

TED UNIVERSITY

Department of Computer Engineering

CMPE 491 Senior Design Project I

Project Analysis Report

KOVAN

Surveillance system with swarm drones that rearranges itself according to mission priority

Sürü Drone ile Görev Önceliğine Göre Kendini Yeniden Düzenleyen Gözetleme Sistemi

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1 Introduction

KOVAN studies how a group of simulated unmanned aerial vehicles (UAVs) shares monitoring work when region priorities or vehicle availability change [1, 2]. An operator should be able to see which regions have coverage, what prompted a change, and which work the remaining vehicles cannot take on.

Following the course analysis guidelines [3], this report defines the behavior that the team and evaluators can check in a scenario. At the time of analysis, the team has not built a working prototype. Scenario values, diagrams and screen layouts illustrate the proposed behavior. Performance figures will come from later runs.

2 Current system

The project starts with a new simulator application. Its reference case is a fixed-assignment patrol. For example, two vehicles may start in Region A and one in Region B. If B becomes more important, the original assignments continue. If the vehicle in B returns to base, the reference case leaves its work uncovered.

A fair comparison will use the same regions, starting vehicles, battery events, priority changes and run duration in both scenarios. The fixed-assignment run will still allow a low-battery vehicle to return. The difference under evaluation is whether work can move between vehicles when circumstances change.

3 Proposed system

3.1 Overview

A mission starts with a home base, predefined regions and a fleet. A scenario supplies the initial priorities and any day/time rules. During the run, the operator can request a priority change in English. The system checks the command, updates the affected region if valid, and reviews assignments using the vehicles still available.

The first demonstration targets three to five simulated vehicles. The 2D view, the 3D simulation and the event history describe the same mission. A region with no active assignment must remain visible so an evaluator can distinguish an uncovered area from a display problem.

Scope. The simulation uses fictional regions and synthetic vehicle states. The analysis covers patrol assignments, simulated energy, operator commands and estimated coverage. Physical flights, camera processing and identification of people fall outside the project scope [2].

3.2 Functional requirements

The identifiers retain their meaning from the Specifications Report [2]. The last column points to the verification scenarios in Section 3.5.1.

ID	Required behavior and observation	Scenario
FR-01	Load the configured fleet, home base and named regions. At startup the operator can identify each vehicle and region.	S1
FR-02	Store a configurable importance value for each region. Show the effective value used for the current assignment.	S1, S2
FR-03	Apply both scheduled day/time changes and valid operator requests to the specified region.	S2, S3
FR-04	Assign available vehicles according to current region priorities. Show the resulting vehicle-to-region assignments.	S1, S2
FR-05	A vehicle assigned to a region follows a repeatable patrol within its boundary. Its progress is observable over simulated time.	S1, S7
FR-06	After a priority change, review the allocation. Change assignments when redistribution is warranted and show the outcome.	S2, S3
FR-07	Maintain and display a simulated battery level for every vehicle, including one returning to base.	S4
FR-08	When a vehicle reaches the configured low-battery threshold, mark it as returning and exclude it from ordinary patrol assignments.	S4, S6
FR-09	Reconsider unfinished coverage when a vehicle leaves patrol. Assign feasible work to other active vehicles and expose any gap.	S4, S6
FR-10	Interpret the supported subset of English priority commands. Identify the region and requested change or report why the input is unusable.	S2, S5
FR-11	Show vehicle positions, assigned regions, patrol status, battery levels and effective region priorities in the mission interface.	S1, S8
FR-12	When both views are active, their assignments and vehicle states must agree for the same mission update.	S8
FR-13	Record mission events and evidence of priority changes, returns, reassignment and estimated coverage so a run can be reviewed.	S2, S4, S7, S8

3.3 Nonfunctional requirements

Each quality requirement from [2] has a concrete check. Timing and fleet-size limits beyond the initial demonstration remain to be measured.

ID	Quality requirement	Proposed check
NFR-01	Run at least three concurrent simulated UAVs.	Start three in one scenario and inspect their independent state histories. Record hardware and actual fleet size.
NFR-02	Keep mission allocation independent of visualization and flight simulation.	Exercise the same mission events with the graphical views closed. Inspect the resulting assignments.
NFR-03	Provide repeatable setup instructions and a sample configuration.	A teammate follows the instructions and checks the sample run against its expected events.
NFR-04	Expose assignment changes and command outcomes.	Use the display and event history to identify the input, affected region or vehicle, and resulting state.
NFR-05	Record the elapsed time from an event to the resulting redistribution.	For an event that changes assignments, compare its receipt time with the published update on the same clock.
NFR-06	Use synthetic mission data.	Inspect the scenario inputs and recorded output for fictional regions and simulated states only.
NFR-07	Record the software versions used in a run.	Check the setup record for ROS 2, Gazebo and PX4 if enabled, then reproduce the scenario with that configuration.

3.4 Pseudo requirements

The specifications identify Python for coordination, ROS 2 for communication and Gazebo for the 3D simulation [2]. These choices constrain implementation. The analysis uses a common mission state so that the 2D display and the 3D simulation can be checked together.

PX4 Software-in-the-Loop (SITL) is a candidate for simulated flight control. Its inclusion depends on the integration prototype. The team expects to use available workstations and free or open-source tools where practical. The allocation algorithm, route method, command parser, battery model and package versions remain open.

3.5 System models

3.5.1 Scenarios

These are proposed tests. The example uses one base, regions A and B, and vehicles D1, D2 and D3. For tests that start in patrol, load a fixture with D1 and D2 in A and D3 in B. Region names and the initial split are test inputs.

ID and case	Event or input	Expected observation
S1 Start and patrol	Start a three-vehicle mission with valid regions and inspect one complete patrol cycle.	Each vehicle has a unique ID. The operator can inspect assignments and priorities and follow a patrol as it repeats within its region.
S2 Operator change	Start with B below the highest configured priority. Enter “Increase the priority of Region B.”	B’s priority rises and an allocation review is recorded. In a fixture that requires redistribution, the new assignment appears in both views.
S3 Scheduled change	Advance simulated time from just before a configured day/time boundary to just after it.	The designated region changes at the boundary. Later ticks in the same interval do not repeatedly trigger the same transition.
S4 Battery threshold	With D3 patrolling B, move its battery from above the threshold to exactly the threshold, then below it.	D3 enters return status once. Its patrol ends, the system reviews B’s unfinished work and D3 reaches the base if the modeled return completes.
S5 Invalid command	Enter “Increase the priority of Region Z” when Z does not exist. Also try a command with no region.	Each input yields a visible explanation. The command changes neither the priorities nor the existing assignments.
S6 No eligible vehicle	Bring all vehicles to their return threshold while work remains. Then request a priority change.	The priority can update. The system assigns no returning vehicle to patrol and shows unfinished work as unassigned.
S7 Coverage count	Revisit an already observed map cell during an illustrative cell-based run.	A repeated observation adds no new distinct cell. Save the region, observation window and counts used to estimate coverage.
S8 View consistency	After a return or priority change, compare both views at a common mission update.	The vehicle ID, assignment and mode agree. The history links the triggering event to the same run and outcome.

Worked example for S2

One possible test configuration gives the higher-priority region two vehicles and the other region one. Starting with D1 and D2 in A and D3 in B, raise B above A. Under this test policy, the expected split is one in A and two in B. Either D1 or D2 may move. The test checks the split without prescribing a tie-break or adopting this policy for the final system.

3.5.2 Use case model

The operator starts and supervises a mission. The evaluator inspects its behavior and reviews recorded evidence. A team member can act in either role. Scheduled changes and low-battery events originate inside the simulation.

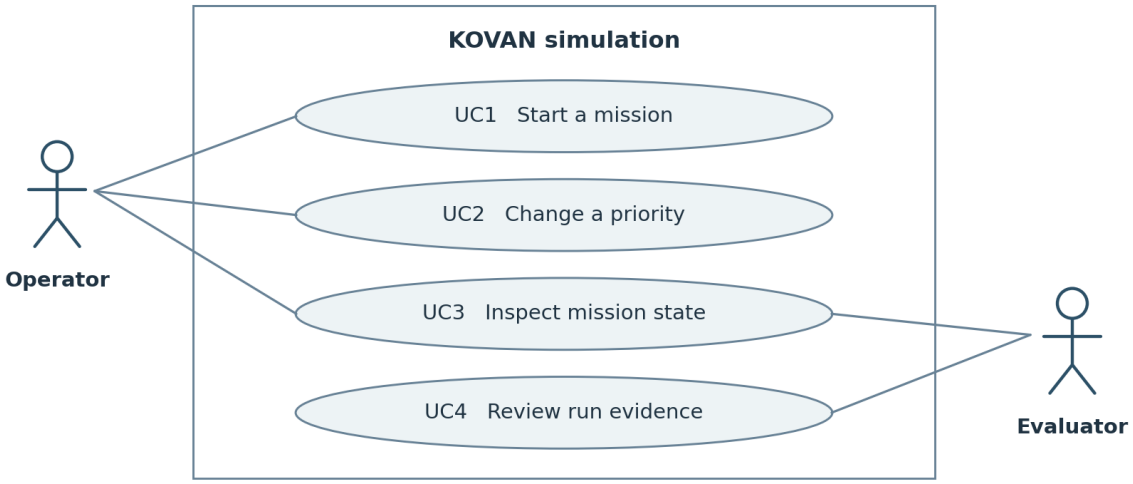

Figure 1. Lines connect each external role to the actions it performs.

UC2 Change a region priority

Entry condition. A mission is active, the named region exists and its configured priority has room to increase.

Main interaction. The operator enters “Increase the priority of Region B.” The system identifies B and the requested increase, applies the change, and reviews the current assignments. The operator sees the outcome and can inspect which vehicles, if any, changed region.

Alternative outcomes. An unknown region or unsupported instruction produces a reason and leaves the mission unchanged. A valid change may leave the allocation unchanged when no additional vehicle is available. The display must distinguish acceptance of the command from movement of a vehicle.

UC4 Review run evidence

Entry condition. A run has recorded events. The evaluator selects the run and inspects a return event or priority change.

Outcome. The history identifies when the event occurred, which vehicle or region was affected, and whether work was reassigned or left uncovered. An empty history should be identified explicitly so an evaluator can tell whether an event has occurred.

3.5.3 Object and class model

The domain model records how responsibilities change over time. An assignment links a vehicle to a region for an interval. Keeping the interval lets an evaluator reconstruct who was responsible before and after a return.

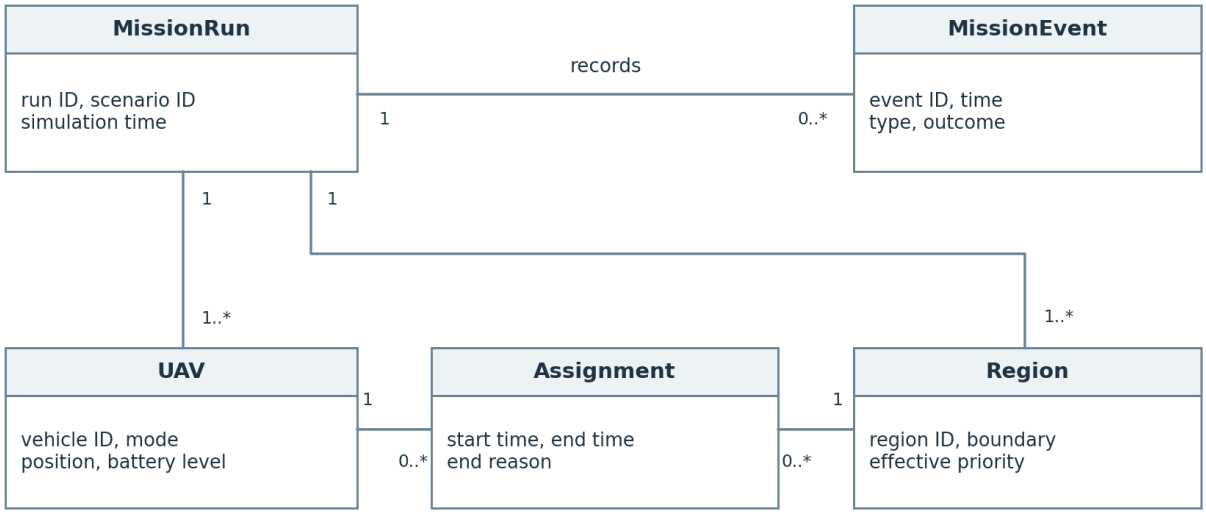

Figure 2. Main domain classes. A run contains its vehicles and regions. Multiplicities count related records over the life of the run.

Relationship	Meaning in a mission
MissionRun and MissionEvent	One run owns its fleet, region set and event history. Each event belongs to one run. A run also identifies its single home base.
UAV and Assignment	An assignment identifies exactly one vehicle. A vehicle can accumulate many assignments, with at most one open patrol assignment at a time in this model.
Region and Assignment	An assignment identifies exactly one region. A region may have several vehicles assigned or may have no active assignment.
Region and priority	Each region has a configured priority. The effective priority is the value in force at a given simulated time after applicable changes.

Example object snapshot

In run R1, assignment A17 links D3 to Region B. When D3 reaches its low-battery threshold, A17 receives an end time. If D2 takes over B, D2's earlier assignment to A ends before its new assignment to B begins. If no vehicle can take over, B has no open assignment. The completed A17 remains in the history.

3.5.4 Dynamic models

The vehicle state controls whether a vehicle can accept patrol work. A vehicle waiting for an assignment is Available. A vehicle that has completed a return is At base. Automatic charging and return to patrol after arrival are outside the behavior specified for the initial demonstration.

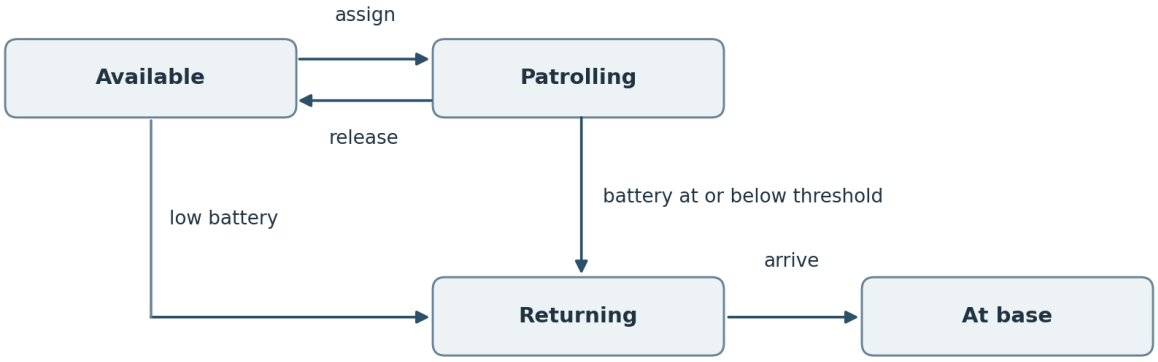

Figure 3. Vehicle states within a run. Reassignment during patrol can replace the active assignment while the vehicle remains in the Patrolling state.

Event trace for a low battery reading

Step	Interaction	Observable result
1	The simulation reports D3's battery at the configured threshold.	D3 changes from Patrolling to Returning. Its ordinary patrol assignment ends.
2	The mission reviews work previously assigned to D3.	Eligible vehicles can take feasible work. Any remaining gap is associated with the affected region.
3	The updated mission state reaches the views and the event history.	D3's return and the assignment outcome can be inspected at the same mission update.
4	The simulation reports D3's arrival at the home base.	D3 is shown At base. The recorded arrival counts as one completed return.

Boundary and simultaneous events

A second low reading while D3 is Returning must not create a second departure. If a priority change arrives in the same update, its outcome must still exclude D3 from patrol. If every vehicle is returning, the updated view must show the coverage gap.

The specifications allow a schedule and an operator to change the same region. They do not yet define which value wins when both arrive together, how long an override lasts, or how equal-priority regions share spare vehicles. A repeatable test of these cases requires an agreed rule and an expected result in the scenario configuration.

3.5.5 User interface and navigation

The mission overview brings the region map and fleet list together. Selecting a region identifies its current priority and assigned vehicles. Selecting a vehicle reveals its position, battery and mode. The interface should let an operator check the consequence of a change without reconstructing it from raw coordinates.

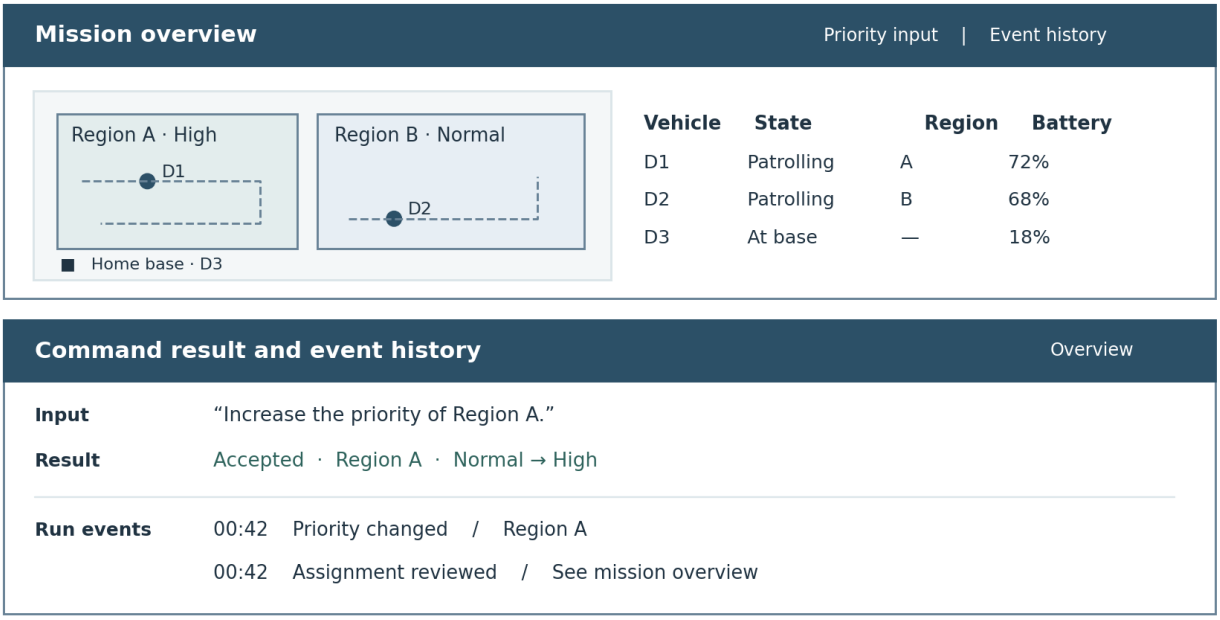

Figure 4. Two proposed screen layouts. Vehicle positions, battery values and times are illustrative. D3 is at the base while D1 and D2 patrol their regions.

Navigation paths

Starting point	User action	Destination or response
Scenario selection	Choose a configured mission and start it.	Mission overview opens with the current regions, fleet and priorities.
Mission overview	Open priority input and submit a supported English command.	Command result names the region and change. Return to the overview to inspect any reassignment.
Command result	Correct a rejected region name and submit again.	A new result appears. Only an accepted command may change the effective priority.
Mission overview	Open the event history and select a return or priority event.	Inspect the affected vehicle or region, review the outcome and return to the same run.

When both displays are active, compare the 2D assignment and the 3D vehicle state at a common simulation update. A delay in drawing a frame can otherwise make two valid views appear inconsistent.

3.5.6 Evaluation and open decisions

The following measures define what to collect during a fixed-assignment run and a priority-aware run. The team has not yet set numerical pass thresholds.

Measure	Definition for a repeatable comparison
Estimated coverage	For a cell-based test, divide distinct observed cells in a region by all eligible cells in that region and multiply by 100. Use the same grid, footprint and observation interval in both runs. Report each region separately.
Redistribution latency	For each event that changes assignments, subtract its receipt time from the publication time of the revised allocation. Use the same elapsed-time clock for both. Record "no assignment change" separately.
Unassigned work	At each review, count work units still needing service that have no eligible assignee. Define the work unit, such as a region or route segment, in the scenario before comparing runs.
Completed returns	Count distinct return episodes that end with arrival at the base. A threshold crossing alone starts an episode. It does not count as a completed return.

Before testing, the team must select a priority scale and conflict rule, a footprint and work unit, and a battery model with its return threshold. The integration trial will inform the PX4 decision. A workstation baseline will establish feasible fleet size and response-time targets.

4 Glossary

Term	Meaning in KOVAN
Effective priority	The importance value used for a region at the current simulation time.
Footprint	The modeled area counted as observed by a vehicle at a given time.
Patrol assignment	A vehicle's responsibility for a named region during a stated interval.
Redistribution	A change in how active vehicles share monitoring work after a mission event.
ROS 2 / SITL / UAV	Robot Operating System 2 / Software-in-the-Loop / unmanned aerial vehicle.

5 References

[1] Team KOVAN. Project Proposal. TED University, CMPE 491, Fall 2026–2027.

[2] Team KOVAN. Project Specifications Report. TED University, CMPE 491, Fall 2026–2027. Sections 1 and 2.

[3] TED University, Department of Computer Engineering. CMPE 491 Senior Design Project I Course Syllabus. Fall 2026–2027. Analysis Report guidelines.