TECHNICAL WHITE PAPER / SITE & PERIMETER SURVEILLANCE

# Autonomous surveillance vehicle

## More ground. More context.

A configurable ground platform for larger private sites. Bring route planning, mobile sensing and remote supervision together for perimeter rounds and repeatable area checks.




Product visualization. Illustrative application; not a verified deployment photograph.

## Executive summary

Larger sites create a coverage problem: the same team must inspect gates, walkways and remote corners while maintaining a consistent record. A mobile ground platform can carry sensors along agreed routes and provide a second viewpoint. This reference design concerns controlled private-site operation; public-road autonomy is outside its scope.

**Design status**

These technical white papers describe proposed system architectures for Xcugas surveillance applications. Hardware, software integrations and operating limits are selected and validated for each project. Diagrams and interactive missions are illustrative; they are not live telemetry or evidence of tested product performance.

01 / TECHNICAL REFERENCE

# Purpose and operating context

## Consistent coverage

Plan rounds around site zones and expose checkpoints that could not be visited.

## Mobile evidence

Connect an observation to a location, route and timestamp instead of sending an isolated image.

## Configurable payloads

Choose the sensor mast, body, onboard processing and connectivity around the terrain and task.

## Application environments

| Environment | Potential use |
| --- | --- |
| **Campus perimeters** | Repeat controlled patrols along designated private lanes and boundaries. |
| **Industrial yards** | Observe selected access points and storage areas without assuming every surface is traversable. |
| **Large facilities** | Provide a mobile viewpoint for operators investigating a site event. |

**The observation-to-action boundary**

The platform collects observations and presents evidence. A candidate event is not an established incident. An assigned operator reviews the context, records the outcome and follows the site response process.

02 / TECHNICAL REFERENCE

# The mission, step by step

The following sequence describes a normal mission. Each transition should have an explicit acknowledgement or readiness condition; completion cannot be inferred from a command being sent.

| Step | What happens |
| --- | --- |
| **01. Define the route** | An operator selects a permitted private-site route, inspection zones and the response policy. Boundaries and no-go areas belong to the mission configuration. |
| **02. Check the vehicle** | Check sensing, position confidence, drive health, energy and the local stop path. Starting requires the selected route and ground conditions to be within the validated envelope. |
| **03. Follow the patrol lane** | Fuse available localization inputs, plan a feasible path and follow it with terrain-aware operating limits. Avoid assuming that a path on the map is physically traversable. |
| **04. Inspect the zone** | Collect observations at the checkpoint. A persistent object in a configured review zone can become a candidate event; it is not automatically classified as a threat. |
| **05. Notify the operator** | Send location, capture time and selected evidence. The operator assesses the context, acknowledges the event and decides whether to dispatch a response. |
| **06. Close the round** | Return to the assigned base when feasible. Reconcile completed zones, interruptions and event delivery so the next shift sees an accurate mission record. |

**An obstruction changes the route**

The proposed vehicle stops before the obstruction. A new route is permitted only inside the validated operating area; this example pauses for assistance because no alternate lane has been approved.

**Remote link unavailable**

The example applies a local controlled-stop policy and stores the observation for later delivery. A remote supervisor cannot be assumed to see live video or issue timely commands during the outage.

03 / TECHNICAL REFERENCE

# Architecture and technology

Proposed allocation of responsibilities. Final components, software versions and interfaces are selected during project engineering.

01 / PROPOSED LAYER

### Sense the site

Range, camera and motion sensors

02 / PROPOSED LAYER

### Locate & route

Onboard fusion / route planning

03 / PROPOSED LAYER

### Control the base

Drive control + independent stop path

04 / PROPOSED LAYER

### Supervise remotely

Telemetry gateway + operator panel

## Localization across a changing site

A project may combine wheel feedback, inertial sensing, LiDAR localization and GNSS where available. Buildings and foliage can affect satellite reception; slip changes wheel-based estimates. The system should evaluate confidence rather than treating every coordinate as ground truth.

## Plan for the real chassis

The navigation model must reflect width, turning radius, stopping behavior and payload overhang. Candidate Nav2 components can separate path generation and tracking, but controller selection and validation depend on the drive geometry and site conditions.

## From an object to a reviewable event

A camera can provide a candidate object observation. Escalation should incorporate persistence, zone rules and operator review. A bag-like shape does not establish intent, ownership or danger; the event should describe what was observed.

**Local control boundary**

The local platform must have an assessed response when connectivity or mission logic fails. A web dashboard or language model does not replace the local control and stop / recovery systems.

04 / TECHNICAL REFERENCE

# Hardware and configuration

Configure each subsystem against the actual site and payload. The following describes candidate roles, not a fixed bill of materials or a claim that all options are supplied together.

| Subsystem | Candidate configuration | What to verify |
| --- | --- | --- |
| **Ground chassis** | Drive system, wheels and payload mounts | Turning radius, surface compatibility, braking and center of gravity. |
| **Localization** | Encoders, IMU; GNSS / LiDAR by scope | Source quality, calibration, frame alignment and behavior during degraded positioning. |
| **Observation payload** | RGB camera; optional thermal / other sensors | Viewing angle, vibration, illumination and task-specific evidence quality. |
| **Onboard compute** | Mission computer and drive interface | Power demand, thermal design, diagnostics and control deadlines. |
| **Energy system** | Battery management and service / charging arrangement | Mission load, reserve, return distance and recovery procedure. |
| **Site communications** | Wi-Fi / cellular options subject to coverage | Dead zones, uplink demand, authentication and command timeout behavior. |

**Specifications to establish**

Document dimensions, mass, payload, operating speed, usable energy, runtime, environmental limits, connectivity and service intervals for the selected configuration. No numerical performance, ingress rating, certification or endurance claim is made in this paper.

## Configuration baseline

Retain the hardware revision, sensor calibration, software versions, map or route revision and acceptance-test record together. Repeat relevant tests after changing the payload, drive system, sensors, controller parameters or mission logic.

05 / TECHNICAL REFERENCE

# Interfaces and evidence lifecycle

| Interface | Information exchanged | Integration requirement |
| --- | --- | --- |
| **Vehicle > localization** | Wheel feedback, inertial data and selected position inputs | Define coordinate frames and quantify uncertainty and data age. |
| **Mission > drive control** | Route segments and bounded movement requests | Constrain to approved lanes and require local authority checks. |
| **Payload > event service** | Observation metadata and evidence references | Separate candidate detections from reviewed incidents. |
| **Operations > vehicle** | Mission requests, pause / resume and diagnostics | Expose command acknowledgement and reject stale or unauthorized requests. |

**Capture** – **Queue** – **Receive** – **Acknowledge** – **Resolve**

Capture time, receipt time and operator acknowledgement are different facts. Preserve event identifiers across retries, retain original timestamps and make stale data visible.

## Illustrative event contract

```
{
  "event_id": "vehicle-example-001",
  "mission_id": "patrol-example",
  "platform": "vehicle",
  "captured_at": "2026-11-01T10:00:00Z",
  "location": {
    "frame": "site_map",
    "checkpoint": "review-zone"
  },
  "type": "observation_for_review",
  "evidence_ref": "access-controlled-reference",
  "delivery_state": "queued",
  "review_state": "unreviewed"
}
```

Example fields only. This is not a published API or a live event. Select authentication, transport, retention and access rules for the deployment.

06 / TECHNICAL REFERENCE

# Operating limits and failure responses

## Private-site operating envelope

Public-road use, unrestricted mixed traffic and all-terrain operation are not established by this design.

## Weather and ground variation

Ingress rating, temperature range, slope, traction and rain tolerance need configuration-specific evidence.

## Localization quality

GNSS availability is not continuous everywhere. Define recovery for degraded or conflicting position sources.

## Unspecified capacity

Range, speed, gradeability, runtime, payload and communication distance are not asserted here.

| Condition | Proposed response | Acceptance evidence |
| --- | --- | --- |
| **Lane becomes obstructed** | Stop and evaluate only approved alternate paths; otherwise request assistance. | Maintain clearance without entering an unvalidated surface or route. |
| **Position sources disagree** | Reduce operation or stop under the agreed confidence policy. | Log uncertainty and prevent unbounded continuation on an unreliable pose. |
| **Remote communication fails** | Apply the local controlled-stop policy and retain events for later transfer. | The dashboard indicates stale telemetry and prevents misleading live-state claims. |
| **Energy reserve is reached** | Abort the patrol and use the approved return or recovery procedure. | Return energy includes surface, payload and route effects; no range guarantee is inferred. |

07 / TECHNICAL REFERENCE

# Deployment and acceptance testing

Set thresholds and test conditions before the pilot. Retain incomplete missions, false alerts and interventions in the record instead of reporting only successful runs.

| Phase | Required outcome |
| --- | --- |
| **1. Scope** | Define the site, task, operating area, users and intervention responsibilities. |
| **2. Integrate** | Select hardware and software, calibrate sensors and document the interfaces and exception policies. |
| **3. Pilot** | Exercise normal missions and failure cases under controlled conditions. Retain logs and operator observations. |
| **4. Accept** | Review measured results, train operators and agree maintenance and revalidation procedures. |

| Measure | How to evaluate | Test conditions |
| --- | --- | --- |
| **Coverage per mission** | Completed zones / scheduled zones | Record missed zones and their causes. |
| **Ground mobility** | Successful runs across the agreed surface matrix | Separate dry, wet, sloped and obstacle cases where in scope. |
| **Position confidence** | Measured route error and recovery events | Test poor reception and wheel-slip scenarios. |
| **Event quality** | Reviewed true events, false alerts and missed test events | Use representative site footage and a documented labelling protocol. |
| **Network resilience** | Outage detection, stop behavior and eventual event delivery | Test dead zones and reconnection with duplicate-event handling. |

## Before the scoping discussion

Provide a private-site map, surface and slope information, traffic rules, permitted lanes, payload expectations, network coverage and a recovery plan. Identify the operator responsible for interventions and incident review.

08 / TECHNICAL REFERENCE

# Governance, sources and next steps

## Access and retention

Define device identity, operator roles, authenticated connections, evidence access and a retention schedule. Limit capture to the agreed task; use restricted zones and masking where required by the site.

## Human decision ownership

Assign who reviews candidate observations, acknowledges incidents, authorizes privileged commands and recovers interrupted missions. Detection output should not be treated as a conclusion about identity, intent or wrongdoing.

## Optional language interface

An LLM connector may propose a structured task. The mission service must validate it against permitted actions and site constraints; it must not bypass control limits or replace operator review.

## Technical sources

**1. Nav2: navigation servers**
Explains the separation of planning, control and recovery in a ROS-based navigation system.
https://docs.nav2.org/jazzy/getting_started/navigation_concepts/navigation_servers/

**2. ROS 2: quality of service**
Describes message delivery policies and publisher/subscriber compatibility.
https://github.com/ros2/ros2_documentation/blob/jazzy/source/Concepts/Intermediate/About-Quality-of-Service-Settings.rst

Sources reviewed 1 November 2026. External documentation explains candidate components, not Xcugas implementation status. Pin supported versions and verify integrations during the project.

## Terms used in this paper

| Term | Meaning |
|---|---|
| **Pose** | Position and orientation in a defined coordinate frame. |
| **Telemetry** | Reported platform state, health and mission information. |
| **Acceptance test** | A measured check against criteria agreed before deployment. |
| **SLAM** | Simultaneous localization and mapping; estimating motion while constructing a map. |

## Discuss your configuration: hello@xcugas.com

Online technical showcase and interactive mission