ZT-WP-004 | ZERO-TRANSIT RESEARCH WORKING PAPER

Evidence-Gated Research and Development for Zero-Transit: A Six-Phase, Sixteen-Step Validation Pathway

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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

Foundational research programs are vulnerable to momentum: once a compelling mechanism or prototype exists, organizational incentives can cause the program to advance faster than the evidence. Zero-Transit uses an evidence-gated pathway intended to make repetition, failure, and retention legitimate outcomes. This paper formalizes six program phases - foundational concept, laboratory development, integrated testing, terrestrial deployment, orbital development, and global capability - and a sixteen-step R&D; cycle repeated inside each phase. The cycle begins with a research question and competing hypotheses, forces early viability testing before expensive engineering, requires natural-baseline comparison and blind anomaly trials, and ends with independent, security, intellectual-property, and advancement review. Statistical multiplicity, model uncertainty, provenance, and reproducibility are treated as governance issues as well as analytical issues. Advancement is evidence-based rather than calendar-driven.

Keywords: *research governance, technology readiness, falsification, Bayes factors, false discovery rate, independent review, R&D; pathway*

1. Why an Evidence Gate Is Necessary

An unconventional research question creates two symmetrical risks. Skepticism can terminate a viable line before a meaningful test exists, while enthusiasm can protect a weak line from disconfirmation. The Zero-Transit pathway attempts to reduce both risks by making advancement criteria explicit and by defining failure as an informative result rather than an organizational defeat.

The program therefore separates scientific evidence, engineering maturity, security/release readiness, and intellectual-property status. A prototype may be technically impressive while still lacking scientific validity; a reproducible effect may be scientifically important while still unsuitable for public release.

2. Six Program Phases

Phase 1, foundational concept, develops the measurement taxonomy, mathematical framing, natural-reference architecture, and explicit null hypotheses. Phase 2, laboratory development, builds benchtop interfaces, calibration methods, synthetic signals, and early viability tests. Phase 3, integrated testing, combines multiple instruments and introduces blind anomaly trials. Phase 4, terrestrial deployment, evaluates stationary observatories and regional reference arrays. Phase 5, orbital development, concerns future partner payloads and ground-to-space correlation. Phase 6, global capability, is contingent on the earlier phases and would involve broader evaluation and deep-space references.

These phases are not dates. A phase advances when evidence supports it. A program can remain in a phase, return to an earlier stage, or retain a result without transition.

3. The Sixteen-Step Cycle

The repeated cycle is: research question; competing hypotheses; early viability test; instrument requirement; simulation and modeling; component design; prototype fabrication; calibration; controlled test; natural-baseline comparison; blind anomaly trial; independent review; analyze and revise; security and release review; intellectual-property review; and advance, repeat, or retain.

The early viability test is deliberately near the beginning. It asks whether a proposed measurement can, even in principle, discriminate among hypotheses at a useful sensitivity. This avoids spending heavily on hardware that cannot answer the question that motivated it.

4. Competing Hypotheses and Model Uncertainty

Every cycle should contain mundane and instrumental hypotheses alongside any novel physical hypothesis. Bayesian model comparison is one established framework for representing evidence among competing models and avoiding the fiction that only one model exists (Kass and Raftery 1995). Zero-Transit can use Bayes factors or other model-comparison tools where assumptions are appropriate, but the governance requirement is broader: alternatives must be visible and their priors or assumptions documented.

If a novel explanation becomes the default label before known alternatives are tested, the cycle has failed procedurally even if the later conclusion happens to be correct.

5. Multiple Testing and Blind Trials

Integrated observatory data invite large numbers of exploratory comparisons. False-discovery-rate controls such as the Benjamini-Hochberg procedure are relevant when interpreting families of tests (Benjamini and Hochberg 1995), but statistical adjustment cannot substitute for replication. A pattern discovered after extensive tuning should be re-tested on held-out data or at an independent site.

Blind anomaly trials can use known natural events, injected synthetic patterns, and null intervals. The goal is not simply to maximize detection. It is to quantify false positives, missed detections, timing sensitivity, and the influence of analyst expectations.

6. Provenance, Reproducibility, and Review

Each stage should generate a durable research object containing source data references, software versions, configuration, decisions, and review outcomes. FAIR principles and formal provenance models provide established foundations for this practice (Wilkinson et al. 2016; Lebo, Sahoo, and McGuinness 2013). Continuous-analysis approaches demonstrate how computational workflows can be rerun and audited when code or data change (Beaulieu-Jones and Greene 2017).

Independent review should be adversarial enough to challenge timing, calibration, statistics, environmental context, and mechanism. Review comments and responses should be retained even when the result does not advance.

7. Release and Intellectual-Property Gates

A research result can be scientifically mature but inappropriate for immediate public release because of security, contractual, privacy, export, or intellectual-property considerations. Those considerations should not retroactively alter the scientific record. The system therefore stores a release decision separately from the underlying scientific state.

This separation supports two responsibilities at once: protecting legitimate controlled information and preventing secrecy from becoming a substitute for evidentiary weakness.

8. Advancement Decision

The final decision has three acceptable outcomes: advance, repeat, or retain. Advance means the evidence and engineering justify the next step. Repeat means the question remains viable but the current evidence is inadequate. Retain means the result is preserved as a negative, null, calibration, or contextual contribution without further investment.

This structure makes the program robust to failure. The scientific value of a cycle is the information it adds to the reference architecture, not whether it confirms the most interesting hypothesis.

9. Conclusion

The Zero-Transit pathway is designed to keep ambition coupled to evidence. Its six phases describe a possible trajectory from foundational concept to a future distributed observatory, while the sixteen-step cycle prevents the trajectory from becoming an assumption. A credible program is one that can show not only why it advanced, but also where it stopped, what failed, and what evidence would be required to try again.

References

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