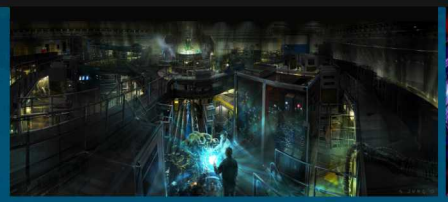
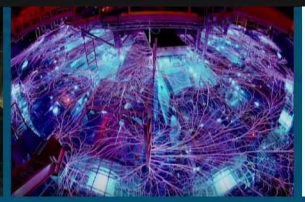
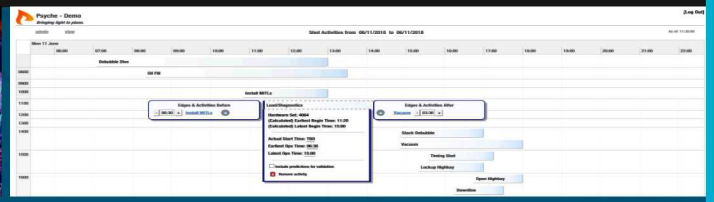
SAND2018-7131C

Extensions of a Simple Temporal Network Coordinating Emergent Knowledge Processes in a Collaborative System-of-Systems







PRESENTED BY

Michael A. Schaffner, R&D Systems Engineer

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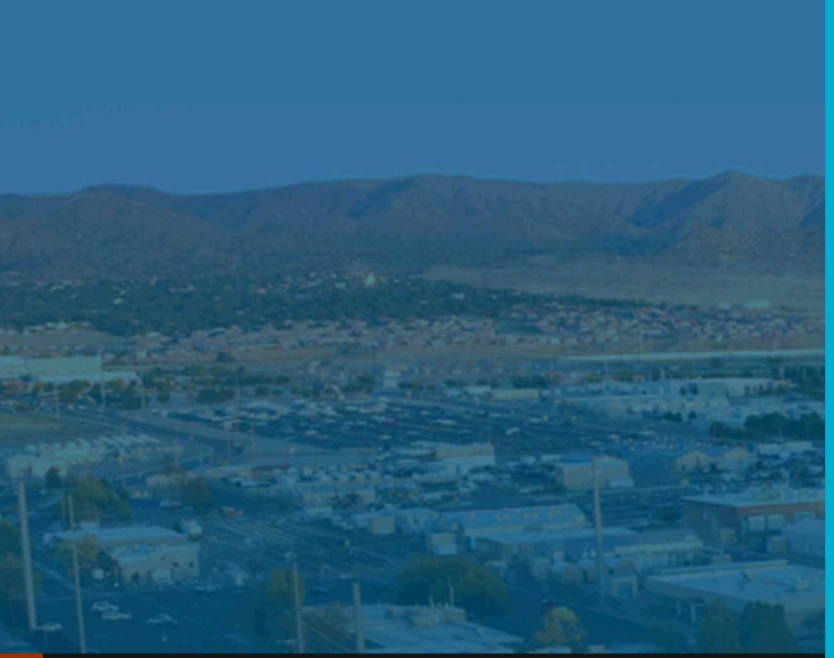
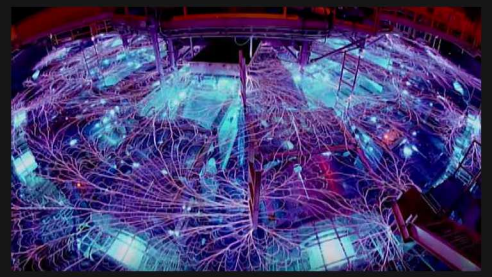
Agenda

1. Brief Introduction to Sandia's Z Machine
   - Collaborative System-of-Systems
   - Emergent Knowledge Processes
2. Planning with SYstematic CHronological Estimates (PSYCHE)
   - The goal
   - The application
3. Preliminary Verification and Validation
4. Questions, Feedback, Ideas, etc
   - Please! ☺





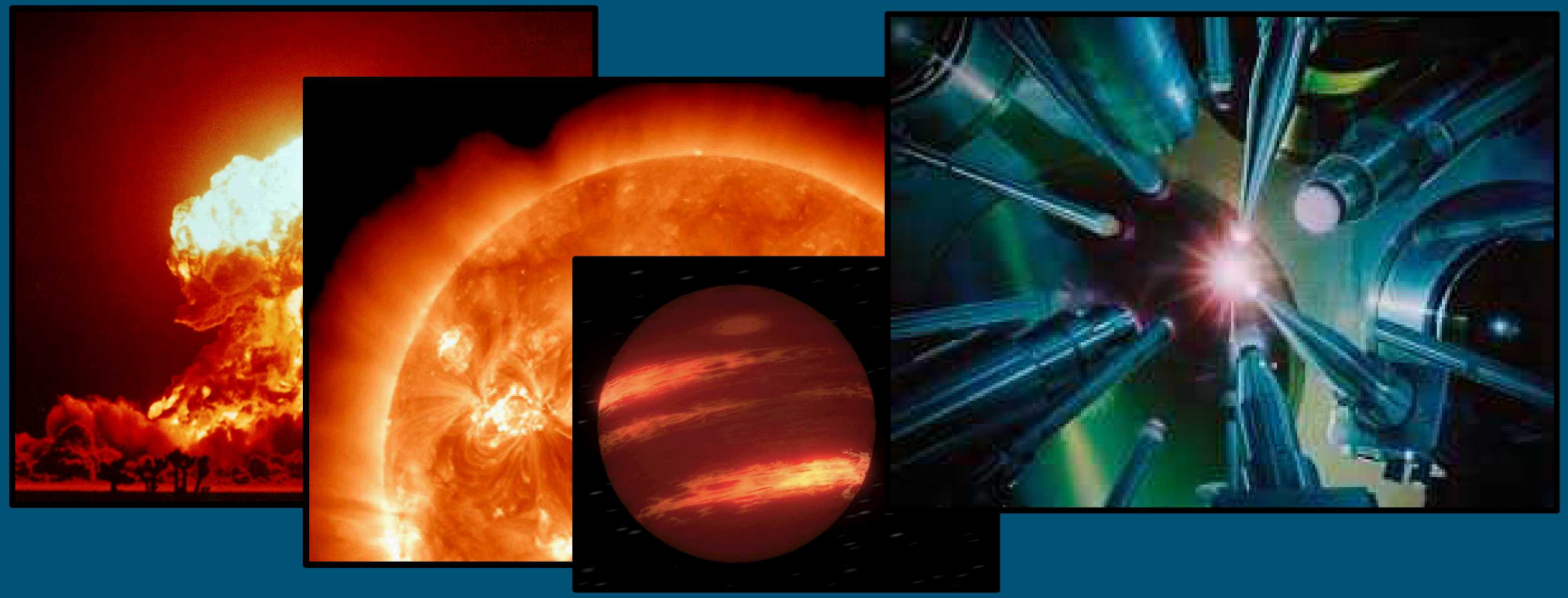
The Z Machine

A brief introduction to the world's largest x-ray source

The Z Machine

World's largest x-ray source (2-3 MJ) capable of delivering over 20MA of electrical current in microseconds

Used for pursuit of ignition in the laboratory (i.e., Inertial Confinement Fusion), academic and government science, and US nuclear stockpile stewardship programs



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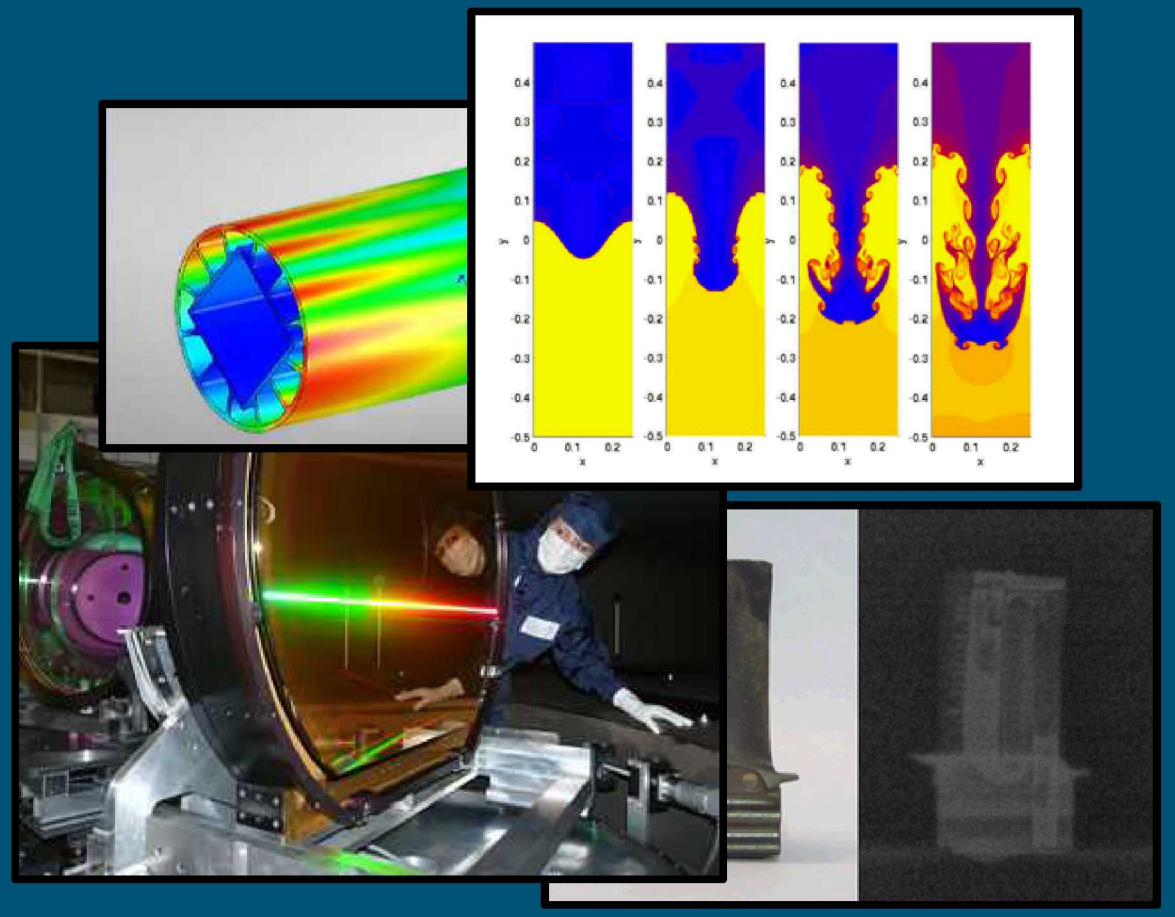
Requires experts from many disciplines:

- High Energy Density physics
- Electrical and mechanical engineering
- Laser technologies
- Atomic spectroscopy, neutron diagnostics
- Electro-mechanical and real-time control systems



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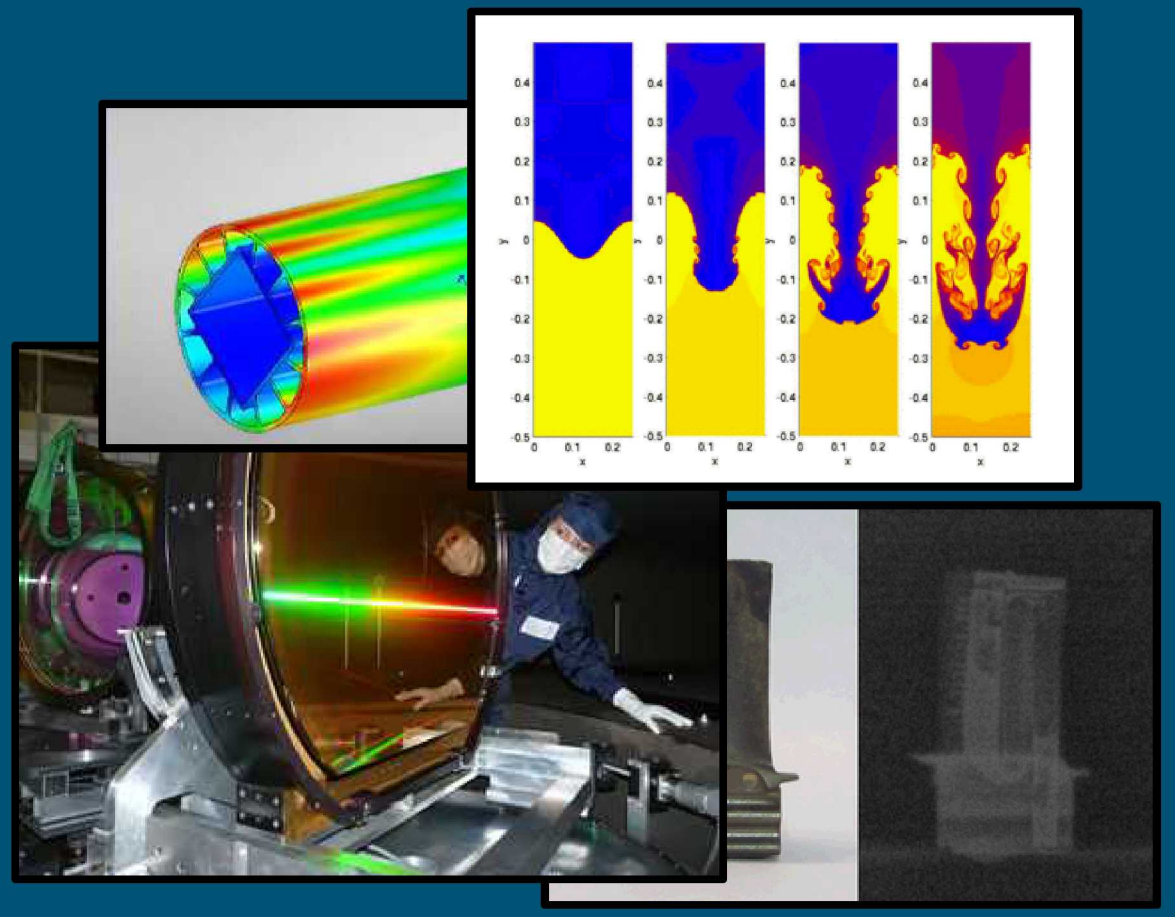
Regularly attempts a 1-experiment-per-day model

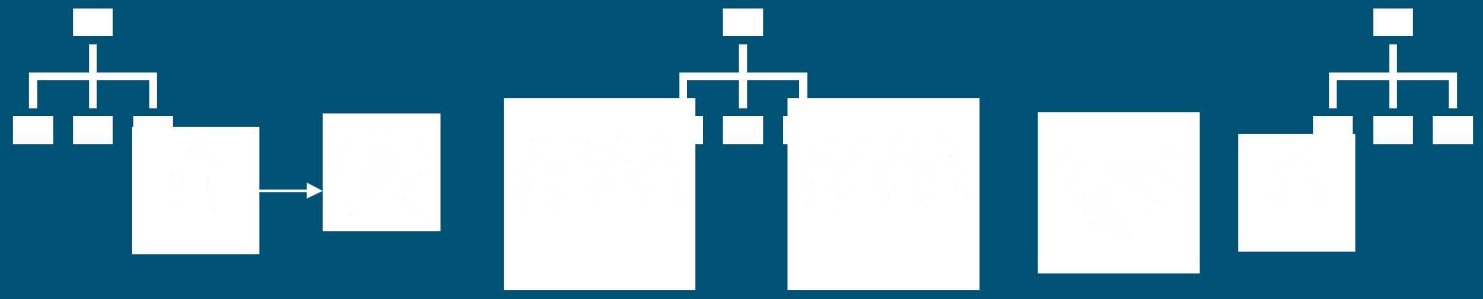


The Z Machine: Collaborative System-of-Systems

Operating within Sandia National Lab's research organization of ~10,000 employees (of which only 100-200 are "dedicated" to Z experiments) leads to collaborative work with traits like:

- Operational independence of participants and groups
- Managerial independence of resources and participants
- No recognized central authority on experiments or facility operations
- No centrally or commonly defined roles or responsibilities for experiments/operations

These are all traits of a **Collaborative System-of-Systems** (Maier 1998).



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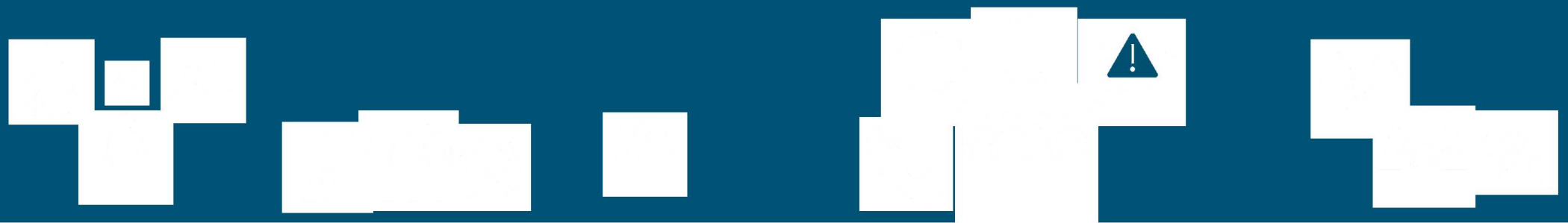
These also happen to be red flags for anyone attempting planning/scheduling! ☹

The Z Machine: Emergent Knowledge Processes

Operating on the fringes of established science leads to a dizzying distribution of dynamicity:

- The mix of backgrounds and expertise brought to bear can differ for each experiment.
- The work is largely cognitive and deliberative, and the extent to which consensus is required is unknown.
- The work is largely unstructured and to a great extent unstructurable. No optimal sequence/result exists.
- No one individual or group has a complete grasp of both the general and specific knowledge that applies.
- It is not possible to know in advance who will necessarily be involved.
- Participants may be infrequent or even one-time.
- Participants have considerable discretion over their use of methods and tools.

These are all traits of **Emergent Knowledge Processes** (Markus 2002).



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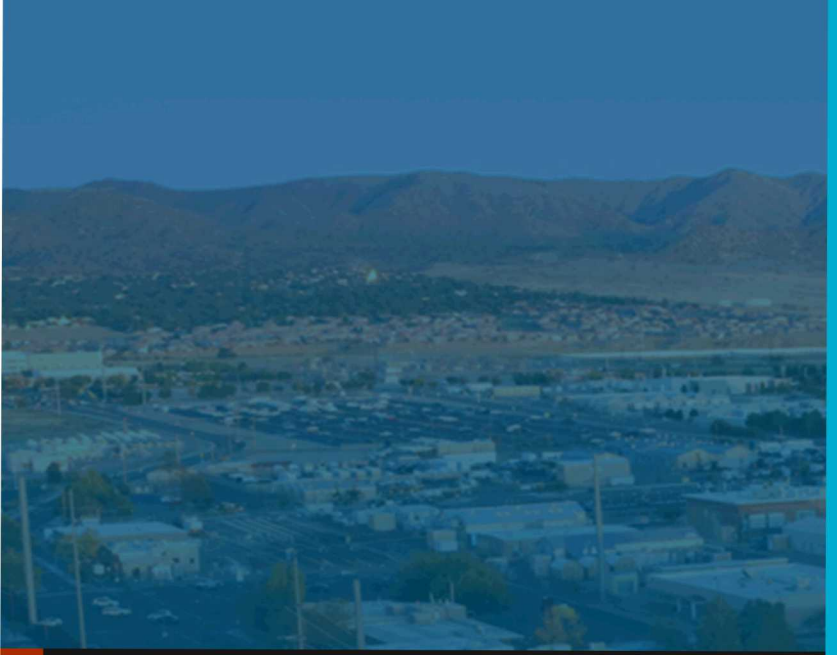
These also happen to be particularly deleterious to any attempted planning/scheduling! ☹



PSYCHE

Bringing plans to light

PSYCHE: The goal

Given the centrality of Emergent Knowledge Processes in our Collaborative System-of-Systems, the motivating research question is:

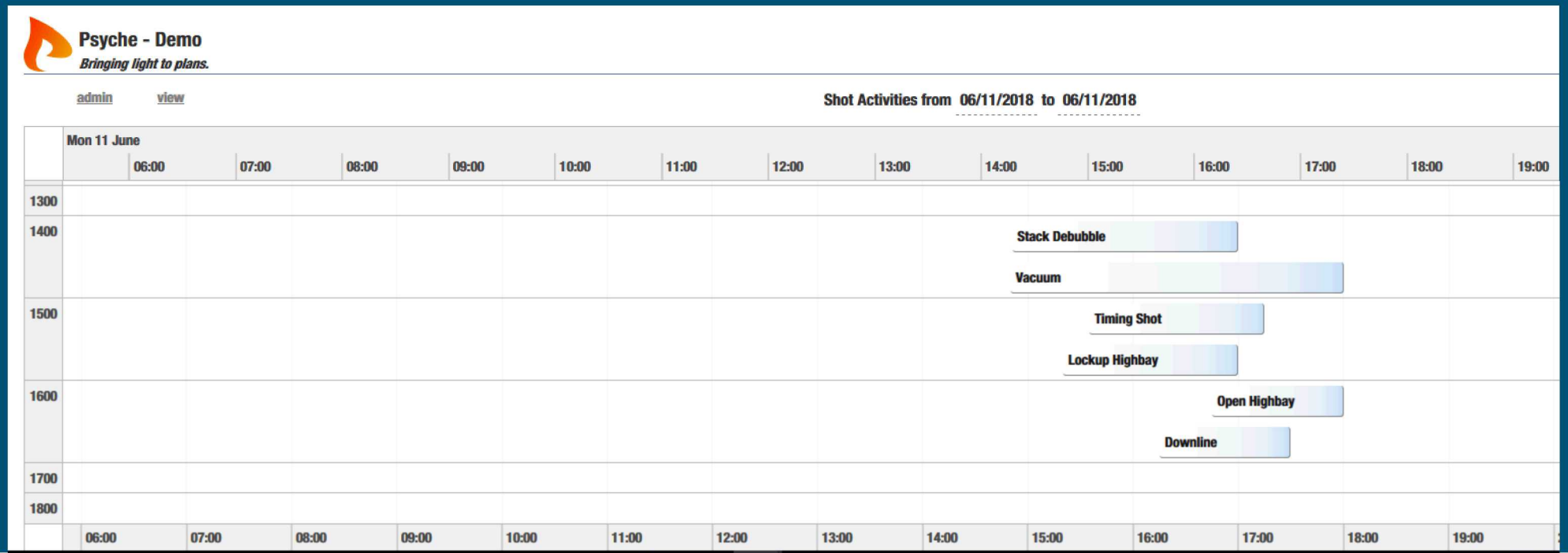
- Can we better coordinate workers by producing reliable schedule information even when so much of the work is unknown or unpredictable?
- My hypothesis is "Yes" – if we follow recommended methods for EKPs and SoS.

The goal is **more efficient coordination** by providing consistently actionable information regarding alternative temporal scenarios, while requiring as little information as possible from participants.

PSYCHE: The application

PSYCHE:

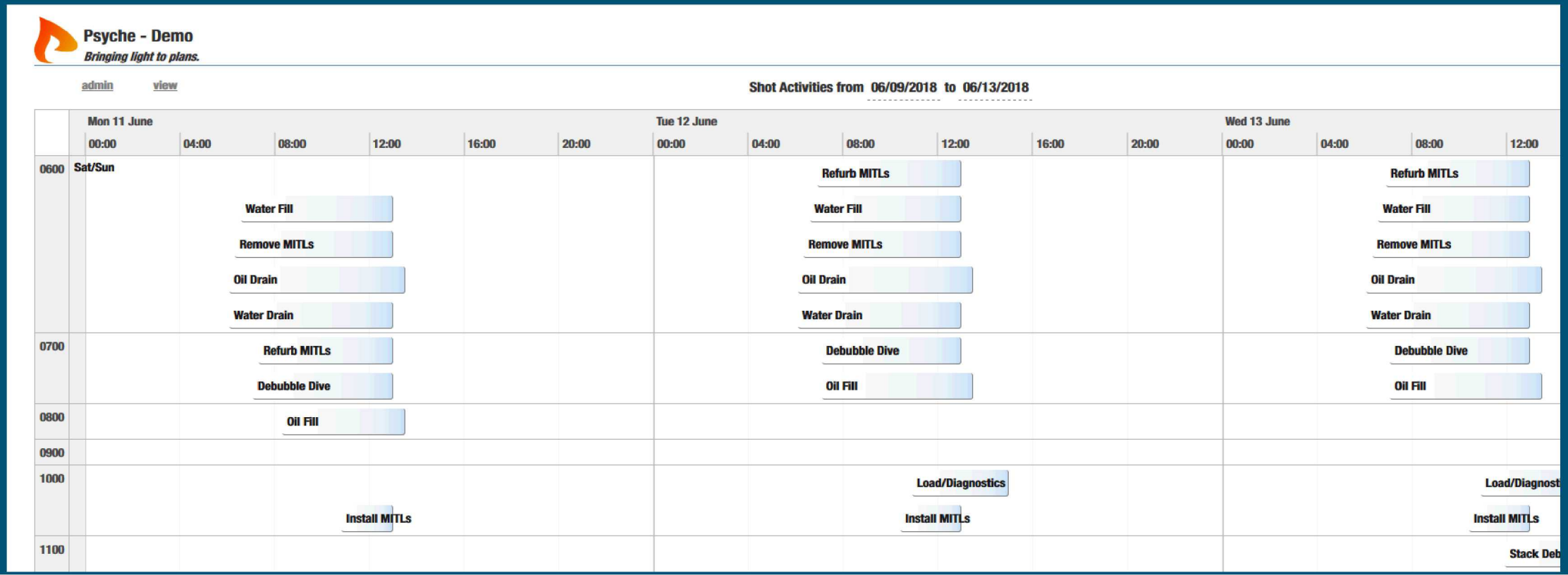
- Is a web-based application that generates, stores, and displays simple temporal networks of experiment activities planned on the Z-Machine
- Is a working prototype at present
- Provides earliest possible times for activities to start
- Provides latest cutoff times for activities to start



PSYCHE: The application

PSYCHE:

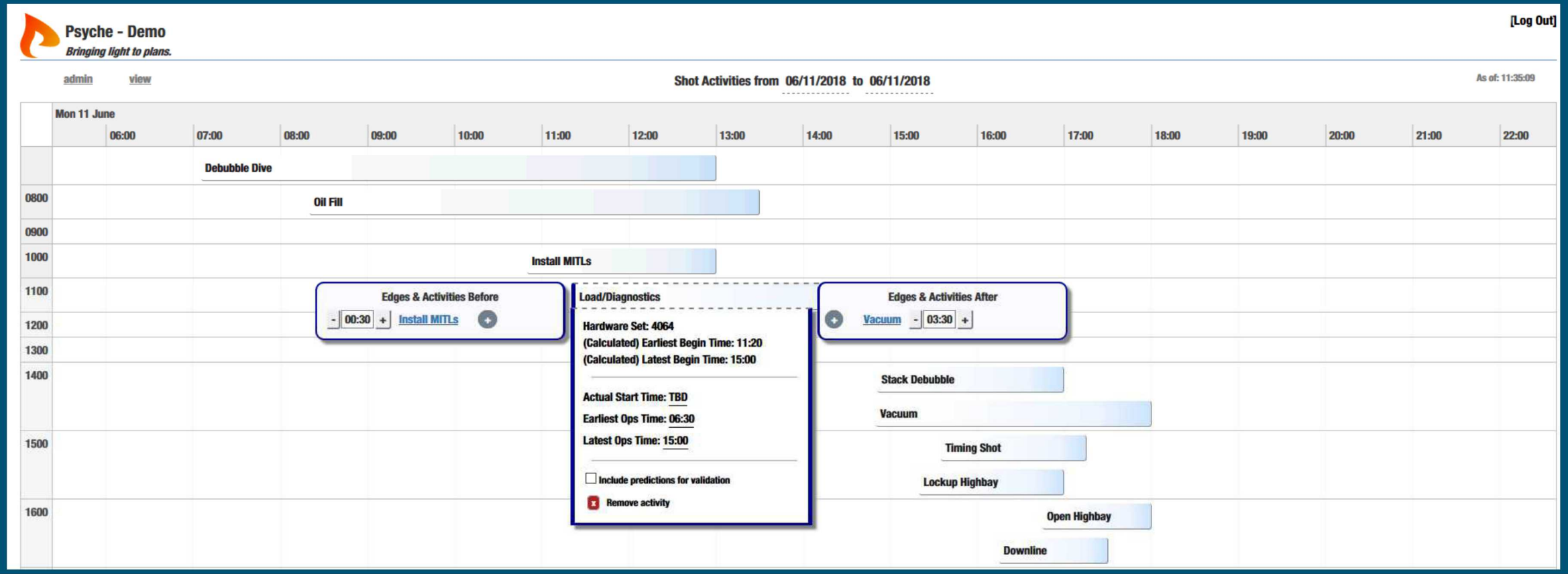
- features an interactive timeline based on visjs.org, allowing quick scaling from day to multi-day views and activities for multiple experiments (or multi-day experiments)

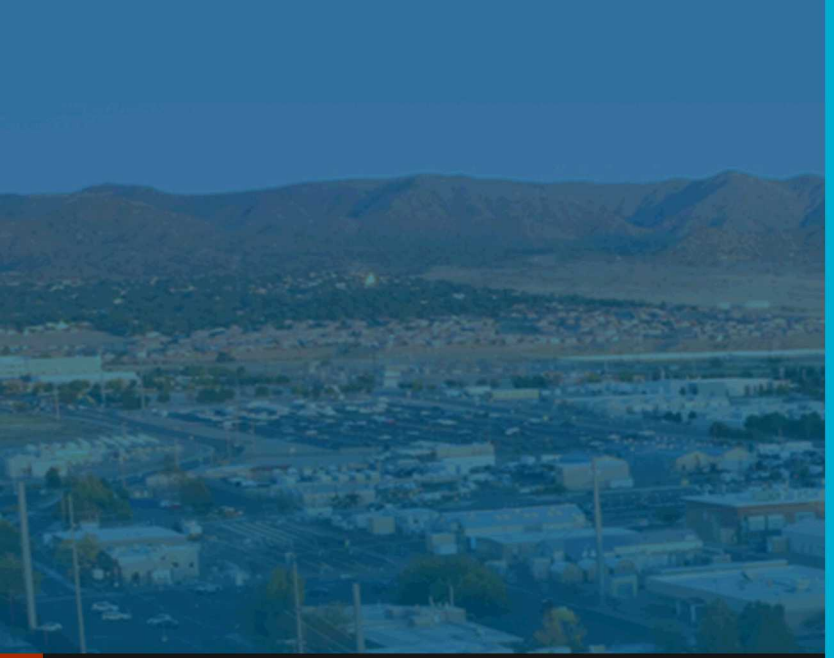


PSYCHE: The application

PSYCHE:

- features interactive viewing/editing on-demand, including user-specified values, inter-activity relationships, and up-to-the-minute calculated values of estimates





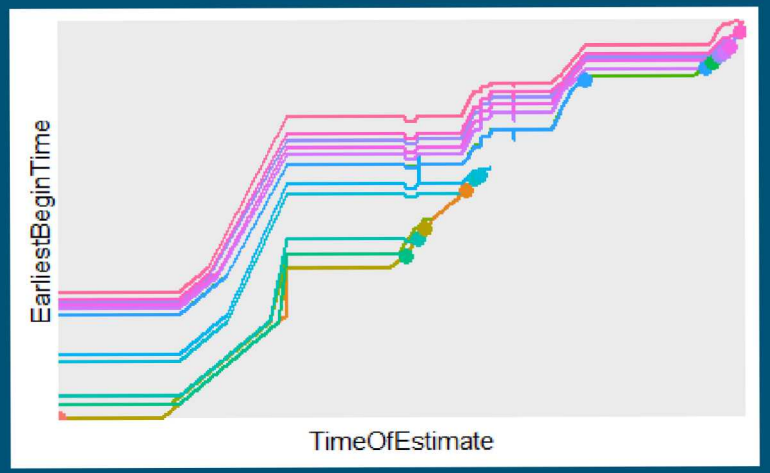
Verification and Validation

Did we build the thing right? Did we build the right thing?

Verification and Validation:

Verification of Earliest Time Estimates:

- Are PSYCHE's Earliest Time Estimates updated to only be later in time?
  - This trait of ETEs is necessary for participants to avoid being surprised
- Graph of sample day:



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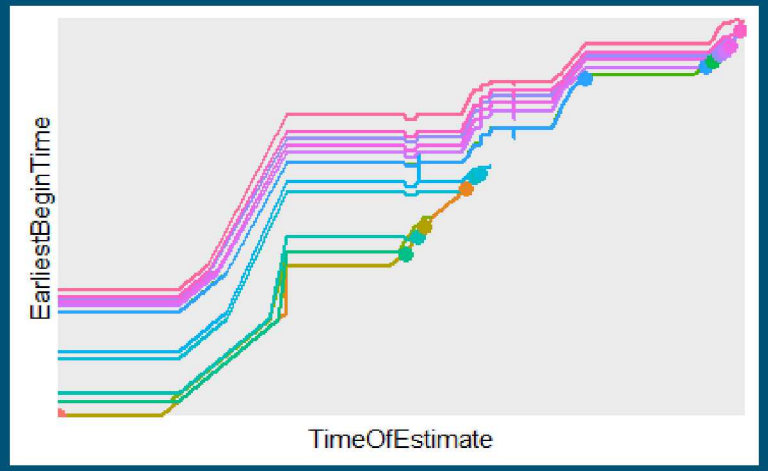
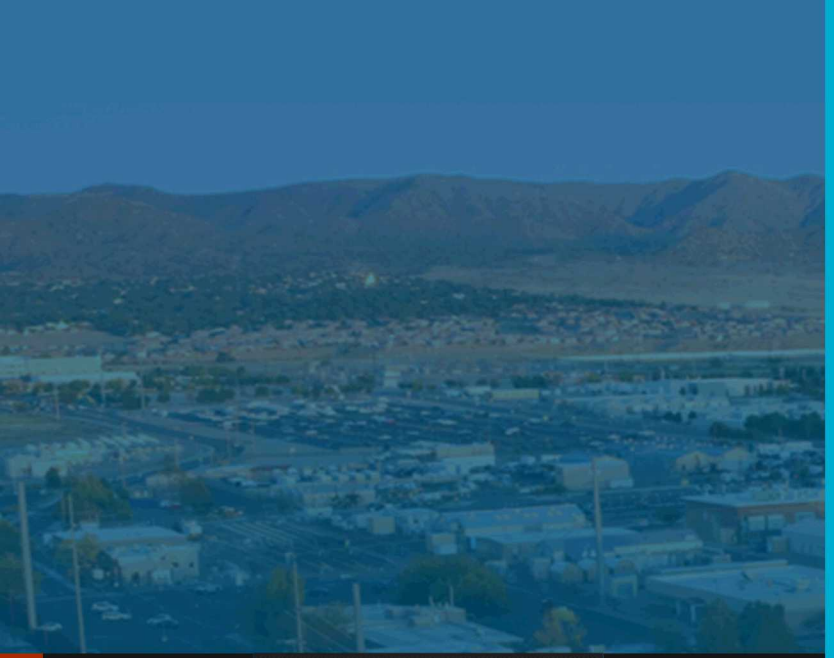


Human Validation:

- Do participants believe they are able to make more informed decisions given Earliest Time Estimates?
- Conducted in-situ with scientists, technical staff, and operations technologists



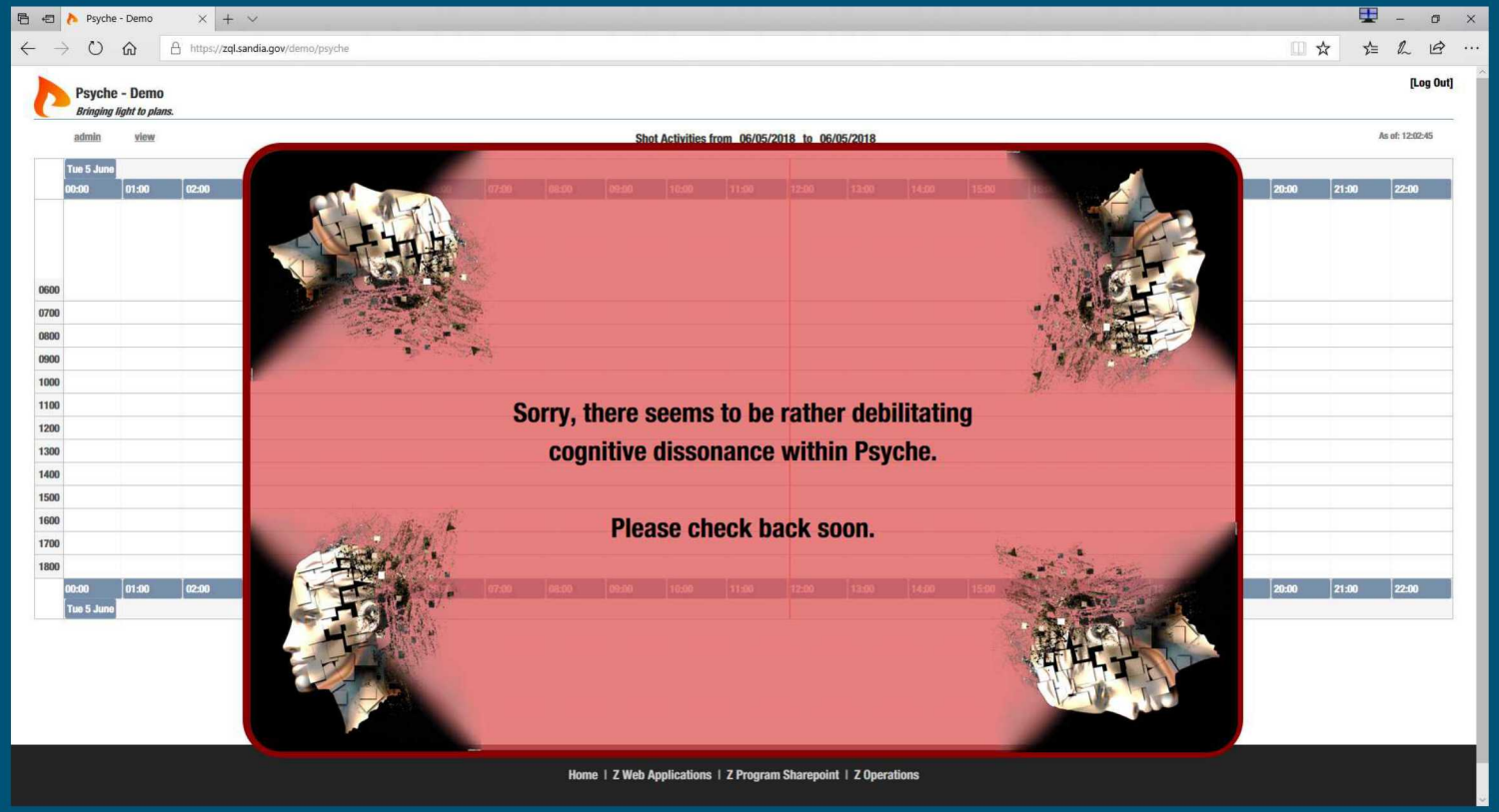
Next Steps

Where we could go from here

Next Steps

Better state estimation

- Current sensing is inadequate for higher resolution than 1-2 hour chunks
- Frequent missed signals and/or false signals



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Better state estimation

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Automated re-planning/re-scheduling

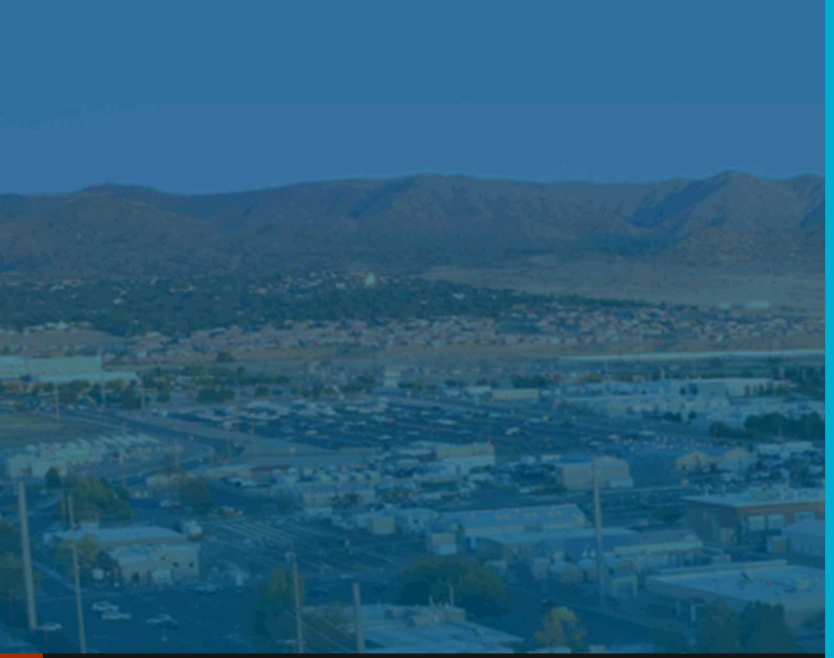
- More difficult due to frequent troubleshooting modes
- Current sensing capability is insufficient to determine what state we've entered

Probabilistic Simple Temporal Network

- Strictly for human planners in advance; not for broad communication
- Lack of data, non-conforming samples, etc, lead to statistical challenges

Estimating "confidence" of Earliest Time Estimates

- Adding entropy "ratings" to individual activities
  - Automated fluid drains, for instance, usually don't have uncertainty associated with them
  - What about activities for which we don't have a value?
- How to communicate broadly?



Questions, Feedback, Ideas, etc

For the purpose of furthering dialogue