

# HMAA-UAV Governance Simulator

## Simulation User Guide

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# Document Control

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# 1. Purpose, Scope, and Assumptions

This guide provides operating procedures for the HMAA-UAV (Authority-Governed UAV Platform) simulation. The simulation implements the complete governance pipeline for unmanned aerial vehicle autonomy featuring 3D flight visualization, Extended Kalman Filter state estimation, SATA trust fusion across 8 sensor channels, HMAA authority computation, waypoint navigation, geofence enforcement, Return-to-Launch protocols, and ERAM escalation monitoring.

**Intended Audience:** EB2-NIW petition evaluators, defense/aerospace reviewers, academic peers, and technical collaborators seeking independent verification of governance pipeline behavior.

**Scope:** Operation of the HMAA-UAV Governance Simulator simulation. Does not cover mathematical theory (see published paper) or hardware specifications (see [Blueprint.am](#)).

## 1.1 Assumptions and Constraints

- The user has a modern browser with JavaScript enabled and HTTPS access.
- All parameter values are synthetic research placeholders, not calibrated against physical hardware.
- The simulation models governance logic only. Physical dynamics (aerodynamics, acoustics, electromagnetics) are simplified.
- Cryptographic operations (SHA-256 audit chain) use the WebCrypto API, not hardware TPM/HSM.
- Results are valid for demonstrating architectural behavior, not for operational safety assessment.

### IMPORTANT

This simulation is a research prototype. Not for operational planning, safety-critical decisions, or system certification. All parameters are synthetic.

## 2. Quick Start

**Step 1.** Open the simulation HTML file in Chrome over HTTPS.

**Step 2.** Review the interface panels and identify the main controls.

**Step 3.** Click RUN or START to begin the simulation loop.

**Step 4.** Observe the governance pipeline processing sensor inputs through all modules.

**Step 5.** Use export/download buttons to save session data as JSON for verification.

### NOTE

All computation runs client-side. No data leaves your browser. Requires HTTPS (not file://).

## 3. System Requirements and Security Considerations

Browser	Chrome 90+, Firefox 88+, Safari 15+, Edge 90+
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Protocol	HTTPS required (WebCrypto API for SHA-256 audit hashing)
Display	Min 1280x720; recommended 1920x1080+
CPU/Memory	Any modern processor. Monte Carlo (100+ runs): multi-core recommended, ~200MB RAM peak
GPU	WebGL-capable recommended for 3D visualizations (Three.js)
Network	Internet for initial CDN load (~500KB). All computation client-side after load.
Installation	None — zero install, no login, no backend, no database, no cookies

### 3.1 Security Considerations

- **No data exfiltration:** All computation runs in the browser. No data is sent to any server.
- **CDN dependencies:** React, ReactDOM, and Babel load from cdnjs.cloudflare.com (Cloudflare CDN with SRI hashes where available).
- **Audit integrity:** SHA-256 hash chain via WebCrypto API. Each audit entry links to the previous entry's hash. VERIFY button recomputes the entire chain.
- **No authentication:** The simulation has no login system. All state is ephemeral in browser memory.

## 4. Interface Layout and Navigation

### 4.1 Panel Layout

The interface features a 3D flight visualization with tabbed control panels. **3D View:** Three.js rendering of UAV, terrain, geofence boundary (cylinder), waypoints (spheres), and flight path trail. Camera orbits around the UAV. **Top Bar:** Eight tabs — SIM, SYSTEMS, MISSION, MAVLINK, PARAMS, SCENARIO, HIL, MAIVA. **SIM Panel:** Authority gauge, sensor trust array (8 channels), flight instruments (altitude, speed, heading), battery level, ERAM score. **MISSION Panel:** Waypoint editor with geofence radius and RTL altitude sliders. **SCENARIO Panel:** Fault injection toggles for GPS jam, IMU drift, barometer bias.

### 4.2 Navigation Tabs

SIM	Main dashboard: 3D view, authority gauge, sensor trust panel, flight instruments
SYSTEMS	Subsystem health: EKF, GPS, IMU, barometer, magnetometer, battery, comms
MISSION	Waypoint editor: set waypoints, geofence radius, RTL altitude, mission parameters
MAVLINK	MAVLink protocol monitor: heartbeat, system status, GPS fix, attitude
PARAMS	Configuration parameters: physics mode, control gains, sensor noise models
SCENARIO	Fault injection: GPS jam, IMU drift, barometer bias, magnetometer interference
HIL	Hardware-in-the-loop WebSocket bridge for MAVLink/ROS 2 integration
MAIVA	Multi-agent swarm coordination panel (when multiple UAVs are configured)

**TIP**

Hover over interface elements for tooltips. Most gauges include ARIA labels for screen reader accessibility.

## 5. Operating Procedures

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### 5.1 Startup

1. Navigate to the simulation URL or click Launch Simulation from burakoktenli.com.
2. Wait for loading (2-5 seconds). CDN scripts load from cdnjs.cloudflare.com.
3. Verify interface loads completely. All panels should be visible.

### 5.2 Standard Operation

1. Open the simulation via Launch Simulation or navigate to uav-simulation.html.
2. The 3D view initializes showing the UAV on the ground with the geofence boundary visible.
3. Click START MISSION in the SIM tab. The UAV takes off and begins waypoint navigation.
4. Monitor the sensor trust panel: 8 sensors (GPS, IMU, barometer, magnetometer, camera, LiDAR, optical flow, ESC) display real-time trust scores.
5. Switch to the SCENARIO tab and inject a GPS jam. Observe SATA cross-validation detecting the anomaly and HMAA reducing authority.
6. If authority drops below the RTL threshold, the UAV automatically initiates Return-to-Launch.
7. Use the MISSION tab to modify waypoints, geofence radius (default 150m), and RTL altitude (default 25m).
8. Switch to SYSTEMS to monitor EKF state estimation quality. Sensor faults degrade EKF confidence.
9. Toggle physics mode in PARAMS between simplified and full rigid-body dynamics.

### 5.3 Shutdown

1. Export session data. 2. Close browser tab (all state discarded).

**IMPORTANT**

State is not persisted. Export before closing to preserve results.

## 6. Parameter Reference

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Geofence Radius	MISSION tab	50 - 500m	150m	Distance boundary triggering RTL
RTL Altitude	MISSION tab	10 - 100m	25m	Return-to-Launch target altitude

Physics Mode	PARAMS tab	Simple/Full	Simple	Toggle rigid-body physics
Circle Altitude	Slider siCircleAlt	10 - 100m	varies	Orbit altitude for circle mode
Circle Radius	Slider siCircleR	20 - 200m	varies	Orbit radius for circle mode

**NOTE**

All defaults are synthetic. Replace with empirically derived values before operational use.

## 7. Scenario Reference

Continuous mode. Inject faults manually using controls in Section 5.

## 8. Metrics, Formulas, and Verification

### 8.1 Key Metrics

#### Flight Authority

HMAA-computed authority governing UAV operational capability. Below threshold triggers automatic RTL.

#### Sensor Trust Array

8-channel trust scores from SATA fusion: GPS (ZED-F9P), IMU (ICM-42688-P), barometer, magnetometer, camera (RealSense D435), LiDAR (TFmini-S), optical flow, ESC telemetry.

#### EKF State

Extended Kalman Filter position, velocity, and attitude estimates. Accuracy degrades with sensor faults.

#### ERAM Score

Escalation risk assessment monitoring cross-domain risk for the UAV platform.

#### Battery Level

Remaining battery capacity. Progressive depletion reduces authority as reserves decrease.

#### Geofence Status

Distance to boundary and violation status. Breach triggers immediate authority reduction and RTL.

### 8.2 Verification Checklist

Perform the following checks to verify correct simulation behavior:

Start simulation (RUN/START)	Interface loads. Governance pipeline begins processing.
Observe default state	Authority at nominal level. All pipeline stages PASS.

Inject a fault or attack	Authority reduces proportionally. Affected stage shows FAIL.
Monitor recovery	If CARA active, observe GREP recovery phases.
Export session data (JSON)	File downloads with parameters, history, and audit trail.
Reload and verify reproducibility	Same seed + params = identical outputs.

## 9. Data Export and Reproducibility

Click export/download to save session JSON with parameters, history, and audit trail.

**Verification:** 1) Export JSON. 2) Note PRNG seed. 3) Reload with same seed/params. 4) Verify bit-exact match.

### 9.1 Reproducibility Guarantee

PRNG	Mulberry32 (32-bit seeded)
Math.random()	Zero calls in computation paths
Cross-Browser	Verified: Chrome, Firefox, Safari, Edge
Cross-Platform	Verified: Windows, macOS, Linux
Audit Chain	SHA-256 via WebCrypto (SubtleCrypto API)

## 10. Limitations and Threat Considerations

Simulation-Only Evidence	Browser-based computation. No physical sensor data or hardware measurements.
Uncalibrated Parameters	All values are synthetic research parameters, not empirically derived.
No Real-Time Guarantees	JavaScript engine provides no timing guarantees for safety-critical operations.
Simulated Cryptography	SHA-256 uses WebCrypto. TPM/HSM operations are modeled, not hardware-backed.
Single-Session State	All state held in memory. Closing the tab discards all data.

### 10.1 Threat Considerations

- **CDN compromise:** React/Babel load from cdnjs.cloudflare.com. A CDN compromise could inject malicious code. Mitigation: Subresource Integrity (SRI) hashes on script tags where available.
- **Browser extensions:** Malicious extensions could modify simulation DOM/state. Mitigation: test in Incognito mode for clean results.
- **Local modification:** Users can modify simulation code via DevTools. Exported data should be verified against the published source on burakoktenli.com.

## 11. Troubleshooting

Black screen after loading	React render error or CSP violation	Open F12 Console for error details. Try Chrome Incognito mode.
Simulation runs slowly	CPU-intensive Monte Carlo or 3D rendering	Close other browser tabs. Reduce sample count.
Controls not responding	Browser tab lost focus	Click inside the simulation window. Ensure tab is active.
Export button not working	Pop-up/download blocked	Allow downloads from the simulation domain in browser settings.
Loading screen never completes	CDN scripts blocked by firewall/extension	Disable ad blockers. Allow cdnjs.cloudflare.com.

## 12. Glossary and References

### 12.1 Glossary

HMAA-UAV	HMAA-UAV (Authority-Governed UAV Platform)
SATA	Sensor Attestation and Trust Anchoring — trust fusion
HMAA	Human-Machine Authority Architecture — authority computation
CARA	Control Authority Regulation Architecture — recovery protocol
Authority Level	Computed governance authority (0.0-1.0) governing operational actions
PRNG	Pseudo-Random Number Generator — Mulberry32 seeded for reproducibility
Governance Pipeline	Sequential processing chain: SATA -> HMAA -> MAIVA -> FLAME -> CARA

### 12.2 References

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### 12.3 Contact

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For questions about this simulation or the governance architecture research program, use the contact form at [burakoktenli.com](https://burakoktenli.com).

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