PERCEPTO

Percepto Autonomous OGI Drone & AI Software

ALTERNATIVE TEST METHOD

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1. SCOPE AND APPLICATION

This alternative test method uses the Percepto Air Max OGI, an autonomous drone equipped with OGI inspection technology, to detect and efficiently pinpoint methane emissions in the oil and gas sector. This method is broadly applicable to onshore oil and gas infrastructure in the United States and may be used at sites that 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. The method demonstrated a 90% detection probability for methane leaks of 100 g/hr (0.1 kg/hr).

This alternative test method utilizes the Percepto Air Max OGI autonomous drone, an airborne mobile remote-sensing instrument, and is intended to meet the inspection and monitoring requirements applicable to fugitive emissions components affected facilities, covers, and closed vent systems under 40 C.F.R. § 60.5398b, specifically demonstrating compliance through periodic screening per 40 C.F.R. § 60.5398b(b), as approved per 40 C.F.R. § 60.5398b(d). The Air Max OGI drone is equipped with a Sierra-Olympia Ventus OGI™ camera, capable of detecting certain gases including methane with precision down to the component level. This method supports compliance with the Environmental Protection Agency's 40 C.F.R. Part 60 New Source Performance Standards, Subparts OOOOb, and OOOOc for Oil and Natural Gas Sector Operations.

This document outlines the protocols employed by trained Percepto personnel and Percepto's contractors when conducting an inspection for methane emissions using the Air Max OGI drone-in-a-box. The proposed method outlines automated and manual workflows for the Air Max OGI drone which enable it to quickly detect and locate the exact source of emissions through repetitive and frequent component inspections. The owner or operator of the site (hereafter the Site Owner/Operator) can then leverage this data to quickly and efficiently pinpoint and repair leaks. The Air Max OGI can be operated unmanned, in areas that would be hard to reach on foot using handheld OGI, and can be utilized for repetitive missions to ensure thorough and repeatable monitoring. By using the Air Max OGI to inspect facilities, oil and gas companies can enhance environmental compliance and emissions reductions, optimize operational efficiency, and improve facility and personal safety.

1.1. ANALYTE LIST, CAS NUMBERS, MATRICES, AND SENSITIVITY

The test method is applicable to methane emissions from oil and gas infrastructure.

Compound	CAS number	Matrices	Limit
Methane	74-82-8	Gas Emissions	0.1 kg/hr

The Air Max OGI drone-based inspection system demonstrates a 90% detection probability for methane leaks of 100 g/hr (0.1 kg/hr) and higher across various conditions, including winds up to 20 kph at distances that range from 20 to 140 feet horizontally and 60 to120 feet vertically.

At this detection threshold, the Air Max OGI satisfies the minimum detection threshold requirement for periodic emissions monitoring as prescribed under § 60.5398b(b) and Tables 1 and 2 of Subpart OOOOb of Part 60. A 90% detection probability was established by applying a five-tiered classification system for leak visibility, where the top three tiers were considered positive detections, and the bottom two tiers represented non-detections.

A third-party team of certified OGI inspectors independently reviewed the Air Max OGI leak detection data. Only leaks confirmed by at least four of five OGI inspectors upon review of the visual evidence, were counted towards the 90% detection probability calculation. Additionally, the system can detect smaller leaks of approximately 60 g/hr (0.06 kg/hr), however the probability of detection was lower than 90% at this leak rate.

With a 90% detection probability for methane leaks of 100 g/hr across varying environmental conditions, the sensitivity of Percepto's proposed method is below the 1 kg/hr minimum detection requirement in Tables 1 and 2 Subpart OOOOb of Part 60.

2. SUMMARY OF METHOD

2.1. PROPOSED METHOD FOR METHANE EMISSION DETECTION

The proposed method leverages the Air Max OGI, an autonomous drone-in-a-box equipped with an EPA-approved Sierra-Olympia Ventus OGI camera, and Percepto AIM cloud-based software. The OGI payload is a high-resolution mid-wave infrared camera with a 25mm lens mounted on the drone to enable efficient and accurate methane emissions detection.

The process includes the following key steps:

2.2. ON-SITE DEPLOYMENT

The Air Max OGI drone-in-a-box is deployed in the field in a permanent deployment process. Hereafter, the ruggedized, weather-proof solution 'lives' on-site, enabling unmanned operations. A detailed site map is created, outlining critical infrastructure such as compressors, tanks, and pipelines. 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

In accordance with a waiver from the Federal Aviation Administration ("FAA"), [1] an FAA-certified pilot oversees the autonomous flight, executing the pre-programmed flight plan. The FAA waiver enables a single pilot to remotely operate up to 30 drones simultaneously, saving significant

[1] See Percepto waiver in supporting documents.

amounts of time and manpower.[2] Although programmed to be an autonomous flight, during the flight, the pilot can perform manual operations as follows:

1. **Pause and Reposition:** Manually pause the autonomous flight and reposition the drone 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.
2. **Assume Full Manual Control:** Assume full manual control of the drone to conduct a more detailed inspection of a POI, potentially extending the observation time beyond the default 10 seconds.

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

1. **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.
2. **Review Post-Flight Video:** Analyze the recorded video footage after the flight to confirm the presence of any detected methane emissions.

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 report may 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. DEFINITIONS

Term	Definition
ADS-B	Automatic Dependent Surveillance-Broadcast
AIM (software)	Autonomous Inspection & Monitoring is the software through which the Site Owner/Operator can interact with the drone, execute flights, and view and retrieve collected data.
Air Max OGI	A Percepto-manufactured autonomous drone equipped with a mounted OGI camera

[2] Percepto employs drone operators; however the Site Owner/Operator can operate the drone if they use FAA-certified pilots and otherwise adhere to all applicable regulations.

API	Application Programming Interface is a set of rules and protocols that allows different software applications to communicate with each other and exchange data.
AWS	Amazon Web Services
DATP	Deployment Acceptance Test Procedures are 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.
Delta T	Temperature difference between the objects in the field of view of the camera and gas detected.
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FAI	First Article Inspection
FATP	Flight Acceptance Test Procedures 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.
GATP	Ground Acceptance Test Procedures 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.
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
OGI	Optical Gas Imaging
PCB	Printed Circuit Board
POI	Points of Interest
PTZ	Pan-Tilt-Zoom
QA/QC	Quality Assurance / Quality Control
RGB	Red, green, blue
sUAS	small Unmanned Aircraft System

4. INTERFERENCES FOR METHOD'S OPERATING ENVELOPE

Condition	Summary	Mitigation
Winds	In aerial winds above 45 km/hr (28 mph) or gusts higher than 30 km/hr (18.6 mph) the system cannot reliably detect emissions.	AIM software prevents the drone from taking off if wind speed or gusts exceed these parameters.
	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 drone 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 reliably detect emissions	AIM software prevents the drone 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 drone from taking off if precipitation exceeds this parameter.
Icing	Ice can interfere with system operations.	No flight into known icing.
Lightning	Lightening can interfere with system operations.	No flights during lightning.
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 drone can safely maneuver to within 20 horizontal feet of a POI and to within 40 vertical feet of a POI; at this proximity the system can achieve a 90% probability of emission detection.
Maintenance	Battery or rotor replacement can impose temporary downtime of the drone.	Strict guidelines for scheduled maintenance reduce downtime and allow for more predictable periods when the drone is out of service.[3]
External Factors	High temperatures from emission flares can affect image quality.	The drone maneuvers to a distance and angle where interference is lower.

5. SAFETY[4]

The safety of the drone 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:

[3] See appendices A & B to Percepto's Shielded Operations with One to Many Concept Of Operations in the supporting documents.
[4] Ibid.

5.1. EQUIPMENT FUNCTIONALITY

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

- Each component of the Air Max OGI drone is meticulously examined upon receipt and before drone assembly.
- Percepto personnel conduct preflight checkups, which include a review of drone charging rate and base station operation.
- During the flight, an over-heating component or a connectivity problem prompts the drone to safely return to base. In case of emergency, the drone is also equipped with a parachute, preventing it from an accelerated fall on people or property.
- Additional post-flight measures are discussed in Section 11, *infra* (Quality Control and Procedure).
- Percepto has a thorough periodic maintenance procedure which is covered in the maintenance manual, [5] and incorporates component manufacturer recommendations.
- **Weather is constantly monitored** remotely by the drone pilot through a weather station that is installed on the base station. In case of severe weather conditions, the drone cannot take off. Weather is re-evaluated every few seconds.
- **Detect and Avoid** software enhances operational safety by actively identifying and navigating around potential obstacles or conflicting air traffic.
- **Training** Is provided to a Site Owner/Operator. Prior to deploying the system at an owner/operator's site, a Site Owner/Operator receives training on how to use the AIM software to consume and visualize data. Separately, drone pilots receive training on applicable FAA requirements and Percepto's BVLOS waiver as the pilots take certified thermography course.[6]
- **Data recording** is conducted by the drone, the base station, the AIM software, and through a video of the mission, which gives Percepto full visibility of the system's functionality and the ability to investigate as appropriate.

6. EQUIPMENT AND SUPPLIES

The proposed method utilizes several pieces of equipment:[7]

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[5] See ATP & routine maintenance document in supporting documents.
[6] See Section 11.1 for more details.
[7] *See* System Description – Air Max OGI (Aug. 22, 2024) for a full description of the drone and its systems in supporting documents

- **Air Max OGI** is the main component of the alternative method for detecting emissions. The Air Max OGI drone is an drone-in-a-box equipped with an OGI camera, a day camera, and a landing camera. It also includes a parachute as a safety measure. The Air Max OGI is equipped with a flight controller, a telemetry communication system, and a GPU processor.
- **Gimbal and Sierra-Olympia Ventus OGI™** is a cutting edge OGI camera mounted onto a 2-axis gimbal on the drone. The Ventus OGI camera is a 640 x 512 resolution MWIR camera with a 25mm lens. The Ventus OGI is designed to detect and visualize hydrocarbon gases, and can recognize a number of gases, including methane, propane, and butane.[8] The Ventus OGI GEM colorizes gas leaks to enhance visibility of leaks at well pads, tank farms, gas processing facilities, pipelines, refineries, etc. quickly and accurately. The Ventus OGI camera is OOOOa, OOOOb, OOOOc, and Appendix K certified.[9]
- The **Percepto Base** is an industrial grade weatherproof shelter which protects the drone from weather and hazards. It has a take-off and landing zone for the drone. The base station is equipped with a charging dock to enable continuous operations and an air conditioning unit to preserve the durability of the drone. A Davis Vantage Pro2 weather station is installed on the base station, which provides real-time meteorological information (wind speed, temperature, precipitation, etc.).
- **Percepto AIM software** is a cloud-based solution that acts as a control system for the drone and manages and analyzes data collected. The software enables 24/7 monitoring, inspection planning, control, management of the drone from any location. Additionally, users can customize flight missions, watch real-time footage, and analyze data collected by the Air Max OGI. 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. REAGENTS AND STANDARDS

Percepto's proposed ATM does not use reagents.

[8] See Sierra Olympia Technologies Inc., "Ventus OGI EPA Appendix K Test Report".
[9] See Sierra-Olympia Technologies, Inc., Ventus OGI™, https://sierraolympia.com/product/ventus-ogi/.

8. SAMPLE COLLECTION, PRESERVATION AND STORAGE

The Air Max OGI does not collect samples; it only collects data. The system collects data from the following sources:

1. Drone
    a. Footage recording (RGB / OGI video and images)
    b. Drone parameters including position, velocity, altitude, yaw, gimbal parameters, battery health status
    c. Mission logs
2. Base station – Base status and operation logs
3. Local weather station co-located with the base station
4. Weather conditions from web API
5. Users interactions via web client interface
6. ADS-B

In general, all data generated and collected by the system is sent to a centralized server in AWS which is physically located in different availability zones in the United States. The server infrastructure uses different databases to store different data types. Drone-related data, including footage, parameters, and logs, is collected during missions or while the drone 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 a physical on-ground station and a web API, with both sets of data stored in a cloud database. User interactions with the system are also recorded in the database. Lastly, ADS-B flight data is pulled from a web API during drone missions and stored in the cloud database.[10]

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.

9. QUALITY ASSURANCE / QUALITY CONTROL

The following is a chronological list of QA/QC and maintenance procedures during the lifecycle of the Air Max OGI.

1. Component incoming inspection
2. Mechanical assembly inspection
3. GATP – Ground Acceptance Tests Procedures

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

4. FATP – Flight Acceptance Tests Procedures
5. DATP – Deployment Acceptance Tests Procedures at the owner/operator site
6. Pre-Flight checks and Routine Maintenance

9.1. COMPONENTS INCOMING INSPECTIONS[11]

As a first step in the quality control process, particularly for new or first-time parts, Percepto performs a comprehensive First Article Inspection (FAI)[12] on the entire order. This step ensures that new or first-time parts meet all specifications and standards before mass production. In addition to FAI, Percepto conducts thorough quality checks on printed circuit board (PCB) functionality and adheres to established shipping protocols to ensure that sensitive electronic components were adequately protected during transit, thereby minimizing the risk of damage that could affect the performance and reliability of a component once installed in the Air Max OGI drone or base.

Percepto systematically audits its suppliers and subcontractors, with a heightened frequency of audits for key partners such as those that supply a high volume of components. These audits are integral to ensuring compliance with integration standards and reduce the likelihood of incidents that could lead to equipment damage or delays in delivery.

Rejected parts are segregated and discarded upon identification of a defect or non-conformance, and non-conformance reports are issued to the supplier to document component issues. Percepto tracks the following quality issues:

- Visual defects (e.g., cracks or tears);
- Functional problems (e.g., assembly difficulties or electrical issues); and
- Any deviations from established assembly protocols.

When a quality issue is identified, quality engineers initiate investigations by generating quality tickets, which facilitates a structured process for addressing the issues. This includes segregating the suspected faulty parts and conducting inventory checks to rule out discrepancies. Once the root cause is determined, quality engineers collaborate with relevant Percepto teams—such as Percepto's Engineering, Research & Development, and Supply Chain departments—to decide on appropriate corrective actions such as repair, scrapping, redesigning, or a software patch.

9.2. MECHANICAL ASSEMBLY INSPECTIONS

Percepto uses a structured inspection process for mechanical subassemblies that ultimately comprise the drone and base. Once a gimbal (or any other external part) is assembled, Percepto

[11] See Incoming Inspection Report and Supplier Quality Audit Report in supporting documents.
[12] Ibid

conducts a thorough evaluation to ensure it meets all required specifications and quality standards.[13]

9.3. GATP & FATP AND DATP[14]

During the GATP phase, each part within each system (engine, communications, current, etc.) undergoes a pass/fail review to assure its functionality.

This stage is followed by the FATP stage, during which the drone's capabilities are stress-tested under extreme conditions (e.g., speed and manual maneuvers) by Percepto personnel. This stage also includes pass/fail criteria. After the stress tests, a functional flight test is conducted for all subsystems such as flight-critical systems, safety systems, and data collection systems, including the cameras.

Finally, the DATP phase includes a functionality test at the owner/operator's site to validate the site setup and the day-to-day operation of the system at the owner/operator's location. The DATP is conducted after installation at the site and before the system is handed over to the owner/operator for day-to-day use.

Ongoing Operations: The camera inspection system is a specialized setup designed to enable a certified drone pilot to conduct thorough inspections of the drone-in-a-box, specifically the drone, without being physically present on-site. This system utilizes multiple cameras installed both within the base station and on poles surrounding it. These cameras provide comprehensive visual coverage of the aerial vehicle's components, allowing operators to perform daily remote inspections of the drone and preflight checks as described below in section 9.4.

Remote Visual Inspection: Remote visual inspection takes place every 100 flights, every two weeks, or after maintenance activities, whichever comes first during daylight hours and involves a full cycle of over 40 predefined viewpoints covering the drone, base station, and surrounding operating environment.

The camera inspection system is equipped with video and image monitoring software, which allows the remote operator to adjust camera views, capture images of any anomalies, and document the condition of the drone. The primary purpose of the camera inspection system is to ensure that the drone remains airworthy by facilitating inspections with the same level of detail and scrutiny as an on-site physical inspection. This includes identifying structural issues or environmental factors that may impact the drone's operation and reporting these findings for maintenance and safety purposes.

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

9.4. PREFLIGHT CHECKS AND ROUTINE MAINTENANCE[15]

The drone undergoes the following pre-flight, in-flight, and post-flight checks and inspections:

1. Preflight Inspections and Safety Checks

The operational safety of the Air Max OGI drone and the base station are rigorously managed and maintained through automated preflight inspections. Prior to every flight, the system carries out automated checks to ensure that the aircraft is fit for operation. These checks include assessments of airworthiness, the drone's structural integrity, and weather conditions. If any issues arise, such as adverse weather conditions or technical faults, the flight will be canceled or postponed until the issues are resolved or adverse conditions abate. Additionally, automated drone health and safety protocols are in place for all stages of the flight, including preflight, in-flight, and landing phases.[16] All findings are documented, and the drone pilot must confirm the results before proceeding. In the event of any failed preflight checks, the mission is immediately aborted.

2. Routine Maintenance and System Inspections

The Air Max OGI undergoes regular routine inspections and maintenance performed by Percepto personnel. [17] These inspections ensure that the Air Max OGI remains fully operational, with maintenance logs kept for all performed activities. Maintenance tasks include visual inspections of the Air Max OGI structure, lights, and other critical components like propellers, motors, and landing pads. Percepto personnel also examine the weather stations and other equipment associated with the base station during these checks. Maintenance may also involve more extensive procedures, such as the planned periodic replacement of motors and charging to prevent wear-related issues. Parachute systems and other safety-critical parts are regularly inspected and replaced as needed to ensure emergency preparedness according to the maintenance manual.[18]

3. Automated Contingency Procedures and Emergency Protocols

The Air Max OGI has automated contingency procedures designed to handle any malfunctions that occur during operations. These protocols are guided by FAA requirements and are in place to automatically manage a range of emergencies, including degraded functionality or communication failures. If the Air Max OGI experiences a critical issue such as GPS or power failure, the system initiates emergency protocols to prevent accidents. These include pausing the mission, returning to a safe zone, or landing the drone autonomously. Should the drone lose contact with the remote pilot, failsafe layers are in place to ensure that it can return to base or hover until it reaches a critical battery level, at which point it will automatically attempt to land safely.

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

4. **Post-mission Safety Procedures**

Once the drone returns to the base station it undergoes a test flight to confirm operational readiness for future missions. In the event of any incidents or accidents during a mission, operations will cease until a full post-mission analysis is conducted to determine the cause, followed by corrective actions to mitigate any risk of recurrence.

5. **Communication and Emergency Contacts**

A comprehensive communication plan is in place to support all operational activities. This plan includes emergency contact information for personnel and a protocol for reporting any incidents or safety events. The communication plan is updated and maintained at each of the ground control stations located in Midland, Texas and West Palm Beach Florida, which ensures that all drone pilots have immediate access to the plan. This communication framework underpins the entire operation, ensuring coordinated responses and facilitating rapid communication between the drone pilot, the owner/operator site personnel, and technical support in the event of emergencies.

In addition, the Air Max OGI features automated responses that manage various safety scenarios, such as failed pre-flight checks or in-flight anomalies. If an issue occurs, the drone may pause and hold its position, return to the primary base station, move to a designated secondary safe zone, or land immediately in its current location.

9.5. QUALITY ASSURANCE

Percepto uses a two-week quality assurance cycle, which is divided between new feature testing and regression analysis. The first week focuses on validating new functionalities through two testing cycles, ensuring feature performance and integration. The second week shifts to comprehensive regression and stability testing, guaranteeing that existing functionalities remain unaffected and the system operates reliably under varied conditions. Post-release validation ensures smooth deployments by confirming successful updates, validating critical functionalities in the production environment, and actively monitoring for and addressing any deployment-related issues.

The overall scope of the comprehensive quality assurance process includes verifying all system aspects, including software and hardware features, simulated and real flight testing, thorough bug validation, and in-depth production issue analysis. This comprehensive approach aims to maintain high-quality standards, deliver reliable solutions, and facilitate continuous system performance and stability improvements.[19]

[19] See Quality Assurance Work Methodology in supporting documents.

10. OGI CALIBRATION AND STANDARDIZATION

Percepto calibrates the OGI camera prior to each mission to adjust the lens focus, ensuring optimal performance at an effective distance of 16 meters from the assets. An ATP is in place for the gimbal to verify that each drone meets quality standards before release to a Site Owner/Operator.[20] This includes an Image Quality ATP to confirm the accuracy of the focus calibration. The camera is considered calibrated if cooling is complete and the image appears normal before takeoff. Calibration and ATP are completed after drone and base assembly or following any repair work. 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 drone.

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

11. PROCEDURE

Percepto uses procedures to ensure compliance and operational efficiency. Detailed descriptions and specific protocols for these procedures are included in the Confidential Business Information (CBI) portion of Percepto's submission. Access to this information is restricted to authorized personnel to protect proprietary and sensitive business information.

11.1. TRAINING[21]

Percepto trains its drone operators with the knowledge and skills to safely and effectively plan and execute various drone missions utilizing the Air Max OGI systems while adhering to all applicable safety protocols and regulatory requirements. Trainees must hold a valid drone pilot certificate in accordance with FAA regulations. The duration of Percepto's drone 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:

- Fundamentals: Introduction to drone flying, pre-flight planning, manual flight maneuvers, and understanding of FAA regulations.
- System Operations: In-depth training on the Air Max OGI 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.

[20] See ATP & routine maintenance procedures in supporting documents.
[21] See UAS Remote Operator – Course Syllabus in supporting documents.

- Advanced Topics: This section covers remote operations, leveraging Percepto's Shielded Operations FAA waiver,[22] and provides insights into the oil and gas industry operations and infrastructure, component monitoring, and past incident analysis for enhanced safety awareness.
- Practical Training: Hands-on experience with drones for flight operations and practical application of AIM software for mission building and execution.

11.2. MISSION PLANNING

At the mission planning stage, Percepto personnel create a detailed site map, which includes the locations of compressors, tanks, hatches, pipelines, and additional POIs. Based on this map, an autonomous flight path is designed that outlines the drone's route during the inspection. POIs are designated along the flight path, each with specific parameters: distance from the POI, camera angle, camera mode (including GEM mode), and observation time (default 10 seconds). Temporary no-fly zones can be created within the flight path to accommodate dynamic site changes, such as the temporary presence of equipment.[23]

11.3. FLIGHT

A single certified Percepto pilot can manage multiple flights simultaneously. During a mission, the drone captures video of the entire flight and images at each POI. The operator, who is trained to identify potential emissions, monitors the live video feeds from each drone. When a potential methane leak is detected by the Air Max OGI, the operator analyzes the video and places a bookmark at the specific time point for quick reference. After a mission, the Site Owner/Operator also is notified via API or email about the location of the potential methane leak.

To ensure that potential emissions are thoroughly investigated, the drone operator can intervene at any point during the flight to ensure that critical information is not missed due to the drone continuing on its pre-programmed path. This might involve pausing the autonomous mission to reposition the drone to get a closer look at the potential leak, or taking full manual control to conduct a more detailed inspection. Having one operator oversee multiple autonomous flights, with the option of manual intervention as needed, greatly increases the efficiency and coverage of methane emission monitoring. Furthermore, the Air Max OGI can access and inspect hard-to-reach areas, providing comprehensive surveillance of a site. This approach not only reduces the need for manual inspections but also allows for more frequent and consistent monitoring, thereby minimizing the risk of missed leaks and contributing to a safer and more environmentally responsible operation.

[22] The waiver enables one-to-many drone operations, meaning one pilot can control multiple drones. It helps increase the efficiency and productivity in inspected sites and of drone operations.
[23] See Section 6.1 "Site Setup" in supporting document "System Description – Air Max OGI"

11.4. POST FLIGHT

Immediately after the drone completes its flight, the video and images are automatically uploaded to a secure cloud-based server and stored within the AIM system. This allows for a comprehensive post-flight analysis, providing an additional layer of inspection and reducing the need for repeated flights. A certified OGI inspector reviews the data within the AIM system, carefully examining the video footage and images for any signs of methane emissions. Only a certified OGI inspector may confirm whether a leak exists based on the data collected by the Air Max OGI. If a potential leak is confirmed, the OGI inspector can annotate the video with bookmarks at the specific time points where the emissions are visible. Additionally, the OGI inspector can mark the corresponding still images, highlighting the precise location of the leak and providing detailed information about the affected component, the severity of the emissions, and other relevant observations. This thorough post-flight analysis ensures that potential emissions are identified and documented accurately, even if they were not initially detected during the live flight monitoring.

11.5. REPORT DELIVERY

Following the post-flight analysis, upon request by the Site Owner/Operator, Percepto can generate and deliver a detailed report to the Site Owner/Operator. This report provides a comprehensive overview of the inspection, including an image of each asset inspected, the component, dwell time, distance from the component, coordinates, timestamp, link to the video, and if an anomaly was detected. The report also includes an image of the flight path with inspected assets and information regarding general weather conditions during the mission including temperature, wind speed, and direction.

12. DATA ANALYSIS & CALCULATIONS

The Air Max OGI method is used for detection of methane emissions, but not for quantification of the emission rate. Qualitative aspects of this method include the visual identification of methane plumes in video and still images, leveraging the expertise of certified OGI inspectors to distinguish actual leaks from other visual artifacts. Certified OGI inspectors analyze the characteristic plume shape and movement patterns of methane gas within the context of surrounding infrastructure and environmental factors to verify the existence of a methane leak. Percepto notifies a Site Owner/Operator of all detected leaks. Quantitative aspects involve determining the probability of detection for different known emission rates and distances.

13. METHOD PERFORMANCE

13.1. VALIDATION RESULTS

The Air Max OGI 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[24]

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 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 drone.

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 method, based on a combination of controlled release experiments and real-life data collection (discussed below).

13.3. REAL LIFE DATA COLLECTION[25]

Real life data collection consisted of deploying the Air Max OGI 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

[24] See Metec Testing For OGI Inspectors spreadsheet in supporting document
[25] See Real World Testing For OGI Inspectors spreadsheet in supporting document

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 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.

13.5. DETECTION ACCURACY AND LIMITS

The Air Max OGI 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.

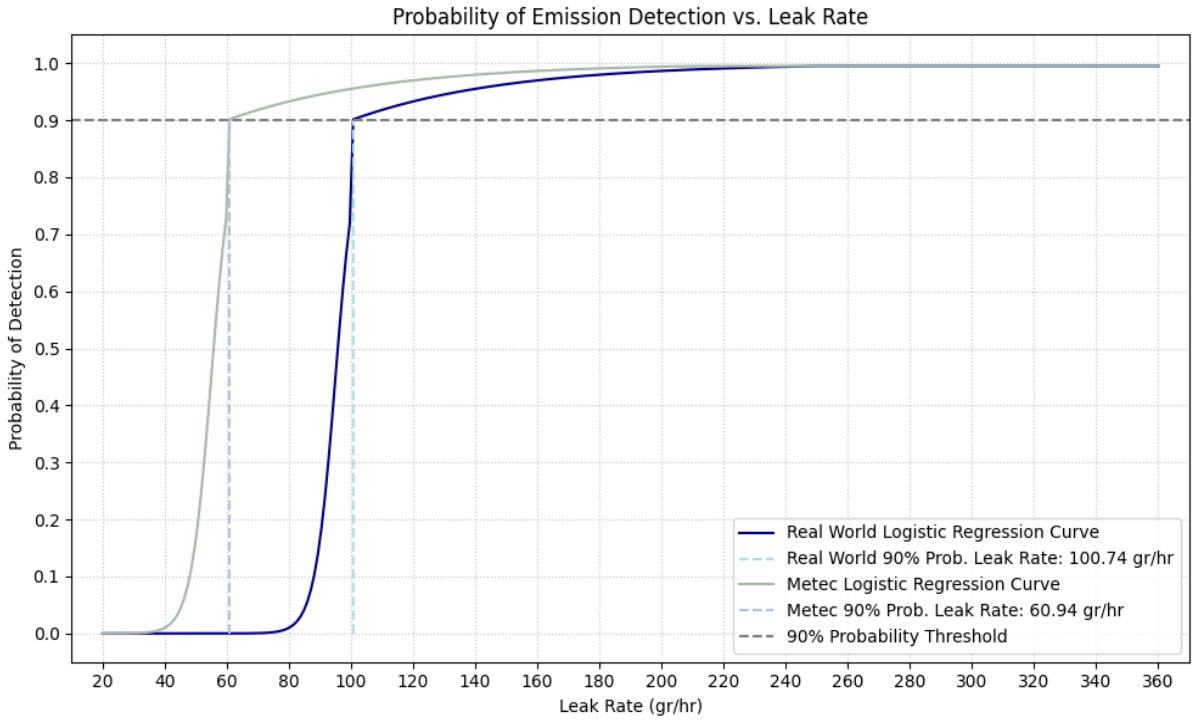

Figure 1

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.

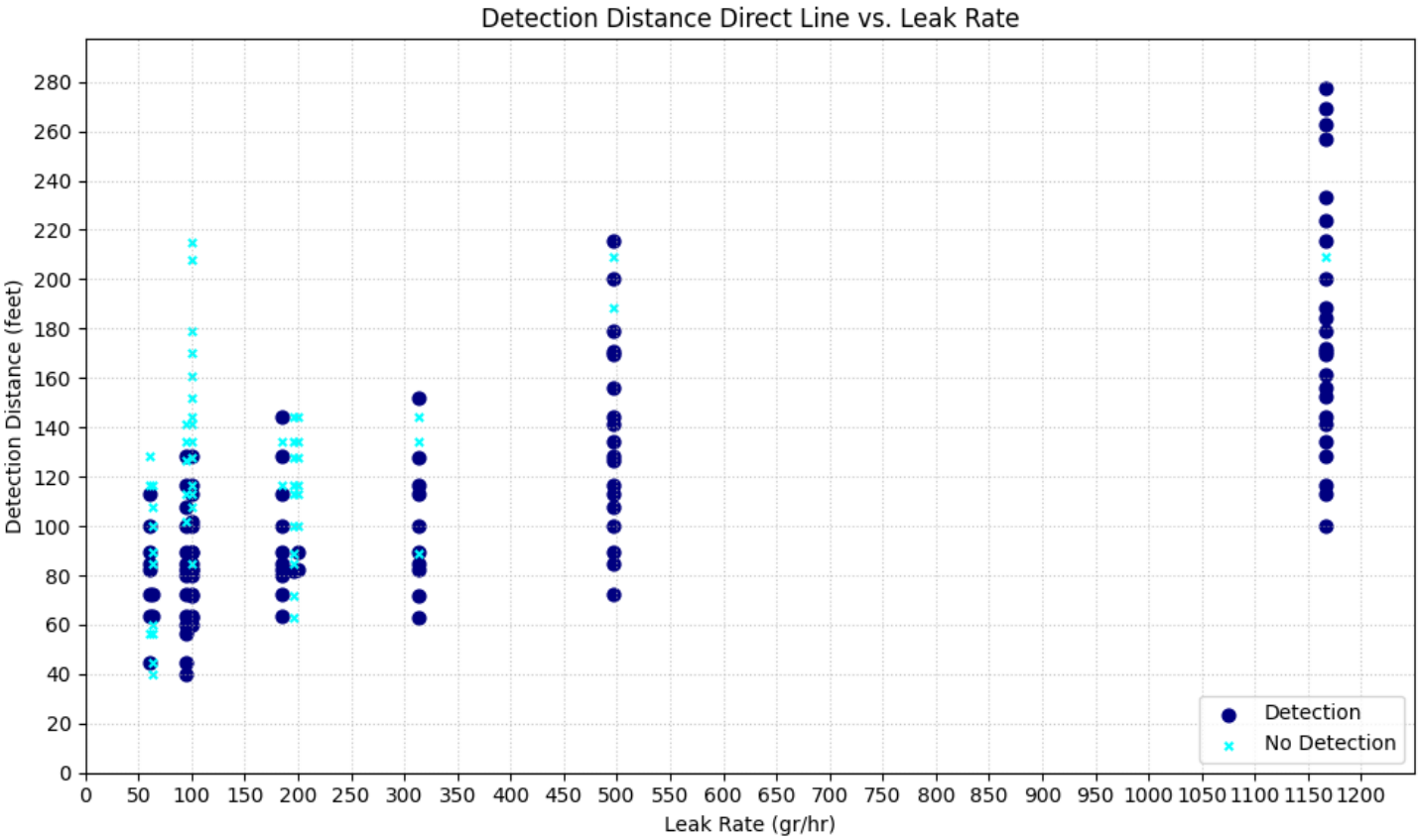

Figure 2

As shown in Figure 2 above, 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 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.

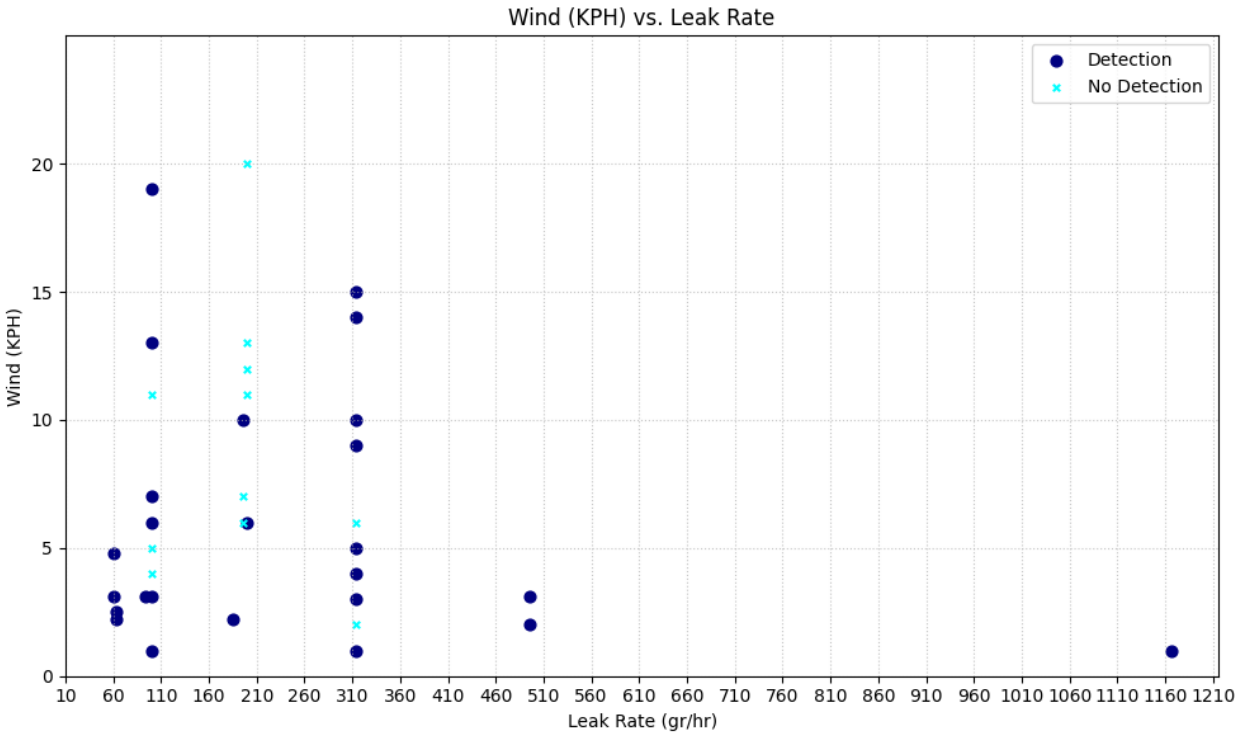

Figure 3

To summarize, with respect to distance, the drone 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 drone 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 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 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. POLLUTION PREVENTION

Using a drone such as the Air Max OGI 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 drone is battery powered and does not emit.

15. WASTE MANAGEMENT

[Reserved]

16. REFERENCES

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- 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. TABLES, DIAGRAMS, FLOWCHARTS AND VALIDATION DATA

17.1. DATA HANDLING AND STORAGE

Data sources, types, and storage locations are as follows:

Source	Type	When collected	Storage Place
Drone	Footage	During drone mission	Cloud storage
Drone	Drone parameters	As long as drone is on	Cloud DB
Drone	Logs	As long as drone is on	Cloud storage
Base station	Base status (open, close, charging etc.)	As long as the base is on	Cloud DB
Base station	logs	As long as the base is on	Cloud storage
On ground weather station	Wind, temperature, precipitation	As long as the base and weather station are on	Cloud DB

Weather condition from web API	Wind, temperature, precipitation	Constantly (every 30 minutes)	Cloud DB
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 drone is on a mission	Cloud DB

Connectivity between data sources