BLADE-MARITIME Governance Simulator

Simulation User Guide

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1. Purpose, Scope, and Assumptions

This guide provides operating procedures for the BLADE-MARITIME simulation implementing maritime autonomous surface vehicle governance with 13 fault scenarios, GIUK Gap mission map, COLREGs compliance, hydroacoustic sonar model with thermocline/SVP effects, MAD (Magnetic Anomaly Detection), 3-link communications (SATCOM/HF/UHF), C2 dead-man switch, and HITL WebSocket bridge.

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 BLADE-MARITIME 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+
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 split-screen maritime operations display. **Left Panel:** GIUK Gap mission map showing ASV position, track contacts (AIS/sonar), detection zones, EEZ/UNCLOS boundaries, and COLREGs compliance indicators. **Right Panel:** Eight sensor sliders (Speed, Sonar SL, Range, MAD, AIS, GNSS, Radar, Wave Height), C2 heartbeat button, authority gauge, and governance pipeline status. **Tab Bar:** Seven tabs — Mission, Governance, Pipeline, Audit, Validation, Monte Carlo, Assurance. **Assurance Tab:** DO-178C certification evidence matrix, ROC curve, WCET analysis.

4.2 Navigation Tabs

Mission	GIUK Gap mission map with track positions, detection zones, and EEZ/UNCLOS boundaries
Governance	Authority computation, ROE decision matrix, and governance pipeline status
Pipeline	11-stage governance pipeline visualization with per-stage timing
Audit	Hash-chained audit trail with integrity verification
Validation	TLA+ invariant monitoring and formal property verification
Monte Carlo	Statistical analysis across multiple fault injection trials
Assurance	DO-178C / MIL-STD-882E certification evidence traceability matrix, ROC curve, WCET analysis

4.3 Panel Descriptions

Sensor Sliders. 8 sliders: Speed (sl_speed), Sonar Level (sl_SL), Detection Range (sl_R), MAD (sl_mad), AIS (sl_ais), GNSS (sl_gnss), Radar (sl_radar), Wave Height (sl_wave)

C2 Heartbeat. Dead-man switch for human operator presence. Loss triggers authority reduction.

Track Display. AIS and sonar contacts with classification (merchant, fishing, military, submarine)

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

5. Operating Procedures

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 blade-maritime-simulation.html.

2. Click RUN to start the maritime surveillance mission in the GIUK Gap.

3. Monitor the mission map: tracks appear as the ASV transits. Sonar contacts show detection probability based on SVP/thermocline model.

4. Adjust the sensor sliders to simulate varying conditions: increase wave height to degrade sonar, reduce GNSS to simulate GPS denial.

5. Click C2 HEARTBEAT to send a heartbeat pulse. If heartbeat is not maintained, the dead-man switch triggers authority reduction.

6. Inject Byzantine fault by clicking the B button. A compromised node is introduced. Click Restore B to remove it.

7. Switch to the Assurance tab to review the DO-178C certification evidence traceability matrix and ROC curve analysis.

8. Run Monte Carlo for statistical analysis of governance performance across multiple fault configurations.

9. Click HOLD to manually lock authority at the current level for inspection.

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

Speed	Slider sl_speed	0 - 25 kts	12	ASV speed in knots
Sonar Source Level	Slider sl_SL	100 - 220 dB	180	Active sonar source level
Detection Range	Slider sl_R	1 - 50 km	varies	Maximum detection range
MAD Sensitivity	Slider sl_mad	0 - 100%	varies	Magnetic anomaly detection sensitivity
AIS Coverage	Slider sl_ais	0 - 100%	varies	AIS transponder coverage percentage
GNSS Quality	Slider sl_gnss	0 - 100%	varies	GPS/GNSS signal quality
Radar Range	Slider sl_radar	0 - 100%	varies	Radar detection range percentage
Wave Height	Slider sl_wave	0 - 10m	varies	Sea state wave height

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

Maritime Authority

Operational authority for the autonomous surface vehicle. Governs engagement, navigation, and communication actions.

Sonar Performance

Detection probability modeled from source level, propagation loss, thermocline depth, and ambient noise. SVP (Sound Velocity Profile) affects acoustic ray paths.

MAD Detection

Magnetic anomaly detection score for submarine-class contacts. Effective range depends on magnetic signature and sensor sensitivity.

COLREGs Compliance

Collision regulation compliance status. Monitors right-of-way, crossing situations, and overtaking obligations.

ROE Matrix

Rules of Engagement authorization matrix: maps threat classification to permitted response actions.

Certification Evidence

DO-178C / MIL-STD-882E traceability matrix mapping requirements to verification evidence.

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

BLADE-MARITIME	BLADE-MARITIME
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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