TLP:AMBER

FULL SPECTRUM SPACE CYBERSECURITY PROFESSIONAL

REFERENCE WORKBOOK

METEORSTORM Data Model

The Taxonomic Element Nomenclature (TEN) reference.
Five layers defining 30 taxonomic elements,
each carrying its published definition verbatim.

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CONTENTS

BACKGROUND

WHO DEVELOPED IT AND HOW IT EVOLVED

METEORSTORM comes out of a decade of standing in the middle of the space information sharing problem, not from a whiteboard. It did not begin life as a framework at all. It began as a practical way to generate multi-domain mission scenarios: exercises that had to place realistic adversary activity across terrestrial, aquatic, aerial, orbital, and deep space platforms at once. Building those scenarios kept exposing the same gap. There was no shared vocabulary that could name where on a converged platform something happened, what it touched, and what it meant, in terms every organization at the table could read. The scenario generator's working vocabulary hardened into a data model, the data model proved out in analyst curation workflows, and the result grew into a global framework for converged space platforms.

The author's path runs through the rooms where that gap costs the most:

- Co-Chair, Space ISAC Information Sharing Working Group, and Member Analyst, Space ISAC Analyst Working Group (2020-2022)
- Founder, ethicallyHackingspace (eHs) (2022-2023)
- Technical Editor, IEEE Space Systems Cybersecurity (S2CY) Working Group (2023-present)
- Lead, Space Systems Integration Layer Subgroup, IEEE S2CY Working Group (2026-present)
- Co-Chair, Space Information Sharing and Analysis Center (ISAC) Space System Extended Bill of Material (BOM) Working Group
- MITRE Hardware SIG (2024-present)
- U.S. Air Force from 1993 as a Meteorological and Navigational Systems Specialist, then Instructor of Technology and Military Science at Keesler AFB under Air Education and Training Command until 1997

The meteorology background is not incidental: it is where "nature as an adversary" enters the model. An analyst trained to read weather as an operational force treats the environment as a first-class actor, and that instinct became the model's first layer, the Primary Capability Environment, and the deconfliction question no other framework asked: is this environmental, or is it cyber physical?

THE FOUR PROBLEMS IT WAS BUILT TO SOLVE

1. **Fragmented data schema across domains.** Threat and telemetry data from terrestrial, aerial, aquatic, orbital, and deep space systems use incompatible structures, preventing seamless integration or automated cross-correlation.
2. **Incomplete context for threat attribution.** Indicators rarely carry sufficient metadata to distinguish between environmental layer, segment, or service function, making multi-domain attribution inconsistent and error-prone.
3. **Limited machine interpretability of threat indicators.** Existing feeds lack standardized, machine-readable classifications for space-specific threats, constraining automated fusion, enrichment, and detection workflows.
4. **Tagging inconsistency and analytical noise.** Overlapping or ambiguous labels applied by different organizations introduce redundancy and confusion, eroding the reliability of shared threat intelligence.

The framing thesis: the convergence of terrestrial, aquatic, aerial, space, and deep space platforms is both the challenge, keeping pace with AI enabled adversaries, and the opportunity, moving professional skills from non-kinetic to kinetic platforms.

HOW IT IS EVOLVING

The model was formally integrated into MISP in October 2025, and now lives as a published, machine-readable taxonomy in the MISP taxonomy repository, at version 2. That is what lets any organization tag intelligence in the shared vocabulary today and exchange it machine to machine, including with the Space ISAC Exchange. Around the model, a full delivery apparatus has grown: the Full Spectrum Space Cybersecurity Professional program teaches the five functions end to end on a working platform scenario, and its credentials put the framework in the hands of the workforce that has to run it.

THE FORMAL DEBUT: CYBERSAT 2025

The model was presented formally at CYBERSAT 2025 in the session Space Collective Defense: Collective Response. The talk laid out the four information sharing problems the model answers, walked all five layers with the design rationale for each, and closed not with a product pitch but with a call to action: three community missions, a Minimum Priority Intelligence Requirements Baseline, a Minimum Converged Detection Engineering Baseline, and a Minimum Telemetry Instrumentation Baseline, with a public entry point at launch.collectivedefense.space. The framing was deliberate. The model was offered to the community as the first big step toward aligning government, commercial, and academic threat intelligence at a global level.

INTRODUCTION

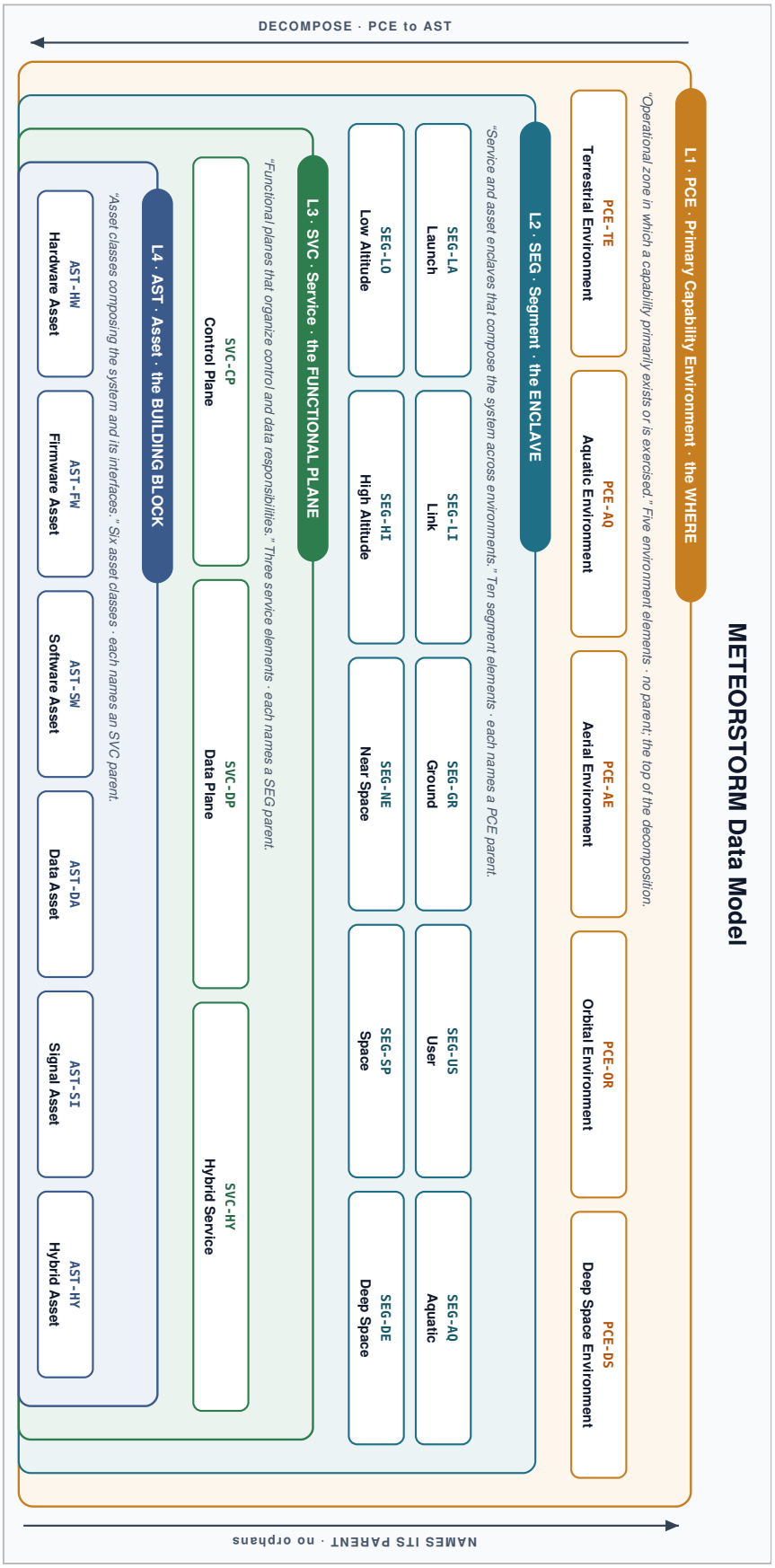
This is the METEORSTORM TEN data model: five layers defining 30 taxonomic elements, each named by a Taxonomic Element Nomenclature (TEN) that carries its published definition. The verbatim rule below governs every definition.

METEORSTORM DATA MODEL FIELDS

LAYER	The layer the element belongs to: **PCE**, **SEG**, **SVC**, **AST**, or **AN**.
TAG	The published tag for the element within its layer, for example **OR**.
LABEL	The published name that corresponds to the tag, for example **Orbital**.
DEFINITION	The published definition for the element, quoted verbatim.

Every element below is printed in full. To name one real occurrence on your platform, switch to the colon ETEN nomenclature in the companion ETEN reference.

> **Verbatim rule.** Every definition in the tables below is the published METEORSTORM taxonomy text, quoted exactly. On this platform an element definition is never abbreviated, paraphrased, or reworded. When you need to describe how an element applies to your actual system, that is the job of the ETEN, not an edit to the definition.



L1 PRIMARY CAPABILITY ENVIRONMENT (PCE)

WHY THIS LAYER EXISTS

Analysts needed to operationalize the attribution of platform environments during threat intel curation, and no existing framework carried a mechanism for it. Nature can create adverse conditions in every one of the five environments, so the environment must be a first-class attribute of every record, not a footnote.

> *"This layer was crucial as current frameworks simply skipped over mechanisms to operationalize key enrichment sources like Space Domain Awareness (SDA), terrestrial weather, maritime activity, and other environmental dimensions that need to be top of mind for analyst. No environmental context so how would you ever know if it was environmental or cyber physical?"*
>
> THE ETHICALLYHACKINGSPACE (EHS) TEAM

Predicate: "Operational zone in which a capability primarily exists or is exercised." The WHERE, the zone. PCE elements have no parent; they are the top of the decomposition.

TERRESTRIAL ENVIRONMENT

TEN NOMENCLATURE

```
PCE-TE-Terrestrial Environment-Surface-based operational zones on planetary bodies.
```

LAYER	**PCE** Primary Capability Environment (L1)
TAG	**TE**
LABEL	Terrestrial Environment
DEFINITION	Surface-based operational zones on planetary bodies.

AQUATIC ENVIRONMENT

TEN NOMENCLATURE

```
PCE-AQ-Aquatic Environment-Water-based operational zones, including but not limited to Earth's maritime domains.
```

LAYER	**PCE** Primary Capability Environment (L1)
TAG	**AQ**
LABEL	Aquatic Environment
DEFINITION	Water-based operational zones, including but not limited to Earth's maritime domains.

AERIAL ENVIRONMENT

TEN NOMENCLATURE

```
PCE-AE-Aerial Environment-Atmospheric operational zones spanning lower, upper, and near-space regions.
```

LAYER	**PCE** Primary Capability Environment (L1)
TAG	**AE**
LABEL	Aerial Environment
DEFINITION	Atmospheric operational zones spanning lower, upper, and near-space regions.

ORBITAL ENVIRONMENT

TEN NOMENCLATURE

```
PCE-OR-Orbital Environment-Operational zones within planetary or satellite orbits.
```

LAYER	**PCE** Primary Capability Environment (L1)
TAG	**OR**
LABEL	Orbital Environment
DEFINITION	Operational zones within planetary or satellite orbits.

DEEP SPACE ENVIRONMENT

TEN NOMENCLATURE

```
PCE-DS-Deep Space Environment-Operational zones beyond planetary orbital regimes.
```

LAYER	**PCE** Primary Capability Environment (L1)
TAG	**DS**
LABEL	Deep Space Environment
DEFINITION	Operational zones beyond planetary orbital regimes.

L2 SEGMENT (SEG)

WHY THIS LAYER EXISTS

Ten segments, including aquatic, low altitude, high altitude, and near space, modeled before the attack trends that later proved them out. The layer builds a distributed, cyber-physical platform mindset: a platform is not one place, it is services and assets composed across enclaves.

> *“We had considered aerial, aquatic and other less frequently explored segments before the renewed focus on issues like oceanic cable attacks and rogue aerial platforms. These increased attack patterns simply codified that our approach to using the evolving adversary mindset to decompose systems made sense.”*
>
> THE ETHICALLYHACKINGSPACE (EHS) TEAM

Predicate: “Service and asset enclaves that compose the system across environments.” The ENCLAVE of services and assets. Every SEG names its PCE parent.

LAUNCH

TEN NOMENCLATURE

```
SEG-LA-Launch-Surface-based services and assets for primary launch operations.
```

LAYER	**SEG** Segment (L2)
TAG	**LA**
LABEL	Launch
DEFINITION	Surface-based services and assets for primary launch operations.

LINK

TEN NOMENCLATURE

```
SEG-LI-Link-Services and assets enabling platform communications across signal paths.
```

LAYER	**SEG** Segment (L2)
TAG	**LI**
LABEL	Link
DEFINITION	Services and assets enabling platform communications across signal paths.

GROUND

TEN NOMENCLATURE

```
SEG-GR-Ground-Surface-based services and assets for primary platform operations, serving as the primary locus of control plane activity.
```

LAYER	**SEG** Segment (L2)
TAG	**GR**
LABEL	Ground
DEFINITION	Surface-based services and assets for primary platform operations, serving as the primary locus of control plane activity.

USER

TEN NOMENCLATURE

```
SEG-US-User-Services and assets for primary end-user operations.
```

LAYER	**SEG** Segment (L2)
TAG	**US**
LABEL	User
DEFINITION	Services and assets for primary end-user operations.

AQUATIC

TEN NOMENCLATURE

```
SEG-AQ-Aquatic-Water-based services and assets for primary platform operations, not limited to Earth's maritime domains.
```

LAYER	**SEG** Segment (L2)
TAG	**AQ**
LABEL	Aquatic
DEFINITION	Water-based services and assets for primary platform operations, not limited to Earth's maritime domains.

LOW ALTITUDE

TEN NOMENCLATURE

```
SEG-LO-Low Altitude-Aerial services and assets in the lower atmosphere.
```

LAYER	**SEG** Segment (L2)
TAG	**LO**
LABEL	Low Altitude
DEFINITION	Aerial services and assets in the lower atmosphere.

HIGH ALTITUDE

TEN NOMENCLATURE

```
SEG-HI-High Altitude-Aerial services and assets above the lower atmosphere but below near space.
```

LAYER	**SEG** Segment (L2)
TAG	**HI**
LABEL	High Altitude
DEFINITION	Aerial services and assets above the lower atmosphere but below near space.

NEAR SPACE

TEN NOMENCLATURE

```
SEG-NE-Near Space-Aerial services and assets above high altitude and below orbital regions.
```

LAYER	**SEG** Segment (L2)
TAG	**NE**
LABEL	Near Space
DEFINITION	Aerial services and assets above high altitude and below orbital regions.

SPACE

TEN NOMENCLATURE

```
SEG-SP-Space-Services and assets operating in planetary or satellite orbits.
```

LAYER	**SEG** Segment (L2)
TAG	**SP**
LABEL	Space
DEFINITION	Services and assets operating in planetary or satellite orbits.

DEEP SPACE

TEN NOMENCLATURE

```
SEG-DE-Deep Space-Services and assets operating beyond planetary orbital regimes.
```

LAYER	**SEG** Segment (L2)
TAG	**DE**
LABEL	Deep Space
DEFINITION	Services and assets operating beyond planetary orbital regimes.

L3 SERVICE (SVC)

WHY THIS LAYER EXISTS

Space systems are too diverse for any fixed catalog of service definitions to survive contact with real platforms. The layer stays deliberately small, three elements, and lets every platform owner nest their own service definitions beneath it, so diversity does not fracture the shared schema.

> *"Space systems are simply too diverse in terms of service definitions and descriptions. Grounding the service decomposition into control plane, data plane, and hybrid while allowing the platform owner to nest their organizational specific service definitions made the most sense."*
>
> THE ETHICALLYHACKINGSPACE (EHS) TEAM

Predicate: "Functional planes that organize control and data responsibilities." The functional PLANE. Every SVC names its SEG parent.

CONTROL PLANE

TEN NOMENCLATURE

```
SVC-CP-Control Plane-Services for managing and orchestrating platform control functions.
```

LAYER	**SVC** Service (L3)
TAG	**CP**
LABEL	Control Plane
DEFINITION	Services for managing and orchestrating platform control functions.

DATA PLANE

TEN NOMENCLATURE

```
SVC-DP-Data Plane-Services for managing and orchestrating mission product functions.
```

LAYER	**SVC** Service (L3)
TAG	**DP**
LABEL	Data Plane
DEFINITION	Services for managing and orchestrating mission product functions.

HYBRID SERVICE

TEN NOMENCLATURE

```
SVC-HY-Hybrid Service-Services integrating both control and data plane functionalities.
```

LAYER	**SVC** Service (L3)
TAG	**HY**
LABEL	Hybrid Service
DEFINITION	Services integrating both control and data plane functionalities.

L4 ASSET (AST)

WHY THIS LAYER EXISTS

Six asset classes ground the enormous variety of real components, and the hybrid element is the deliberate bridge to how engineers already think: it aligns the model with the concept of a subsystem while preserving owner-nested definitions beneath the shared classes.

> *"Space systems are simply too diverse in terms of asset definitions and descriptions. Grounding the asset decomposition into data, signal, hardware, firmware, software, and most importantly having a hybrid element to enable alignment with the concept of a 'subsystem' while allowing the platform owner to nest their organizational specific asset definitions made the most sense."*
>
> THE ETHICALLYHACKINGSPACE (EHS) TEAM

Predicate: "Asset classes composing the system and its interfaces." The building-block COMPONENT. Every AST names its SVC parent.

HARDWARE ASSET

TEN NOMENCLATURE

```
AST-HW-Hardware Asset-Physical components supporting platform operations.
```

LAYER	**AST** Asset (L4)
TAG	**HW**
LABEL	Hardware Asset
DEFINITION	Physical components supporting platform operations.

FIRMWARE ASSET

TEN NOMENCLATURE

```
AST-FW-Firmware Asset-Embedded control code governing hardware functions.
```

LAYER	**AST** Asset (L4)
TAG	**FW**
LABEL	Firmware Asset
DEFINITION	Embedded control code governing hardware functions.

SOFTWARE ASSET

TEN NOMENCLATURE

```
AST-SW-Software Asset-Applications and logic executing operational tasks.
```

LAYER	**AST** Asset (L4)
TAG	**SW**
LABEL	Software Asset
DEFINITION	Applications and logic executing operational tasks.

DATA ASSET

TEN NOMENCLATURE

```
AST-DA-Data Asset-Information generated, processed, or consumed by the platform.
```

LAYER	**AST** Asset (L4)
TAG	**DA**
LABEL	Data Asset
DEFINITION	Information generated, processed, or consumed by the platform.

SIGNAL ASSET

TEN NOMENCLATURE

```
AST-SI-Signal Asset-Communication channels and transmission frequencies.
```

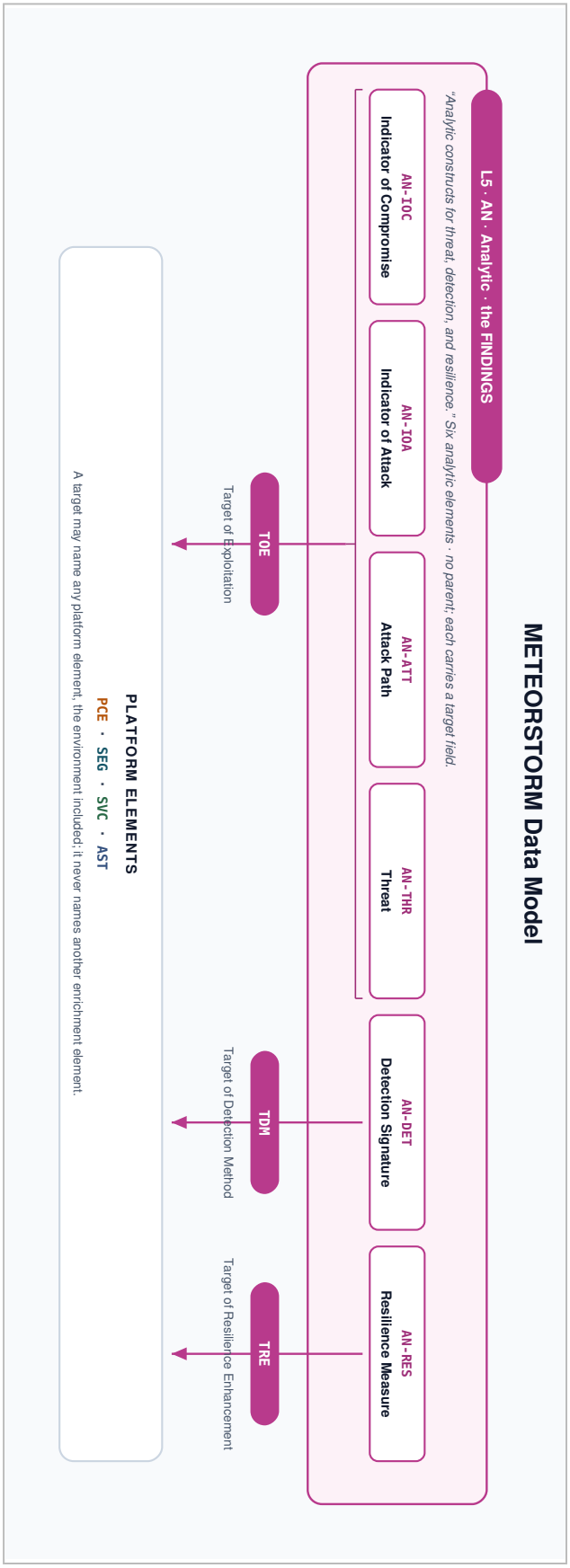
LAYER	**AST** Asset (L4)
TAG	**SI**
LABEL	Signal Asset
DEFINITION	Communication channels and transmission frequencies.

HYBRID ASSET

TEN NOMENCLATURE

```
AST-HY-Hybrid Asset-Composite elements combining multiple asset types.
```

LAYER	**AST** Asset (L4)
TAG	**HY**
LABEL	Hybrid Asset
DEFINITION	Composite elements combining multiple asset types.



L5 ANALYTIC (AN)

WHY THIS LAYER EXISTS

Six elements, scoped against analyst fatigue. Each one answers a single operational question an analyst must dispatch quickly: is something compromised, is it under attack, is an attack path known, is a specific threat involved, is a detection signature available, is a resilience measure available.

> *"We had to focus on the key points without inducing analyst fatigue. Is something compromised, under attack, advertising an attack path, related to a specific threat and is there an available detection signature or resilience measure?"*
>
> THE ETHICALLYHACKINGSPACE (EHS) TEAM

Predicate: "Analytic constructs for threat, detection, and resilience." The ENRICHMENT layer. Every AN element is an enrichment element; it anchors to the platform element it concerns through its target field.

METEORSTORM DATA MODEL FIELDS

TOE	**Target of Exploitation.** Carried by Attack Path, Indicator of Compromise, Indicator of Attack, and Threat; names the platform elements the adversary activity is directed at.
TDM	**Target of Detection Method.** Carried by Detection Signature; names the platform elements the signature observes.
TRE	**Target of Resilience Enhancement.** Carried by Resilience Measure; names the platform elements the measure protects.

The target field is fixed by the element; it is never chosen freely. It references platform elements in any layer, PCE, SEG, SVC, or AST, so a threat can anchor to the environment itself; it never references another enrichment element.

INDICATOR OF COMPROMISE

TEN NOMENCLATURE

```
AN-IOC-Indicator of Compromise-Confirmed indication that a converged space system has been compromised.
```

LAYER	**AN** Analytic (L5)
TAG	**IOC**
LABEL	Indicator of Compromise
DEFINITION	Confirmed indication that a converged space system has been compromised.
TARGET	**TOE** Target of Exploitation

INDICATOR OF ATTACK

TEN NOMENCLATURE

```
AN-IOA-Indicator of Attack-Confirmed indication that a converged space system has been attacked.
```

LAYER	**AN** Analytic (L5)
TAG	**IOA**
LABEL	Indicator of Attack
DEFINITION	Confirmed indication that a converged space system has been attacked.
TARGET	**TOE** Target of Exploitation

ATTACK PATH

TEN NOMENCLATURE

```
AN-ATT-Attack Path-Confirmed attack path for a converged space system.
```

LAYER	**AN** Analytic (L5)
TAG	**ATT**
LABEL	Attack Path
DEFINITION	Confirmed attack path for a converged space system.
TARGET	**TOE** Target of Exploitation
SOURCES	**RDS** Required Data Source · **RSS** Required Signal Source

THREAT

TEN NOMENCLATURE

```
AN-THR-Threat-Confirmed and active threat against a converged space system.
```

LAYER	**AN** Analytic (L5)
TAG	**THR**
LABEL	Threat
DEFINITION	Confirmed and active threat against a converged space system.
TARGET	**TOE** Target of Exploitation

DETECTION SIGNATURE

TEN NOMENCLATURE

```
AN-DET-Detection Signature-Validated and operational pattern, signal, or logic that triggers on contextualized threat behavior for a converged space system.
```

LAYER	**AN** Analytic (L5)
TAG	**DET**
LABEL	Detection Signature
DEFINITION	Validated and operational pattern, signal, or logic that triggers on contextualized threat behavior for a converged space system.
TARGET	**TDM** Target of Detection Method
PLAYBOOK	**PB** the authorized response this signature triggers

RESILIENCE MEASURE

TEN NOMENCLATURE

```
AN-RES-Resilience Measure-Validated and operational protective capability ensuring converged space system resistance or recovery from confirmed threats.
```

LAYER	**AN** Analytic (L5)
TAG	**RES**
LABEL	Resilience Measure
DEFINITION	Validated and operational protective capability ensuring converged space system resistance or recovery from confirmed threats.
TARGET	**TRE** Target of Resilience Enhancement

> **Enumeration.** This card carries the taxonomy and ontology of the METEORSTORM data model. Enumerating a platform against it produces the ETEN record: each element named with an ordinal and a description. The companion ETEN reference applies all five layers to the Kestrel Orbital Day-1 CONOPS: a tailored enumeration of 44 elements scoped to the telecommand path under Function 01, Concept of Operations, not the whole platform.