ElectroCap mid-program pitch deck

Aerial–Ground Mesh Networking for Wilderness Search and Rescue

Restoring communications when terrain breaks rescue teams apart

Instituto Superior Técnico
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Team

Students

Leonardo Catarino	106778
Henrique Ferreira	110385
Dylan Félix	110749
Vicente Ferreira	110420
Pedro Gonçalves	87559
Eduardo Curião	109709

Supervision Team

Scientific Advisor
Prof. Ayman M. Radwan

Scientific Co-advisor
Mariana Santana

The Problem

- Forest and mountain teams lose line-of-sight links.
- Mesh splits break voice, routing, and command visibility.
- Existing options are costly, proprietary, or infrastructure-dependent.

When teams cannot communicate, rescue becomes slower, riskier, and less coordinated.

Target Users and Stakeholders

Primary users

- Firefighters
- Police and SAR units
- Field teams operating in disconnected terrain
- Command post operators

Stakeholders

- Civil protection organizations
- Public safety and emergency agencies
- Air operation coordinators
- Technical partners for UAV payload integration

Why they care

Reliable field communications without cellular infrastructure.

Our Solution

- Portable ground nodes create an offline mesh.
- A UAV relay reconnects separated teams.
- Local services: voice, map, monitoring.
- The relay repositions from mesh telemetry.

Our solution is an offline communication kit that detects partitions and restores connectivity with an aerial relay.

Value Proposition

Operational value

- Faster restoration of team-to-team communications
- Better responder safety through improved coordination
- Reduced dependence on pre-existing infrastructure
- Repeatable deployment in remote terrain

Product value

- Open and reproducible architecture
- Integrated voice, map, and network monitoring
- UAV-assisted repair instead of only static relays
- Measurable validation criteria instead of vague connectivity claims

Market Opportunity

- Target: institutional emergency operators.
- First use: SAR, mountains, wildfire response, field coordination.
- Adjacent use: drills and off-grid public-safety operations.

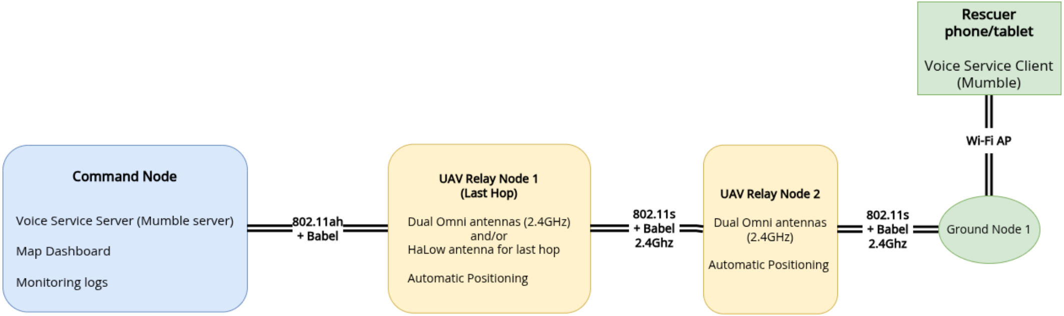
Positioning

Not a consumer device. A deployable capability for public-safety teams.

How It Works

1. Ground nodes provide Wi-Fi and form the mesh.
2. The command node hosts Murmur/Mumble, maps, and logs.
3. Telemetry and probes detect a partition.
4. The UAV relay joins and repositions.
5. Connectivity recovers and the system logs the result.

Diagram of the Proposed Solution Architecture



Murmur is the server component that powers the Mumble voice service used by the team nodes and command node.

Status of solution development

- OpenWrt mesh simulation running over 802.11s + Babel.
- Supports bring-up, telemetry, and route updates.
- Interactive visualizer changes link quality in real time.
- Controlled environment for loss and recovery tests.

Current maturity

Current artifact: a controllable mesh-network simulator.

Business and Deployment Model

Deployment model

- Portable kit assigned to a rescue team or command post
- Pre-planned relay placement before mission start
- UAV relay used on demand when ground connectivity degrades
- Closed offline operation during field missions

Adoption model

- Institutional procurement by emergency and civil protection entities
- Pilot projects and validation drills with partner organizations
- Prototype today, scalable operational kit later
- Open stack reduces lock-in and improves reproducibility

Competitive Advantage

Dimension	Our solution	Typical alternatives	Why it matters
Offline mesh operation	Yes	Partial / vendor-specific	Works without internet or external infrastructure
UAV relay support	Yes	Often limited	Restores links where ground placement is insufficient
Autonomous repair	Yes	Usually manual or absent	Reduces operator burden during failures
Integrated voice + map + monitoring	Yes	Often fragmented	Gives one operational workflow instead of isolated tools
Open / reproducible stack	Yes	Often proprietary	Supports transparency, lower lock-in, and academic validation

Costs and Benefits

Prototype cost baseline

- 3 GL-AR300M16-Ext nodes: approx. € 120
- 3 power banks: approx. € 60
- Smartphones use each node Wi-Fi AP as the user interface

Updated minimum BOM total: approx. € 180

Expected benefits

- Low-cost, low-risk iteration
- Enough hardware for mesh, power, and integration tests
- Reusable path from simulation to hardware
- Evidence before heavier RF upgrades

Interpretation

Goal: prove viability, not final pricing.

Hardware Class Justification

Class	Justification
Prototype	40 g ultra-light OpenWrt node. Minimal cost, safe to crash, validates mesh, boot, power, and integration. Low RF performance by design, not for final range.
Class 1	Compact outdoor omni radio. 150–200 g, around 6 dBi, about 300–500 m radius, suitable for a 7" long-range quad. Moderate resilience.
Class 2	Direct-mount radio with external omni. Around 300 g total, 5–9 dBi, about 500–900 m radius, suitable for 7–10" multirotor or fixed-wing platforms. Good resilience.
Class 3	Dual-antenna 2x2 outdoor radio. About 350–500 g, dual omnis, around 700 m–1 km radius, suitable for heavy multirotor or hexacopter platforms. Highest resilience.

Core logic

Prototype validates mesh, boot, power, and integration at low cost. Higher classes trade weight for gain, range, stability, and resilience.

Achieved results

Concrete outputs obtained

- Simulation-first architecture defined
- OpenWrt mesh simulator with telemetry and route adaptation
- Pre-planning tool requirements refined
- Prototype BOM simplified
- Air Force feedback collected

Stakeholder feedback

- Concept seen as promising
- Clearer use cases still needed
- Multirotor rotation suggested
- Start with simulation

Deviations from the initial schedule

- Hardware limits shifted us to simulation-first validation.
- Routing changed from BATMAN-adv to Babel.
- UAV control narrowed to MAVLink APIs.
- Pre-planning requirements were revised.
- HaLow became an optional extension.
- AAN, SORA, and approvals entered the plan.

Interpretation

Result: lower risk and a clearer path.

Risks and Challenges

Area	**Main risk**	**Mitigation**
Software / networking	Configuration drift and degraded behavior under loss	Scripted configs, replay tests, acceptance harness
Hardware / power	Payload runtime shortfall and mechanical reliability	Power budgeting, current logging, ruggedized mounting
RF / field conditions	Terrain and vegetation causing unstable links	Walk tests, telemetry maps, spacing rules, altitude guidance

Challenges (technical and non-technical)

Technical

- Reliable routing under changing link quality
- Integration between mesh telemetry and autonomy logic
- Transition from simulation to hardware validation
- UAV guidance/control integration through MAVLink
- Deciding when HaLow is worth the added complexity

Non-technical

- Hardware availability and procurement timing
- Balancing scope against available time
- Aligning technical choices across the team
- Securing partner feedback and realistic operational constraints
- Keeping deliverables coherent while the architecture is still being refined

Performance Metrics

Metric	**Target**	**Why**
Recovery after UAV join	≤ 30 s	Usability
Boot-to-mesh time	≤ 60 s	Responsiveness
Connectivity restoration rate	100%	Repair works
PTT restoration delay	≤ 10 s	Voice recovery
Field setup time	≤ 10 min	Practicality
Ground autonomy	≥ 8 h	Mission duration

Validation Plan

What we prove	**Success criteria**
Partition exists	No route, ping fail, PTT fail, topology split
UAV joins fast enough	Boot-to-mesh ≤ 60 s
Connectivity is restored	Route, ping, and PTT return
Recovery is useful	Reconvergence ≤ 30 s
Deployment is practical	Setup ≤ 10 min
Ground system lasts	Autonomy ≥ 8 h

Primary demonstration: fail before UAV, pass after UAV.

Schedule of activities until the end of the project

Period	**Planned activity**
Early April	Finalize deck, use cases, and simulation baseline
Mid April	Integrate telemetry, monitoring, and test harnesses
Late April	Access MAVLink and prepare approvals/SORA path
Early May	Implement and tune repair logic
Mid May	Validate scenarios and collect KPIs
Late May	Prepare transition to available hardware
Early June	Finalize communication materials
Late June	Deliver ElectroDay demo and final package

Contributions of each team member to the results

- Pedro Gonçalves: simulator, visualizer, Wi-Fi emulation
- Henrique Ferreira: Murmur/Mumble voice workflow
- Dylan Félix: repair algorithm implementation
- Eduardo Curião: node/UAV hardware feasibility
- Leonardo Catarino: drone-class and payload study
- Vicente Ferreira: HQ dashboard and logs
- Team: architecture, scope, BOM

Why our product matters

- Clear operational problem
- Practical and differentiated solution
- Low-cost prototype path
- Measurable validation plan
- Strong fit with institutional emergency users

Our product turns UAV-assisted connectivity repair into a concrete, testable field capability.