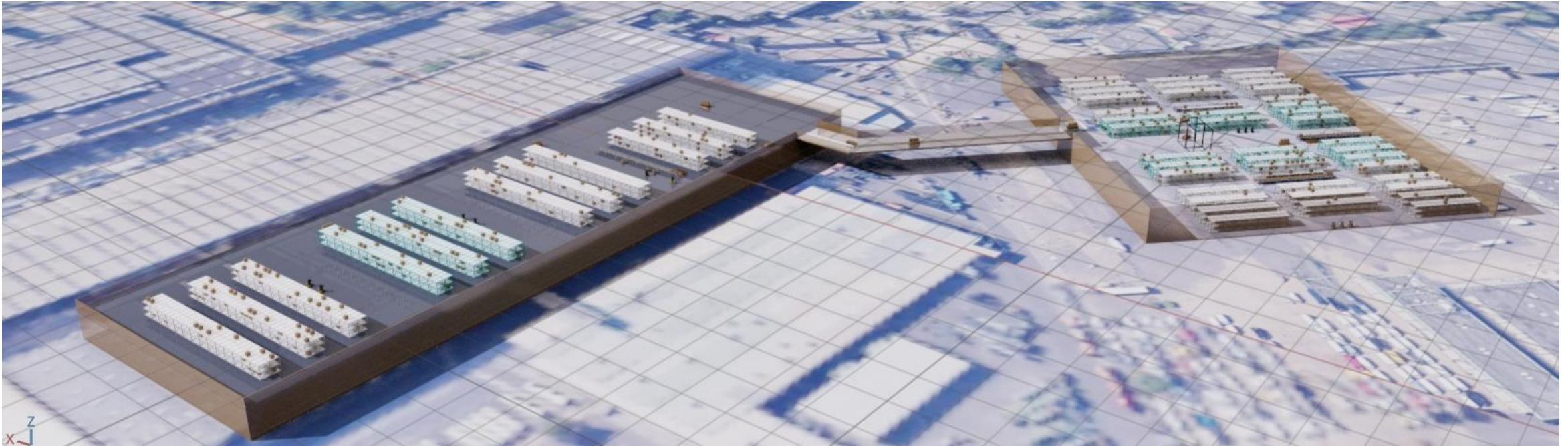




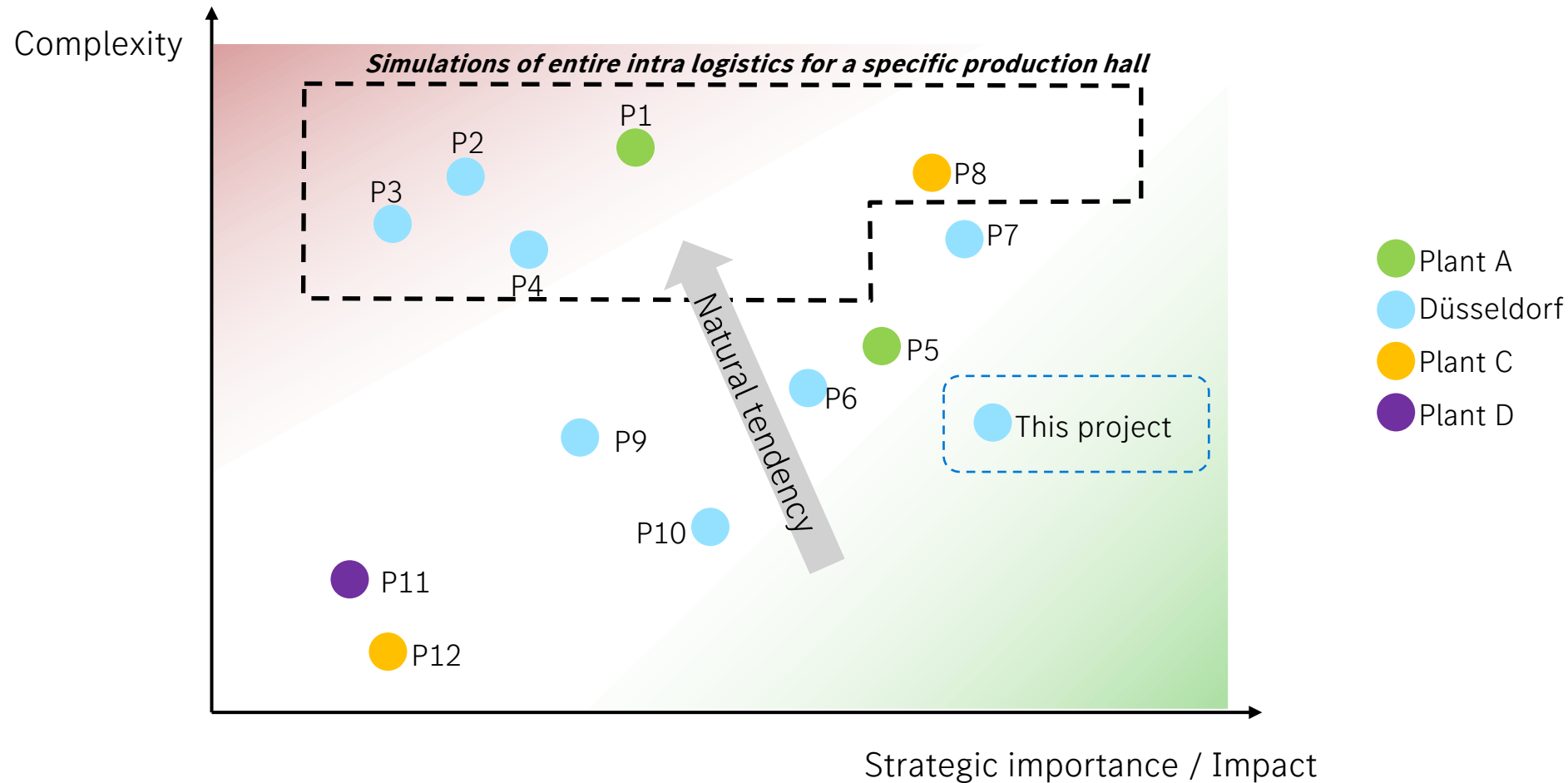
MERCEDES-BENZ

From Concept to Reality: Iterative Simulation in Dynamic Green-Field Planning Projects



Why I chose this specific project

Project Portfolio Intra Logistics Simulation and Analytics



Mercedes-Benz Vans Simulation Team

Our Team is allocated as a central function within the Van/Operations Organization

Mercedes-Benz Group AG (Holding)

Mercedes-Benz AG

Van Organization

Operations

Sales

Strategy

R&D

[...]

Production of each plant

Engineering

QM

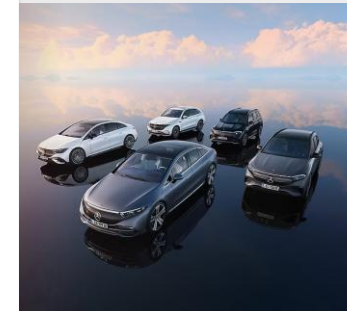
Operational Excellence → **our Simulation Team**

[...]

→ **Intra Logistics**



Passenger Cars Organization



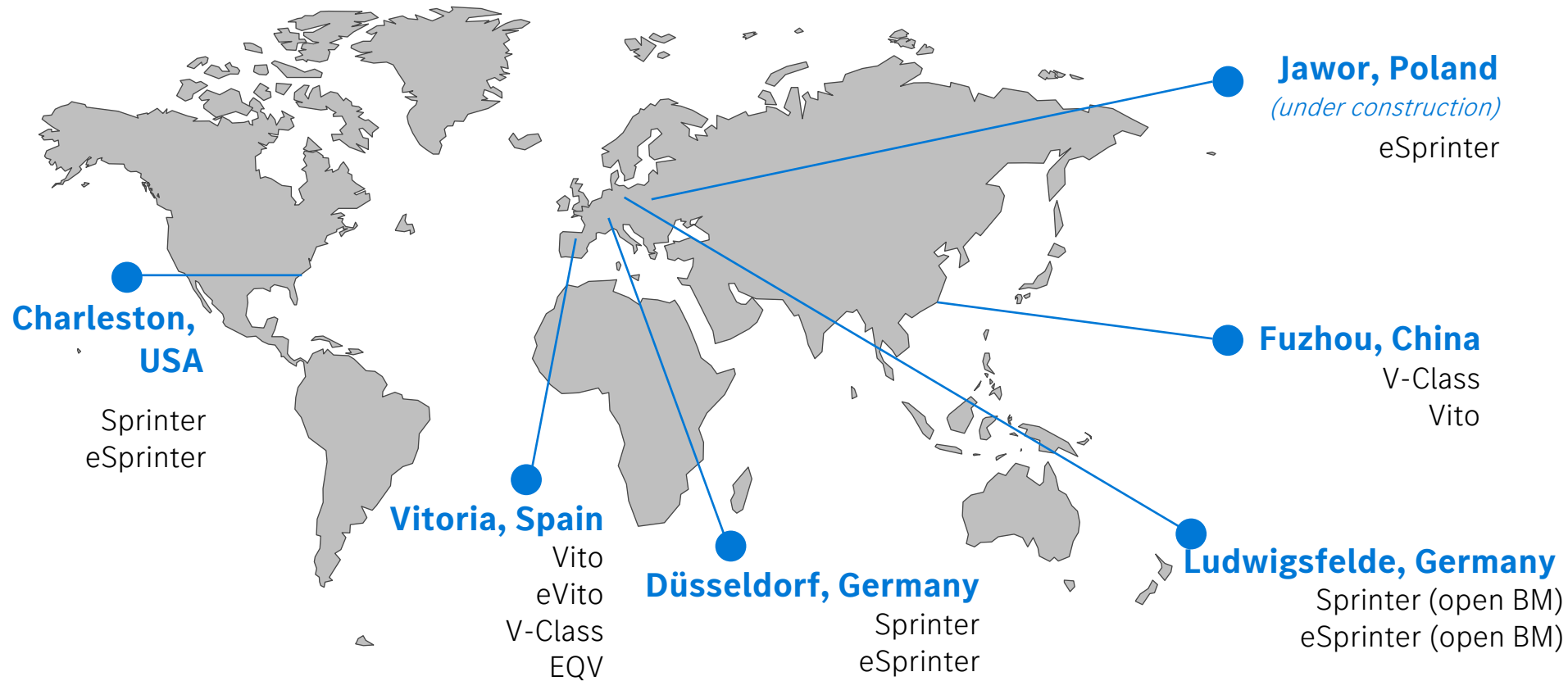
MB Mobility AG

Joint Ventures

[...]

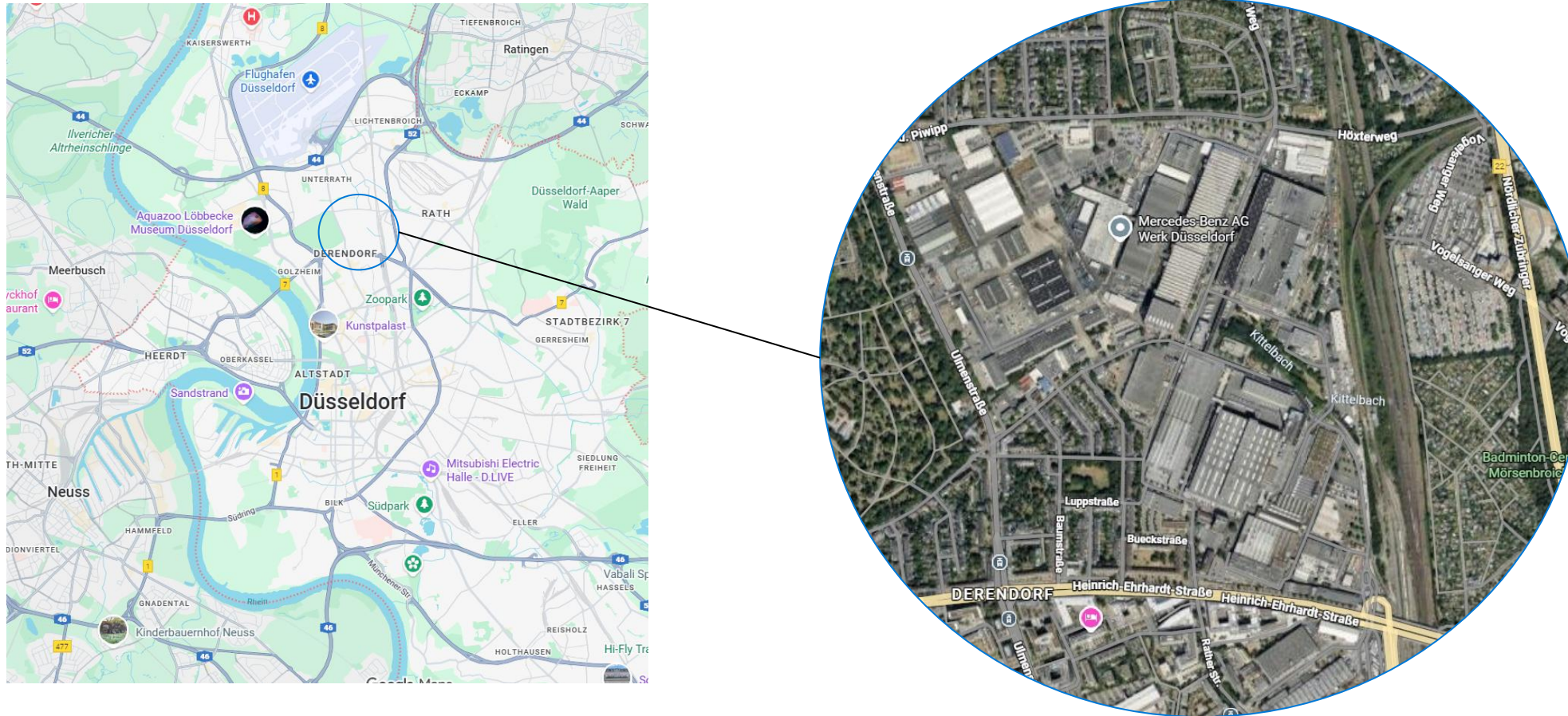
Mercedes-Benz Vans Production Network

There are 6 main production facilities, all supported by our simulation team



Mercedes-Benz Plant Düsseldorf

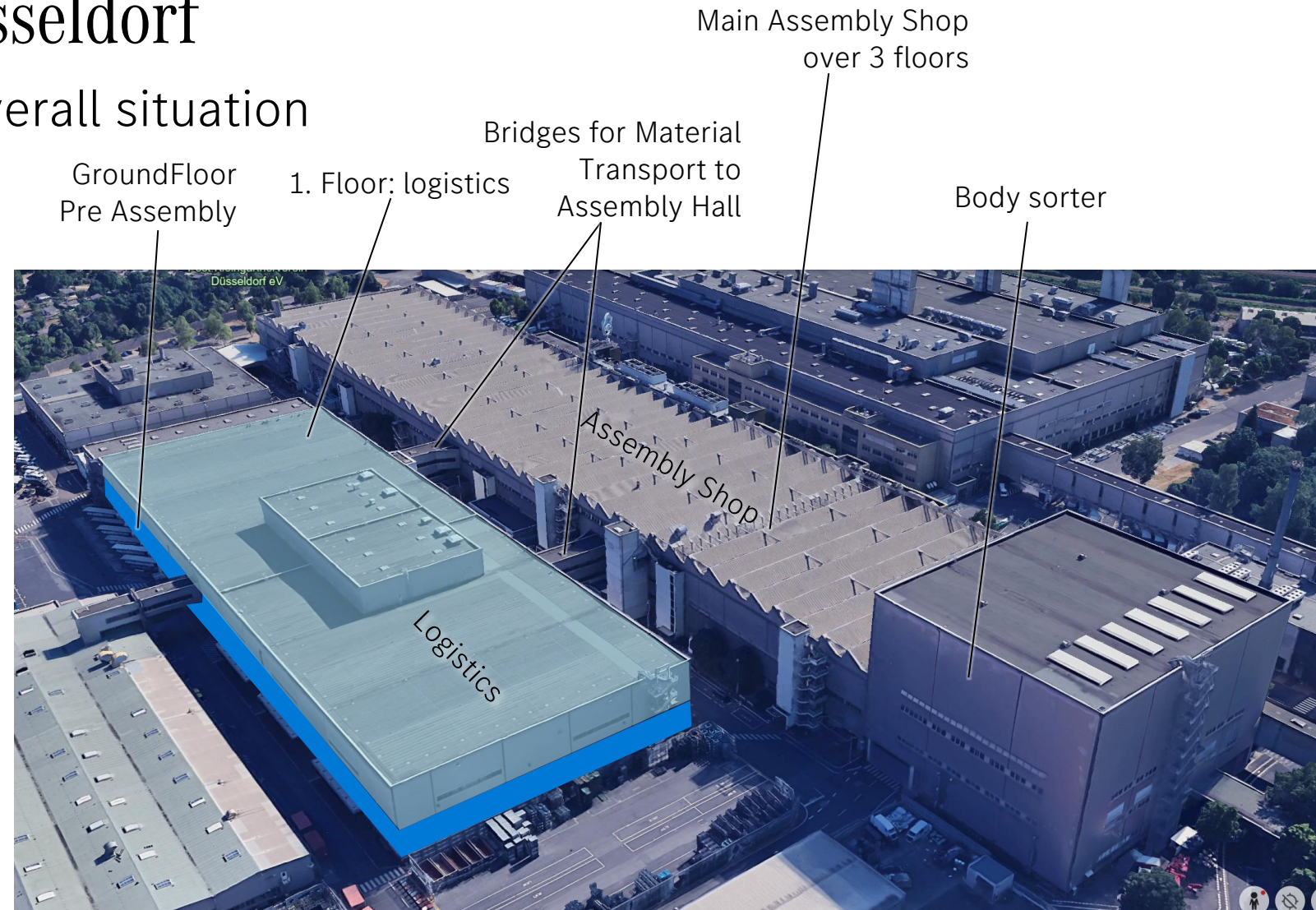
location



Source: Google Maps

Mercedes-Benz Plant Düsseldorf

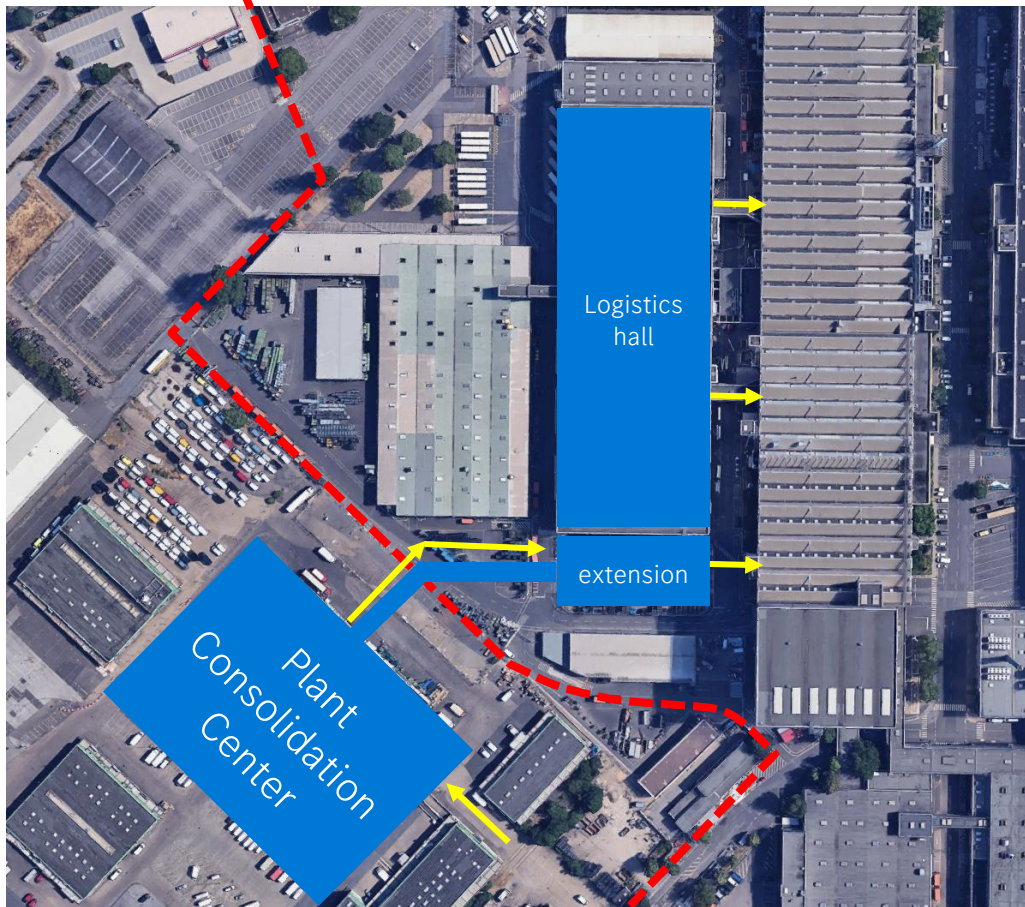
General plant structure and overall situation



Source: Google Maps and Google Earth

Project Plant Consolidation Center (PCC)

Building a new logistics hall that handles all material inbound



Origin

Background Information on Project

- Inbound process for Van.EA production Material: GLTs (Containers) should arrive in PCC outside of plant-area
- From there, material should be transported in logistics hall first floor using AGVs, lifts and a bridge.
- In the first step, most material will be unloaded from AGVs in logistics hall



Target

Question und Purpose of the Analysis

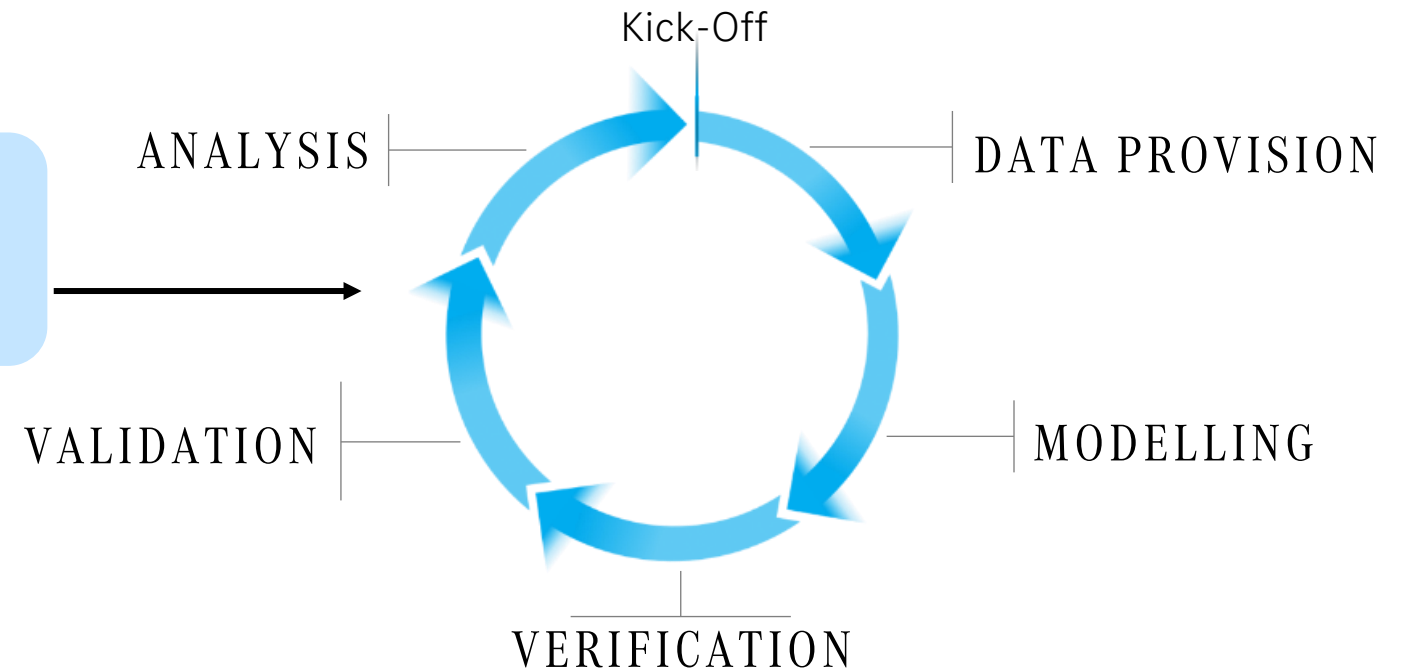
- Concept validation
- Digital validation of planning along with the planning process
- Decision support

Decision for an iterative approach

Main challenge: only few information at the beginning of the project

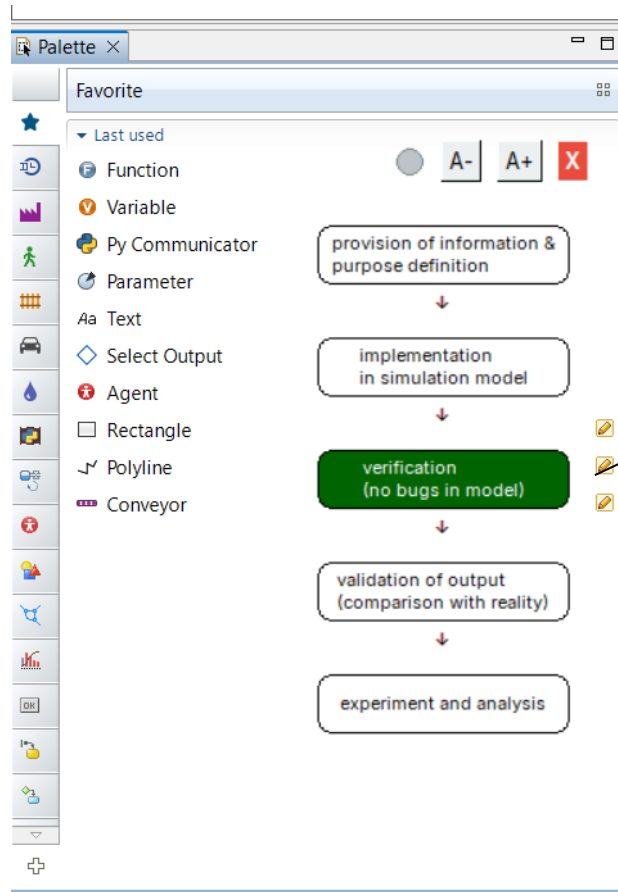
Iterative Approach

- Step 1: Choose a **specific question**, to be answered
- Step 2: Start with a kick-off, clearly setting the target / expectation for this iteration
- Step 3: go through regular simulation project cycle
- Step 4: set results as new standard
- Step 5: Repeat



Avoiding to constantly get new requirements

small widget in first meetings to constantly show project status



Status in current iteration

Target: customer knows at all times where we are currently

Mercedes-Benz

Iteration 1

Iteration 1: Bridge design - 2 or 4 lane bridge?

Most urgent topic: building application



relevant to the question

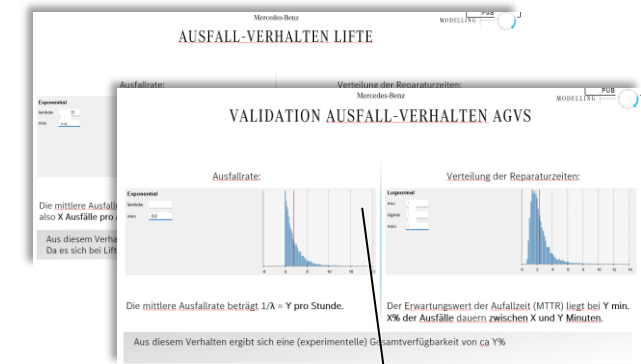
- Number of containers that need to be transported
- AGV speed and failure behaviour
- How many containers per drive per AGV?

not yet very relevant to the question

- Layout of PCC
- Storing / Retrieval Process
- material inbound process (Trucks arrival)

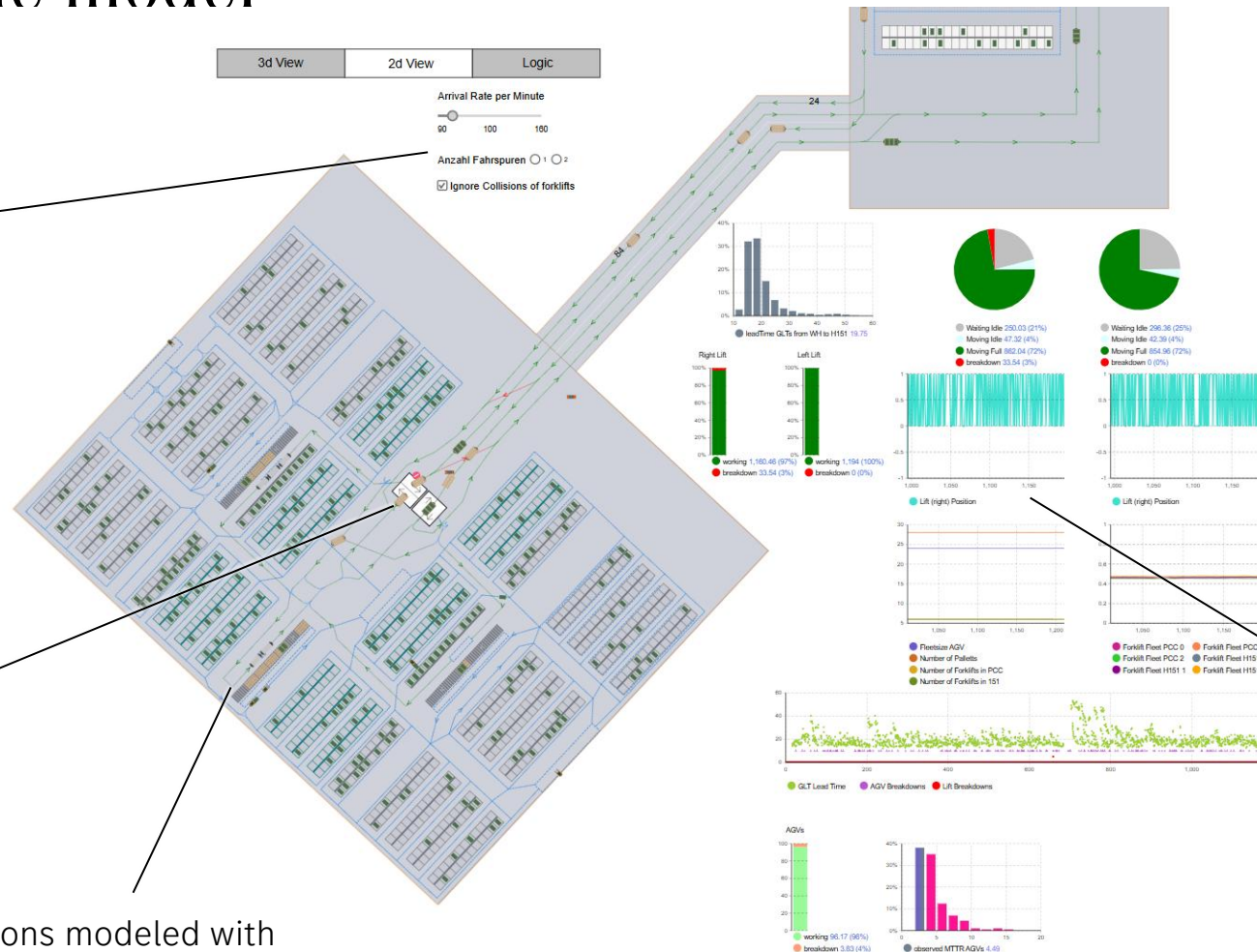


Iteration 1: The model



Great focus on validation of AGV and lift breakdown behaviour

Statistics with relevance to lead time and breakdown behaviour



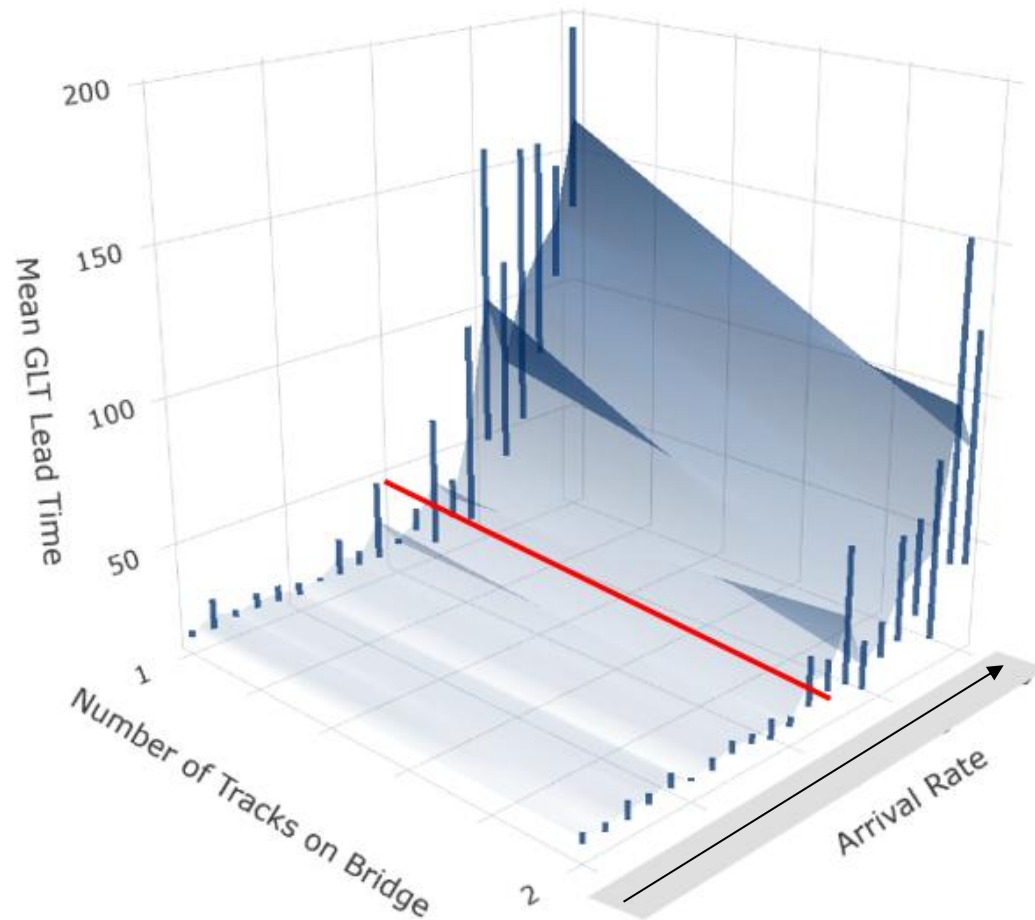
Option to use 2 or 4 lanes on bridge

Standard Anylogic Lift object

Stations modeled with pallets on conveyors

Iteration 1:

Maximal throughput was evaluated



- Lead-Time increases rapidly at a specific throughput
- The impact of the number of driving tracks on bridge is neglectable
 - lifts are the bottleneck
 - they smoothly distribute AGVs on bridge
- Spread of different seeds relatively high
 - in border area high sensitivity to random failures



Final Result of evaluation:

A two-road bridge is sufficient

Iteration 1: Omniverse integration to showcase concept

A good visualization is advantageous during concept phase

Conveyors
at stations



Anylogic standard lift
objects



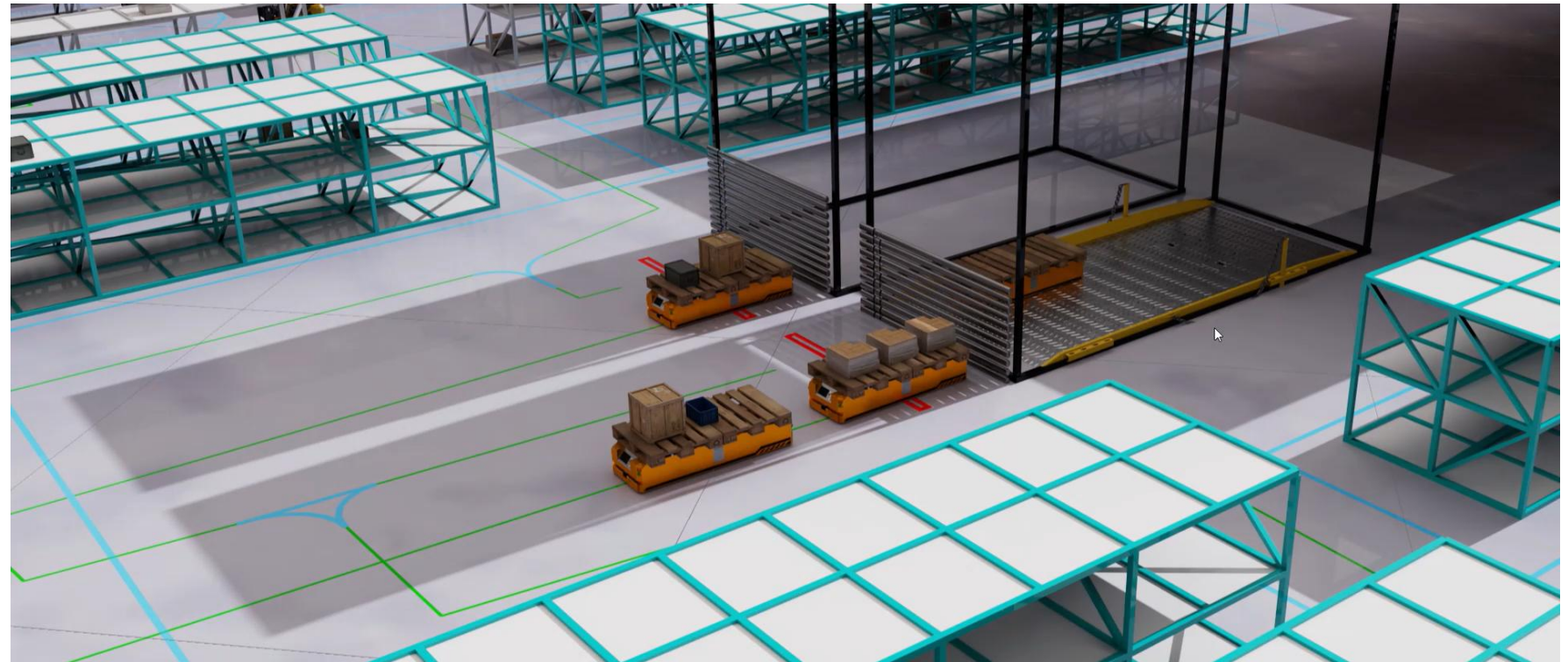
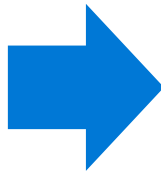
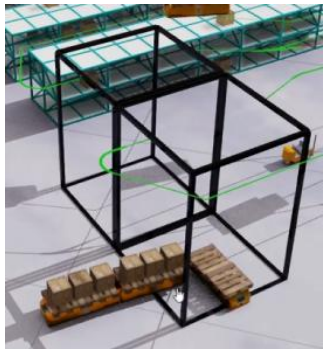
Up to three containers
per AGV

"AGV" (<https://skfb.ly/oTVes>) by lazier6666 is licensed under Creative Commons Attribution (<http://creativecommons.org/licenses/by/4.0/>).

Iteration 2

Iteration 2: lift design

Replacing standard Anylogic Lift objects with custom made lift objects



"AGV" (<https://skfb.ly/oTvEs>) by lazier6666 is licensed under Creative Commons Attribution (<http://creativecommons.org/licenses/by/4.0/>).

Iteration 2: the model

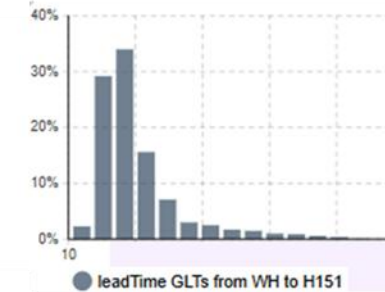
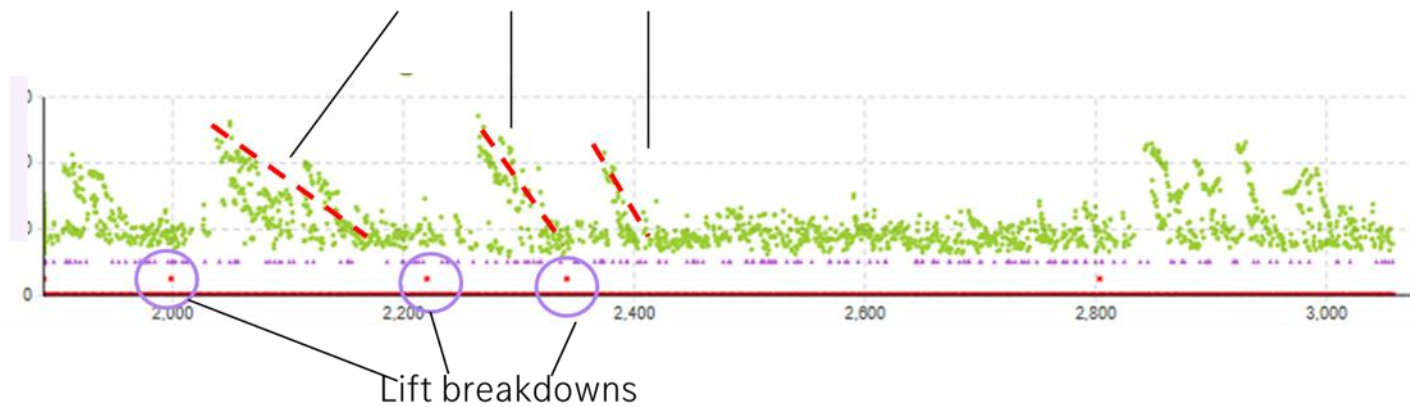
lift objects and stations were adjusted



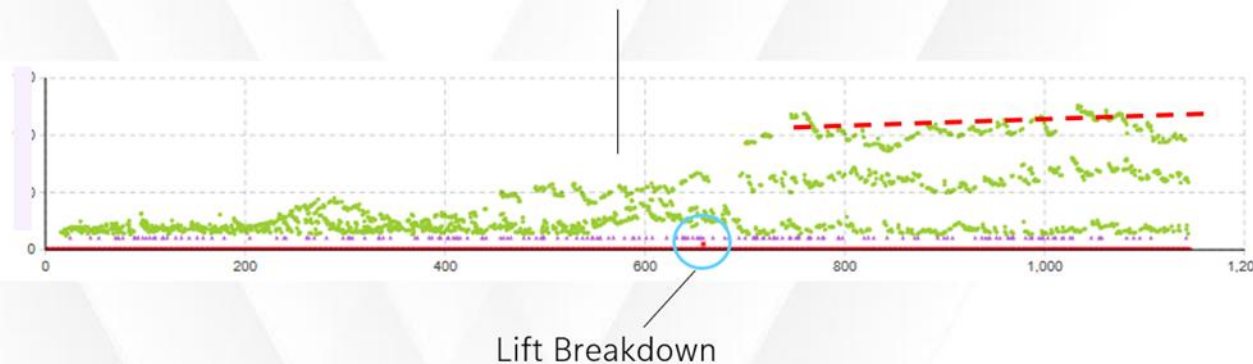


Iteration 2: Analysis Impact of Lift Failures on Delivery time

Fast Recoveries of Lead-Times after Failure

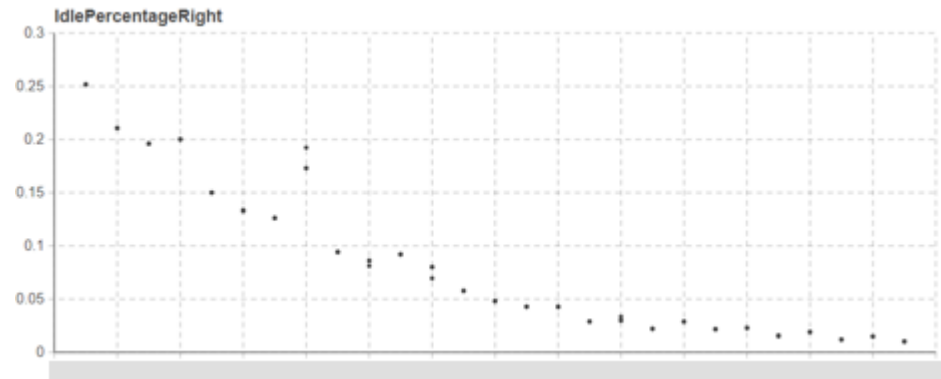


No Recovery of Lead-Times after Failure



- Plotting Lead time of each GLT
- Using this chart, we could visualize the „recovery time“ of the system, after a lift failure

Sensitivity Analysis: Door opening Times



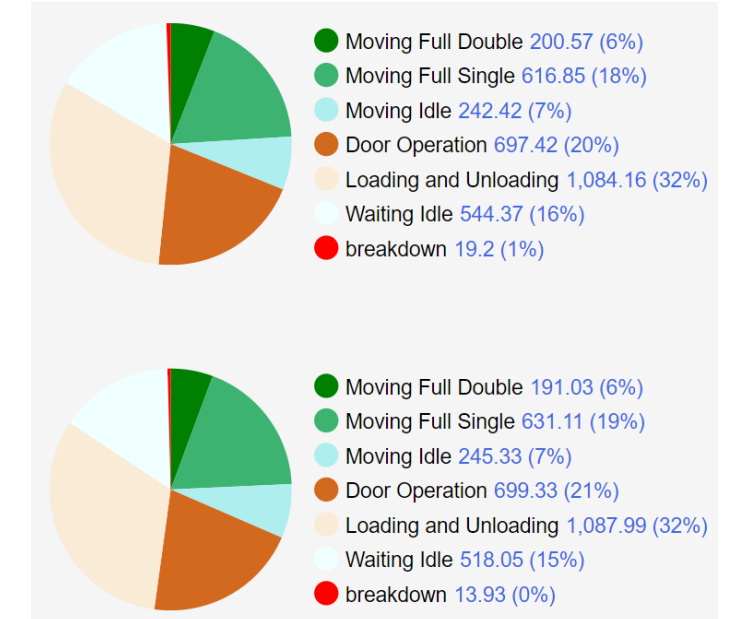
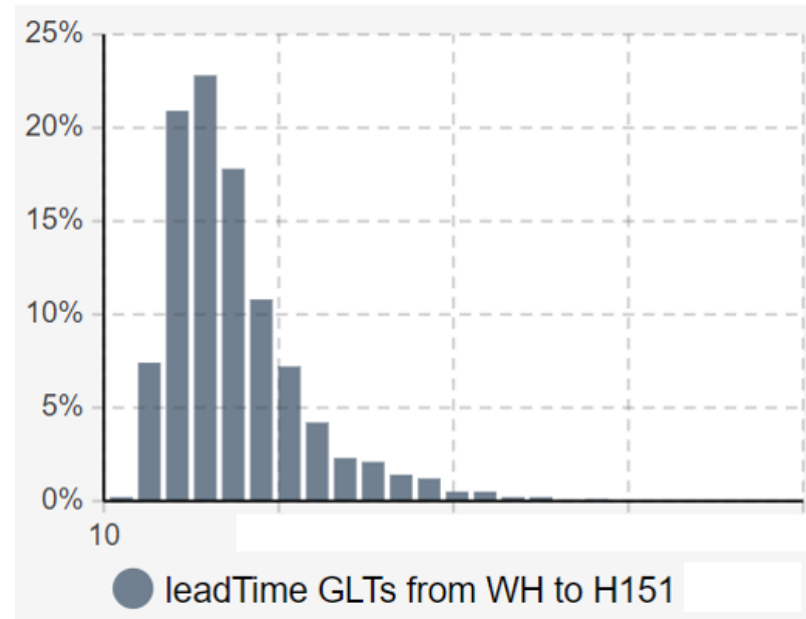
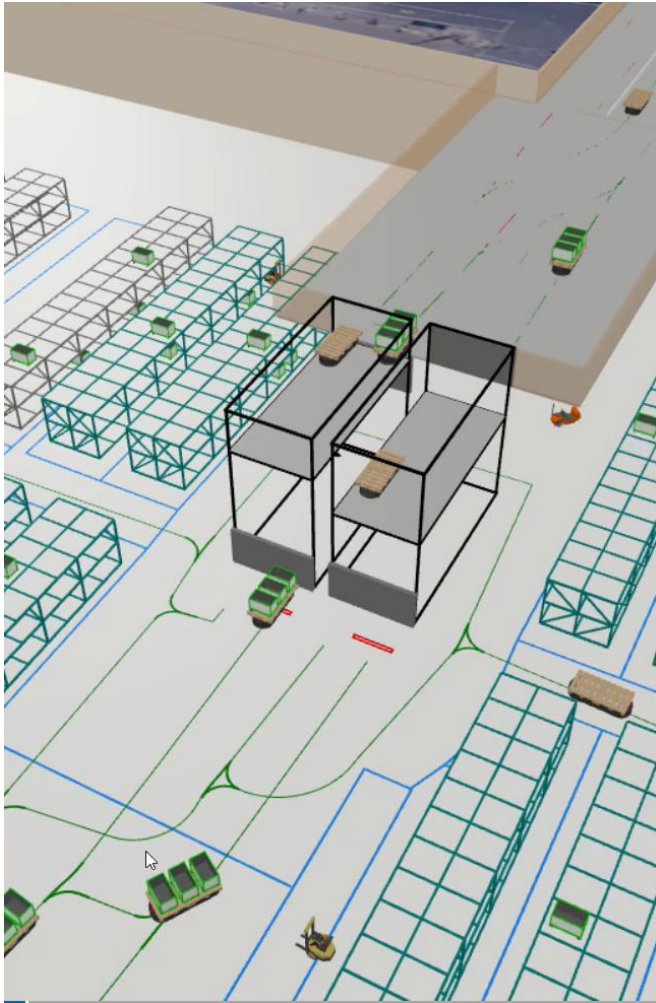
We found that door opening times have a significant impact on lift utilization.

→ Recommendation was to clarify as early as possible with supplier, if expected door opening times can be reached.





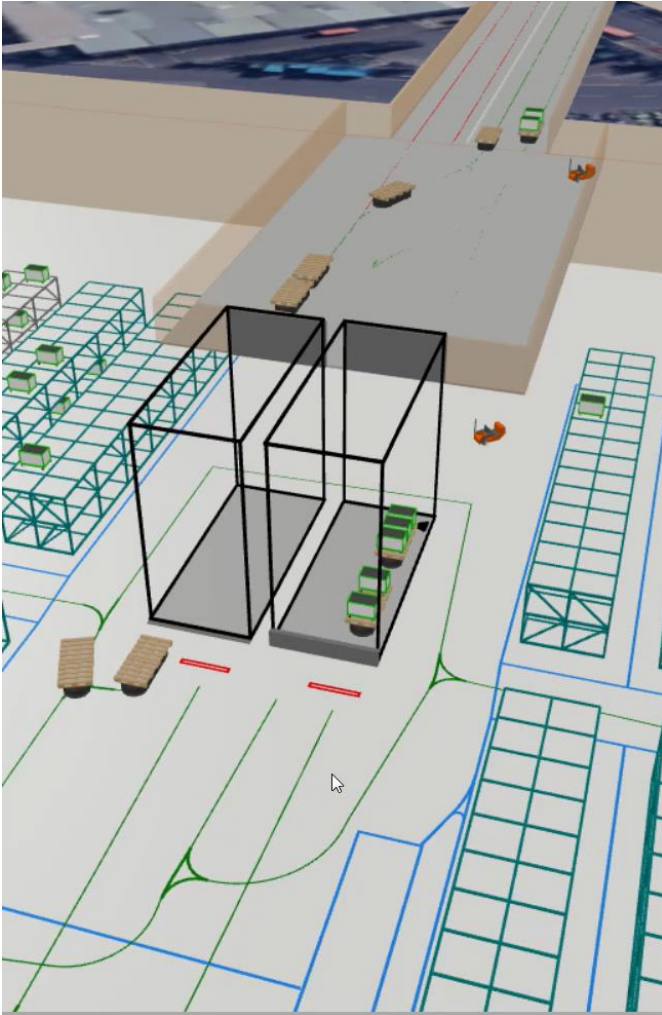
Lift Analysis: Example - Two bidirectional Double-Lifts



- Lifts have 15% idle-Time and are only half loaded 75% of the time
→ Inefficient, but most secure process
- Lift breakdowns can be fully compensated by second lift even for longer breakdown periods
- Shortest Average Lead-Time (X min)
- Most expensive Scenario
- Crossing AGV Tracks

Lift Analysis: Further Scenarios

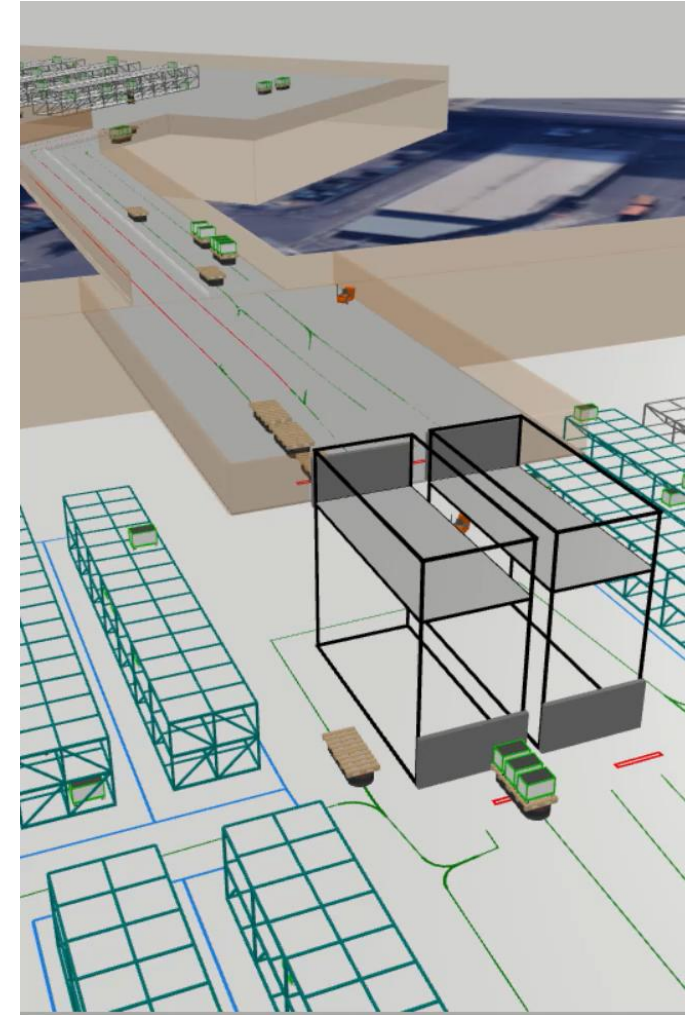
Two unidirectional double lifts



Two bidirectional single lifts



One bidirectional double lift





Iteration 2: Comparison of all lift options

Final recommendation based on five different aspects

Scenario	Utilization	Breakdown Compensation	Lead-Time	No crossing AGV Tracks	costs (expect.)
1) Two Bi-Directional Double Lifts	✓	✓	✓	✗	✗
2) Two Uni-Directional Double Lifts	0	0	0	✓	0
3) Two Bi-Directional Single Lift	0	0	✓	✗	0
4) One Bi-Directional Double Lift	✗	✗	0	✓	✓

✓ low risk or good

✗ risky or bad

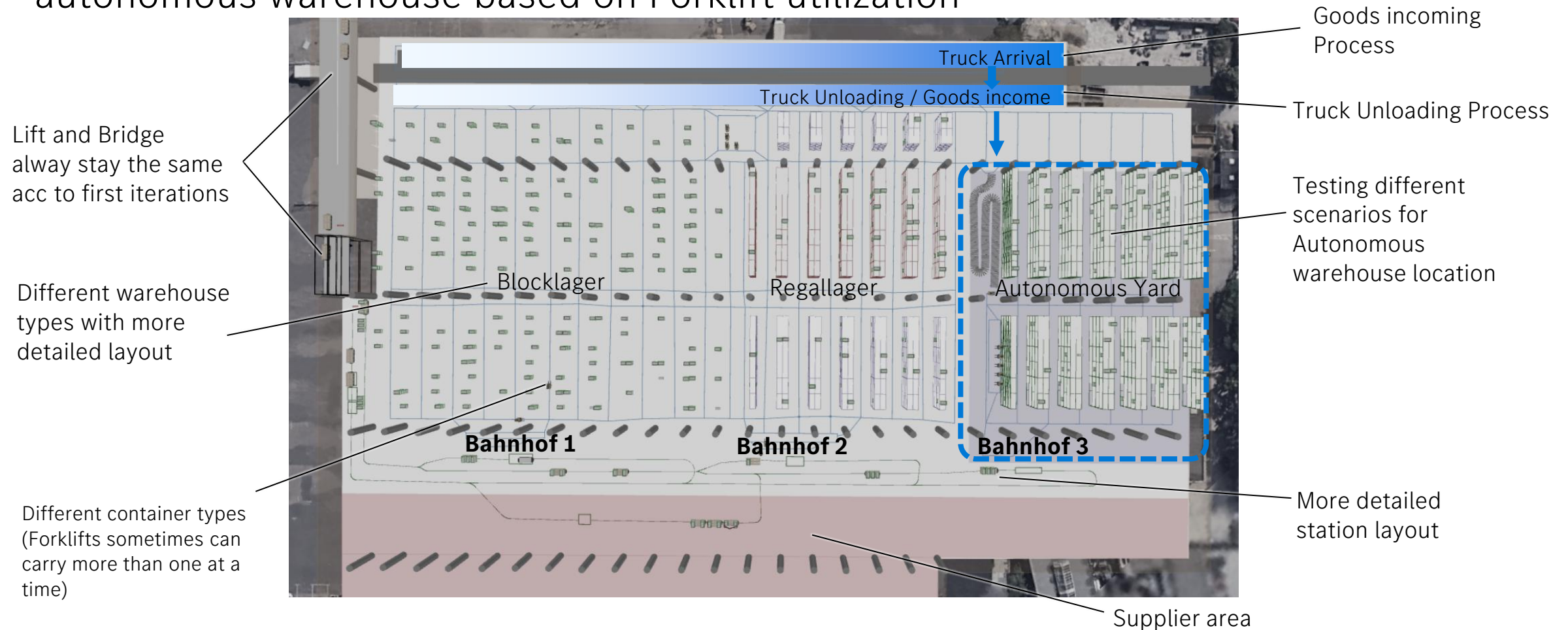
0 neutral

Summary and Recommendation:

- All scenarios generally worked but Scenario 4) was not recommended due to a very high utilization and a big risk in case of failures
- Scenario 1) was the safest version and was preferred, if price similar to other scenarios
- Scenario 2) and 3) are equally feasible from a throughput perspective. 3) had better lead-time but 2) has the advantage of no crossing AGV-Tracks

Fast Forward...

3rd and 4th iteration – choosing best rack orientation and best location for an autonomous warehouse based on Forklift utilization



Versioning and collaboration

Git is used to avoid version chaos and keep control with different scenarios

Repository: W065_PCC-H151_Bridge	
Id	Message
aa481c2	quotation of 80/20 with and withouth automatic glts implemented
3102897	started with new 80/20 Truck assignment logic. Batching needs refactor
f927641	non-stable: layout adjusted and storage distribution implemented
9eee942	non-stable: remodeled to new layout
26ac3f7	non-stable: changed block-storage with regular and
36d58b0	adjusted run config
71bed82	V9.1.1 manualStorage adjust fleed capacity inbound to 8
cfadd46	adjust run config
c525cab	adjusted fleet sizes for testing
388dafc	prepared for experiment
1d43f77	Manual Storage implemented
a436bbb	yard moved to the middle
6ee5d63	9.1.3 origin/dev_auto... changed layout so that AY is on top
1642c38	9.1.2 moved autonomous yard to middle and added conveyors
c329f6d	Lifts now have a home position where they return to
d884a30	included output file generation for fleet utilizations
dfa2294	adjusting Truck arrival lane
cd1baeb	added names to nodes and adjusted run-config plus parameter assignment
641cf81	V9.0 introduced stats reset, increased inbound fl fleetsize to 8

Example:

- Creating new branch for testing a specific scenario (here: manual Storage)
- After scenario has been tested. If we do not follow-along with a specific scenario, the branch is not further developed and eventually delted

- Version naming convention:

- Major update, always merged to Master branch
- Minor update, usually only in dev_branch
- Comparison of different scenarios

9.1.2

Versioning

Alignment of Anylogic Cloud and GIT

- Versions, that are published in cloud, get a GIT tag
- Versions in AL-Cloud get the Version name
- Description field in AL-Cloud is used to describe main updates for end-user

Id	Message
946b290	improved Truck Arrival by use of road traffic library
563465b	improved truck unloading
9104782	non-stable: Truck unloading under development
7068add	reorganized Truck inbound streets, not working
485984c	debug arrival statistics
156a746	smaller adjustments. Arrival statistics not going
dcd9a74	Truck Process drafted
db3f3b9	implementation of storage systems
95079c5	update to Version 8.9.5
6dbbf3e	model made ready for cloud
6e30d82	V6.4 no changes
902895e	option for unidirectional lifts included
22a218d	V6.3 adjusted run configuration
24c2309	Included option to activate and deactivate double lifts and no lifts
037d12a	Refactoring LiftStatechart and ProcessFlow complete, stats open
369a85f	Statechart in rebuild
2c5df1d	started refactoring statistics
fbbc6e9	Include Lift Control Agent in Markup. Improved Failure behaviour.
63a4208	improved liftMarkup: id now set automatically
c26cabf	Sensitivity Analyse hinzugefügt
f116fb3	some layout improvements performed
ebce63c	bug-fix: non-reproducible runs
40c70fd	V6.2 added agv buffer statistics
80ca611	added agv Buffer statistics
59ec28e	fixed omniverse presentation bug in unloading H151

The screenshot displays the Anylogic Cloud interface for the project 'W065_VANEA_pccBridge'. The interface is divided into two main sections: a version list on the left and a detailed view of a selected version on the right.

Version List (Left):

- + New experiment
- V6.4** (6 months ago)
- Experiment Johannes Simulation
- Experiment Simulation
- Impact of AGVs Repl... Variation with replications
- + New experiment
- V6.2** (7 months ago)
- + New experiment
- V6.1** (7 months ago)
- + New experiment
- V6.0

Version Details (Right):

The detailed view for version V6.4 shows a video thumbnail with a play button and 708 views. Below the video are social media sharing icons (Facebook, Twitter, LinkedIn, etc.).

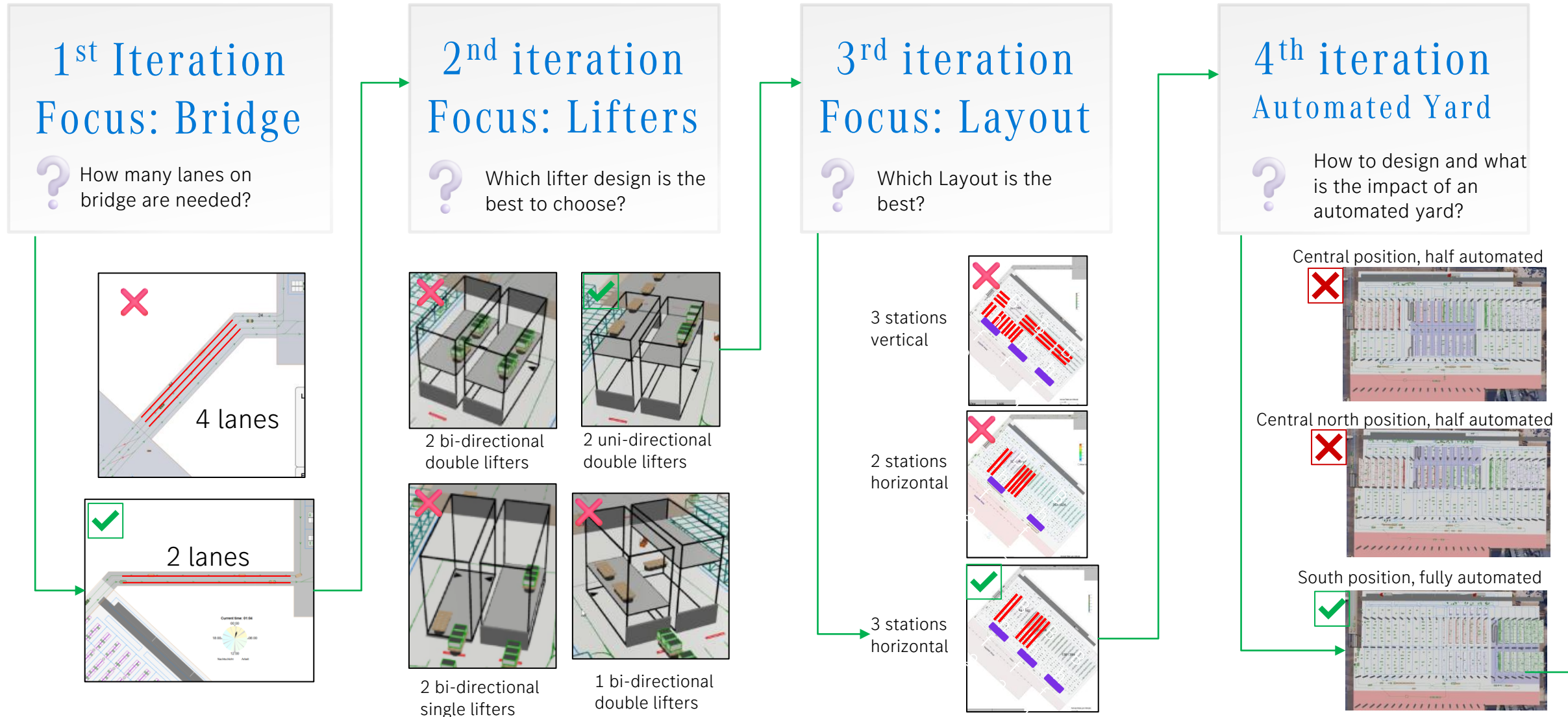
Description:

- V6.4 include option to use unidirectional lifts
- V6.3 include option to use 1 or 2 lifts, activate or deactivate double lifting, improved lift statistics (incl door and loading operation) reorganized Parameters
- V6.2 lifts only operate if exit is free, added agv buffer stats, further bug fixing of lifts stopping in certain situations
- V6.1 Bug fix lift stops after breakdowns
- V6.0 double lift included
- V5.0 Pallet pickup logic adjusted and shift schedule implemented
- V4.1 improved statistics overview

Metadata Fields:

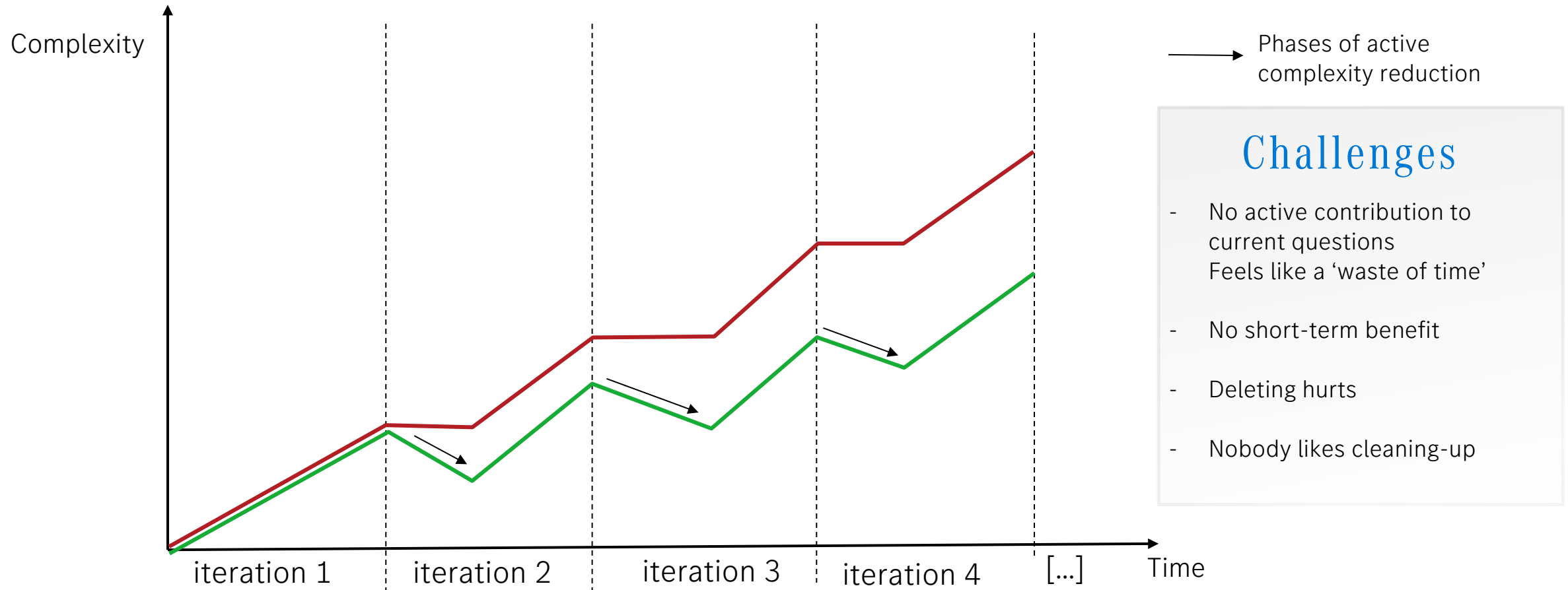
- Model name: W065_VANEA_pccBridge
- Categories: Transportation and Logistics
- Application areas: (empty)
- Simulation methods: Agent Based, Discrete Event
- Tags: (empty)

Looking Back: Decisions after each Iteration



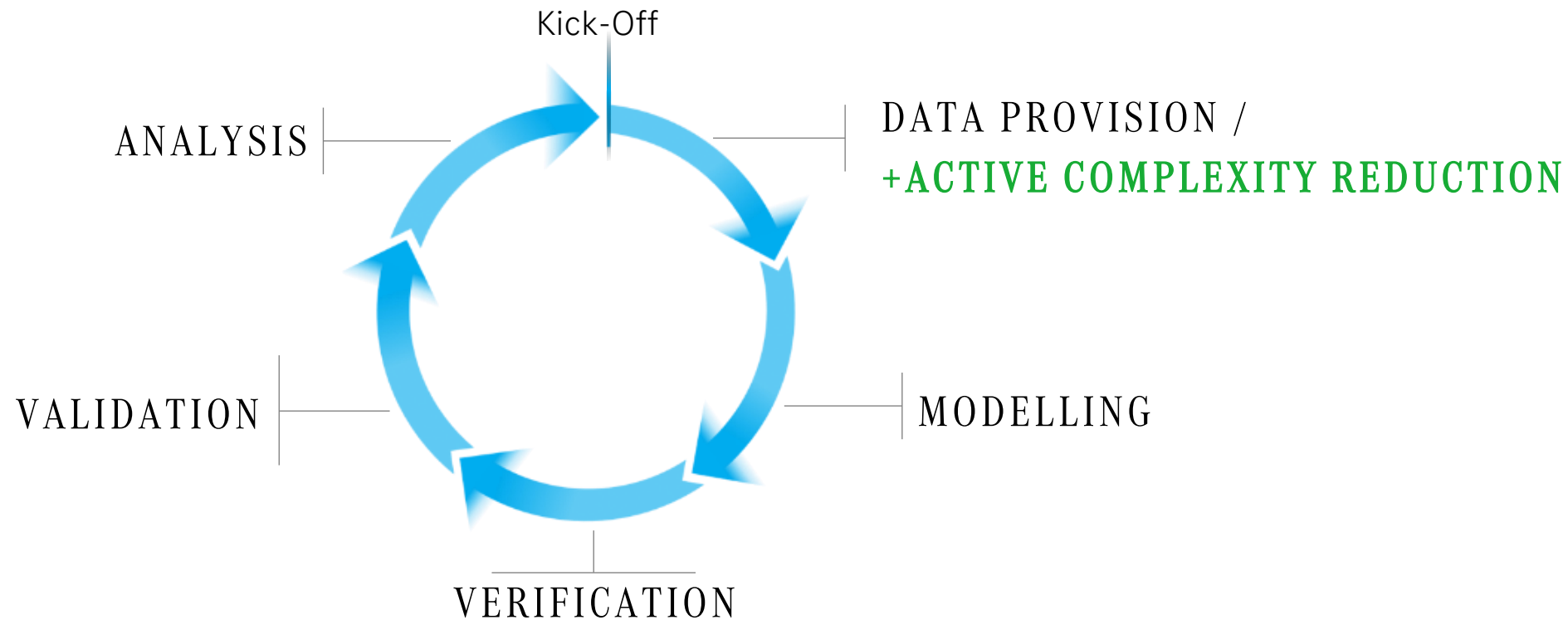
Trying to avoid constantly increasing complexity of model

It feels natural to simply add more and more functions to a model



Data Provision Phase can be used for Active Complexity reduction

Getting rid of stuff that is not needed in the next iteration



Further Iterations

5th Iteration:
Station-logic +
Number of AGVs

finished April 2025

- Refine the station concept
- Find out necessary number of AGVs

6th Iteration:
Number of
Automatic Forklifts

finished Aug 2025

- Find out number of autonomous Forklifts in automatic warehouse

7th Iteration:
Number of
sequence AGV

work in progress....

- Find out number of AGVs for sequence delivery

8th Iteration
tbd...

outlook

- Impact of Traffic from logistics hall to production hall



New Model

Construction Site Traffic Simulation



finished



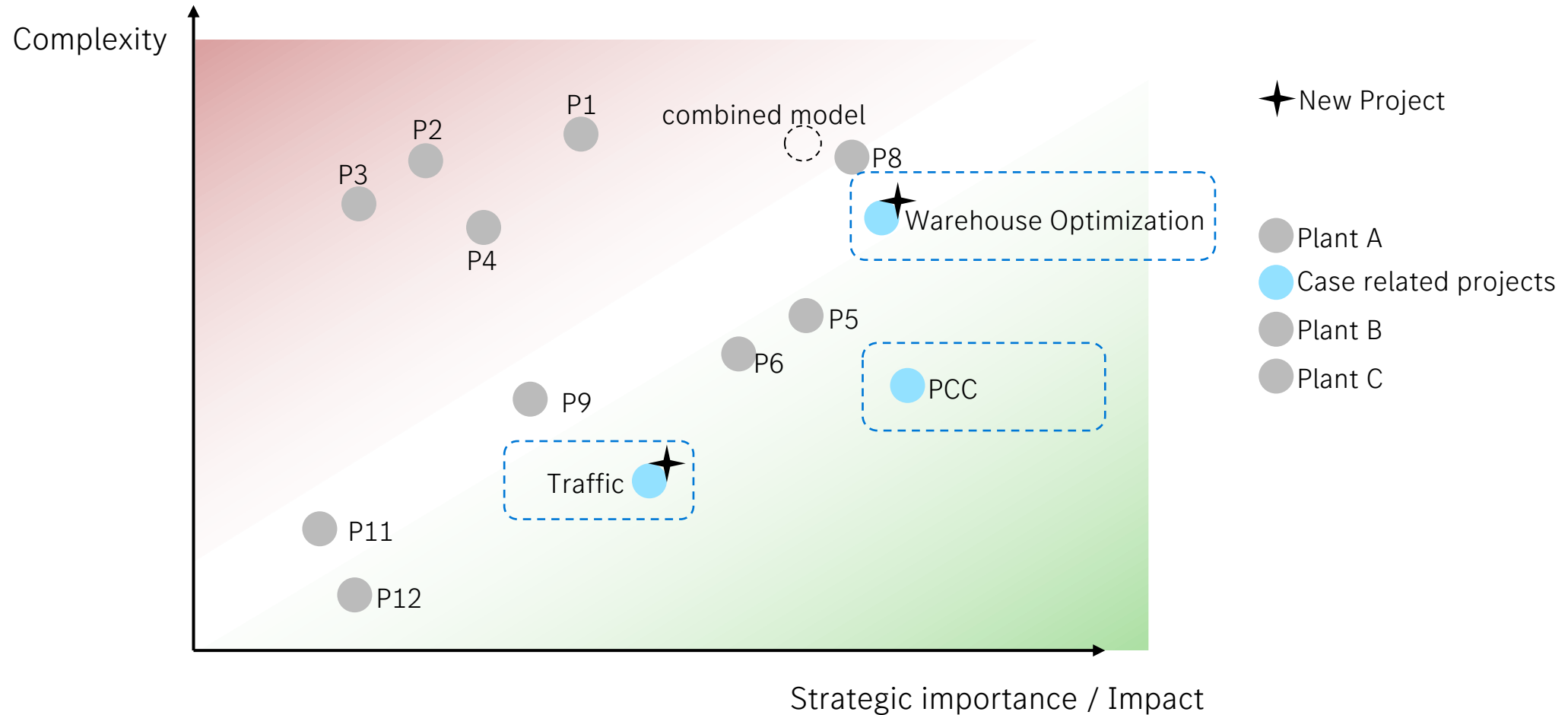
New Model

Warehouse optimization (*Machine Learning*)



Impact of having 3 specified models instead of one

better 3 models in green zone, than one model in red zone



Thank you!



Presenter:

Robert Aschenbrenner

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Mercedes-Benz AG

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