FULL SPECTRUM SPACE CYBERSECURITY PROFESSIONAL

MODULE WORKBOOK · STUDENT EDITION

Module 01
Concept of Operations

The method behind the Day-1 decomposition, taught once, and the complete telecommand deliverable it produced, element by element.

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STUDENT EDITION

The teaching chapters and the complete worked deliverable. Your instructor holds the instructor edition, which adds the session plan and the marking guidance.

SCOPE AND STANDING OF THIS WORK · READ BEFORE JUDGING THE ENUMERATION

What this is. Kestrel Orbital's first application of the METEORSTORM framework, produced by three departments who had never used it before, in five working days. It is a deliberately scoped first pass over the telecommand path: the command-and-control chain from the operator console to execution on orbit.

Why that scope, and not more. The mandates chose it. Executive Order 14144 puts the command and control of an operational platform first, and the NIS2 Directive places a duty of care and a reporting clock on the ground operator. The fleet is already flying, so the first pass ran on the part that would end the mission if an adversary took it. Enumerating everything else first would have been thorough and useless.

What it is not, stated plainly. It is not an exhaustive model of the platform and does not claim to be. Elements off the telecommand path are not enumerated. Some assets group several physical units where those units share an owner, a build and a patch path. Gaps in the ordinal sequence mark elements the register tracks outside this scope. Every one of those is a recorded decision taken at the enumeration meeting, not an oversight discovered later.

How it grows. Ordinals are issued once and never renumbered, so everything enumerated here keeps its identifier as the register expands. The same eight-step procedure runs on the next scope, and the one after that. A first pass that names its boundary can be extended. One that hides its boundary has to be rebuilt.

The standard we hold ourselves to. A scope choice is stated openly. A defect is fixed, never narrated. If you find an element misnamed, a parent wrong, or a count that does not add up, that is a defect and we want to hear about it. If you find something outside the telecommand path missing, that is the scope, it was chosen deliberately, and it is on the roadmap. The two are not the same criticism, and this work is built so you can tell them apart.

CONTENTS

PART I

Orientation

Why three departments describing one platform three different ways is the problem you were hired to solve, and what one shared description buys.

CH 1 THE DAY IN ONE PAGE

You are building SCOR, the department that delivers its mission by giving the three departments, Security Operations, Satellite Operations, and Satellite Design & Engineering, one unified view of the platform, context and enrichment together. You do not need to be the expert in each; your job is to build the team and give it a shared framework.

IN THE CLASSROOM

This module runs as slides, then a classroom of three parts. Have this workbook, the question set and the day's meeting minutes open. The classroom does this, in this order:

THE WORKBOOK	Chapter 4, How Elements Are Named. The worked example in 4.3. Write one complete identifier for an element on the telecommand path. All five fields. With its parent. Use the worked example as the pattern.
THE QUESTION SET	Questions 1, 9 and 2 are worked and marked in the classroom, each answer given with its reason. The rest are yours.
LESSONS LEARNED FROM THE MINUTES	Open the Day 1 minutes at the decision register and read Item 01, Scope of the first pass; Item 02, Why this framework, and not the one we already use; Item 07, The rules the enumeration has to obey, then the actions table. The rule, the objection and the decision are taken from the record, not from the slide.

Three mandates set the scope, one duty per line:

- **EO 14144:** SCOR writes a detection for each command-and-control protection Executive Order 14144 requires.
- **NIS2:** SCOR executes the incident-sharing thresholds the directive sets: early warning within 24 hours, incident notification within 72.
- **Space ISAC:** SCOR shares a redacted alert on a confirmed command-and-control attack, machine to machine.

Why telecommand first. Because the mandates land on it. Executive Order 14144 sets requirements Kestrel Orbital must meet on the command and control of the space system: encrypt the commands, protect their integrity, authenticate the source, and reject unauthorized commands. The NIS2 Directive puts the ground-based infrastructure that carries it under mandatory cybersecurity risk-management and reporting duties. The path that keeps the satellite under control is the path you must be able to show is protected, so that is where your decomposition starts.

Today, Day 1. Today you decompose the telecommand path, the path that keeps the satellite under control, across the four layers from start to finish. You will leave able to name every part of it the same way, so all three departments can act on what you write. The model you use today already

covers the environments Kestrel Orbital's business plan drives toward, maritime, aerial, and deep space, so nothing you name now needs renaming when those markets arrive.

What you build. A 44-element CONOPS of the telecommand path, run end to end: 4 PCE, 4 SEG, 15 SVC, 21 AST, every PARENT link populated, no orphans. Chapter 6 prints the whole deliverable.

The week ahead. Day 2 adds the threats to the command path you map today. Day 3 traces how an attacker would move against it, and what data you need to catch them. Day 4 turns that into the detections and response procedures the NIS2 reporting clocks assume. Day 5 builds the defenses that take options away from the attacker. Module 02 consumes exactly what you finish today: it anchors real, contextualized threats to the exact elements you named, so a threat with no anchor in this CONOPS has nothing on the platform to attack until the CONOPS adds the element.

CH 2 ONE DATA MODEL FOR THREE DEPARTMENTS

> "The three departments are not aligned. They each name the same element on the spacecraft differently, so what one department knows does not carry cleanly to the other two."
>
> DEEP DIVE DECK, SLIDES 6 AND 7 · DATA MODEL OVERVIEW · TAXONOMY AND ONTOLOGY

Reading notes, before anything else. Identifiers ahead use the two forms orientation taught, hyphens for a type (TEN), colons plus a two-digit ordinal for an instance (ETEN); you will formalize both later today, and chapter 4 prints the full lesson. The walkthrough ahead runs fourteen enumeration steps across the four layers, one per in-scope element type; a step can produce several elements, and the running tally tracks all forty-four.

The silo problem. Ask the three departments about the same box and you get three answers in three vocabularies. A finding written in one dialect has to be re-keyed before the next department can act on it, and every re-keying loses precision and time. METEORSTORM gives all three departments one shared data model, a taxonomy and an ontology. Every part of the platform is named by exactly one element, sorted into four layers: `PCE`, `SEG`, `SVC`, `AST`.

What each department gets back. Security Operations writes detections that target an exact element. Satellite Operations uses the same names on console to know what is degraded. Satellite Design & Engineering routes patches against the same data model. One name, three uses, no translation.

THE TAXONOMY: THE WORDS

One taxonomy, shared inside and outside the organization, so cyber, space ops, engineering, vendors, peer operators, and Space ISAC members all use the same words for the same things. The full element list per layer:

- `PCE` · **5 elements**: TE Terrestrial, AQ Aquatic, AE Aerial, OR Orbital, DS Deep Space.
- `SEG` · **10 elements**: LA Launch, LI Link, GR Ground, US User, AQ Aquatic, LO Low Altitude, HI High Altitude, NE Near Space, SP Space, DE Deep Space.
- `SVC` · **3 elements**: CP Control Plane, DP Data Plane, HY Hybrid.
- `AST` · **6 elements**: HW Hardware, FW Firmware, SW Software, DA Data, SI Signal, HY Hybrid.

THE ONTOLOGY: THE RELATIONSHIPS

Every element links up to its parent, forming one strict chain: Asset to Service to Segment to Environment. Every element traces up to a `PCE`; nothing floats.

- `SEG` links up to one or more `PCE` instances.
- `SVC` links up to one or more `SEG` instances.
- `AST` links up to one or more `SVC` instances.

Why both. Named by the taxonomy, placed by the ontology, every element carries its full context. Enrichment attaches to one element and inherits every layer above it in a single query, the same chain all three departments read from their own end.

PART II

The method

The four layers, the rules for naming an element, and the enumeration process. Taught once here, applied unchanged for the rest of the week.

CH 3 THE FOUR LAYERS

Four sub-chapters, one per structural layer, in decomposition order. Each opens with the layer's verbatim definition, then carries the per-element depth: every type in the published taxonomy, its full TEN, and, for the types this scenario does not enumerate, why they are out of scope. Deep dive deck, slides 10 through 36; mirrors the full-taxonomy reference slides 13 and 20.

3.1 · PCE, WHERE THE PLATFORM OPERATES

> PCE · Primary Capability Environment · layer definition, verbatim: *"Operational zone in which a capability primarily exists or is exercised."*
>
> DEEP DIVE DECK, SLIDES 10 TO 14 · PCE LAYER INTRO, PCE-TE, PCE-OR, PCE FULL TAXONOMY

Layer 1, the root of the parent chain. Every other layer anchors to a PCE element through the ontology, so getting this right matters: every element beneath inherits that context. PCE is also the layer that deconflicts nature from adversary. When a symptom appears, operations often cannot tell an environmental effect (space weather, atmospheric drag, radiation) from a cyber-physical adversary action, and naming the environment keeps a natural anomaly from being chased as an attack and an attack from being written off as weather.

ELEMENT	FULL TEN (VERBATIM)	DEPTH	SCOPE TODAY
PCE-TE	PCE-TE-Terrestrial-Surface-based operational zones on planetary bodies.	The land surface of a planet: the ground the platform is built and operated on. Two of these sites are in scope today.	**In scope**: the Reston and Kiruna sites.
PCE-AQ	PCE-AQ-Aquatic-Water-based operational zones, including but not limited to Earth's maritime domains.	On or under water: sea-surface and subsurface operating areas.	Out of scope: the platform does not operate there today; the type waits for the maritime market.
PCE-AE	PCE-AE-Aerial-Atmospheric operational zones spanning lower, upper, and near-space regions.	Inside the atmosphere: the lower, upper, and near-space air a platform can fly in.	Out of scope: no Kestrel capability operates in the atmosphere on the telecommand path.
PCE-OR	PCE-OR-Orbital-Operational zones within planetary or satellite orbits.	In orbit around a body: where the satellite itself flies.	**In scope**: the GEO and MEO regimes.
PCE-DS	PCE-DS-Deep Space-Operational zones beyond planetary orbital regimes.	Beyond planetary orbits: interplanetary and deep-space distances.	Out of scope: the fleet flies no deep-space mission; the type waits for that market.

The scope rule that governs the column above: you enumerate a type only when the platform actually operates there. The out-of-scope types complete the taxonomy so you can read any platform, and Step 01 of the ETEN Process (chapter 5) is what keeps them out of this CONOPS.

How the three departments use PCE. Security Operations inherits PCE context on every alert without re-deriving it. Satellite Operations reads PCE to know which regulatory regime and response posture applies. Satellite Design & Engineering reads it because the same hardware behaves differently on the ground than on orbit.

3.2 · SEG, HOW THE PLATFORM IS DISTRIBUTED

> SEG · Segment · layer definition, verbatim: *"Service and asset enclaves that compose the system across environments."*
>
> DEEP DIVE DECK, SLIDES 15 TO 21 · SEG LAYER INTRO, SEG-LI, SEG-GR, SEG-SP, SEG FULL TAXONOMY

Layer 2, anchored to PCE. Adversaries do not attack "the satellite"; they pick an enclave to operate against, like the link, the ground complex, the spacecraft bus, or the operator console. SEG records those enclaves so you can describe what you are actually defending. The SEG boundary is the line your defensive cyber operators hold. Tiebreak for the recurring trap: PCE and SEG share several tag names; zone means PCE, group of services and assets means SEG.

ELEMENT	FULL TEN (VERBATIM)	SCOPE TODAY
SEG-LA	SEG-LA-Launch-Surface-based services and assets for primary launch operations.	Out of scope: the platform is operational on orbit, and the launch enclave is not on the telecommand path; the launch-control work that persists lives as a Ground service.
SEG-LI	SEG-LI-Link-Services and assets enabling platform communications across signal paths.	**In scope**: one link enclave carries telecommand up and telemetry down.
SEG-GR	SEG-GR-Ground-Surface-based services and assets for primary platform operations, serving as the primary locus of control plane activity.	**In scope**: two ground enclaves, Reston and Kiruna, hold command authority and the radio.
SEG-US	SEG-US-User-Services and assets for primary end-user operations.	Out of scope: the customer edge is a taxonomy type but out of scope for this platform, so it is not enumerated.
SEG-AQ	SEG-AQ-Aquatic-Water-based services and assets for primary platform operations, not limited to Earth's maritime domains.	Out of scope: tied to an environment the platform does not operate in.
SEG-LO	SEG-LO-Low Altitude-Aerial services and assets in the lower atmosphere.	Out of scope: tied to an environment the platform does not operate in.
SEG-HI	SEG-HI-High Altitude-Aerial services and assets above the lower atmosphere but below near space.	Out of scope: tied to an environment the platform does not operate in.
SEG-NE	SEG-NE-Near Space-Aerial services and assets above high altitude and below orbital regions.	Out of scope: tied to an environment the platform does not operate in.
SEG-SP	SEG-SP-Space-Services and assets operating in planetary or satellite orbits.	**In scope**: the spacecraft enclave on orbit.
SEG-DE	SEG-DE-Deep Space-Services and assets operating beyond planetary orbital regimes.	Out of scope: tied to an environment the platform does not operate in.

How the three departments use SEG. Security Operations scopes threat hunts to a SEG (“anything on the Link”). Satellite Operations holds the segmentation boundary. Satellite Design & Engineering owns the architecture decisions that put each asset inside the right enclave.

3.3 · SVC, WHAT THE PLATFORM DELIVERS

> SVC · Service · layer definition, verbatim: *"Functional planes that organize control and data responsibilities."*
>
> DEEP DIVE DECK, SLIDES 22 TO 27 · SVC LAYER INTRO, SVC-CP, SVC-DP, SVC-HY

Layer 3, anchored to SEG. Two enclaves tagged identically can still do completely different jobs. SVC records the function an enclave delivers, so you can say what is actually at risk when something happens. Services that span more than one segment set DISTRIBUTED to Y and list every participating SEG in PARENT.

ELEMENT	FULL TEN (VERBATIM)	DEPTH	SCOPE TODAY
SVC-CP	SVC-CP-Control Plane-Services for managing and orchestrating platform control functions.	The part that commands the platform.	**In scope**: 10 instances.
SVC-DP	SVC-DP-Data Plane-Services for managing and orchestrating mission product functions.	The part that moves mission product.	**In scope**: 1 instance.
SVC-HY	SVC-HY-Hybrid-Services integrating both control and data plane functionalities.	Services that do both, like Command and Data Handling.	**In scope**: 4 instances.

All three service types earn a place on the telecommand path, so no SVC type is out of scope in this scenario; scope at this layer is enforced per instance, not per type. Only the services that authorize, protect, carry, or execute commands on the path are enumerated.

How the three departments use SVC. Security Operations writes detection rules at the SVC layer so the rule fires against the function, not the specific box, and survives hardware refreshes. Satellite Operations writes the continuity plan at SVC ("telecommand authentication is offline, fall back to…"). Satellite Design & Engineering owns the SVC interface contract that every AST must implement.

3.4 · AST, WHERE THE WORK HAPPENS

> AST · Asset · layer definition, verbatim: *"Asset classes composing the system and its interfaces."*
>
> DEEP DIVE DECK, SLIDES 28 TO 36 · AST LAYER INTRO, AST-HW, AST-FW, AST-SW, AST-DA, AST-SI, AST-HY

Layer 4, anchored to SVC. Enrichment that names a service or a segment cannot be acted on by the people who actually patch, monitor, replace, or quarantine. Satellite Design & Engineering does not patch "the control plane"; they patch a specific firmware image on a specific box at a specific site. AST is where the work happens, and where your three departments converge.

ELEMENT	FULL TEN (VERBATIM)	SCOPE TODAY
AST-HW	AST-HW-Hardware-Physical components supporting platform operations.	**In scope**: 7 instances.
AST-FW	AST-FW-Firmware-Embedded control code governing hardware functions.	**In scope**: 2 instances.
AST-SW	AST-SW-Software-Applications and logic executing operational tasks.	**In scope**: 6 instances.
AST-DA	AST-DA-Data-Information generated, processed, or consumed by the platform.	**In scope**: 4 instances.
AST-SI	AST-SI-Signal-Communication channels and transmission frequencies.	**In scope**: 2 instances.
AST-HY	AST-HY-Hybrid-Composite elements combining multiple asset types.	Taught, no instance today: no composite element on the telecommand path needed asset-level resolution as a unit; enumerate the type only when a composite is the right resolution.

How the three departments use AST. Security Operations targets its work at specific AST instances rather than at abstract services. Satellite Operations logs incidents at AST resolution. Satellite Design & Engineering owns the asset inventory, the patch pipeline, and the vulnerability management work at this layer. Each AST element takes an optional SUBSYSTEM tag, because one physical asset often serves several services on space platforms.

CH 4 HOW ELEMENTS ARE NAMED

> "An ETEN is written `LAYER:TAG:LABEL:ORDINAL:Description`."
>
> DEEP DIVE DECK, SLIDES 38 AND 39 · FIVE-FIELD NOMENCLATURE · IDENTIFIER FORMATS

Two forms, one lesson. The TEN names a type and is read from the published taxonomy; the ETEN names one real instance on your platform and is what you produce. Reading the data model means reading TENs; applying it means writing ETENs.

THE TEN, FOUR HYPHENATED FIELDS

A TEN is written `LAYER-TAG-LABEL-Definition`. It names a category of element, not one specific thing, and carries the framework's canonical Definition for that category. That Definition reads the same on every platform. Every TEN is published in the taxonomy: you look it up and never invent it. Four worked walkthroughs, one per layer:

FULL TEN	LAYER	TAG	LABEL	IN PRACTICE
`PCE-OR-Orbital-Operational zones within planetary or satellite orbits.`	`PCE` · root layer; the environment the platform operates in	`OR` · selected from the published taxonomy; never invented	Orbital · the exact published name for that tag	Class-level talk about orbital environments: "Every PCE-OR instance needs a conjunction-risk feed."
`SEG-SP-Space-Services and assets operating in planetary or satellite orbits.`	`SEG` · a self-contained enclave with one operational role	`SP` · selected from the published taxonomy; never invented	Space · the exact published name for that tag	On the space segment: "`SEG-SP` assets share the orbital safety boundary."
`SVC-CP-Control Plane-Services for managing and orchestrating platform control functions.`	`SVC` · the function an enclave delivers	`CP` · selected from the published taxonomy; never invented	Control Plane · the exact published name for that tag	"Every `SVC-CP` service is in scope for command-link integrity."
`AST-SW-Software-Applications and logic executing operational tasks.`	`AST` · the concrete thing that implements a service	`SW` · selected from the published taxonomy; never invented	Software · the exact published name for that tag	"`AST-SW` elements must enter SBOM tracking."

In every row the fourth field, the Definition, is framework canon and is the same on every platform.

THE ETEN, FIVE COLON-DELIMITED FIELDS

An ETEN is written `LAYER:TAG:LABEL:ORDINAL:Description`. LAYER, TAG, and LABEL come straight from the published TEN. You add the two-digit ORDINAL that tells instances apart and the per-instance Description that scopes this exact item. All five fields are required on every enumerated element. Field by field:

- **LAYER.** The structural layer the element belongs to: `PCE`, `SEG`, `SVC`, or `AST`. Field 1 of 5.
- **TAG.** The two-letter code that names the element within the layer (for example `TE` for Terrestrial, `GR` for Ground, `CP` for Control Plane, `HW` for Hardware, `SW` for Software). Always picked from the published list, never invented. Field 2 of 5.
- **LABEL.** The plain-English name that goes with the two-letter code, for example Terrestrial for `TE`, Ground for `GR`, Software for `SW`. Field 3 of 5.
- **ORDINAL.** A two-digit number, starting at `00`, that tells multiple instances of the same element apart. The first ground segment is `SEG:GR:Ground:00`, the second is `SEG:GR:Ground:01`, and so on. Ordinals are scoped to the (LAYER, TAG) pair, continue across segments rather than restarting, and are never re-used. Field 4 of 5.
- **DESCRIPTION.** A short, free-text note about this specific instance: what it is, where it is, what role it plays, and anything later work will need to know. The description is what turns a generic code into a concrete piece of your platform. Field 5 of 5.

ONE COMPLETE WORKED ETEN

Kestrel Orbital's Reston mission-operations ground segment, written out as a five-field enumerated element:

FIELD	VALUE
LAYER	`SEG`
TAG	`GR`
LABEL	Ground
ORDINAL	`00`
DESCRIPTION	The Reston, Virginia mission-operations enclave: the control, crypto, access-control, patch, and console services that command the constellation.

Read together: `SEG:GR:Ground:00:The Reston, Virginia mission-operations enclave: the control, crypto, access-control, patch, and console services that command the constellation.` Its PARENT names the environments it operates from, `PCE:TE:Terrestrial:00` and `PCE:TE:Terrestrial:01`, so parents exist before children and nothing floats.

The canonical-description rule. One identifier carries exactly one description, everywhere it appears: deck, workbook, detection, ticket, diagram. `PCE:OR:Orbital:00` is the geostationary regime, and its one description is: “The geostationary orbit regime (~35,786 km) part of the fleet flies in, fixing its coverage geometry, contact windows, and radiation exposure.” A teaching example that needs a different description uses a different ordinal or a platform outside the deliverable. The description is a required, scoping field of the record, so two descriptions on one identifier would be two different records wearing the same name.

CH 5 THE ETEN PROCESS, ONCE, THEN THE DELTAS

> "Eight steps, fixed order. The frame repeats for each layer; only the input, the parent rule, and the scope change."
>
> DEEP DIVE DECK, SLIDES 42, 44, 46, AND 50 · THE FOUR ENUMERATION PROCESS SLIDES

The normative ETEN Process is printed once below, in full, as it is applied at the PCE layer, the first walk. After it come the three per-layer deltas, side by side, so the one thing each layer changes reads as the headline instead of being buried in identical framing.

THE NORMATIVE ETEN PROCESS · EIGHT STEPS, FIXED ORDER · APPLIED AT THE PCE LAYER

1. **Set the SCOPE.** From the resilience objective and the requirements that drive the decomposition: the command-and-control mission Executive Order 14144 and the NIS2 Directive hold Kestrel Orbital to, giving the Day-1 CONOPS its scope, the telecommand path. An element outside the scope is not enumerated.
2. **Select the LAYER.** Working top down, the first structural layer is PCE. The gate is the layer definition, verbatim: *"Operational zone in which a capability primarily exists or is exercised."* You are naming a WHERE, a zone, not a thing in it. Zone means PCE; a group of services and assets means SEG. An element that fails the gate is reclassified, not forced through.
3. **Select the TAG.** From the taxonomy for this layer: `TE`, `AQ`, `AE`, `OR`, `DS`. Never invent one. On the telecommand path the Step 01 scope admits `TE` and `OR`.
4. **Write the LABEL.** Exactly as the taxonomy publishes it for the selected tag: Terrestrial (TE), Aquatic (AQ), Aerial (AE), Orbital (OR), or Deep Space (DS).
5. **Assign the ORDINAL.** Two digits from `00`, counted per TAG. Two terrestrial sites become `PCE:TE:Terrestrial:00` and `PCE:TE:Terrestrial:01`; the two orbital regimes become `PCE:OR:Orbital:00` and `PCE:OR:Orbital:01`.
6. **Link the PARENT.** PCE is the root of the ontology: it takes no PARENT. Every SEG enumerated next names one or more of these environments, so parents exist before children.
7. **Set the OPTIONAL FIELDS.** None at this layer. DISTRIBUTED belongs to services, SUBSYSTEM to assets; TARGET and SOURCE belong to the analytic elements of Functions 02 through 05.
8. **Write the DESCRIPTION.** One plain sentence for this exact instance, written at its own layer: the operational zone, its location, role, and jurisdiction. The Step 02 gate applies again here; a zone described as the things inside it is non-compliant.

Repeat for the next instance. When no more remain, the layer is fully enumerated.

The same eight steps, in the same fixed order, run at every layer. What follows is everything that actually changes.

THE SEG DELTA

The delta. Segments add the first PARENT links: every element names at least one PCE above it; three segment types in scope.

Whose input. The environments are already enumerated. With the Security Operations Center, the two build-and-operate departments scoped the enclaves on the telecommand path: three segment types, Space and Link (the segments EO 14144 covers at minimum) and Ground (the ground-based infrastructure NIS2 binds); the User customer edge is a taxonomy type but out of scope for this platform, so it is not enumerated. **Output.** One ETEN of the form `SEG:TAG:LABEL:ORDINAL:Description` per enclave. **Constraints.** Every SEG element names at least one PCE in PARENT at Step 06; existing segment diagrams were imported and tagged rather than redrawn. **Review.** Confirm each segment links up to its environment before presenting.

STEP	WHAT CHANGES AT SEG
02 Gate	The layer definition, verbatim: *"Service and asset enclaves that compose the system across environments."* You are naming an ENCLAVE, a grouping of services and assets, not the zone it sits in and not the hardware inside it.
03 Tag	Ten published tags; the Step 01 scope admits `SP`, `LI`, and `GR`.
05 Ordinal	The Reston and Kiruna ground enclaves become `SEG:GR:Ground:00` and `SEG:GR:Ground:01`.
06 Parent	One or more PCE ETENs already enumerated. `SEG:GR:Ground:00` names its terrestrial sites; `SEG:SP:Space:00` spans both regimes and names `PCE:OR:Orbital:00, PCE:OR:Orbital:01`.
07 Optional	None at this layer.
08 Description	The enclave of services and assets, its role, the site or regime it occupies, redundancy posture, and the interfaces it exposes. An enclave described as the hardware inside it is non-compliant.

THE SVC DELTA

The delta. Services can span segments: one element, DISTRIBUTED Y, every participating SEG in PARENT.

Whose input. The segments are already enumerated. Satellite Operations named the services it runs and Satellite Design & Engineering the services it built: on the telecommand path, the fifteen services that authorize, encrypt, carry, and execute commands, including the cryptography and command-acceptance (ACA) services the mandates' duties land on. **Output.** One ETEN of the form `SVC:TAG:LABEL:ORDINAL:Description` per service. **Constraints.** Cross-segment services list every participating SEG in PARENT at Step 06, set `DISTRIBUTED` to Y at Step 07, and stay one service element, not duplicates. **Review.** Confirm the function each service delivers before presenting; naming the function, not the box, is what lets the Security Operations Center write detections that survive a hardware refresh.

STEP	WHAT CHANGES AT SVC
02 Gate	The layer definition, verbatim: *"Functional planes that organize control and data responsibilities."* You are naming a functional RESPONSIBILITY, what the platform does, not what it is built from.
03 Tag	Three published tags: `CP`, `DP`, `HY`, matching the responsibility the service carries.
05 Ordinal	Counted per TAG across the whole layer, continuing across segments: `SVC:CP:Control Plane:00` and `SVC:DP:Data Plane:00` coexist; a second control-plane service is `SVC:CP:Control Plane:01`.
06 Parent	One or more SEG ETENs. A cross-segment service lists every participating segment and stays one element, not duplicates.
07 Optional	`DISTRIBUTED`: Y when PARENT lists two or more segments, N when the service runs on a single segment.
08 Description	The functional responsibility, beginning "The service that …". A service described as the box it runs on is non-compliant.

THE AST DELTA

The delta. Assets take one or more SVC parents each, with ordinals used aggressively for unit-level resolution.

Whose input. The services are already enumerated. Satellite Design & Engineering supplied the concrete assets from its inventory lists, BOMs, and CMDB exports: on the telecommand path, the twenty-one hardware, software, firmware, data, and signal assets that implement the command-path services, ACA software and credentials among them. **Output.** One ETEN of the form `AST:TAG:LABEL:ORDINAL:Description` per element. **Constraints.** Every AST element names at least one SVC in PARENT at Step 06, never zero, and every service a shared asset actually carries; ordinals were used aggressively so unit-level detections resolve to the exact instance. **Review.** Confirm each asset traces up to its service before presenting; this is the resolution at which a detection fires and a patch lands, and where all three departments converge.

STEP	WHAT CHANGES AT AST
02 Gate	The layer definition, verbatim: *“Asset classes composing the system and its interfaces.”* You are naming a CONCRETE ELEMENT, a real component the platform is built from.
03 Tag	Six published tags: `HW`, `FW`, `SW`, `DA`, `SI`, `HY`, matching the category of the concrete element.
05 Ordinal	A distinct ordinal for every physical or logical unit, so unit-level detections resolve to the exact instance.
06 Parent	Exactly one SVC ETEN, never zero, never two (for example, `AST:SW:Software:00` names `SVC:CP:Control Plane:00`). An asset that appears to implement two services is decomposed further until each element implements one.
07 Optional	`SUBSYSTEM`, optional: a short free-text group name reused verbatim on every asset in one coherent group (an antenna plus its controller plus its tracking software). Otherwise leave blank.
08 Description	One plain sentence beginning with the element class: “The physical …”, “The embedded …”, “The flight software …”, “The stored …”, “The transmitted …”. Include make, model, or version where applicable.

In every walk, at every layer, the constants are the same: eight steps in fixed order, tags read from the published taxonomy and never invented, the Step 02 gate applied twice (once selecting the layer, again writing the description), and the loop line: repeat for the next instance until none remain.

PART III

The deliverable

The complete telecommand decomposition, element by element, and what changes in the Security Operations Center once the taxonomy is deployed.

CH 6 THE TELECOMMAND DECOMPOSITION, COMPLETE

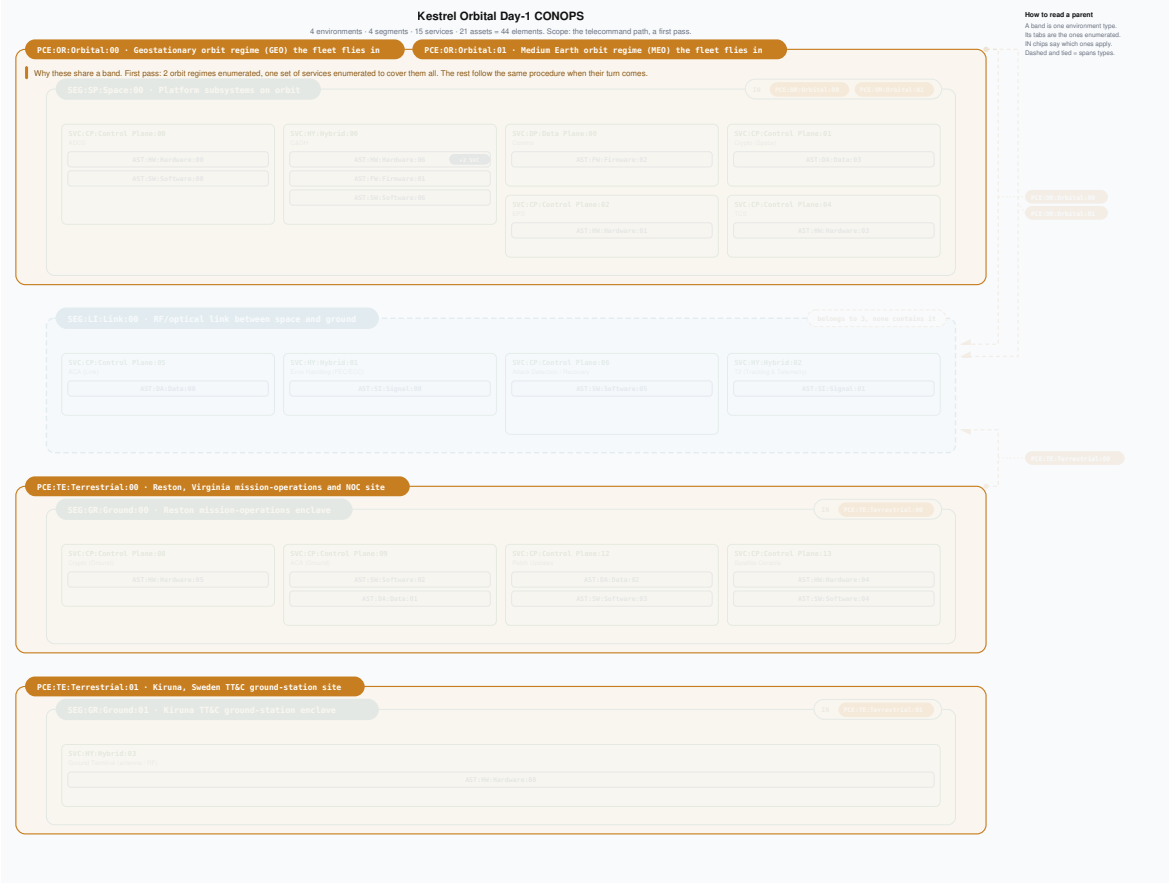
> “The deliverable. Four PCE elements, four SEG elements, fifteen SVC elements, and twenty-one AST elements: forty-four ETENs in canonical form, every parent link populated, one shared data model all three departments can act on, ready to present and carry into Day 2.”
>
> DEEP DIVE DECK, SLIDES 40 TO 53 · THE BRIDGE AND THE EIGHT TC SELECTION SLIDES AND THEIR ENUMERATION WALKTHROUGHS

Every element of the Day-1 CONOPS, in deck order by layer, with its identifier, canonical description, parent, and source reference. Nothing here lives behind a click: this chapter is the full catalogue the deck pages through. The full ETEN of any row is its identifier joined to its description: `LAYER:TAG:LABEL:ORDINAL:Description`.

PCE	SEG	SVC	AST
4	**4**	**15**	**21**
ENVIRONMENTS	SEGMENTS	SERVICES	ASSETS

6.1 · PCE, 4 ELEMENTS

STAGE 1 OF 4 · 4 OF 44 ELEMENTS · ENVIRONMENTS ONLY



Four environments, and nothing under them yet. The rest of the figure is dimmed because it is not enumerated yet, not because it does not exist.

Why only four environments. Kestrel operates in more places than this. This pass enumerates the telecommand path, so it enumerates the environments that path crosses and no others. The taxonomy still carries Aquatic, Aerial and Deep Space, and they take ordinals the day the business flies there. Enumerating an environment the platform does not use would be padding, and padding is what makes a model impossible to maintain.

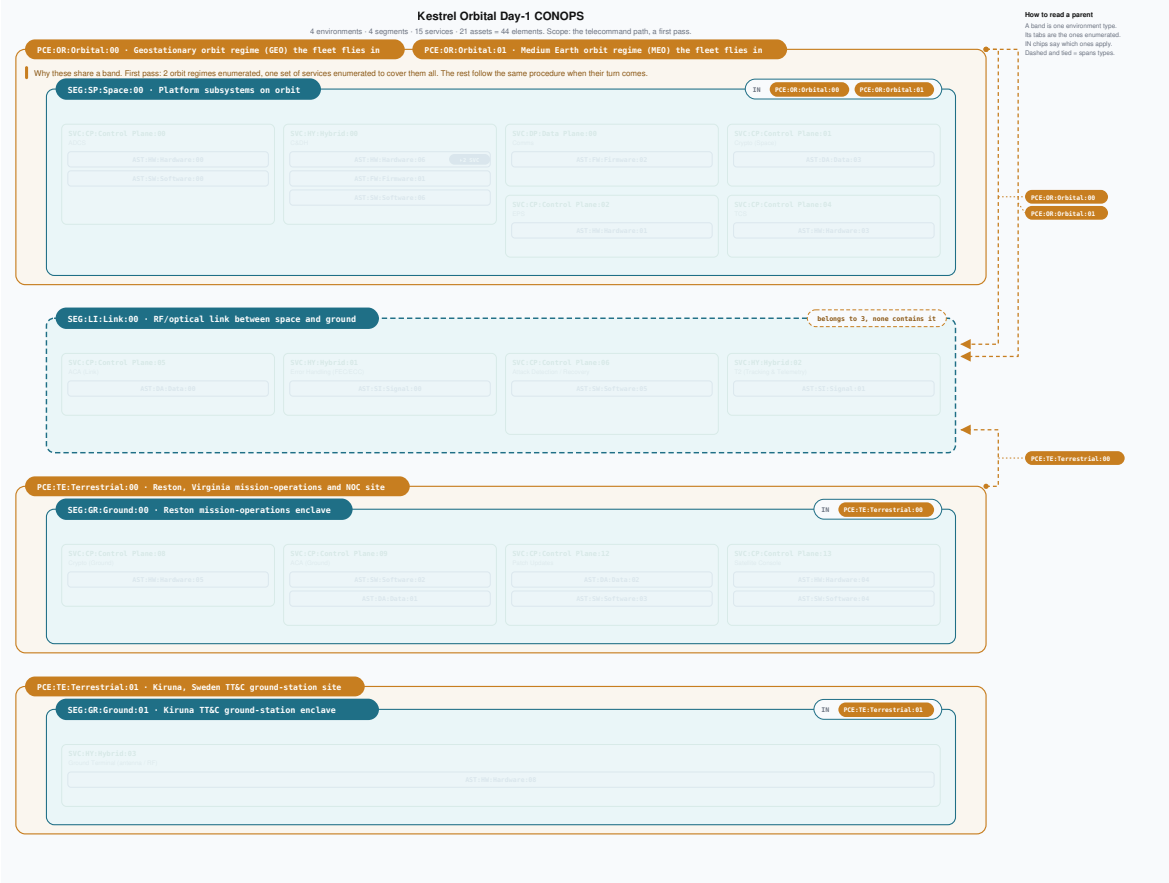
SCOR convenes the departments that own where the platform lives: Satellite Operations, which flies the constellation, and Satellite Design & Engineering, which built it, with the Security Operations Center sitting in. The room finds two distinct terrestrial sites and two orbital regimes, so Terrestrial takes two ordinals and Orbital takes two. PCE is the only layer with no parent: these four elements are the anchors the rest of the CONOPS hangs from.

IDENTIFIER	ELEMENT	CANONICAL DESCRIPTION	PARENT	REFERENCE
PCE:OR:Orbital:00	GEO regime	The geostationary orbit regime (~35,786 km) part of the fleet flies in, fixing its coverage geometry, contact windows, and radiation exposure.	none (root)	METEORSTORM Quick Guide; NIST IR 8270
PCE:OR:Orbital:01	MEO regime	The medium Earth orbit regime (~8,000 km) part of the fleet flies in, with its own orbital periods, contact windows, and radiation environment.	none (root)	METEORSTORM Quick Guide; NIST IR 8270
PCE:TE:Terrestrial:00	Reston site	Reston, Virginia land site hosting the primary mission-operations complex, its control facilities, and the network operations center.	none (root)	METEORSTORM Quick Guide; NIST IR 8401
PCE:TE:Terrestrial:01	Kiruna site	Kiruna, Sweden polar TT&C ground-station site (67.9°N) that carries the command path into the link; a separate site with its own ordinal for clean failover and jurisdiction analysis.	none (root)	METEORSTORM Quick Guide; NIST IR 8401

FIELD NOTE · Satellite Operations wanted one orbital entry; Satellite Design & Engineering needed per-regime enrichment, because a GEO bird and a MEO bird do not share space weather. Ruling: one PCE per regime, two ordinals. First win: radiation and conjunction context now attaches to the right regime instead of averaging across the fleet.

6.2 · SEG, 4 ELEMENTS

STAGE 2 OF 4 · 8 OF 44 ELEMENTS · ENVIRONMENTS AND SEGMENTS



Four segments attach to the environments. Notice the link: it is the one element that belongs to more than one environment type, so it is drawn outside the bands and tied to each.

Why four segments and not more. A real operator has segments this pass does not touch: user terminals, a corporate estate, a launch chain. They are out because the command path does not run through them, not because they are safe. The User segment type is in the taxonomy and deliberately unenumerated here, which is the honest way to record a boundary.

The room traces the actual command flow: an operator originates a command at a console, mission operations authorizes it on the Ground, the Link carries it as an RF or optical signal, and the spacecraft executes it in Space. Four enclaves are enumerated on the path; the User customer edge is a taxonomy type but out of scope for this platform, and Launch and the physical regimes AQ, LO, HI, NE, and DE drop out at Step 01.

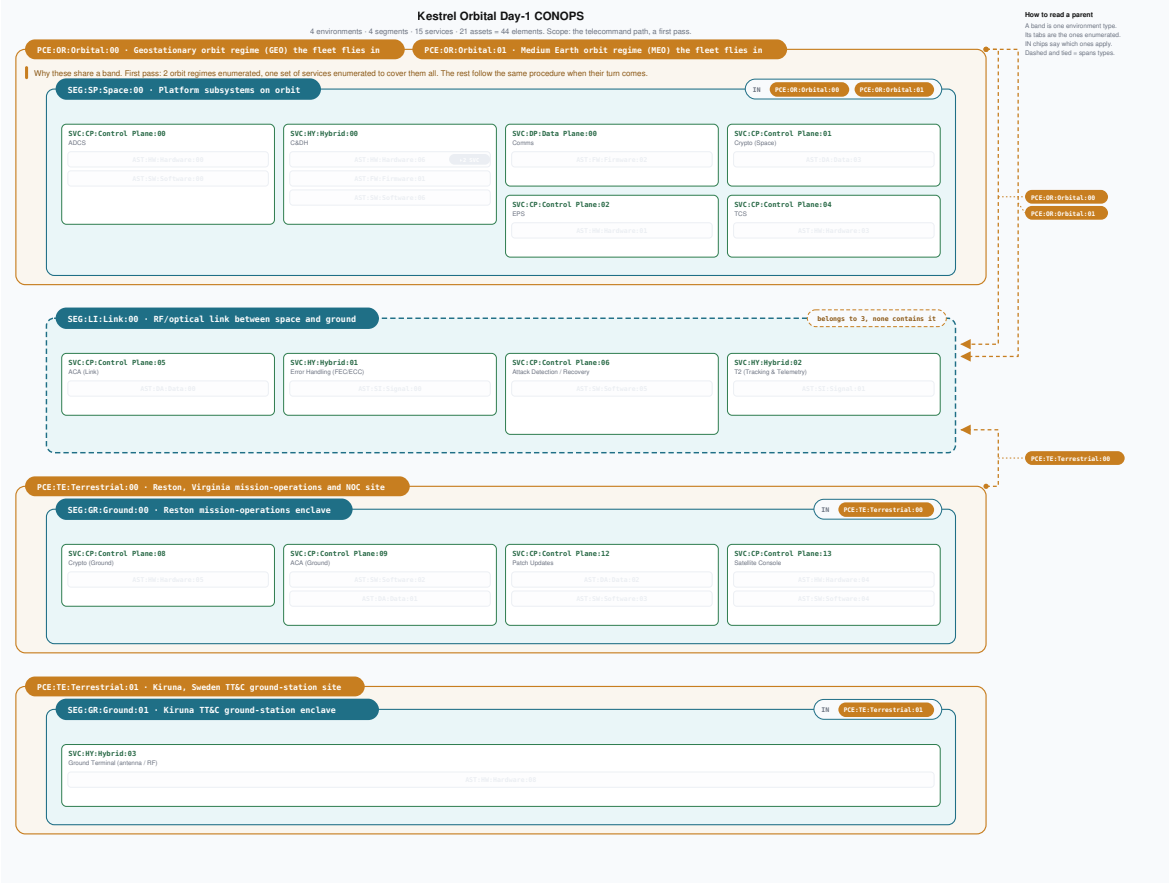
IDENTIFIER	ELEMENT	CANONICAL DESCRIPTION	PARENT	REFERENCE
SEG:SP:Space:00	Space enclave	The on-orbit enclave: the flight services and their assets operating on the constellation spacecraft, beyond physical reach.	PCE:OR:Orbital:00, PCE:OR:Orbital:01	NIST IR 8270
SEG:LI:Link:00	Link enclave	The link enclave: the services and assets carrying telecommand up and telemetry and mission data down across the RF and optical signal path between space and ground.	PCE:OR:Orbital:00, PCE:OR:Orbital:01, PCE:TE:Terrestrial:00	NIST IR 8270; CCSDS 232.0-B
SEG:GR:Ground:00	Reston ground enclave	The Reston, Virginia mission-operations enclave: the control, crypto, access-control, patch, and console services that command the constellation.	PCE:TE:Terrestrial:00	NIST IR 8270; NIST IR 8401
SEG:GR:Ground:01	Kiruna ground enclave	Kiruna, Sweden polar TT&C ground-station enclave; the second terrestrial ground segment, distinct from Reston, hosting the site RF ground terminal.	PCE:TE:Terrestrial:01	ESA/SSC Esrange-Kiruna documentation; NIST IR 8401

FIELD NOTE · Two orbital environments, one Space segment: the fleet flies as one commanded constellation, and splitting every flight service per regime would have doubled the inventory before the split earned its keep. Plan of record: track the SDA (space domain awareness) to measure what is MEO-specific versus GEO-specific, then build the longer-term plan to coordinate enumerating the entire platform.

> The **User** segment (type `SEG-US-User`) remains part of the METEORSTORM data model but is **out of scope for this platform**, so it is not enumerated in the Kestrel CONOPS. Example ETEN form, for reference only: `SEG:US:User:00`.

6.3 · SVC, 15 ELEMENTS

STAGE 3 OF 4 · 23 OF 44 ELEMENTS · SERVICES ADDED



Fifteen services fill the segments. This is where the decomposition starts to look like a platform rather than a diagram.

Why fifteen services. Three departments in one room, working a fixed time box, resolved the command path to fifteen services. A second pass would find more, and would split some of these where a distinct owner or a distinct patch path appears. Fifteen is what this pass earned; claiming it is exhaustive would be the dishonest part, not the number itself.

Satellite Operations named the services it runs and Satellite Design & Engineering the services it built. Ordinals continue across segments inside each tag, so no ordinal repeats anywhere in the layer: Space consumed Control Plane 00 to 04 and Hybrid 00, the Link took Control Plane 05 to 07 and Hybrid 01 and 02, and the Ground took Control Plane 08 to 13 and Hybrid 03. All twenty run inside a single segment, so DISTRIBUTED is N for each.

SEG:SP:Space:00

Space segment services, 6

The space segment's job for telecommand: keep the vehicle alive on orbit, accept commands, execute and route them, and move payload data home. Five control-plane, two data-plane, one hybrid C&DH.

IDENTIFIER	SERVICE	CANONICAL DESCRIPTION	PARENT	REFERENCE
SVC:CP:Control Plane:00	ADCS	The service that determines and controls spacecraft orientation (ADCS).	SEG:SP:Space:00	NASA/ESA ADCS
SVC:CP:Control Plane:01	Crypto (Space)	The service that encrypts and authenticates on board, including telecommand authentication (Crypto, space).	SEG:SP:Space:00	NIST SP 800-57; Falco et al. 2024
SVC:CP:Control Plane:02	EPS	The service that generates, stores, and distributes electrical power (EPS).	SEG:SP:Space:00	NASA SST (Power)
SVC:CP:Control Plane:04	TCS	The service that holds every component within its temperature limits (TCS).	SEG:SP:Space:00	NASA SST (Thermal)
SVC:DP:Data Plane:00	Comms	The service that carries telemetry and payload product to the ground (Comms).	SEG:SP:Space:00	CCSDS 232.0-B; NIST IR 8270
SVC:HY:Hybrid:00	C&DH	The service that executes commands and moves data across the vehicle, on both the control and data planes (C&DH).	SEG:SP:Space:00	ESA OBDH

FIELD NOTE · One C&DH, one EPS, one ADCS entry serves both fleets by the scoping decision. Ordinals count per TAG and survive re-parenting, so if SDA tracking later justifies a per-regime split, every identifier keeps its name; only PARENT fields change. Win: Security Operations and Engineering stopped keeping two names for the same flight function.

SEG:LI:Link:00

Link segment services, 4

The link segment's job for telecommand: authenticate inbound commands, detect channel attacks, route payload commanding, correct bit errors, and run tracking and telemetry.

IDENTIFIER	SERVICE	CANONICAL DESCRIPTION	PARENT	REFERENCE
SVC:CP:Control Plane:05	ACA (Link)	The service that authenticates command sources and enforces command acceptance on the uplink (ACA, link).	SEG:LI:Link:00	Falco et al. 2024; NIST SP 800-57
SVC:CP:Control Plane:06	Attack Detection / Recovery	The service that detects hostile command or state manipulation on board and recovers from it.	SEG:LI:Link:00	NIST IR 8270; Falco et al. 2024
SVC:HY:Hybrid:01	Error Handling (FEC/ECC)	The service that detects or corrects bit errors on the link (FEC/ECC error handling).	SEG:LI:Link:00	CCSDS 231.0-B
SVC:HY:Hybrid:02	T2 (Tracking & Telemetry)	The service that tracks the vehicle and returns telemetry across the control loop and the data path (T2).	SEG:LI:Link:00	CCSDS TT&C

SEG:GR:Ground:00 · SEG:GR:Ground:01

Ground segment services, 5 (4 Reston + 1 Kiruna)

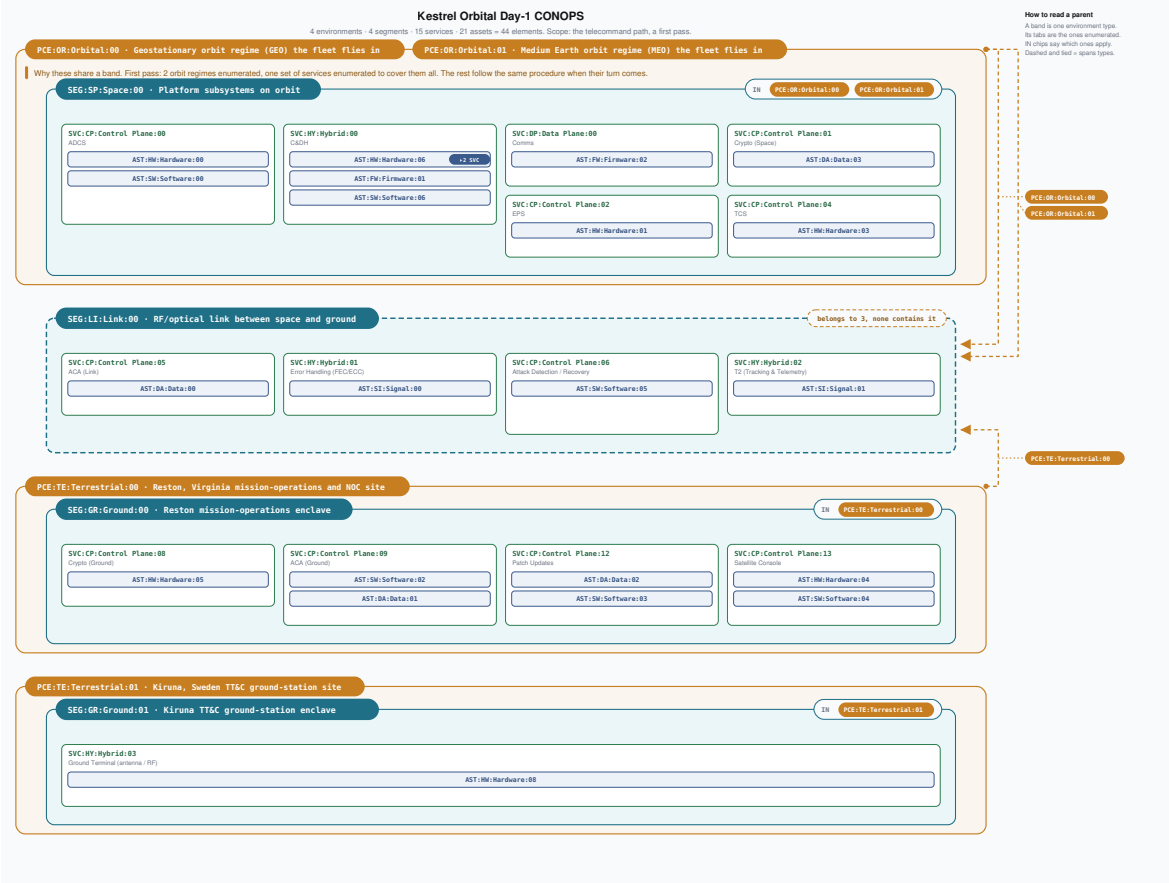
The ground segment's job for telecommand: mission operations, command authorization and preparation, key management, flight dynamics, and monitoring. Six control-plane services hold command authority at Reston; the Kiruna enclave holds the radio.

IDENTIFIER	SERVICE	CANONICAL DESCRIPTION	PARENT	REFERENCE
SVC:CP:Control Plane:08	Crypto (Ground)	The service that protects commands before uplink and data after downlink (Crypto, ground).	SEG:GR:Ground:00	NIST SP 800-57
SVC:CP:Control Plane:09	ACA (Ground)	The service that decides who may command and which commands are released to the link (ACA, ground).	SEG:GR:Ground:00	Falco et al. 2024; NIST SP 800-57
SVC:CP:Control Plane:12	Patch Updates	The service that delivers and installs software and firmware updates under control (Patch Updates).	SEG:GR:Ground:00	NIST SP 800-40
SVC:CP:Control Plane:13	Satellite Console	The service that gives operators the mission-ops console: telemetry monitoring and command issue.	SEG:GR:Ground:00	NIST IR 8401
SVC:HY:Hybrid:03	Ground Terminal (antenna / RF)	The service that transmits the command uplink and receives the downlink at the Kiruna ground station (RF ground terminal).	SEG:GR:Ground:01	NIST IR 8401; CCSDS TT&C

FIELD NOTE · Six control-plane services hold command authority at Reston; the Kiruna enclave holds the radio. The PARENT step made the meeting state on the record which enclave actually radiates, a question that had lived in hallway knowledge until it had an identifier to hang on. Win: failover and jurisdiction analysis now cite enclaves, not buildings. Ground ACA (CP:09) is a separate element from ACA on the link (CP:05) even though the two share a role, because each is authored and runs on its own segment.

6.4 · AST, 21 ELEMENTS

STAGE 4 OF 4 · 44 OF 44 ELEMENTS · COMPLETE



Twenty-one assets close every branch. Every element now traces to an environment, so nothing in the model is unowned.

What this is, and what it is not. This is a complete, parented decomposition *of the telecommand path*, not a complete model of Kestrel Orbital. It is a first pass on one platform under a real time constraint. Some assets group several physical units where those units share an owner, a build and a patch path; where any of those diverge, the element splits and takes the next ordinal. The gaps in the ordinal sequence are elements the register still tracks outside this scope. Say all of this out loud when you present it: a decomposition presented as finished invites a reviewer to find the missing thing, while one presented as a scoped first pass invites them to fund the next one.

Satellite Design & Engineering supplied the concrete assets from its inventory lists, BOMs, CMDB exports, and console inventories. Every asset names every service it carries in PARENT, at least one; ordinals continue per tag across the whole platform, so unit-level detections resolve to the exact instance. This is the resolution at which a detection fires and a patch lands.

SEG:SP:Space:00

Space segment assets, 9

Four Hardware, three Software, two Firmware, and one Data asset realize the seven flight services. The OBC boot code and the repeater's operating code live in non-volatile memory on a separate signing and uplink path, so they are Firmware, not Software.

IDENTIFIER	ASSET	CANONICAL DESCRIPTION	PARENT	REFERENCE
AST:FW:Firmware:01	OBC boot firmware	The embedded OBC boot firmware, the root of trust that runs first at power-on.	SVC:HY:Hybrid:00	NIST SP 800-193
AST:FW:Firmware:02	Repeater firmware	The embedded repeater firmware that governs receive, process, and retransmit on the link.	SVC:DP:Data Plane:00	NIST SP 800-193; CCSDS 232.0-B
AST:HW:Hardware:00	ADCS sensors	The physical attitude sensors: star trackers, sun sensors, gyros, magnetometers.	SVC:CP:Control Plane:00	NASA/ESA ADCS
AST:HW:Hardware:01	EPS power chain	The physical power chain: solar arrays, batteries, power distribution.	SVC:CP:Control Plane:02	NASA SST (Power)
AST:HW:Hardware:03	Thermal control hardware	The physical thermal hardware: heaters, radiators, coatings, insulation.	SVC:CP:Control Plane:04	NASA SST (Thermal)
AST:HW:Hardware:06	OBC + OBDH bus	The physical on-board computer and OBDH bus on each constellation spacecraft.	SVC:HY:Hybrid:00	ESA OBDH
AST:SW:Software:00	ADCS flight software	The flight software that runs the ADCS control algorithms.	SVC:CP:Control Plane:00	NASA cFS
AST:SW:Software:06	C&DH flight software	The flight software that executes commands and runs FDIR for C&DH.	SVC:HY:Hybrid:00	NASA cFS; ESA OBDH
AST:DA:Data:03	Space crypto key store	The stored flight keys and certificates the space cryptographic service encrypts and authenticates with.	SVC:CP:Control Plane:01	CCSDS 355.0-B (SDLS); CCSDS 357.0-B; NIST SP 800-57

FIELD NOTE · The SUBSYSTEM tag groups the shared spacecraft bus so the inventory can be queried by physical subsystem regardless of which service each asset anchors to: the Bus group gathers the on-board computer and data bus (HW:06), the C&DH flight software (SW:06), the boot firmware (FW:01), and the power chain. One flight key store and one boot-firmware entry cover both fleets. Win: which binary on which bird became one identifier instead of a meeting.

SEG:LI:Link:00

Link segment assets, 4

The stored credentials, the two waveforms, the encoder, and the attack-detection software: the link is a channel, not a host, so no asset here forms a physical subsystem group.

IDENTIFIER	ASSET	CANONICAL DESCRIPTION	PARENT	REFERENCE
AST:DA:Data:00	Link ACA credentials	The stored link ACA credentials the access-control service checks.	SVC:CP:Control Plane:05	NIST SP 800-57
AST:SI:Signal:00	TC uplink waveform	The transmitted telecommand uplink waveform that carries commands from ground to spacecraft.	SVC:HY:Hybrid:01	CCSDS 231.0-B; CCSDS 232.0-B
AST:SI:Signal:01	Telemetry and ranging waveform	The transmitted telemetry and ranging waveform: the modulated downlink signal, its framing, coding, and ranging tones.	SVC:HY:Hybrid:02	CCSDS 132.0-B (TM Space Data Link); CCSDS TT&C
AST:SW:Software:05	Attack-detection and recovery software	The flight software that detects hostile command or state manipulation in flight and recovers.	SVC:CP:Control Plane:06	NIST IR 8270; Falco et al. 2024

SEG:GR:Ground:00 · SEG:GR:Ground:01

Ground segment assets, 8 (7 Reston + 1 Kiruna)

Four Software, two Data, two Hardware, and one Firmware asset under Reston, plus the Kiruna antenna hardware, each tracing up to the ground service it implements.

IDENTIFIER	ASSET	CANONICAL DESCRIPTION	PARENT	REFERENCE
AST:DA:Data:01	ACA credential store	The stored ACA credentials the ground authentication service relies on.	SVC:CP:Control Plane:09	NIST SP 800-57
AST:DA:Data:02	Patch binaries (FW/SW)	The stored patch binaries, firmware and software, staged for deployment.	SVC:CP:Control Plane:12	NIST SP 800-40; NIST SP 800-193
AST:SW:Software:02	Ground ACA software	The ground software that enforces command acceptance before release to the link (ACA).	SVC:CP:Control Plane:09	Falco et al. 2024; NIST SP 800-57
AST:SW:Software:03	Patch deployment pipeline	The software pipeline that builds, signs, distributes, and installs patches.	SVC:CP:Control Plane:12	NIST SP 800-40
AST:HW:Hardware:04	Operator console	The physical operator workstation from which telemetry is monitored and commands are issued.	SVC:CP:Control Plane:13	NIST IR 8401
AST:SW:Software:04	Console operator software	The software C2 application on the operator console, the ground command-and-control suite.	SVC:CP:Control Plane:13	NIST IR 8401
AST:HW:Hardware:05	Ground cryptographic module (HSM)	The physical ground cryptographic module (HSM) that stores ground keys and performs encryption, decryption, signing, and verification.	SVC:CP:Control Plane:08	CCSDS 355.0-B (SDLS); NIST SP 800-57
AST:HW:Hardware:08	Kiruna antenna and RF front end	The physical Kiruna antenna, feed, and low-noise / high-power RF front end.	SVC:HY:Hybrid:03	NIST IR 8401; CCSDS TT&C

FIELD NOTE · Two coherent groups take the SUBSYSTEM tag: the patch pipeline plus the binaries it stages form a Patch Deployment subsystem, and the operator workstation plus the console application it runs form an Operator Console subsystem. Every asset names one service, every service one enclave, every enclave one site. Win: all three departments now cite the same 44 identifiers, and nothing on the telecommand path is described twice in two vocabularies.

Assets are the leaf layer of the CONOPS. Each one names the SVC it implements as its PARENT, and each of those services already traces up through its SEG to a PCE, so every asset closes a branch that runs from PCE to asset. With all 44 elements enumerated, the CONOPS is complete and ready to hand off for threat attachment on Day 2.

CH 7 DEPLOYING THE TAXONOMY IN THE SOC

> "That single data model is the Concept of Operations the next four METEORSTORM functions build on, and it deploys today into the Security Operations Center's MISP-based Threat Intel Platform."
>
> DEEP DIVE DECK, SLIDE 58 · SOC DEPLOYMENT: THE METEORSTORM TAXONOMY

The same model you enumerated by hand this morning is published as the `meteorstorm` namespace in the public MISP (Malware Information Sharing Platform) taxonomies repository, live and open source. Your organization adopts it with no re-architecture: tag the threat intel, alerts, and events you already produce, and the structural context travels with every finding to each department and every Space ISAC partner.

THE MACHINE TAG

A machine tag is a triple: `namespace:predicate="value"`. Two worked examples:

- `meteorstorm:SEG="SEG-GR"` · a finding on the Ground segment.
- `meteorstorm:AST="AST-FW"` · a firmware asset.

The predicate is the layer, the value is the TEN tag, so a tagged event carries its structural context in machine-readable form. The finding itself cites the exact instance by its ETEN, and the parent chain above that element rides along without being restated.

THE THREE DEPLOYMENT STEPS

1. **RETRIEVE** the namespace; it ships with MISP.
2. **ENABLE** it in `taxonomies/index`.
3. **APPLY** it to every event.

THE THREE DOORS

Deploying the taxonomy into the Security Operations Center's MISP-based Threat Intel Platform is the **Activate** entry point from orientation, executed: the first of the three doors opened. Satellite Design & Engineering takes the **Integrate** door when the next platform leaves the drawing board, and all three departments meet at **Engage** on the exercise floor later this week.

What deployment closes the loop on: information sharing with Space ISAC is a company mandate, and this taxonomy is what makes it work machine to machine. A confirmed command-and-control attack becomes a redacted, tagged event whose structural context any partner running the same namespace reads without translation.
