



Simulation as a Risk Mitigation Tool at Amazon Transportation Yards

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Presentation Agenda

1. Amazon Fulfillment Network Summary
 - i. Amazon network breakdown by linehaul workstream and businesses
 - ii. Amazon supply chain network breakdown by scheduling
 - iii. Transportation yard significance by package flow to customers
2. Simulating Transportation Yard Operations
 - i. Process-based simulation using Process Modeling library
 - ii. Geospatial simulation using transporters, and storages to measure yard congestion
3. Output Validation and Solution Proposals
 - i. Validation measures and what-if scenarios to determine the yard capacity threshold
4. Conclusion and Future Work

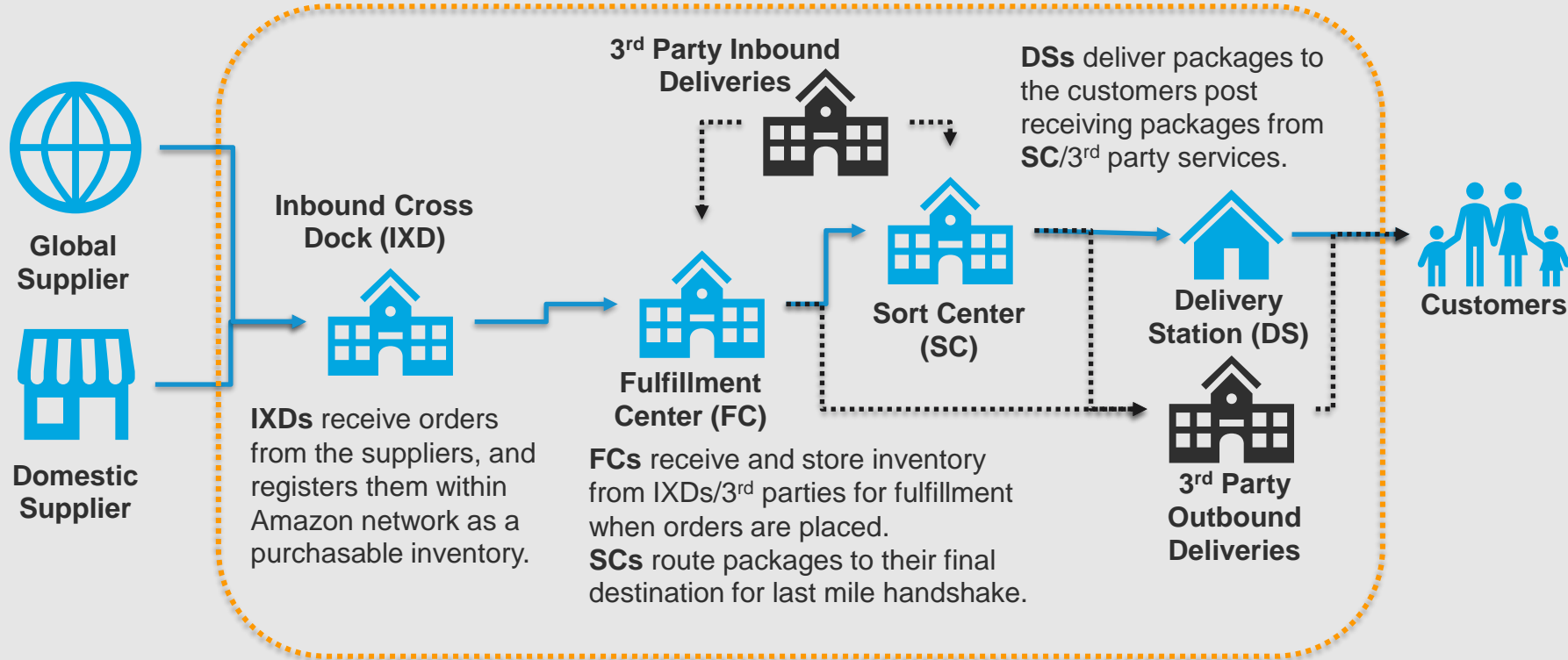
1. Amazon Fulfillment Network Summary

Amazon network breakdown by linehaul workstream and businesses.

First Mile

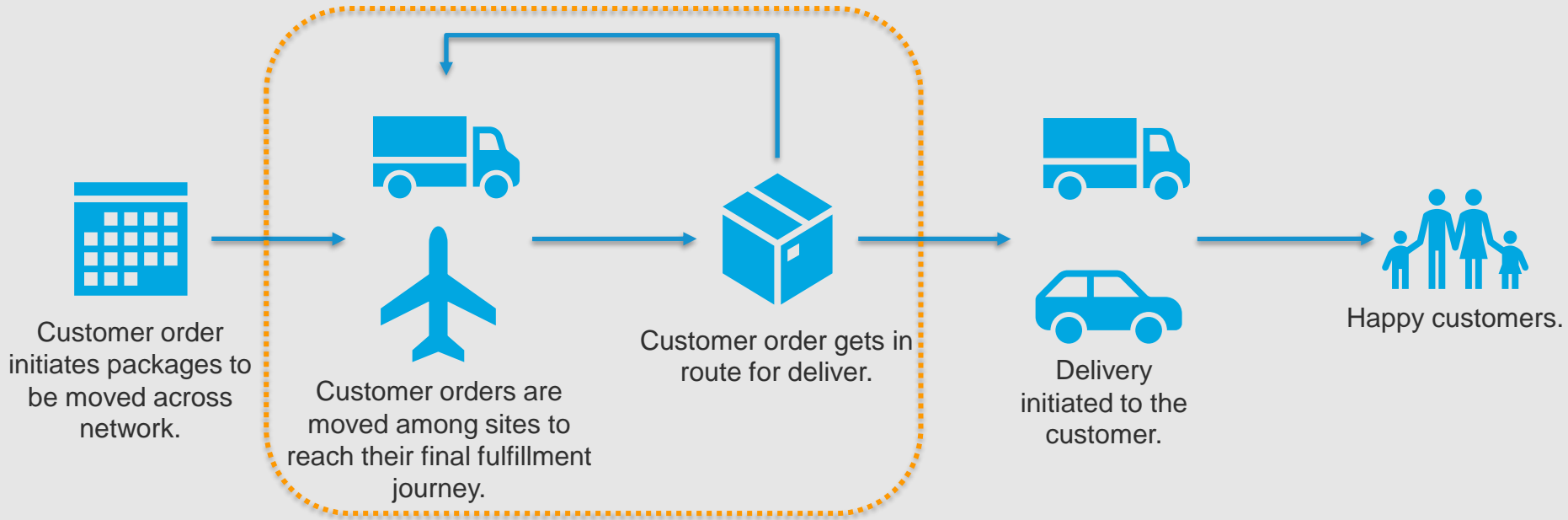
Middle Mile

Last Mile



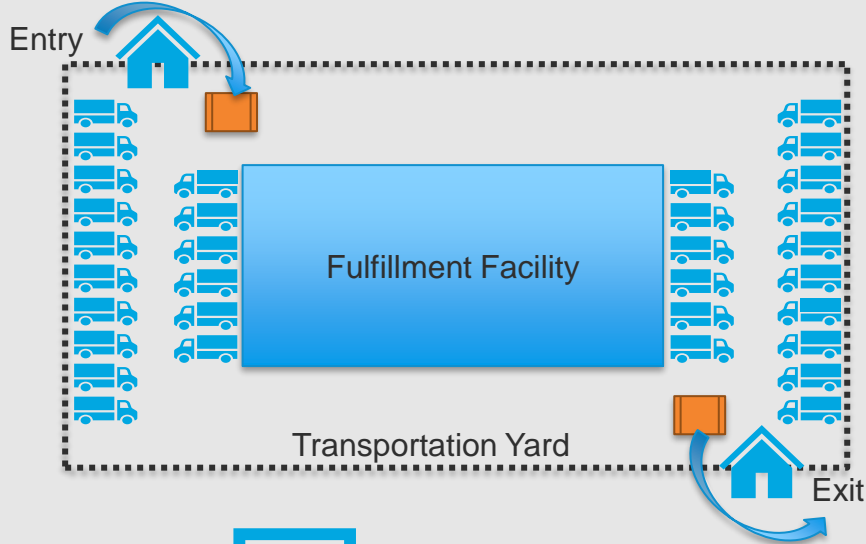
1. Amazon Fulfillment Network Summary

Amazon supply chain network breakdown by scheduling overview.



1. Amazon Fulfillment Network Summary

Transportation yard significance by unit/package flow to customers.

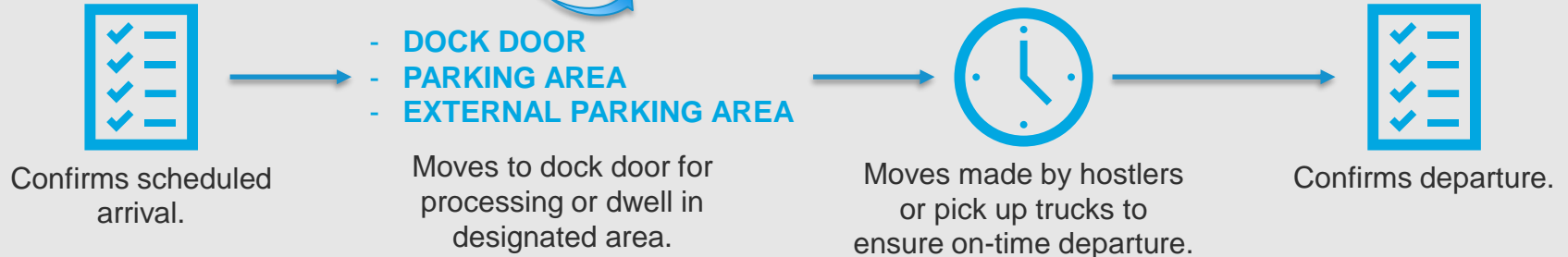


Significance of inbound/outbound flow of packages.

- As the facilities are physical infrastructure, they are constrained by resource such as equipment, labor, and available space (dock doors/parking spots) that limits the operability of the yard.

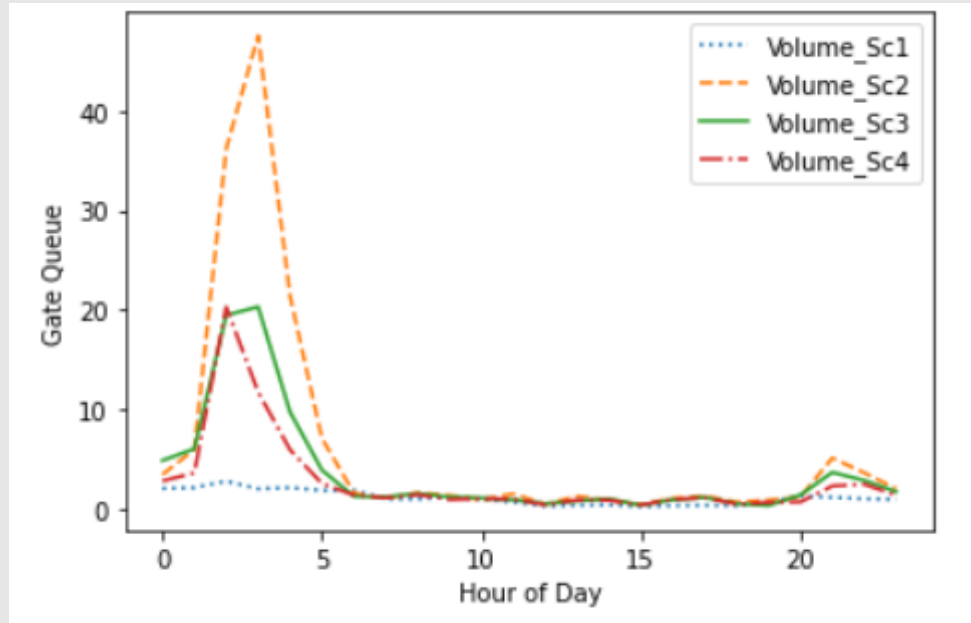
Limitations of equation based models.

- The varying constraints which differ on hourly bases limit the usage of equation base models.
 - Example 1 -> the number of trucks checking in increases, causes delay in unloading activity.
 - Example 2 -> outbound departure time missed due to trailers not being available.



1. Measuring Transportation Yard Risks with Simulation

Transportation yard significance by unit/package flow to customers.



Agent-based modeling solution to capture yard variabilities.

- Able to populate inbound/outbound trailers by the latest minute and measure the unload/load timelines based on the varying yard constraints.
 - Example 1 -> if the yard utilization increase, an over-the-road shuttle would remove low priority trailers from the yard to create space.
 - Example 2 -> if the number of empty outbound trailer is below a threshold, an empty trailer would be called.

2. Simulating the Transportation Yard Operations

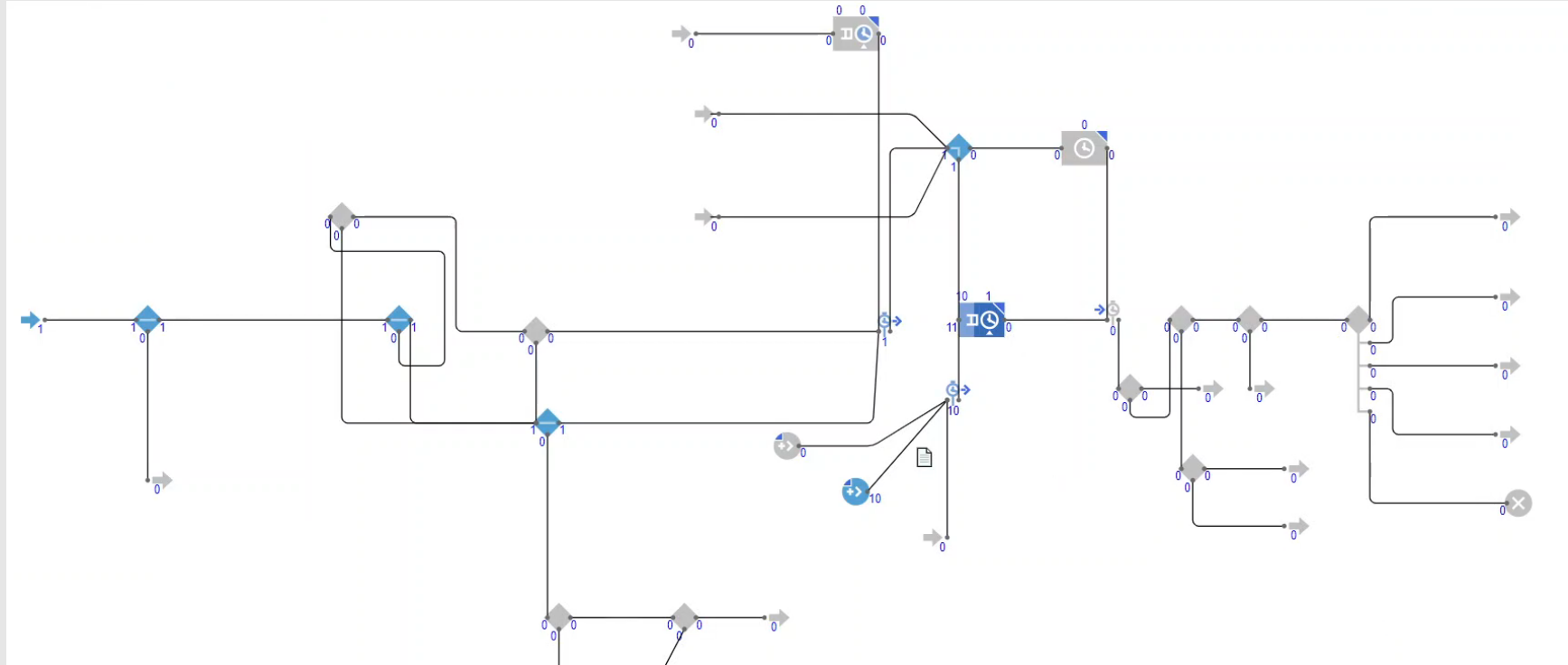
Process-based simulation using process modeling library.



- **Agents** populated representing trailers, dock doors, hostlers, guard shack check in/out resources each containing parameters loaded from the historical actuals.
 - Example 1 -> the dock door configuration varies per site where different dock doors are able to process specific loads.
 - Example 2 -> the number of check in lanes may differ per headcount allowing additional truck to enter/depart.
- **Source/enter block** places trailer loads within the model triggering resources such as bobtails and hostlers to make their moves.
- **Events/Queues triggering** moves ensuring on-time arrivals and departures and probabilistic moves made to ensure operability by exceeding set threshold.
- **Use Cases:**
 - Faster model run using essential inputs among yard and scheduling attributes able to determine the max capacity.

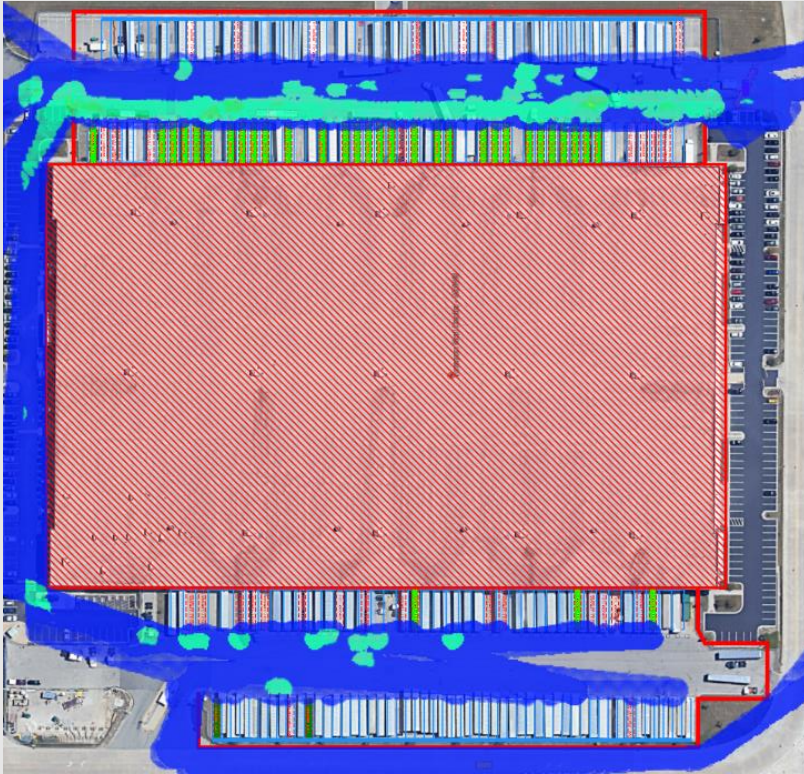
2. Simulating the Transportation Yard Operations

Process-based simulation using process modeling library.



2. Simulating the Transportation Yard Operations

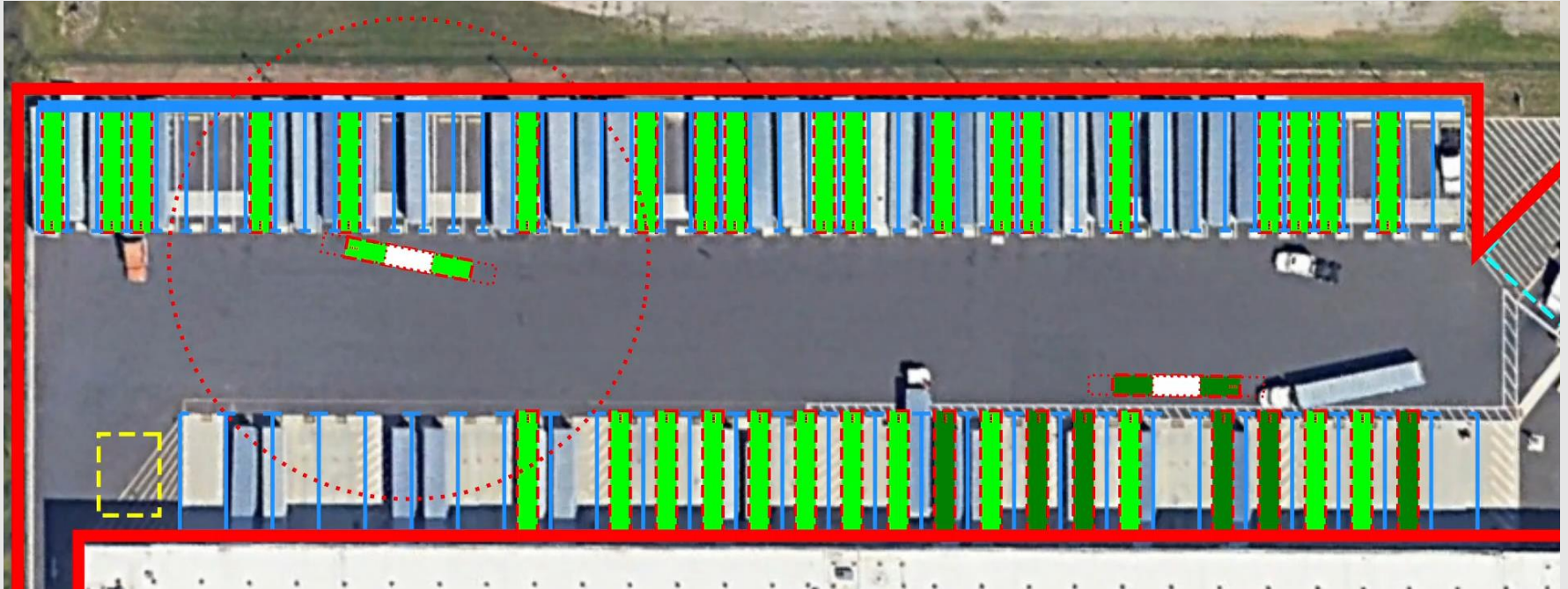
Traffic flow simulation using transporters and storages to measure congestion zones.



- **Density map** to detect the yard congestion zones within the yard per physical attributes.
 - The physical attributes consists of dock door, guard shack, and parking area locations.
- **Safety logic** to pause movement of oncoming traffic when trailer is being moved by a bobtail.

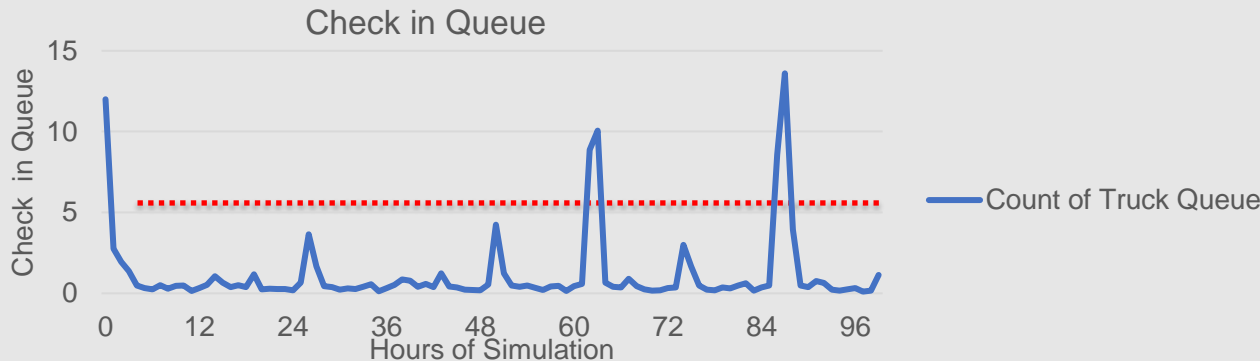
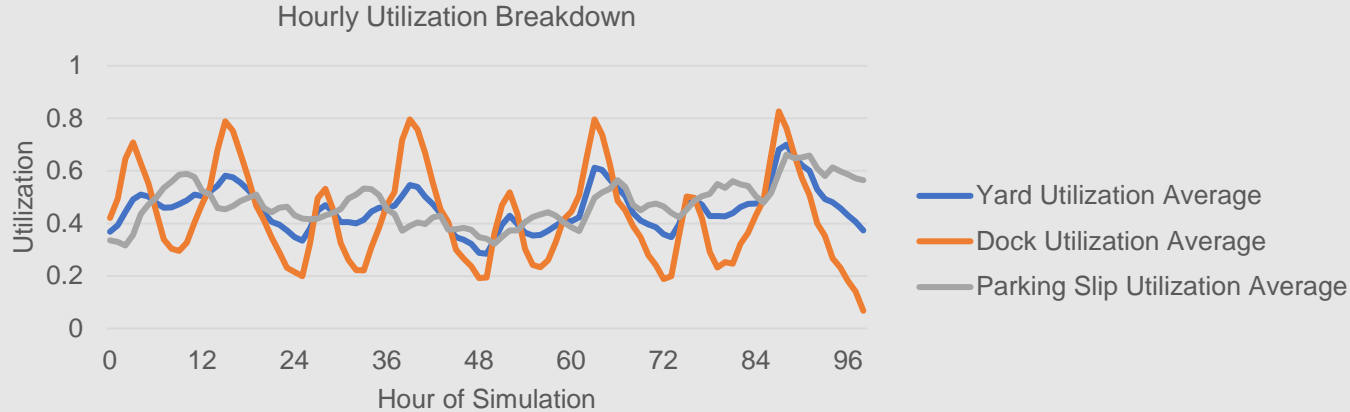
2. Simulating the Transportation Yard Operations

Traffic flow simulation using transporters and storages to measure congestion zones.



3. Output Validation and Solution Proposals

Validation measures and what-if scenarios to determine the capacity threshold.



Example -> High dock door utilization impacting gate queue.

- Dock door utilization shows steady trend reaching near the max threshold of 95%.
- Due to the yard being closer to gridlock, the gate queue post 48 hours of running the schedule increases aligned with the highest dock door utilization hours.

3. Output Validation and Solution Proposals

Validation measures and what-if scenarios to determine the capacity threshold.

Model Metrics	Method	Average Value
Accuracy Metrics	Mean Absolute Error (MAE)	6%
	Root Mean Square Error (RMSE)	7%
Distance Metrics	Dynamic Time Wrapping (DTW)	2.123

- **Validation** of output is done from various accuracy metrics. The goal is below 10% and the alignment with the analysis request.
- **Scenario** runs to provide additional insights among Amazon yards based on the received constraints.
 - **Scenario 5** suffices the customers need by not exceeding the **95%** utilizations and the gate queue under **7** which was a constraint provided by the customer.

	Volume	Volume +/-	Yard Utilization	Dock Utilization	Hostler Utilization	Gate Queue
Scenario 1	100,000		68.0%	63.00	44.00	1
Scenario 2	130,000	+ 30%	83.0%	87.83	57.80	4
Scenario 3	140,400	+ 8%	90.0%	93.00	64.00	7
Scenario 4	143,208	+ 2%	86.0%	93.04	61.46	7
Scenario 5	140,343	- 2%	83.0%	93.00	60.21	6



4. Conclusion & Future Work

Conclusion

- Long term strategic design -> simulation used for yard right sizing and predicting potential issues.
- Operational capacity setting -> experiments providing maximum volume per site rightsizing infrastructure and equipment allocation.
- Tactical risk mitigation -> models used for *operational* planning and identifying differences among facilities within the network.

Future work

- Model capable of learning from historical events and provide recommendations.
- AL Cloud for on-demand simulations.



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Q&A

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