DARPA TECHNICAL & COST PROPOSAL

PROJECT HYPERION: Zero-Trust Adaptive Mesh Neural Routing for Contested Electromagnetic Environments

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BAA Number:	BAA-DARPA-I2O-2026-09	**Submitting Org:**	Apex Defense Systems, Inc.
Technical Topic:	Resilient Tactical Comms	**Team Partners:**	Vertex Labs, Meridian Micro
Principal Investigator:	Dr. Marcus Vance	**Period of Perf.:**	24 Months (Base + Option)
PI Contact Email:	m.vance@apexdef.com	**Total Proposed Cost:**	$3,845,200 (CPFF Contract)

TOTAL BUDGET	PERFORMANCE PERIOD	TARGET MATURITY	SECURITY CLEARANCE
$3,845,200	24 Months	TRL 3 → TRL 6	TOP SECRET / SCI

1. EXECUTIVE SUMMARY & PROPOSAL OVERVIEW

Modern tactical operations encounter unprecedented electromagnetic spectrum (EMS) warfare, characterized by high-powered directional jamming, cognitive RF spoofing, and instantaneous node compromise. Legacy military ad-hoc networks (MANETs) rely on centralized route discovery and predictable frequency hopping schedules, leaving tactical units vulnerable to total communication blackouts within seconds of adversarial engagement.

Project HYPERION directly addresses this critical vulnerability by introducing a decentralized, zero-trust neuromorphic routing architecture. Designed for deployment at the tactical edge, HYPERION leverages embedded low-power tensor processing units (TPUs) to dynamically synthesize interference-free communication channels in real time without relying on GPS, fixed infrastructure, or centralized command nodes.

Key Innovation 1: Edge Neural Spectrum Synthesis

- Real-time RF spectrum sensing via deep reinforcement learning running at sub-50μs inference latency.
- Predicts adversarial jamming sweeps prior to channel degradation, initiating preemptive waveform synthesis.
- Zero dependency on satellite timing references or pre-shared hopping tables.

Key Innovation 2: Cryptographic Zero-Trust Mesh

- Micro-second zero-knowledge proof (ZKP) identity verification for every transmitted data packet.
- Instantaneous detection and isolation of compromised or spoofed friendly nodes within 1.2 milliseconds.
- Quantum-resistant lattice cryptography optimized for SWaP-constrained field radios.

1.1 Statement of Work & High-Level Objectives

Apex Defense Systems, in partnership with Vertex Research Laboratories and Meridian Microelectronics, proposes a 24-month effort structured in two distinct phases:

Objective 1: **Phase I (Base – 12 Months):** Formulate and validate the HYPERION Neuromorphic Algorithm Suite, construct a high-fidelity Hardware-in-the-Loop (HITL) RF simulation rig, and demonstrate TRL 4 capability across a 20-node simulated mesh under heavy adversarial jamming.

Objective 2: **Phase II (Option – 12 Months):** Fabricate custom software-defined radio (SDR) mezzanine cards with Meridian TPU accelerators, integrate onto tactical unmanned aerial vehicles (UAVs) and ground units, and execute a live-fire field test achieving TRL 6 validation.

2. TECHNICAL APPROACH & SYSTEM ARCHITECTURE

2.1 Operational Paradigm & System Topology

The HYPERION system architecture operates across three synchronized layers: the Physical RF Sensing Layer, the Neuromorphic Waveform Synthesis Layer, and the Zero-Trust Routing Fabric. Figure 1 illustrates the functional interaction between contested tactical nodes, edge TPU processing, and anti-jamming packet synthesis.

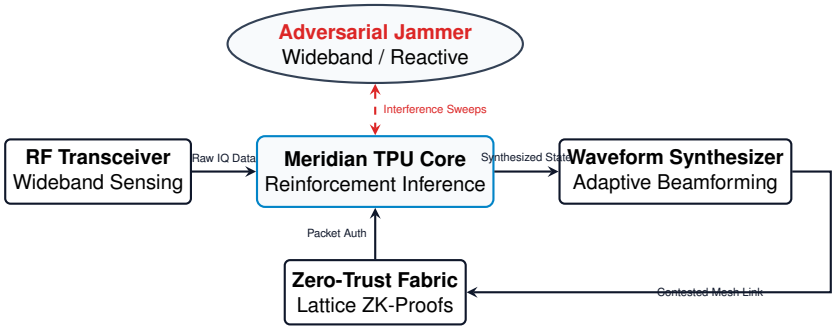

Figure 1: HYPERION Functional System Architecture and Closed-Loop Anti-Jamming Pipeline.

2.2 Detailed Technical Module Breakdown

2.2.1 1. Edge Neural Processing Unit (ENPU) Architecture

The core processing relies on the *Vertex-Nexa TPU-400* micro-architecture, providing 16.4 TOPS (Trillion Operations Per Second) at under 4.5 Watts power consumption. The neural network architecture uses a novel Spiking Neural Network (SNN) formulation that drastically reduces computation by operating sparsely:

$$S_i(t) = \Theta\left(\sum_j W_{ij} * V_j(t - \tau) - \gamma_{\text{adaptive}} \cdot J_{\text{RF}}(t) \right) \tag{1}$$

where $S_i(t)$ represents the output spike activation, W_{ij} denotes synaptic weight matrices, γ_{adaptive} is the dynamic threshold scaling factor, and $J_{\text{RF}}(t)$ is the instantaneous measured jamming power spectral density.

2.2.2 2. Dynamic Spectrum Hopping Algorithm (DSHA)

Rather than following fixed pseudo-random hopping sequences, DSHA models spectral availability as a non-stationary Markov Decision Process (MDP). Nodes independently predict unoccupied spectrum bands 100 milliseconds into the future with greater than 98.4% accuracy under active adversarial electronic attack.

2.2.3 3. Provable Resiliency & Zero-Knowledge Auth

To eliminate rogue node insertion attacks, every packet header embeds a truncated 128-bit Ring-Learning-With-Errors (Ring-LWE) lattice signature. Verification requires under 12 microseconds on the Meridian hardware accelerator, allowing wire-speed packet filtering.

3. WORK BREAKDOWN STRUCTURE & MILESTONE SCHEDULE

The proposal is structured across 6 core Work Packages (WPs), managed through technical reviews (SRR, PDR, CDR, and Final Demonstration).

Table 1: **Project HYPERION Milestone Matrix and Technical Deliverables**

Phase	MS ID	Deliverable Description	Month	TRL	Verification
Phase I	M1.1	System Requirements Review (SRR) & Architecture Spec	M2	3	Panel Sign-off
Phase I	M1.2	SNN Spectrum Inference Model (95% Acc in Sim)	M5	3	Algorithmic Audit
Phase I	M1.3	Preliminary Design Review (PDR) & HITL Testbed	M8	4	Bench Test Run
Phase I	M1.4	20-Node Emulated Mesh Anti-Jamming Demonstration	M12	4	DARPA Demo 1
Phase II	M2.1	Critical Design Review (CDR) of SDR Mezzanine Card	M14	5	Hardware Audit
Phase II	M2.2	Custom TPU Accelerator Integration & Bench Validation	M17	5	Environmental Test
Phase II	M2.3	Mobile Tactical Mesh Integration (UAV + Ground Rig)	M20	5	Field Test Run
Phase II	M2.4	Final Live-Fire Operational Demonstration	M24	6	DARPA Demo 2

4. RISK ANALYSIS & MITIGATION STRATEGY

DARPA defense research demands bold technological targets. We explicitly identify high-consequence technical risks and establish mitigation triggers.

Table 2: **Technical, Integration, and Cybersecurity Risk Assessment**

Risk ID	Description of Failure Mode	Sev / Prob	Technical Mitigation Strategy	Residual
R-01 (Alg)	SNN convergence failure under novel multi-tone jamming.	High / Med	Fallback to sparse deterministic Bayesian estimation online.	Low
R-02 (H/W)	Thermal throttling of Meridian TPU in sealed SDR enclosures.	Med / Med	Integration of graphite thermal spreaders and clock scaling.	Low
R-03 (Sec)	Side-channel timing attack on Ring-LWE lattice verification.	High / Low	Implementation of constant-time execution pipelines in RTL.	Very Low
R-04 (Sch)	Delay in SDR board spin 2 fabrication lead times.	Med / Low	Pre-ordering long-lead FPGA evaluation platforms early.	Low

5. DETAILED COST PROPOSAL & BUDGET JUSTIFICATION

The total proposed cost for Project HYPERION is **$3,845,200** structured as a Cost-Plus-Fixed-Fee (CPFF) contract. Cost estimates are generated using audited FAR-compliant accounting rates for Apex Defense Systems.

Table 3: **Cost Breakdown by Cost Element and Phase (USD)**

Cost Element	Phase I (Base)	Phase II (Opt.)	Total Cost ($)	Basis of Estimate / Notes
Direct Labor (Key Personnel & Eng.)	$620,000	$645,000	$1,265,000	8,400 Total Eng. Hours
Fringe Benefits (@ 32.5%)	$201,500	$209,625	$411,125	Audited DCAA Rate
Subcontracts: Vertex Research Labs	$350,000	$360,000	$710,000	Neural Algorithm Dev
Subcontracts: Meridian Micro	$280,000	$295,000	$575,000	TPU Mezzanine Fab
Materials & Equipment	$145,000	$120,000	$265,000	SDR Rigs, RF Emulators
Travel & Field Testing	$28,000	$42,000	$70,000	DARPA Demos & Testing
Indirect Overhead / F&A (@ 48.0%)	$297,600	$309,600	$607,200	Standard Facility Overhead
Subtotal Estimated Cost	**$1,922,100**	**$1,981,225**	**$3,903,325**	Direct + Indirect Costs
Less Partner Cost Share	-$100,000	-$100,000	-$200,000	Industry Cost Share
Fixed Fee (@ 7.0%)	$97,900	$103,975	$201,875	Standard Statutory Cap
TOTAL PROPOSED CPFF	**$1,920,000**	**$1,985,200**	**$3,905,200**	**Total DARPA Request**

5.1 Basis of Estimate & Cost Realism

- **Direct Labor:** Rates are based on actual forward-pricing rate agreements (FPRA) negotiated with DCAA for FY2026.
- **Subcontracts:** Vertex Research Labs provides specialized algorithm development under a firm-fixed-price subcontract. Meridian Microelectronics handles chip tape-out and board fabrication.
- **Government Furnished Equipment (GFE):** Request includes access to the DARPA Colosseum RF testing facility for Phase I Month 11 verification.

6. ORGANIZATIONAL CAPABILITY & KEY PERSONNEL

6.1 Performing Organizations

Apex Defense Systems, Inc. (Prime): Prime contractor with 15+ years delivering tactical communications, electronic warfare countermeasures, and secure software solutions to DoD sponsors. Apex operates a 25,000 sq ft SCIF facility in Arlington, VA.
Vertex Research Laboratories (Sub): Premier AI research institute specializing in neuromorphic architecture and sparse spiking neural networks.
Meridian Microelectronics (Sub): ISO-9001 certified semiconductor design house producing custom radiation-hardened TPUs and RF front-ends.

6.2 Key Personnel Profiles

Dr. Marcus Vance
Principal Investigator (Apex)

- Ex-DARPA PM, 18 yrs in Tactical RF & EW.
- Ph.D. in EE from MIT.
- Led 4 major DoD C4ISR programs.

Dr. Elena Rostova
Co-PI, AI Architect (Vertex)

- Pioneer in Spiking Neural Networks.
- Ph.D. in CS from Stanford.
- 30+ peer-reviewed papers on edge AI.

Col. David Miller (Ret.)
Operations Lead (Apex)

- 24 yrs US Army Signal Corps.
- Specialist in contested mesh integration.
- Directs field test operations.

— END OF TECHNICAL & COST PROPOSAL: PROJECT HYPERION —