CTOP

Cyber Terrain Operations Platform

Explainable AI-Enabled Mission Assurance

A Mission Assurance Decision-Support Prototype for Air Force Global Strike Command

Assured NC3 Visibility • Mission Thread Integrity • Evidence-Linked Analysis

CTOP is a cyber terrain knowledge graph prototype built to help Air Force users pull together systems data, supporting documents, dependencies, and mission threads that are usually spread across separate tools and repositories. For Air Force Global Strike Command, the value is straightforward: give analysts and mission leaders a clearer view of how critical NC2 and NC3 assets connect, where hidden dependencies sit, and which disruptions matter most to mission assurance.

Executive Summary

Cyber Terrain Operations Platform (CTOP) is a prototype decision-support capability intended to help operators make sense of complex cyber terrain when data is distributed, dependencies are difficult to trace, and mission impact is not immediately clear.

At its core, CTOP connects structured data, technical artifacts, and unstructured documents into a single graph-based environment that users can explore and verify. It is not intended to automate command decisions. Its purpose is to help analysts and mission stakeholders understand relationships, supporting context, and source evidence more quickly than is possible when working across disconnected systems and repositories.

This white paper presents CTOP in two complementary layers:

- A reusable, explainable AI-enabled decision-support foundation for cyber terrain awareness
- An Air Force mission-assurance framing centered on Air Force Global Strike Command, with broader relevance to Sixteenth Air Force stakeholders responsible for cyber terrain awareness and information advantage

Together, these layers illustrate how the same technical foundation can be tailored to an Air Force mission problem without overstating maturity or diminishing the role of operator judgment.

1. The Mission Assurance Challenge for Air Force Global Strike Command

Air Force Global Strike Command operates in mission environments where assured command, control, and communications are fundamental to deterrence credibility. In this environment, the challenge is often not a lack of data, but a lack of integrated context.

Critical information about systems, documents, interfaces, policies, and supporting infrastructure frequently exists across separate repositories, technical artifacts, and organizational boundaries. That fragmentation slows analysis and makes it harder to understand how mission threads actually traverse NC2 and NC3 environments.

As a result, analysts and mission stakeholders must routinely:

- Pull data from multiple disconnected systems and document sources
- Manually reconstruct system relationships, dependencies, and message paths
- Assess the mission impact of degraded nodes, links, or aging systems
- Explain and defend analytical conclusions to senior decision-makers

CTOP addresses this challenge by adding an analytical layer above existing Air Force systems and data sources. Rather than replacing systems of record, it helps users build a more coherent and usable picture of cyber terrain and mission dependencies.

2. Introducing CTOP

CTOP ingests, normalizes, and links structured data, unstructured documents, and existing system information into a graph that analysts can explore. In practice, that gives users one place to examine how systems, documentation, dependencies, and mission-relevant relationships fit together.

In an Air Force context, CTOP is best understood as a mission-assurance support capability. It helps users move from fragmented technical knowledge toward a clearer understanding of critical NC2 and NC3 terrain, while preserving analyst control and interpretive authority terrain.

Core design principles

Principle	Description
Human in the loop	CTOP supports decisions; it does not make them. Human judgment remains central.
Explainability and traceability	Insights are grounded in linked relationships, source documents, and visible provenance.
Integration over replacement	CTOP complements existing Air Force systems and workflows rather than displacing them.
Domain adaptability	The same technical foundation can be tailored to specific mission threads, ontologies, and operational contexts.

3. CTOP Platform Foundation

The CTOP core is intentionally modular and adaptable. It gives users a way to correlate data, explore relationships, and answer mission questions through an explainable graph rather than a black-box workflow.

Across the available CTOP materials, four integrated capabilities recur as the platform's foundational value proposition:

- **Unified map** - a consolidated representation of NC2/NC3 assets and their relationships within an interactive knowledge graph
- **Evidence linking** - direct connections from graph nodes and edges to supporting documents, policies, diagrams, and technical artifacts
- **Intelligent search** - a single search experience spanning graph entities and documents using keyword, semantic, and relationship-aware discovery
- **Natural language reasoning** - plain-English mission questions translated into graph-backed answers without requiring specialized query syntax

4. Mission Thread Analysis in an Air Force Mission Context

One of the most practical AFGSC use cases for CTOP is mission thread analysis. In that role, CTOP helps operators trace how a mission-relevant platform, collaboration layer, network segment, or supporting cyber asset connects to the broader NC2 and NC3 environment.

This approach allows analysts to move beyond static diagrams and inventories toward a more dynamic understanding of dependency paths and mission impact.

Mission assurance is not simply an inventory problem. It requires understanding which paths actually matter to mission execution, which dependencies are shared across mission threads, and where a single failure could have broader operational effects. CTOP supports this by enabling analysts to:

- Identify shared dependencies across mission threads
- Reveal single points of failure and high-consequence bottlenecks
- Support what-if analysis for degraded nodes, systems, or message paths
- Provide defensible, evidence-linked answers for senior leaders and mission stakeholders

5. Analyst-Centered Exploration and Search

CTOP is designed so operators can move between graph exploration, search, filtering, and supporting evidence without bouncing across several separate tools. It brings relationship discovery and document context into one analytical workflow.

Users can refine the graph by relationship type, asset class, or mission-relevant criteria, examine entity details, and ask plain-language questions that return traceable graph paths and linked documentation.

Key analyst-centered features include:

- Graph-based relationship discovery and path traversal
- Multi-dimensional filtering for focused terrain analysis
- Document-aware search spanning uploaded artifacts and graph entities
- Natural-language interaction that reduces friction for technical and non-technical users

6. Explainability, Governance, and Trust

For Air Force use, trust is not optional. CTOP is therefore framed as explainable decision support, not black-box AI.

Natural-language interaction is included to reduce analytic friction, but outputs remain grounded in visible relationships, paths, and source evidence. Users can move from an insight directly back to the documentation or relationship that supports it.

This approach supports three expectations that matter in mission-assurance environments:

- Insights are explainable rather than opaque
- Data provenance and evidence paths remain visible to the operator
- Human operators retain authority over interpretation, prioritization, and action

CTOP is also framed with classification-aware handling, role-based access control, and alignment to RMF and ATO-oriented environments in mind. That supports government integration planning without overstating maturity or deployment status.

7. Value to Air Force Stakeholders

For mission assurance leaders, analysts, engineers, and program stakeholders, CTOP shows how a cyber terrain knowledge graph can improve understanding while preserving command authority and analyst control.

Stakeholder value	Operational relevance
Reduce cognitive burden	Compresses the time needed to understand complex cyber terrain and supporting evidence.
Improve mission thread integrity	Reveals how platforms, systems, documents, and dependencies connect across NC2/NC3 environments.
Support defensible decisions	Provides evidence-linked answers that can be explained to leadership and reviewed by analysts.
Focus limited resources	Helps identify the highest-impact assets, bottlenecks, and vulnerabilities for deeper attention.

Strengthen deterrence assurance	Improves authoritative visibility into the terrain that underpins assured command and control.
Support broader Air Force relevance	Provides a reusable foundation that can also inform Sixteenth Air Force cyber terrain awareness and cross-domain operational understanding.

8. Illustrative Decision Support Questions

By combining graph analytics, evidence linking, and plain-language interaction, CTOP can help answer mission-assurance questions that would otherwise require time-consuming manual reconstruction, such as:

- Which systems, documents, and message paths support a given NC2 or NC3 capability?
- What assets and mission threads are affected if a particular node, network segment, or dependency is degraded?
- Which collaboration tools or supporting services intersect with mission-relevant NC2/NC3 workflows?
- Where do aging systems, shared dependencies, or incomplete documentation create elevated mission risk?

These are illustrative prototype questions, not claims of fielded operational use. They show the type of graph-backed reasoning CTOP is intended to support Air Force mission environments.

9. Conclusion

CTOP is best understood as a reusable decision-support foundation adapted to an AFGSC mission-assurance context. It helps turn fragmented cyber terrain information into a coherent, queryable operational picture that users can trace back to source material.

For Air Force Global Strike Command, that means better visibility into mission threads, a clearer understanding of hidden dependencies, and stronger support for mission assurance decisions that leaders can explain and defend.

As a prototype and R&D capability, CTOP is intended to complement existing systems, reduce analytic friction, and give users practical insight where complexity currently slows understanding.

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