

Facility AI at Every Tier

TORUS does not just detect, it classifies and correlates. Machine learning runs where the data is born, on the node, at the gateway, and in facility operations.

TORUS turns raw signal into a smaller, more certain facility event at each stage, so what travels the network and reaches the operator is a validated track, not a raw feed or a bare alarm.

1 Why AI, not thresholds

A tripwire counts; an engine understands.

- **Classify by type, not just presence.** Footfall, vehicle, or digging; voice, engine, or breaking glass. The system reports what it is, with a confidence, not merely that something happened.
- **Corroborate by fusing across domains.** A seismic cue plus an acoustic cue from a neighbouring node is a stronger track than either alone. Fusion is where confidence is earned.
- **Suppress false alarms.** Wind, rain, traffic, cooling equipment, and wildlife are the main sources of nuisance alarms for an unattended sensor. On-device models learn the background and suppress false alarms.

2 Three tiers of facility AI

AI is distributed, not centralised. Every tier runs the inference its power and vantage allow, and passes a smaller, richer product to the next.

Tier 1 • Edge / node • on-device TinyML FIELDDED

Seismic and acoustic classification on the ESP32-S3, quantized for a battery budget. Hardware wake-on-seismic, then an ML pass confirms and classifies before any radio use. Event vs background discrimination cuts the message rate and the power bill. Audio is classified at the node; raw audio never leaves it.

ESP32-S3 • quantized TinyML

Tier 2 • Gateway / MEG • accelerated edge inference CONCEPT

NVIDIA Jetson Orin runs thermal and visual inference on cued imagery from the masts. Detect, track, and classify at the gateway, so backhaul carries decisions, not video. Multi-node fusion across the local ring before anything leaves the site.

Jetson Orin • thermal /

visual / fusion

Tier 3 • Facility operations / CCISRT • correlation & tracks RUNNABLE

Clusters corroborating events across nodes into a single track with aggregate confidence. Classification fusion, equipment-background learning, and false-alarm suppression across the whole facility. Explainable rule-based correlator today; a learned model drops in behind the same interface.

CCISRT • correlation / tracking

3 The facility-event pipeline

Raw signal in, decision out.

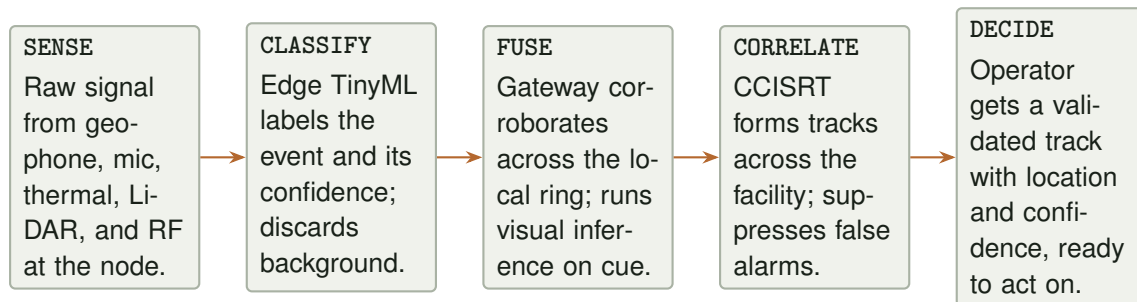


Figure 1: The TORUS facility-event pipeline, where each stage reduces data and raises certainty.

Data reduction

Each stage reduces data and raises certainty. A raw waveform becomes a labelled event, a set of events becomes a track, and a track becomes a decision, so the network carries kilobytes of event data rather than megabytes of feed.

4 Models and method

Tier	Runtime	Approach
Edge	ESP32-S3, no accelerator	Small quantized classifiers (TinyML) sized to RAM and the battery budget; wake-gated so inference runs only on a real cue
Gateway	NVIDIA Jetson Orin	Accelerated detection / tracking on thermal and visual streams; on-site so raw imagery stays local

Tier	Runtime	Approach
Facility ops	CCISRT server	Rule-based correlation today (explainable, auditable); learned multi-target tracking and classification fusion drop in behind the same track interface; northbound REST and webhooks publish events to facility systems
All tiers	Isaac Sim	Scenarios generate labelled data and validate detection and false-alarm rates before facility trials

Explainable first

The CCISRT correlator ships as transparent rules so an operator can see why a track formed. Learned models are introduced behind that interface, with the rule-based path retained as a fallback and a sanity check.

5 Data governance and facility privacy

Classify at the source, keep raw data local.

Area	Principle	Detail
Privacy	Raw stays put	Audio and imagery are processed where captured; only compact labelled events cross the network.
Signature	Less on the wire	Sending decisions instead of feeds cuts bandwidth, power, and RF signature, which supports passive facility monitoring.
Assurance	Auditable inference	Track formation and command actions are logged, so an analyst can reconstruct why the system decided what it did.

6 Roadmap

From rules to learned fusion.

Now	Next
On-device seismic / acoustic classification at the node	Larger vocabularies and per-site adaptation via OTA model updates

Now	Next
Rule-based correlation and track formation at CCISRT	Learned multi-target tracking and cross-domain classification fusion behind the same interface
Isaac Sim scenario data for validation	Active learning from operator confirmations to cut false alarms over time

TRADEMARKS & THIRD-PARTY NOTICE

TORUS is an independent platform. Company names and product model numbers referenced in this document (including but not limited to Espressif ESP32-S3 and NVIDIA Jetson, Orin, and Isaac Sim) are used solely for engineering and bill-of-materials identification and imply no affiliation with or endorsement by those companies. Supply of any such third-party product to the designers, integrators, or evaluators of the TORUS platform remains at the sole discretion of the respective owning company, organisation, or legal entity. "FOR EVALUATION" is a document-handling marking only and denotes no government classification. All trademarks are the property of their respective owners.