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Update on Parallel Process Execution in the Next Generation System Analysis Model (NGSAM)

November 2024

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Idaho National Laboratory

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To the extent discussions or recommendations in this presentation conflict with the provisions of the Standard Contract, the Standard Contract governs the obligations of the parties, and this presentation in no manner supersedes, overrides, or amends the Standard Contract.

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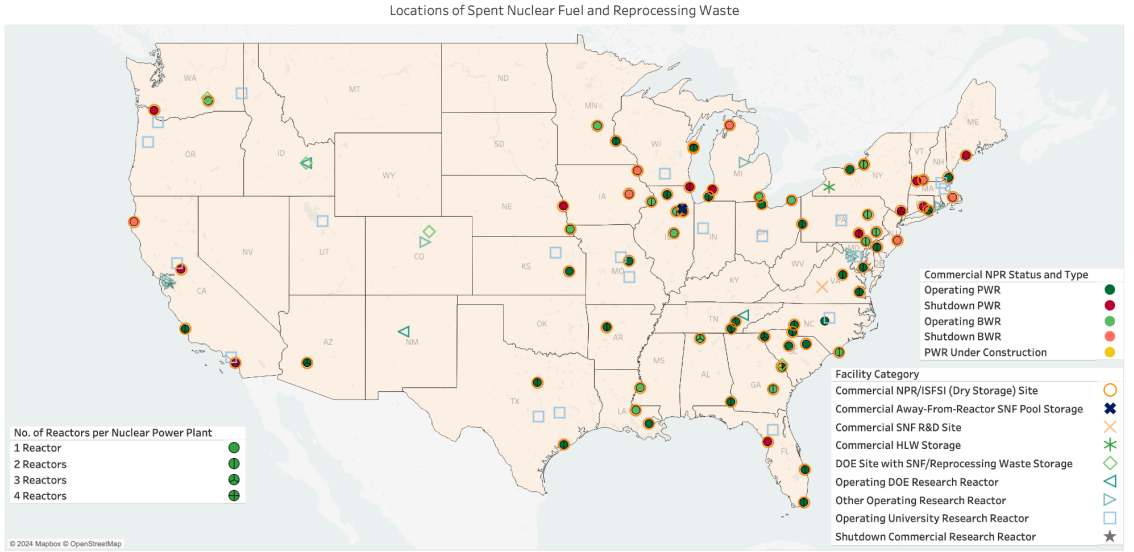
Overview – Office of Spent Fuel & High-Level Waste Disposition (SFWD)

- DOE plans to use a consent-based process to site one or more federal consolidated interim storage facilities (CISFs) for spent nuclear fuel (SNF) from commercial nuclear power reactors.
- DOE recently approved Critical Decision-0 (CD-0) for the Federal CISF Project, including associated transportation infrastructure. CD-0 is the first step of a process that DOE uses to manage capital asset projects and determines a mission need for the agency.
- This work focuses on potentially performing activities in parallel during a spent fuel transportation campaign to gain efficiencies and accelerate de-inventory of sites.



Nearly all existing commercial SNF is stored at the reactor sites where it was generated.

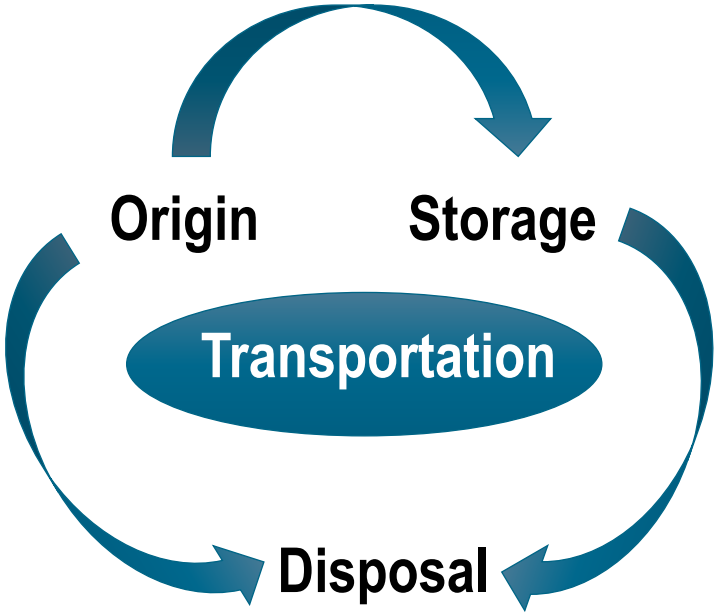
Of the over 70 commercial nuclear power reactor sites with SNF, about one quarter have ceased reactor operations.

Outline

- Next Generation System Analysis Model (NGSAM)
- Sequential vs. Parallel Processing
- Turnaround Time (TAT) Analysis and Implications
- Conclusions and Future Work

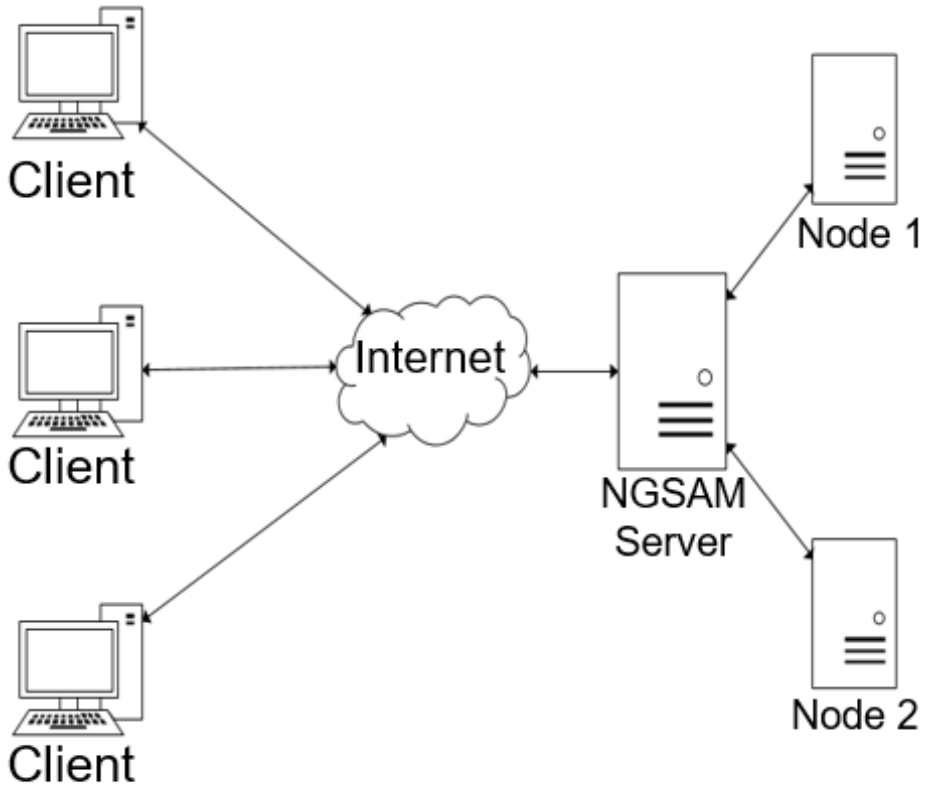
NGSAM

- NGSAM Background Information
  - Agent-based simulation toolkit
  - Used to answer, “What if ?” questions/scenarios
  - Collaborative effort (ANL, INL, ORNL, PNNL, SNL)
- System analyst goals include
  - Producing information regarding various alternatives
  - Understanding system performance, inter-dependencies, and sensitivities
  - Generating cost estimates for scenarios



NGSAM (cont.)

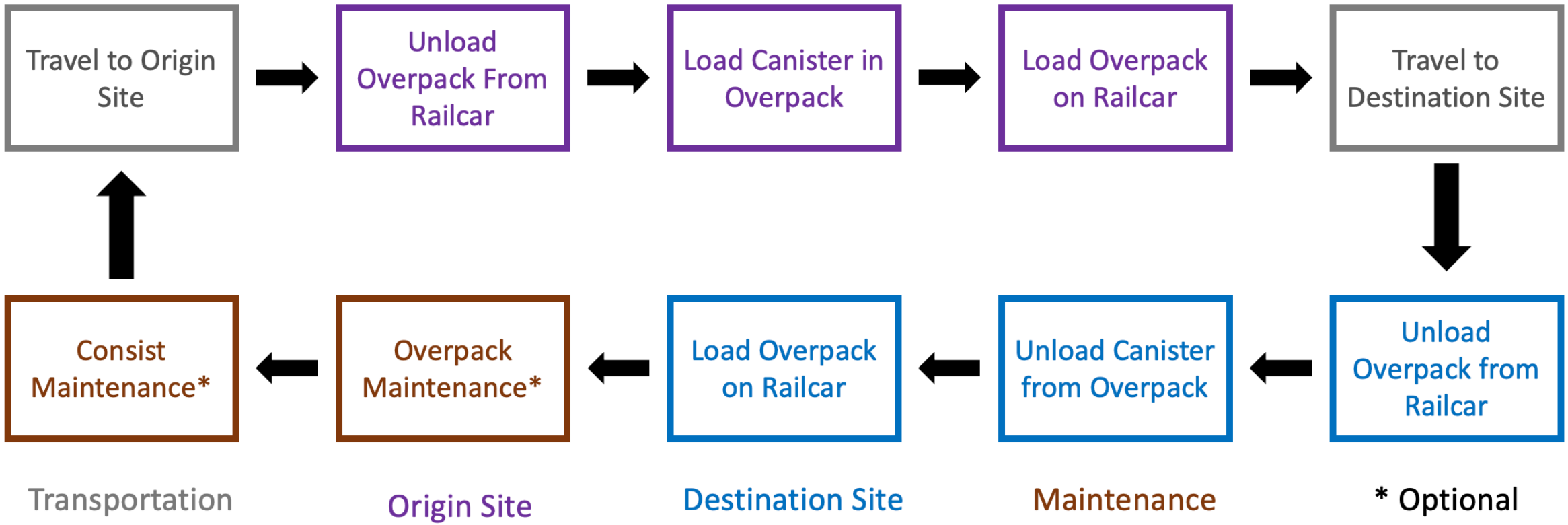
- Data for NGSAM analysis
  - Unified Database (UDB)
  - Transportation routing information from the **S**takeholder **T**ool for **A**ssessing **R**adioactive **T**ransportation (START)
  - Scenario-specific data (allocation priority, emplace capacity, etc.)
- Backend of NGSAM
  - Java Transportation Operations Model
  - Transportation scheduler (movement of SNF from sites)



NGSAM (cont.)

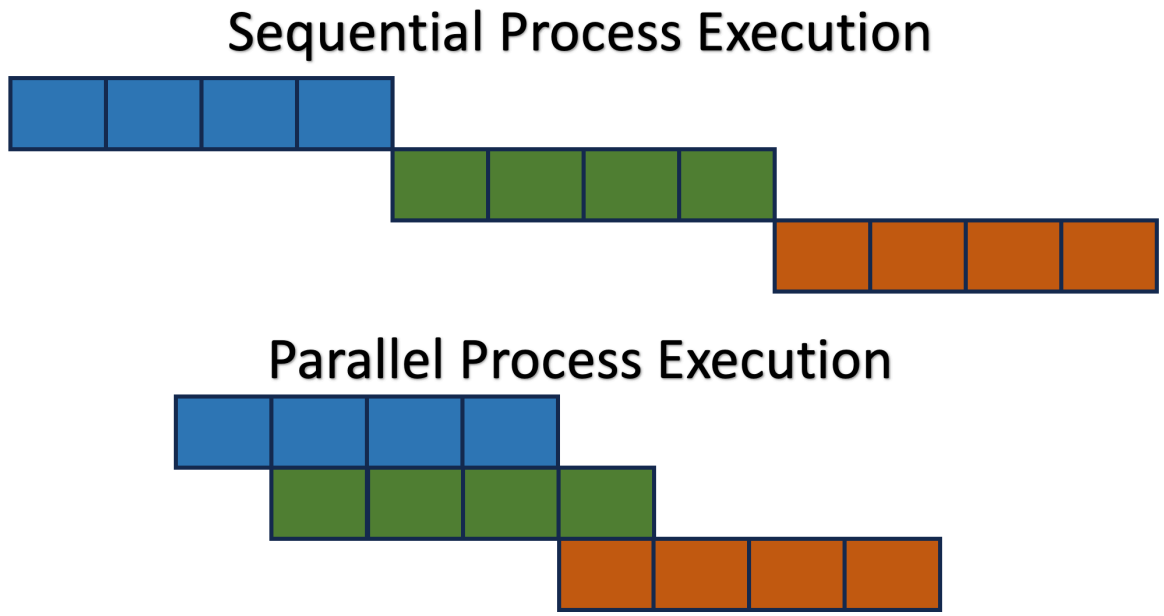
- Rail – preferred mode of transportation
  - Rail connects more geographical regions vs. navigable waters
  - Heavy haul trucks (HHTs): package weight beyond legal weight limit
- Operable rail infrastructure not available at all sites
- Intermodal transportation
  - Barges
  - HHTs
  - Combination of barges and HHTs
- Trips start and end at the fleet maintenance facility (FMF), generally co-located with the destination site

NGSAM (cont.)


Travel to Origin Site
Unload Overpack From Railcar
Load Canister in Overpack
Load Overpack on Railcar
Travel to Destination Site
Unload Overpack from Railcar
Unload Canister from Overpack
Load Overpack on Railcar
Overpack Maintenance*
Consist Maintenance*
Transportation
Origin Site
Destination Site
Maintenance
* Optional

Sequential vs. Parallel Processing

- Sequential processing used in site-specific de-inventory reports
  - Tasks completed one after the other
  - Provides a conservative estimate
- Sequential processing was traditionally used in NGSAM
- Parallel processing follows principles of the lean methodology → increase efficiency



Sequential vs. Parallel Processing (cont.)

- Advantages of parallel operations
  - Increase SNF shipping capacity with fixed transportation infrastructure
  - Speed up site clearance
- Assumptions used in this work
  - 7-car rail consist is used
  - Required infrastructure, physical area, and resources are readily available at the origin, destination, and transload sites
  - The FMF is co-located with the destination site
  - The origin, transload, and destination sites operate 8, 8, and 16 hours a day, respectively

TAT Analysis and Implications

- Turnaround time (TAT) is defined as time between two consecutive rail shipments from the FMF
- Performing tasks in parallel is anticipated to decrease TAT
- Only process time is considered (no parallelization during travel)
- Four scenarios considered in this work
  - Rail-only shipment
  - Rail shipment with barge transload
  - Rail shipment with HHT transload
  - System-wide U.S. fleet analysis

TAT Analysis and Implications (cont.)

- Process times
  - Loading/unloading transportation overpack/cask from railcar, barge or HHT: **4 h**
  - Loading/extracting a canister into/from a transportation overpack: **16 h**
- Process time was rounded up from a conservative standpoint

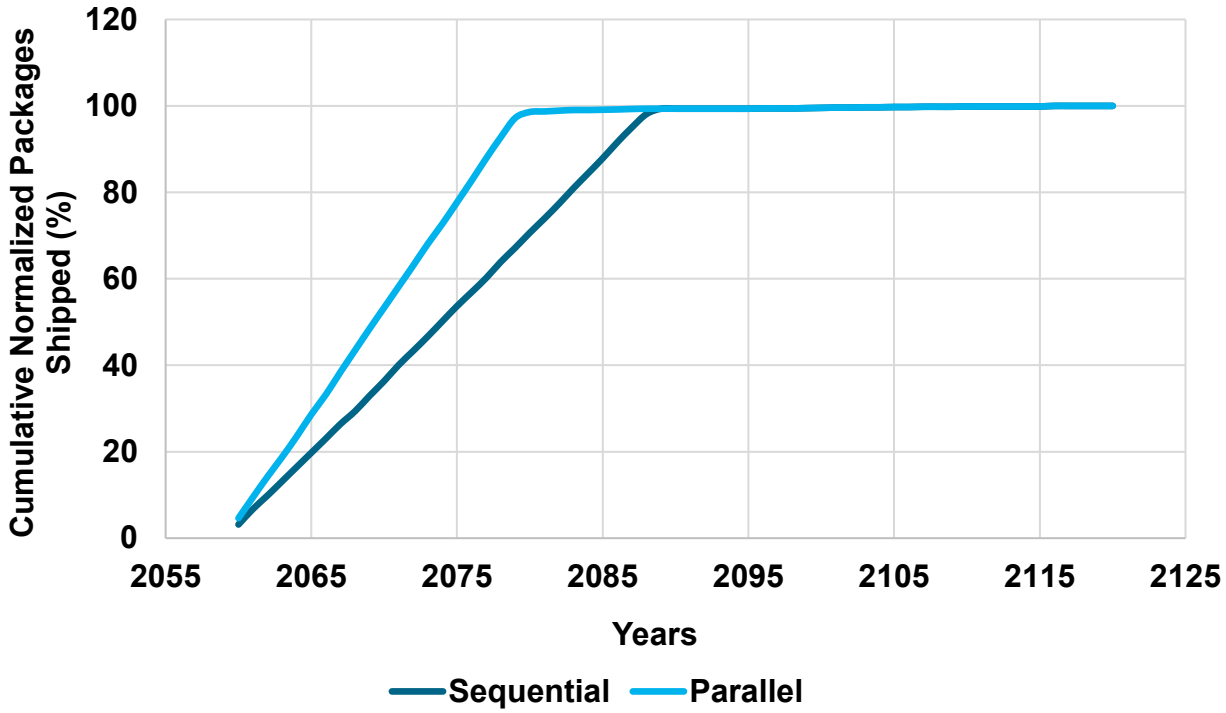
Transportation Scenario	TAT – Sequential Process Execution (days)	TAT – Parallel Process Execution (days)	Reduction in Processing Time (%)
Rail Only	34	23	32.4
Rail with HHTs	42	31	26.2
Rail with barges	42	31	26.2

TAT Analysis and Implications (cont.)

- U.S.-Fleet-wide analysis performed to understand system-level implications of parallel process execution
- Transportation infrastructure
  - 49 total railcars (seven 7-car consists)
  - Shipping start starts in 2060
  - Oldest fuel first pickup logic
  - Convoy-styled shipment
- U.S. Fleet scenario was run to compare differences in cumulative normalized packages shipped per year

TAT Analysis and Implications (cont.)

- Parallel processing enables higher shipment rates (reduced TAT)
- A maximum cumulative difference of ~30% was observed



Conclusions and Future Work

- The functionality, use cases of NGSAM as well as the concept and potential advantages of parallel processing were explored
- TAT analysis was performed for several modes of transportation
- Over 25% reduction in TAT was observed using parallel processing
- Future work
  - perform a study considering site-specific infrastructure and advances in CISF design
  - suggest any changes to the time and motion studies to accommodate parallel processing

References and Resources

1. Pacific Northwest National Laboratory (PNNL), CURIE Resource Portal for DOE Nuclear Waste Management Information, Map accessed May 28, 2024, https://curie.pnnl.gov/map
2. R. JOSEPH et al., “Transportation and Systems Analysis Collaborations in Support of a Federal Consolidated Interim Storage Facility,” (2024); https://doi.org/10.48550/ARXIV.2403.18861
3. Gadey, Harish R., Kacey D. McGee, and Patrick D. Royer. "Progress in the Verification and Validation Efforts for Start: A Spent Fuel Routing Tool." (2023): arXiv:2311.11179. https://doi.org/10.48550/arXiv.2311.11179
4. R. F. AZIZ and S. M. HAFEZ, “Applying lean thinking in construction and performance improvement,” Alexandria Engineering Journal 52 4, 679 (2013); https://doi.org/10.1016/j.aej.2013.04.008
5. H. GADEY, L. V. WAL, and R. JOSEPH, “Implementation of Parallel Process Execution in the Next Generation System Analysis Model,” (2024); https://doi.org/10.48550/ARXIV.2403.09848
6. Condon, Caitlin, Mark Abkowitz, Harish Gadey, Robert Claypool, Steven Maheras, Matthew Feldman, and Erica Bickford. "Verification and Validation of Start: A Spent Nuclear Fuel Routing and Decision Support Tool." (2023): arXiv:2306.12319. https://doi.org/10.48550/arXiv.2306.12319
7. R. JOSEPH et al. The Next Generation System Analysis Model: Capabilities for Simulating a Waste Management System - 19131. United States: N. p., 2019. Web.
8. Condon, Caitlin, Philip Jensen, Patrick Royer, Harish Gadey, Mark Abkowitz, Robert Claypool, Steven Maheras, and Matt Feldman. "Verification and Validation of the Stakeholder Tool for Assessing Radioactive Transportation (Start)." (2023): arXiv:2306.09901. https://doi.org/10.48550/arXiv.2306.09901
9. AREVA FEDERAL SERVICES LLC, “Initial Site-Specific De-Inventory Report for Trojan,” (2016); https://www.osti.gov/servlets/purl/1582066
10. Condon, Caitlin, Kacey McGee, Harish Gadey, and Patrick Royer. "Stakeholder Tool for Assessing Radioactive Transportation (Start) Verification and Validation Efforts." (2023): arXiv:2306.11938. https://doi.org/10.48550/arXiv.2306.11938
11. Gadey, Harish, Caitlin Condon, Steven Maheras, and Kacey McGee. "Update on the Verification and Validation Efforts for the Stakeholder Tool for Assessing Radioactive Transportation." (2023): arXiv:2306.09465. https://doi.org/10.48550/arXiv.2306.09465
12. H. R. Gadey et al., “System Analysis Modeling and Intermodal Transportation for Commercial Spent,” (2023); https://doi.org/10.48550/ARXIV.2306.02446

THANK YOU