Improved Time Behavior and Inventory Management to Support Nuclear Material Accounting in Cyclus

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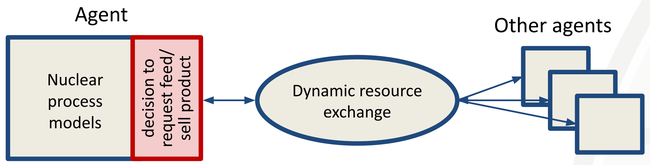
Introduction & Motivation

- Use of fuel cycle simulators in nonproliferation has been limited by ability to model nuclear materials moving between facilities
  - Including previous MTV work to simulate synthetic nuclear material accounting reports
  - Capability gap in the models that decide when to request new feed material and offer product



Mission Relevance & Expected Impact

Fuel cycle simulators could be used as synthetic testbeds to look for new signatures of diversion or ways to quantitatively analyze a fuel cycle.

- This project addresses key capability gaps preventing these tools from being deployed effectively as a way to generate synthetic nuclear material accounting reports

MTV Impact

- Project conducted at/with Los Alamos National Lab
- Worked with Safeguards Science & Technology group since Jan 2021

Los Alamos NATIONAL LABORATORY

LA-UR-24-22604

Technical Approach

- Implement new strategies governing when additional feed material should be requested
- Strategies are flexible, but inspired by real material movement patterns
- Using the Cyclus toolkit so any facility model can take advantage of the new strategies, including closed-source facility models

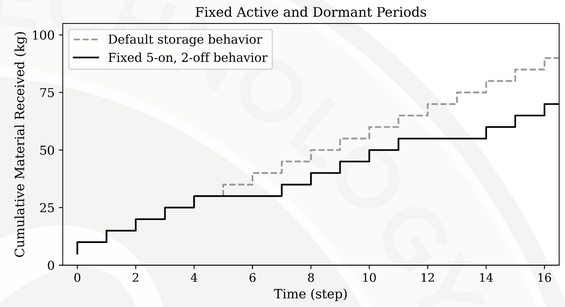


Fig 1. Behavior of a simple 5 workdays on, 2 weekend days off active/dormant cycle

Results

- New system-wide random number generator
  - Supports facility models implementing stochastic behavior, both for nuclear process modeling and for resource exchange

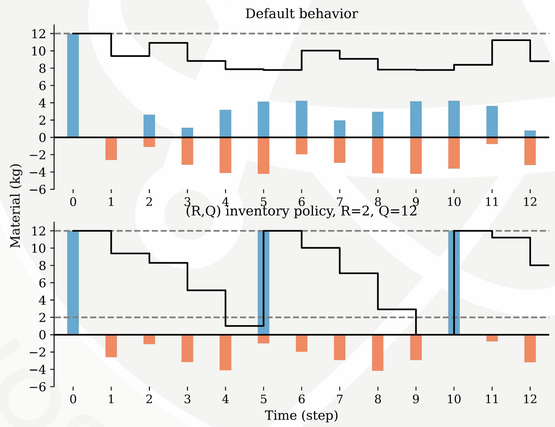


Fig 2. (R,Q) inventory policy only orders new material when inventory on-hand is less than a specified amount R, and new material is ordered in quantity Q

New periodic and continuous review inventory policies

- Active and dormant cycles
  - fixed time length, Fig 1
  - sampled from random distributions, Fig 3
  - Can mix and match
- Random request size sampled from distribution, Fig 3
- (R,Q) and (s,S) inventory policies, Fig 2
- Active period based on receiving a cumulative amount of material regardless of time, with dormant cooling-off period, Fig 4

Each facility samples distributions independently, so multiple facilities created from the same template will use different random numbers, Fig 5

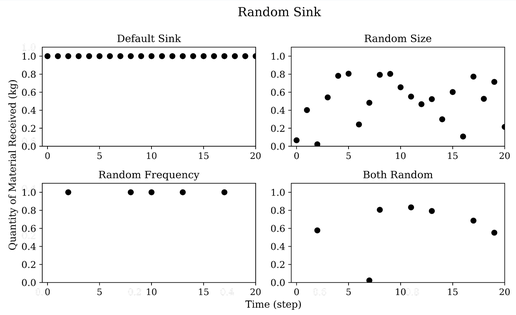


Fig 3. Random request size can be coupled with random frequencies for more complex material movement patterns

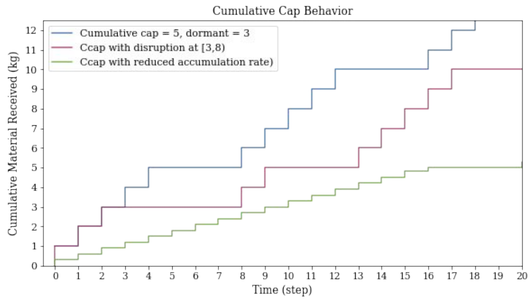


Fig 4. Cumulative cap acts like active/dormant cycling by time step, but won't go dormant until a set amount of material is received

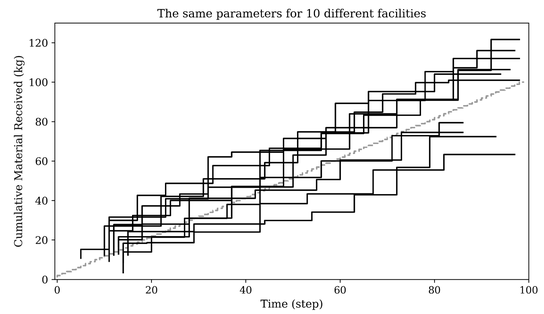


Fig 5. Deploying facilities with the same parameters no longer results in 10 facilities acting in lockstep

Conclusion

- New capabilities can be used in nearly every step of the fuel cycle to add fidelity to nuclear material movement patterns
- Easier to add stochastic behaviors across the fuel cycle

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Next Steps

- New tools to replicate packaging and transport units
- Graduate!

National Nuclear Security Administration

This work was funded in-part by the Consortium for Monitoring, Technology, and Verification under DOE-NNSA award number DE-NA0003920. This work was also performed under appointment to the Nuclear Nonproliferation International Safeguards Fellowship Program sponsored by the U.S. Department of Energy, National Nuclear Security Administration's Office of International Nuclear Safeguards (NA-241).