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Authoring Mission Threads with Semantic Technologies

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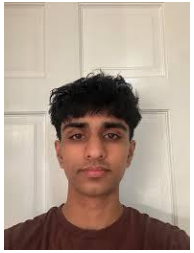

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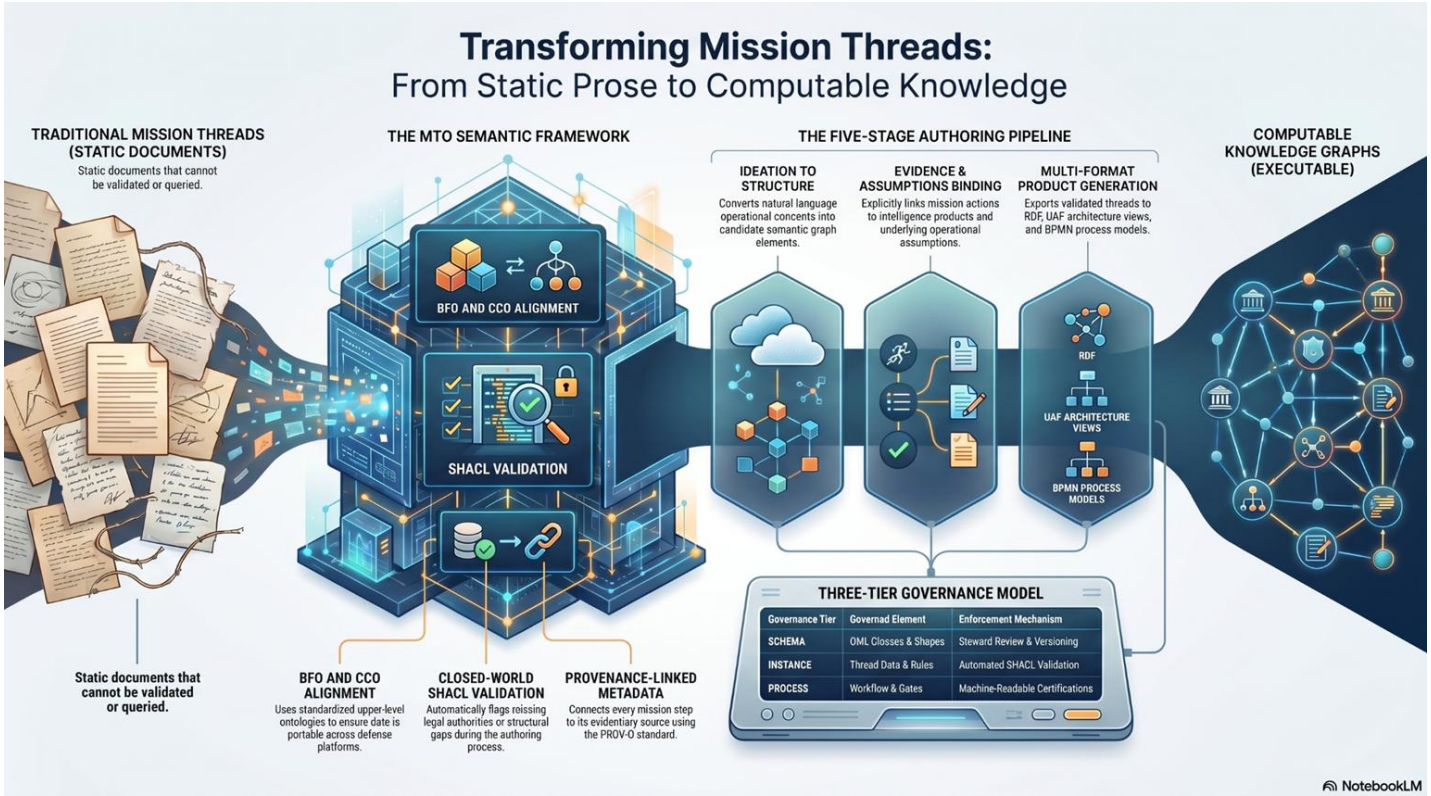
Outline

Mission Thread Authoring Workbench
- Demo
- Use case description

Motivation & Background
- How are current Mission Threads authored?
- Neuro-symbolic AI Augmented Wargaming & Acquisition

How do you use the tool?
- Use case exemplar

Enabling Technologies
- Mission Thread Ontology



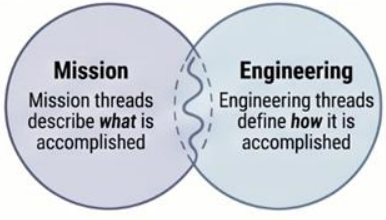
Semantic Mission Thread Authoring: From Ambiguous Sketches to Validated Architecture

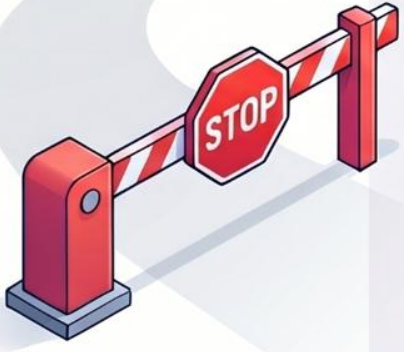
AMBIGUOUS SKETCHES

THE PROBLEM: AMBIGUOUS SKETCHES & INVISIBLE GAPS

STATIC FORMATS STIFLE DOWNSTREAM TOOLS:
Word docs and PPT "swim lanes" lack the triplestore queries and validation needed for simulation.

MISSION VS. MISSION ENGINEERING THREADS





VALIDATED ARCHITECTURE

THE SOLUTION: MTO & VALIDATED WORKFLOW

SHACL-GUIDED AUTHORING PIPELINE
A five-stage workflow uses automated constraints to flag logic violations at authoring time.

100% SUCCESS IN SEAD VALIDATION
Tested on third-party MQ-99 data with zero shape violations and 12/12 competency questions passed.

PORTABILITY IS NON-NEGOTIABLE
Built on open standards (RDF, OWL 2, SHACL) to ensure interoperability across NATO partners.

COMPARISON: LEGACY VS. SEMANTIC AUTHORING

FEATURE	LEGACY AUTHORING (TODAY)	SEMANTIC AUTHORING (MTO)
FORMAT	Word, PowerPoint, Whiteboards	RDF, SHACL, Knowledge Graphs
VERIFICATION	Manual Human Review	Automated Reasoner-Verified
TRACEABILITY	Implicit/Silent Assumptions	Evidence-linked Provenance

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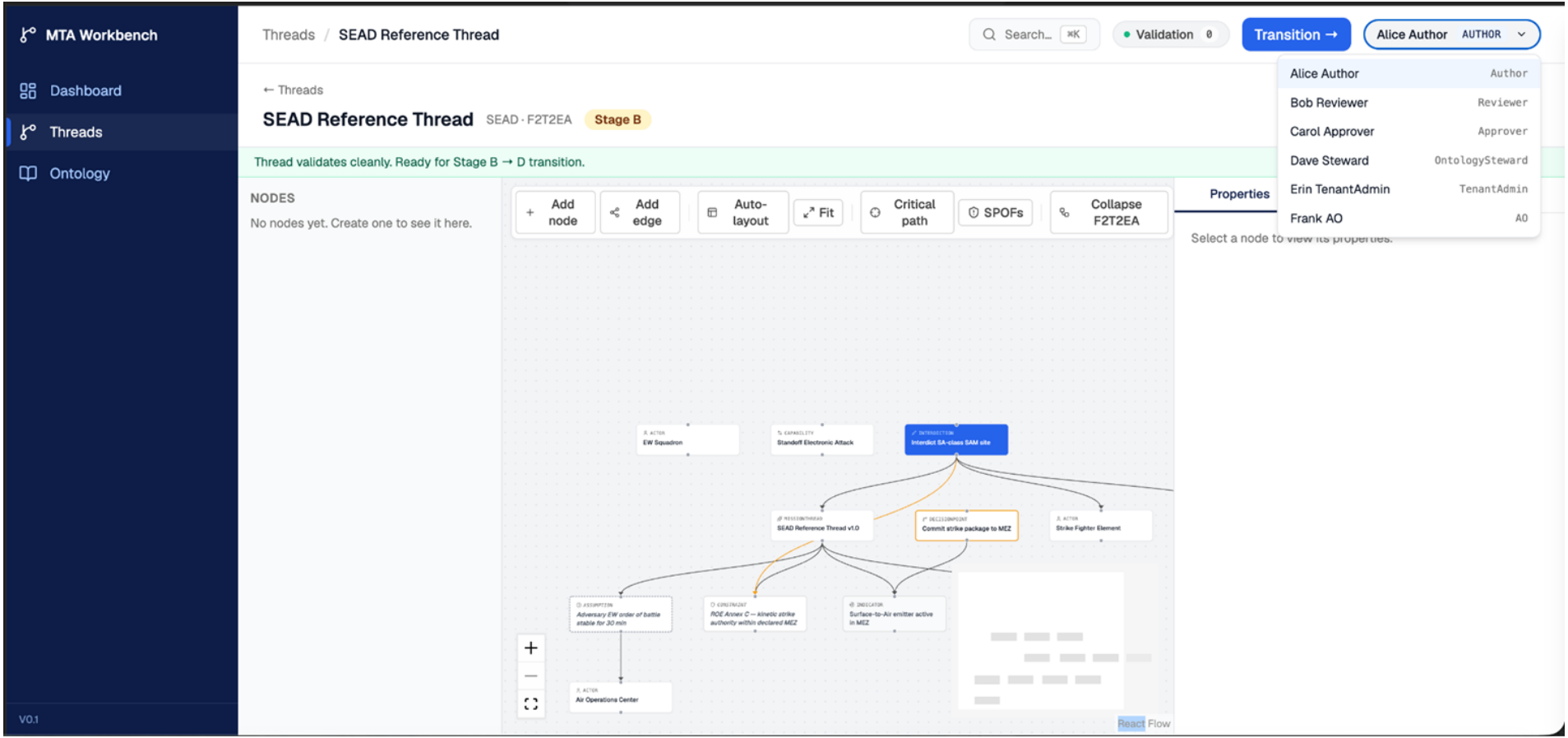
NotebookLM


MTA Workbench
Dashboard
Threads
Ontology
V0.1
Threads / SEAD Reference Thread
Search… ⌘K
Validation 0
Transition →
Alice Author AUTHOR
Alice Author Author
Bob Reviewer Reviewer
Carol Approver Approver
Dave Steward OntologySteward
Erin TenantAdmin TenantAdmin
Frank AO AO
← Threads
SEAD Reference Thread SEAD · F2T2EA Stage B
Thread validates cleanly. Ready for Stage B → D transition.
NODES
No nodes yet. Create one to see it here.
Add node
Add edge
Auto-layout
Fit
Critical path
SPOFs
Collapse F2T2EA
Properties
Select a node to view its properties.
EW Squadron
Standoff Electronic Attack
Interdict SA-class SAM site
SEAD Reference Thread v1.0
Commit strike package to MEZ
Strike Fighter Element
Adversary EW order of battle stable for 30 min
ROE Annex C — kinetic strike authority within declared MEZ
Surface-to-Air emitter active in MEZ
Air Operations Center
React Flow

Mission Thread: Detecting Drones Approaching a Civilian Airport

Objective: Detect, identify, and alert stakeholders about unauthorized drones before they create a safety hazard.

TERMINOLOGY & DEFINITIONS

What is a Mission Thread?

Mission threads describe *WHAT* must be accomplished.

Mission engineering threads describe *HOW* it is accomplished.

MISSION THREAD (MT) SEQUENCE

Source: Mission Engineering Guide
November 2020 Office of the Deputy Director for Engineering Office of the Under Secretary of Defense for Research and Engineering

THE PROBLEM

Ambiguous mission threads create uncertainty downstream

TODAY

- **Word docs**
- **PowerPoint swim lanes**
- **Whiteboard sketches**
- **Some MBSE Architecture Tools**

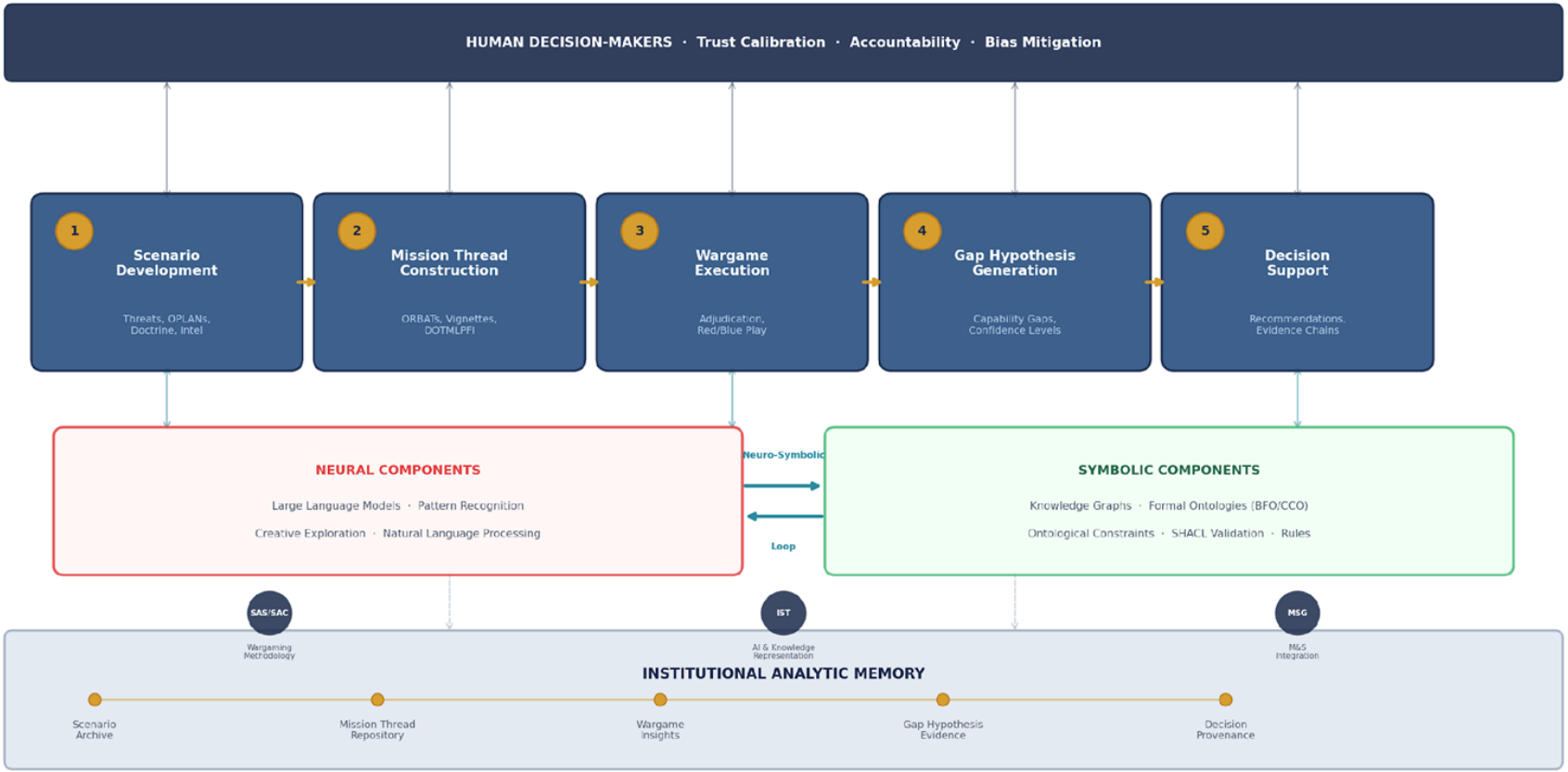
WHAT DOWNSTREAM TOOLS NEED

- **Triplestore queries**
- **SHACL validation**
- **Simulation input**

> *An interdiction thread was reviewed and approved. Months later, a legal advisor asked: “Under what authority?” The thread was silent. The gap was invisible until someone asked the right question in the right room.*

Neuro-Symbolic AI-Augmented Acquisition Wargaming

Conceptual Architecture



PUBLIC RELEASE
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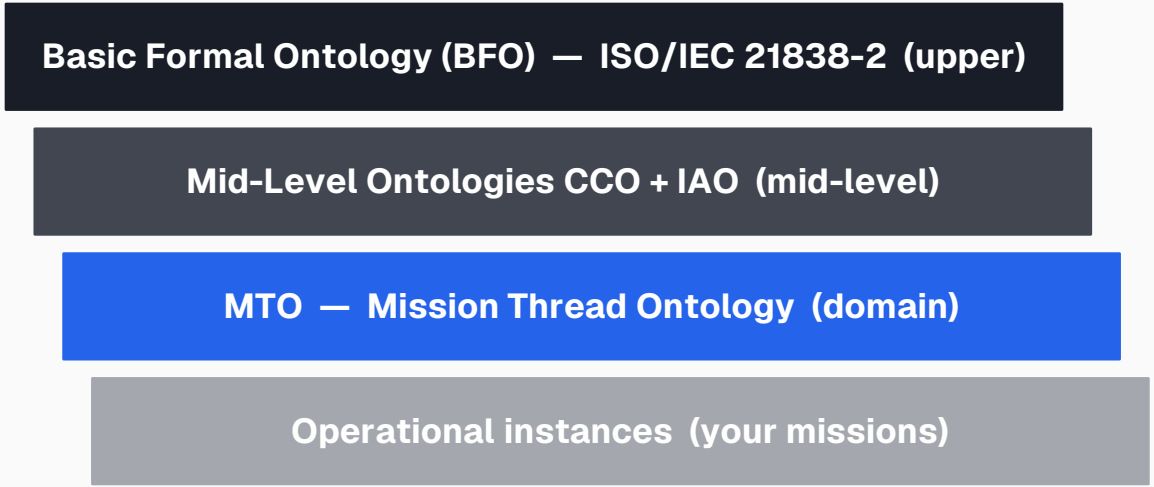
DESIGN PHILOSOPHY

Open standards. Layered ontology.



OPEN STANDARDS USED

- RDF
- OWL 2 DL
- SPARQL
- SHACL
- PROV-O
- SKOS

Portability is non-negotiable.

When the world's at stake, go beyond the headlines.

National security. For insiders. By insiders.

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BECOME A MEMBER

COGS OF WAR

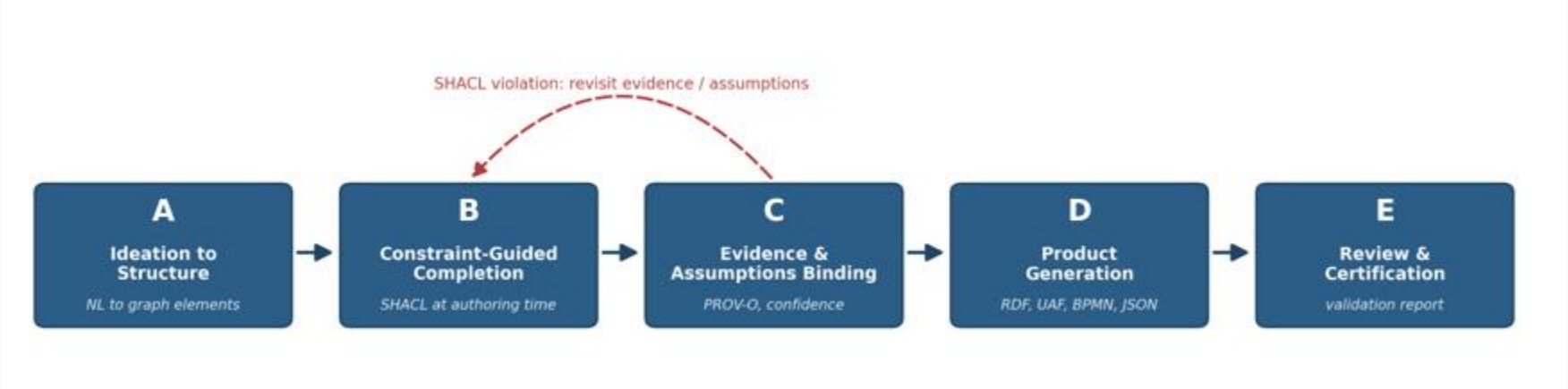
The U.S. Military Risks Letting Contractors Define How It Sees the Battlefield

DAVID KAMIEN

March 31, 2026

AUTHORING PIPELINE

Mission thread authoring workflow.



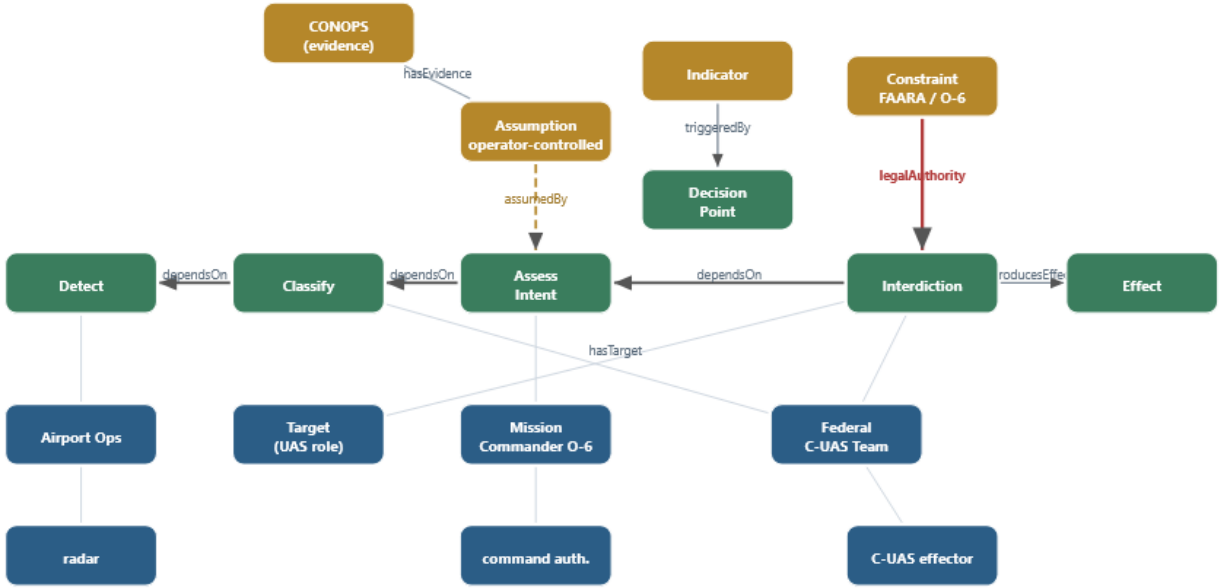
PATTERN LIBRARY

F2T2EA · F3EAD · OODA · detect-classify-track-interdict — every Counter-UAS thread built from the pattern inherits InterdictionShape automatically. Governance is built into the substrate, not bolted on.

Mission Thread: Detecting Drones Approaching a Civilian Airport

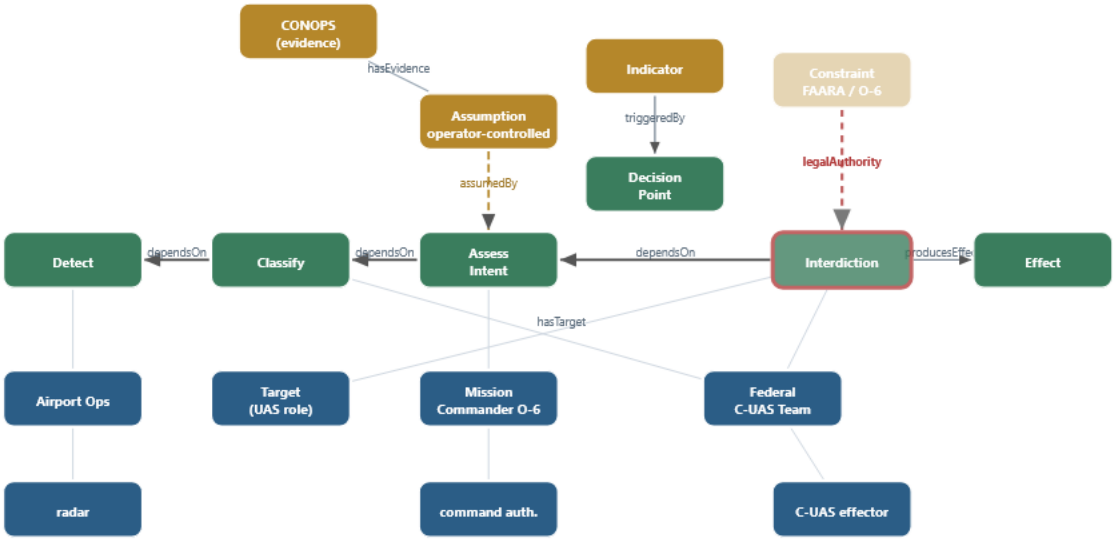
Objective: Detect, identify, and alert stakeholders about unauthorized drones before they create a safety hazard.

Demo



The mission thread

Detect, classify, assess, interdict, plus the authority and assumption layers a prose thread leaves implicit.

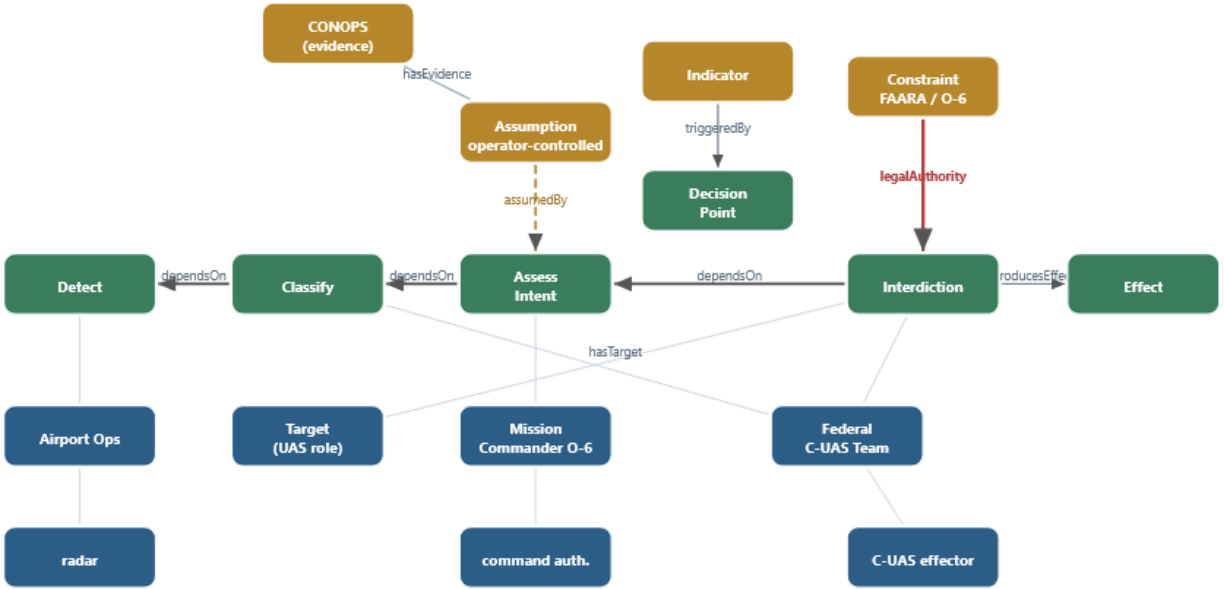


Stage 1: authority left implicit

The thread is authored; the legal authority for a kinetic effect is missing. Validation fires on commit.

⚠ InterdictionShape
Interdiction is missing a legalAuthority link to a Constraint.

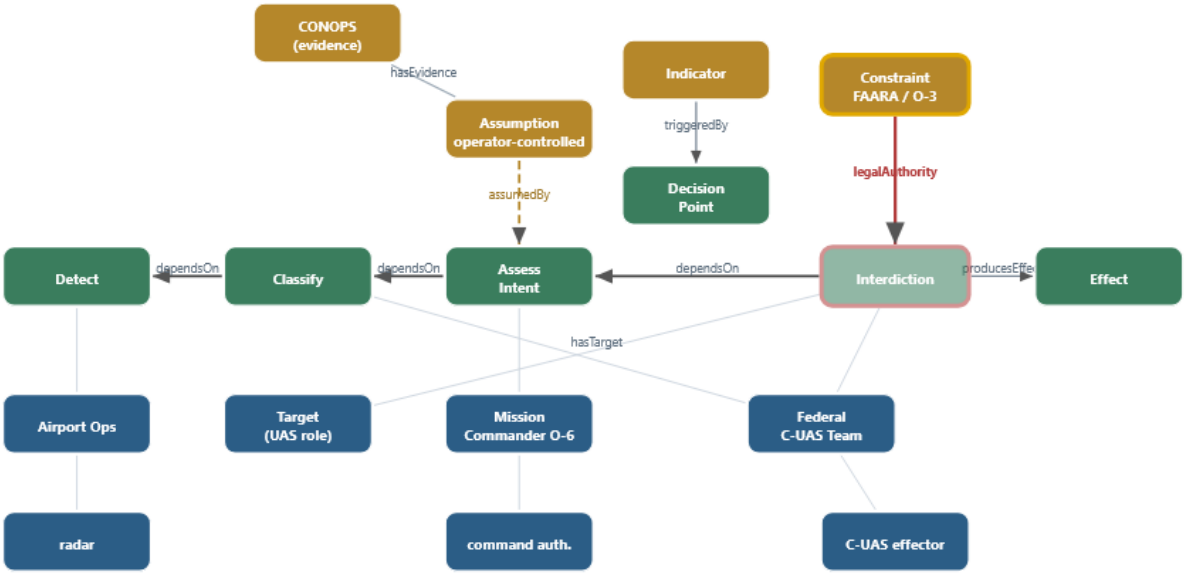
⚠ AuthoritySufficiencyShape
Kinetic interdiction lacks an O-6+ legal authority (engagementMode 'kinetic' requires a Constraint with authorizationLevel in O-6..O-10).



Stage 2: the author binds the FAARA authority

The B-to-C feedback loop: the gap sends the author back to bind the authority. The thread now conforms.

✓ CONFORMS — 0 violations. The thread is well-formed and operationally complete.



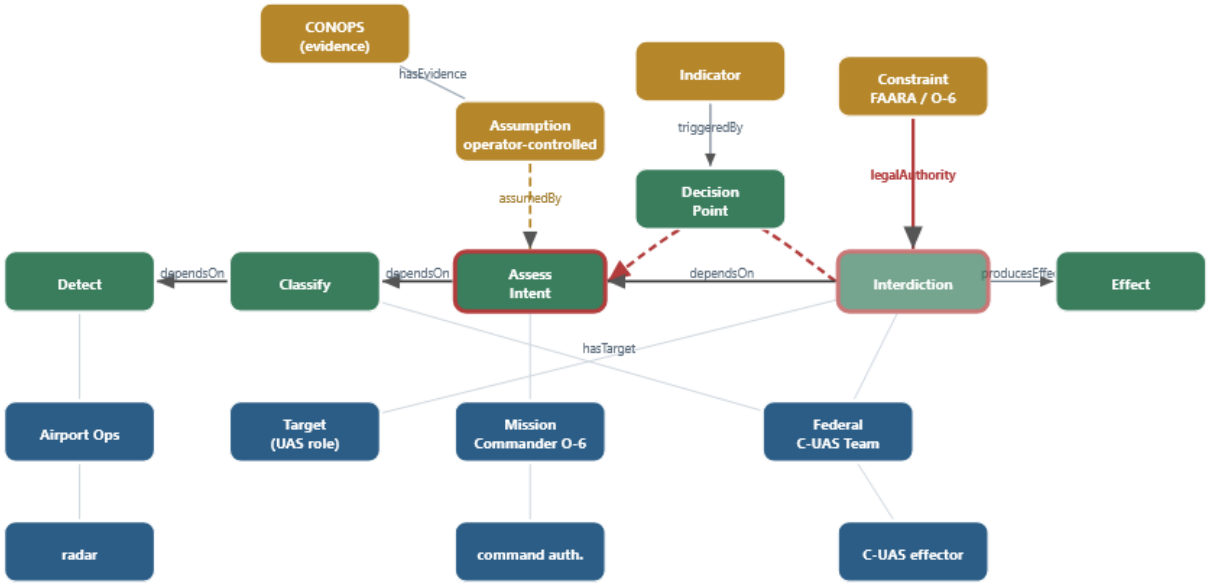
Stage 3: present but under-rank

Authority is linked, but at O-3 for a kinetic effect. Structurally valid, operationally invalid. InterdictionShape passes; AuthoritySufficiencyShape does not.

⚠ AuthoritySufficiencyShape

Kinetic interdiction lacks an O-6+ legal authority (engagementMode 'kinetic' requires a Constraint with authorizationLevel in O-6..O-10).

✓ InterdictionShape passes: the link is present. Only the sufficiency check fails.

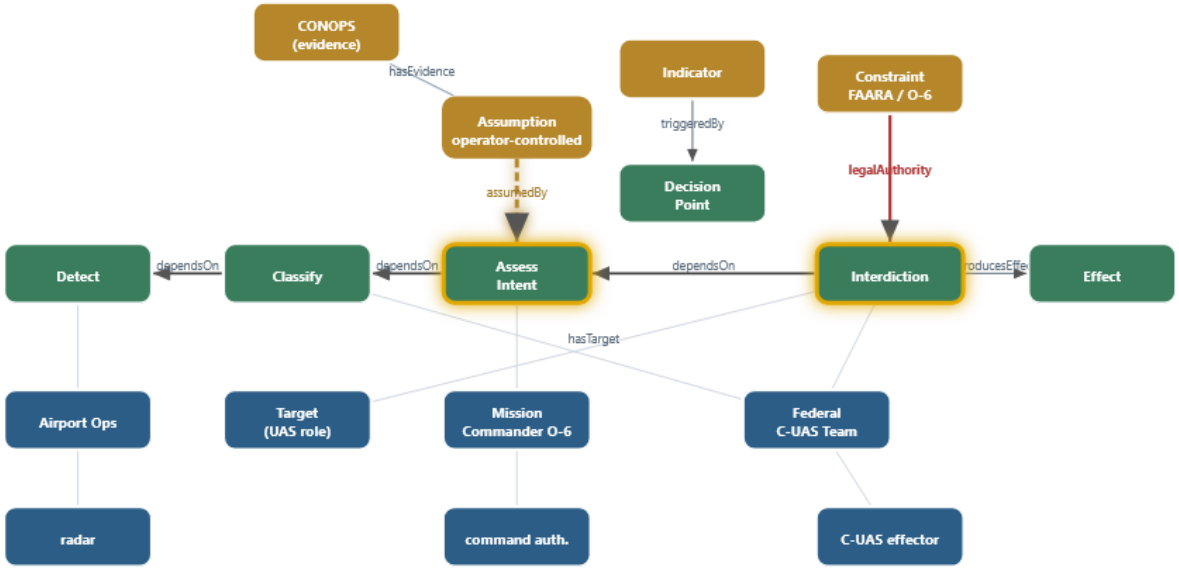


Stage 4: a reassess-after-action edit injects a cycle

A plausible authoring mistake adds a dependsOn edge from Interdiction back to Assess Intent. The acyclicity shape catches it.

⚠ DependencyAcyclicityShape

Action participates in a dependsOn cycle (dependsOn+ reaches itself).



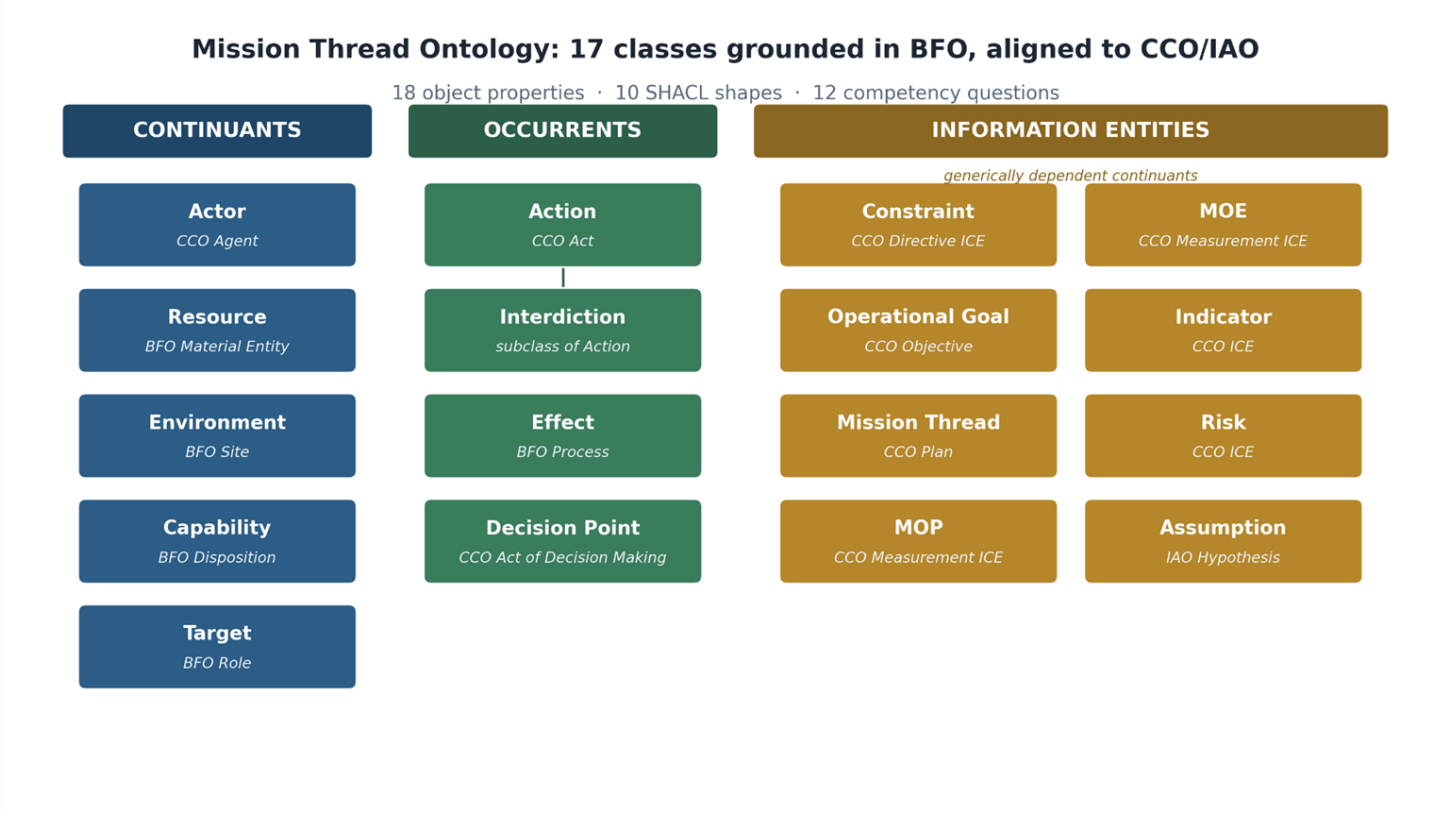
Stage 5: assumption sensitivity

If the operator-controlled assumption fails, which steps are at risk? One query (assumedBy then dependsOn*) answers it. A prose thread cannot.

Steps at risk if the assumption fails:

- **Assess Intent**
- **Interdiction**

The MTO is organized under BFO.



Each class traces a subclass chain back to BFO and maps cleanly to UAF (OV-5b, OV-2, OV-6c).

Our three key contributions.

01 **A reasoner-verified Mission Thread Ontology (MTO)**

02 **A SHACL-guided authoring workflow**

03 **Computational validation on authentic data**

Validation on a Suppression of Enemy Air Defenses (SEAD) data.

Source: independently authored MQ-99 “Berserker” SEAD model from IGNITE Hackathon 2026 as well as in the UAOS / openCAESAR family — a third-party mission-engineering artifact.

CHECK	TOOL	RESULT
Logical consistency	HermiT	0 unsatisfiable classes
Logical consistency	OWL-RL	56,199 inferred triples; 0 owl:Nothing
Shape conformance	pySHACL	0 violations, 0 warnings (10 shapes)
Competency questions	OWL-RL + SPARQL	12/12 execute; 0 strict-invariant failures
Negative tests	pySHACL	unauthorized + under-authorized + cycle: all flagged
Structural metrics	rdflib	17 classes, 18 obj props; rel. richness 0.51

Two findings worth naming: the kill chain's reconnaissance steps (Find / Fix / Track / Target) carry no MOPs in the source model; and the source model carried no legal authority and no evidence-linked assumptions. Both had to be authored — with provenance recorded.

SECTION 3.6

Four corrections the reasoner forced.

01

Constraint = Directive ICE, not Disposition

Deontic norms prescribe; dispositions manifest. Disposition typing is unsatisfiable in OWL 2 DL.

02

Target = Role borne by a Material Entity

Target-hood is anti-rigid and externally grounded — the signature of a BFO Role, not a kind.

03

dependsOn = simple, irreflexive, asymmetric

Closure computed via SPARQL property paths. Transitive + irreflexive + asymmetric is OWL 2 Full.

04

assumedBy reversed: Assumption → Action

Lets propagation chain through dependsOn+, without a non-simple property axiom.

Limits and next steps

Single mission class validated.

One SEAD thread. Coverage of the vocabulary is demonstrated, not exhaustive.

The action-specification problem.

MTO types Action as a BFO Process. But at authoring time, no process has yet occurred — the nodes an author manipulates are specifications of intended acts (directive content), not the acts themselves. A faithful remodel would introduce an action-specification layer of ICEs that prescribe, and are later realized by, the process-level acts. This is paper-wide and the most significant open problem.

SUGGESTIONS AND FUTURE DIRECTIONS

- → Human-centered evaluation (authoring efficiency, interoperability, operational value).
- → Contribute Assumption and Constraint extensions to CCO.
- → MEDS ↔ MTA temporal bridge for end-to-end traceability.
- → Automated reasoning.

IN SUMMARY

Reasoner-verified ontology — 17 classes, 18 object properties.

Validated on a third-party SEAD model with zero shape violations.
A concrete basis for the human-centered evaluation and the action-specification remodel ahead.

Questions.

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