



TRAINING FOR THE DRONE-SATURATED BATTLEFIELD:

ADAPTIVE MODELLING AND SIMULATION
FOR SPACE-ENABLED MULTI-DOMAIN OPERATIONS

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Outline

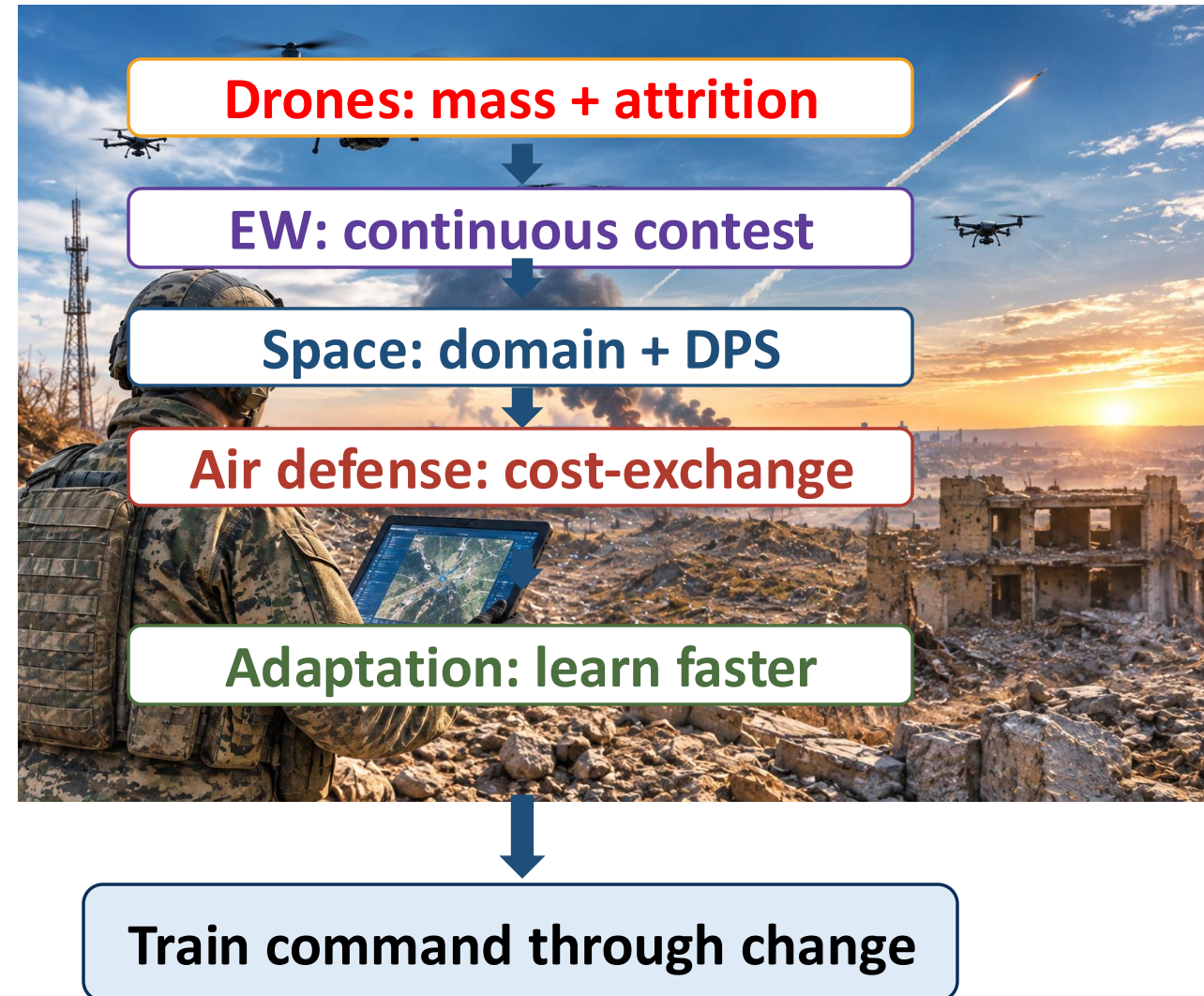
From recent conflict lessons to trainable command decisions

- **Changing Battlefield**
 - **Training Gap**
 - **HMT & CDC**
 - **Adaptive M&S**
 - **Training Vignettes**
- Drones • Space • EW • Cyber
 - Platform models miss adaptation
 - Orchestrate across domain • synchronize effects
 - Degradation • adaptive OPFOR • AAR
 - Train decisions, not demonstrations

Train command adaptation, not technology operation

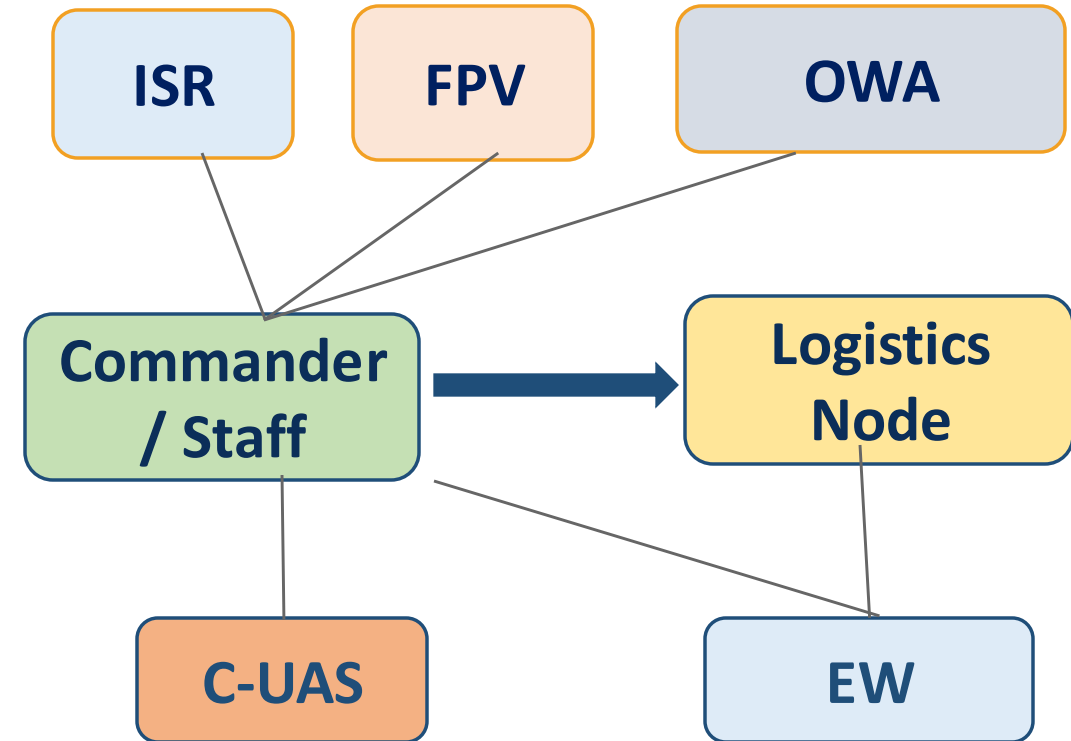
Open-Source Lessons from Recent Conflicts

- Drones reshaping air and ground operations
- EW and spectrum adaptation are continuous contests
- Space DPS enablers and dependencies
- Cost-exchange pressure forces layered defense and smarter training
- Rapid learning cycles compress doctrine, procurement and tactics



The Drone-Saturated Battlefield

- Small UAS provide persistent observation and tactical reach
- Massed one-way drones stress air defense and civil resilience
- FPV drones accelerate target acquisition and strike cycles
- Counter-UAS must combine kinetic, EW and passive measures
- Training must reproduce density, uncertainty and adaptation



Train density • uncertainty • adaptation

Space Domain Data, Products and Services

- Space operational domain
- Delivering Data, Products and Services (DPS) through functional area
- Trusted service providers, **commercial**
- M&S to **reproduce** partial or complete **loss of space services**



Contested Electromagnetic Environment

- GNSS and COMMS jammed, spoofed or degraded
- EW changes quickly as both sides shift frequencies and techniques
- Spectrum awareness becomes a command and training requirement
- Cyber and EW effects interact with space and drone operations
- Synthetic environments must **model degradation** of connectivity

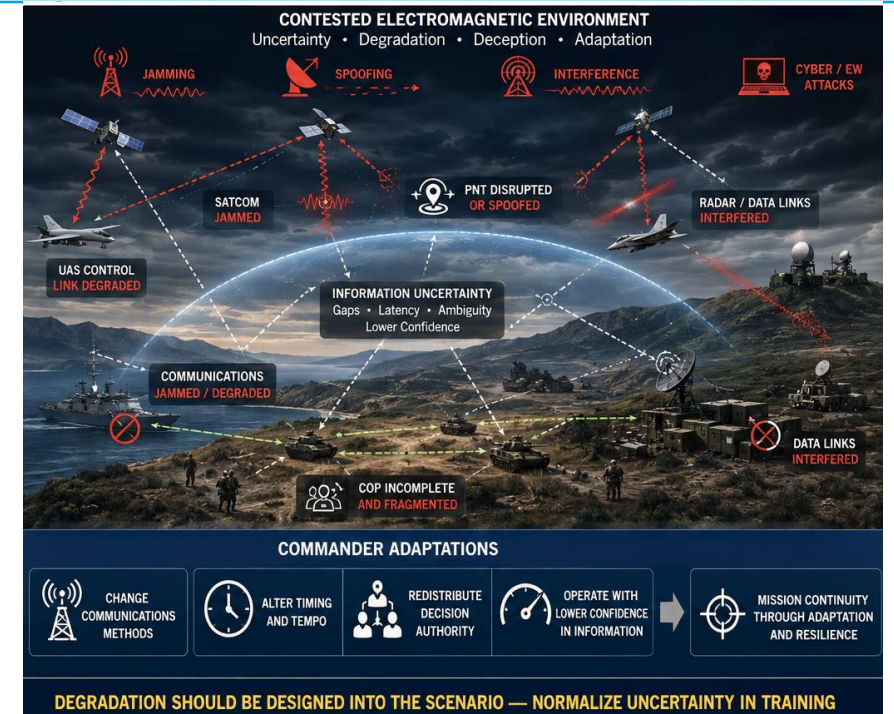
Comms

PNT

UAS C2

Radar

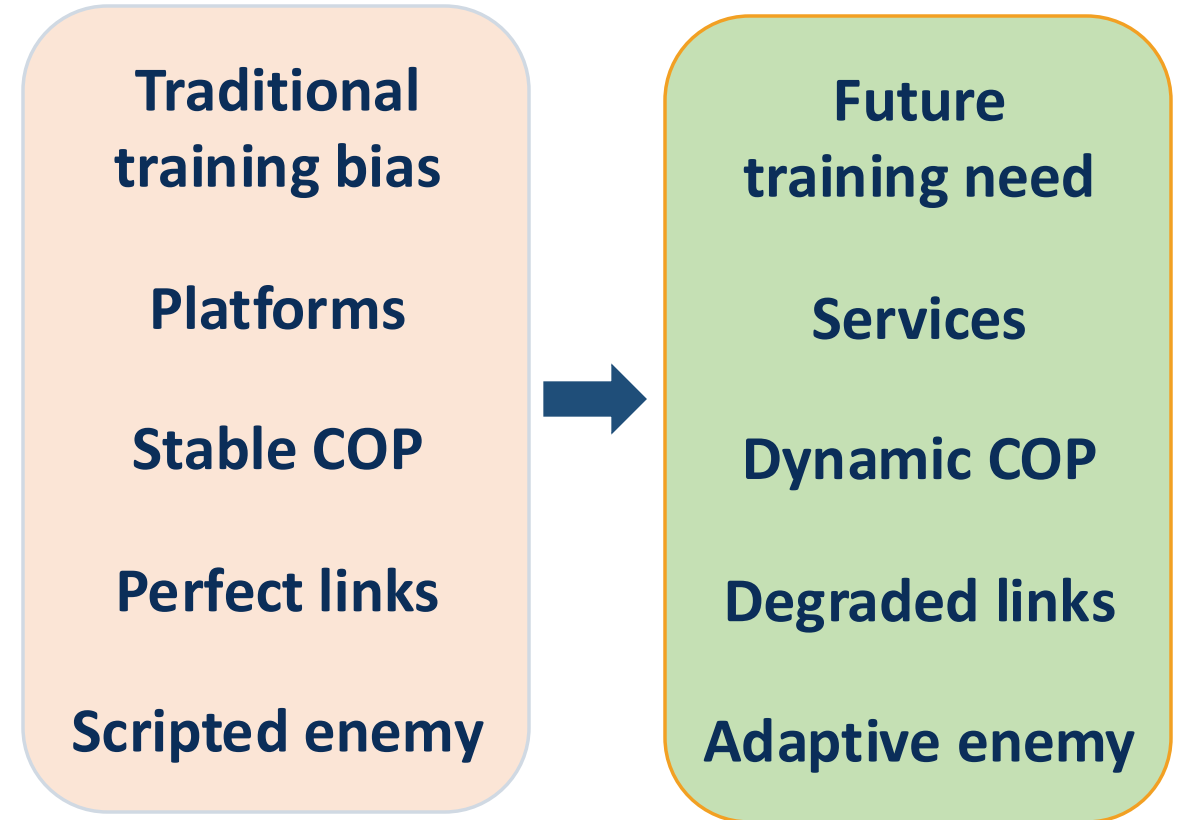
Data Links



Train degraded connectivity

Traditional Training is No Longer Enough

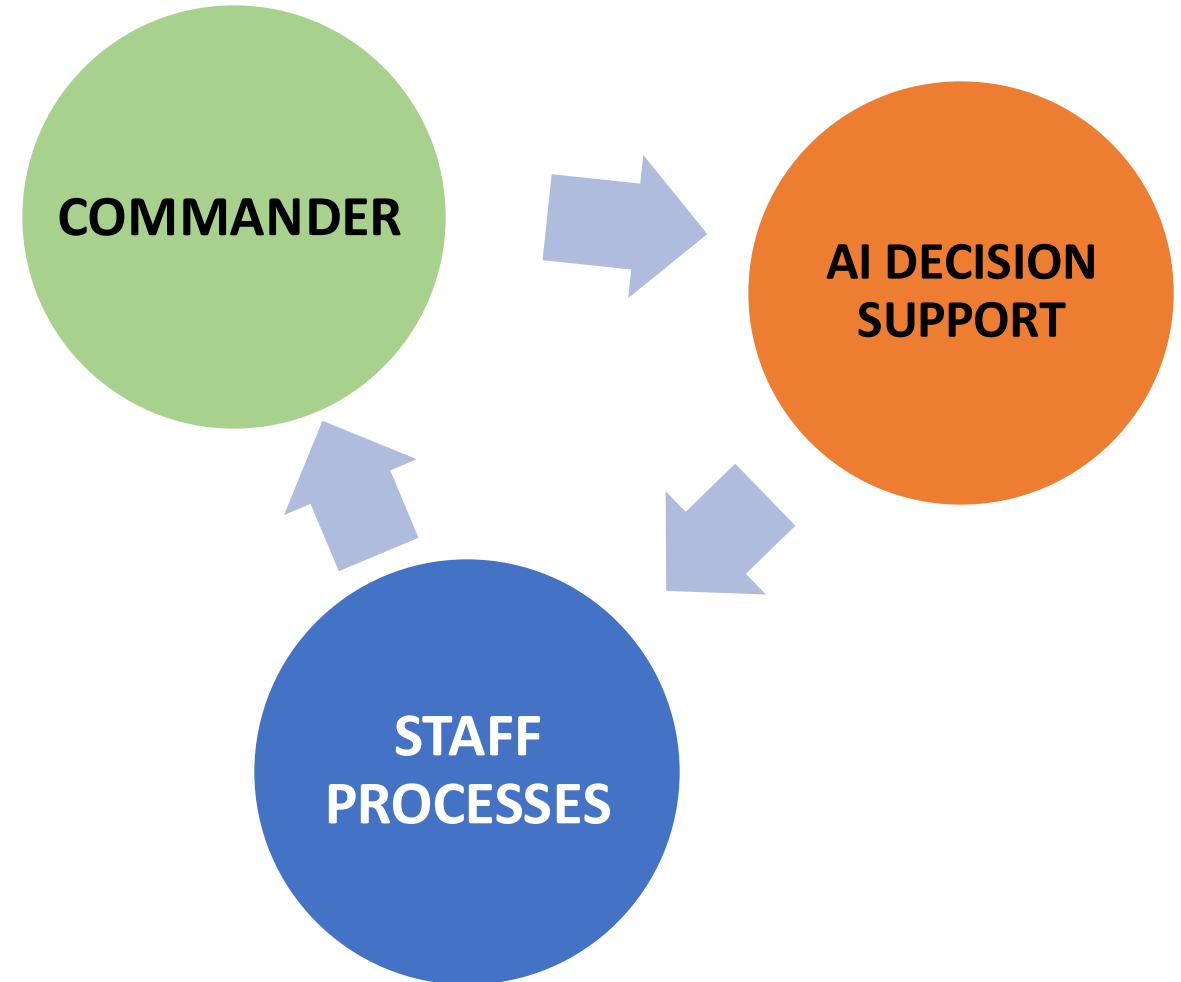
- Platform-centric simulations underrepresent cross-domain dependencies
- Stable scenarios miss the speed of battlefield innovation
- Perfect information creates unrealistic staff behaviours
- Single-domain play does not train space-enabled MDO decisions
- After-action review must assess command adaptation, not only attrition



Assess command adaptation

Human-Machine Teaming as Training Method

- AI accelerates sensing, correlation, prioritization and options
- Humans provide intent, judgment, context and accountability
- Trust must be calibrated through repeated realistic interaction
- HMT training must include AI error, ambiguity and explanation
- The commander closes the loop; AI supports the loop



Intent → machine support → staff action → human judgment

Cross-Domain Command for MDO

- CDC is the evolution of C2 required for MDO
- Command orchestrates across domains and actors
- The commander synchronizes effects across domains and actors
- CDC preserves human authority while exploiting machine-speed support
- Training develops judgment, tempo, orchestration and synchronization

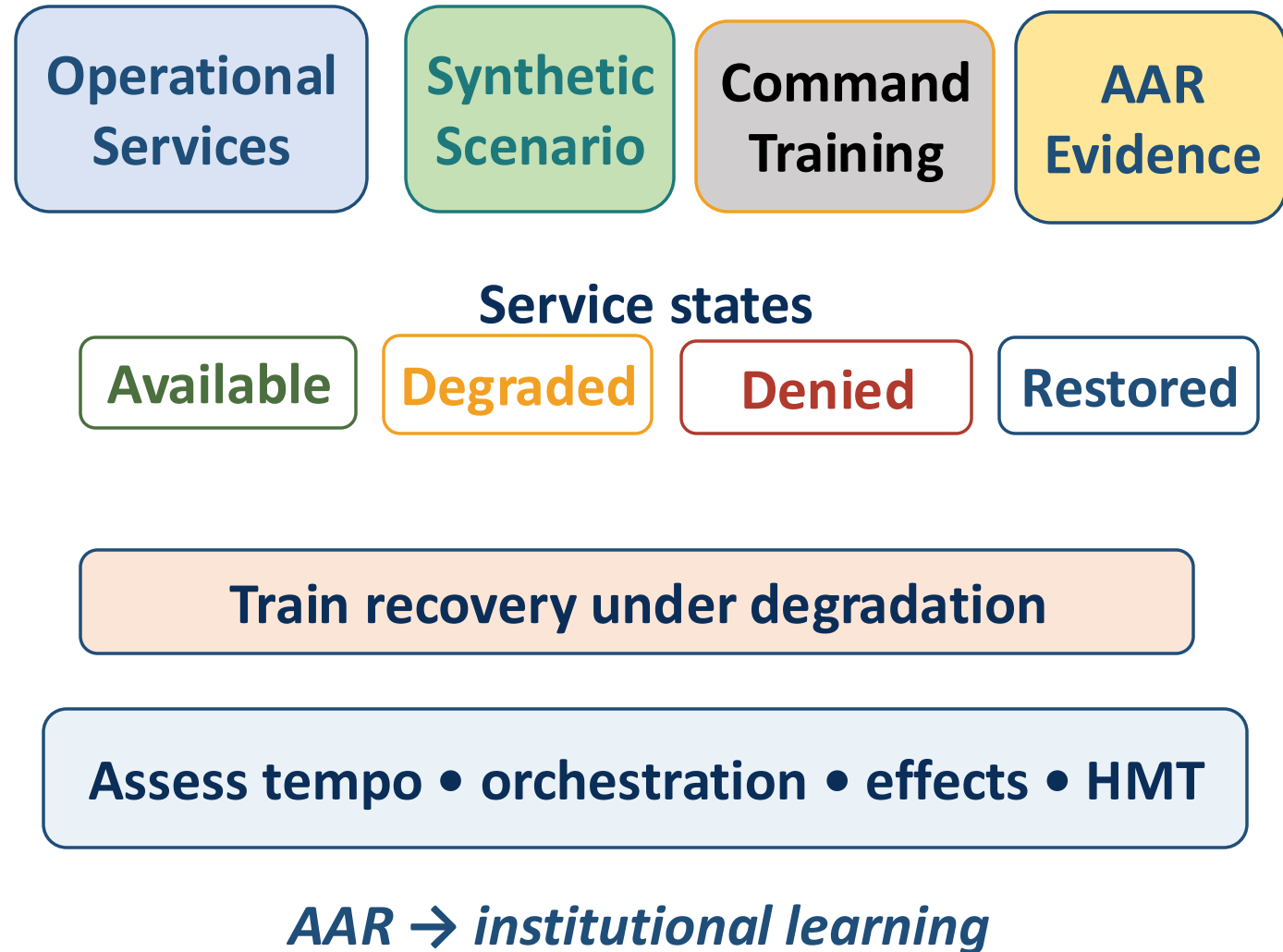


Operations across domains & actors

Orchestrate across domains • Synchronize effects

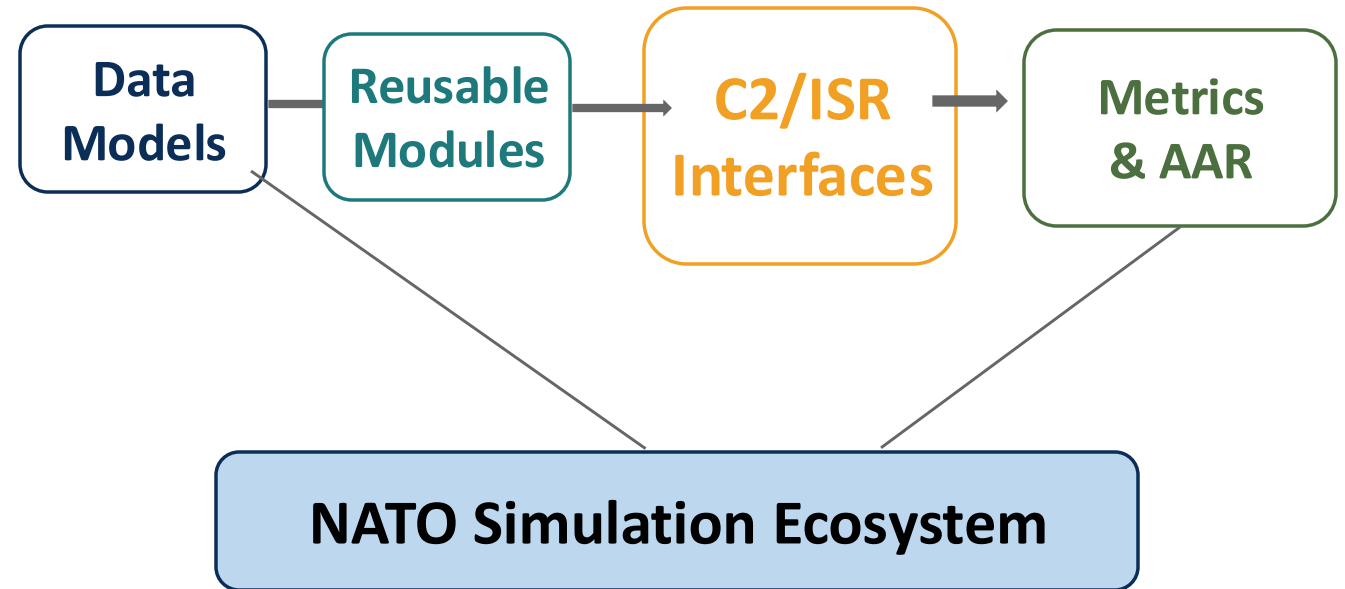
Adaptive M&S Framework: Train the Adaptation Cycle

- Model services, dependencies and sensor-to-shooter webs, not only platforms.
- Represent SATCOM, PNT, spectrum, ISR and data quality as service states.
- Inject adaptive adversary behaviour into scenarios and opposing forces.
- Instrument HMT, decision tempo and AI use.
- Generate AAR evidence on orchestration and effects synchronization.



NATO Simulation Ecosystem Requirements

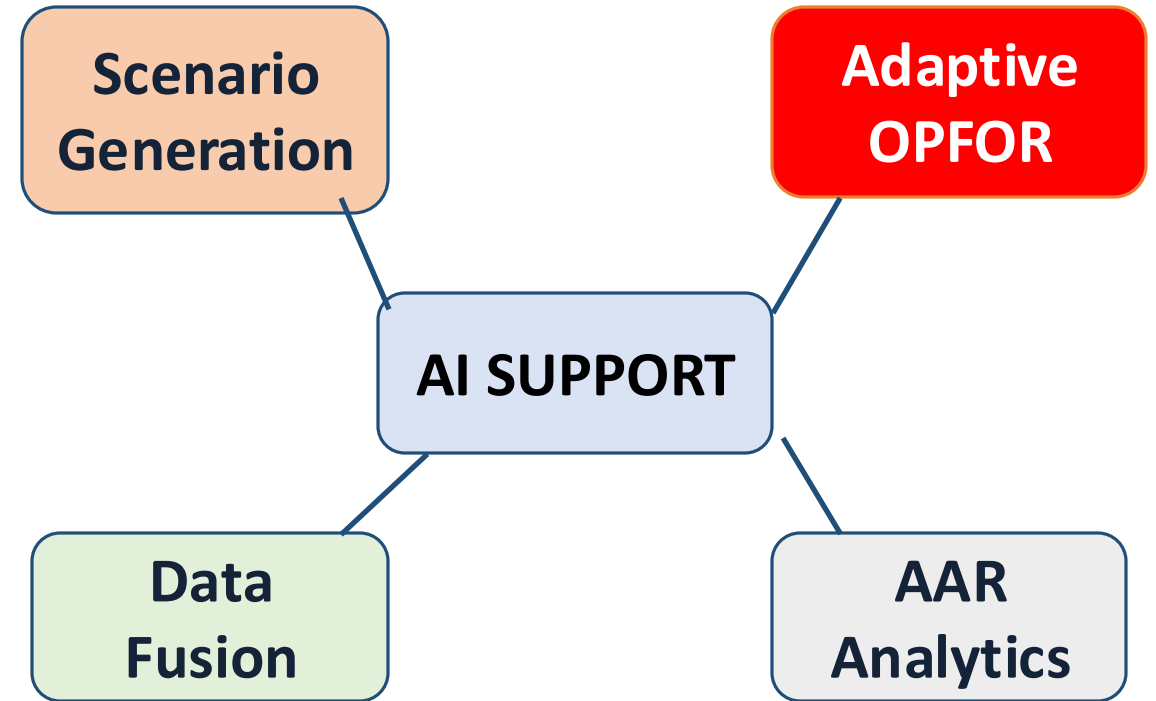
- Interoperable data models for domains, services and effects
- Reusable scenario components for UAS, EW, space and cyber
- Interfaces for C2, ISR, logistics and operational analysis tools
- Common metrics for readiness, tempo and HMT performance
- Open architectures to support multinational and industry integration



Open • interoperable • multinational

AI as Decision Support, Not Autonomous Command

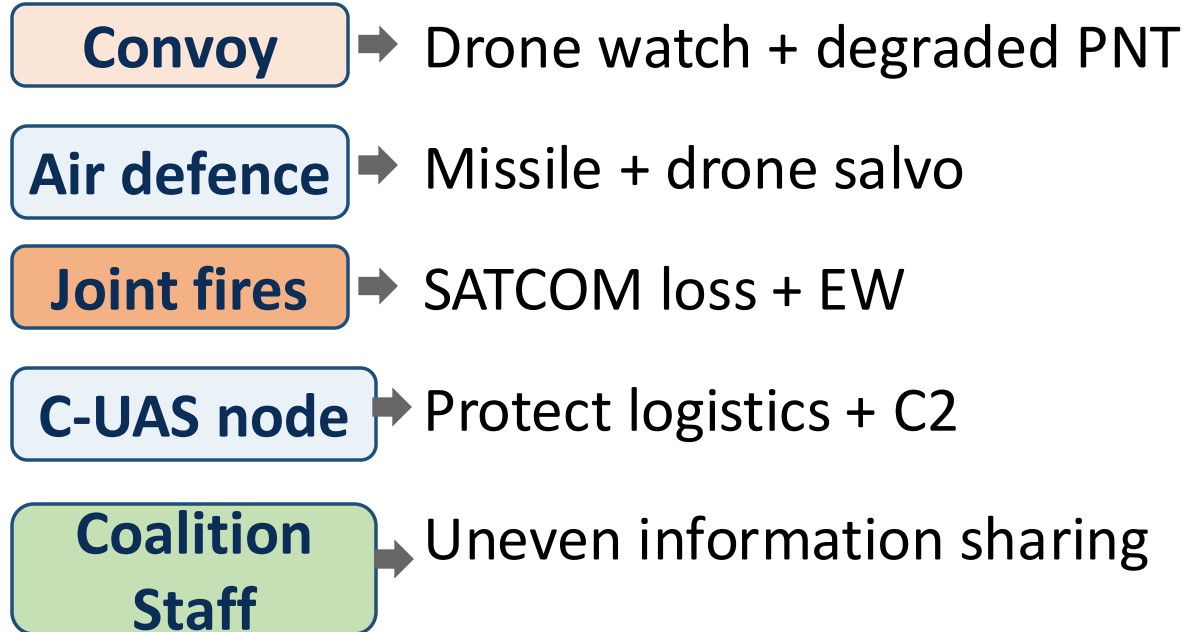
- Generate adaptive scenarios and non-scripted opposing-force behavior
- Fuse multi-source information into explainable decision aids
- Highlight anomalies, uncertainty and confidence limits
- Support automated after-action review and learning analytics
- Preserve governability, accountability and human decision authority



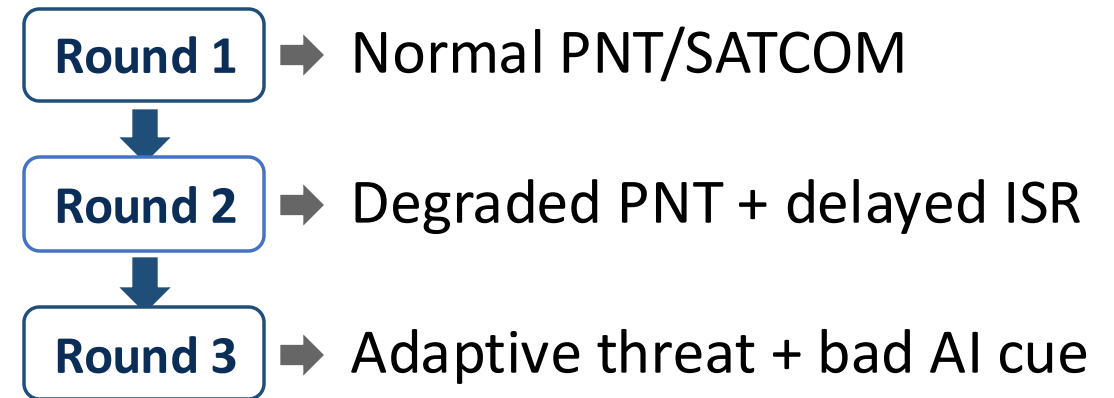
Explainable • governed • human-authorized

Training Vignettes: Decisions under Degradation

Vignettes force decisions



Air-defense triage



Measure: tempo • allocation • AI use • coordination • effects sync

Lessons → command decisions

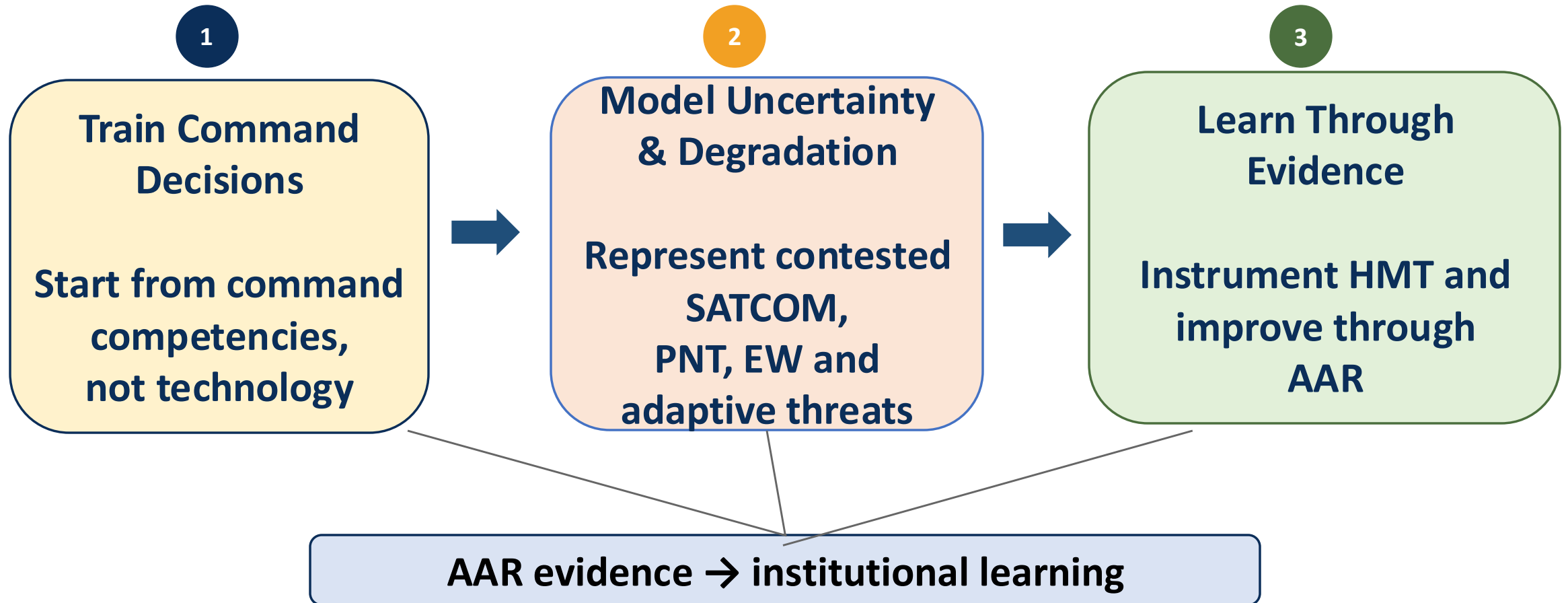
Conclusion



Mission-centric • Human-centered • Space-enabled

Train command, not gadgets.

Recommendations



Questions & Answers

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