PHASE 1 | TECHNOLOGY APPLICATION AND EXECUTION PLAN

ReTest

Know which solar measurement is worth repeating.

HOSTED TECHNOLOGY	CATEGORY	TEAM LEAD
Digital Twin	Computer Science	Rishika Vats | Texas Tech University

Why this project matters

A photovoltaic team tests a new module configuration and records a promising gain. The result is close to the threshold for moving forward. A small error in irradiance, module temperature or timestamp alignment could change the decision. The team needs another measurement, but repeating the full test may waste time and equipment access.

PV testing is a paid service. The Florida Solar Energy Center at the University of Central Florida lists module test packages at $625 and $1,550. The National Laboratory of the Rockies lists a $4,851 commercial 1-sun module calibration. These are published service prices, not assumed retest costs. They demonstrate why the choice of test deserves careful attention. [1, 2]

Our proposed solution

ReTest uses a measurement-updated photovoltaic digital twin to decide which follow-up test is most useful for a specific engineering choice. It compares explanations that fit the same observed data but lead to different go/no-go decisions. The planner then estimates which available measurement could resolve that disagreement at the lowest justified cost. If no check can settle it, ReTest recommends more evidence instead of forcing an answer.

MEASURE	EXPLAIN	CHOOSE
PV output, weather and instrument data	Physics-based twin tests plausible faults	Targeted retest, full rerun or additional evidence

A concrete first use case

In a working pvlib demo, a true +2% module gain appears as +5.2% when an irradiance sensor reads 3% low, falsely clearing a +3% threshold. A basic retest planner selects a reference check and a temperature check at 2 relative cost units versus 8 for a full rerun. The probability of clearing +3% falls from 85% to 2%, reversing a wrong “advance” decision. Weather is simulated, not field data. Code and results: github.com/Irishsss/retest-demo

Research question

Can a PV-specific, fault-aware digital twin reduce verification expense without increasing the risk of accepting an unsupported result or rejecting a genuine improvement?

01 / TECHNICAL APPROACH

What we will build and test

One focused application of digital-twin technology, with a measurable research outcome.

Prototype architecture

1. Model. Create a PV performance model in Python using pvlib. Update its inputs with time-stamped irradiance, temperature and power data from eligible public datasets. Retain measurement uncertainty rather than forcing a single perfect estimate.

2. Diagnose disagreement. Generate physically plausible sensor and synchronization faults, including correlated errors. Keep the scenarios that fit recorded measurements but disagree about a defined performance threshold.

3. Choose the next measurement. Compare reference sensor checks, synchronized readings and full-repeat options using their expected effect on the engineering decision, their time and their estimated cost. The planner can stop when evidence is sufficient or identify a gap that no available test can resolve.

4. Show the evidence. Generate a reproducible recommendation record showing candidate explanations, the proposed retest, the expected decision benefit and the assumptions on which it depends.

Scientific evaluation

We will target 1,200 held-out simulated cases with preassigned ground truth, developed from physical PV models and measured operating patterns. DOE PVDAQ data will provide real weather and performance behavior where the necessary channels exist. Faults will be injected synthetically so that we can measure correctness. The retired PVDAQ V3 API is not part of the data-access plan. [3, 4]

BASELINE	WHY IT MATTERS
Fixed test checklist	What a laboratory might do without decision-specific ranking
Information gain per cost	A conventional method that values uncertainty reduction
One-step value of information	An established decision-focused choice
Goal-driven and risk-aware design	Strong research comparisons, implemented where tractable

How success will be judged

Report false acceptance, false rejection, inconclusive outcomes, total added test cost, runtime and performance under deliberately inaccurate fault assumptions. Compare costs at similar levels of decision error, not simply raw accuracy or the cheapest measurement. An advantage must persist on held-out cases to support the proposed contribution.

Where the research is new

Goal-driven and risk-aware experimental design already exist. [5, 6] ReTest will investigate their use in a specific PV retest setting where interacting measurement faults create competing explanations near an engineering cutoff. The research output is a tested method, not another generic monitoring dashboard.

02 / TEAM AND DELIVERY

A small team with clear ownership

Software development, experimental evaluation and customer research can progress in parallel.

Team and responsibilities

Rishika Vats | Technical lead. Texas Tech Computer Science student with mathematics training. At NSF-funded CASFER, built a React, Node.js and Three.js digital twin visualizing two research testbeds. Also developed a separate research data portal documenting 42 electrolysis experiments, 16 biosolids batches and 17 E-GROW batches across five partner institutions. Worked on energy analytics at Sineng Electric. Leads modeling, algorithm development and integration. linkedin.com/in/rish27.

Ayush Raj | Operations and market study. Experience organizing campus activities and communicating with stakeholders. Responsible for compiling real testing-cost evidence, coordinating user interviews, maintaining the project plan and building the business case.

Uswa Tariq | Evaluation and quality. Experience coordinating student projects and supporting team documentation. Responsible for test-case tracking, regression checks, reproducibility records and usability reviews of the evidence reports.

Milestones and measurable outputs

WINDOW	OUTPUT
Nov 2026 | planning	Lock datasets, test definitions, acceptance thresholds and test protocol after selection.
Dec 2026 | foundation	Working PV model, data-import pipeline and four baseline implementations.
Jan 2027 | prototype	End-to-end retest planner, sample recommendation report and first progress update.
Feb 2027 | evaluation	Held-out fault scenarios, benchmark results and sensitivity analysis.
Mar 2027 | validation	User reviews, revised model and second progress update.
Apr 2027 | delivery	Demonstration, reproducible code, final technical report, full business plan and defense.

Dependencies and testing pathway

The initial build requires open-source Python tools, pvlib, downloadable public data, modest cloud capacity and version control. No laboratory equipment purchase is required. We will first validate the method using synthetic faults and replayed real observations. A later partner study would compare ReTest recommendations with historical borderline cases and actual test decisions, with the laboratory's approval.

Risk controls

Missing sensor channels: select suitable public systems and document synthetic substitutions. Incorrect assumptions: test correlated faults and model mismatch explicitly. Limited laboratory access: deliver the full controlled benchmark and a reproducible demonstration independently of a partner.

03 / COMMERCIALIZATION

Who would buy it and why

A practical entry point into existing PV testing and R&D workflows.

First customer and purchasing decision

The daily user is a PV engineer investigating a borderline result. The likely purchaser is a laboratory manager or an R&D leader responsible for testing budgets and technical decisions. Independent test houses and module manufacturers are the first two customer segments to examine. ReTest would help prioritize discretionary follow-up measurements alongside existing procedures.

What customers already use

TOOL	TODAY'S ROLE	RETEST POSITION
PVsyst	Energy-yield simulation	Different task: deciding which measurement to repeat
pvlib	Open PV performance models	Physical foundation used by ReTest
RdTools [7]	Performance and degradation analysis	Complementary time-series analysis, not a retest planner

These are adjacent tools, not an exhaustive competitive audit. We will interview buyers and review laboratory-specific software before claiming a defensible market gap.

How we would sell the first version

Discover demand. Conduct eight structured interviews with test engineers, laboratory managers or module R&D leads. Record actual frequency, cost, approval and handling of borderline measurements.

Pilot offer. Propose an eight-week evaluation using historical records and a limited set of test actions. Compare ReTest recommendations with the lab's chosen tests and actual outcomes.

Pricing to test. Ask buyers to react to a $750 to $1,500 pilot and a $2,500 to $5,000 annual laboratory license. These are proposed price points to validate, not booked sales.

Buyer value. At a proposed $2,500 annual license price, avoiding four discretionary tests priced like UCF's $625 standard package would cover the fee. Customer interviews will determine whether those savings are realistic. Required certification tests would remain unchanged.

Commercial roadmap and ten-year model

After a successful pilot, we would test direct laboratory licensing and distribution through an established PV testing or engineering-software provider. The Phase 2 plan will model ten years of pilot conversion, annual site revenue, retention, support costs, compute, sales expense, operating cash flow and net present value under conservative, base and growth assumptions.

For scale only, 20 laboratories at $3,000 per year would represent $60,000 in gross annual license revenue before costs. This is a planning scenario, not a market estimate. The immediate objective is to identify a paying customer and establish whether the improvement is large enough to justify adoption.

04 / RESOURCES AND COMPLIANCE

An execution budget built for the actual project

The research can be completed without an unsecured laboratory partnership.

Use of a $7,500 Phase 1 grant

PROJECT EXPENSE	BUDGET
Simulation and cloud computing	$1,450
Public data preparation, storage and quality checks	$850
Benchmark and reproducibility testing	$1,300
PV measurement-method review	$800
Buyer interviews and usability evaluation	$600
Prototype interface and data import	$950
Independent software verification	$950
Contingency for compute and testing	$600
TOTAL	$7,500

The budget prioritizes software, reproducible testing and outside review. External services will be engaged only within approved grant rules and agreed scopes. The initial build does not depend on acquiring or booking specialized PV equipment.

Institutional compliance

The team will follow applicable Texas Tech and other institutional policies covering research data, intellectual property, use of university resources and research participants. Development will use original code, public or simulated datasets and correctly licensed software. Any later work with identifiable customer records will require permission and appropriate safeguards.

References

[1] UCF Florida Solar Energy Center, PV Module Testing Fee Schedule (2025): publications.energyresearch.ucf.edu/wp-content/uploads/2025/10/PV_Test_Fees_2025-0930.pdf

[2] National Laboratory of the Rockies, Device Performance Calibration Pricing (2026): nlr.gov/pv/pvdpc/pricing

[3] PV Performance Modeling Collaborative, pvlib-python: pvpmc.sandia.gov/tools/

[4] National Laboratory of the Rockies, PVDAQ V3 status and new download routes: developer.nlr.gov/docs/solar/pvdaq-v3/

[5] Go, Qian and Yoon (2026), Goal-driven Bayesian Optimal Experimental Design: arxiv.org/abs/2605.26093

[6] Jakeman et al. (2026), Risk-Aware Goal-Oriented Bayesian Optimal Experimental Design: arxiv.org/abs/2609.08023

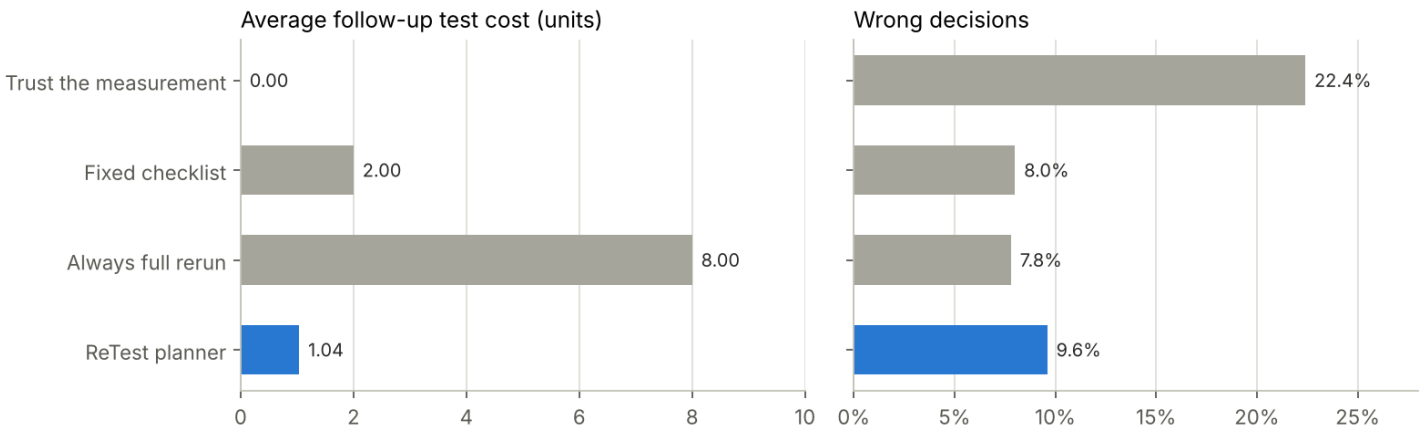
[7] RdTools documentation: rdtools.readthedocs.io/en/latest/

APPENDIX | INITIAL PROTOTYPE EVIDENCE

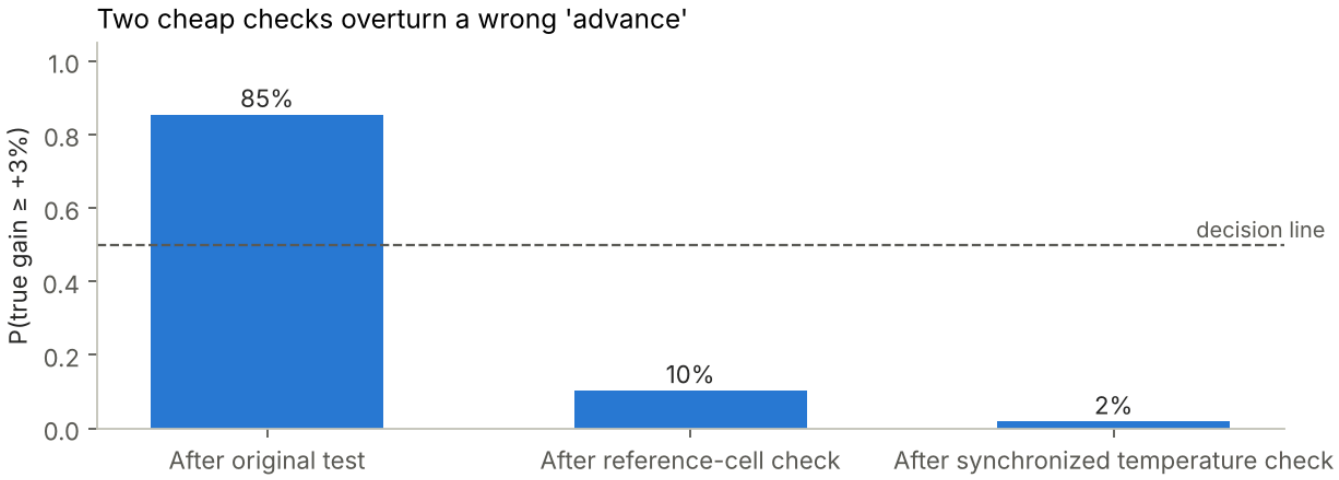
ReTest: simulation results

Synthetic PV data and relative testing costs, not field validation.

01 Follow-up costs and incorrect decisions



02 A wrong advance decision corrected by two checks



500 simulated scenarios. ReTest: 9.6% wrong decisions, 1.04 cost units.

Fixed checklist: 8.0% wrong decisions, 2.00 cost units.

Example decision confidence: 85% before checks, 2% afterward.

All testing costs are relative units. Results do not establish field savings.

Code and method: github.com/Irishsss/retest-demo