceptance Test[12]	Each part within each system (e.g., engine, communications, current) undergoes a pass/fail review to assure functionality.	During the GATP phase.	A part that fails does not proceed to the next stage.
FATP – Flight Acceptance Test (Stress Test)	The UAS's capabilities are stress-tested under extreme conditions (e.g., speed and manual maneuvers). Pass/fail criteria are met.	During the FATP stage, following GATP.	Ensures the UAS can handle extreme operational conditions.
FATP – Flight Acceptance Test (Functional Flight)	All subsystems, including flight-critical systems, safety systems, and data collection systems (including cameras), are functional.	After stress tests, during the FATP stage.	Verifies functionality of all critical systems before deployment.

[11] See Supplier Quality Audit Report in supporting documents.
[12] See ATP & routine maintenance procedures in supporting documents.

Test Specifications	Acceptance Criteria	Frequency of QC Procedure	Corrective Actions
DATP – Deployment Acceptance Test	A functionality test validates the site setup and the day-to-day operation of the system at the owner/operator's location.	After installation at the site and before the system is handed over for day-to-day use.	Confirms the system is fully operational in its intended environment before handover.
Ongoing Operations: Remote Visual Inspection[13]	A full cycle of over 40 predefined viewpoints covering the UAS, base station, and surrounding operating environment is completed. The UAS is deemed airworthy.	Every 100 flights, every two weeks, or after maintenance, whichever comes first (during daylight hours).	Structural issues or environmental factors that may impact operation are identified and reported for maintenance and safety purposes.
Automated Pre-flight Inspection	The system carries out automated checks on airworthiness, UAS structural integrity, and weather conditions.	Prior to every flight.	If issues arise (adverse weather, technical faults), the flight is canceled or postponed until resolved.
Pre-flight Confirmation[14]	UAS pilots must confirm the results of the automated pre-flight checks before proceeding.	Prior to every flight, after automated checks.	In the event of any failed preflight checks, the mission is immediately aborted.
Routine Maintenance & Visual Inspections[15]	Inspections of the Air Max OGI UAS structure, lights, propellers, motors, landing pads, weather stations, camera and other associated equipment.	Regular intervals, performed by Percepto personnel.	Ensures the system remains fully operational. Maintenance logs are kept for all activities.
Routine Maintenance & Component Replacement	Planned periodic replacement of components to prevent wear-related issues.	According to the maintenance manual schedule.	Motors, charging systems, parachute systems, and other safety-critical parts are inspected and replaced as needed to ensure emergency preparedness.
Automated Contingency Procedures	Automated management of a range of emergencies, including degraded functionality or communication failures, guided by FAA requirements.	Automatically during operations upon detection of a malfunction.	The system may pause the mission, return to base, move to a safe zone, or land autonomously to prevent accidents.

[13] Ibid
[14] See appendices A & B to Percepto's Shielded Operations with One to Many Concept Of Operations in the supporting documents.
[15] See ATP & routine maintenance procedures in supporting documents. Intervals are based on manufacturers requirements.

Test Specifications	Acceptance Criteria	Frequency of QC Procedure	Corrective Actions
Failsafe Protocols for Lost Communication	Failsafe layers ensure the UAS can manage a loss of contact with the remote pilot.	Automatically when contact with the remote pilot is lost.	The UAS will return to base or hover until it reaches a critical battery level, at which point it will attempt to land safely.
Post-mission Operational Readiness Test	The UAS undergoes a test flight to confirm operational readiness for future missions.	After the UAS returns to the base station.	Ensures the UAS is ready for its next scheduled mission.
Post-incident Analysis	A full post-mission analysis is conducted to determine the cause of any incidents or accidents.	Following any incident or accident during a mission.	Operations cease until the cause is determined and corrective actions are taken to mitigate any risk of recurrence.
Software QA: New Feature Testing[16]	Two testing cycles validate new functionalities, ensuring feature performance and integration.	During the fi rst week of a two-week quality assurance cycle.	Ensures new features work as intended without introducing issues.
Software QA: Regression & Stability Testing	Comprehensive testing guarantees that existing functionalities remain unaffected and the system operates reliably under varied conditions.	During the second week of a two-week quality assurance cycle.	Maintains high-quality standards and system stability
Post-Release Validation	Confirm successful updates, validate critical functionalities in the production environment, and actively monitor for issues.	After each software or system release.	Ensures smooth deployments and allows for active monitoring and addressing of any deployment-related issues.

10.0 Calibration and Standardization

10.1 Calibration procedures

During the manufacturing process, the camera is calibrated to the operational range which enables it to detect emissions. Following manufacturing and after UAS and base assembly or any repair work, an Acceptance Test Procedure (ATP) is conducted for the gimbal to verify that each UAS meets quality standards prior to release to a Site Owner/Operator.[17] This ATP includes an Image Quality test to confirm the accuracy of the focus calibration. Detailed documentation of these activities is maintained to track the history of each camera and gimbal, aiding in the prevention of potential future failures. Percepto continuously monitors and analyzes gimbal and camera performance through logs retrieved from the UAS.

[16] See Quality Assurance Work Methodology in supporting documents.
[17] See ATP & routine maintenance procedures in supporting documents.

Note: During scheduled maintenance, Percepto personnel thoroughly clean the camera lens to remove dust and stains, which ensures image clarity and consistent equipment quality.

10.2 Training

Percepto trains its UAS operators with the knowledge and skills to safely and effectively plan and execute various UAS missions utilizing the Air Max OGI UAS systems while adhering to all applicable safety protocols and regulatory requirements. [18] Trainees must hold a valid UAS pilot certificate in accordance with FAA regulations. The duration of Percepto's UAS operator training is approximately 40 hours, depending on trainee progress and skill level. Trainees must pass a final exam with a minimum score of 80 percent on system safety procedures and routines, remote operations, mission building, the AIM software, and components monitoring, among other topics. Refresher training courses occur on an as-needed basis (e.g., to account for changes to software). The program includes a comprehensive curriculum covering various topics, including:

a) Fundamentals: Introduction to UAS flying, pre-flight planning, manual flight maneuvers, and understanding of FAA regulations.

b) System Operations: In-depth training on the Air Max OGI UAS and base station, including system components, safety procedures, and AIM software utilization. This covers mission planning, execution, and data analysis with a focus on identifying and recording gas emissions.

c) Advanced Topics: This section covers remote operations, leveraging Percepto's Shielded Operations FAA waiver[19] and provides insights into the oil and gas industry operations and infrastructure, component monitoring, and past incident analysis for enhanced safety awareness.

d) Practical Training: Hands-on experience with UASs for flight operations and practical application of AIM software for mission building and execution.

11.0 Analytical Procedure

[Reserved]

12.0 Detection and Alerting

12.1 Detection

For the purposes of this method, a detection is defined as a fugitive methane emission that has been visually confirmed by a certified Optical Gas Imaging (OGI) inspector. This method uses a qualitative, expert-driven approach to ensure the accuracy of every detection. The process is as follows:

12.1.1 Data upload

Immediately after the UAS completes its survey, all video (OGI/RGB/GEM) and telemetry data are automatically uploaded to the secure, cloud-based Percepto AIM platform for processing and archival.

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[18] See UAS Remote Operator – Course Syllabus in supporting documents.

[19] The waiver enables one-to-many UAS operations, meaning one pilot can control multiple UASs. It helps increase the effi ciency and productivity in inspected sites and of UAS operations.

12.1.2 Expert Analysis

A certified OGI inspector reviews the collected data within the AIM system. The inspector performs a qualitative analysis of the footage, evaluating the characteristic plume shape and movement patterns of methane gas in the context of surrounding infrastructure and environmental factors. This expert review is essential to verify the existence of a methane leak and distinguish it from other thermal or visual artifacts.

12.1.3 Confirmation and Annotation

If a leak is confirmed, the certified OGI inspector annotates the inspection data. This includes bookmarking the specific timestamps in the video where the emission is visible and marking the corresponding still images to highlight the precise component-level location of the leak.

12.2 Alerting

For the purposes of this method, an alert is defined as the formal notification delivered to the site owner/operator that a confirmed detection requires a response. Any detection confirmed by the certified OGI inspector in Section 12.1 is classified as an alert and transmitted to the operator.

Following the confirmation of a leak during the post-flight analysis, a detailed inspection report is generated and delivered to the site owner/operator. This report serves as the primary alert and provides a comprehensive overview of the findings to facilitate leak detection and repair (LDAR) activities. The report includes:

a) General information regarding the mission

b) General meteorological data from the time of the mission, including temperature, wind speed, and direction.

c) An image of each inspected component where an emission was detected.

d) The specific component name or identifier.

e) Asset coordinates, camera dwell time, and distance from the component.

f) A direct link to the video evidence, bookmarked at the relevant timestamp.

g) An image of the flight path showing all inspected assets.

13.0 Method Performance

13.1 Validation Results

The Air Max OGI UAS platform's performance was evaluated through two distinct testing phases: controlled release experiments at the Methane Ethane Emissions Technology Evaluation Center (METEC) and real-world data collection at customer sites. Both phases employed a five-tiered classification system for emission detection: Very Clearly Observable, Clearly Observable, Observable, Barely Observable, and Not Observable. For analysis, detections classified as Very Clearly Observable, Clearly Observable, and Observable were considered positive detections, while Barely Observable and Not Observable were classified as non-detections. Percepto has conducted approximately 15 controlled release experiments at both sites to establish the Air Max OGI's detection capabilities.

13.2 Controlled Release Experiments

METEC is a research facility based at Colorado State University that specializes in testing and evaluating technologies used to detect and quantify methane leaks in the oil and gas industry, essentially acting as a controlled environment to test various leak detection methods under simulated real-world conditions. METEC testing[20] involved controlled releases of methane from cans using a flow meter. Methane releases of known rates, ranging from 60 g/hr to 1166 g/hr, were simulated at various distances from the Air Max OGI UAS.

At METEC, controlled releases were conducted within the facility using Colorado State University equipment in a realistic but highly controlled environment. Weather conditions were measured using the weather station installed on the base station (described above). To simulate real-world conditions, the releases were conducted on components such as tanks, compressors, and separators during the experiments. Third-party OGI inspectors used the five-tiered classification system to verify detections reported during each of the controlled release experiments. The probability of detection was calculated based on the proportion of leaks identified at various emission rates and distances and verified by a third-party certified OGI inspector. Estimating detection limits involves determining the minimum leak rate that can be reliably detected with a 90% probability. This was established at 0.1 kg/hr for the Air Max OGI UAS method, based on a combination of controlled release experiments and real-life data collection (discussed below).

13.3 Real World Data Collection

Real life data collection[21] consisted of deploying the Air Max OGI UAS platform at an Owner/Operator site in the Permian Basin to evaluate detection in real life conditions. This phase provided crucial insights into the platform’s performance under real-world operating conditions, including a broader range of environmental factors and potential background sources.

While the controlled release experiments at the METEC were conducted in an open field setting, simulating real-world scenarios required a different approach. To more accurately reflect actual operational conditions, these releases took place in close proximity to operational and active components, including compressors, tanks, and separators, thus providing a more realistic and complex environment for observation and data collection. Similar to the METEC experiments, third-party OGI inspectors used the five-tiered classification system to categorize detections.

13.4 Spatial Resolution Limits of Air Max OGI Platform

The Air Max OGI UAS platform demonstrated accurate detection of methane emissions at the component level within the tested vertical range of 40 to 100 feet and horizontal range of 20 to approx. 250 feet based on data from both the METEC and real-world experiments, depending on the leak size. The resulting data was used to determine the probability of detection for different emission rates and distances.

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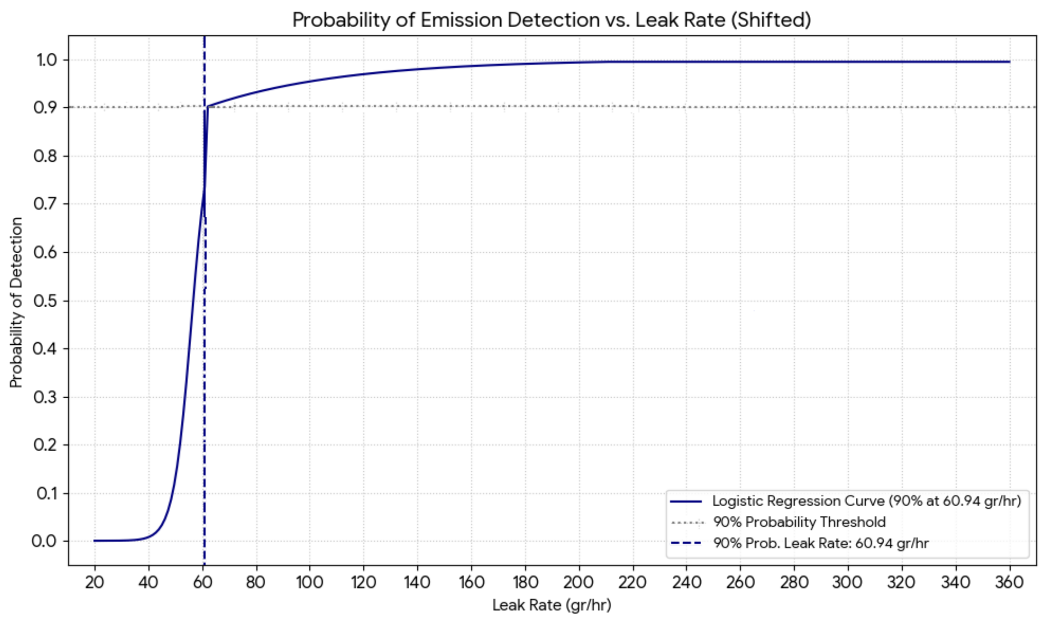
[20] METEC Testing For OGI Inspectors datasheet in supporting document

[21] See Real World Testing For OGI Inspectors datasheet in supporting document

13.5 Detection Accuracy and Limits

The Air Max OGI UAS method has a minimum operational detection level of 0.1 kg/hr with a 90% probability of detection. Both the METEC experiments and real-world data collection showed a 90% probability of detecting methane leaks of 0.1 kg/hr or greater under real-world conditions. As shown in Figure 1 below. Smaller leaks (60 g/hr) were detectable only under specific conditions, such as wind speeds up to 5 kph at the METEC facility.



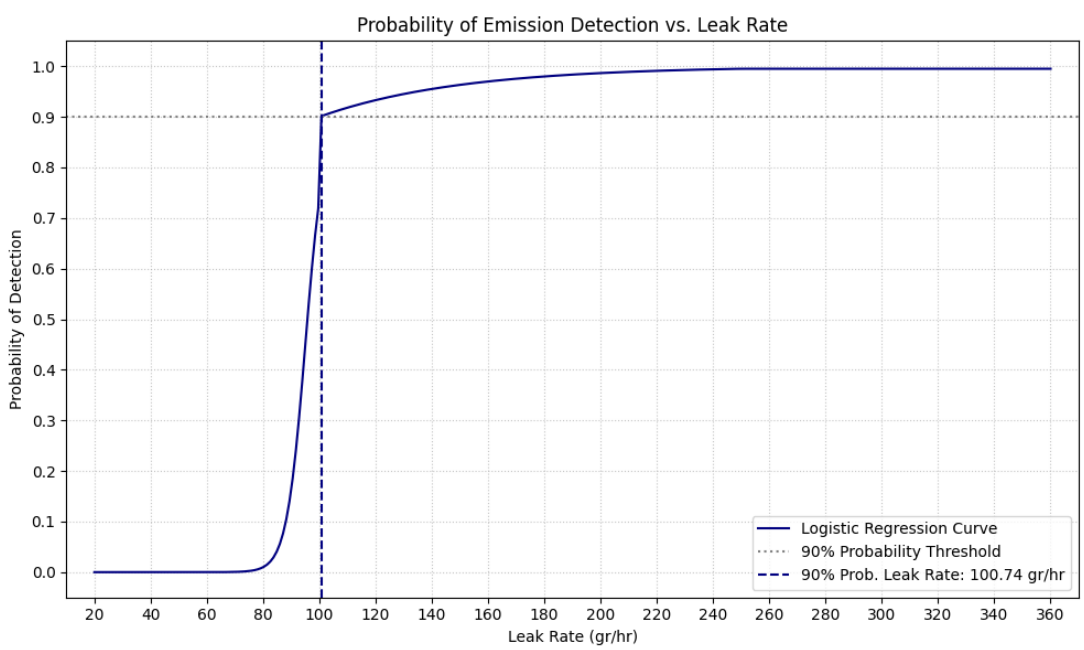


Figure 1 - ***Distance and wind speed are the primary factors that were evaluated to determine their effect on the ability to detect emissions with a 90% probability.***

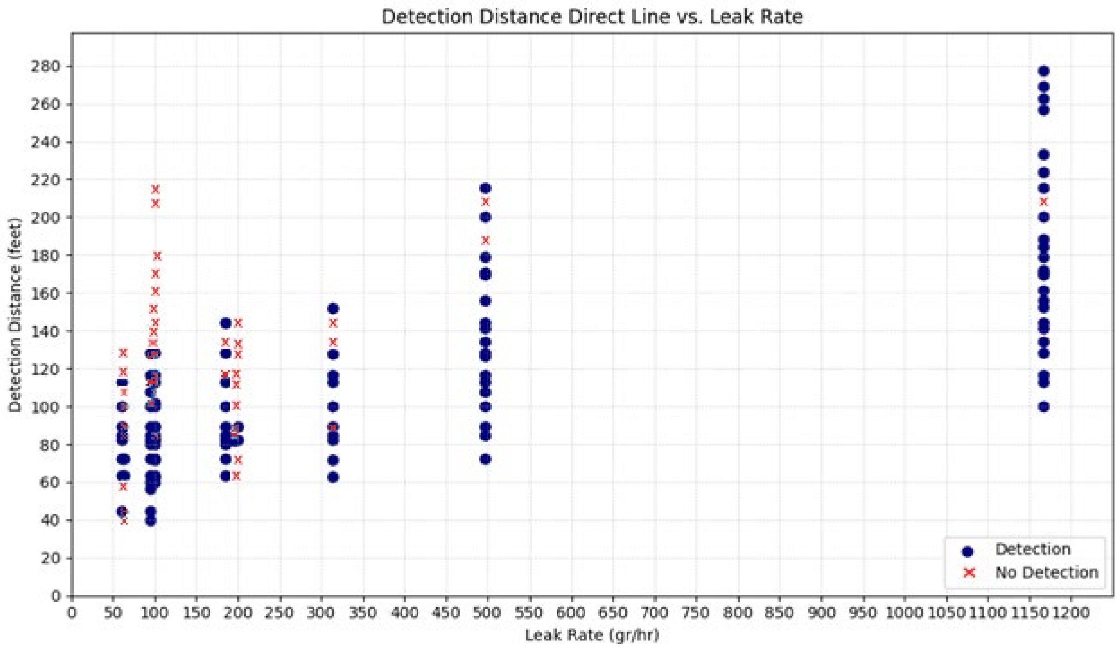


Figure 2*: A 0.1 kg/hr detection threshold and higher was consistently observed across a range of vertical distances from 40 to 100 feet and horizontal distances from 20 to approx. 250 feet. For instance, for a 100 g/hr leak, the average detection distance (with probability of 90%) was approximately 110 feet, while a 314 gr/hr leak was detected at 140 feet, and a 500 gr/hr was detected at 220 feet away.*

As shown in Figure 2, the Air Max OGI UAS can detect leaks from a greater distance as the leak rate increases. In regard to wind, the testing was conducted in winds of up to 20 kph and gusts of up to 33 kph. As shown in Figure 3 below, there is a weaker correlation between wind/gust speed and detection. In many cases leak detection was achieved in winds above 12 kph. This suggests that the effect of wind on detection ability may be less strong than distance.

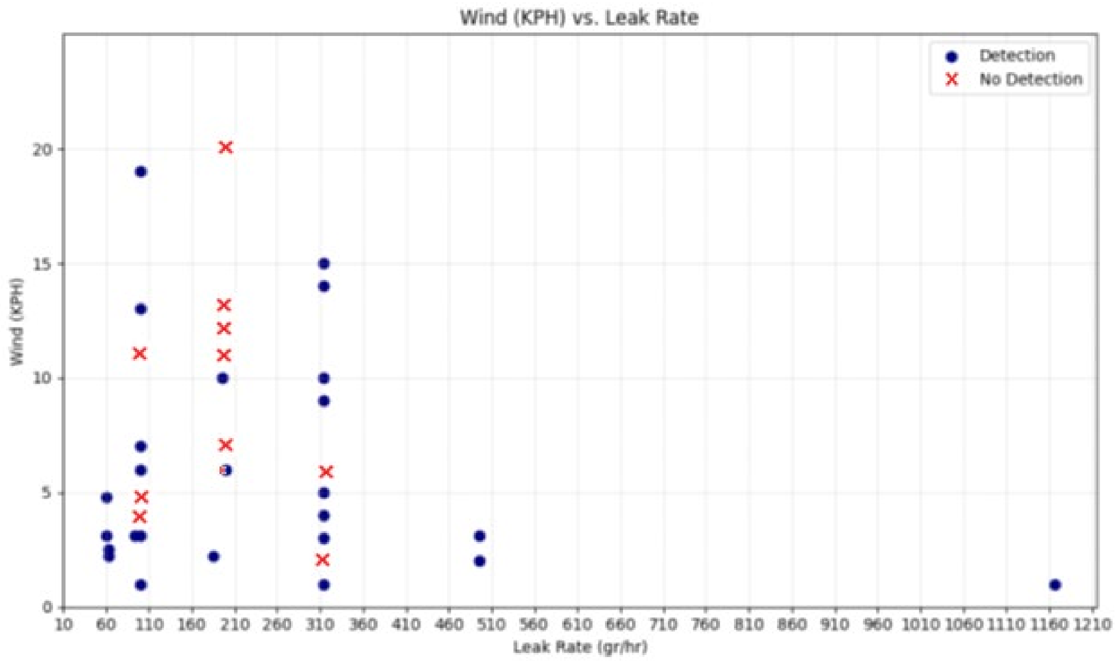


Figure 3: With respect to distance, the UAS can effectively detect emissions up to approximately 250 feet away for emission rates of 1 kg/hr. This distance decreases with lower emission rates, requiring closer proximity to the source. For instance, at 500 gr/hr, the detection range is 220 feet, and for 100 gr/hr, the UAS needs to be within 110 feet of the object. Therefore, flight paths are planned to maintain appropriate distances based on the target emission rate. As for wind speed, the Air Max OGI UAS can detect leaks of 100 gr/hr in winds up to 7 kph. Higher emission rates allow for detection in stronger winds, with 300 gr/hr leaks detectable in up to 15 kph winds. The lowest detectable leak rate was 60 gr/hr.

13.6 Bias

While a formal bias study was not conducted, the use of controlled release experiments with known emission rates allowed for an assessment of the accuracy of the Air Max OGI UAS platform's leak detection capabilities.

13.7 Limitations

The reported performance metrics are specific to both tested environmental conditions (winds up to 20 kph with gusts up to 33 kph and temperatures between 9 and 33°C) and the specified distance ranges.

Performance may be affected by more extreme weather conditions, distances outside the tested ranges, or other unforeseen factors.

14.0 Pollution Prevention

Using a UAS such as the Air Max OGI UAS to perform inspections reduces fuel consumption and emissions compared to traditional ground-based inspection methods that require the use of a vehicle to access POIs across the site because the UAS is battery powered and does not emit.

15.0 Waste Management

[Reserved]

16.0 References

(a) Caico C., et. al., “An evaluation of an optical gas imaging system for the quantification of fugitive hydrocarbon emissions”, Concawe Report, 2/17, 2017.

(b) Chiemezie Ilonze, et. al., “Methane Quantification Performance of the Quantitative Optical Gas Imaging (QOGI) System Using Single-Blind Controlled Release Assessment”, MDPI, 2024, 24(13).

(c) Ravikumar A., et al., “Are Optical Gas Imaging Technologies Effective For Methane Leak Detection?”, Environ. Sci. Technol. 2017, 51, 718−724.

(d) Ventus OGITM EPA Appendix K Test Report, Operating Envelope of the Sierra Olympia Technologies, Inc., Ventus OGITM Camera, January 15th 2024.

(e) Zimmerle, D., et. al., “Detection Limits of Optical Gas Imaging for Natural Gas Leak Detection in Realistic Controlled Conditions”, Environ. Sci. Technol. (2020), 54, 18, 11506–11514.

17.0 Tables, Diagrams, Flowcharts, and Validation Data

17.1 Data Handling and Storage

Table 17-1. Data sources, types, and storage locations are as follows:

Source	**Type**	**When Collected**	**Storage Place**
UAS	Footage	During UAS mission	Cloud Storage
UAS	UAS Parameters	As long as UAS is active	Cloud DB
UAS	Logs	As long as UAS is active	Cloud Storage
Base Station	Base status (open, close, charging, etc…)	As long as base station is active	Cloud DB
Base Station	Logs	As long as base station is active	Cloud Storage
Ground Weather Station	Wind, Temperature, precipitation	As long as weather station is active	Cloud DB
Weather condition from web API	Wind, temperature, precipitation	Every 30 minutes	Cloud DB

Source	Type	When Collected	Storage Place
Users (web interface)	User Operation	Every time there is an interaction with the system	Cloud DB
ADS-B (from web API)	ADS-B flight data of air vehicles in the area of the base station	When UAS is on a mission	Cloud DB

17.2 Connectivity between data sources