TECHNICAL WHITE PAPER / AERIAL INSPECTION & SURVEILLANCE

# Autonomous drone-in-a-box

## A wider view. A complete mission.

An aerial observation concept that brings the aircraft, mission software and ground dock into one workflow. Plan a site inspection, capture useful evidence and return for a verified landing and recharge.




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

## Executive summary

Aerial inspection can connect observations across large or hard-to-reach assets. A drone-in-a-box concept adds a ground dock and repeatable mission workflow to the aircraft. The difficult part is the complete operating cycle: readiness, permitted flight, useful sensing, return, landing confirmation and energy recovery. Each transition needs observable state and a defined failure response.

**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

## Repeatable inspection routes

Plan an observation mission around asset rows or selected checkpoints and retain a record of completed coverage.

## Useful aerial evidence

Associate images with mission time and position. Select an RGB, thermal or other payload only when its task and integration are defined.

## A closed operational loop

Treat the dock, return procedure, landing confirmation and charging checks as part of the system design.

## Application environments

| Environment | Potential use |
| --- | --- |
| **Solar installations** | Observe panel rows and send candidate anomalies for specialist review. |
| **Large private facilities** | Gather elevated views of agreed assets and boundaries within a permitted operating area. |
| **Infrastructure inspection** | Repeat asset-focused missions with a payload and flight profile selected for the inspection task. |

**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. Plan the inspection** | An operator defines the permitted flight area, route, payload task, return location and response policy. A scheduled time alone is not permission to launch. |
| **02. Check launch readiness** | Check aircraft and dock status, position quality, available energy and the environmental operating limits. Launch remains inhibited when any required condition is not met. |
| **03. Fly the approved route** | The flight controller manages flight while mission logic coordinates the inspection task. Maintain the configured flight boundary and return-energy policy. |
| **04. Capture the asset** | Capture evidence at the selected asset location. An RGB anomaly or thermal pattern is a review cue; interpretation depends on the payload and capture conditions. |
| **05. Report for review** | Send a candidate observation with time, location and evidence. An operator evaluates the event and follows the site's response process; the demo does not diagnose a fault. |
| **06. Return, land, verify** | Execute the validated return procedure, confirm the landing and verify charging before marking the system ready again. A return command alone is not proof of docking. |

**The inspection ends early**

The mission is interrupted when the configured energy reserve is reached. The example returns toward the dock; remaining inspection points are marked incomplete. Actual return or landing behavior depends on the tested flight configuration.

**Ground link lost**

A preconfigured flight-controller response handles the link loss. This example returns toward the home position while evidence remains queued. Return, landing or hold policies must be selected and tested for the site; cloud commands cannot be assumed available.

03 / TECHNICAL REFERENCE

# Architecture and technology

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

01 / PROPOSED LAYER

### Observe

RGB / thermal payload by scope

02 / PROPOSED LAYER

### Coordinate the mission

Companion computer / mission service

03 / PROPOSED LAYER

### Fly & respond locally

Flight controller + onboard sensing

04 / PROPOSED LAYER

### Recover & prepare

Ground dock + operator platform

## Two computing responsibilities

In a candidate PX4-based architecture, the flight controller and companion computer have distinct jobs. The flight controller handles flight; the companion supports mission and observation logic. Higher-level software should not bypass configured aircraft limits.

## Mission exchange is not mission success

A protocol such as MAVLink can exchange mission plans with an aircraft. Uploaded, accepted, active, interrupted and completed are different states. The operator needs confirmation of execution and recorded coverage, not only an upload result.

## Docking is a sequence of checks

Returning near a dock, landing on it and establishing charge are separate outcomes. Define how alignment, contact, charging and enclosure status are verified. A failed landing or charging check should keep the system out of the ready state.

**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 |
|---|---|---|
| **Aircraft** | Airframe, motors, propulsion and flight controller | Payload mass, balance, vibration, controllability and energy consumption. |
| **Navigation sensing** | Selected position, inertial and height sensors | Position quality and behavior when individual inputs degrade. |
| **Inspection payload** | RGB, thermal or other scoped sensor | Resolution at the working distance, calibration, capture conditions and mounting. |
| **Companion compute** | Optional mission / perception processor | Interface compatibility, processing load, heat and power consumption. |
| **Dock** | Landing interface, charging and enclosure systems | Alignment, contacts, environmental protection, interlocks and status feedback. |
| **Communications** | Telemetry and evidence links | Coverage, bandwidth, authorization and tested link-loss 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 |
| --- | --- | --- |
| **Operator > mission system** | Route, inspection task and permitted area | Validate the mission before upload and record configuration revision. |
| **Mission system > flight controller** | Mission exchange / telemetry through a selected interface | Track acceptance, execution state and interruption; supported commands are project-specific. |
| **Payload > evidence service** | Images and capture metadata | Preserve timestamps, sensor settings and location quality. |
| **Dock > operations** | Landing, enclosure, charge and fault states | Require positive confirmation before advertising readiness for the next launch. |

**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": "drone-example-001",
  "mission_id": "patrol-example",
  "platform": "drone",
  "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

## Operating permission

Flight permissions and local operating constraints must be established for the installation. This document does not establish regulatory authorization.

## Environmental envelope

Wind, precipitation, visibility, temperature and electromagnetic conditions need explicit limits and a no-launch policy.

## Inspection interpretation

A thermal or visual pattern alone does not prove a fire or equipment fault. Sensor calibration and specialist review may be required.

## Unspecified capacity

Flight endurance, range, payload, wind rating, inspection accuracy and autonomous-docking success are not claimed here.

| Condition | Proposed response | Acceptance evidence |
|---|---|---|
| **Readiness check fails** | Inhibit launch and expose the failed condition to the operator. | A schedule cannot override aircraft, dock or environmental readiness. |
| **Energy reaches reserve** | Interrupt inspection and execute the validated return or landing policy. | Incomplete coverage is recorded; reserve is verified for the actual payload and conditions. |
| **Ground link is lost** | Apply the configured onboard flight response and buffer available evidence. | The selected response is tested; the ground view is marked stale. |
| **Landing or charge is unconfirmed** | Keep the system unavailable for a new launch and request intervention. | Return-to-home, landing and charging are measured as separate outcomes. |

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 |
|---|---|---|
| **Launch readiness** | Correctly inhibited / permitted test launches | Exercise failed sensors, unavailable dock and out-of-envelope conditions. |
| **Inspection coverage** | Usable captured checkpoints / planned checkpoints | Report image quality and interrupted missions. |
| **Evidence quality** | Reviewable observations against a labelled reference set | Account for height, angle, lighting and selected payload. |
| **Recovery behavior** | Observed response to link, energy and position faults | Test the chosen policy in controlled conditions before site use. |
| **Docking cycle** | Return, landing and verified charge success rates separately | Log each transition; do not count arrival near the dock as success. |

## Before the scoping discussion

Provide asset layouts, proposed inspection tasks, operating permissions, site constraints, payload needs, communications coverage, environmental limits and a dock location. Nominate the flight-operations owner and the team that reviews evidence.

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. PX4: system architecture**
Describes flight-controller and companion-computer responsibilities.
https://docs.px4.io/main/en/concept/px4_systems_architecture

**2. PX4: failsafe configuration**
Describes configurable responses to battery, position and connection faults.
https://docs.px4.io/main/en/config/safety

**3. MAVLink: mission protocol**
Describes exchanging mission, geofence and safe-point plans with an aircraft.
https://mavlink.io/en/services/mission.html

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. |
| **Companion computer** | A processor supporting mission or perception tasks alongside the flight controller. |

## Discuss your configuration: hello@xcugas.com

Online technical showcase and interactive mission