

Clustered Monte Carlo on Cloud Systems

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Overview

- What Are Some of the Key Issues with Simulators today?
- What is a Monte Carlo Simulation?
- How Are Monte Carlo Simulations Useful to DoD?
- What Are Some of the Key Issues with Scaling Monte Carlo Simulations?
- How Have We Implemented Monte Carlo?
- How Can We Visualize the Results?
- Summary

What Are Some of the Key Issues with Simulators today?

- Most users are forced to run one-time discrete event simulators as few SE modeling tools have a Monte Carlo capability
- Many users choose not to run simulations as their set up is complex and (in discrete event) their results are inaccurate
 - Often ignoring the 10% chance they fail
- Monte Carlo simulations are computationally expensive and are user time-consuming

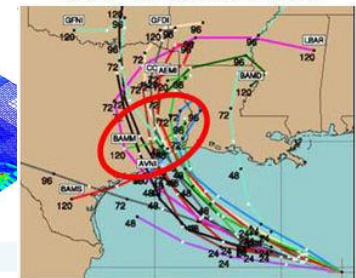
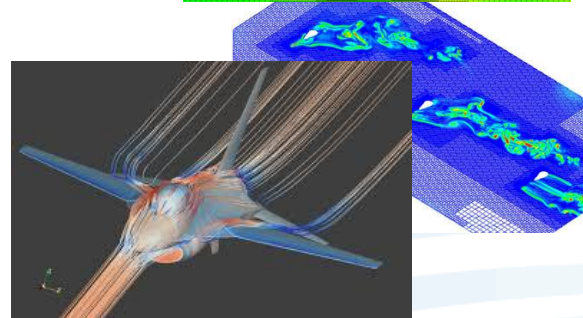
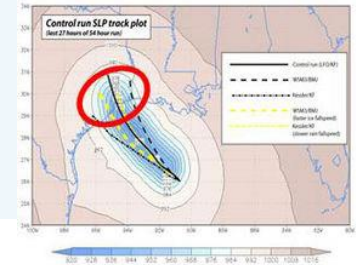
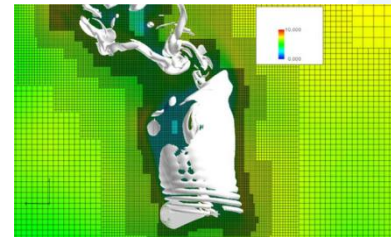
What Is A Monte Carlo Simulation?

- Modern version came from Los Alamos during the late 1940s
 - Stan Ulam, Nick Metropolis, and John Von Neumann
- Repeatedly samples random distributions to calculate non-deterministic problems
 - Critical as most measures have significant variances, which we capture as distributions
- Used in fluid dynamics calculations (e.g., aerodynamics), sensitivity analyses, and quantitative risk analysis

*This technique has proven very useful for
DoD problems*

How Is Monte Carlo Useful to DoD?

- Statistical many-on-many engagement models
- Weather prediction/forecasting
- Support to V&V of complex, expensive systems
- Weapons effects modeling
- Cost estimation
- Fault-tree analysis
- ...



New applications emerge every day



What Are Some of the Key Issues with Scaling Monte Carlo Simulations?

- Most Monte Carlo simulators are single threaded
- Almost all are designed for a single desktop or server
- All resources of a single desktop or server are cannibalized; reducing worker productivity

How Have We Implemented Monte Carlo?

- We developed a multi-thread, modularizing simulator
- The simulator scales automatically to use as many servers as needed for a particular problem
- Statistics are calculated in real time
- Uses advanced, scalable database technologies

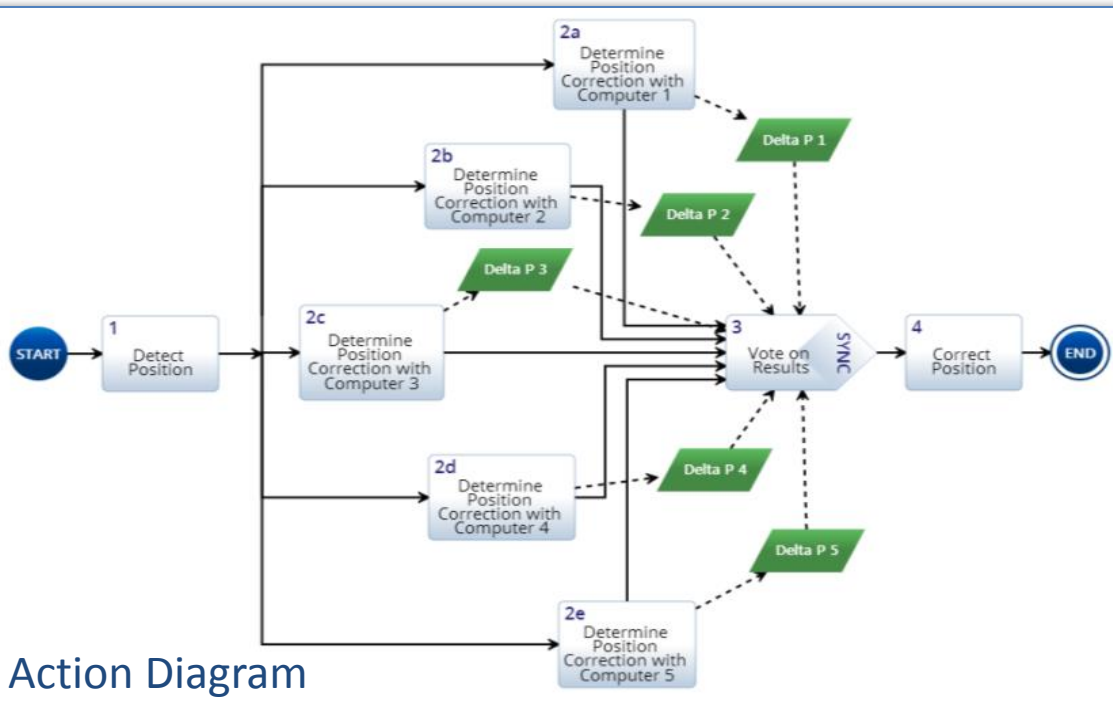
Action Modeling (Functional View)

The screenshot displays a software interface for Action Modeling (Functional View). The top navigation bar includes 'MENU', 'Database', 'Requirements', and 'Search'. A red circle highlights the 'Simulate' button, with a red arrow pointing to it and the text 'Discrete event and Monte Carlo simulations available'. The interface shows a library of actions on the left, including 'IO', 'Parallel', 'Loop', 'OR', and 'Sync'. The main workspace contains a flowchart titled 'RM.1 FireSAT Design Reference Mission (DRM)'. The flowchart starts with 'START' and proceeds through 'RM.1.1 Launch into Space', 'RM.1.2 Deploy into Parking Orbit', 'RM.1.3 Perform Spacecraft Initialization', 'RM.1.4 Maneuver to Mission Orbit', and 'RM.1.5 Perform Payload Initialization'. From 'RM.1.5', the flow goes to 'RM.1.6 Continue Operations?' (a LOOP action). From 'RM.1.6', the flow can go to 'RM.1.7 Determine Operation Type' (an OR action) or 'Cease Ops'. 'RM.1.7' branches into 'Contingency' (leading to 'RM.1.8 Perform Contingency Ops') and 'Normal' (leading to 'RM.1.9 Perform Normal Ops'). Both 'RM.1.8' and 'RM.1.9' lead to 'RM.1.10 Transmit Update'. 'RM.1.10' leads to 'RM.1.11 Perform Deorbit Manuever', which ends at 'END'. The flowchart also includes external elements like 'FireSAT Satellite', 'Expanded Booster', 'Platform Telemetry', 'Payload Telemetry', and 'Payload Data'.

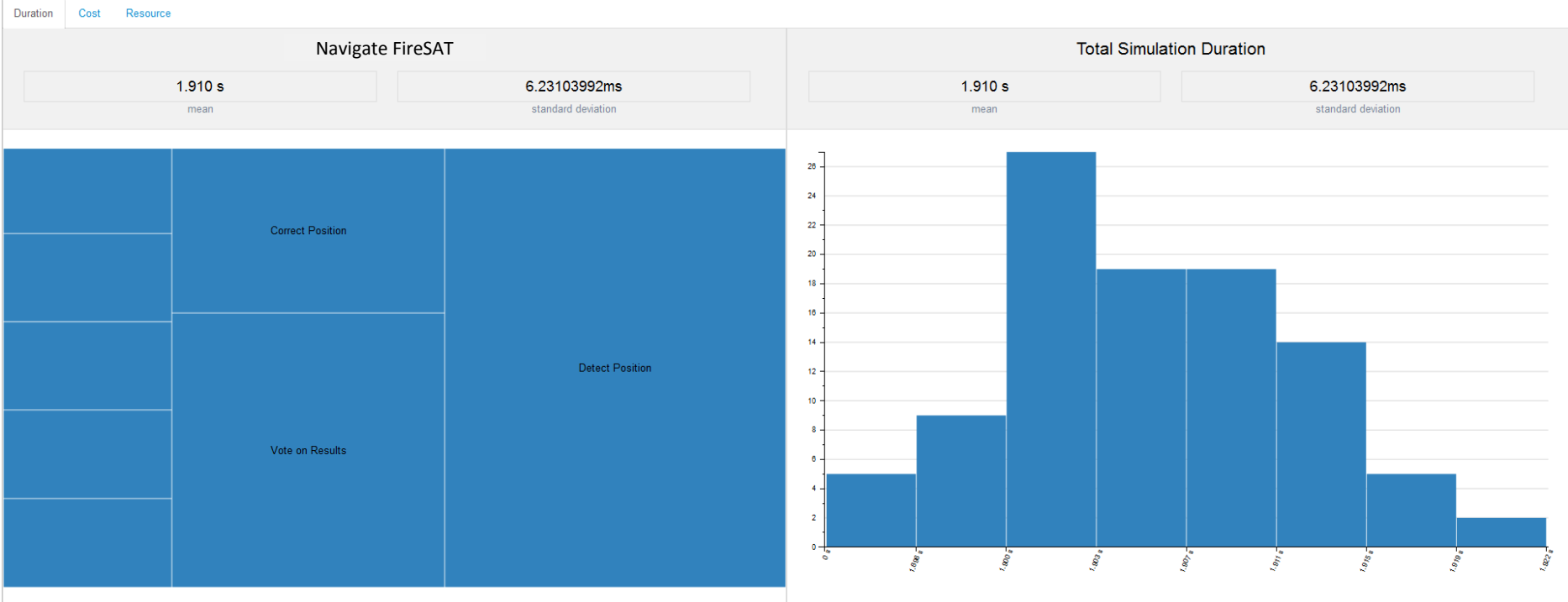
We use the Discrete Event Simulation to test out paths and algorithms - we then use the Monte Carlo to gather statistically relevant information

Voting Computers

- Functional model equivalent using Action Diagram
- Timing provided for each computer can be a random distribution, as can failure modes

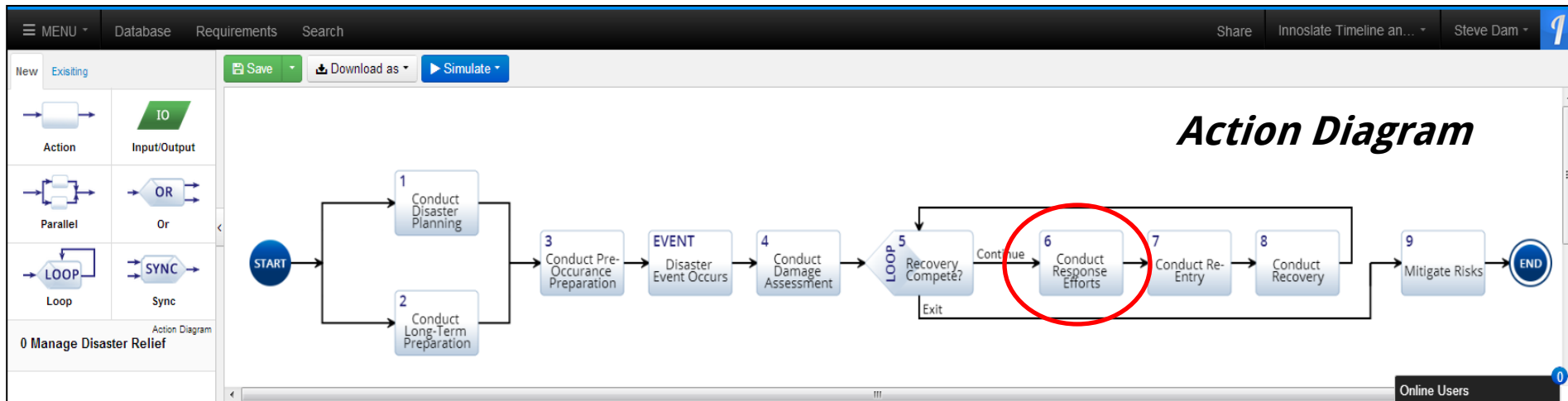


Monte Carlo Simulation of Action Diagram



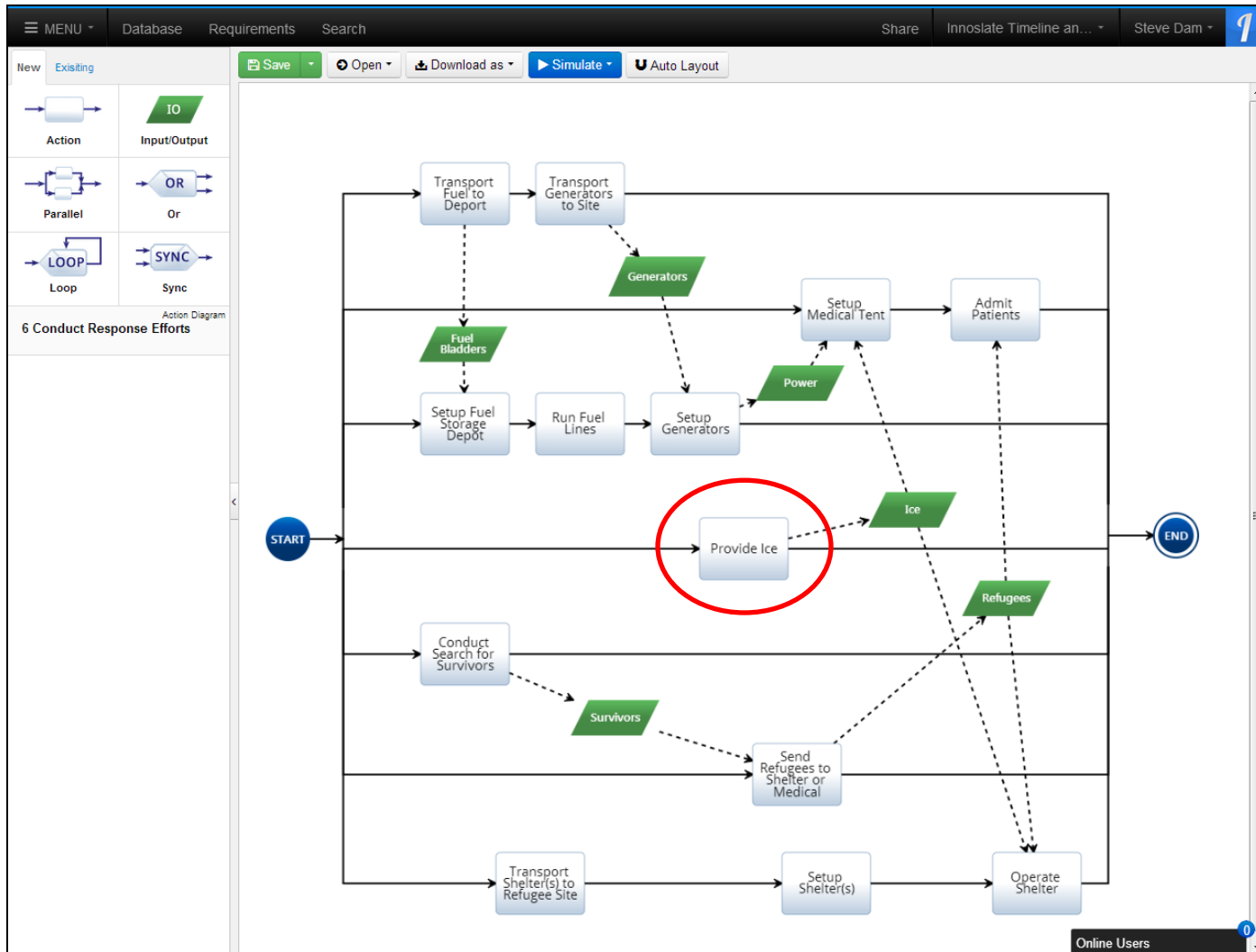
- Executing the model with random time distributions provides way to derive key metric requirements

Another Example: Disaster Response

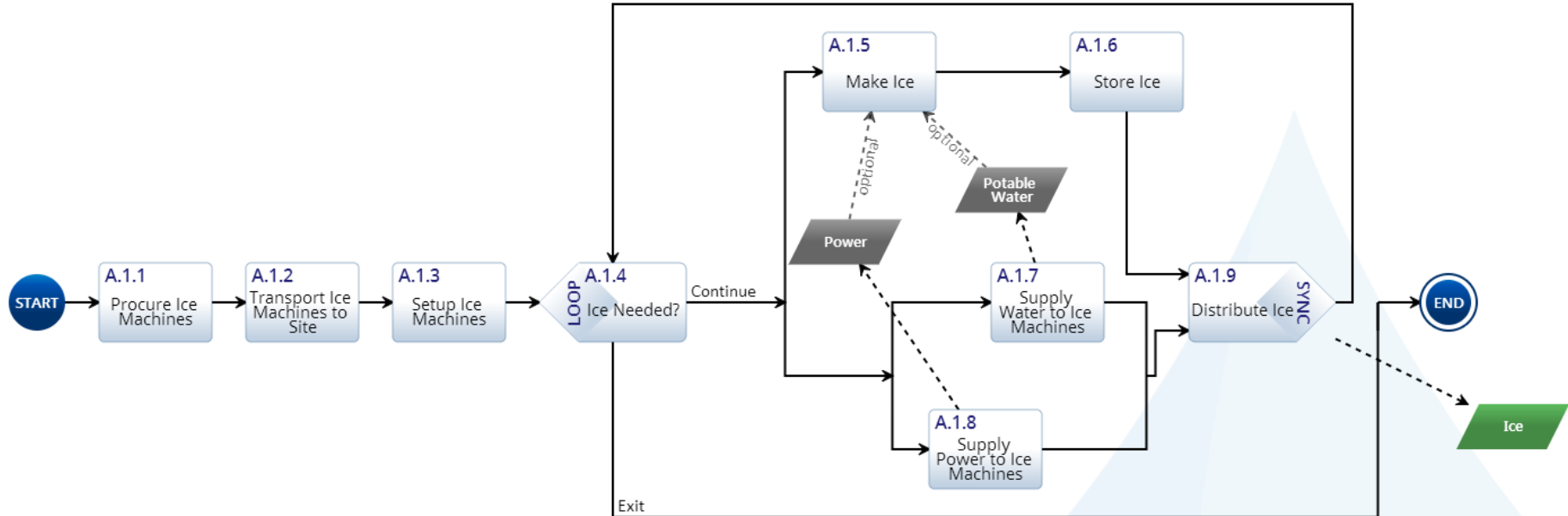


- Usually, a significant amount of disaster management planning has been done
 - Supplies are pre-positioned by State and National organizations (e.g., FEMA)
 - Detailed roles and responsibilities, MOU, contracts, etc. have been negotiated
- Focus on “Conduct Response Efforts”

Decomposed "Conduct Response Efforts"



Alternative 1: Make Ice Locally



- Adds complexity as significant amount of fault tolerance occurs on-site
- Less expensive option

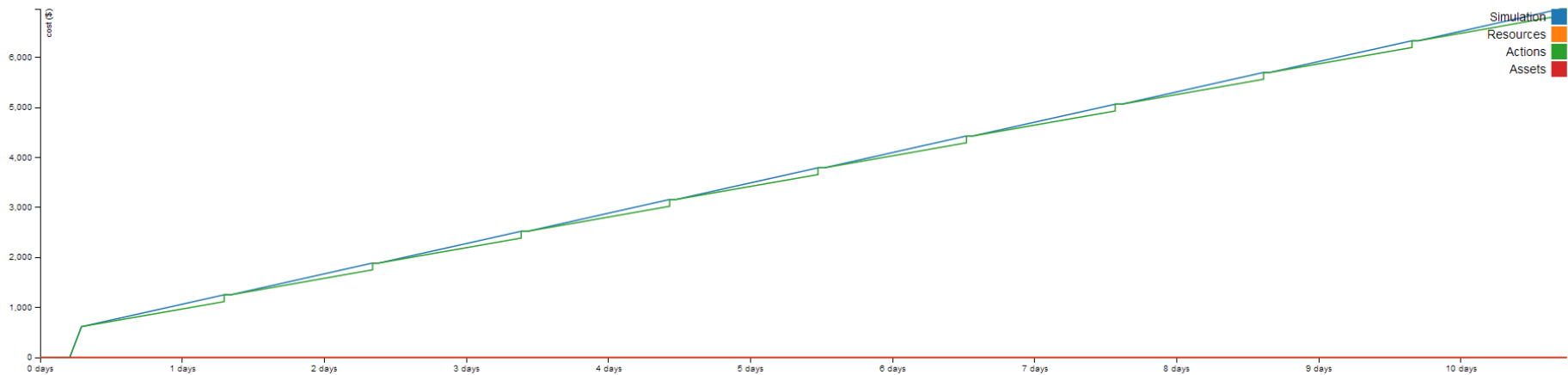
Discrete Event Simulation Results

Simulation of A.1 Alternative 1: Make Ice Locally Action Diagram

Simulation Complete! Your simulation is now complete and the results are displayed.

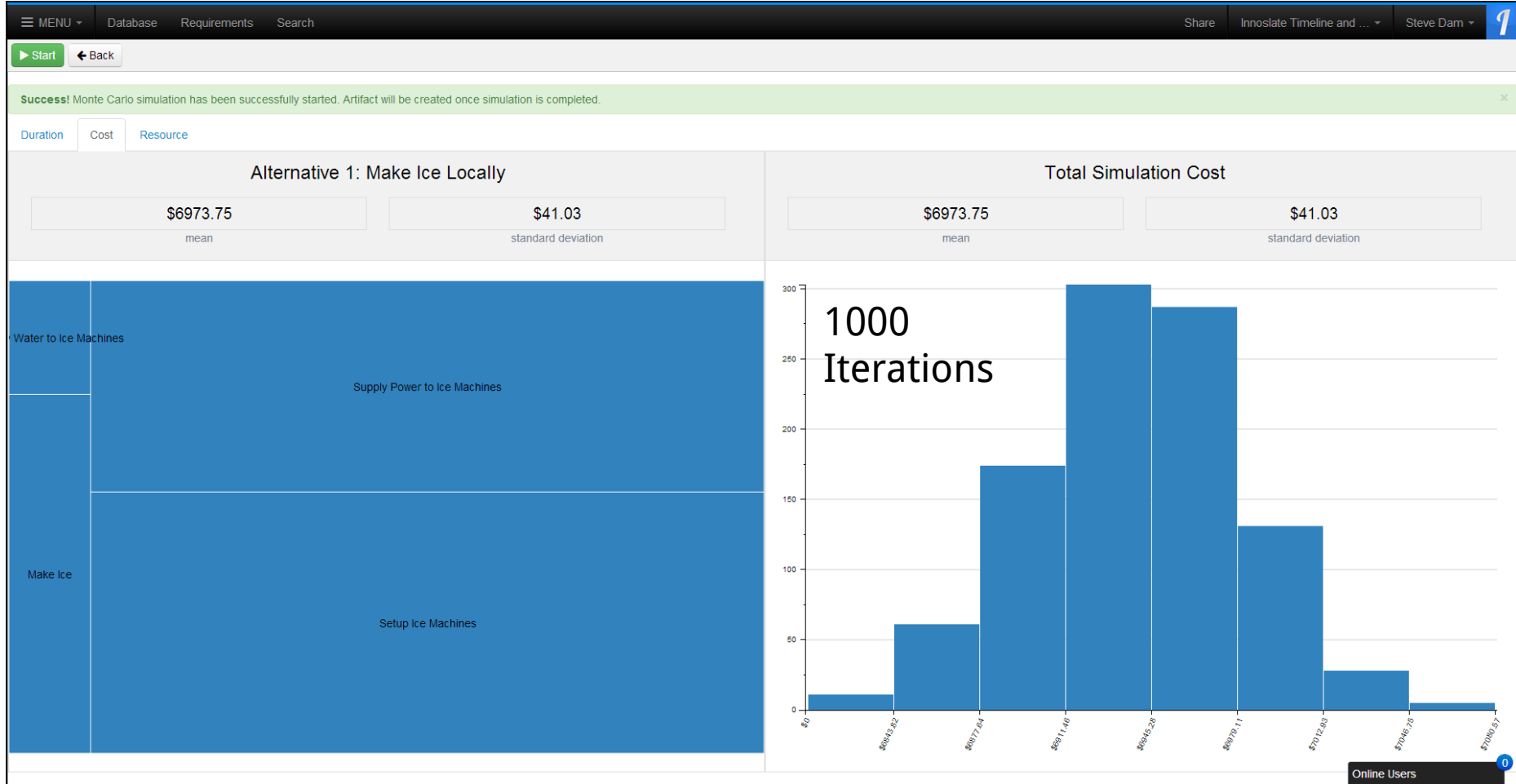
Gantt Chart Table Charts

Cost Over Time



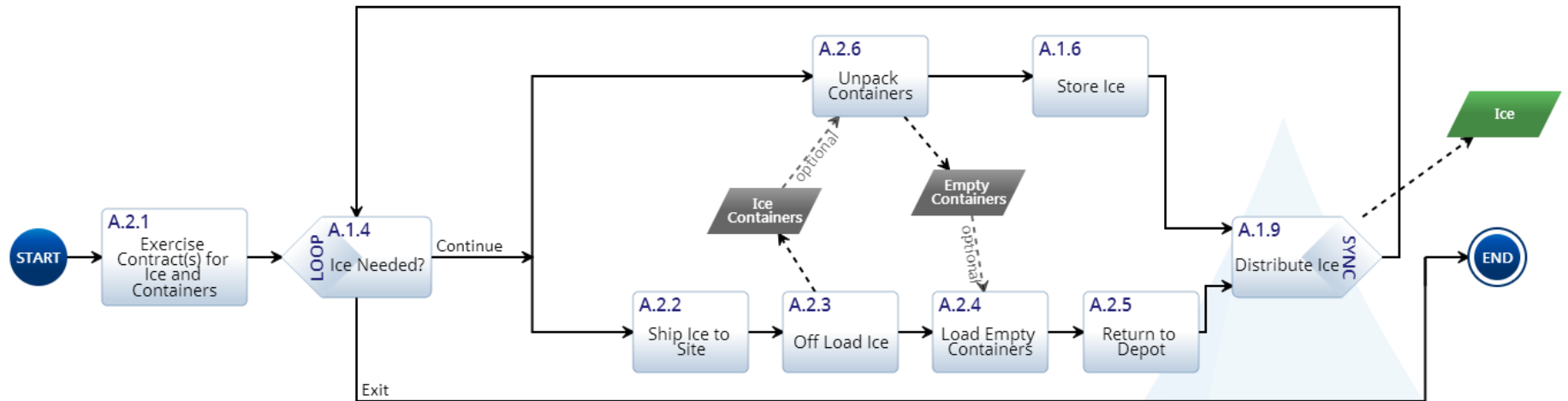
- Includes cost of setup, water and power needed to produce ice
- Total accumulated cost over 11 day <\$7,000

Monte Carlo Simulation Results



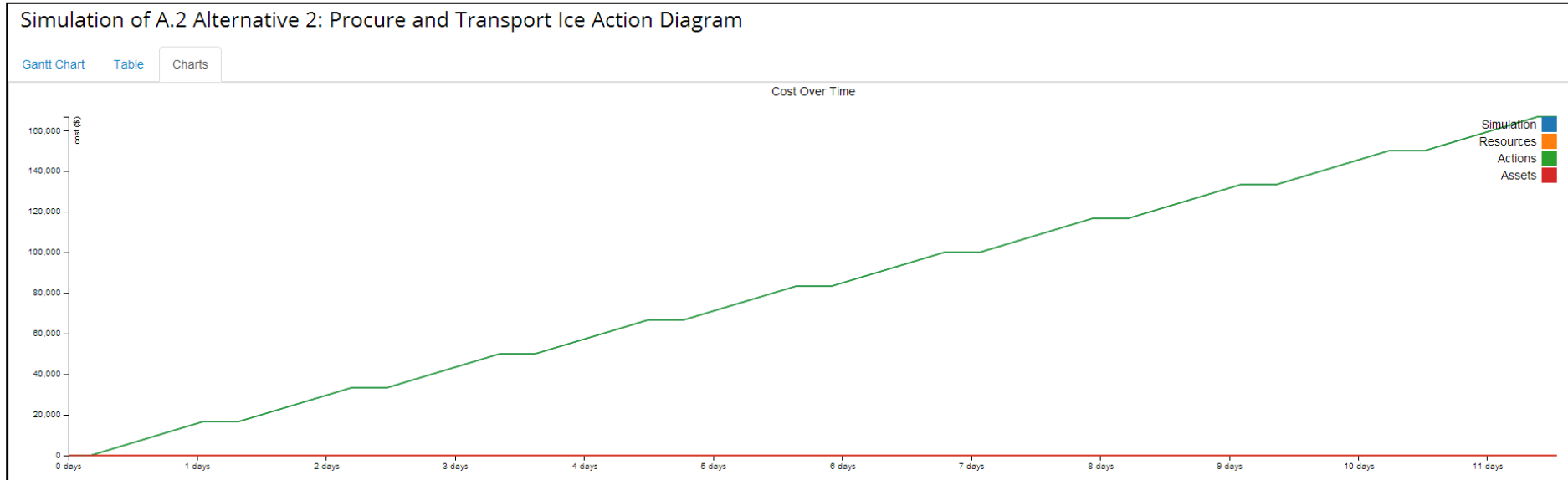
Note: Monte Carlo is only available on Pro Version

Alternative 2: Bring In Ice



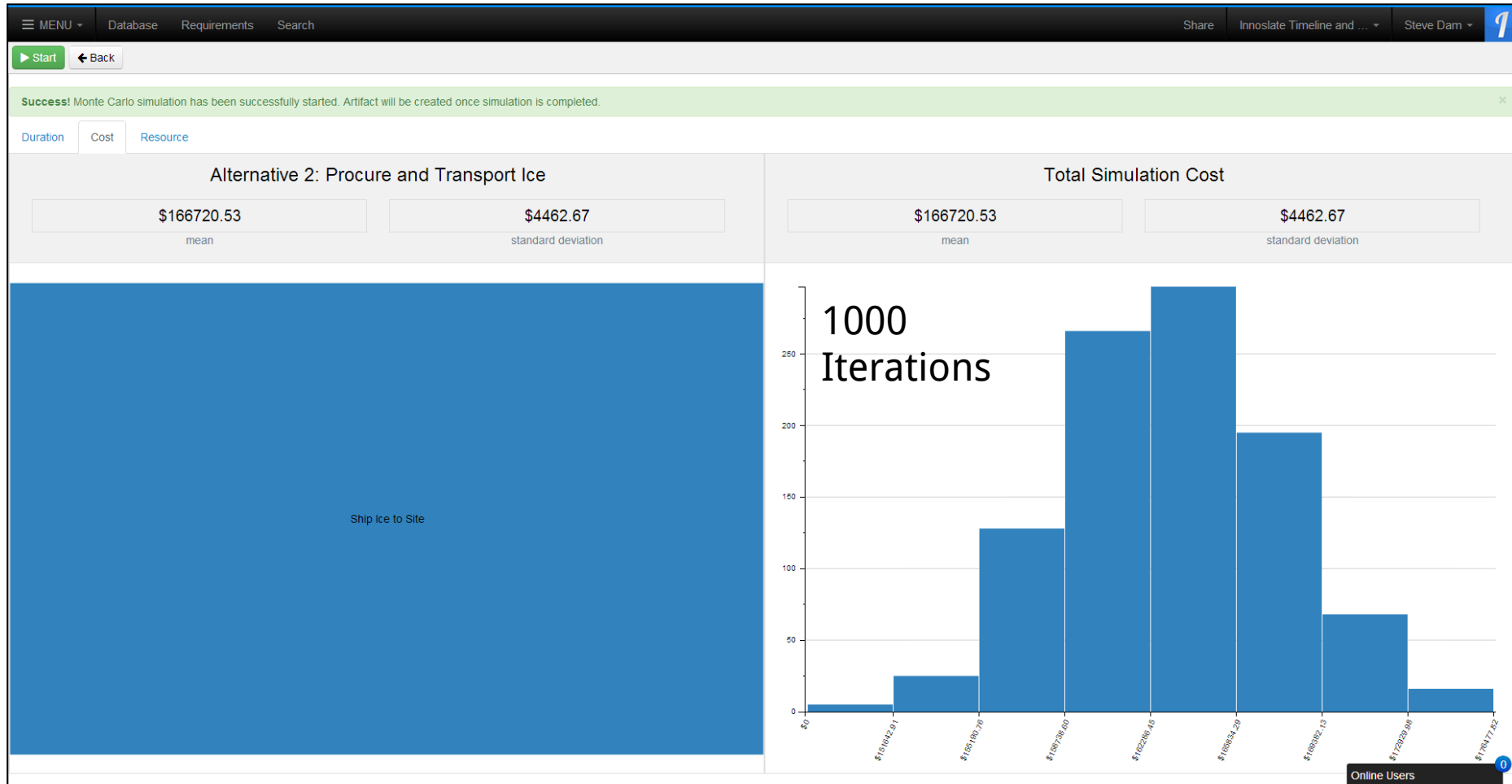
- Less complex process
- More expensive

Discrete Event Simulation Results



- Cost accumulated by process steps over 11 day period
- Total accumulated cost >\$160k

Monte Carlo Simulation Results



Note: Monte Carlo is only available on Pro Version

Summary

Summary

- The cloud allows for Monte Carlo simulations that:
 - Scale automatically
 - Complete quickly
 - Increase worker productivity (the worker no longer has to wait for a simulation to finish to continue working)
 - Increased accuracy of model