UX Case Study

Intuitive Control for Multi-Drone ISR Missions

Ulm 25.06.2025

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Why Does C2 Need a Rethink?

MISSION & NUTZERKONTEXT
(SLIDES 3 – 7)

RESEARCH INSIGHTS
(SLIDES 8 – 13)

OPERATIONAL JOURNEY
(SLIDES 14 – 15)

CORE INTERACTION FLOWS
(SLIDES 16 – 34)

KEY TAKE-AWAYS & NEXT STEPS
(SLIDES 35 – 39)

Mission Context & Constraints

Why it matters

The Challenge

Modern ISR missions require managing multiple drones in real time under pressure – in complex, often challenging terrain

The Objective

Design a clear and scalable UI for controlling

5 semi-autonomous ISR drones, enabling:

- Mission assignment
- Status monitoring
- Timely human intervention

Core Parameters

Drones	max. 5 semi-autonomous units
User Role	Human operator with full mission oversight
Context	Urban or forested terrain, real-time ops
UX Focus	Clarity, prioritization, cognitive relief

Operator Insight

Who we're designing for

Role Tactical Operator in ISR Missions

Context
- Operates solo in field-based ISR missions
- Works under pressure: noise, time-critical, unstable signals

Task flow Mission planning → Drone deployment → Monitoring & intervention

Key Needs
- Situational clarity at a glance
- Reliable system feedback under stress
- Minimal friction: low interaction cost, fast action paths
- Trust in autonomy – with clear options to intervene

Operator Insight

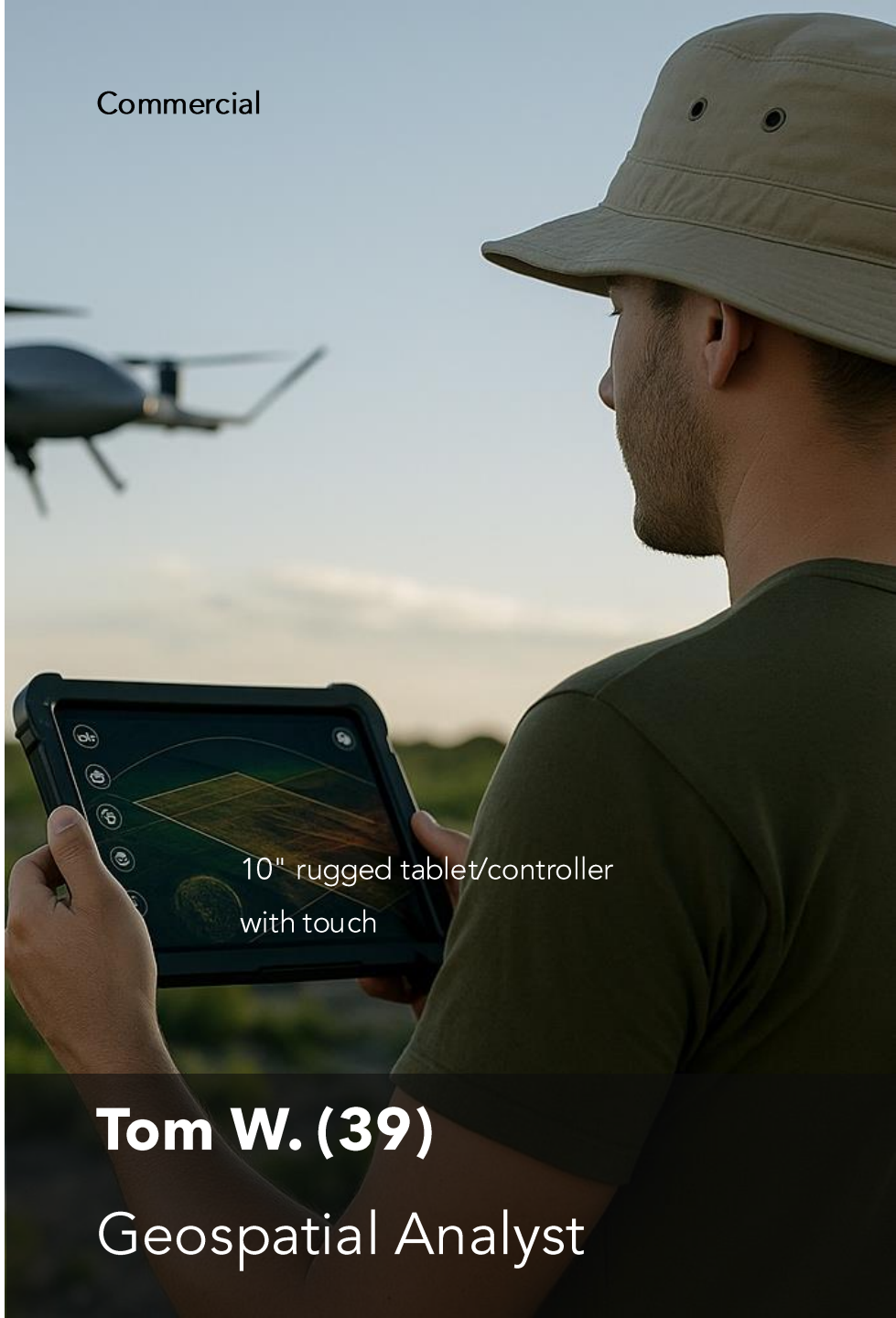
Who we're also designing for

Role Environmental Surveyor / Drone Mapping Specialist

Context
- Deploys VTOL drones with LiDAR/multispectral sensors
- in remote terrain under sun, wind & signal limits

Task flow Plan → Fly → Scan → Process

Key Needs
- Quick route & terrain adjustment
- Seamless sensor integration
- Reliable autonomy + manual override
- Rugged, intuitive UI for long outdoor use



Operator Insight

Government vs. Commercial Operators

Government ISR Operator

- Surveillance, recon, tactical ISR
- Hostile, noisy, signal risk, high stress
- Thermal, visual, radio, radar
- Real-time awareness, threat detection
- Speed, clarity, trust in autonomy
- Manual override critical

Commercial Surveyor

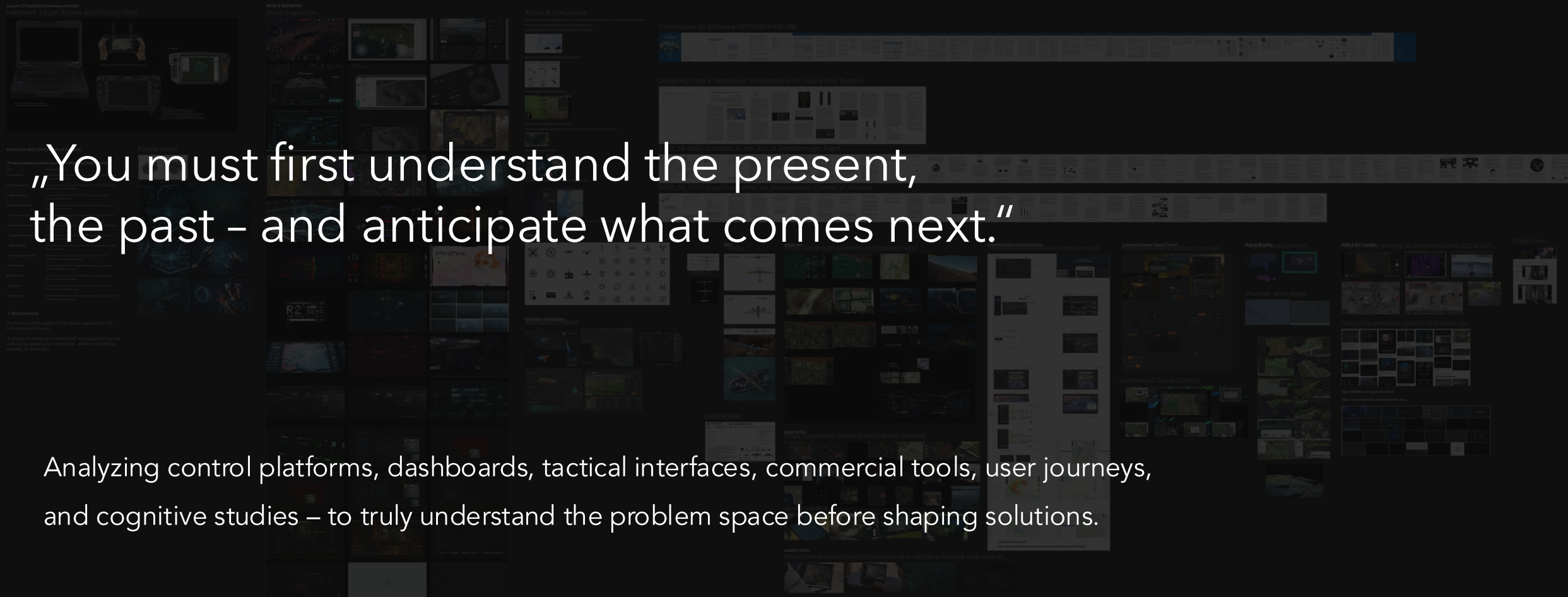
- Mapping, agriculture, terrain inspection
- Remote, sunny, variable terrain
- LiDAR, multispectral, RGB
- Accurate data acquisition
- Stability, post-processing, offline capability
- Autonomy with safety fallback

Shared Core Flow

Plan → Fly → Scan → Process

This applies to both, but differs in tools, UI focus & environment

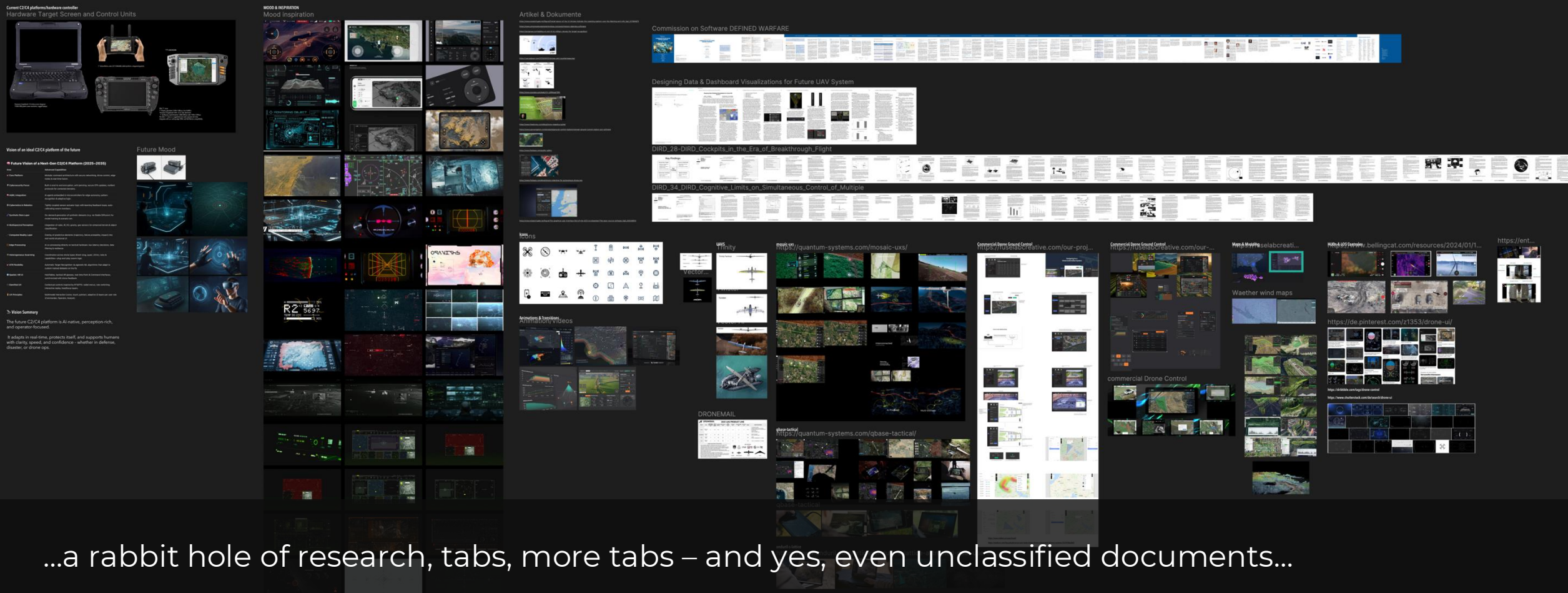
First, Understand the Present



„You must first understand the present,
the past – and anticipate what comes next.“

Analyzing control platforms, dashboards, tactical interfaces, commercial tools, user journeys, and cognitive studies – to truly understand the problem space before shaping solutions.

From Field Notes to Patterns



...a rabbit hole of research, tabs, more tabs – and yes, even unclassified documents...

Existing systems and control paradigms

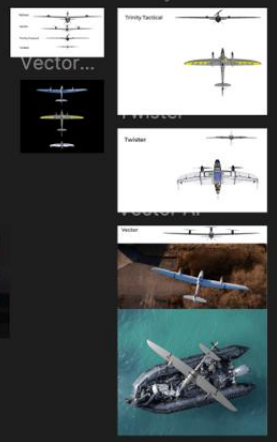
Icons

Animations & Transitions

Animation/Videos

UAVS

Trinity

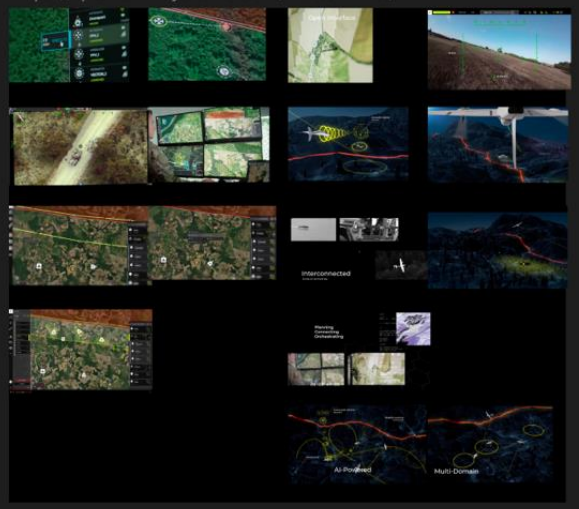


Vector...

DRONEMAIL

mosaic-uxs

https://quantum-systems.com/mosaic-uxs/



qbase-tactical

https://quantum-systems.com/qbase-tactical/

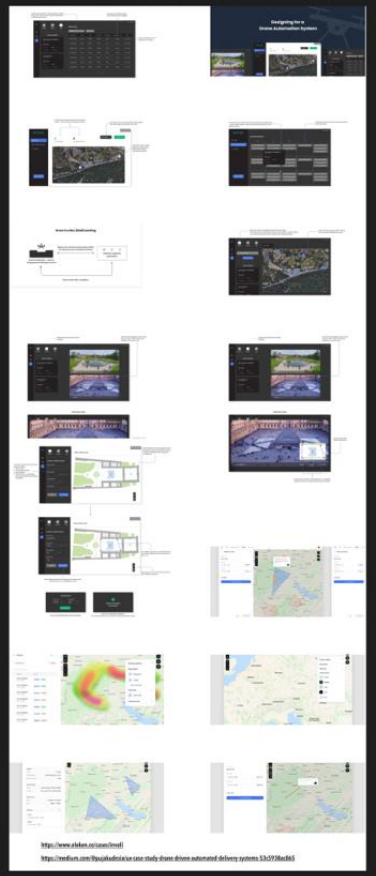
qbase-tactical

anduril-s-lattice

https://www.anduril.com/article/anduril-s-lattice-a-trusted-dual-use-co...

Commercial Drone Ground Control

https://fuselabcreative.com/our-proj...



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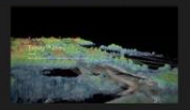
commercial Drone Control

Maps & Mapping

https://fuselabcreati...

Waether wind maps



HUDs & LOS Controle

https://dribbble.com/tags

https://www.shutterstock.

Real-world operator and challenges

Artikel & Dokumente

Commission on Software DEFINED WARFARE

Designing Data & Dashboard Visualizations for Future UAV System

DIRD_28-DIRD_Cockpits_in_the_Era_of_Breakthrough_Flight

DIRD_34_DIRD_Cognitive_Limits_on_Simultaneous_Control_of_Multip

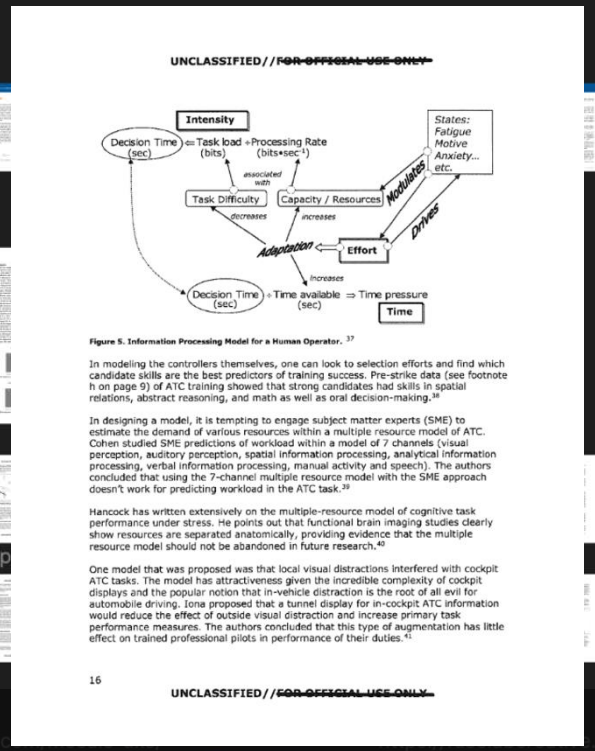


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Figure 5. Information Processing Model for a Human Operator. [37]

In modeling the controllers themselves, one can look to selection efforts and find which candidate skills are the best predictors of training success. Pre-strike data (see footnote h on page 9) of ATC training showed that strong candidates had skills in spatial relations, abstract reasoning, and math as well as oral decision-making.[38]

In designing a model, it is tempting to engage subject matter experts (SME) to estimate the demand of various resources within a multiple resource model of ATC. Cohen studied SME predictions of workload within a model of 7 channels (visual perception, auditory perception, spatial information processing, analytical information processing, verbal information processing, manual activity and speech). The authors concluded that using the 7-channel multiple resource model with the SME approach doesn't work for predicting workload in the ATC task.[39]

Hancock has written extensively on the multiple-resource model of cognitive task performance under stress. He points out that functional brain imaging studies clearly show resources are separated anatomically, providing evidence that the multiple resource model should not be abandoned in future research.[40]

One model that was proposed was that local visual distractions interfered with cockpit ATC tasks. The model has attractiveness given the incredible complexity of cockpit displays and the popular notion that in-vehicle distraction is the root of all evil for automobile driving. Iona proposed that a tunnel display for in-cockpit ATC information would reduce the effect of outside visual distraction and increase primary task performance measures. The authors concluded that this type of augmentation has little effect on trained professional pilots in performance of their duties.[41]

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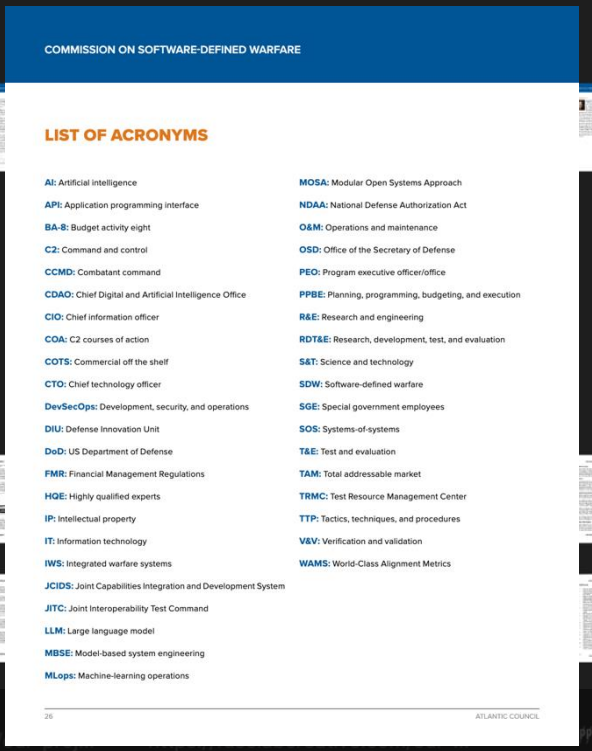


COMMISSION ON SOFTWARE-DEFINED WARFARE

LIST OF ACRONYMS

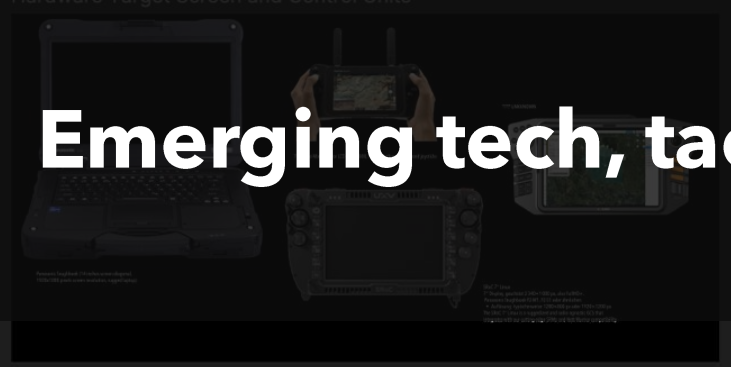
AI: Artificial intelligence
API: Application programming interface
BA-8: Budget activity eight
C2: Command and control
CCMD: Combatant command
CDAO: Chief Digital and Artificial Intelligence Office
CIO: Chief information officer
COA: C2 courses of action
COTS: Commercial off the shelf
CTO: Chief technology officer
DevSecOps: Development, security, and operations
DIU: Defense Innovation Unit
DoD: US Department of Defense
FMR: Financial Management Regulations
HQE: Highly qualified experts
IP: Intellectual property
IT: Information technology
IWS: Integrated warfare systems
JCIDS: Joint Capabilities Integration and Development System
JITC: Joint Interoperability Test Command
LLM: Large language model
MBSE: Model-based system engineering
MLops: Machine-learning operations
MOSA: Modular Open Systems Approach
NDAA: National Defense Authorization Act
O&M: Operations and maintenance
OSD: Office of the Secretary of Defense
PEO: Program executive officer/office
PPBE: Planning, programming, budgeting, and execution
R&E: Research and engineering
RDT&E: Research, development, test, and evaluation
S&T: Science and technology
SDW: Software-defined warfare
SGE: Special government employees
SOS: Systems-of-systems
T&E: Test and evaluation
TAM: Total addressable market
TRMC: Test Resource Management Center
TTP: Tactics, techniques, and procedures
V&V: Verification and validation
WAMS: World-Class Alignment Metrics

26 ATLANTIC COUNCIL

Icons

Animations & Transitions

Emerging tech, tactical interfaces from the past & future



Vision of an ideal C2/C4 platform of the future

Future Vision of a Next-Gen C2/C4 Platform (2025–2035)

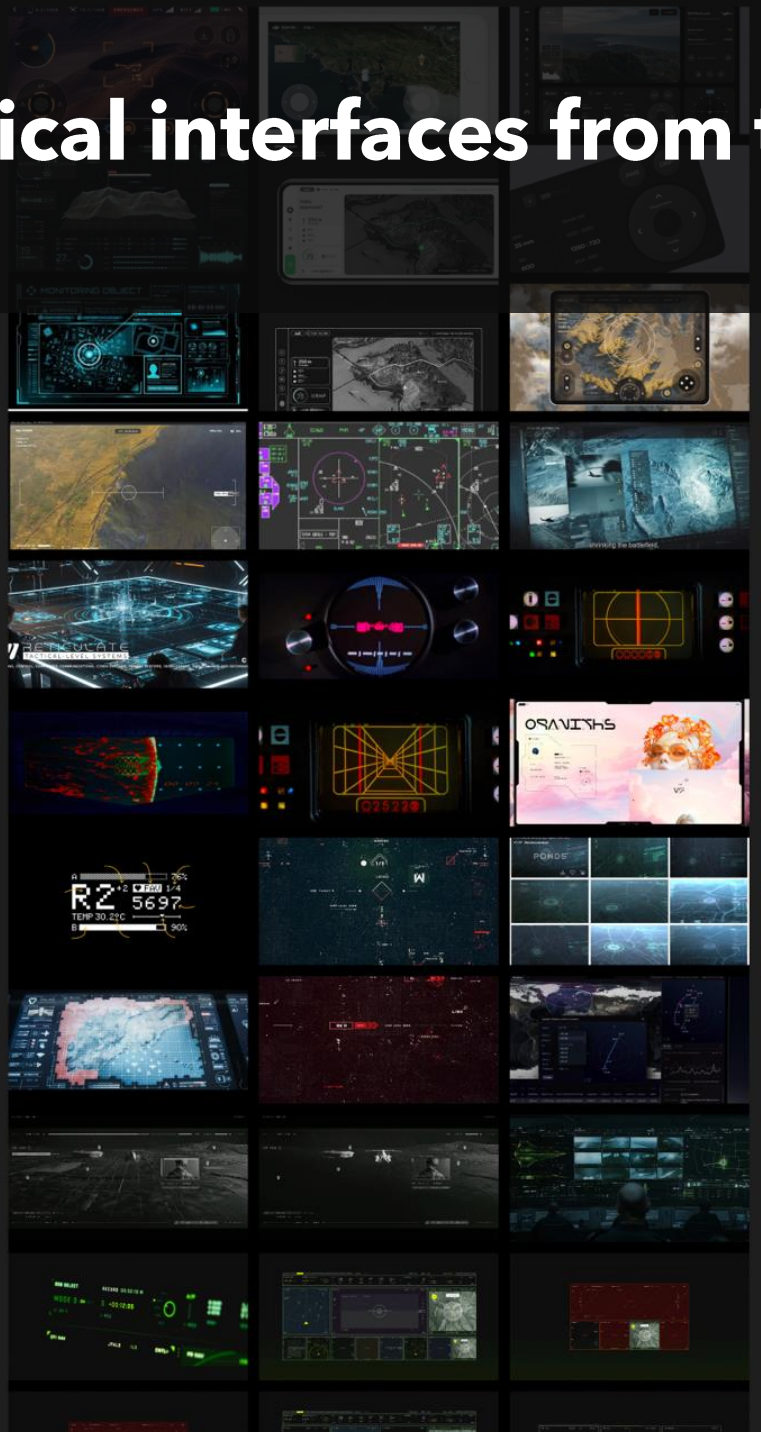
Area	Advanced Capabilities
Core Platform	Modular command architecture with secure networking, drone control, edge nodes & real-time fusion.
Cybersecurity Focus	Built-in end-to-end encryption, anti-jamming, secure OTA updates, resilient protocols for contested domains.
AI/ML Integration	AI agents embedded in microcontrollers for edge autonomy, pattern recognition & adaptive logic.
Cybernetics in Robotics	Tightly coupled sensor-actuator logic with learning feedback loops; auto-calibrating swarm members.
Synthetic Data Layer	On-demand generation of synthetic datasets (e.g. via Stable Diffusion) for model training & scenario sim.
Multispectral Perception	Integration of radar, IR, EO, gravity, gas sensors for enhanced terrain & object classification.
Computed Reality Layer	Overlay of predictive elements (trajectory, failure probability, impact) into real-world situational UI.
Edge Processing	AI co-processing directly on tactical hardware: low-latency decisions, data filtering & resilience.
Heterogeneous Swarming	Coordination across drone types (fixed-wing, quad, UGVs), roles & capabilities—plug-and-play swarm logic.
ATR Flexibility	Automatic Target Recognition via agnostic ML algorithms that adapt to custom-trained datasets on the fly.
Spatial / AR UI	Holofables, tactical AR glasses, real-time Point & Command interfaces, synchronized with drone feedback.
Gamified UX	Contextual controls inspired by RTS/FPS: radial menus, role-switching, interactive replay, heatfocus layers.
UX Principles	Multimodal interaction (voice, touch, pointer), adaptive UI layers per user role (Commander, Operator, Analyst).

Vision Summary

The future C2/C4 platform is AI-native, perception-rich, and operator-focused.

It adapts in real-time, protects itself, and supports humans with clarity, speed, and confidence – whether in defense, disaster, or drone ops.

Future Mood



Key Research Insights

Concept Idea	**Meaning** (What It Is)	**Support by Research** (Why It Matters)
Hybrid Modes with Focus	Context-based modes only show what is important at the right time	Reduces visual overload, supports situational awareness
Mental Model for UI	Spatial layout helps switch between phases or views	Spatial awareness & cognitive clarity help massively
Mission-Centered Interface	Interface is goal-oriented, not just about control	Shift from control to goal fulfillment
Modular UI Zones	Adaptive sections like Map, Alerts, Feed shift based on need	Adaptive displays & focus shift
AI & Automation in UI	AI supports decision-making, suggests actions, auto-prioritizes	Shared autonomy & cognitive offloading

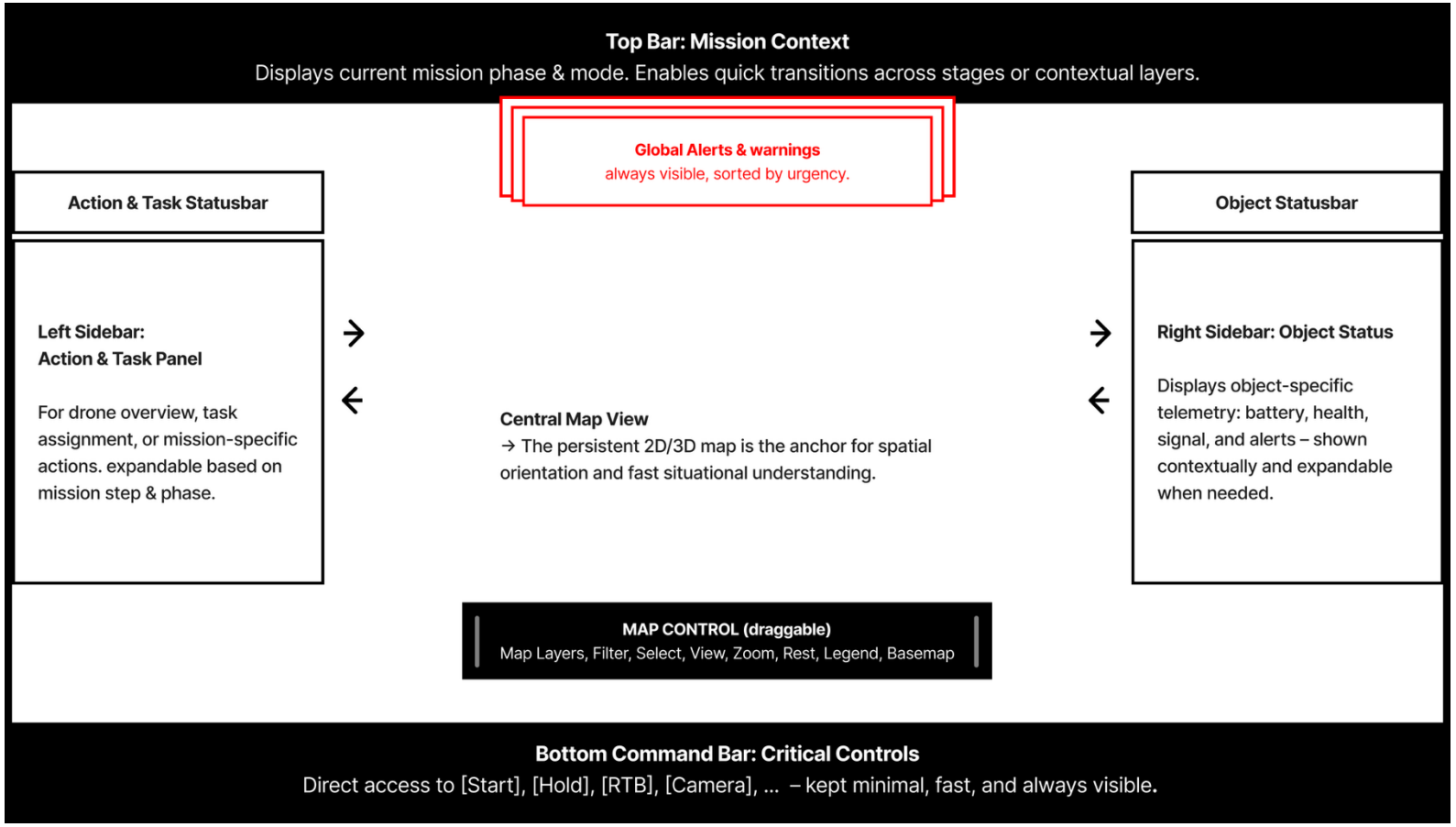
Design Principles

Principle	How it helps the operator
Single-glance clarity	Fleet health must be readable in < 2 s (NATO STANAG 4671 human-factors rule-of-thumb).
Progressive disclosure	Show only what's abnormal by default; expand on demand.
Spatial anchoring	Pair every status cue with its geo-location on the map → instant context.
Alert triage	Sort by Severity > Age > Asset so the worst item is always top left / top of list.
Redundancy of modality	Combine colour, shape, icon + short sound to survive vision, glare or stress limits.

4-Phase Mission Journey

Phase	User Focus	UX Priority	Key Interactions
01 Prepare	Mission setup & drone readiness	Overview & validation	Area selection, zone drawing, drone checklists
02 Deploy	Launch & initial positioning	Feedback & confidence	Launch commands, status confirm, live position
03 Operate	Real-time monitoring & alerts	Focus & quick reaction	Alert stack, feed switch, manual override
04 Recover	Return & mission wrap-up	Safety & transparency	RTB commands, battery view, data debrief

Scalable Mental Model



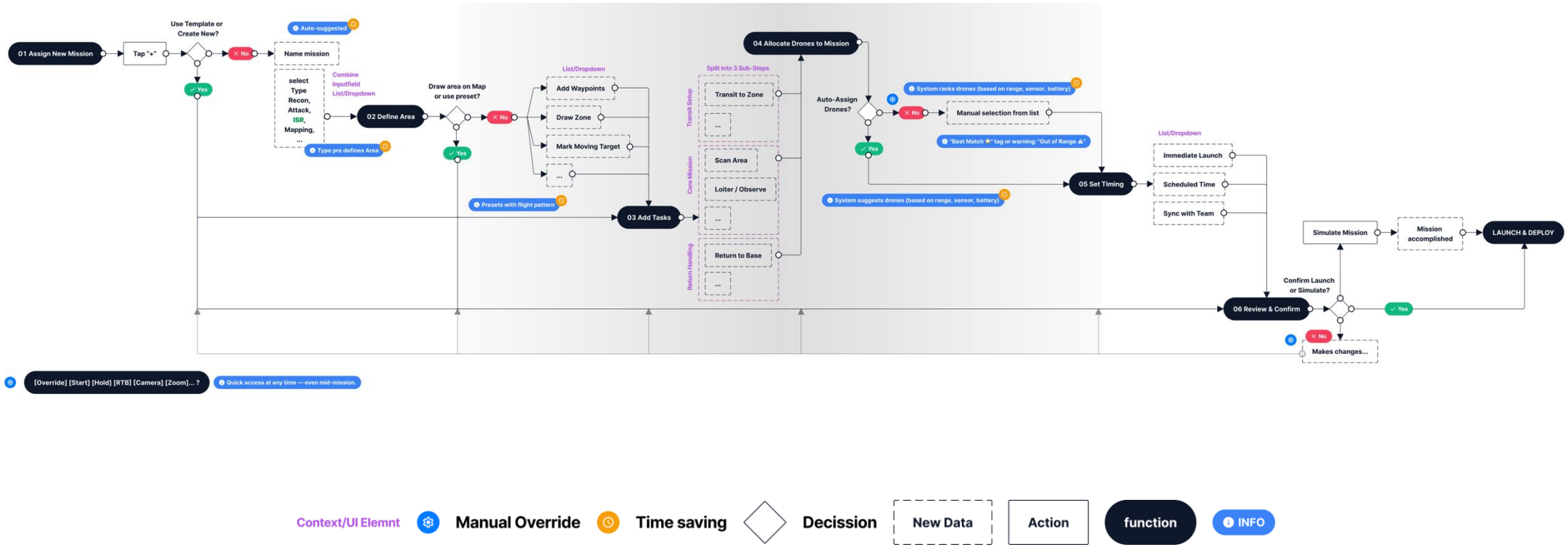
Defines the core layout logic – what stays visible, what changes with context.

Focuses on

- Spatial clarity (map as anchor)
- Fast access to mission-critical actions
- Context-driven panels for tasks & telemetry
- Foundation for future UI design & interaction flow

Journey Detail – Assign & Launch

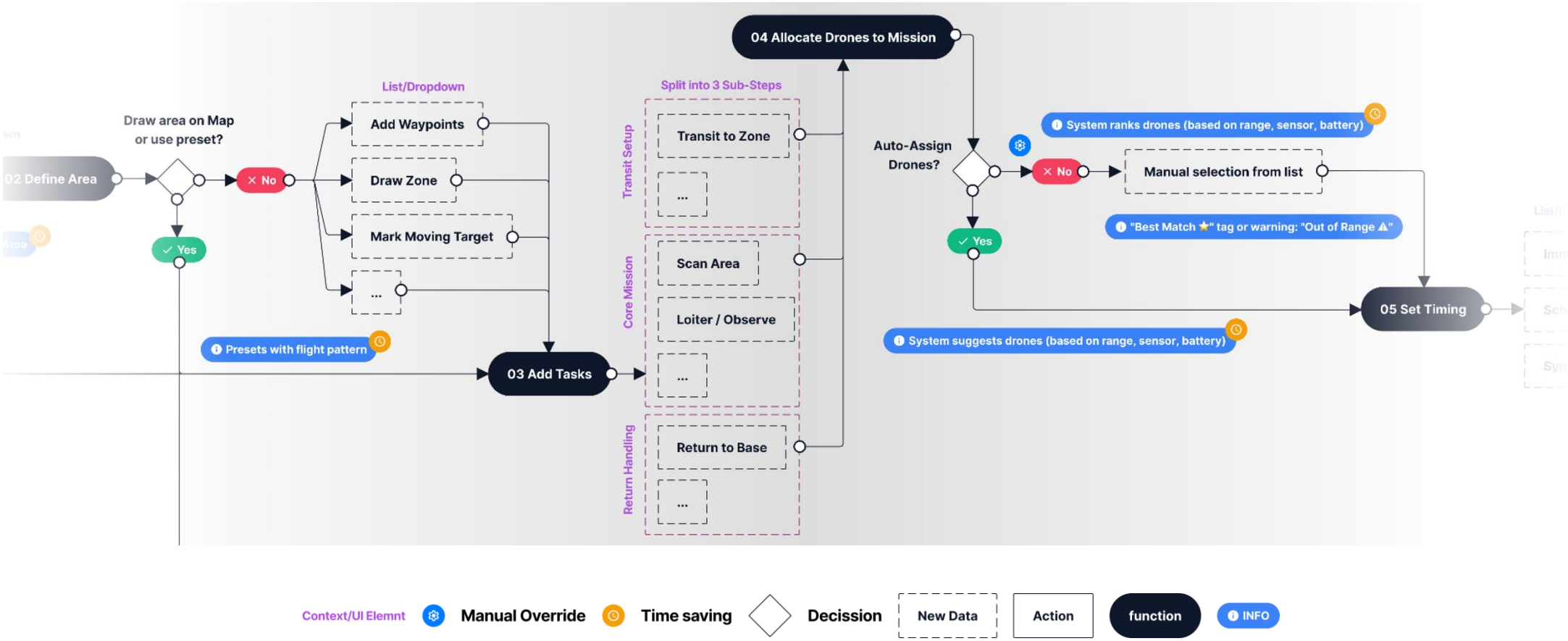
Problem: Operators must turn high-level ISR intent into an executable, multi-drone plan fast and intuitively, with automation but instant override.



Context/UI Elemnt · Manual Override · Time saving · Decission · New Data · Action · function · INFO

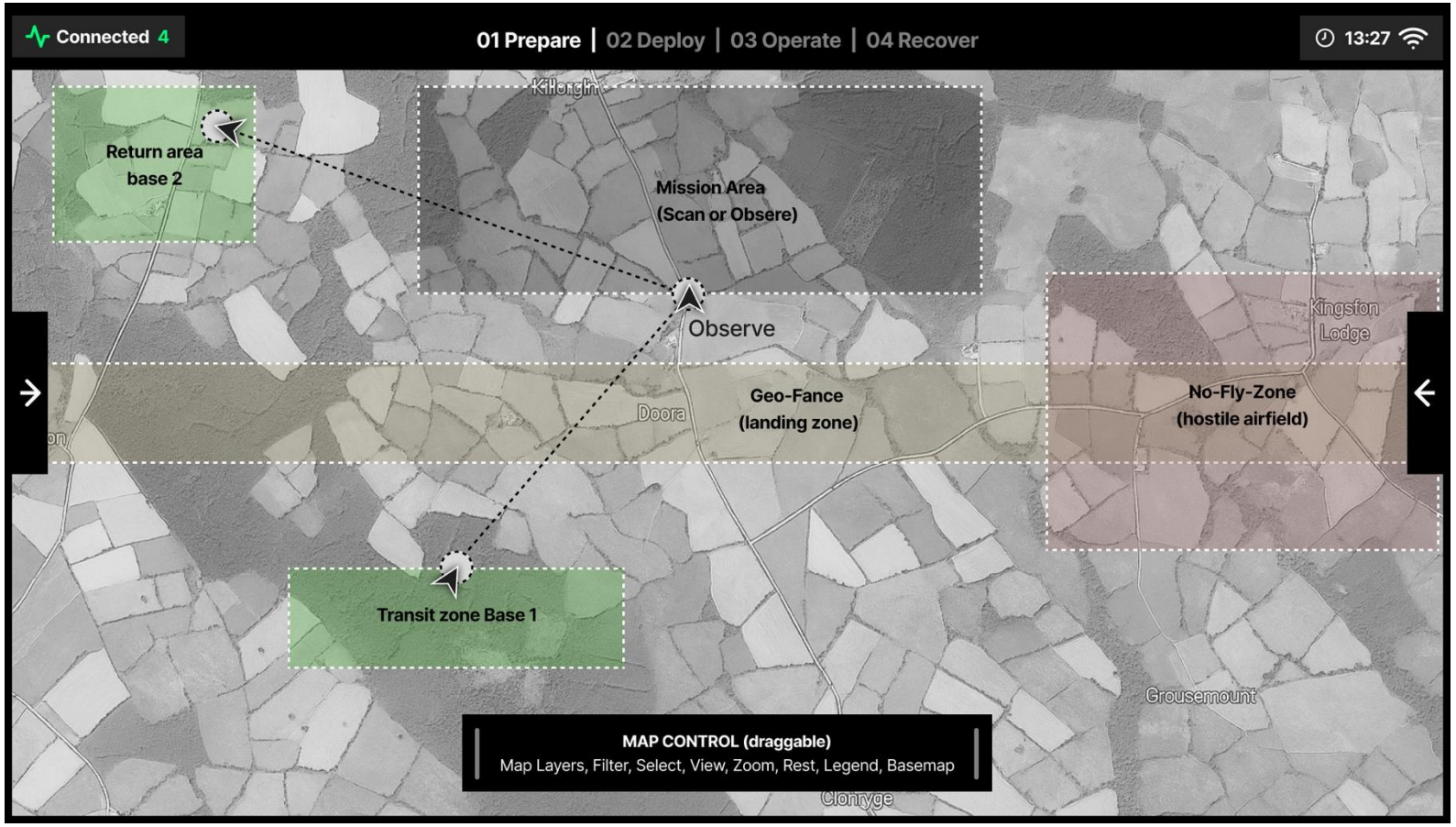
Flow Diagram – Assign + Launch

Assign mission to drones represents just one epic or part of the entire user journey:



Wireframes – Task & Asset Allocation

"Mission owns UAVs, not the other way around" (= ***mission-first***)



UAS Mission – Prepare Phase

Colour-coded map layers:
Transit (Base 1), Mission Area,
Geo-Fence (landing),
No-Fly Zone, Return (Base 2)…

Dashed arrows trace planned route:
launch → observe → return

Top ribbon shows 4-step workflow
(Prepare | Deploy | Operate | Recover)

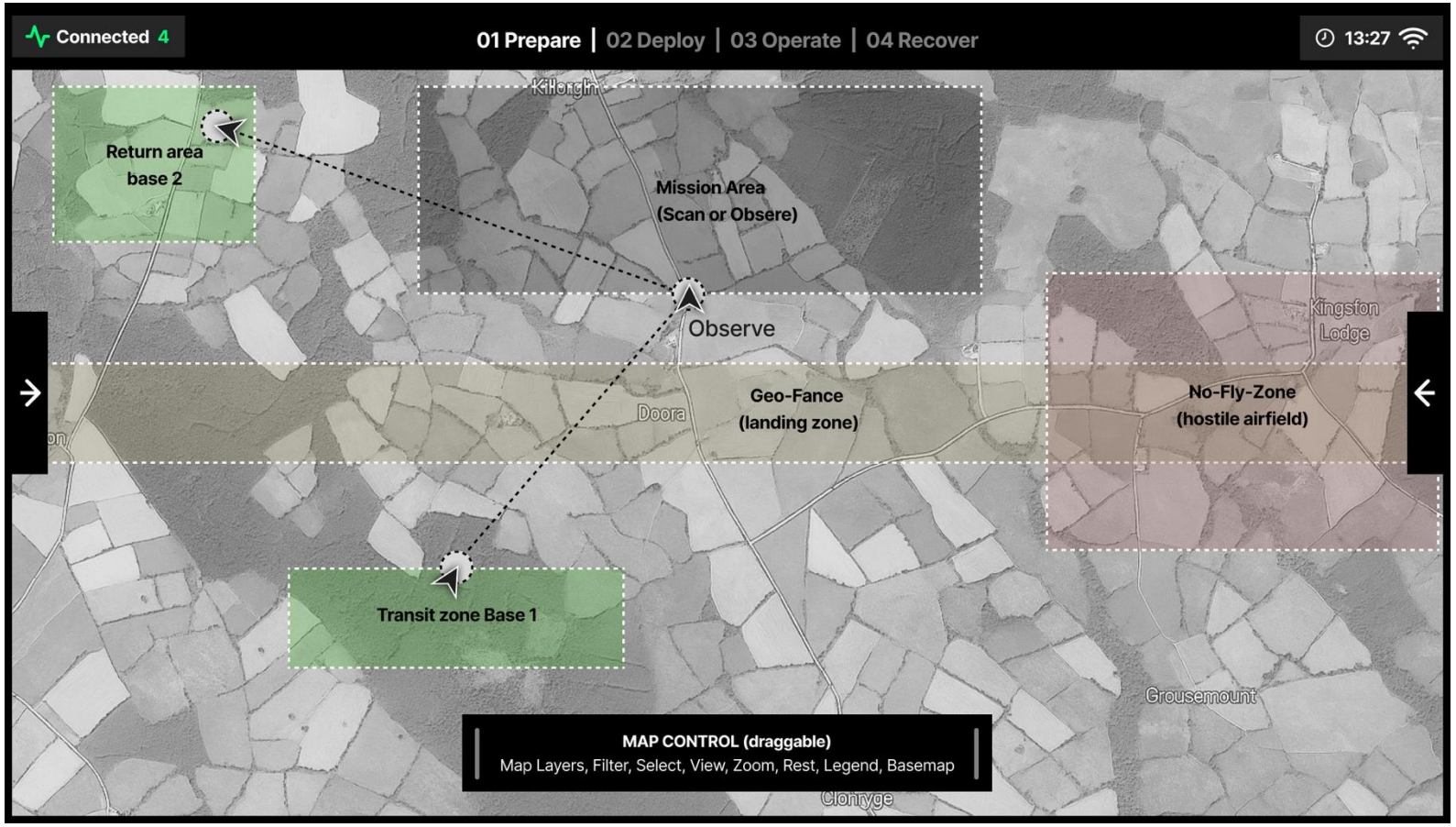
Map control/filter panel for layer-toggle & zoom

Quick-action keys listed: Start, Hold, RTB, Camera, Zoom

Wireframes – Task & Asset Allocation

"Mission owns UAVs, not the other way around" (= ***mission-first***)

> **Mission-first logic:** "Define the job → let the system propose assets → you approve."



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"Mission owns UAVs, not the other way around" (= ***mission-centric***)

UAV Allocation – Prepare Phase
(before & after assignment)

Select from the Available UAVs list, previewing key specs + status

Assign individually or via Auto-assign;

Each mission drone is tagged with route and RTB base (e.g., Route A RTB2).

Inventory counters update; Assign buttons grey-out once quotas met.

Live map and MAP CONTROL stay visible for spatial context and quick shortcuts.

Wireframes – Task & Asset Allocation

"Mission owns UAVs, not the other way around" (= ***mission-centric***)

> **AI-powered Automation:** "Automate with templates → let the system optimize the process → you override when needed."

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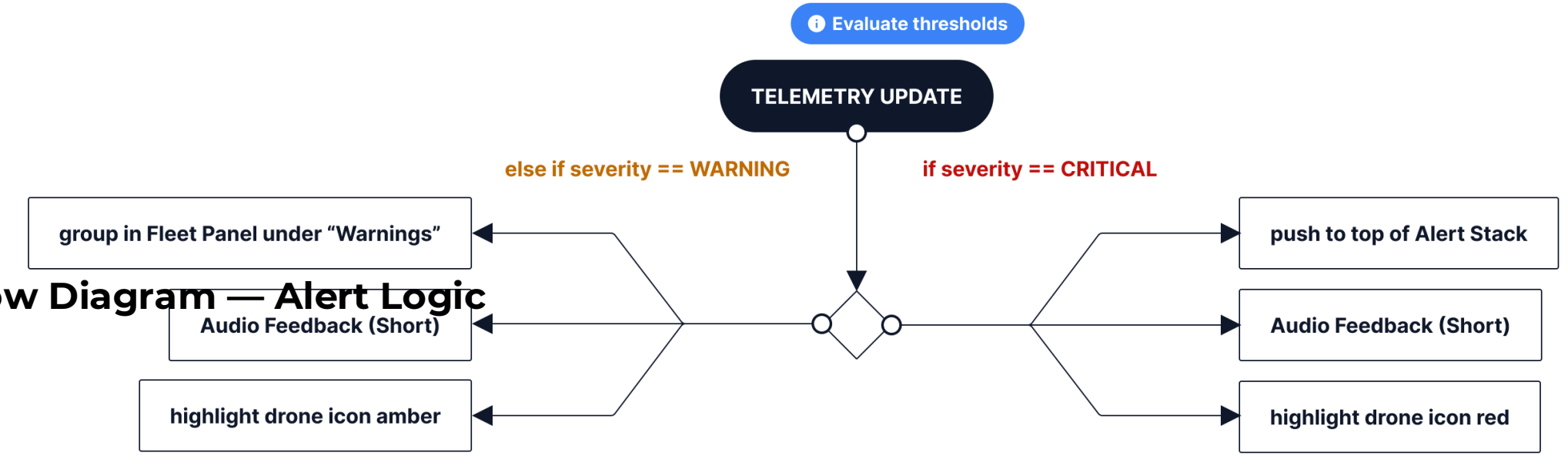
Flow Diagram – Alert Logic

Problem: Monitor the status of all drones at a glance (including alerts)



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Wireframes – Alert Handling

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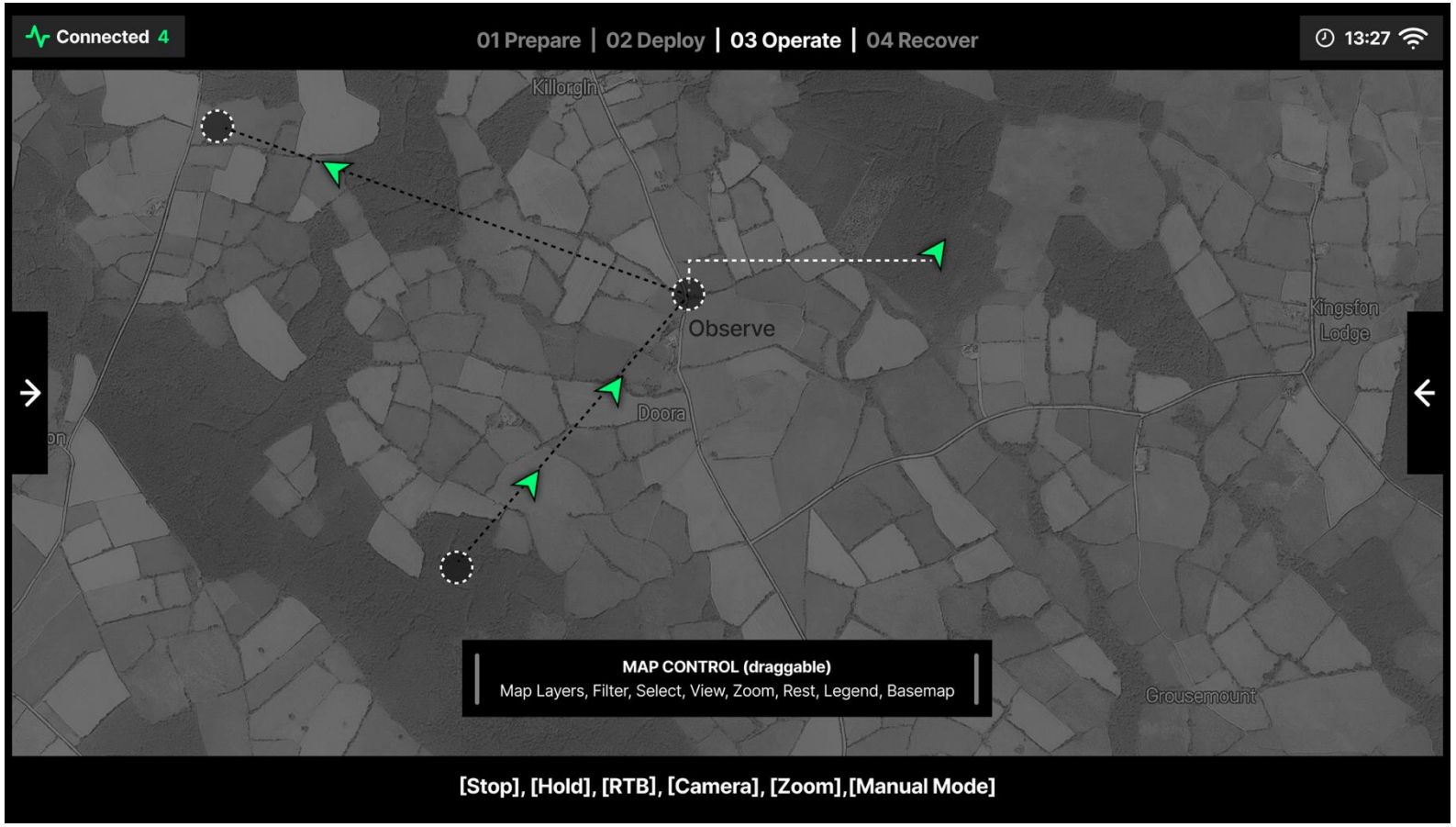

➜ Normal ops

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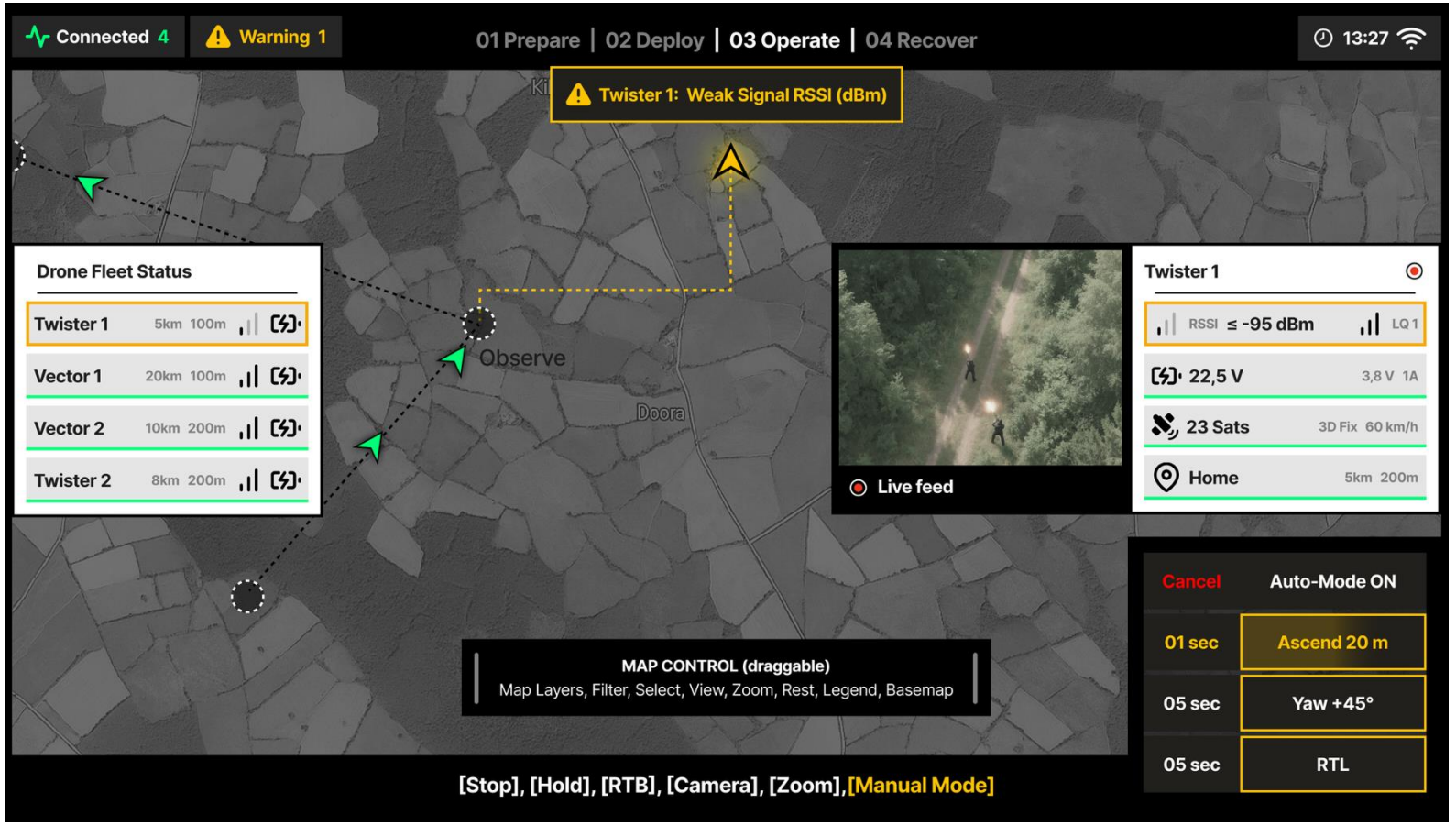

→ Normal ops

→ Weak-signal alert pops,
Quick-AI suggests:
"Ascend 20 m / Yaw +45°"

Audio Feedback (Short)

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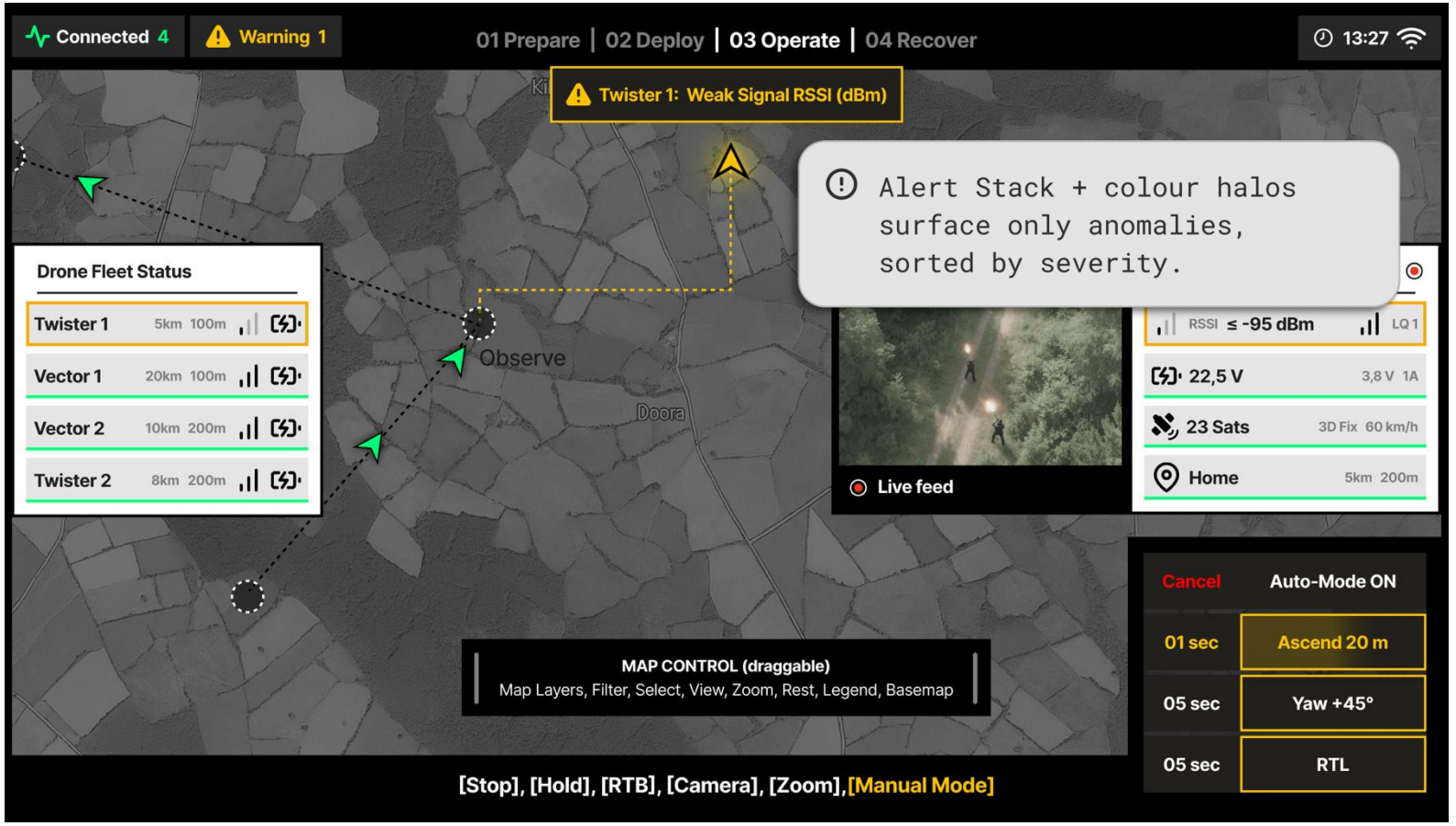

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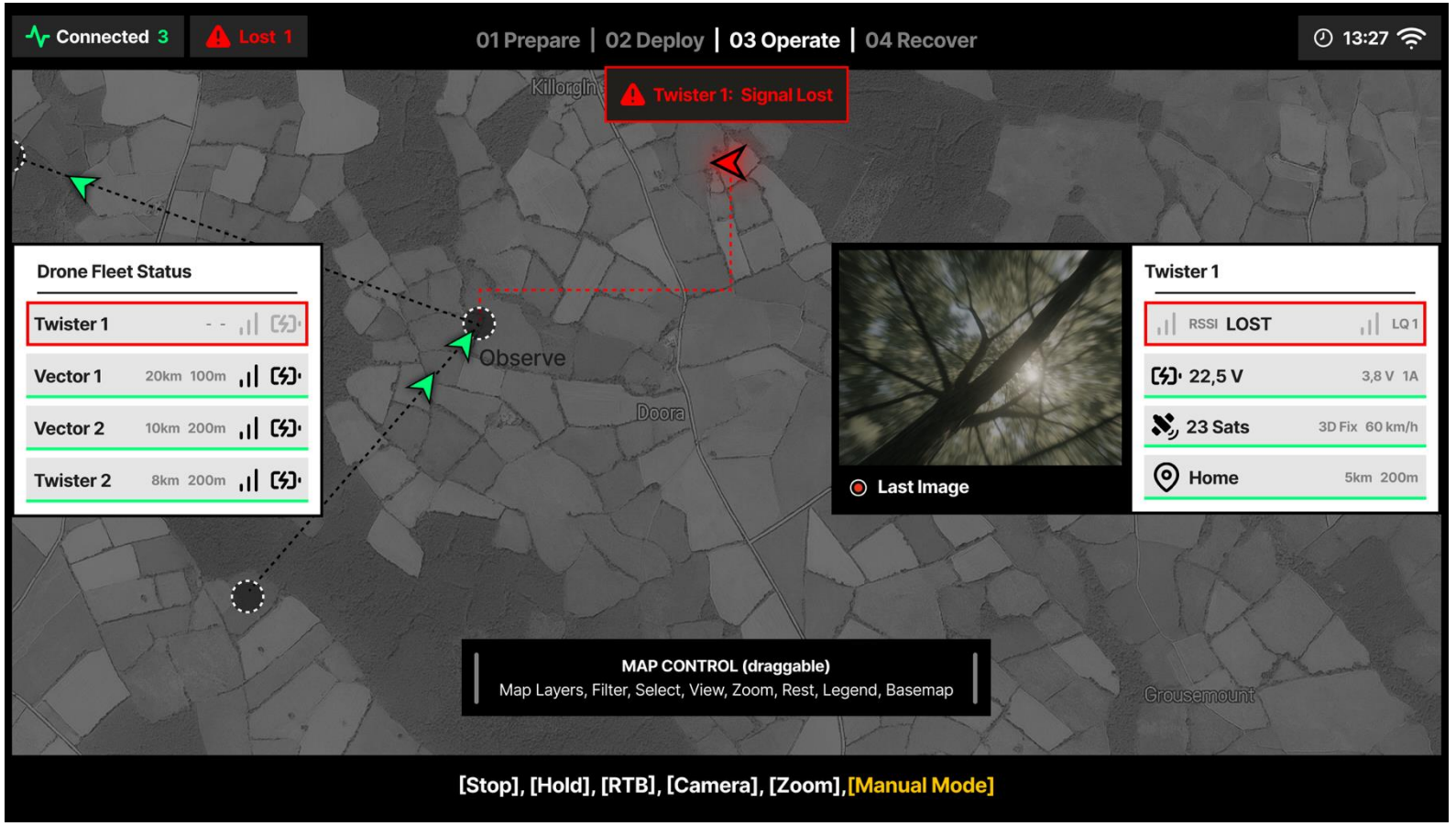

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→ Link breaks, UI shows last frame + red "Signal Lost" status.

Audio Feedback (Long)

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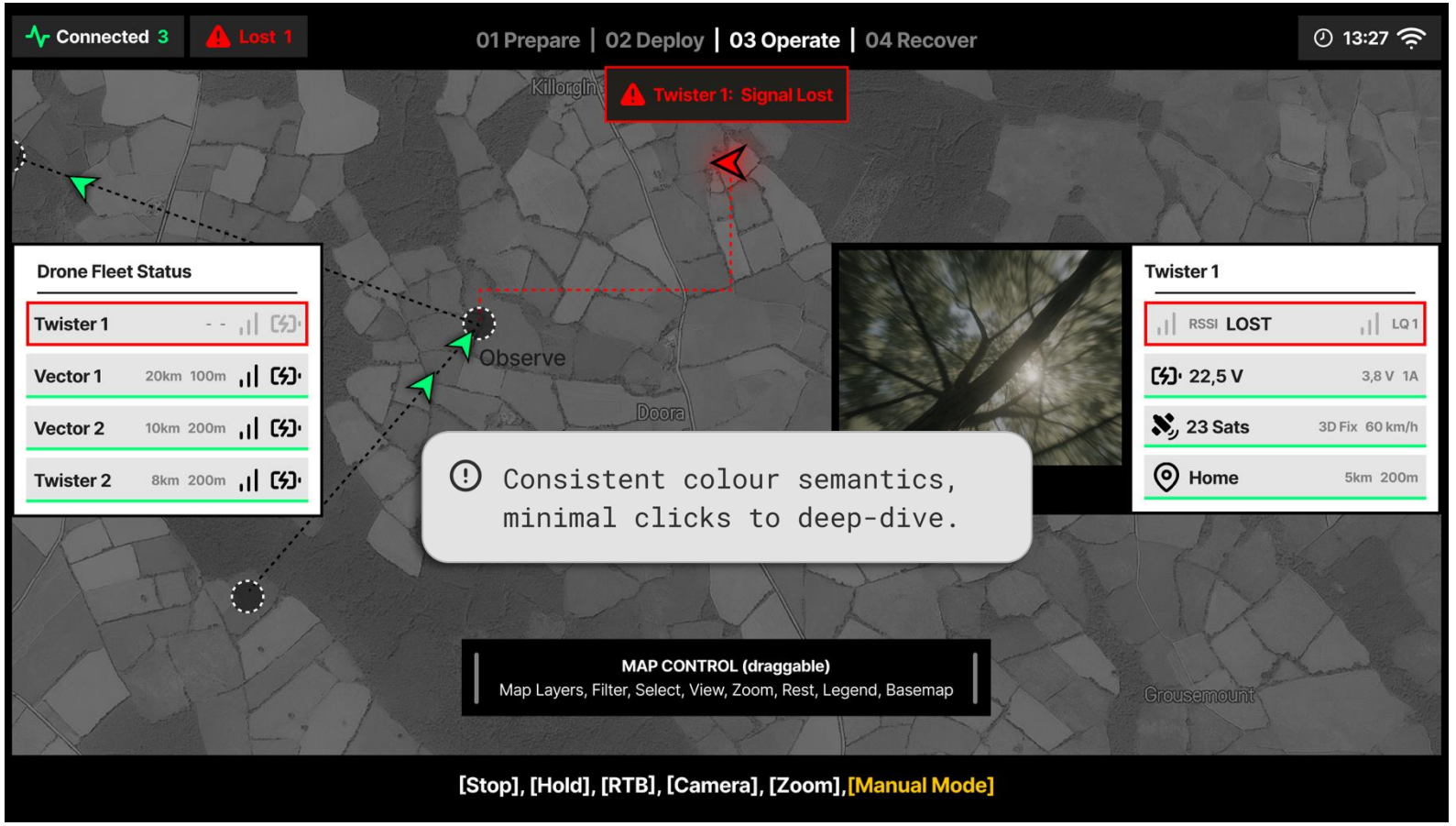

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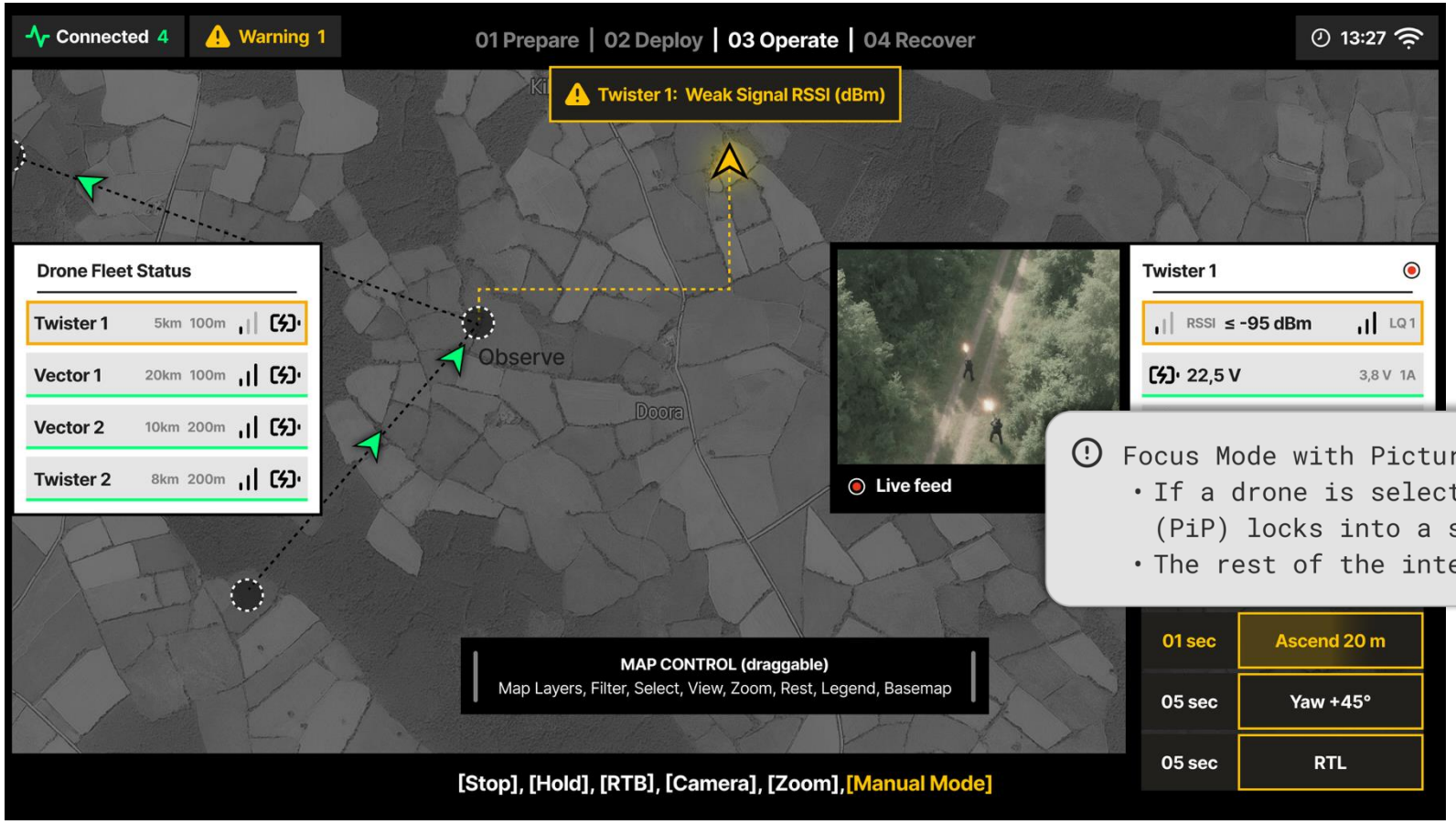
Audio Feedback (Long)

Wireframes – Real-Time Intervention

Problem: Interact or intervene with a specific drone when necessary, without losing overall situational awareness



➜ Tap the weak-signal drone in the fleet strip or switch to manual mode

Focus Mode with Picture-in-Picture

- If a drone is selected for deeper interaction, a mini live feed (PiP) locks into a screen corner.
- The rest of the interface stays fully navigable.

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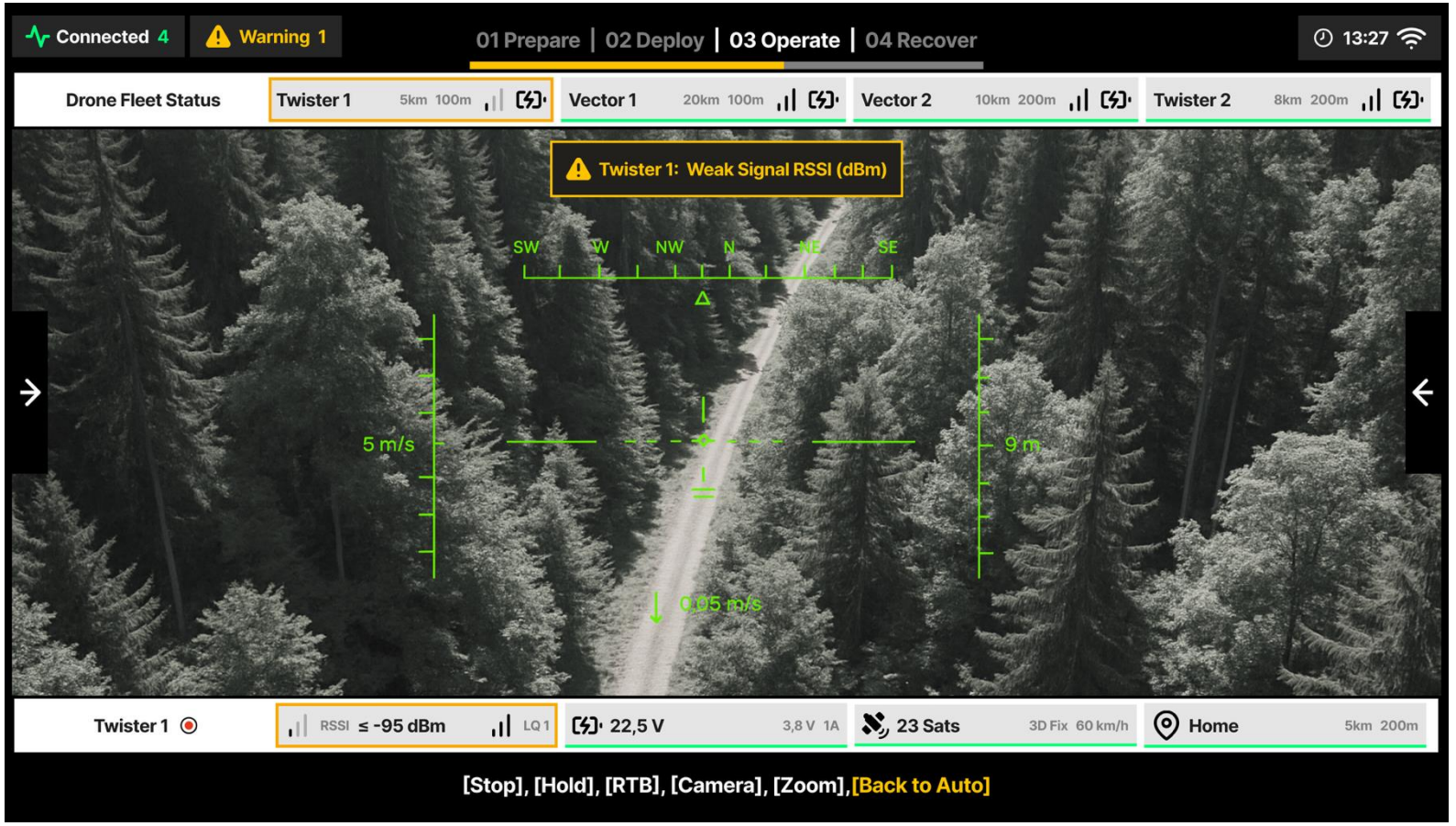

→ Tap the weak-signal drone in the fleet strip or switch to manual mode

→ the UI fans out a focused detail card and quick-action panel, yet the live HUD and the rest of the fleet remain on screen.

→ You can step in on Twister 1 without losing the big-picture view

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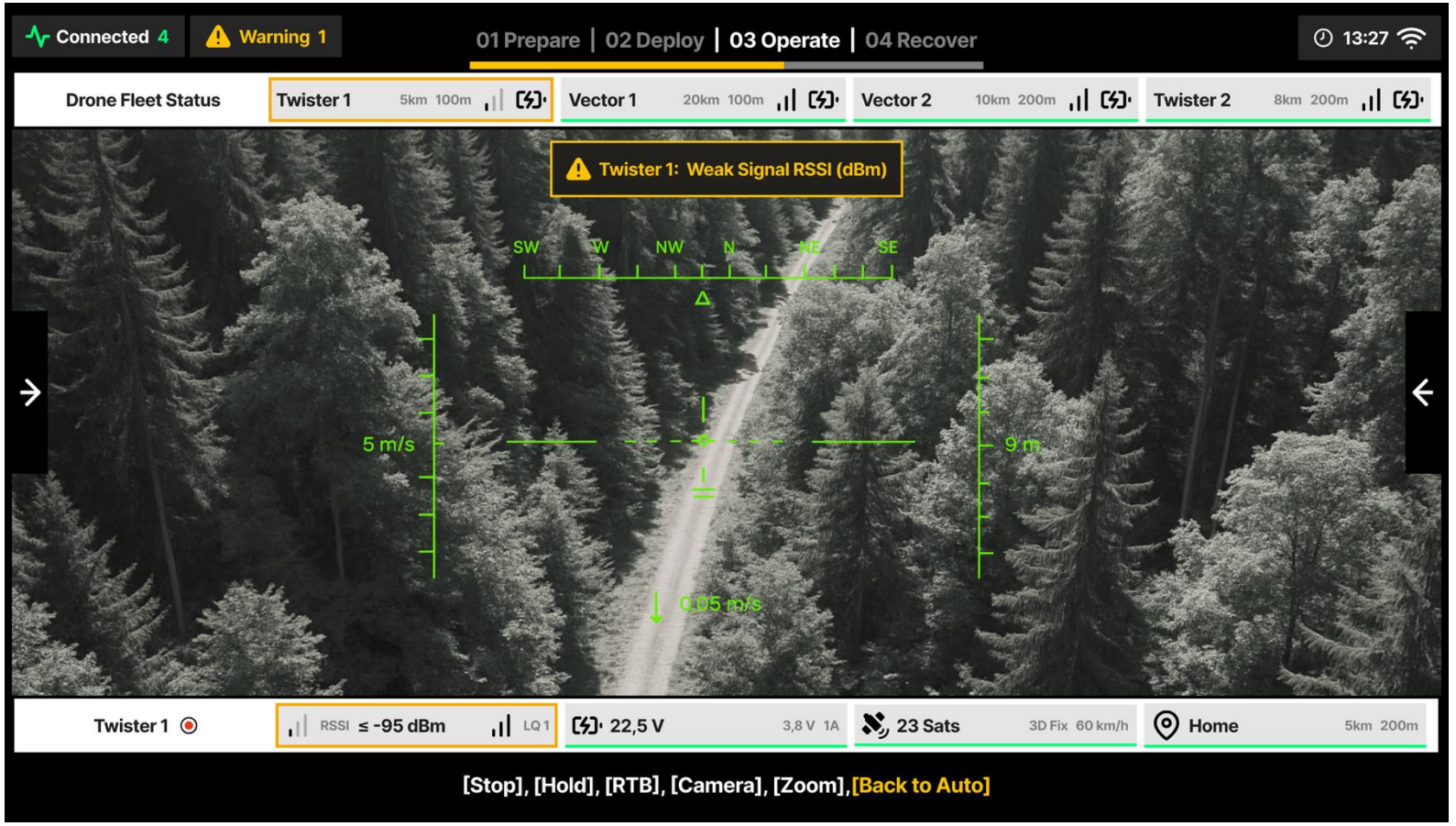

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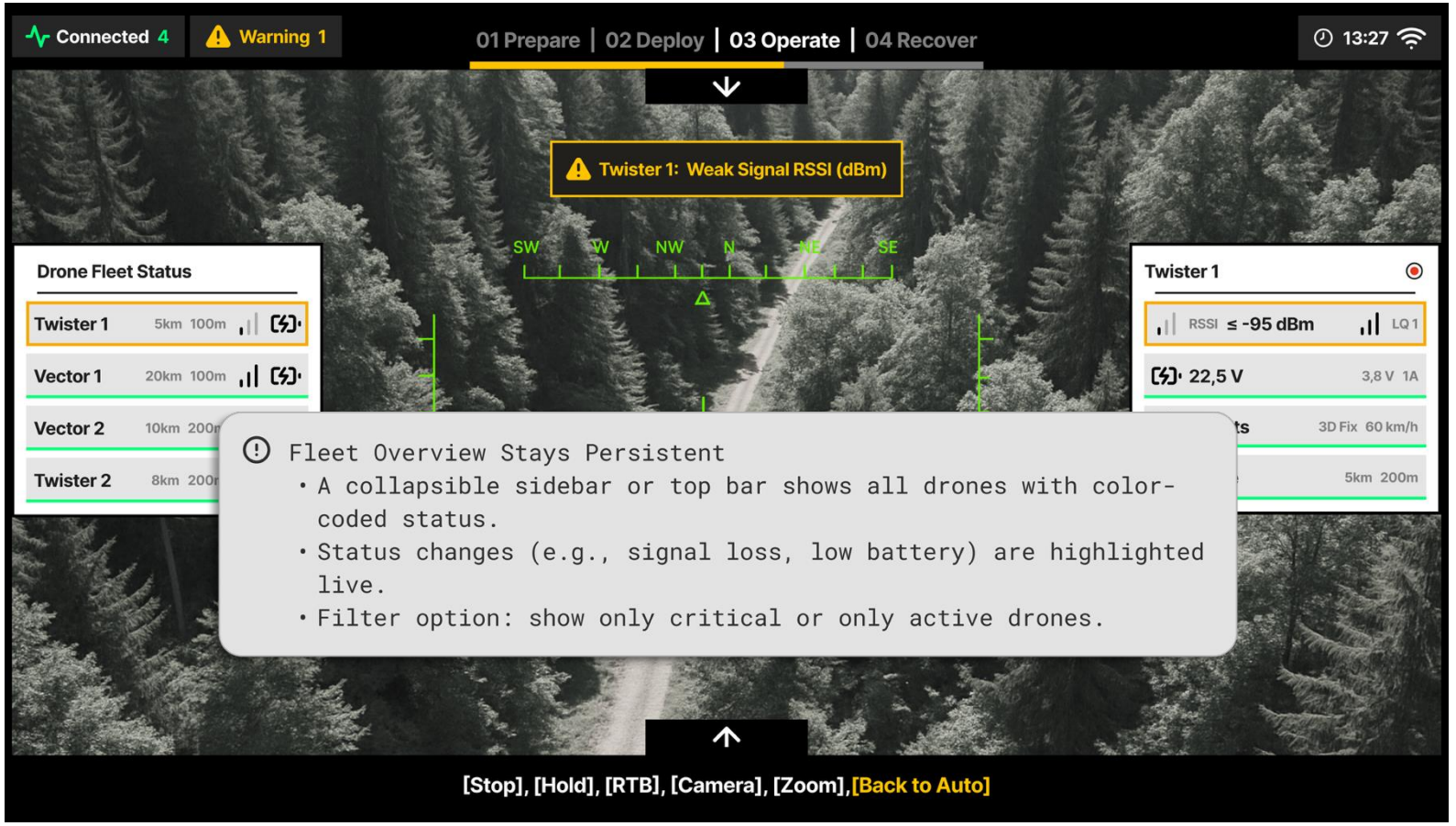
→ whether horizontal or lateral panels adapt to the user's field of vision or needs

Wireframes – Real-Time Intervention

Problem: Interact or intervene with a specific drone when necessary, without losing overall situational awareness



→ Tap the weak-signal drone in the fleet strip

→ the UI fans out a focused detail card and quick-action panel, yet the live HUD and the rest of the fleet remain on screen.

→ You can step in on Twister 1 without losing the big-picture view

→ whether horizontal or lateral panels adapt to the user's field of vision or needs

Journey Revisited:
Recover & Debrief

Why this structure works

- Matches operator’s mental model under pressure
- Enables phase-aware UI behavior (adaptive, not static)
- Clear entry/exit logic for each step → less cognitive load

Latency & Cognitive-Load Strategy

Gamified UX Principles Applied

Impact Metrics & Future Work

Key Take-aways & Next Steps

We can‘t wait to see what we will achieve together!