GEMSTONE

NSF PROGRAMMABLE CLOUD LABORATORY TEST BED
COOPERATIVE AGREEMENT · AWARD NO. 2607573

Generalizable Experimental Methods and Standards for Transparent, Open, Networked Execution

Standards and AI to Connect Programmable Cloud Laboratories at Industrial Scale



THE CHALLENGE

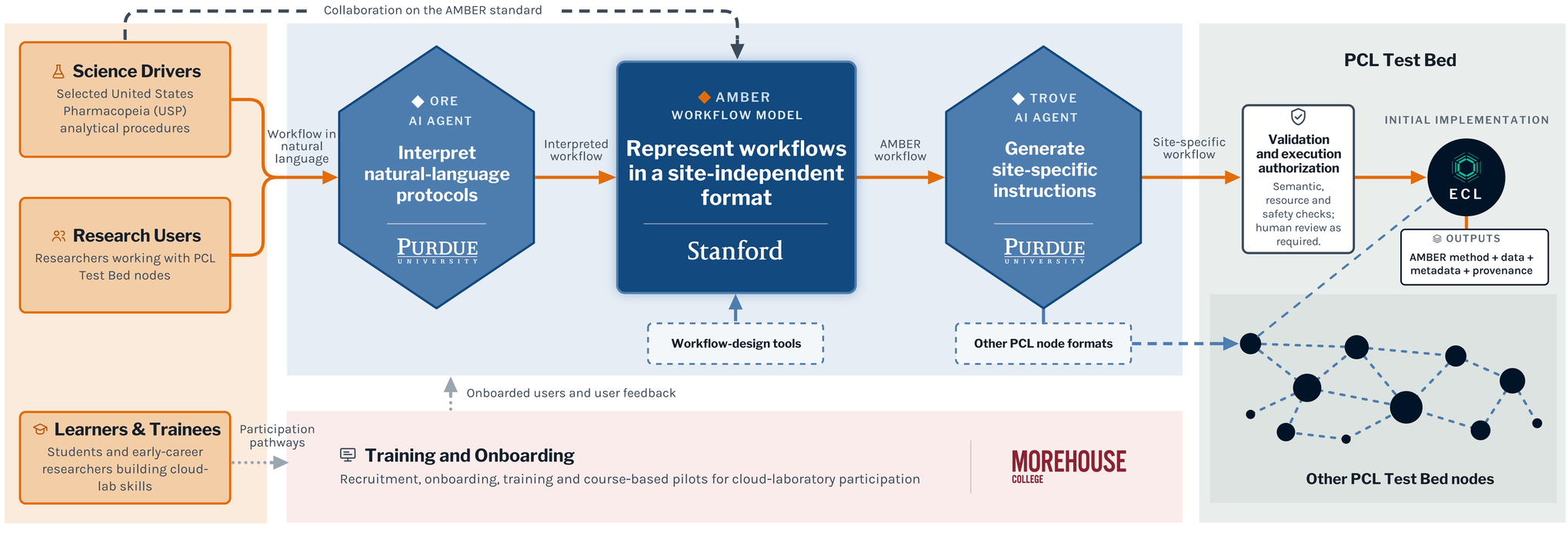
From prose to execution

Protocols are written for humans and often leave critical details implicit. This makes them difficult to execute in a programmable lab and reproduce across laboratories.

GEMSTONE is developing an open workflow representation and AI agents that translate written protocols into instructions for programmable labs.

TOWARD NETWORK INTEROPERABILITY

AMBER provides a shared workflow format designed for translation into each programmable lab's execution language. It keeps methods linked to their data, metadata, and provenance.



What we're building

A shared representation. AMBER aims to do for lab automation what STEP did for manufacturing: a common representation, adapted to each laboratory's capabilities. It must be abstract enough to describe workflows across scientific disciplines, yet precise enough to preserve the detail required for executable laboratory specifications.

AI agents with safeguards. ORE and TROVE read, disambiguate and translate written methods. AI-generated instructions cannot authorize an experiment on their own: validation and human review precede execution.

Traceable methods and reusable outputs. Methods, data, metadata and provenance will support reuse, with sharing governed by applicable permissions and agreements. Results inform method refinement.

First science driver

Developing and evaluating automated implementations of selected USP analytical procedures for pharmaceutical quality testing and characterization.

GEMSTONE will evaluate whether explicit, machine-actionable methods improve consistency, traceability and reproducibility, distinguishing within-laboratory repeatability from cross-node reproducibility.

EVALUATION

We will assess translation accuracy, experimental precision, agreement with applicable reference criteria, preparation time, corrections needed, and user feedback.
Additional science drivers will be selected as the platform develops.

Broadening access

Morehouse College coordinates recruitment, onboarding, training and course-based pilots, with technical support from project partners.

- Outreach to R1, R2, undergraduate, two-year, nonprofit and startup laboratories, including researchers and institutions with limited access to advanced instrumentation.
- Recruitment and onboarding workshops, training materials and user feedback.
- Supervised remote laboratory activities and course-based pilots.

Five partners, one PCL node

Five organizations operate GEMSTONE as a single NSF PCL Test Bed node, with the initial implementation at Emerald Cloud Lab.

Stanford University STANDARDS
Data standards and the AMBER representation
Stanford, CA

Emerald Cloud Lab CLOUD LAB
Laboratory operations, interfaces and experiment execution
Austin, TX

Purdue University AI
Agentic AI for laboratory applications
West Lafayette, IN

Morehouse College EDUCATION
Recruitment, onboarding, training and course-based pilots
Atlanta, GA

U.S. Pharmacopeia SCIENCE DRIVER
Authorized reference methods and targeted expert input
Rockville, MD

LEADERSHIP

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gemstoneproject.org
Scan for project information, team and updates