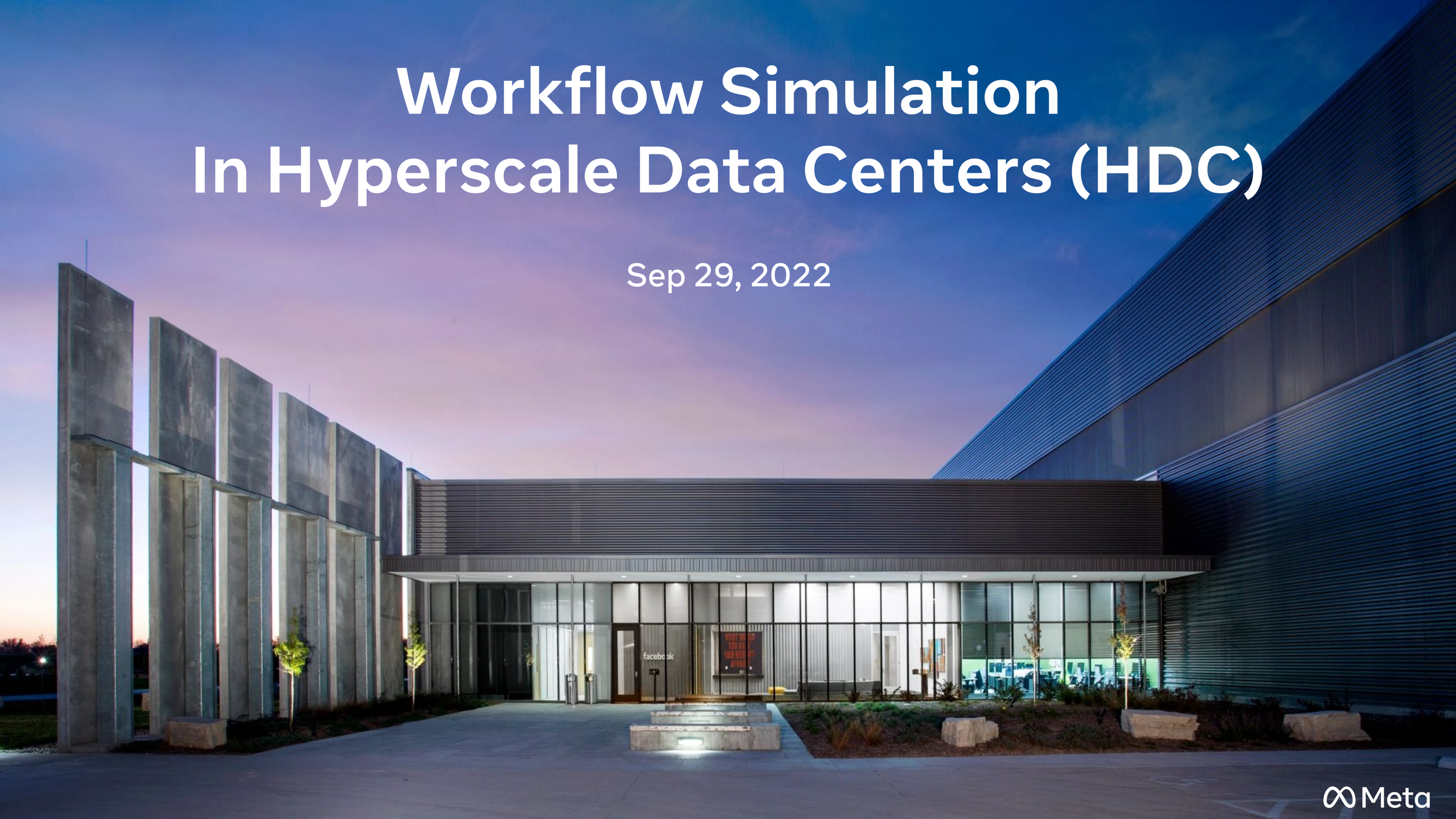
# Workflow Simulation In Hyperscale Data Centers (HDC)

Sep 29, 2022

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# Meet the Team

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# Agenda

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- Opportunity Statement
- 3D Visualization
- Modeling Approach
- HDC Model Assumptions
- HDC Model Parameters
- HDC Throughput Capability Results
- HDC Throughput Capability Model Optimization
- Monte Carlo Simulation
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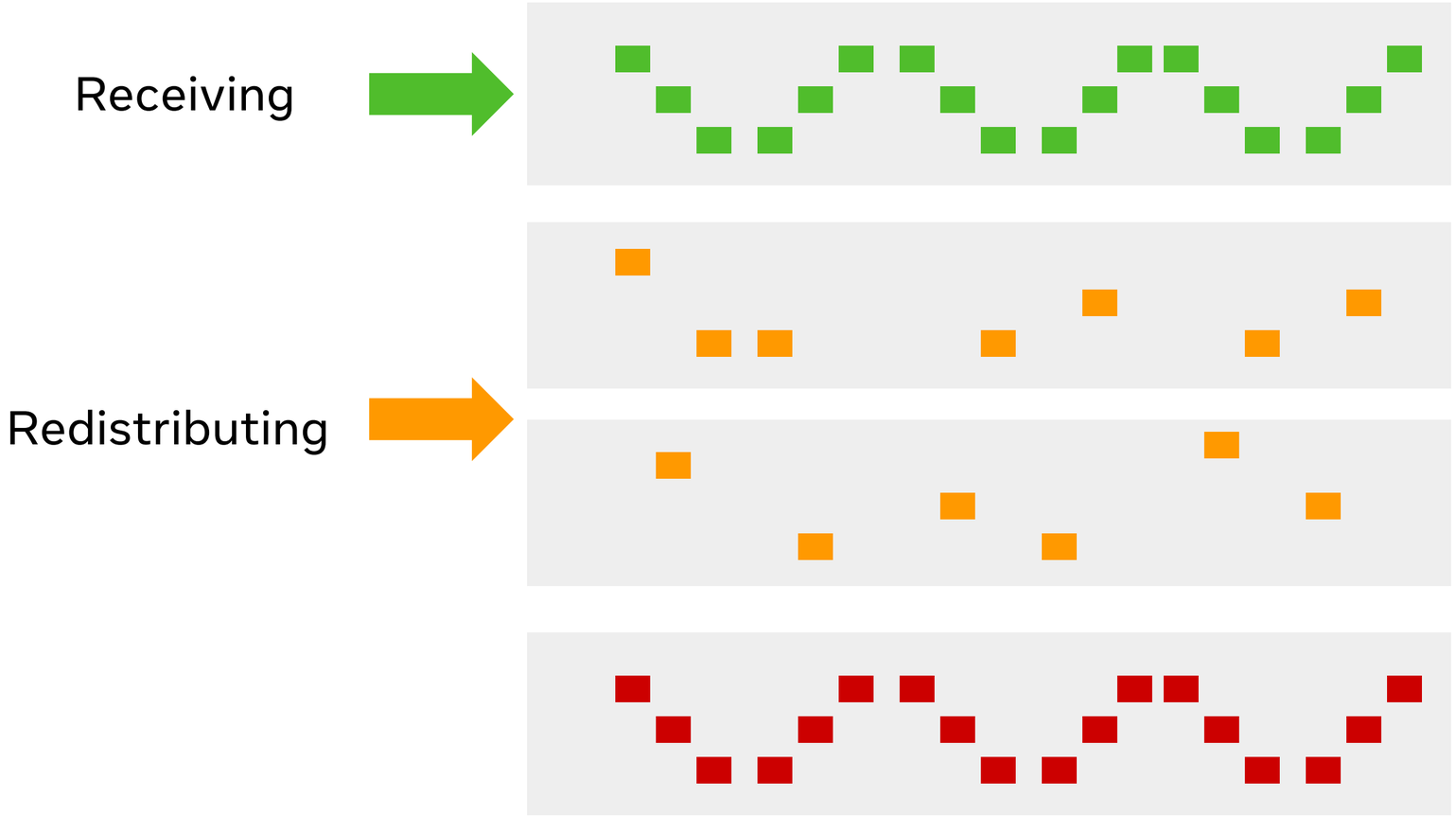
# Overview

Hyperscale Data Centers (HDC) are massive business-critical facilities designed to support various engineering processes. A single HDC can host thousands of compute and storage racks and network equipment which are managed by a highly skilled workforce. Optimization of operational cost and hardware availability is the top priority for HDC.

The team modeled HDC designs by parametrization key aspects of the DC workflows - i.e. workforce availability, dimensional aspects of buildings, and volume of rack flow.

This study demonstrates rack delivery workflow modeling using different features of Anylogic software. The model was further validated and optimized using multiple constraints and Monte Carlo simulation to show what parameters need to be changed to arrive at best throughput for the rack workflows in HDC.

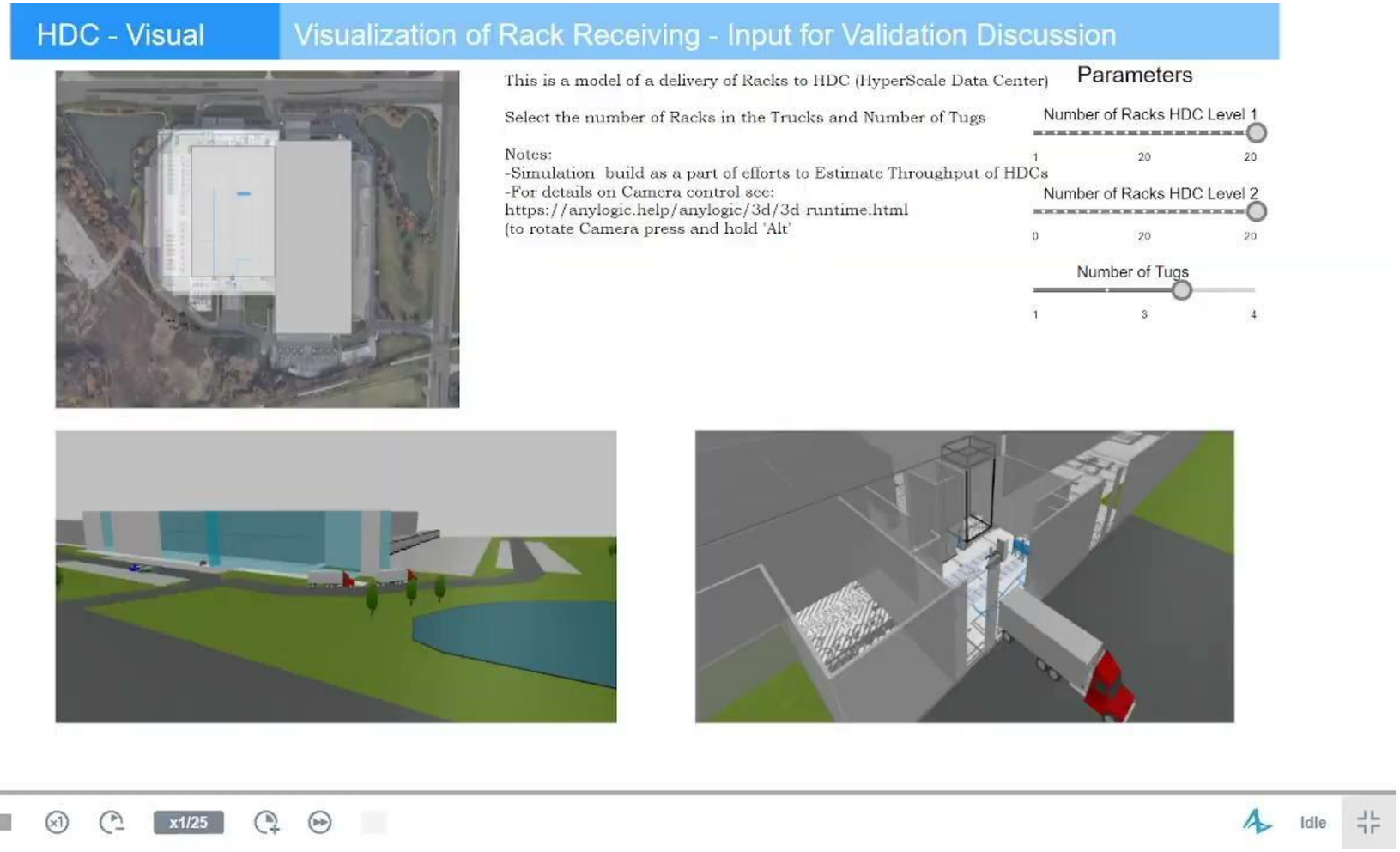
# Opportunity Statement




Each workflow has multiple steps and potential constraint areas

Establish **a process and a tool to visualize & simulate operational constraints** in HDC Designs to analyze bottlenecks & throughput capability

# 3D Visualization




**Visualization models** facilitate rack flow data validation and accelerates teams workflow & resource learnings

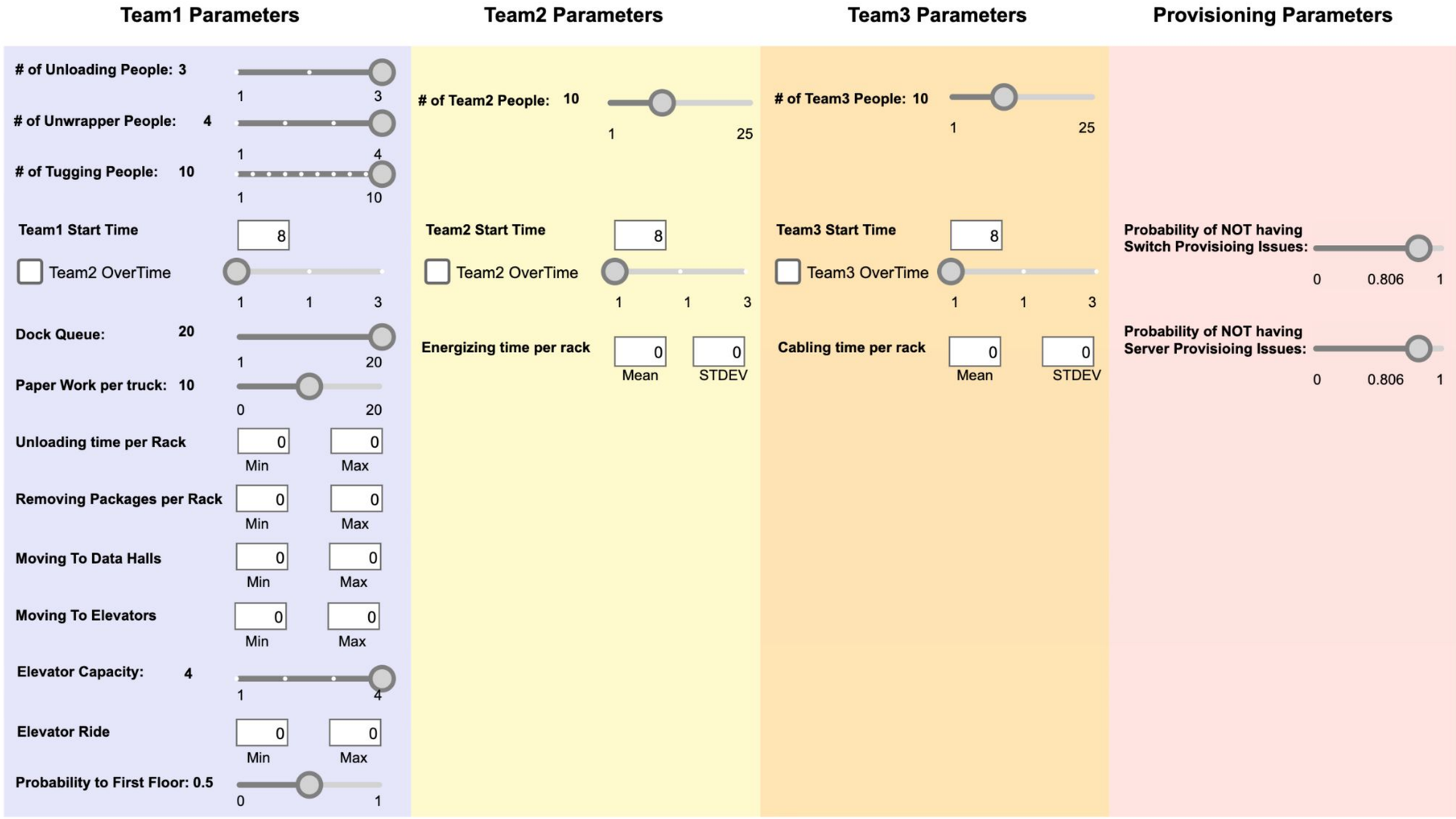
# Modeling Approach

# HDC Modeling Assumptions

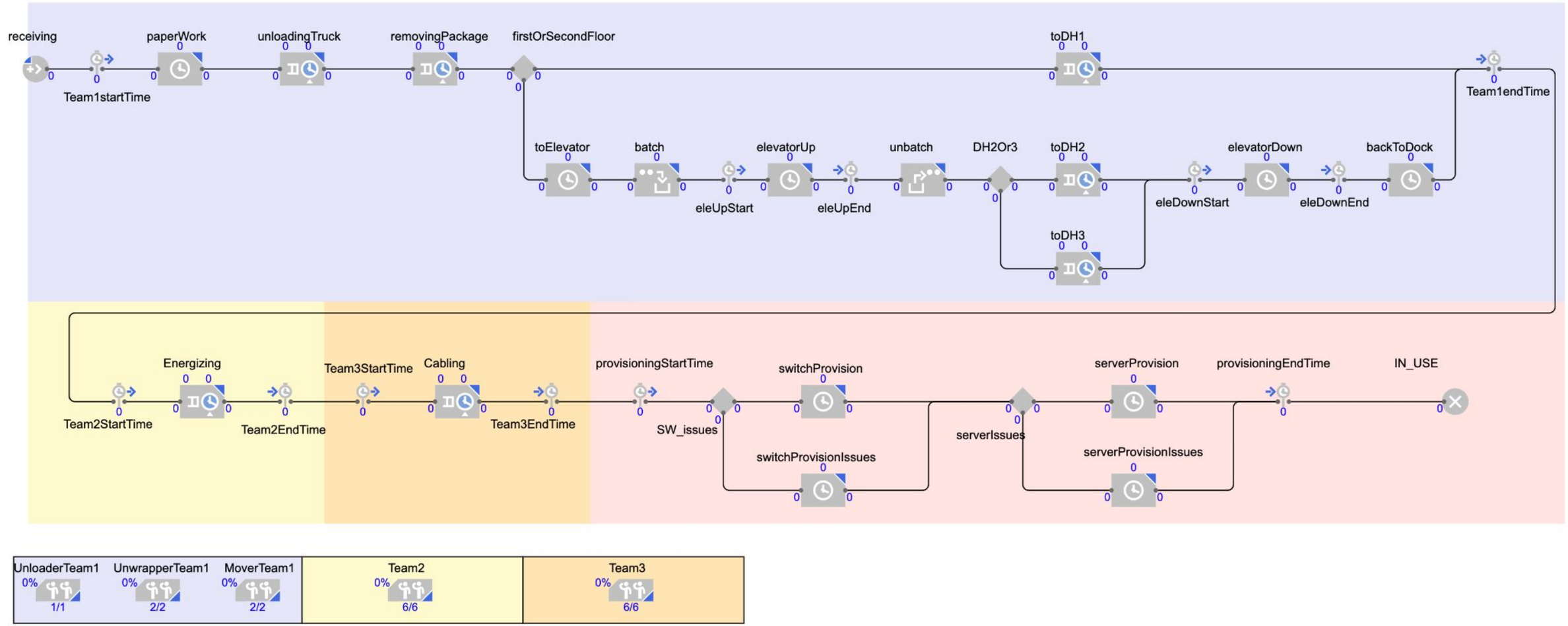
- We treat **Hyper Data Center** building as an **object** with multiple parameters. we can predict the **Throughput** of a variety of HDC types.
- Rack receiving process can be modeled with the entities presented in the following. (*Receiving, Positioning, Energizing, Cabling, Provisioning*)


- Simulation is just for one week, and the throughput of the model is shown by the percentage of total.
- Number of resources in each team is configurable and utilization is set to between **60%** and **80%**
- Shifts start time is by default at **8 AM** and overtime is allowed.
- Team1 processes:
    a. *1-Unloading of the Truck, 2-Unpacking and PaperWork, 3-Dock Queue, 4-Data hall runs, 5-Elevator Capacity, 6- 1st floor or 2nd floor.*
- Energizing and Cabling have normal distribution
- Provisioning:
    a. Switch provisioning is set to 80% (20% rework rate)
    b. Server Provisioning is set to 80% (20% rework rate)

# Receiving Model Parameterization



# DES Model Overview

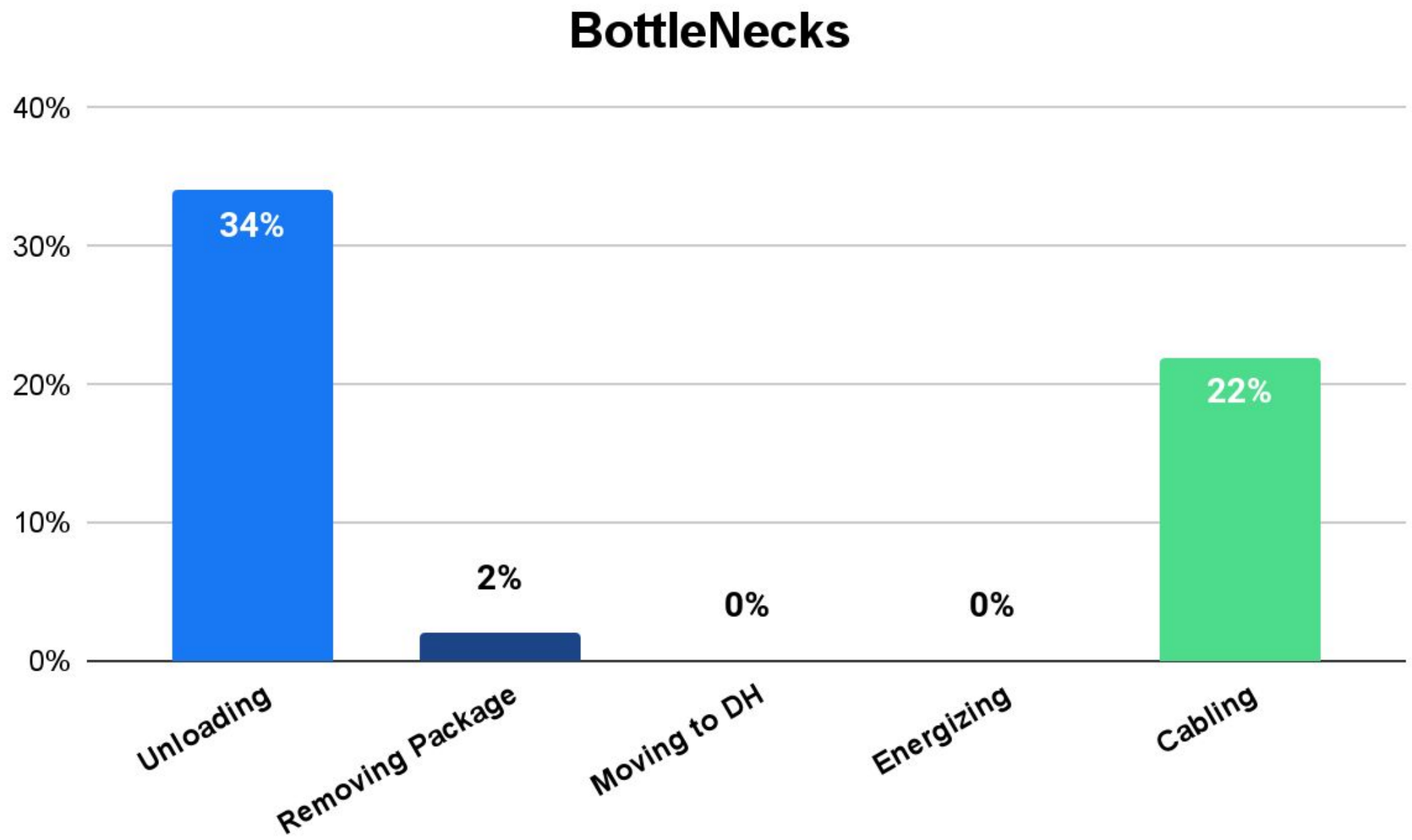


# Summary of Model Results:

| Throughput Target (%) | | Team 1 | Team 2 | Team 3 | Throughput | Avg Duration (days) |
|---|---|---|---|---|---|---|
| 100% | # of people | Unloaders: 1<br>Unwrappers: 2<br>Movers: 6 | 10 | 10 | 40% | 3.7 |
| | Start time | 8 AM | 8 AM | 8 AM | | |
| | Overtime | 0 | 0 | 0 | | |

| Step | Throughput |
|---|---|
| Receiving | 100% |
| In Position | 65% |
| Energizing | 65% |
| Cabling | 40% |
| Provisioning | 40% |

# Summary of Model Results:



# Optimization model for the simulation model

**Objective function:**

maximize Throughput

**Constraints:**

Throughput ≤ 100%

# of people ≤ 20 for each team

8 AM ≤ Starting time ≤ 10 AM for each team

0 hr ≤ Overtime ≤ 2 hr

60% ≤ Utilization ≤ 80%

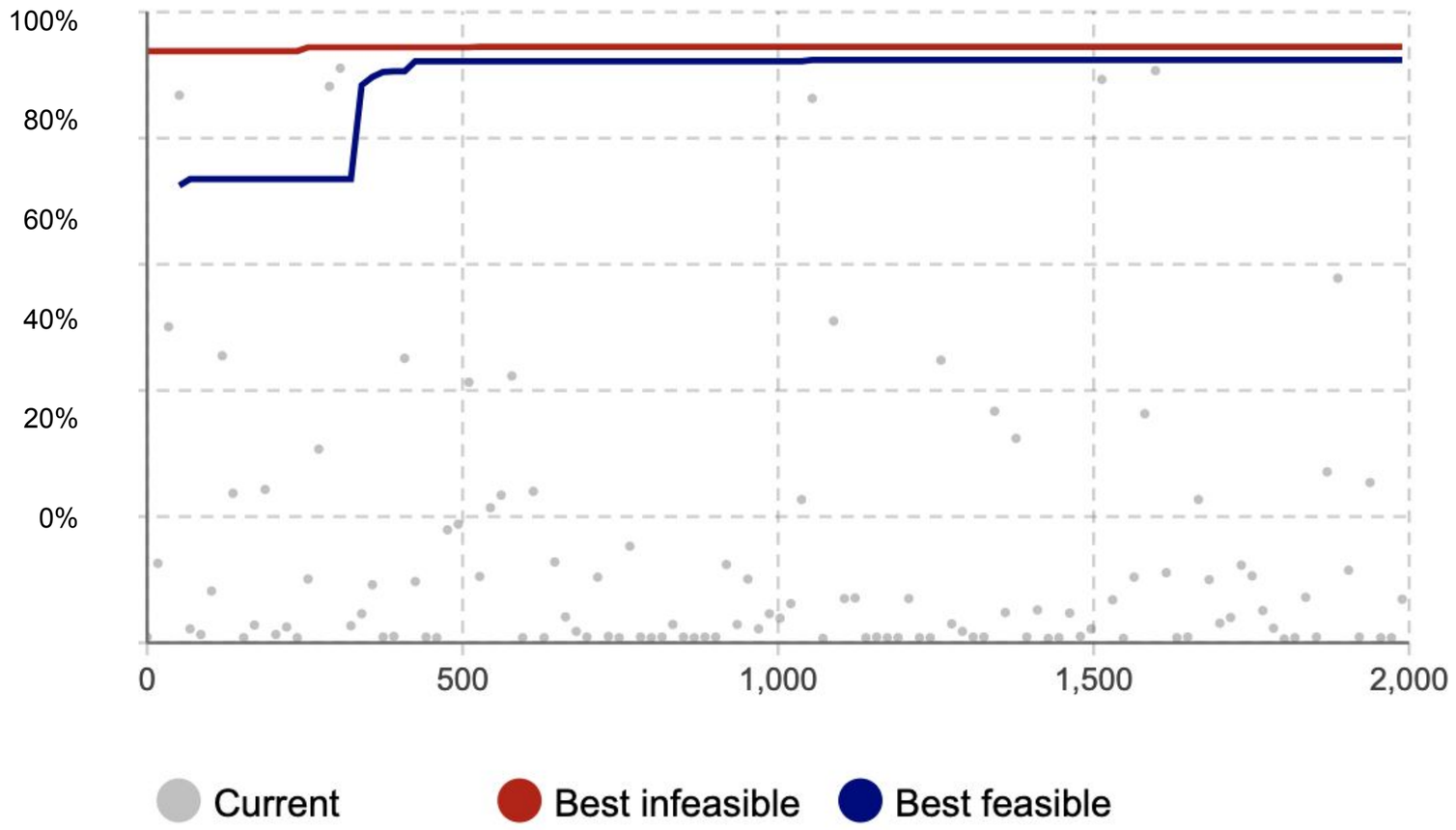
**Iterations: 2000**

# Optimization Results

| Team | Parameter | Value |
|---|---|---|
| **Team 1** | # of Unloaders | **1** |
| | # of Unwrappers | **3** |
| | # of Movers | **6** |
| | Start time | **8 AM** |
| | Over time | **0** |
| **Team 2** | # of people | **19** |
| | Start time | **9 AM** |
| | Over time | **2** |
| **Team 3** | # of people | **20** |
| | Start time | **10 AM** |
| | Over time | **2** |

| | Current | Best |
|---|---|---|
| **Iterations Completed** | 2000 | 1040 |
| **Objective: ↑** | 73% | 92% |

# Optimization Results *Continued*



# Summary of Optimized Model:

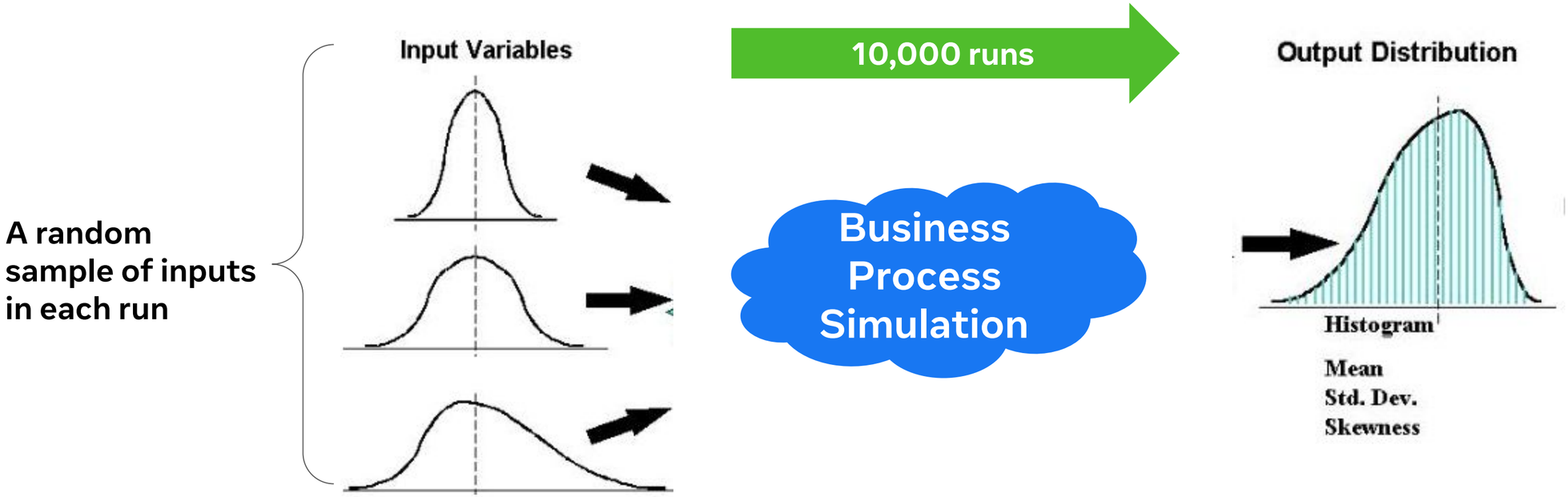
| Throughput Target (%) | | Team 1 | Team 2 | Team 3 | Throughput | Avg Duration (days) |
|---|---|---|---|---|---|---|
| 100% | # of people | Unloaders: 1<br>Unwrappers: 3<br>Movers: 6 | 19 | 20 | 92% | 2.2 |
| | Start time | 8 AM | 9 AM | 10 AM | | |
| | Overtime | 0 | 2 | 2 | | |

**Automated without human interfere** →

| Step | Throughput |
|---|---|
| Receiving | 100% |
| In Position | 100% |
| Energizing | 100% |
| Cabling | 100% |
| Provisioning | 92% |

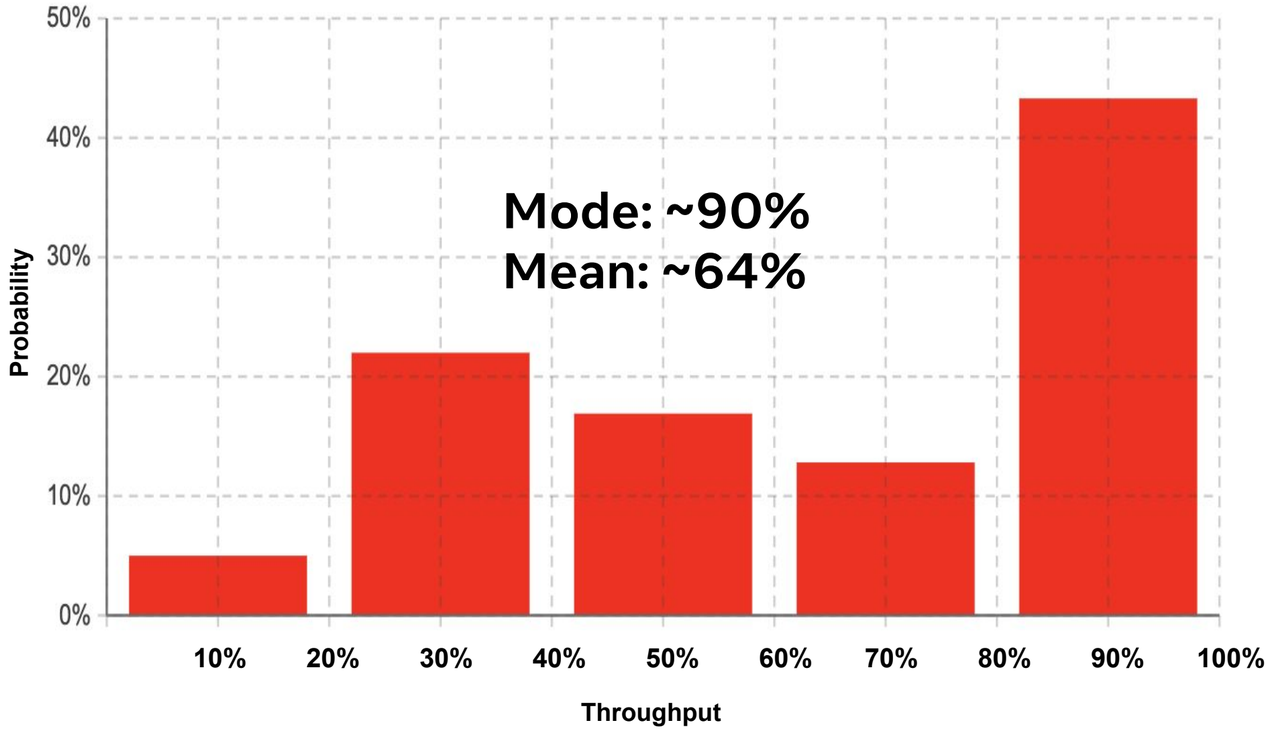
# Modeling Approach - Monte Carlo Method

- MC is a stochastic method that uses a random sample of inputs and creates an output for the model.
- After running multiple times, we can define a distribution for output instead of having one output.
- MC method is used when we know a set of scenarios can happen but we are not sure what will happen.

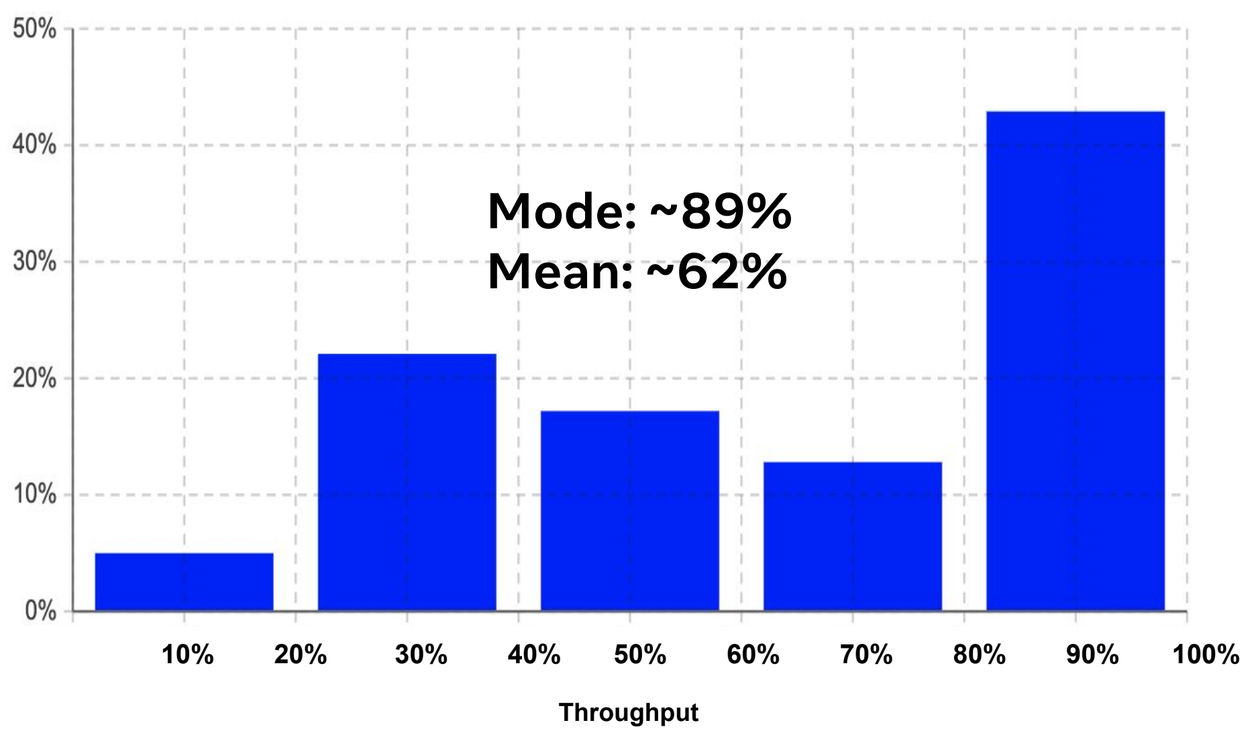


# Monte Carlo Results - Based on Optimized Model

## In Position Distribution




## In Use Distribution




**Mode is the most probable outcome in reality**

# Next Steps

- Adding redistributing and refreshing processes to the model.
- Adding more details to Energizing, Cabling, and Provisioning steps.
- Creating Sensitivity Analysis to find out the best values for parameters.
- Increasing the time of simulation to one year and analyze the results.

# Q & A

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# Thank You

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