# MOC: Current State Analysis (As-Is)

**Summary:** This note serves as a Map of Content (MOC) for all documents detailing the current state of VanGuard Pipeline's technology, operations, and user workflows.

**Body:**
This collection of notes aims to capture a comprehensive picture of VanGuard's existing systems before we introduce the new computer vision capabilities. Understanding the "As-Is" state is critical for successful integration.

## Key System Components

- **Patent Synopsis:** 2024-08-19-Patent-Analysis-WO2024129496A1
- **Hardware:** 2024-08-19-Current-State-Hardware
- **Software:** 2024-08-19-Current-State-Software
- **UI/UX:** 2024-08-19-Current-State-UI-UX
- **User Stories (PRD):** 2024-08-19-Current-State-User-Stories-PRD

# Current State: Hardware

**Summary:** This document details the physical hardware components for VanGuard's operations. It distinguishes between the existing OGI system, the proposed hardware for the production CV system, and the minimal hardware for the initial "Sign-of-Life" MVP.

**Body:**

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## 1. Existing OGI System Hardware

This is the system currently in operation for methane detection.

- **Sensor Pod:** Falcon-XL Gas Imaging Pod. The patent reveals a dual-shell, **vibration-isolated** design.
- **Primary Sensor:** Optical Gas Imaging (OGI) sensor for methane detection.
- **Video Camera:** A video camera is mounted coaxially with the laser, used for aiming the pod.
- **On-board Computer:** A **Raspberry Pi** runs a local server for processing and communication.
- **GPS Unit:** Provides real-time location data for geotagging.
- **Operator Interface:** Apple iPad running a custom monitoring application, connected via Ethernet.

- **Controls:** A joystick controls a motor to physically aim the internal scope assembly.

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## 2. Proposed CV System Hardware (Phase 2 / Operational MVP)

This is the target hardware for a future, operational version of the threat detection system.

- **Primary Camera:** Sony ILX-LR1 (61MP Full-Frame Sensor). This choice dictates the high resolution and quality of the video feed the production model will process.
- **Primary Lens:** Sony FE 24-70mm f/2.8 GM II Lens. The variable focal length provides operational flexibility, which the software may need to account for.
- **Compute Unit:** TBD, with the **NVIDIA Jetson family** as the leading candidate. The selection of the specific model (e.g., Orin Nano vs. AGX Orin) will be based on the performance benchmarks from the Phase 1 MVP.

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## 3. "Sign-of-Life" MVP Hardware (Phase 1)

This is the minimal hardware required to execute the initial proof-of-concept.

- **Camera:** Standard USB Webcam to simulate the video feed.
- **Computer:** A consultant-provided laptop with a discrete NVIDIA GPU.
- **Power:** The laptop's internal battery.
- **Key Principle:** The MVP is a **completely standalone system**, requiring zero integration with the aircraft's hardware, power, or data systems. This de-risks the initial development and allows for rapid validation of the core software.

# Current State: Software

**Summary:** This document details the software systems, data formats, and data flows of VanGuard's current operational technology.

**Body:**

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## 1. Core Software Components

- **On-board Firmware:** Custom firmware running on the sensor pod's hardware manages the motors, sensors, and raw data processing.
- **On-board Server:** A server application runs on the **Raspberry Pi**, communicating with the firmware. Its primary job is to process sensor data and serve it to the iPad app.

- **Operator Interface:** A custom **Apple iPad application** serves as the primary display and control interface for the operator in the cockpit.

# 2. Data Formats & Communication

- **Communication Protocol:** The iPad and Raspberry Pi communicate over a direct **Ethernet connection** using a proprietary protocol.
- **Geospatial Data Format:** The system uses **KMZ files** (a zipped version of KML) to store and load pipeline route and flight path data. This is a standard Google Earth format.
- **Data Export:** The system can export survey results as **CSV files** or **KMZ files** for post-flight analysis in tools like Google Earth.

# 3. Key Feature: "Autotrack" System

The "autotrack" feature is a critical software component that automates the aiming of the sensor pod.

## 3.1. Data Flow & Processing

The software follows a simple, linear data flow:

1. **KMZ Data:** A pre-loaded KMZ file containing the pipeline's route is stored locally on the system.
2. **GPS Input:** The system receives a constant stream of GPS coordinates for the aircraft's current location.
3. **Control Loop:** The on-board server/firmware runs a continuous control loop that compares the aircraft's current GPS location to the pipeline's path in the KMZ file.
4. **Motor Control:** The software sends commands to the pod's motors to adjust the camera's aim, keeping it pointed at the pipeline corridor on the ground.
5. **Video Stream:** The video feed is sent to the iPad for the operator to monitor.

## 3.2. Operator Interaction

- **Supervisory Role:** The operator's primary role is to supervise the autotrack system and monitor the OGI sensor feed for methane alerts.
- **Manual Override:** The operator can take manual control of the camera at any time using a joystick to investigate a specific area more closely. This is the expected workflow when a methane leak or a visual anomaly is detected.

# Current State: UI/UX (User Interface / User Experience)

**Summary:** This document describes how operators (pilots, sensor operators) interact with the current system during a typical mission, based on website descriptions.

**Body:**

The user experience is centered around an iPad application designed for simplicity and real-time decision-making.

# Operator App Interface

The iPad app serves as the command center and simultaneously displays three key pieces of information:

1. **Live Video Feed:** A clear view of the pipeline right-of-way from the pod's downward-facing camera.
2. **Live Methane Readings:** Real-time Parts Per Million (PPM) data.
3. **Live GPS Map:** Accurate tracking and recording of the aircraft's position and the detection area.

# Operator Workflow

1. **Pre-Flight:**
    - Likely involves loading mission data, including the **pipeline coordinate file (KMZ) that enables the autotrack feature.**
2. **In-Flight (Normal Operations):**
    - The operator **engages the "autotrack" mode**. The system automatically keeps the camera aimed at the pipeline corridor.
    - The operator's primary task shifts from continuous manual aiming to **supervising the system**. They monitor the video feed and data readouts.
    - The joystick is likely used for making minor corrections or temporarily taking manual control to inspect something off the direct pipeline path.
3. **In-Flight (Leak Detection Event):**
    - When an alert occurs, the operator likely disengages autotrack and uses the joystick for precise manual aiming to investigate the source.
4. **Post-Flight:**
    - The operator uses the iPad's sharing features to export the mission data as a KML/KMZ file.
    - This file is then opened in Google Earth on another device to visualize the results.

# Key Learnings for CV Project

- **Reduced Operator Focus (During Normal Ops):** The autotrack feature is a game-changer. It means the operator is not in a constant, high-focus aiming loop. Their cognitive load is lower during routine surveillance.
- **Challenge vs. Opportunity:** This is a major opportunity. Because the operator is in a supervisory role, they will be more receptive to our threat alerts. An alert is less likely to be an unwelcome distraction and more likely to be a valuable piece of new information that directs their attention.

- **Alerts Should Trigger Action:** A key part of our UX design should be how an operator interacts with an alert. A threat detection could trigger a state change, prompting the operator to take manual control to get a closer look, confirming or dismissing the threat.

# Current State: User Stories (PRD)

**Summary:** This document reverse-engineers a simple Product Requirements Document (PRD) from VanGuard's existing system by defining its functionality in the form of user stories. This is based on information from their public website.

**Body:**

This exercise helps clarify the core jobs-to-be-done that the current system accomplishes, providing a baseline for our new functionality.

## Epic: Automated Pipeline Leak Detection

- **As an** operator, **I want to** load a pipeline map before my flight, **so that** the system knows the intended patrol route.
- **As a** system, **I want to** use the aircraft's GPS and the pipeline map to automatically aim the sensor pod at the corridor, **so that** the operator is freed from constant manual control.
- **As an** operator, **I want to** supervise the live video feed and data readouts while the system is in autotrack mode, **so that** I can maintain situational awareness.
- **As an** operator, **I want to** be able to seamlessly take manual joystick control at any time, **so that** I can override automation to investigate specific points of interest.
- **As a** pilot/operator, **I want to** monitor a live video feed, methane data, and a GPS map on a single iPad screen, **so that** I have complete situational awareness during my patrol.
- **As a** pilot/operator, **I want to** use a joystick to precisely aim the methane sensor while looking at the video feed, **so that** I can ensure accurate scanning of the pipeline right-of-way.
- **As a** sensor system, **I want to** correlate all methane readings with GPS coordinates in real-time, **so that** every piece of data is actionable.
- **As an** operator, **I want to** receive an immediate and clear alert on my screen when a methane leak is detected, **so that** I can be instantly aware of a potential issue.
- **As an** operator, **I want to** easily export the entire mission's data log as a KMZ file directly from my iPad, **so that** I can perform a simple and streamlined post-flight analysis in Google Earth.

## Key Learnings for CV Project

- **Core Value Proposition:** The system's value is in providing **highly automated, real-time intelligence** with a simple workflow. The goal is to maximize the operator's effectiveness by reducing manual workload.
- **Framing Our Addition:** Our CV system is a new layer of automated intelligence that runs in parallel to the methane detection.

  - **New User Story Example:** "As an operator supervising an automated patrol, I want to be alerted to physical threats on the ground automatically, so that my attention is drawn to potential issues I might otherwise miss."
- **Simplicity is Key:** The success of their current system appears to be its simplicity ("no complex post-flight analysis"). Our system must not betray this principle. Threat alerts should be clear, and the data export should be just as simple as the existing one.

# Patent Analysis: WO2024129496A1

**Summary:** This document provides a synopsis of the key technologies and claims described in VanGuard's international patent filing for their "AERIAL METHANE GAS LEAK DETECTION POD."

**Body:**

This patent reveals the core mechanical and optical design of the Falcon-series sensor pods. It details a sophisticated system designed for actively scanning for methane from a fixed-wing aircraft.

## Key Technical Components & Concepts

1. **Dual-Shell Design:**
   - The pod consists of an **external shell** that mounts to the aircraft and an internal **scope assembly** that houses the sensitive optics.
   - Crucially, the scope assembly is **vibration isolated** from the external shell using multiple mounts, protecting the sensors from aircraft engine and aerodynamic vibrations.
2. **Motorized, Rotatable Scope:**
   - The entire internal scope assembly (containing the laser, camera, and detector) is **rotated by a motor**.
   - This rotation is controlled **based on the video feed from an internal video camera**. This confirms the operator's joystick likely controls the motor, not just a digital gimbal.
3. **Optical System:**
   - **Infrared Laser:** The primary sensor. It directs a beam through a central aperture in a mirror.
   - **Video Camera:** Mounted to view downward through the same central aperture in the mirror. This means the video feed is perfectly coaxial with the laser's target.
   - **Mirror System & Photon Detector:** A complex series of mirrors (flat, primary, secondary) collects the backscattered laser light from the ground and directs it to a photon detector, which measures the methane concentration.

## Implications for Our Project (Key Learnings)

- **The Video Feed is Central:** The patent confirms the video camera is not just for passive viewing; it's an integral part of the system's aiming and control loop. Accessing this feed is absolutely critical.

- **Physical Integration is Complex:** The vibration isolation and motorized scope mean we are not just dealing with a simple camera. Any new hardware must not interfere with the delicate balance and mechanics of this system.
- **Coaxial View:** The fact that the camera and laser share an optical path is a major advantage. What the camera sees is precisely where the laser is pointing. This simplifies the correlation of our future CV detections with their existing methane data.

# Connections

- This analysis directly informs:
  - 03_Technical_Deep_Dive/2024-08-19-Current-State-Hardware
  - 03_Technical_Deep_Dive/2024-08-19-Current-State-Software
  - 03_Technical_Deep_Dive/2024-08-19-Current-State-UI-UX