PERCEPTO

Percepto Autonomous OGI Drone & AI Software

Description of Technology

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CONTENTS

1. DESCRIPTION OF THE MEASUREMENT TECHNOLOGY

1.1. SCIENTIFIC THEORY

The Air Max OGI drone is equipped with a fully integrated optical gas imaging ("OGI") camera, specifically the Sierra Olympia Ventus OGI™ 640 x 512 resolution mid-wave infrared ("MWIR") camera. The Ventus OGI is an optical gas imaging camera designed to detect and visualize hydrocarbon gases. OGI cameras are based on the principle of thermal imaging. They detect and visualize gases by sensing the specific infrared wavelengths that gases absorb or emit, which is proportional to their temperature and concentration.

OGI cameras leverage the unique spectral signatures of different gas molecules in the infrared range, which are characteristic of each gas type. By isolating and capturing these distinct wavelengths, OGI cameras create a clear visual representation of gas presence and movement. This is achieved through the camera's ability to detect the subtle changes in infrared radiation emitted or absorbed by the gas molecules, allowing it to accurately identify and track the gas.

The cameras are sensitive to various environmental factors that can affect their ability to detect and visualize gas emissions. Wind speed and direction influence plume behavior, and strong winds may impact the OGI camera's effectiveness.[1]

The ambient temperature affects the thermal contrast between the gas and its surroundings, with higher temperatures increasing the camera's sensitivity to certain gases. The temperature difference (Delta T) between the gas and its background is for a factor detection, as a larger temperature differential enables improved visibility and easier identification of gas plumes by the OGI camera.

Known limitations of the technology are discussed in more detail below.

[1] Ravikumar A., et al., "Are Optical Gas Imaging Technologies Effective For Methane Leak Detection?", Environ. Sci. Technol. 2017, 51, 718−724.
Caico C., et. al., "An evaluation of an optical gas imaging system for the quantification of fugitive hydrocarbon emissions", Concawe Report, 2/17, 2017.

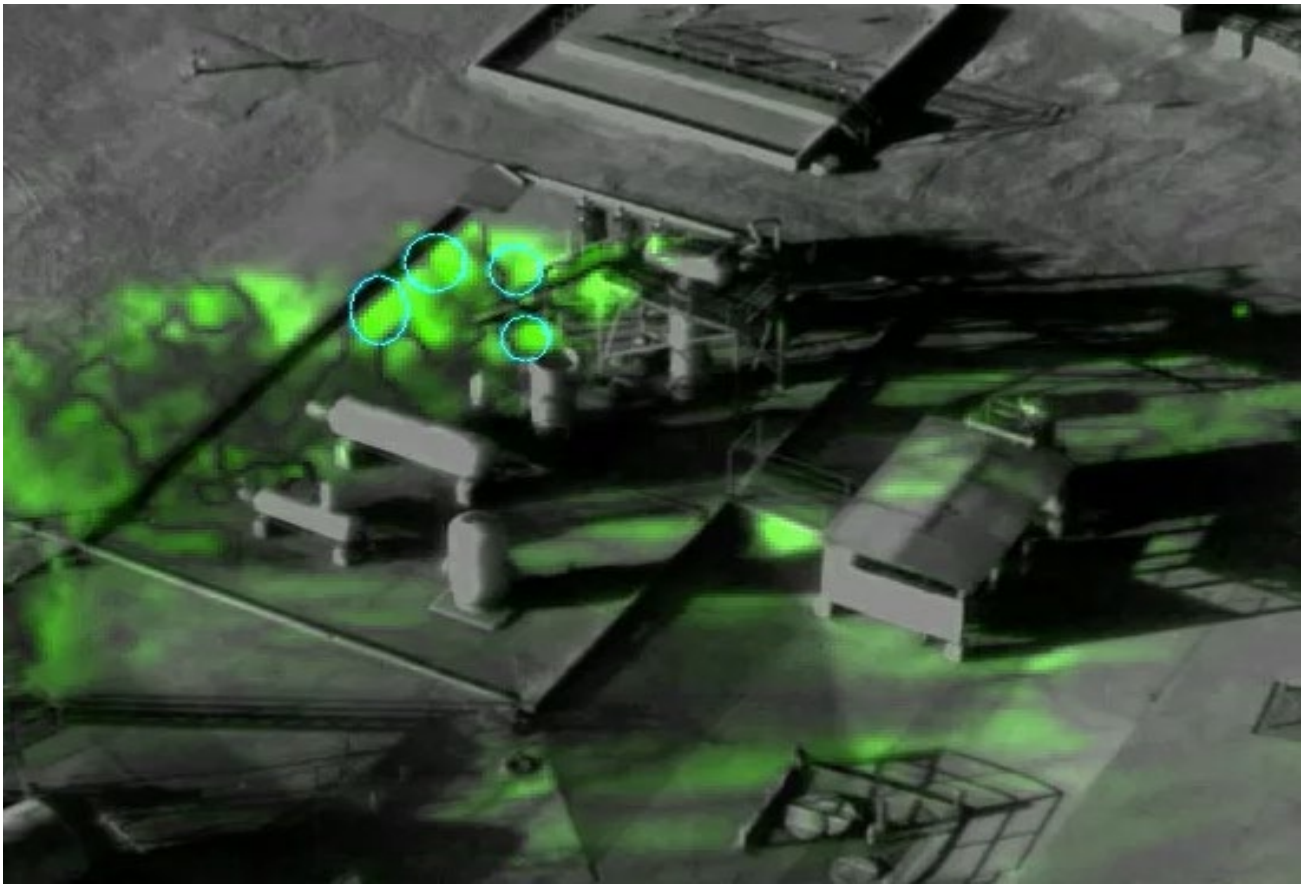

Figure 1: Image of methane leaks from tanks captured by the Air Max OGI

1.2. PHYSICAL INSTRUMENTATION

Percepto's remote OGI surveying solution is composed of three main components:

1.2.1. AIR MAX OGI DRONE

An autonomous drone 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 Drone is controlled by a flight controller and is equipped with a telemetry communication system and GPU processor for communications.

The drone is powered by Percepto Autonomous Inspection & Monitoring (AIM) software (described in more detail below) and carries out ad hoc or pre-assigned missions and autonomously returns to the Percepto Base recharge.

Figure 2: Air Max OGI drone

1.2.2. VENTUS OGI:

The Air Max OGI drone is equipped with a fully integrated OGI camera, namely the Sierra Olympia 640 x 512 resolution MWIR camera with a 25 mm lens. The Ventus OGI is an optical gas imaging camera designed to detect and visualize hydrocarbon gases, and can recognize a number of gases including methane, propane and butane. The Ventus OGI Gas Enhancement Mode (GEM) colorizes gas leaks to detect 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.[1]

Figure 3 - Sierra Olympia Ventus OGI Camera

[1] *See* Sierra-Olympia Technologies, Inc., Ventus OGI™, https://sierraolympia.com/product/ventus-ogi/.

DETECTOR

Detector Type	High operating temp MWIR
Array Format	640 x 512
Pixel Pitch	15 Micron
Spectral Response	MWIR
Frame Rate	30 Hz
NETD	<50 mK

ENVIRONMENTAL

Power Dissipation	6W Typical | 12W Peak
Operating Temperature	-35°C to +65°C
Certifications	25 mm: 0000aCertified (<=60 g/hr)

SYSTEM

Analog Video Output	NTSC/PAL
Digital Video Output	Uncorrected 14-bit CameraLink®
Digital Zoom/Pan	2x, 4x, 8x
Camera Control/Command Interfaces/System Control	Ethernet Serial (RS-422/RS-232)
Input Voltage	12VDC

LENS MODELS

F#	1.5
FOV or H/FOV	25 mm: 21.7° 50 mm: 11°
Size (L x W x H)	25 mm: 147 x 71 x 73 mm 50 mm: 138 x 71 x 77 mm
Weight	25 mm: 541g 50 mm: 570g
Focus	Thread focus

Figure 4: Ventus OGI payload specifications

1.2.3. PERCEPTO BASE:

The Percepto Base is an industrial-grade, weatherproof shelter and charging station with a take-off and landing zone for the Air Max OGI. The base includes a temperature control unit, and an on-site weather station which is located on the base to provide weather information such as wind conditions, precipitation, ambient temp and more.

The base has automatic rapid charging which enables the drone to operate autonomously with minimal human intervention.

Figure 5 – Percepto Base closed and open

1.2.4. PERCEPTO AIM SOFTWARE:

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, mission planning, control, and management of the Air Max OGI System by an operator from any location.

The software provides an interface for:

- Site setup - defines the physical parameters of the site, including 'free fly zones', 'no-fly zones', and 'flight routes' to ensure safe and optimal operation.
- Mission setup - defines and programs the sUA missions, choosing from various mission applications like Navigate, Track, Area Mapping, and Area Scan.
- Mission scheduling - schedule and manage completed, ongoing, and future missions for the sUA.
- Monitoring of the Air Max OGI system - AIM software allows for 24/7 monitoring and management of the Air Max OGI system, providing an interface for live activation, monitoring, and data analysis.

AIM communicates with the drone and the base station. The drone pilot programs and schedules flight routes and manages the drone's activity via the AIM software. AIM includes a web-based management system which allows the drone pilot to customize flight missions, watch real-time footage, and analyze data collected by the Air Max OGI.

Below is a flow chart depicting the steps from mission dispatch to data availability to customer:

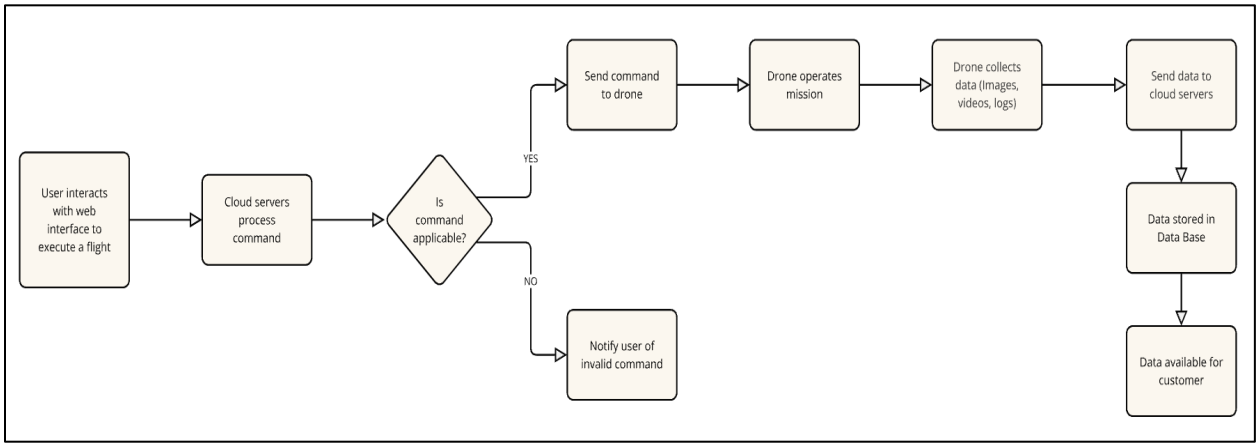

Figure 6: Percepto AIM communications flow chart

Specific inspection features include high resolution snapshots with the day camera and OGI camera; live video stream of the mission; live GEM mode video stream of the mission; and creation of 3D models.

Figure 7 - Live Mission Display in AIM

1. **Flight Planning**

Flight planning aligns customer methane detection needs with Air Max OGI capabilities. Our testing, conducted in various rigorous conditions and with verified results by a third party, defines the system's operational limits, allowing creation of tailored flight profiles. This ensures required detection rates within proven performance parameters, considering factors like wind and temperature.

Example - If an owner/operator desires a methane detection rate of 100 g/hr and the location has an average wind speed of 15 kph:

> Flight Plan - Each potential leak point will be surveyed from a vertical distance of 60 feet and a horizontal distance of 40 feet. At each point we would spend 10 seconds surveying the point. An OGI inspector watching the missions in real time has the ability to pause the flight to further investigate a potential leak at a specific source.

Example - Owner/operator desires a methane detection rate of 500 g/hr and the location has an average wind speed of 20 kph

> Flight Plan - Each potential leak point will be surveyed from a vertical and horizontal distance of 80 feet. This greater operational distance is possible because the Air Max OGI are targeting larger leaks. The Air Max OGI will survey each point for 10 seconds. An OGI inspector monitoring the mission in real time has the ability to pause the flight for further investigation of any potential leak.

Figure 8 below depicts the data collection process. First, the drone begins by navigating pre-programmed GPS coordinates, where it captures both visual and thermal snapshots of each

designated inspection zone. After a 10-second pause to stabilize, the system activates its Gas Enhancement Mode (GEM) on the Ventus OGI camera, a specialized sensor likely optimized for detecting hydrocarbons like methane. Data is collected during another 10-second interval, then GEM is deactivated, followed by a final visual image. This sequence ensures comprehensive data capture, combining visual, thermal, and specialized gas sensing. Figure 6 below shows the operational area of this system, an industrial site, with red arrows indicating the planned flight path. The view of tanks, provided by thermal and regular cameras, is a view from the drone. This multi-sensor approach, orchestrated by the AIM software, enables thorough and efficient inspections, pinpointing potential leaks by identifying infrared radiation changes specific to escaping gases.

Figure 8 – Data Collection Sequence

2. **Calibration**

Prior to each mission the operator conducts a camera calibration by adjusting the lens focus to ensure optimal performance at an effective distance from the assets.

An Acceptance Test Plan (ATP) is in place for the gimbal to verify that each unit meets quality standards before release. This includes an Image Quality (IQ) ATP, performed to confirm the accuracy of the focus calibration.

Calibration and ATP are completed after assembly of the drone and following any repair work to the drone. Detailed documentation of these activities is maintained by Percepto to track the history of each camera and gimbal, aiding in the prevention of potential future failures.

Gimbal and camera performance are continuously monitored through log analysis which is sent from the drone and the base to the cloud.

An automatic vibration scoring system is used to evaluate performance after each landing and detect any degradation.

During scheduled maintenance, the camera lens is thoroughly cleaned to remove dust and stains, ensuring image clarity and consistent equipment quality.

The drone operator ensures the OGI camera is properly calibrated by verifying that cooling is complete and the image appears normal before takeoff. The drone operator also verifies that the weather conditions fall within the Air Max OGI's operational envelope. Once these conditions are met, the operator can dispatch the mission.

1.3. TYPE OF MEASUREMENT AND APPLICATION

Air Max OGI application is aerial—a drone provides optical gas images (video and still) from its camera. The Air Max OGI can be utilized for methane leak detection at fugitive emissions components, covers, and closed vent systems at regulated oil and natural gas facilities, including well sites, centralized production facilities, or compressor stations.

The Air Max OGI drone-based inspection system has 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 and at distances of 40 to 100 feet and horizontal range of 20 to approx. 250 feet. This 90% detection probability was rigorously established using 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 data; only leaks confirmed by at least four OGI inspectors, based on visual evidence, were counted towards the 90% probability calculation.

While the system could detect smaller leaks of 60 g/hr (0.06 kg/hr), the probability of detection was reduced at this lower leak rate.

1.3.1. KNOWN LIMITATIONS OF THE TECHNOLOGY

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.[2]

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

External Factors	High temperature from emission flares can affect image quality.	The drone maneuvers to a distance and angle where interference is lower.

2. TECHNOLOGY CONVERSION TO MASS EMISSION RATE

Not applicable.

At this time, the Air Max OGI cannot quantify the emission rate of a leak that is detected during a mission.

3. DATA COLLECTION, HANDLING, AND STORAGE

3.1. DATA (INCLUDIN G METADATA) COLLECTION, MAINTENANCE, AND STORAGE

Gas leaks and OGI camera data is collected by the drone (which is equipped with an OGI camera). Data from different sources and types may be added to the system by the following end points:

1. Drone
2. Percepto Base - base status and operation
3. Local, on ground weather station
4. Weather conditions from web API
5. Users via web client interface
6. ADSB

All data 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.

Data security:

Percepto follows rigid procedures and guidelines for data security. We have ISO 27001 and Soc2 Type 2 certificates.

Below is a visualization of data interactions between the user, the drone, and the base through the cloud:

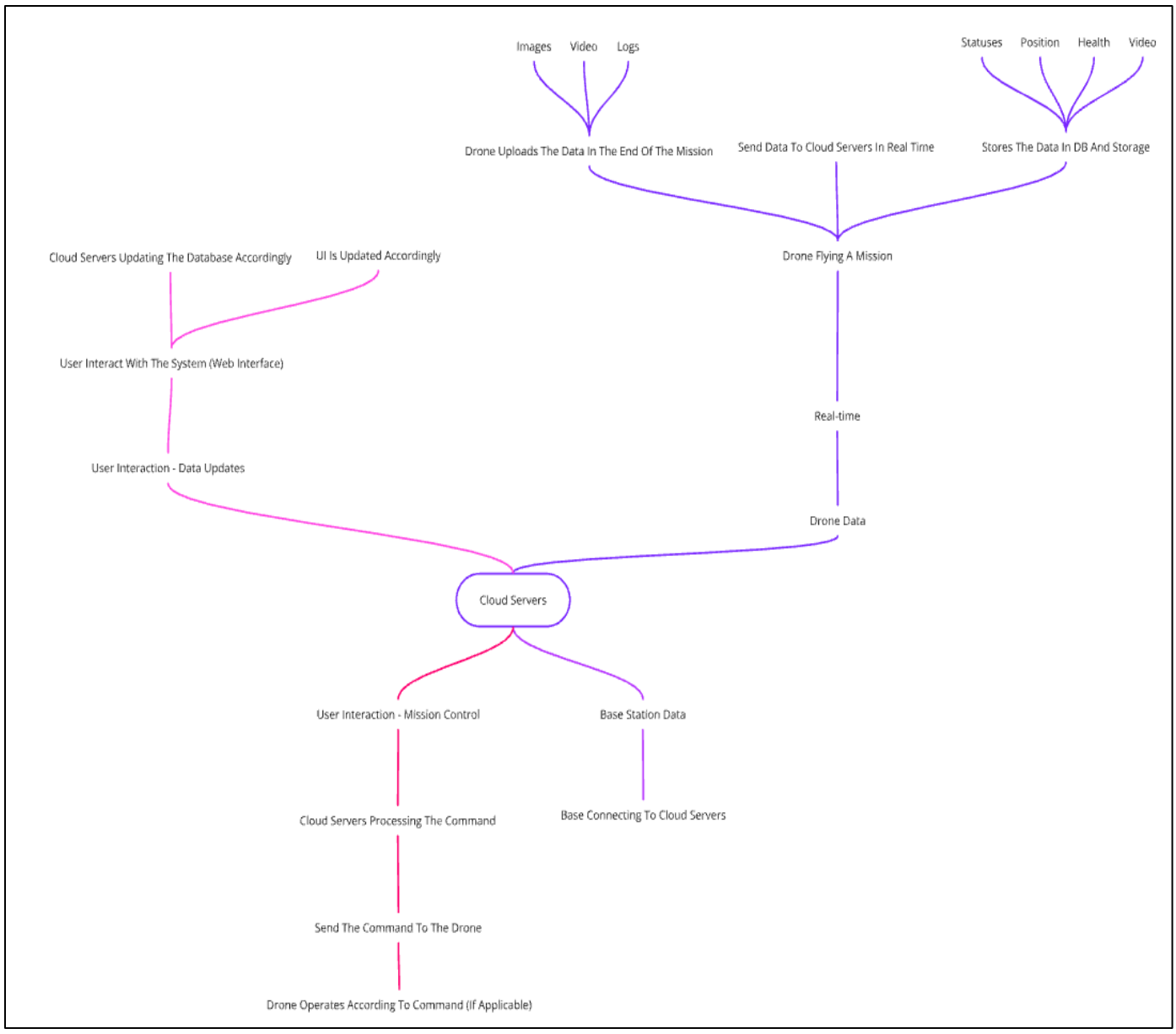

Figure 9: Cloud data interactions

3.2. DESCRIPTION OF PROCESSING OF RAW DATA STREAMS

See detailed description in section 3.1.

3.3. DESCRIPTION OF DATA STREAMS PROVIDED TO THE END USER

The following data streams are provided to and available for the end-user in the AIM system within minutes of the inspection:

- Videos
- RGB and GEM images
- API requests including bookmarks and issues marked, mission number and if the data was shared.

In addition, the customer may request a report of the inspection findings after a mission. This report contains data and information on weather conditions (wind speed, direction and ambient temperatures), the location of the anomalies on the image, the coordinates of the component, a link to the video where the emission was detected, dwell time, and distance from the component. The report is then sent by e-mail to the customer. In case of a leak, the pilot notifies the customer shortly after the mission is completed.

These data streams are kept “hot” for one year, meaning the user can access them easily and quickly and after that they are stored “cold” indefinitely, unless the customer requests otherwise. Percepto guarantees to keep the data available for at least a year.

4. SUMMARY

The Percepto Air Max OGI is a system developed for autonomous gas leak detection using Optical Gas Imaging (OGI) technology. The system’s goal is to provide accurate identification and visualization of methane gas emissions by detecting infrared radiation specific to different gas molecules. The system’s effectiveness is optimized by monitoring environmental factors, such as wind, which influence gas plume behavior and visibility. Through rigorous testing, the system has demonstrated a detection threshold of 0.1 kg/hr for methane leaks at distances aligned with operational standards, underscoring its sensitivity and accuracy in various conditions.

The remote OGI system is composed of three main components: the Air Max OGI drone, the Percepto Base, and Percepto AIM software. The Air Max OGI drone is fully integrated with a Ventus OGI camera capable of detecting gases like methane and propane with precision. The weatherproof base station provides an automated charging station with on-site weather monitoring, enabling the drone to operate autonomously and maintain high operational readiness. Percepto AIM software facilitates 24/7 mission planning, control, and monitoring of the system, allowing for remote customization and real-time data analysis, ensuring effective and timely response capabilities.