[TECHNICAL PROJECT CATALOG · VERSION 2.0 · JULY 2026]

TECHNICAL PROJECT CATALOG & CAPABILITY OVERVIEW

Authority lifecycle governance infrastructure for safe autonomous systems. Seven governance architectures, twelve hardware platforms, nineteen reproducible simulations, and thirty-three public works, documented at their actual standing for technical review.

7	12	19	33	4	9
GOVERNANCE ARCHITECTURES	HARDWARE PLATFORMS	REPRODUCIBLE SIMULATIONS	PUBLIC WORKS & DEPOSITS	PROVISIONAL PATENTS	APPLICATION DOMAINS

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DOCUMENT CONTROL AND DISTRIBUTION

Document Title	Technical Project Catalog and Capability Overview
Program	AUTHREX (Authority Lifecycle Governance) research program
Author	Burak Oktenli, Independent Researcher, AI Governance and Safety-Critical Autonomous Systems
Imprint	Authority & Architecture (imprint of record)
Version / Date	Version 2.0, July 2026
Revision note	Version 2.0 is a full redesign and expansion pass: unified visual system, enlarged registers, per-item status labels, and consolidated evidence, alignment, and risk matrices.
Identifiers	ORCID 0009-0001-8573-1667 · burakoktenli.com · authrex.systems
Distribution	Public. Open distribution under Creative Commons Attribution 4.0 (CC BY 4.0).
Purpose	To present the author's systems, hardware platforms, simulations, and publications in a structured technical format suitable for review by defense, aerospace, infrastructure, and academic readers.

Notice. This is an independent research portfolio. It is not a government document and is not affiliated with, endorsed by, or produced for the U.S. Department of Defense or any other government agency. All maturity levels, validation states, and limitations are stated plainly so that a technical reviewer can assess the work on its actual standing. Capabilities described at low technology readiness levels are research artifacts, not fielded systems.

Reading note. Technology readiness level (TRL) follows the standard nine-point scale. Open-access deposits (Zenodo) and working papers (SSRN) are public disclosures with registered identifiers; they are not described as peer-reviewed. Provisional patent applications are unexamined filings, not granted patents.

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[PORTFOLIO INTRODUCTION]

EXECUTIVE OVERVIEW

This catalog documents the technical work of Burak Oktenli, an independent researcher in AI governance and safety-critical autonomous systems. The work is conducted under the AUTHREX research program and published through the Authority & Architecture imprint.

[THE PROBLEM]

Autonomous systems are increasingly asked to act faster than a human can supervise, on sensor data that may be degraded or deliberately corrupted, and no standardized architecture governs how authority is granted, constrained, and recovered as conditions change. Policy frameworks such as the NIST AI Risk Management Framework establish principles but do not enforce them in hardware. DoD Directive 3000.09 requires appropriate human judgment over the use of force but does not specify a technical enforcement mechanism. Planning-layer safety systems constrain behavior but do not govern whether a command reaches an actuator. This work proposes an architecture for that missing enforcement layer.

[THE CONTRIBUTION]

Authority itself is treated as an engineered lifecycle. Sensor trust is computed continuously, converted into a graded authority level, screened for adversarial deception, reconciled across multiple agents, gated by a deliberation window before irreversible action, and recovered deterministically to a safe state when trust collapses. The same pipeline applies across nine application domains without retraining the underlying autonomy.

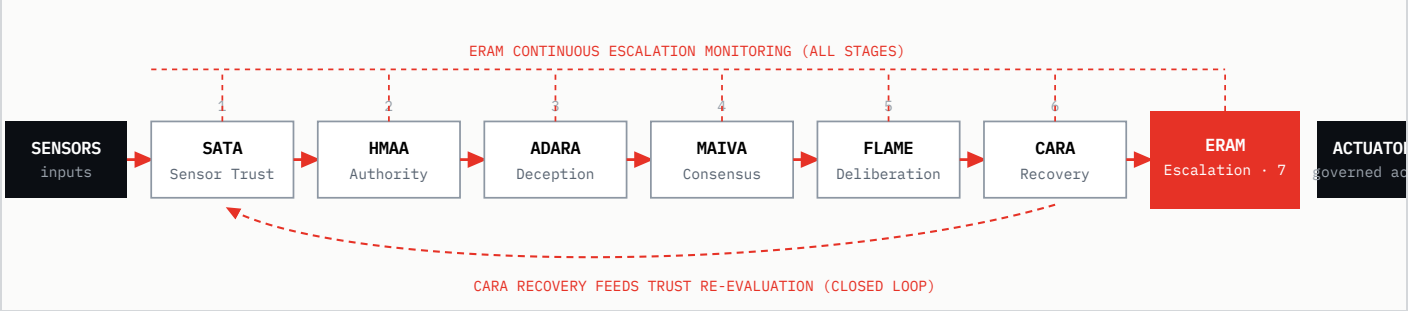


Figure 1. The AUTHREX seven-stage authority lifecycle. Sensor inputs enter at left; governed action exits at right. ERAM monitors all stages continuously, and CARA recovery feeds back into trust re-evaluation, forming a closed loop rather than a one-shot pipeline.

[WHAT THIS CATALOG CONTAINS]

Seven governance architectures, twelve hardware research platforms, six software reference architectures, nineteen browser-based simulations, thirty-three public technical works, four provisional patent applications, and a ten-volume technical reference series. These artifacts share one architectural foundation and are documented individually with maturity, evidence, and domain relevance consolidated in the matrices of Sections 13 through 15.

[SCOPE]

SYSTEM BOUNDARY AND READINESS STATEMENT

The scope of the work is specific. AUTHREX governs the path between the autonomy software and the actuator; it does not replace the autonomy and does not make targeting or mission decisions. Figure 2 shows that boundary, including the hardware interlock and the operator, so a reviewer can see exactly what the architecture controls and what remains outside it.

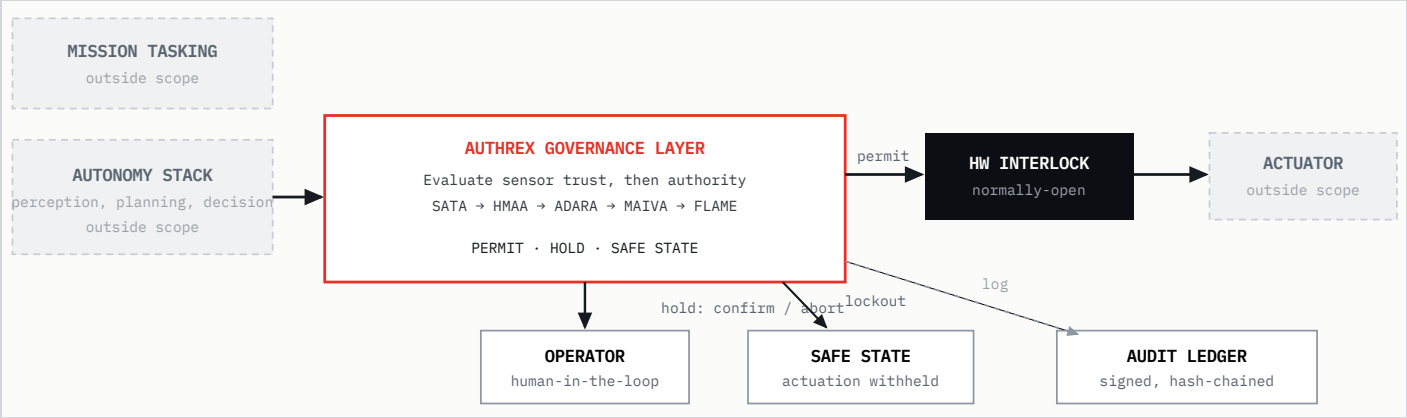


Figure 2. AUTHREX system boundary. The autonomy stack proposes an action; the governance layer evaluates trust and authority and either permits, holds for operator confirmation, or commands a safe state; a hardware interlock sits between the decision and the actuator; every decision is written to an audit ledger. Autonomy logic, mission tasking, and the physical actuator remain outside the governance scope.

[WHY THE WORK MAY BE RELEVANT]

The architecture maps onto stated public priorities: autonomous-weapons human-control requirements (DoD Directive 3000.09); trustworthy AI in critical infrastructure (NIST AI RMF); automated-vehicle safety and false vehicle-control commands (NHTSA framework and the SELF DRIVE Act of 2026, H.R. 7390); orbital autonomy under signal delay (NASA SBIR EXPAND.3.S26B and Space Policy Directive 5); safe adoption of agentic AI (CISA, NSA, and Five Eyes guidance, May 2026); counter-unmanned-aircraft authority (Executive Order 14305 and the FY26 NDAA); and operational-technology security (NIST SP 800-82, ISA/IEC 62443, NERC CIP). The work is structured so that future evaluation can be mapped against DO-178C and DO-333 for airborne software, MIL-STD-882E for system safety, and ISO 26262 for automotive.

[HONEST READINESS STATEMENT]

The program is at an early technology readiness level, generally TRL 2 to 4. Simulations demonstrate the governance logic with seeded, reproducible runs, and the HMAA authority state machine is formally verified in TLA+ (48,751 reachable states, 8 safety properties). The hardware platforms are specified to the bill-of-materials level but are not yet built. Independent peer review and red-team evaluation are planned, not complete. The concept addresses a defined governance gap and the architecture is internally consistent; it is not yet proven, deployment-ready infrastructure, and this catalog does not present it as such.

[PORTFOLIO STRUCTURE]

CAPABILITY AREAS AND APPLICATION DOMAINS

The portfolio organizes into the capability areas below. Only areas genuinely supported by the work are listed; each is cross-referenced in the readiness, evidence, and alignment matrices.

CAPABILITY AREA	SYSTEMS IN THIS CATALOG	CURRENT MATURITY
AI and Autonomy Governance	AUTHREX pipeline; SATA, HMAA, ADARA, MAIVA, FLAME, CARA, ERAM	Research / simulation-demonstrated
Human-Machine Systems	HMAA; FLAME deliberation gating	Research / simulation
Defense Technology	BLADE-EDGE, BLADE-CUAS, BLADE-SWARM, BLADE-AGENT-HSM	Design complete / BOM-specified
Cyber and Security	AUTHREX-AGENT, AUTHREX-AGENT-CYBER, AUTHREX-ASSURE	Reference architecture
Resilient Infrastructure	BLADE-INFRA, BLADE-INFRA-OT, AUTHREX-ICS-GATE	Design / reference
Space and Aerospace	BLADE-SPACE, AUTHREX-SPACECYBER	Preliminary design (TRL 2-3)
Economic and Supply-Chain Security	BLADE-FINANCE	Simulation (synthetic data only)
Simulation Systems	ERAM Strategic Command, JADC2 Theater, MDO Testbed, and others (19 total)	Operational research tools
Technical Research and Publications	33 publications, 4 provisional patents, 10-volume reference series	Published / disclosed

[NINE APPLICATION DOMAINS · ONE GOVERNANCE LOGIC]

The same seven-stage governance logic is instantiated against nine distinct application domains with domain-specific sensors, standards, and hardware. This breadth is the basis for describing AUTHREX as a cross-domain governance architecture rather than a single-domain product.

AIRCRAFT
Flight control integrity

GROUND VEHICLE
Drive-by-wire safety

MARITIME USV/UUV
Surface and subsurface

DEFENSE UAS
Targeting authority

POWER GRID
ICS / SCADA control

SPACE / ORBITAL
Onboard autonomy

AGENTIC AI
Tool-use governance

CYBER-DEFENSE
Autonomous patching

CRITICAL OT
IT / OT boundary

AI AND AUTONOMY: AUTHORITY GOVERNANCE

SYSTEM · UNIFIED GOVERNANCE PIPELINE

AUTHREX Integrated Authority Lifecycle

RESEARCH ARCHITECTURE · TRL 3-4

[PROJECT STATUS]

Research architecture integrating seven published frameworks. Demonstrated in seeded, reproducible simulation runs; formally verified in part. Not deployed.

[SUMMARY]

AUTHREX is a governance layer that sits between an autonomous system's decision logic and its actuators. It does not make the system more intelligent. It determines, in real time, whether the system is permitted to act, under what authority, and what happens when trust degrades. The intelligence stays in the autonomy; the authority is governed.

[TECHNICAL DESCRIPTION]

SATA computes a continuous sensor-trust scalar using weighted Dempster-Shafer fusion. HMAA converts trust and context into a graded authority level via a finite-state machine. ADARA reduces authority when deception is likely. MAIVA reconciles authority across agents using Byzantine fault-tolerant voting (3f+1). FLAME imposes a deliberation window scaled to consequence before irreversible actions. CARA executes deterministic recovery to safe states on lockout. ERAM monitors all stages and assesses escalation risk. Enforcement is designed to terminate at a hardware boundary, a normally-open relay between decision logic and actuator, so that compromise of the software stack does not by itself permit actuation.

[KEY CAPABILITIES]

- Graded, non-binary authority proportional to real-time trust
- Continuous per-source sensor-trust assessment (Dempster-Shafer)
- Adversarial deception screening before authority is committed
- Byzantine-resilient multi-agent consensus (f faults in 3f+1)
- Consequence-scaled deliberation gating; deterministic recovery
- Cryptographically signed decision audit chain (ECDSA P-256)

[INTENDED USE CASES]

- Defense autonomy authority gating (Replicator-class mass, CCA)
- Automotive driver-assist handoff on an ASIL-D pathway
- ICS / SCADA and IT/OT boundary command adjudication
- Orbital autonomy under ground-loop signal delay
- Agentic-AI tool-use containment
- Counter-UAS detection-to-authority handoff

VALIDATION: 2,800+ SIM RUNS ON FLIGHT-RELEVANT PLATFORMS, NO UNSAFE ACTIONS IN SIMULATION · HMAA TLA+ VERIFIED

NO HIL · NO INDEPENDENT RED-TEAM YET

SEVEN FRAMEWORKS, ONE LIFECYCLE

CODE	NAME	FUNCTION	IP / DISCLOSURE	VALIDATION TO DATE
SATA	Sensor Attestation and Trust Anchoring	Continuous sensor-trust scalar via weighted Dempster-Shafer fusion	U.S. Provisional 64/002,453	Sim + TPM-anchor design
HMAA	Human-Machine Authority Architecture	Graded four-level authority (A3-A0) with asymmetric hysteresis	U.S. Provisional 63/999,105	TLA+ verified (48,751 states)
ADARA	Adversarial Deception-Aware Risk Architecture	Authority adjustment by deception prior P(adversarial)	Zenodo deposit	Simulation
MAIVA	Multi-Agent Integrity Verification Architecture	Byzantine-resilient consensus (3f+1), CUSUM detection	Zenodo deposit (MIT)	TLA+ spec, 37 self-tests
FLAME	Flash War Latency Architecture	Consequence-scaled deliberation window; 5-state circuit breaker	U.S. Provisional 64/005,607	Simulation
CARA	Control Authority Regulation Architecture	Deterministic GREP-phase recovery; terminal policy gate	U.S. Provisional 64/000,170	10M-iteration verification
ERAM	Escalation Risk Assessment Model	Escalation-risk quantification for AI-enabled command and control	SSRN working paper	Sim (600 Monte Carlo runs)

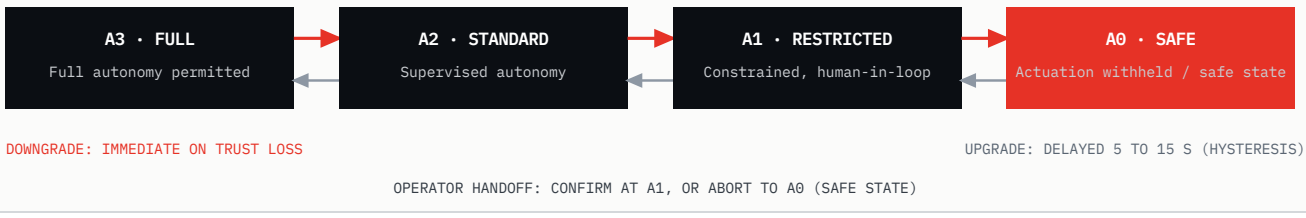


Figure 3. HMAA graded authority levels with asymmetric hysteresis and the operator handoff path. Downgrade is immediate on loss of trust; upgrade is delayed to prevent oscillation. At the restricted level the operator confirms or aborts; the lowest level withholds actuation and commands a safe state.

Reviewer note: the novel element across the register is the treatment of authority as an engineered, trust-proportional lifecycle with formal and hardware anchoring, rather than a binary safety override. Current standing is pre-hardware and pre-independent-review; assess as research architecture, not fielded capability.

[FRAMEWORK PROFILES]

SATA · HMAA · ADARA · MAIVA

SATA · Sensor Attestation and Trust Anchoring

Prov. 64/002,453 (filed 11 Mar 2026) · DOI 10.5281/zenodo.18936251

Foundation trust layer. Produces a continuous trust scalar in the interval zero to one from a hardware-anchored attestation chain, using weighted Dempster-Shafer belief functions across four diagnostics: internal consistency, cross-sensor agreement, temporal stability, and physical plausibility. Every downstream stage consumes this scalar.

HMAA · Human-Machine Authority Architecture

Prov. 63/999,105 (filed 7 Mar 2026) · DOI 10.5281/zenodo.18861653

Converts trust and operational context into a graded, four-level authority state (A3 through A0) with asymmetric hysteresis: authority is reduced immediately on trust loss and restored only after a sustained delay of roughly 5 to 15 seconds. Implemented as a 42-file package with 98 tests and formally verified in TLA+ across 48,751 reachable states and 8 safety properties using the TLC model checker.

ADARA · Adversarial Deception-Aware Risk Architecture

DOI 10.5281/zenodo.19043924

A proactive deception prior that adjusts authority downward in proportion to the probability that inputs have been manipulated. P(adversarial) is computed from input anomalies, temporal correlation, cross-sensor consistency, and Bayesian mission history, with a phantom-fleet module to resist AI-hallucinated or fabricated hostile scenarios.

MAIVA · Multi-Agent Integrity Verification Architecture

DOI 10.5281/zenodo.19015517 · MIT license

Byzantine-resilient aggregation of authority across multiple agents using a trimmed weighted median resistant to f adversaries in a 3f+1 roster, with CUSUM-augmented anomaly detection and DoDD 3000.09 action-gate classification. Carries a TLA+ specification and 37 self-tests.

[FRAMEWORK PROFILES]

FLAME · CARA · ERAM

FLAME · Flash War Latency Architecture

Prov. 64/005,607 (filed 14 Mar 2026) · DOI 10.5281/zenodo.19015618

Treats strategic latency as an engineered system. Before any irreversible action, FLAME imposes a mandatory deliberation window sized by a dynamic delay function over authority, consequence tier, and domain. A five-state circuit breaker with cryptographically signed transitions enforces the delay. The fail-safe default on timeout is abort, not execute.

CARA · Control Authority Regulation Architecture

Prov. 64/000,170 (filed 9 Mar 2026) · DOI 10.5281/zenodo.18917790

Deterministic recovery from authority lockout through GREP phases (Guard, Reduce, Evaluate, Promote) with a terminal non-compensatory policy gate, so that recovery cannot be short-circuited by a single favorable signal. Verified by 10-million-iteration enumeration and a 68-state control-flow analysis.

ERAM · Escalation Risk Assessment Model

SSRN ID 6176802 · working paper

Quantifies decision-time compression and escalation pathways in AI-enabled command and control, modeling how local autonomous actions cascade across domain boundaries. Implemented as the ERAM Strategic Command simulation with 600 Monte Carlo runs and cryptographic provenance.

[TECHNOLOGY READINESS POSITION]

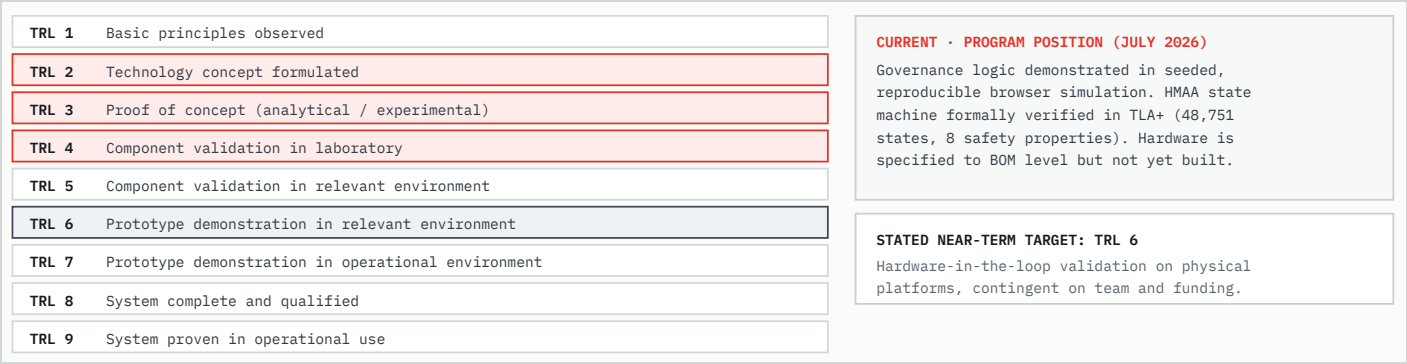


Figure 4. Technology readiness position. Governance logic is demonstrated in reproducible simulation and, for HMAA, in formal verification (TRL 2 to 4). Hardware platforms are specified to the bill-of-materials level but are not yet built. The stated near-term target is TRL 6 through hardware-in-the-loop validation.

BLADE HARDWARE GOVERNANCE PLATFORMS

The BLADE family instantiates the governance pipeline as domain-specific hardware nodes. Each platform is published as a reproducible artifact package with a full bill of materials, interface documentation, and simulation data. All platforms share one pipeline architecture, which is the basis for cross-domain reuse.

DIRECTED-ENERGY DEFENSE · REFERENCE HARDWARE

BLADE-EDGE Governance Node

DESIGN COMPLETE · TRL 3

BLADE-EDGE · REFERENCE HARDWARE INSTANTIATION OF THE AUTHREX PIPELINE

[PROJECT STATUS]

Design complete; prototype specification. Bill of materials defined; not built.

[SUMMARY]

A ruggedized edge-computing governance node that hosts the full nine-module governance pipeline for defense platforms, including directed-energy effectors. The normally-open safety interlock is designed so that an effector cannot fire without governed authorization, even under software compromise.

[TECHNICAL DESCRIPTION]

Dual-redundant NVIDIA Jetson AGX Orin compute paired with dual Xilinx Zynq UltraScale+ FPGAs. Nine-module pipeline (SATA, ADARA, IFF, HMAA, MAIVA, FLAME, CARA, battle-damage assessment, effector gate). 72 components, 103 connections, MIL-STD-810G environmental design target, hardwired normally-open safety interlock relay.

[EVIDENCE]

Zenodo deposit DOI 10.5281/zenodo.19177472; full bill of materials, interface control documentation, and nine-module pipeline specification; reference cost approximately 139,000 dollars.

[LIMITATIONS & REVIEWER NOTE]

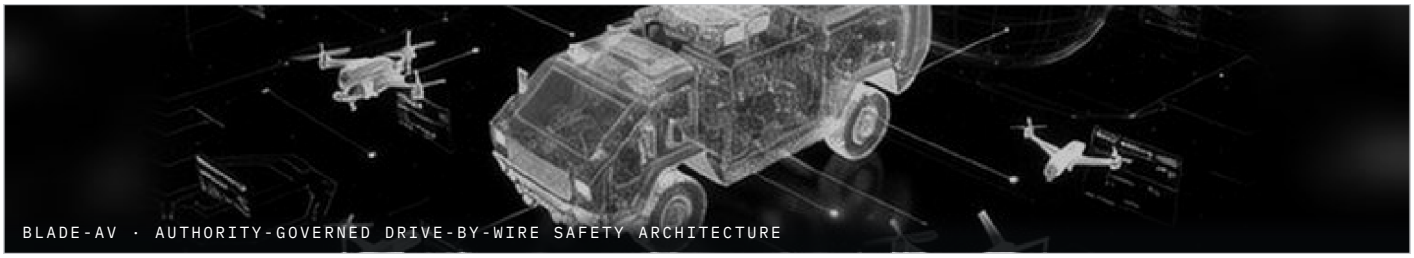
Highest-cost platform and not built. Effector-governance claims rest on simulation and design analysis; the MIL-STD-810G rating is a design target, not a test result. The most developed hardware reference design in the portfolio and the basis for cross-domain reuse (roughly 75 percent reuse into BLADE-CUAS). Read as a detailed reference design pending build and test.

BLADE HARDWARE GOVERNANCE PLATFORMS

AUTOMOTIVE DRIVE-BY-WIRE · ISO 26262 ASIL-D PATHWAY

BLADE-AV Governance Node

PUBLISHED · TRL 3-4



[PROJECT STATUS]

Published on Zenodo. Design complete and demonstrated in simulation; hardware not built.

[MISSION RELEVANCE]

Addresses a structural gap in driver-assist and automated-driving safety. NHTSA documented 1,429 automated-vehicle incidents between 2021 and 2025, and the SELF DRIVE Act of 2026 (H.R. 7390) requires cybersecurity plans for false vehicle-control commands. BLADE-AV is a reference architecture for hardware-enforced command governance.

[TECHNICAL DESCRIPTION]

Nine-module pipeline on Jetson AGX Orin plus Zynq UltraScale+. Three-leg redundant KILOVAC LEV200 fail-safe relay. 62 components. Trust-driven forced driver handoff and brake-to-stop-in-lane degradation. ISO 26262 ASIL-D and SAE J3016 Level 4 design targets.

[EVIDENCE]

Zenodo deposit DOI 10.5281/zenodo.19232130; 1,200 simulation runs with no unsafe actions recorded in simulation; reference cost approximately 16,300 dollars. A co-authored journal manuscript is in preparation with Dr. Victor Lian (Lynn University).

[VALIDATION & LIMITATIONS]

1,200 reproducible simulation runs; cross-domain portability demonstrated in simulation against BLADE-EDGE. No vehicle integration; ASIL-D is a target pathway, not a certification; the journal manuscript is in preparation and is not a published, peer-reviewed paper.

[REVIEWER NOTES]

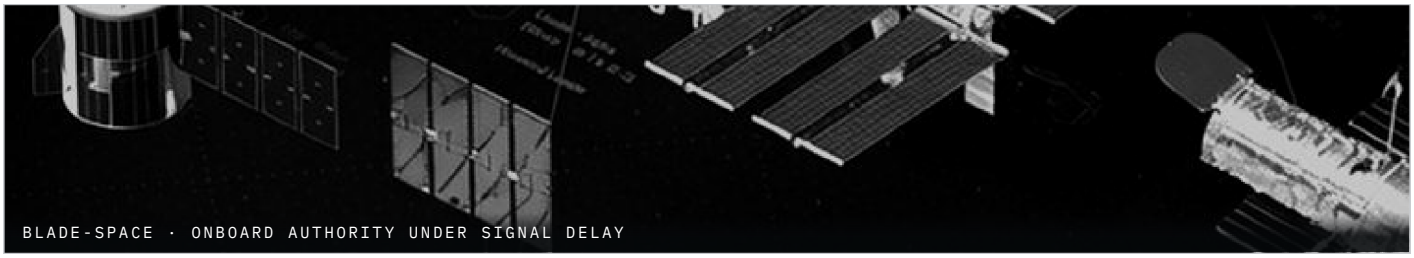
Strong simulation evidence and a clear certification pathway. Published as an artifact but remains pre-hardware. Development path: bench integration of the fail-safe relay, hardware-in-the-loop with a drive-by-wire rig, completion of the co-authored manuscript.

BLADE HARDWARE GOVERNANCE PLATFORMS

ORBITAL LEO AUTONOMY · NASA SBIR TOPIC MAPPING

BLADE-SPACE Governance Node

PRELIMINARY DESIGN · TRL 2-3



BLADE-SPACE · ONBOARD AUTHORITY UNDER SIGNAL DELAY

[PROJECT STATUS]

Preliminary design phase. Engineering package complete; verification and validation specified but not executed.

[MISSION RELEVANCE]

Potentially relevant to NASA SBIR subtopic EXPAND.3.S26B, where onboard authority governance supports autonomous onboard health management for small spacecraft and distributed systems, and to Space Policy Directive 5. Addresses autonomous conjunction-avoidance and payload-firing decisions made on stale or spoofed orbital data.

[TECHNICAL DESCRIPTION]

Microchip RTG4 radiation-tolerant FPGA plus Aitech S-A1760 Venus single-board computer in hot redundancy with sub-200-millisecond failover. Nine-stage pipeline. ECDSA P-256 audit chain anchored in a radiation-tolerant TPM. Three-fault-tolerant payload and thruster firing interlock. ADARA multi-constellation GNSS spoofing detection. 91 components, 6U-plus SmallSat payload module, 30 krad total ionizing dose, five-year design life.

[EVIDENCE]

Zenodo deposit DOI 10.5281/zenodo.20183269; 15-document engineering package; reference cost approximately 505,000 dollars.

[VALIDATION & LIMITATIONS]

Preliminary design with a 15-document package. The verification and validation campaign is specified but not executed; no platform-level simulation campaign completed. The earliest-maturity hardware platform.

[REVIEWER NOTES]

A thorough preliminary design and the least mature platform. Treat as a design study with a defined but unexecuted validation plan. Development path: execute the specified V&V, build the orbital simulation campaign, pursue NASA SBIR alignment.

[PLATFORM PROFILES]

ROVER · UAV · MARITIME · INFRA

Rover Testbed

Design complete, build in progress · DOI 10.5281/zenodo.19143190 · ~$484

A low-cost reference testbed for authority-governed autonomy. Dual compute (Raspberry Pi 5 and ESP32) running the SATA-HMAA-CARA pipeline; 37 verified components, 76 electrical connections, 7 fault scenarios. 350 simulation runs recorded no unsafe actions in simulation; the HMAA state machine is TLA+ verified.

Robotics testbed · ROS 2 · TRL 3-4

HMAA-UAV Platform

Design complete, build in progress · DOI 10.5281/zenodo.19128769 · ~$4,200

Trust-governed flight autonomy for contested environments. Cube Orange+ flight controller with an NVIDIA Jetson Orin NX companion and a MAVLink hardware-in-the-loop bridge; 52 components. 250 simulation runs across 5 adversarial scenarios, with a Monte Carlo campaign.

UAS testbed · ArduPilot · TRL 3-4

BLADE-MARITIME

Published · DOI 10.5281/zenodo.19246785 · ~$43K

Maritime surveillance governance with hydroacoustic sonar, magnetic anomaly detection, and AIS spoofing detection. Four maritime mathematical extensions include sea-state authority damping and acoustic-delay-aware Byzantine consensus. 84 components, IP68 enclosure, MIL-STD-810G and MIL-STD-461G CE102 design targets.

Maritime (surface / subsurface) · TRL 3 (design complete)

BLADE-INFRA

Published · DOI 10.5281/zenodo.19277887 · ~$11.6K

Critical-infrastructure protection node for ICS and SCADA, power-grid monitoring, water treatment, and pipeline operations. IEC 61850 GOOSE, Modbus TCP/RTU, and PROFINET IO; Pilz PNOZ S7.1 SIL-3 safety relay; 92 components; SIL 3, NERC CIP, and FIPS 140-2 Level 3 design targets.

Critical infrastructure · TRL 3 (design complete)

[PLATFORM PROFILES]

CUAS · AGENT-HSM · SWARM · INFRA-OT · FINANCE

BLADE-CUAS

DOI 10.5281/zenodo.20299604 · ~$43.5K · TRL 2-3 hw / 3-4 sim

Passive counter-UAS governance placed between commercial detection sensors and authorized operators. Four-level HMAA federal-to-SLTT authority handoff; Dempster-Shafer consensus across radar, RF, EO/IR, Remote ID, and LIDAR; ECDSA P-256 tamper-evident evidence record. Aligned with Executive Order 14305 and the FY26 NDAA Safer Skies Act; approximately 75 percent design reuse from BLADE-EDGE.

Counter-UAS · sixth domain instantiation

BLADE-AGENT-HSM

DOI 10.5281/zenodo.20299821 · ~$199 · TRL 2-3 silicon / 3-4 emulator

Tamper-evident hardware root of trust for autonomous agents and the hardware companion to the AUTHREX-AGENT shim. Non-exportable ECDSA P-256/P-384 keys in an NXP EdgeLock SE051 (CC EAL6+); four-level authority state in an Infineon SLB 9670 TPM 2.0; HKDF per-tool tokens; multi-modal tamper cascade that zeroizes keys. Five-opcode 64-byte ABI in USB-A and M.2 Key-E form factors; verified by an adversarial emulator (275 of 275 deterministic checks).

Agentic-AI root of trust · first HSM in the family

BLADE-SWARM

DOI 10.5281/zenodo.20351198 · ~$1,333/node · TRL 3-4 sim / 2 testbed

Authority governance for attritable multi-agent swarms. Byzantine-fault-tolerant two-phase consensus gated by SATA, HMAA, and MAIVA across N = 10, 50, and 500 agents, tolerating f = (N-1)/3 compromised agents per quorum with a quorum-intersection bound and safe-halt-by-default under denied RF. Per-node ECDSA P-256 root of trust and a hash-chained audit ledger; TLA+ verified (5 safety, 3 liveness). Governs decision authority and audit, not weapons.

Swarm autonomy · multi-agent extension of HMAA-UAV

BLADE-INFRA-OT

DOI 10.5281/zenodo.20342067 · ~1U appliance · TRL 2-3 hw / 3-4 sim

A fail-closed, bump-in-the-wire governance appliance at the IT/OT segmentation boundary. Each cross-boundary command is adjudicated to propagate, hold for deliberation, or isolate across four OT regimes (nominal, elevated, lockdown, safe-halt); malformed input fails closed. Xilinx Kria K26 governance plane and x86 network plane; 48 BOM line items; SHA-256 tamper-evident audit ledger.

Operational technology · OT companion to BLADE-INFRA

BLADE-FINANCE

DOI 10.5281/zenodo.20374692 · ~$9,228 · TRL 3-4 sim / 2 hw

Authority arbitration for financial-sector AI decision systems under the U.S. Treasury Financial Services AI Risk Management Framework. An eight-stage pipeline routes each transaction to autonomous clearance, supervised review, elevated confirmation, or manual hold; retrospective swarm-review recovers coordinated low-and-slow activity; SHA-256 evidence chain; YubiHSM 2 in a FIPS 140-2 Level 3 enclosure; 36 components. Synthetic data only; not deployed in any institution.

Economic security · first platform in the domain

[BLADE PLATFORM REGISTER]

TWELVE HARDWARE RESEARCH PLATFORMS

All standards listed are design targets and research mappings, not certifications or audit findings. Component counts marked with a hyphen are not stated as a single figure in the source artifact. TRL pairs denote hardware / simulation maturity.

PLATFORM	DOMAIN	COMP.	REF. BOM	TRL	STANDARDS ALIGNMENT (DESIGN TARGETS)	ZENODO DOI
Rover Testbed	Robotics testbed	37	~$484	3-4	ROS 2; TLA+ verified	10.5281/zenodo.19143190
UAV (HMAA-UAV)	UAS testbed	52	~$4,200	3-4	MAVLink/HIL; ArduPilot	10.5281/zenodo.19128769
BLADE-EDGE	Directed-energy defense	72	~$139K	3 (design)	MIL-STD-810G	10.5281/zenodo.19177472
BLADE-AV	Automotive drive-by-wire	62	~$16.3K	3-4	ISO 26262 ASIL-D; SAE J3016 L4	10.5281/zenodo.19232130
BLADE-MARITIME	Maritime surveillance	84	~$43K	3 (design)	IP68; MIL-STD-810G / 461G	10.5281/zenodo.19246785
BLADE-INFRA	Critical infrastructure (ICS/SCADA)	92	~$11.6K	3 (design)	SIL 3; NERC CIP; FIPS 140-2	10.5281/zenodo.19277887
BLADE-SPACE	Orbital LEO autonomy	91	~$505K	2-3 (prelim)	NASA EXPAND.3.S26B; SPD-5	10.5281/zenodo.20183269
BLADE-CUAS	Counter-UAS	-	~$43.5K	2-3 / 3-4	EO 14305; FY26 NDAA Safer Skies	10.5281/zenodo.20299604
BLADE-AGENT-HSM	Agentic-AI root of trust	-	~$199	2-3 / 3-4	CC EAL6+; TPM 2.0; Five Eyes guidance	10.5281/zenodo.20299821
BLADE-SWARM	Attritable swarm autonomy	-	~$1,333/node	3-4 / 2	DoDD 3000.09; NIST AI RMF	10.5281/zenodo.20351198
BLADE-INFRA-OT	IT/OT boundary governance	48	~1U unit	2-3 / 3-4	NIST SP 800-82; IEC 62443; NERC CIP	10.5281/zenodo.20342067
BLADE-FINANCE	Financial-sector AI	36	~$9,228	3-4 / 2	Treasury FS AI RMF; EO 14179	10.5281/zenodo.20374692

[SIMULATED CAMPAIGN RESULTS]

Across flight-relevant platforms, more than 2,800 simulation runs recorded no unsafe actions in simulation (Rover 350, UAV 250, BLADE-AV 1,200, plus per-framework campaigns). HMAA authority computation completes in under 12 ms (simulated); MAIVA tolerates $f < n/3$ Byzantine nodes. Simulated performance characteristics are research artifacts, not fielded-system measurements.

SIX SOFTWARE REFERENCE ARCHITECTURES

Six software reference architectures carry the same authority pipeline into settings that do not require a dedicated hardware node. All are single-author research and are not deployed in any production environment.

AGENTIC-AI AUTHORITY SHIM · SOFTWARE-ONLY

AUTHREX-AGENT

REFERENCE ARCHITECTURE · TRL 3-4

[PROJECT STATUS]

Reference architecture with a working simulator. Single-author research; not deployed.

[MISSION RELEVANCE]

Aligned with CISA, NSA, and Five Eyes guidance Careful Adoption of Agentic AI Services (1 May 2026) and FY26 NDAA Sections 1513 and 6601. Tool misuse and credential exposure are named risk categories for agentic AI.

[TECHNICAL DESCRIPTION]

Four-level (T3 to T0) HMAA authority gating; per-tool HKDF authorization tokens; sub-agent spawn quorum; SATA input-trust scoring that collapses on credential patterns or prompt-injection signatures; FLAME bounded deliberation with a fail-safe abort on timeout; hash-chained audit ledger. Hardware-anchored by the BLADE-AGENT-HSM root of trust when present.

[EVIDENCE]

A 15-section technical specification with a standards-alignment matrix, an SDK integration guide, and three reference use cases; verified against the AUTHREX-AGENT simulator; documented hardware companion (DOI 10.5281/zenodo.20299821).

[LIMITATIONS & REVIEWER NOTE]

Software-only containment can be bypassed without the hardware root of trust; no production deployment; no independent evaluation. The most directly implementable near-term software application of the pipeline and the closest fit to current federal agentic-AI guidance.

ASSURE · ICS-GATE · AGENT-CYBER · SPACECYBER · SANDBOX

AUTHREX-ASSURE

Pre-deployment assurance gate · reference architecture (TRL 3-4)

An assurance gate a system must clear before it is permitted to act, addressing the validation gap named in the 2026 National Cybersecurity Strategy. Aligned with NDAA Section 1533. Not deployed.

AUTHREX-ICS-GATE

OT authority governance at the IT/OT boundary · reference architecture

Gates AI actions across the IT/OT boundary for critical infrastructure; it authorizes deterministic safety logic and does not make the safety decision itself. Companion to BLADE-INFRA-OT. Aligned with CISA and NSA AI-in-OT principles, NIST SP 800-82, ISA/IEC 62443, and NERC CIP. Not deployed.

AUTHREX-AGENT-CYBER

Autonomous cyber-defense authority · governance only, no offensive function

Constrains what a defensive cyber-reasoning agent may do and when, for example whether it may patch a live OT controller. It treats the agent as a black box and performs no vulnerability discovery itself. Aligned with Five Eyes agentic-AI guidance, DARPA AIxCC, and NDAA Section 1513. Not deployed.

AUTHREX-SPACECYBER

Onboard authority for orbital autonomy · reference architecture

Gates autonomous spacecraft actions under intermittent ground contact. Companion to BLADE-SPACE. Aligned with NASA SBIR EXPAND.3.S26B and Space Policy Directive 5. Not deployed.

AUTHREX-SANDBOX

Test-and-evaluation authority governance · reference architecture

Governs what an AI under evaluation is permitted to do inside a test environment. Aligned with NDAA Sections 1533 and 1534. Not deployed.

SYSTEM	FUNCTION	STANDARDS ALIGNMENT	MATURITY	STATUS
AUTHREX-AGENT	Authority-lifecycle shim for agentic AI	CISA/NSA/Five Eyes; NDAA 1513, 6601	TRL 3-4	Spec + simulator; not deployed
AUTHREX-ASSURE	Pre-deployment assurance gate	2026 Nat'l Cyber Strategy; NDAA 1533	TRL 3-4	Reference; not deployed
AUTHREX-ICS-GATE	OT authority at the IT/OT boundary	CISA/NSA AI-in-OT; NIST 800-82; IEC 62443; NERC CIP	TRL 3-4	Reference; not deployed
AUTHREX-AGENT-CYBER	Autonomous cyber-defense authority (governance only)	Five Eyes; DARPA AIxCC; NDAA 1513	TRL 3-4	Reference; not deployed
AUTHREX-SPACECYBER	Onboard authority for orbital autonomy	NASA EXPAND.3.S26B; SPD-5	TRL 3-4	Reference; not deployed
AUTHREX-SANDBOX	Test-and-evaluation authority governance	NDAA 1533, 1534	TRL 3-4	Reference; not deployed

REPRODUCIBLE RESEARCH TOOLS

The simulations run entirely client-side with a seeded pseudo-random number generator for bit-exact reproducibility, which lets any reviewer independently verify a result. They are the primary current evidence for the governance logic.

Figure 5. Simulation validation workflow. A fixed seed and a scenario definition drive each run; the governed pipeline executes; an unsafe-action check is applied; the run is written to a hash-chained audit log and a result hash is recorded.

SIMULATION · CROSS-DOMAIN ESCALATION RISK

ERAM Strategic Command

OPERATIONAL RESEARCH TOOL

[PROJECT STATUS]

Operational browser-based simulation. The underlying ERAM framework is a working paper on SSRN (ID 6176802).

[TECHNICAL DESCRIPTION]

Six scenarios, 600 Monte Carlo runs, formal property verification, and Merkle provenance chains. Runs fully client-side with a seeded PRNG. Integrates ERAM with SATA, FLAME, and CARA to model how authority integrity degrades and how local autonomous actions cascade across domain boundaries in joint all-domain command and control.

[VALIDATION & LIMITATIONS]

Reproducible simulation outputs; model-based with documented parameter assumptions; not validated against operational data. The framework is a working paper, not a peer-reviewed publication.

[REVIEWER NOTES]

A reproducible analytical tool, useful as a demonstration and study environment rather than an operational decision aid. Development path: peer-reviewed submission, sensitivity analysis, integration with the JADC2 theater simulation.

[SIMULATION REGISTER]

SEVEN FLAGSHIP STANDALONE SIMULATIONS

The portfolio comprises 19 simulations in total: these seven, plus per-framework subsystem demonstrations and per-platform validation runs. All are launchable as interactive consoles on authrex.systems.

SIMULATION	FRAMEWORKS EXERCISED	METHOD	SIZE
ERAM Strategic Command	ERAM, SATA, FLAME, CARA	6 scenarios, 600 Monte Carlo, formal properties, Merkle	86 KB
APEX JADC2 Theater	All seven	Full pipeline, PBFT, Merkle audit trail	28 KB
MDO Digital Twin	HMAA, CARA, MAIVA	Air / maritime / kinetic, Byzantine fault isolation	21 KB
Tactical COP (fratricide)	HMAA, CARA, SATA, ADARA	Blue-on-blue interdiction via common operating picture	21 KB
AUTHREX OS	All seven	Distributed Web Worker nodes, COP, analytics, Merkle	-
Distributed Kernel	MAIVA, CARA	Actor-model mesh, PBFT consensus, emergent interlock	-
Tactical Core	HMAA, CARA	Zero-dependency kinematic engine, flight-termination	-

[WHAT THE SIMULATIONS DEMONSTRATE, AND WHAT THEY DO NOT]

The simulations demonstrate that the governance logic behaves as specified under seeded scenario conditions: authority degrades with trust, deliberation windows hold irreversible actions, Byzantine minorities are outvoted, and recovery follows the defined staircase. They do not prove field performance, timing on target hardware, or resistance to a live adversary; those claims await hardware-in-the-loop testing and independent red-team evaluation.

PUBLIC DISCLOSURE CORPUS

[OPEN-ACCESS CORPUS]

Thirty-three public technical works comprise eighteen open-access deposits with registered DOIs on Zenodo and fifteen working papers on SSRN. These are public disclosures with permanent identifiers; they are not described as peer-reviewed venues. Source code accompanies the deposits under MIT and CC BY 4.0 licenses, and every claim is intended to be independently verifiable through the USPTO Patent Center, Zenodo, SSRN, and ORCID.

[PROVISIONAL PATENT APPLICATIONS]

ARCHITECTURE	APPLICATION NO.	FILED	RECEIPT	DEPOSIT	STATUS
HMAA	63/999,105	7 Mar 2026	74759595	zenodo.18861653	Provisional; pending USPTO action
CARA	64/000,170	9 Mar 2026	74767602	zenodo.18917790	Provisional; pending USPTO action
SATA	64/002,453	11 Mar 2026	74808459	zenodo.18936251	Provisional; pending USPTO action
FLAME	64/005,607	14 Mar 2026	74858888	zenodo.19015618	Provisional; pending USPTO action

Provisional applications are unexamined filings; a twelve-month window to file non-provisional (utility) applications runs to approximately March 2027.

[TECHNICAL REFERENCE SERIES]

A ten-volume technical reference series is published under the Authority & Architecture imprint across three sub-series: The Authority Equation (3 volumes), The Authority Discipline (4 volumes), and Autonomous Authority (3 volumes). ISBNs are registered through Bowker, and The Authority Equation Volume I carries Library of Congress Control Number 2026912260. The series is distributed in print and electronic formats.

[EXTERNAL RECOGNITION]

NHTSA cited the author by name in Federal Register 91 FR 30789, footnote 10. Commentary and analysis have appeared in Modern War Institute at West Point, RUSI, The Defense Post, RealClearDefense, The Space Review, and Military AI, with editorial selection by UPI's Korea Regional Review and the Parliamentary Assembly of the Mediterranean's AI observatory. The full record is maintained at authrex.systems/news.html.

TECHNICAL READINESS SUMMARY

Ratings are stated conservatively. Technical maturity uses the standard TRL scale. Validation describes the strongest evidence that currently exists, and review readiness reflects how prepared an item is for external technical review in its present state.

ITEM	STATUS	MATURITY	DOCS	VALIDATION (STRONGEST CURRENT EVIDENCE)	REVIEW READINESS
AUTHREX integrated pipeline	Research architecture	TRL 3-4	High	Simulation; HMAA formally verified	Moderate
SATA, HMAA, CARA, FLAME	Provisional patents filed	TRL 3-4	High	Simulation; HMAA TLA+ verified	Moderate
MAIVA, ADARA, ERAM	Open-access / SSRN	TRL 3-4	High	Simulation	Moderate
BLADE-EDGE	Design complete	TRL 3	High	Simulation + design analysis	Moderate
BLADE-AV	Published (Zenodo)	TRL 3-4	High	1,200 simulation runs	Moderate-High
BLADE-MARITIME, BLADE-INFRA	Design complete	TRL 3	High	Simulation	Moderate
BLADE-SPACE	Preliminary design	TRL 2-3	High (15-doc package)	Specified, not executed	Low-Moderate
BLADE-CUAS / AGENT-HSM / SWARM / INFRA-OT / FINANCE	Emerging platforms	TRL 2-4	Medium-High	Simulation / emulator	Low-Moderate
Rover and UAV testbeds	Design complete, build in progress	TRL 3-4	High	Simulation (350 / 250 runs)	Moderate
Software reference architectures (6)	Reference architecture	TRL 3-4	Medium-High	Specification + simulator	Low-Moderate
Simulation portfolio (19)	Operational research tools	Tooling	High	Reproducible, seeded runs	High (as tools)
Publications, patents, books	Published / disclosed	n/a	High	Public identifiers (DOI, SSRN, LCCN)	High (as disclosure)

[ARTIFACT TRACEABILITY]

EVIDENCE AND DOCUMENTATION MATRIX

Y indicates the artifact exists and is publicly retrievable. Partial indicates incomplete coverage. Planned or Not yet indicate items identified for development. References are public site paths.

ITEM	PAPER	SIM	CODE	DIAGRAMS	DATA	VALIDATION	REFERENCE
AUTHREX pipeline	Y (TSD)	Y	Y	Y	Y	Sim + formal	authrex.systems
SATA, HMAA, CARA, FLAME	Y (Zenodo)	Y	Y	Y	Y	Sim; HMAA TLA+	burakoktenli.com
MAIVA, ADARA	Y (Zenodo)	Y	Y	Y	Y	Simulation	burakoktenli.com
ERAM	Y (SSRN)	Y	Y	Y	Y	Sim (Monte Carlo)	burakoktenli.com/eram
BLADE-EDGE	Y (Zenodo)	Y	Y (BOM/ICD)	Y	Y	Sim / design	burakoktenli.com/blade-edge
BLADE-AV	Y (Zenodo)	Y	Y	Y	Y	1,200 runs	burakoktenli.com/blade-av
BLADE-MARITIME, INFRA	Y (Zenodo)	Y	Y	Y	Y	Simulation	burakoktenli.com
BLADE-SPACE	Y (15-doc)	Planned	Y (BOM)	Y	Not yet	Specified	burakoktenli.com/blade-space
Emerging platforms (5)	Y	Partial	Y	Y	Partial	Sim / emulator	burakoktenli.com
Software set (6)	Y (spec)	Y	Partial	Y	Y	Simulator	authrex.systems
Simulations (19)	Y (guides)	Y	Y	Y	Y	Reproducible	authrex.systems
Publications, books	Y	n/a	n/a	n/a	n/a	DOI / LCCN	burakoktenli.com

[EVIDENCE CLASSIFICATION]

EVIDENCE CLASS	WHAT BELONGS HERE
Supported	Public deposits and working papers with registered identifiers; reproducible seeded simulations; the HMAA TLA+ verification; bill-of-materials-level design packages.
Partial	Cross-domain portability shown in simulation; standards mappings as design targets; the simulated no-unsafe-action results, which hold in simulation only.
Conceptual	BLADE-SPACE at preliminary design; full hardware enforcement at the actuator boundary; any operational command-and-control relevance.
Unsupported until tested	Deployment readiness; certification; government or agency approval; field or hardware performance. None of these is claimed in this catalog.

[DOMAIN RELEVANCE]

MISSION ALIGNMENT MATRIX

Alignment is marked only where it is genuinely supported. A filled circle marks a primary fit; a half circle marks a contributing or partial fit; a blank cell indicates no claimed alignment.

ITEM	AI	CYBER	INFRA	SPACE	DEF	RES	H-M	NOTES
AUTHREX pipeline	●	●	●	●	●	●	●	Domain-agnostic core
SATA, HMAA, CARA, FLAME	●	◖	◖	◖	●	◖	●	Core frameworks
MAIVA	●		◖	●	◖		◖	Swarm consensus
ADARA	●	●		◖	●		◖	Deception / EW resilience
ERAM	●			◖	●		◖	C2 escalation
BLADE-EDGE					●		◖	Directed-energy defense
BLADE-AV	◖	◖				●	●	Automotive ASIL-D
BLADE-MARITIME	◖				●	◖	◖	Maritime surveillance
BLADE-INFRA	◖	◖	●		◖	●		ICS / SCADA
BLADE-INFRA-OT		◖	●			●	●	IT/OT boundary
BLADE-SPACE	◖	◖		●	◖	◖		Orbital autonomy
BLADE-CUAS	◖	◖			●	◖	●	Counter-UAS
BLADE-AGENT-HSM	●	●					◖	Hardware root of trust
BLADE-SWARM	●	◖		●	◖		◖	Swarm autonomy
BLADE-FINANCE	●	◖	◖			●		Economic security
AUTHREX-AGENT	●	●	◖				◖	Agentic AI
AUTHREX-AGENT-CYBER	●	●	◖		◖	◖		Cyber-defense (governance only)

Legend: AI = AI and autonomy; Cyber = cyber and security; Infra = critical infrastructure; Space = space and aerospace; Def = defense; Res = resilience; H-M = human-machine systems.

[HONEST SELF-ASSESSMENT]

RISK AND LIMITATION ASSESSMENT

This section states the program limitations directly. It is written for a technical reviewer who needs an accurate picture of what has and has not been demonstrated.

[TECHNICAL LIMITATIONS]

The architecture is demonstrated in seeded simulation and, for the HMAA state machine, in formal verification. The central design premise, that authority enforcement terminates at a hardware boundary that software compromise cannot bypass, is specified but has not been demonstrated on physical silicon. No platform has been built. Performance, timing, and fault behavior on real hardware are therefore projected from design and simulation, not measured.

[VALIDATION GAPS]

There has been no hardware-in-the-loop testing and no independent red-team evaluation. Reported run counts and the zero-unsafe-actions results are simulation outcomes under seeded conditions, not field results. Formal verification depth is uneven: HMAA is verified across 48,751 reachable states, while other frameworks carry specifications or self-test suites rather than full state-space proofs. BLADE-SPACE has a specified but unexecuted verification campaign.

[DOCUMENTATION AND REVIEW GAPS]

The work is single-author and has not undergone independent peer review. Open-access deposits and SSRN working papers establish public disclosure and priority but are not peer-reviewed publications. Independent third-party citation is currently limited. Standards mappings are research artifacts that describe how the frameworks relate to those standards; they are not certifications, audits, or designated-engineering-representative findings.

[KEY ASSUMPTIONS]

Sensor-trust computation can be made fast and reliable enough to gate authority in real time on target hardware. The hardware authority boundary can be integrated at the actuator level on the intended FPGA or ASIC platforms. Simulation fault models are representative of the relevant real-world failure and adversarial conditions. Provisional patent applications can be converted to non-provisional filings within the statutory window.

[MISSING EVIDENCE]

Built hardware for any platform, and measured (not simulated) interlock behavior. An independent red-team report against sensor spoofing, authority hijack, Byzantine compromise, and jamming. Peer-reviewed publication of the core frameworks and the ERAM model. Any operational or third-party deployment evidence; BLADE-FINANCE uses synthetic data only.

[ROADMAP]

PRIORITY IMPROVEMENT PLAN

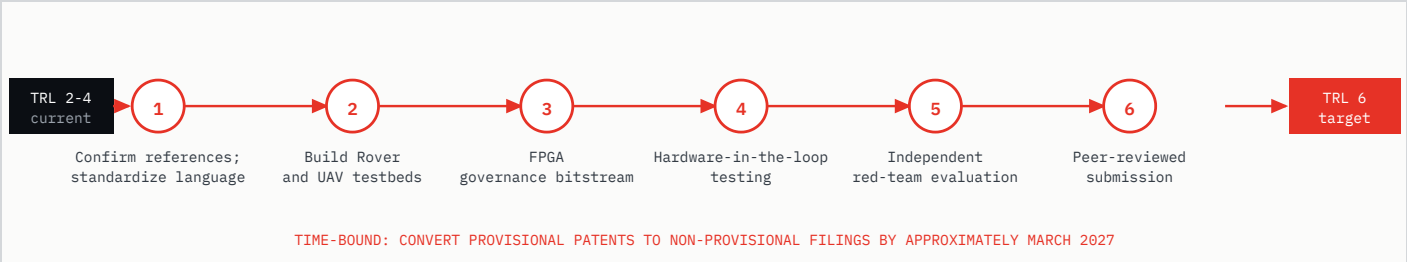


Figure 6. Development roadmap from the current position (TRL 2 to 4) to the near-term target (TRL 6). The sequence runs from reference confirmation and language standardization, through testbed builds and the FPGA governance bitstream, to hardware-in-the-loop testing, independent red-team evaluation, and peer-reviewed submission.

[IMMEDIATE (BEFORE WIDER DISTRIBUTION)]

Standardize the HMAA authority-tier nomenclature across both public sites to the four-level model (A3 to A0 / T3 to T0). Confirm that every cited DOI, SSRN identifier, and patent receipt resolves to a live, correct record. Ensure no public claim states or implies field or hardware results where only simulation evidence exists. Reconcile the small count discrepancies between the two sites to a single canonical figure.

[HIGH PRIORITY (FOR SERIOUS TECHNICAL REVIEW)]

Form a small team to enable independent peer review and a red-team evaluation; both are the largest credibility gaps at present. Convert the four provisional patent applications to non-provisional filings before the window closes in approximately March 2027. Pursue SBIR Phase I funding to commission the FPGA governance bitstream and perform hardware-in-the-loop validation of the SATA-FLAME pipeline. Obtain at least one independent third-party validation or replication of a published result.

[MEDIUM PRIORITY (FOR A STRONGER PRESENTATION)]

Build the Rover and UAV testbeds, whose designs are complete, and report measured results alongside the existing simulation data. Execute the specified BLADE-SPACE verification and validation campaign. Submit the core frameworks and the ERAM model to peer-reviewed venues and track outcomes honestly. Expand the independent citation footprint through targeted dissemination.

[LONG-TERM (FOR FUTURE MATURITY)]

Advance multi-framework governance on physical hardware from TRL 3-4 toward TRL 6. Pursue formal certification pathways where relevant (ISO 26262 ASIL-D for automotive, MIL-STD-882E for defense). Establish a research partnership, OEM adoption, or cooperative research agreement to validate in a relevant operational context. Extend the architecture to additional domains only where a genuine need and a credible validation path exist.

[CONCLUSION]

FINAL PROFESSIONAL SUMMARY AND ENGAGEMENT

[SUMMARY]

The work develops a single idea, authority as an engineered lifecycle, and carries it from formal specification through simulation to a family of domain-specific reference designs. The architecture is coherent across all of its instantiations, and the documentation is unusually complete for an independent research program: every system has a public deposit, a reproducible simulation, and a defined interface. The strongest areas are the coherence of the cross-domain architecture, the formal verification of the HMAA authority state machine, the breadth and reproducibility of the simulation portfolio, and the honesty of the readiness posture. The most important next steps convert simulation evidence into measured hardware evidence and add independent scrutiny; none of these change the architecture, they raise the level of proof behind it.

[HOW THE WORK CAN BE REVIEWED]

Every system in this catalog has a public artifact. The frameworks and platforms are deposited on Zenodo with registered DOIs; the ERAM model and related papers are on SSRN; the four provisional patent applications are filed with the USPTO; and the simulations run client-side in a browser with a seeded pseudo-random number generator, so a reviewer can reproduce a result independently.

[FORMS OF ENGAGEMENT THAT FIT THE CURRENT MATURITY]

Technical review of a specific framework or platform against a defined assurance standard (for example, HMAA against a formal-methods checklist, or BLADE-AV against an ISO 26262 ASIL-D pathway). A cooperative research arrangement or sponsored evaluation to commission the FPGA governance bitstream and perform hardware-in-the-loop validation on the Rover or UAV testbed. An independent red-team evaluation against sensor spoofing, authority hijack, Byzantine compromise, and jamming. SBIR or other early-stage instruments aligned with a named subtopic. Co-authorship or peer review of the core frameworks and the ERAM model. Written technical exchange is the preferred starting point; a scoped review of a single system is a more useful first step than a broad survey of the whole portfolio.

[CORRESPONDENCE]

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[REFERENCE]

APPENDIX A: GLOSSARY

ADARA	Adversarial Deception-Aware Risk Architecture; adjusts authority by a computed deception probability.
AISBOM	AI Software Bill of Materials; an inventory of an AI system's components emitted by the audit ledger.
ASIL-D	Automotive Safety Integrity Level D; the highest integrity level under ISO 26262.
BFT	Byzantine Fault Tolerance; consensus that tolerates arbitrarily faulty or malicious nodes.
BLADE	The family of domain-specific hardware governance platforms in this catalog.
BOM	Bill of Materials; the itemized component list and cost for a hardware platform.
CARA	Control Authority Regulation Architecture; deterministic recovery from authority lockout via GREP phases.
CC EAL6+	Common Criteria Evaluation Assurance Level 6 augmented; a high hardware-security assurance level.
CUAS	Counter-Unmanned Aircraft Systems; defense against small uncrewed aircraft.
DoDD 3000.09	DoD Directive on Autonomy in Weapon Systems; requires appropriate human judgment over force.
DO-178C / DO-333	RTCA standards for airborne software and its formal-methods supplement.
Dempster-Shafer	An evidence-theory method for combining uncertain information from multiple sources.
ECDSA P-256	Elliptic Curve Digital Signature Algorithm over the P-256 curve; used to sign audit records.
ERAM	Escalation Risk Assessment Model; quantifies escalation risk in AI-enabled command and control.
FLAME	Flash War Latency Architecture; imposes a deliberation window before irreversible action.
FPGA	Field-Programmable Gate Array; reconfigurable hardware used for the governance boundary.
GREP	Guard, Reduce, Evaluate, Promote; the phased recovery sequence used by CARA.
HMAA	Human-Machine Authority Architecture; computes a graded authority level from trust and context.
HSM	Hardware Security Module; a tamper-resistant device that protects keys and authority state.
ICS / SCADA	Industrial Control Systems and Supervisory Control and Data Acquisition.
ISA/IEC 62443	A standards series for industrial automation and control-system security.
IT/OT	Information Technology and Operational Technology; the corporate and control-system domains.
MAIVA	Multi-Agent Integrity Verification Architecture; Byzantine-resilient multi-agent consensus.
MIL-STD-810G / 882E	DoD standards for environmental engineering and for system safety.
NDAA	National Defense Authorization Act; annual U.S. defense policy legislation.
NERC CIP	North American Electric Reliability Corporation Critical Infrastructure Protection standards.
NIST AI RMF	NIST Artificial Intelligence Risk Management Framework.
PBFT	Practical Byzantine Fault Tolerance; a classical BFT consensus protocol.
SATA	Sensor Attestation and Trust Anchoring; computes a continuous sensor-trust scalar.
SBIR / STTR	Small Business Innovation Research and Small Business Technology Transfer programs.
SLTT	State, Local, Tribal, and Territorial; non-federal government partners.
TLA+	A formal specification language used to verify the HMAA authority state machine.
TPM	Trusted Platform Module; a hardware anchor for attestation and authority state.
TRL	Technology Readiness Level; a nine-point scale for technology maturity.
USV / UUV / UAS	Uncrewed Surface, Underwater, and Aircraft Systems.

[DISCLAIMERS AND STATUS LABELS]

This catalog presents public-source, self-authored research artifacts. Evaluation is simulation-based unless explicitly stated otherwise. Hardware references are design specifications unless physical testing is specifically identified. The catalog does not represent official government endorsement, sponsorship, or affiliation.

Catalog status labels distinguish between operational physical hardware, browser-based simulations, formal models, reference designs, and future validation plans. A listed reference design should not be read as a certified product or fielded system.

End of document. This catalog is an independent research portfolio authored by Burak Oktenli under the Authority & Architecture imprint and is not a government publication. Best read alongside the program white paper and the per-system deposits, which contain the full bills of materials, simulation data, and source code.

AUTHREX RESEARCH PROGRAM
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