CASE STUDY

Aerial *Thermal* Infrastructure Intelligence

Deploying AI-driven edge computing and multi-spectral drone systems to detect deteriorating structural materials — supplementing and replacing methods that are costly, dangerous, and disruptive.

PROJECT OVERVIEW

CLIENT

State Government Agency (Undisclosed)

CLOUD PLATFORM

Microsoft Azure

PRIMARY DOMAIN

Infrastructure Inspection & Predictive Analysis

CORE CAPABILITY

Multi-Spectral Drone Sensing + Diffusion Model Analysis

01

THE CHALLENGE

Identifying Hidden Deterioration in Critical Infrastructure

Structural deterioration beneath surface layers is one of the most difficult and hazardous problems in infrastructure management. Traditional inspection methods — invasive core sampling, manual ground-level surveys, scaffolding-based visual assessment — are expensive, slow, and expose personnel to significant safety risk.

The client needed a repeatable, scalable, and safe mechanism to identify subsurface material degradation across a portfolio of structures, allowing maintenance teams to prioritize intervention before deterioration reached a critical threshold.

> ***The status quo required inspectors in dangerous positions, with high costs, low frequency, and limited spatial coverage. A data-driven alternative was long overdue.***

PRIMARY CONCERN

Hidden Material Decay

Subsurface & concealed layers

PRIOR METHODS

Manual & Invasive

High cost, safety risk, low frequency

CLIENT TYPE

State Government

Azure enterprise infrastructure in place

02

SOLUTIONS ENGINEERING

Assessing the Environment Before Choosing the Architecture

Soledad's Solutions Engineers began with a thorough assessment of the client's hardware landscape, operational workflows, data turnaround requirements, and tolerance for inference latency. This environment-first approach is foundational to our methodology: the right architecture depends entirely on the operational reality, not a pre-selected technology stack.

A key decision emerged from this assessment: given that immediate on-drone inference was not required — flights were planned, and results reviewed post-mission — deploying AI software into the edge infrastructure rather than aboard the drone itself was the appropriate and more capable choice. This allowed for more computationally intensive models without the weight, power, and thermal constraints of onboard hardware.

→ 01

Business Environment Review

Evaluated existing state agency infrastructure, Azure tenancy, compliance requirements, and procurement constraints to align architecture with organizational realities.

→ 02

Hardware & Sensor Assessment

Reviewed drone fleet capabilities, payload limits, multi-spectral sensor specifications, NIR lens configurations, and battery/range profiles for planned flight missions.

→ 03

Data Turnaround Requirement Mapping

Determined that post-flight batch processing was sufficient, enabling compute-intensive diffusion model inference at the edge layer rather than requiring onboard real-time processing.

→ 04

Architecture Decision

Selected Azure-hosted edge infrastructure as the AI execution layer, with drone systems serving as data collection instruments rather than compute nodes.

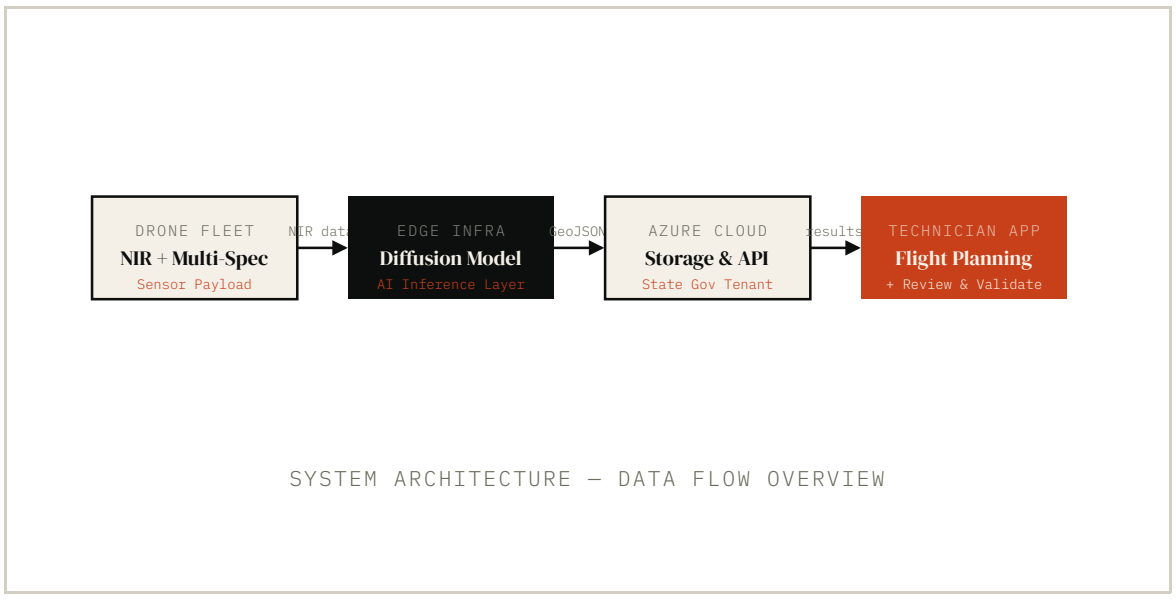
03

SENSING & AI TECHNOLOGY

Multi-Spectral Thermal Sensing with Diffusion-Based Analysis

Drones equipped with multi-spectral sensors and near-infrared (NIR) lenses conducted multiple coordinated flights over each structure of concern. By capturing thermal imagery across the full arc of the day, the system accumulated rich temperature gradient data — exploiting the physical principle that subsurface moisture, voids, and deteriorating materials produce measurable and identifiable surface thermal signatures as solar heating and cooling cycles progress.

A diffusion model — a class of generative AI architecture well-suited to structured spatial data — was trained to analyze these temperature datasets. The model learns to distinguish thermal patterns indicative of healthy material from those suggesting hidden degradation, generating output in the form of GeoJSON mask overlays that spatially map areas of interest directly onto the structure's geographic footprint.



SYSTEM ARCHITECTURE — DATA FLOW OVERVIEW

Multi-Spectral Sensing | Near-Infrared (NIR) | Thermal Gradient Analysis | Diffusion Models | GeoJSON Masking | Edge AI Inference | Microsoft Azure | Embedded Software

04

FULL-STACK DELIVERY

Flight Planning, Analysis Review, and Validation in One Application

Soledad's full-stack engineering team built a purpose-built web application to serve the client's field technicians and analysts. The application provides end-to-end access to the inspection workflow: technicians can plan and schedule drone flight missions, review AI-generated analysis results layered onto geospatial maps, and cross-reference those results against data from traditional inspection methods for ongoing validation and model improvement.

Soledad's systems architects deployed the complete solution into the client's existing Microsoft Azure environment — selected because the client was a state government entity with an established Azure enterprise tenancy, compliance frameworks, and identity management already in place. This approach minimized integration complexity and ensured that the solution met government data residency and security requirements from day one.

∴ FLIGHT PLANNING

Mission Management

Technicians plan multi-pass drone flights over target structures, configuring altitudes, overlap patterns, and sensor parameters for optimal thermal coverage.

∴ AI REVIEW

Geospatial Analysis Output

Diffusion model outputs render as interactive GeoJSON overlays, highlighting areas of thermal anomaly and predicted material deterioration with spatial precision.

∴ VALIDATION

Cross-Method Comparison

Analysts compare AI-derived findings against traditional inspection results within the same interface, enabling continuous validation and trust-building over time.

∴ INFRASTRUCTURE

Azure-Native Deployment

Deployed into the client's existing Azure government tenant, meeting compliance and data residency requirements without additional infrastructure procurement.

05

OUTCOMES & SIGNIFICANCE

A Safer, Smarter Alternative — Now and Into the Future

This engagement demonstrates a compelling alternative to conventional infrastructure inspection: one that reduces personnel exposure to hazardous conditions, dramatically expands the frequency and geographic coverage of inspections, and provides analytically richer data than visual methods alone can offer.

Many of the tools deployed in this engagement remain cutting-edge, and are only now beginning to appear across drone use cases in commercial delivery, agricultural monitoring, and reconnaissance. Soledad was among the early practitioners of this approach for infrastructure intelligence — and the underlying methodology is transferable across a wide range of environments.

> ***Highways, stadiums, bridges, skyscrapers — any structure with a surface and a thermal cycle is a candidate for this approach. We deploy into any cloud, for any environment.***

✓ **Reduced Inspection Costs**

Drone-based multi-spectral surveys at scale replace costly scaffolding, rope access, and invasive sampling at a fraction of the per-inspection cost.

✓ **Eliminated Unnecessary Risk**

Inspectors are removed from dangerous positions at height or in confined spaces, eliminating a significant source of occupational hazard.

✓ **Predictive, Not Reactive**

Thermal diffusion modeling enables early identification of developing deterioration — allowing maintenance teams to act before failure rather than after.

✓ **Transferable to Any Structure**

The core methodology applies across infrastructure categories — highways, public buildings, sports venues, elevated transit, and high-rise facades.

Work with *Soledad* Data Solutions

We deploy in any cloud and solve problems across any environment. Whether your infrastructure challenge is in the sky, on a highway, inside a stadium, or scaling a skyscraper, our teams bring the same rigorous environment-first approach to every engagement.

GET IN TOUCH

Client identity has been withheld at the client's request. All project details presented in this case study have been reviewed and approved for public disclosure. Results are specific to this engagement's scope, environment, and implementation. Individual outcomes may vary based on infrastructure type, sensor configuration, flight parameters, and data conditions.