ZT-WP-005 | ZERO-TRANSIT RESEARCH WORKING PAPER

From Terrestrial Arrays to Orbital References: A Phased Architecture for the Zero-Transit Observatory

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Research status: Foundational concept / methods architecture. This working paper defines testable research structure and does not report a validated long-range detection effect, operational observatory, government partnership, or deployed capability.

ABSTRACT

This paper describes a phased observatory architecture for the Zero-Transit research program. The design begins with stationary terrestrial instruments because calibration, environmental characterization, access control, and independent replication are easier on the ground. Only after cross-domain measurements and natural-reference procedures are validated does the roadmap contemplate partnered orbital reference payloads. The architecture treats each node as independently useful and requires local raw preservation, explicit timing uncertainty, resilient provenance, and domain-aware release controls. A global network is therefore not conceived as one opaque detector but as a federation of auditable measurement sites. The paper specifies node classes, terrestrial reference arrays, orbital roles, data-link assumptions, comparison logic, failure containment, and criteria that must be satisfied before expansion beyond laboratory and terrestrial phases.

Keywords: *observatory architecture, distributed sensing, orbital reference, terrestrial array, resilience, data provenance, Zero-Transit*

1. Architecture Before Scale

The Zero-Transit concept benefits from geographic separation only if each site is independently interpretable. A global network built before local calibration would multiply uncertainty rather than reduce it. The roadmap therefore begins with laboratory and stationary terrestrial nodes, where environmental context and maintenance history can be characterized in detail.

Each node is a measurement site, not a black-box detector. It should produce native observations, health telemetry, timing metadata, environmental context, and provenance records even when no candidate event is present.

2. Node Classes

A practical architecture can distinguish core precision nodes, contextual reference nodes, partner nodes, mobile test assets, and future orbital references. Core nodes carry the highest timing and calibration requirements. Contextual nodes measure local environmental variables. Partner nodes expose data through the Universal Sensor Interface while retaining organizational autonomy. Mobile assets are used for controlled tests rather than as the initial production architecture.

Orbital nodes, if ever justified, should begin as references and correlation partners rather than as assumed primary detectors. Their value would include environmental separation from terrestrial noise, geometry changes, and comparison across ground-to-space baselines.

3. Terrestrial-First Rationale

Terrestrial deployment supports repeatable calibration, physical inspection, redundant power and timing, and controlled stimulus testing. It also makes it possible to quantify local infrastructure and human activity. Those capabilities are essential when the research question concerns weak or ambiguous correlations.

A regional array can test whether a candidate pattern is local, shared by nearby sites, or absent at an independent node. Distance alone does not establish a common physical cause, but spatial comparison can eliminate site-specific explanations and improve the design of later experiments.

4. Timing, Links, and Local Autonomy

Distributed measurement requires time registration and data transport, but the architecture should not depend on a continuous network connection to preserve evidence. Nodes should buffer raw data locally, maintain a stable identity, and record synchronization state. Precision timing technologies such as White Rabbit show that tightly synchronized measurement networks are technically feasible where appropriate (Moreira et al. 2009).

Network outages, clock holdover, dropped packets, and software upgrades should appear as explicit metadata. A candidate that occurs during degraded timing can remain scientifically interesting, but its uncertainty must travel with it.

5. Correlation Without Centralized Fragility

Multisensor fusion architectures often separate acquisition, association, and higher-level inference (Hall and Llinas 1997). Zero-Transit similarly benefits from layered processing. Nodes can validate and package local observations while a correlation service evaluates relationships across sites. The central service should never be the only location where raw evidence exists.

This federation model also supports collaboration. A partner can contribute a bounded dataset or derived product without surrendering operational control of the underlying instrument. Provenance allows the central analysis to retain attribution and quality context.

6. Natural Reference at Network Scale

Global correlation is persuasive only when global natural drivers are represented. Space weather, geomagnetic activity, seismic events, atmospheric systems, and other shared processes can create legitimate multi-site relationships. The NFRL therefore scales with the observatory and must distinguish globally coherent natural phenomena from locally coherent events.

USGS earthquake feeds and NOAA space-weather products are examples of authoritative external context that can be integrated without treating them as Zero-Transit observations. Their role is to make known causes easier to test before a residual is labeled unresolved.

7. Orbital Development as a Contingent Phase

Orbital development should be contingent on demonstrated value from terrestrial work. The scientific case should specify what ambiguity an orbital reference resolves, what measurement family is mature enough to fly, what timing and calibration are required, and how the payload contributes to falsification rather than simply expanding coverage.

Ground-to-space correlation would introduce additional complications: orbital ephemeris, radiation environment, thermal cycling, communications latency, clock behavior, and limited servicing. These factors make orbital deployment a later research phase, not a branding milestone.

8. Expansion Gates

Before a new region or orbital reference is added, the program should demonstrate instrument admission, raw preservation, timing characterization, natural-reference coverage, reproducible analysis, security/release controls, and a scientific question that benefits from the additional geometry. Expansion should have a falsifiable purpose.

A global capability is therefore an outcome of accumulated validated nodes, not a single deployment event. The network grows by adding independent evidence while maintaining the ability to audit each contribution.

9. Conclusion

The Zero-Transit observatory roadmap treats scale as a scientific variable. Terrestrial nodes establish the disciplines of calibration, context, and independent replication. Regional arrays test spatial relationships. Future orbital references are justified only when they answer questions that the ground network cannot. The resulting architecture is a federation of auditable observatories, designed to make both positive and negative results durable.

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