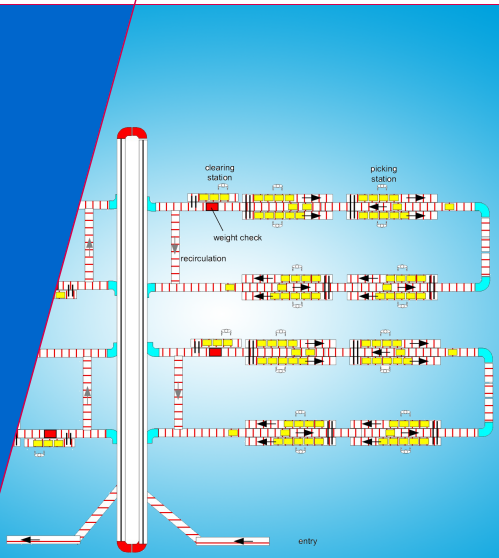
Queueing Theory

Ivo Adan



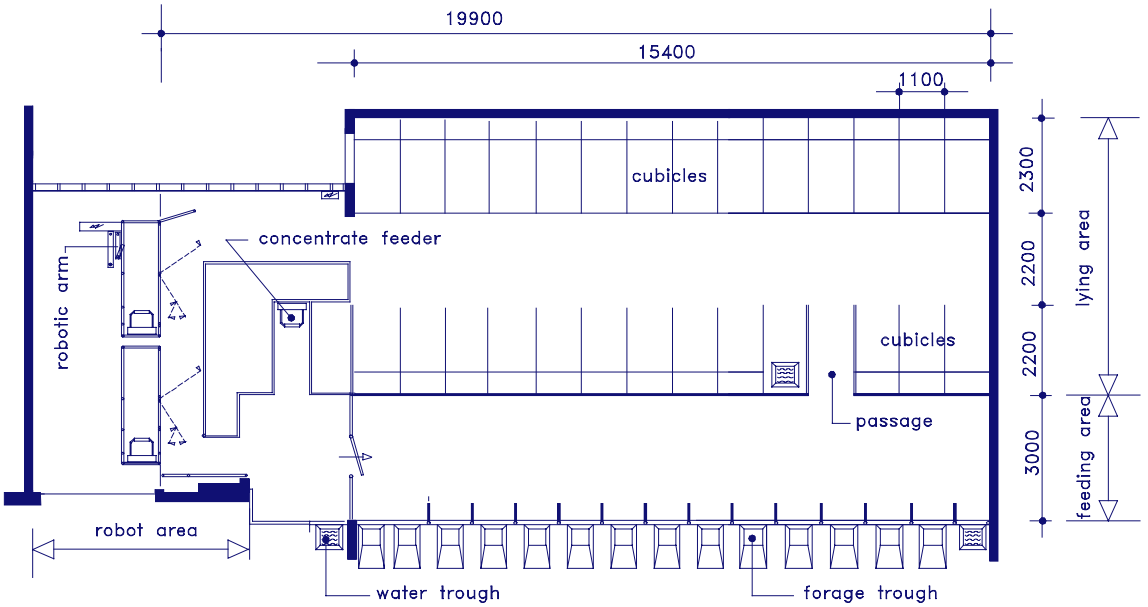
TU/e
Technische Universiteit
Eindhoven
University of Technology

KIVA Systems

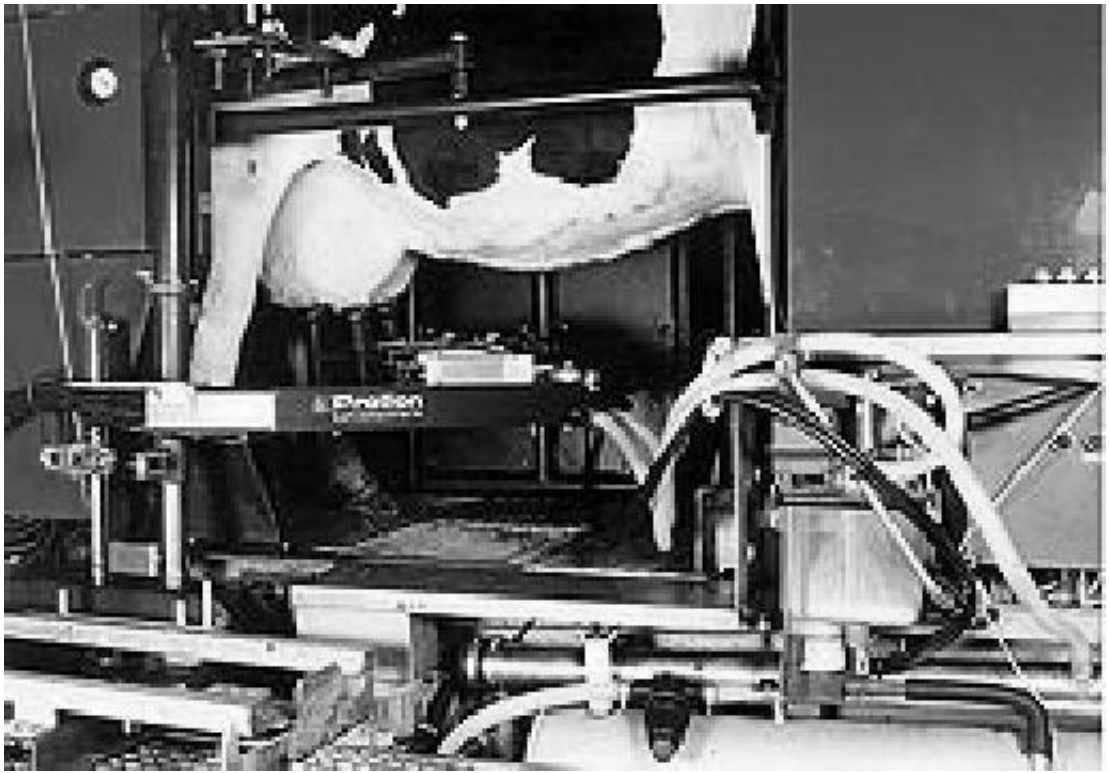
KIVA robot

KIVA warehouse

Robotic Dairy Barn



Milking Robot

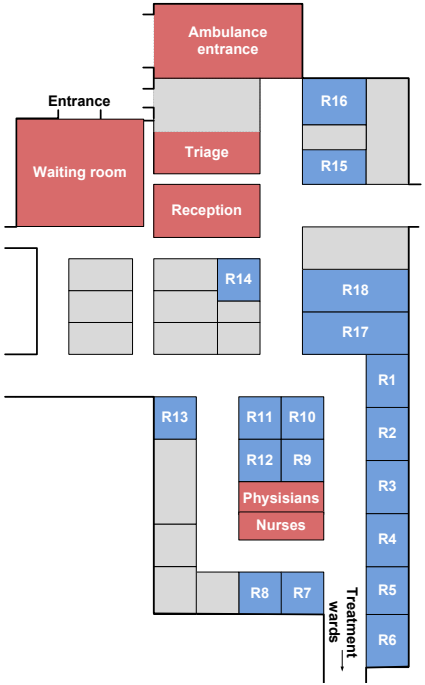


How to design a robotic barn?

Emergency Department

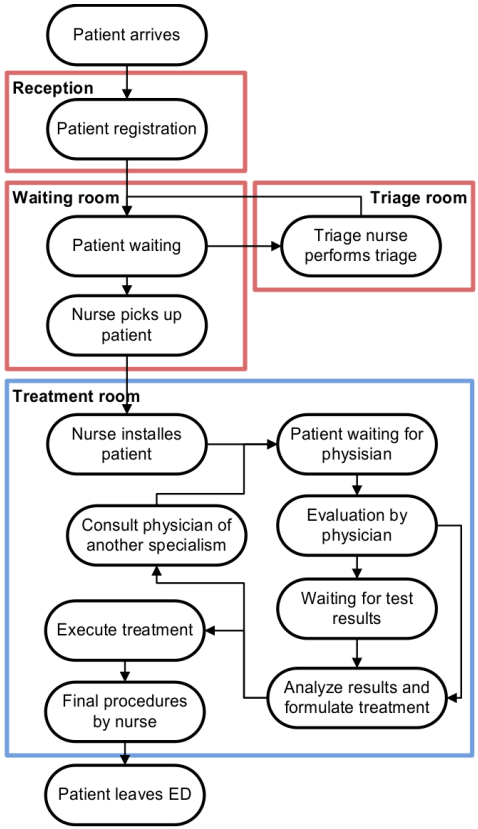
Emergency department (ED) of Catherina Hospital Eindhoven

Emergency Department



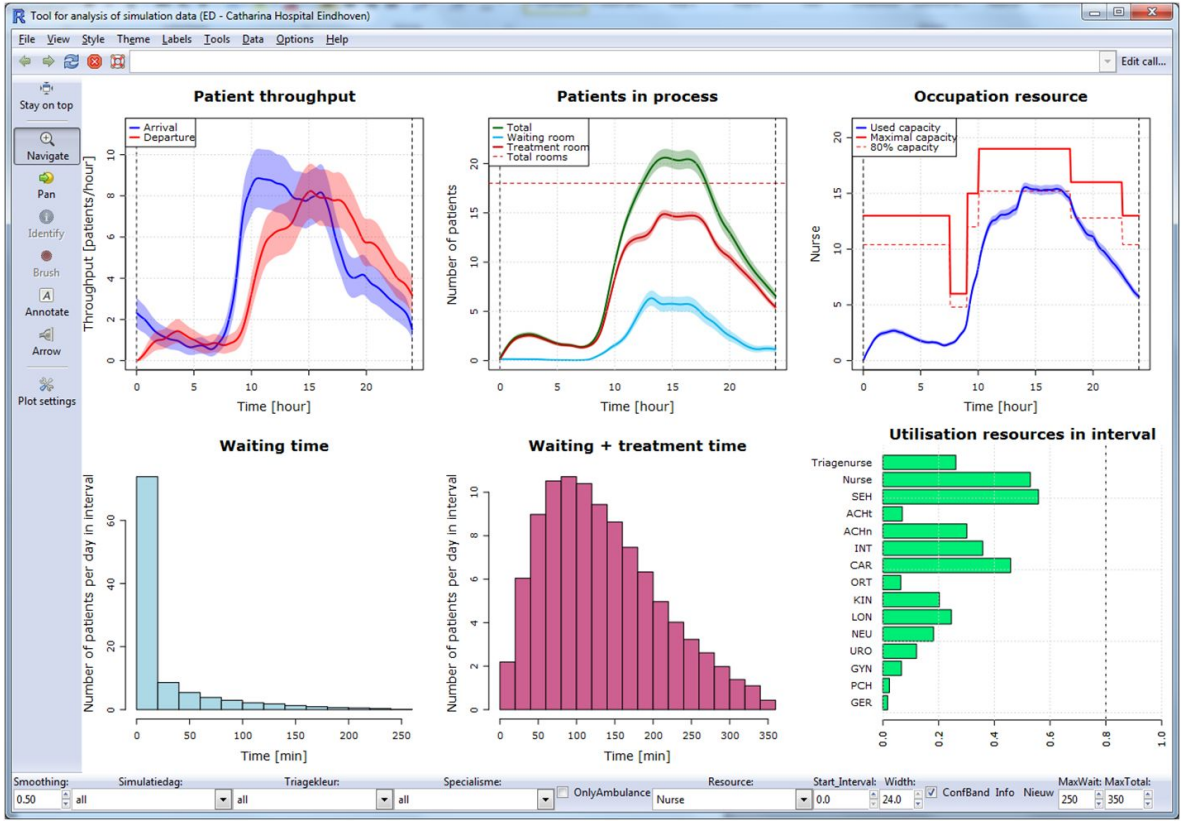
Layout of ED

Emergency Department



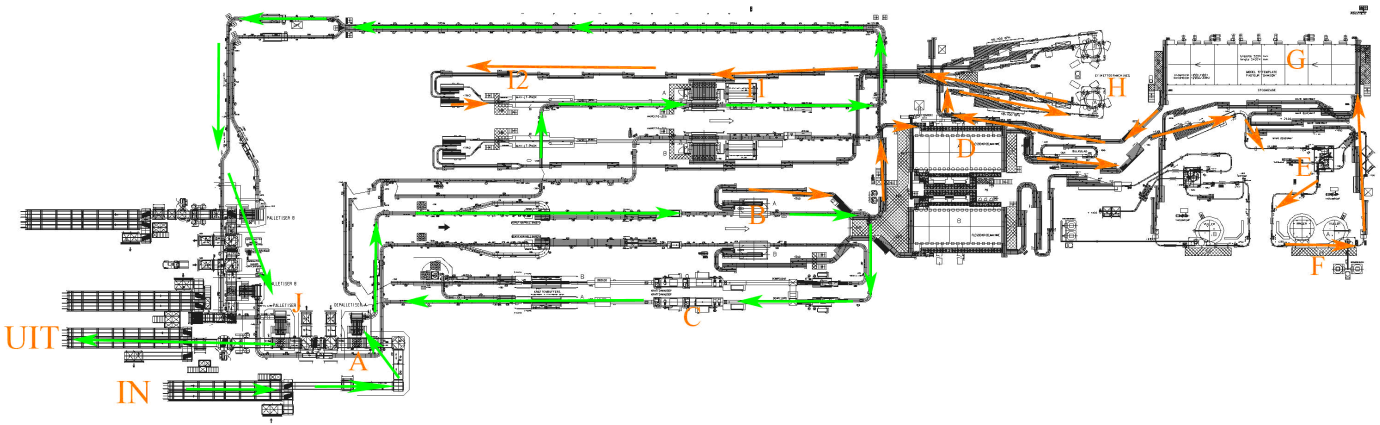
Patient flow through ED: How to improve efficiency?

Emergency Department



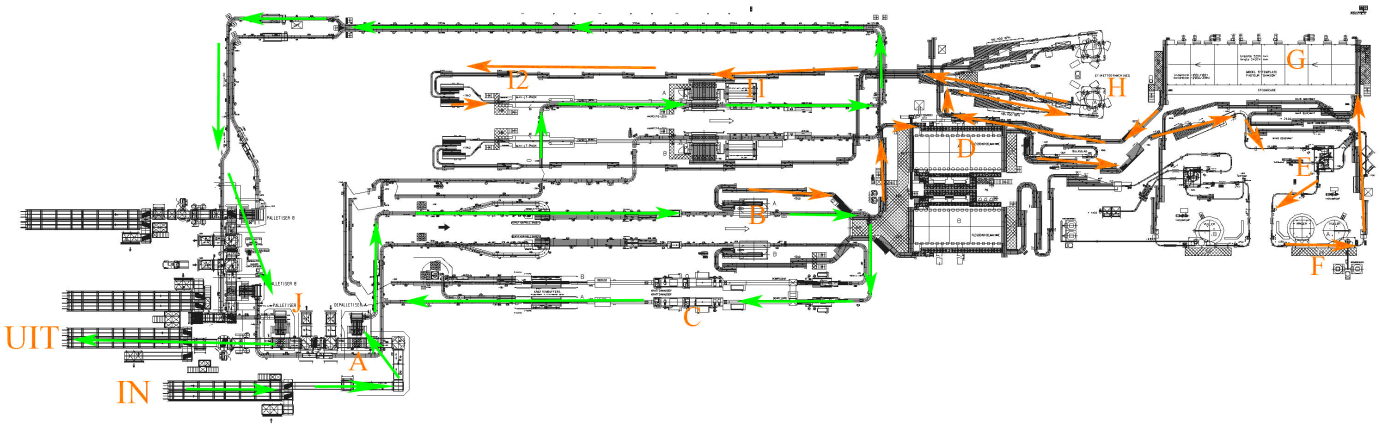
Snapshot output of queueing model

Heineken Bottleline



A. Depalletizer unloads pallets;
logo-detection selects crates to be washed (C).

Heineken Bottleline



A. Depalletizer unloads pallets;
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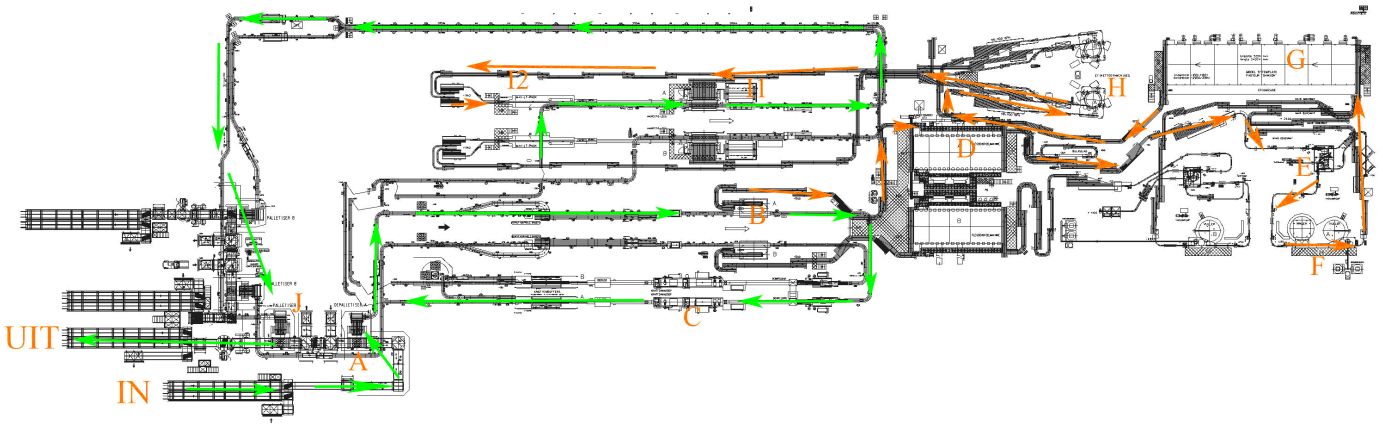
Heineken Bottleline



A. Depalletizer unloads pallets;
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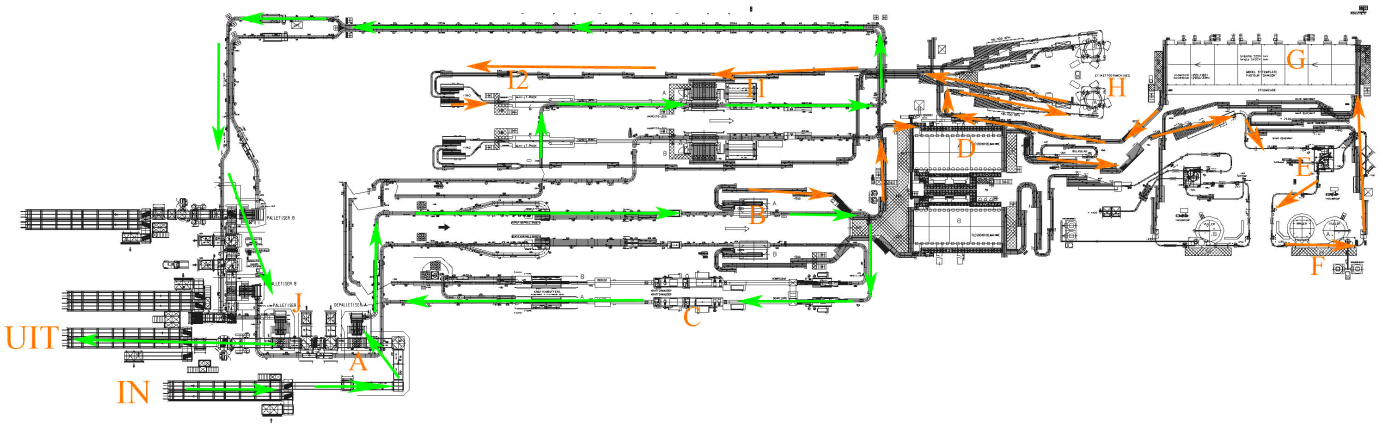
C. Empty crates are being washed.

Heineken Bottleline



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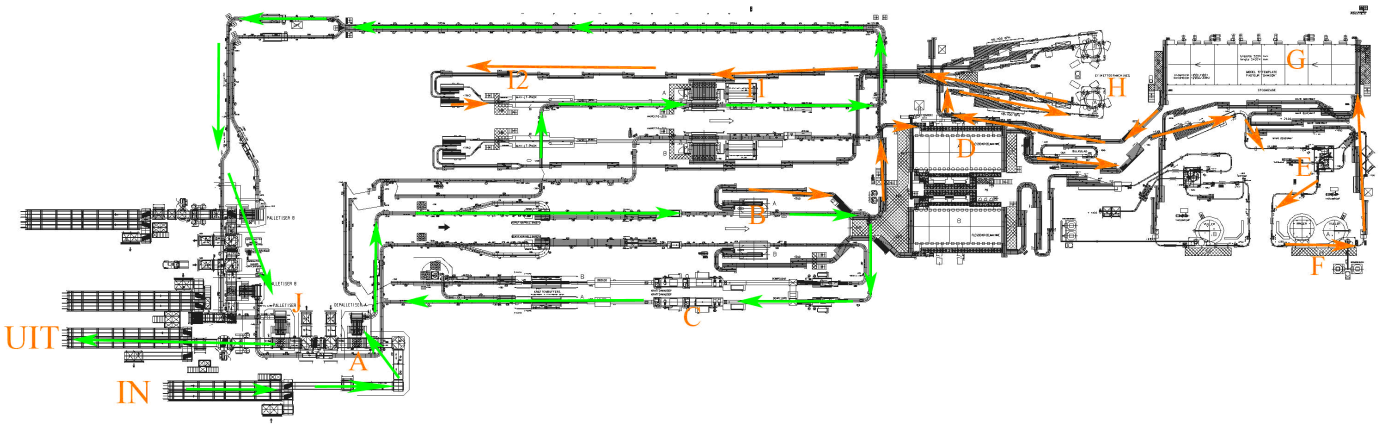
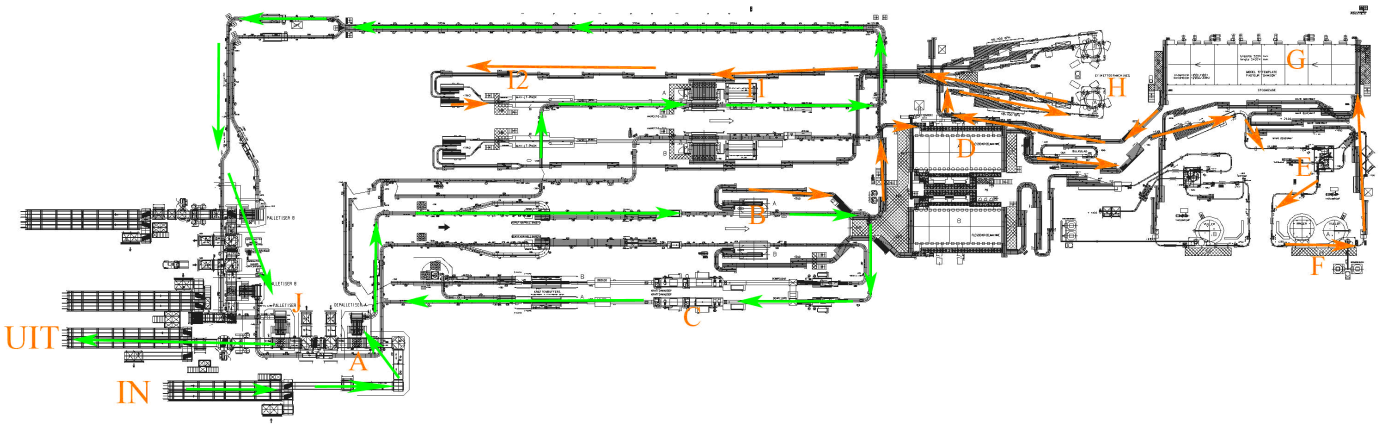
D. Empty bottles are washed by washing machine.

Heineken Bottleline



E. Empty Bottle Inspector (EBI) checks bottles for cracks.

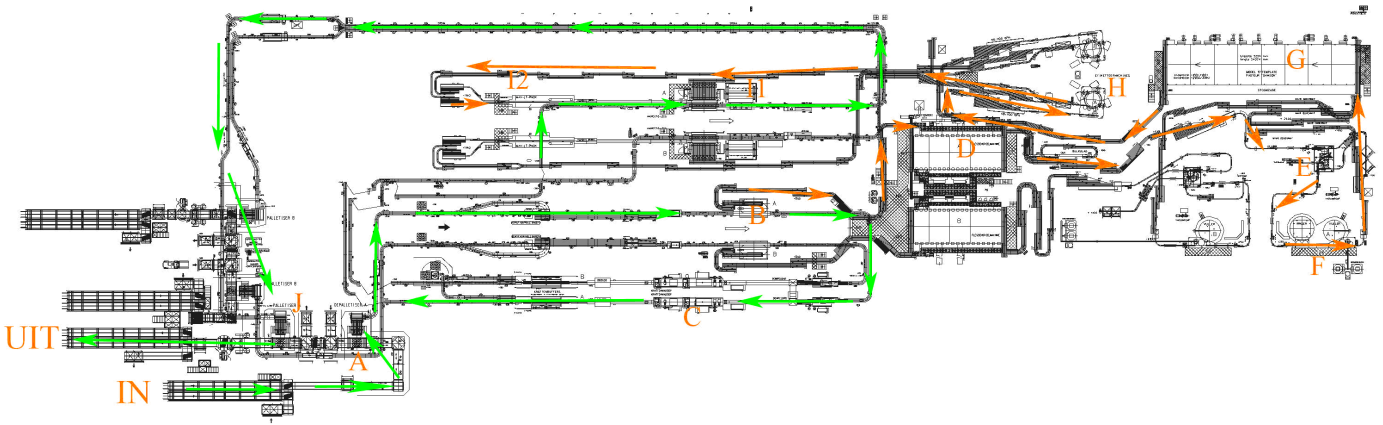
Heineken Bottleline



E. Empty Bottle Inspector (EBI) checks bottles for cracks.

F. Filler is a carrousel filling bottles at high speed (more than 10 bottles per second!).

Heineken Bottleline



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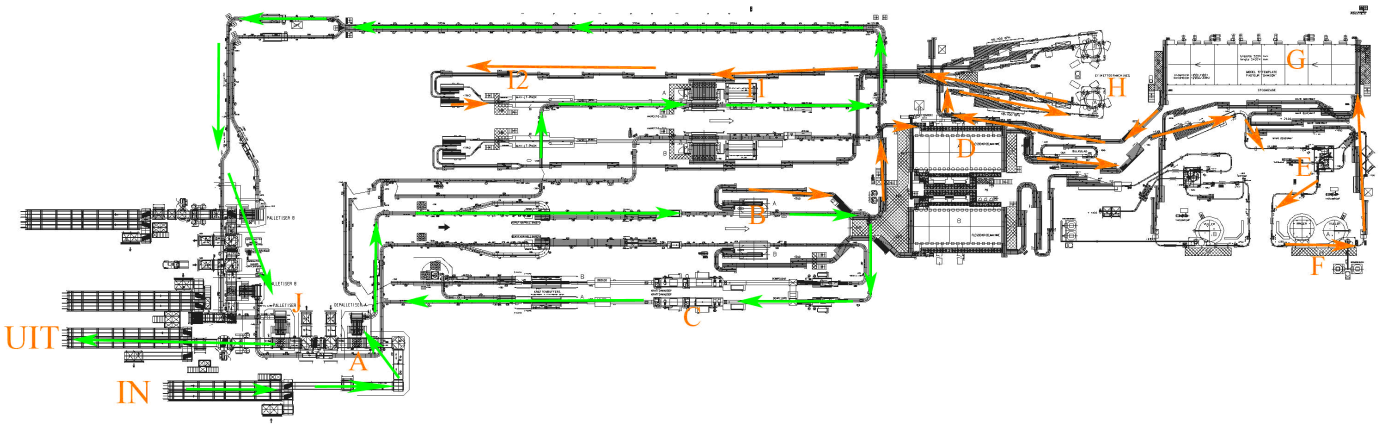
G. Bottles are heated by pasteuriser up to 60^{o} Celsius.

Heineken Bottleline



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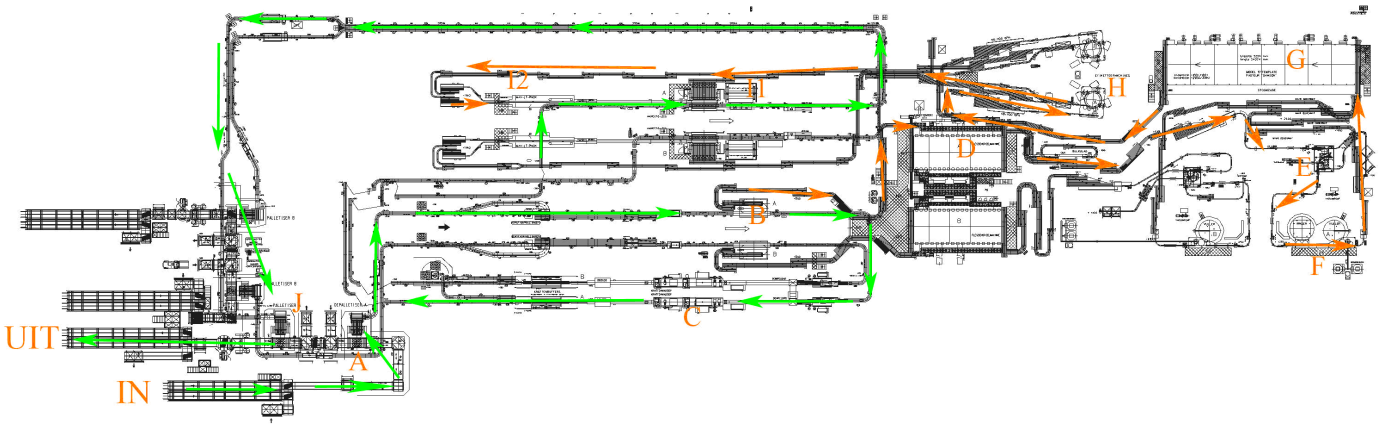
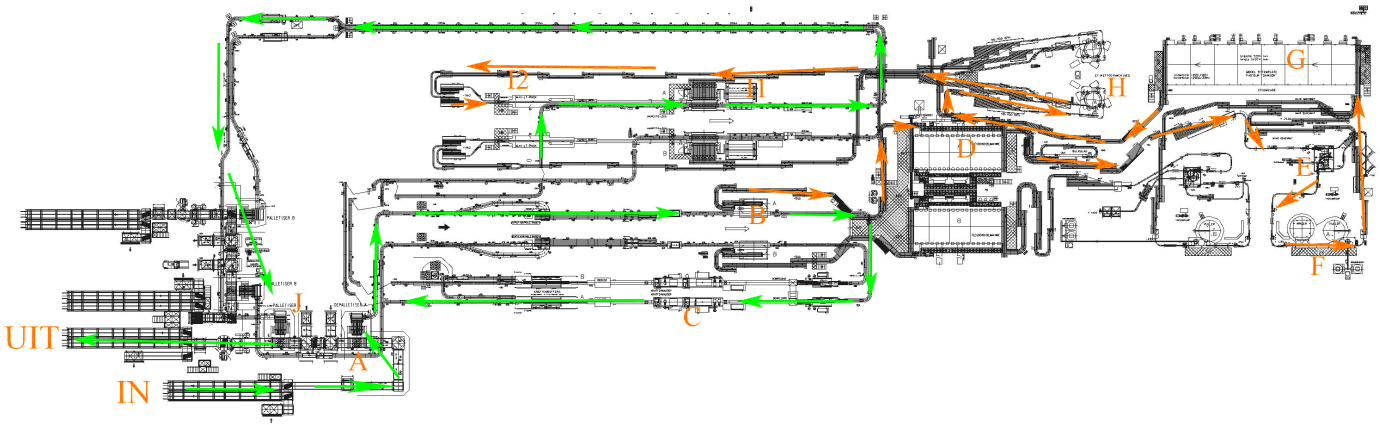
H. labeler puts labels on bottles.

Heineken Bottleline



I1. Bottles are ready and put in crates by packer I1.

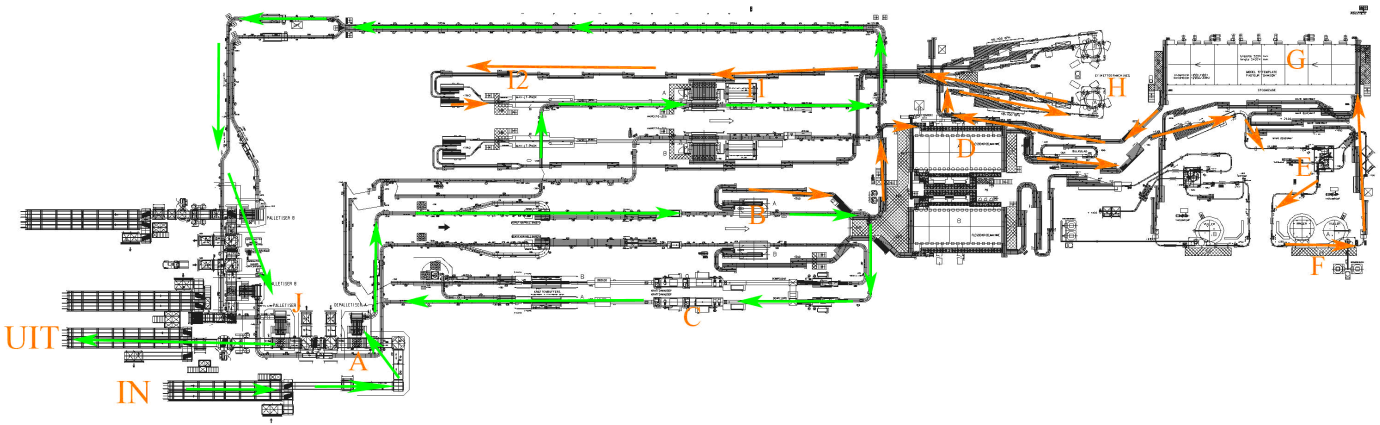
Heineken Bottleline



I1. Bottles are ready and put in crates by packer I1.

I2. Or bottles are six-packed by packer I2.

Heineken Bottleline



I1. Bottles are ready and put in crates by packer I1.

I2. Or bottles are six-packed by packer I2.

J. Cratemanco checks bottles in crates, and finally palletiser puts crates on pallets.

Heineken Bottleline

The filler: a carrousel filling bottles at high speed

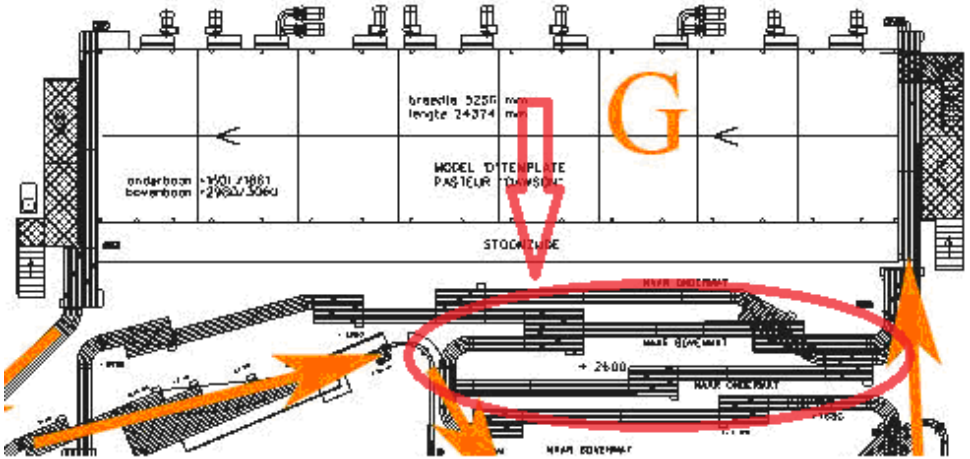
Heineken Bottleline

Conveyor system: transportation and buffering

Heineken Bottleline

More than hundred meters of conveyor belt:

Isn't this too much?



U-turn between filler and pasteuriser

Heineken Bottleline

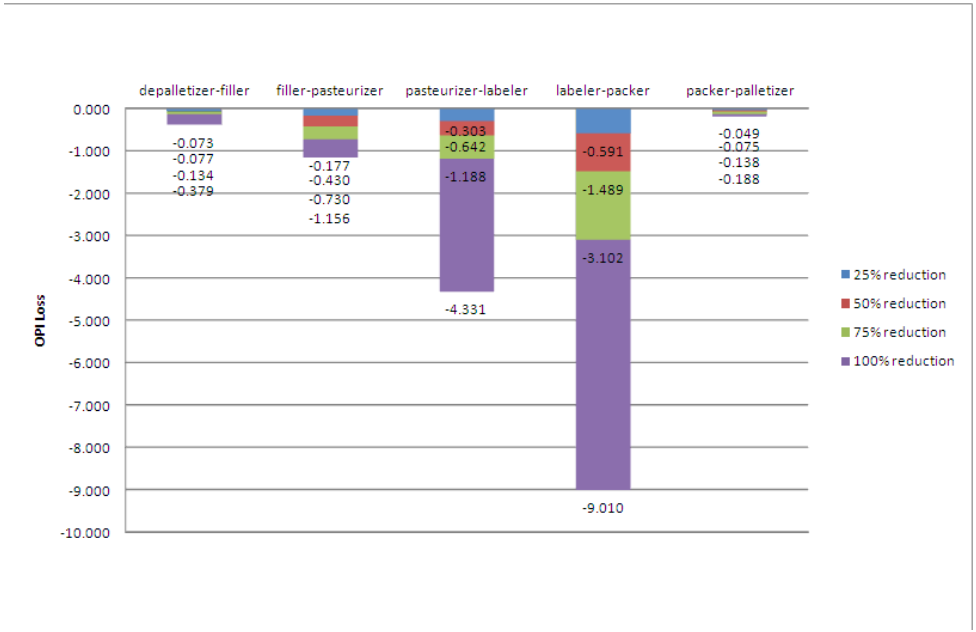
High speed production of bottles justifies:

Fluid flow model with unreliable machines.

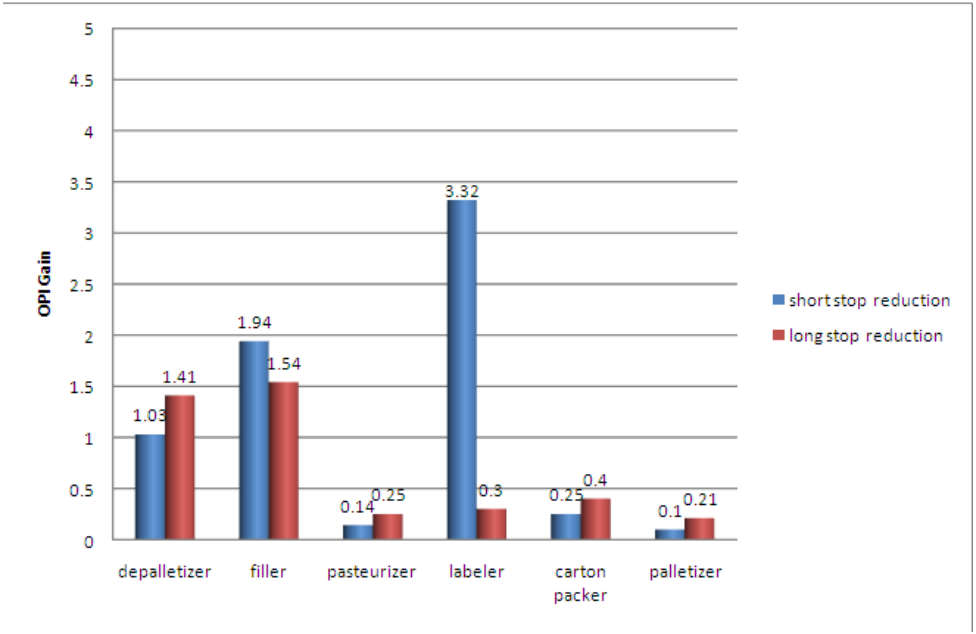
Requires:

- Machine speeds;
- Up time durations;
- Down time durations;
- Buffer capacities.

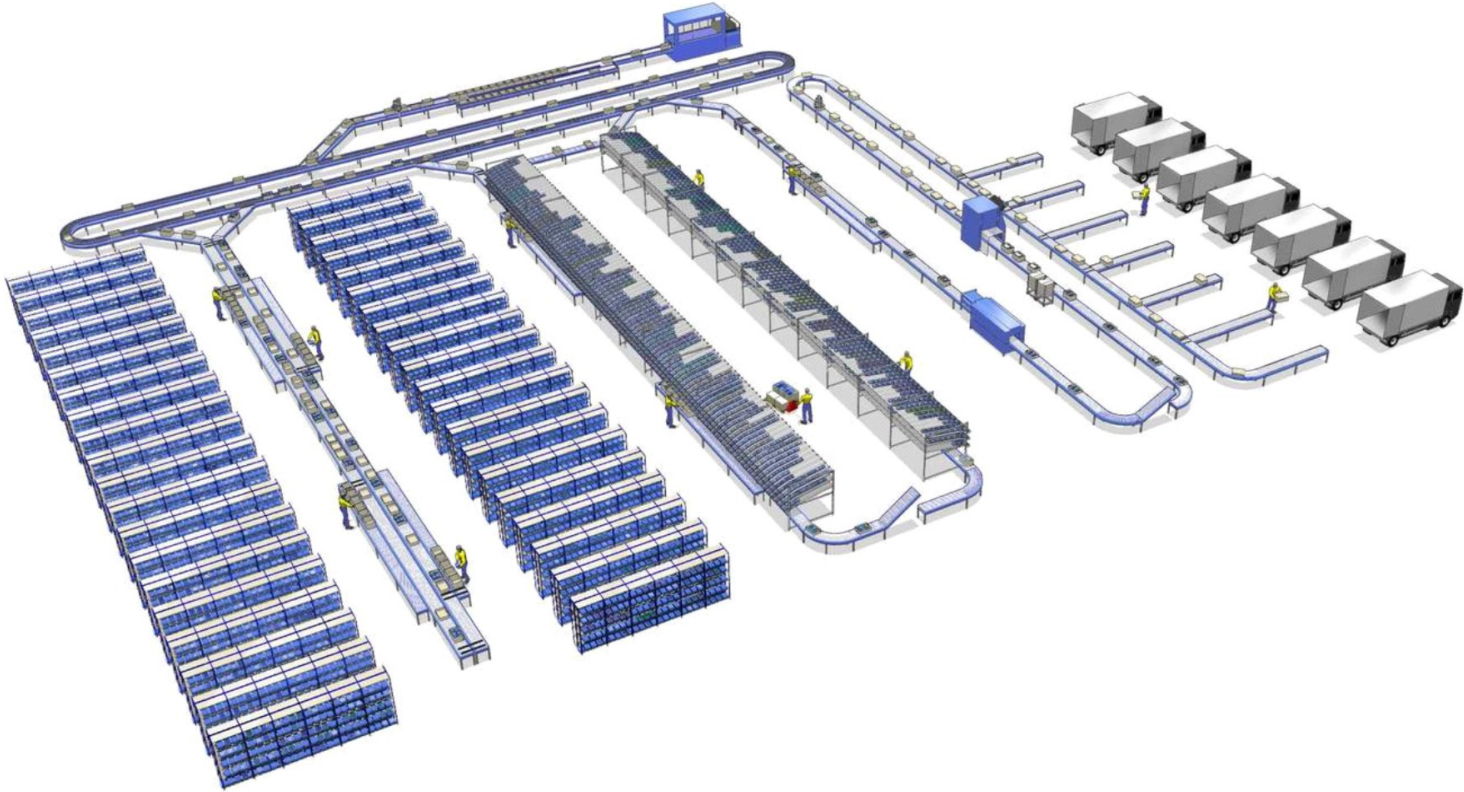
Heineken Bottleline



Heineken Bottleline



Zone-Picking Systems



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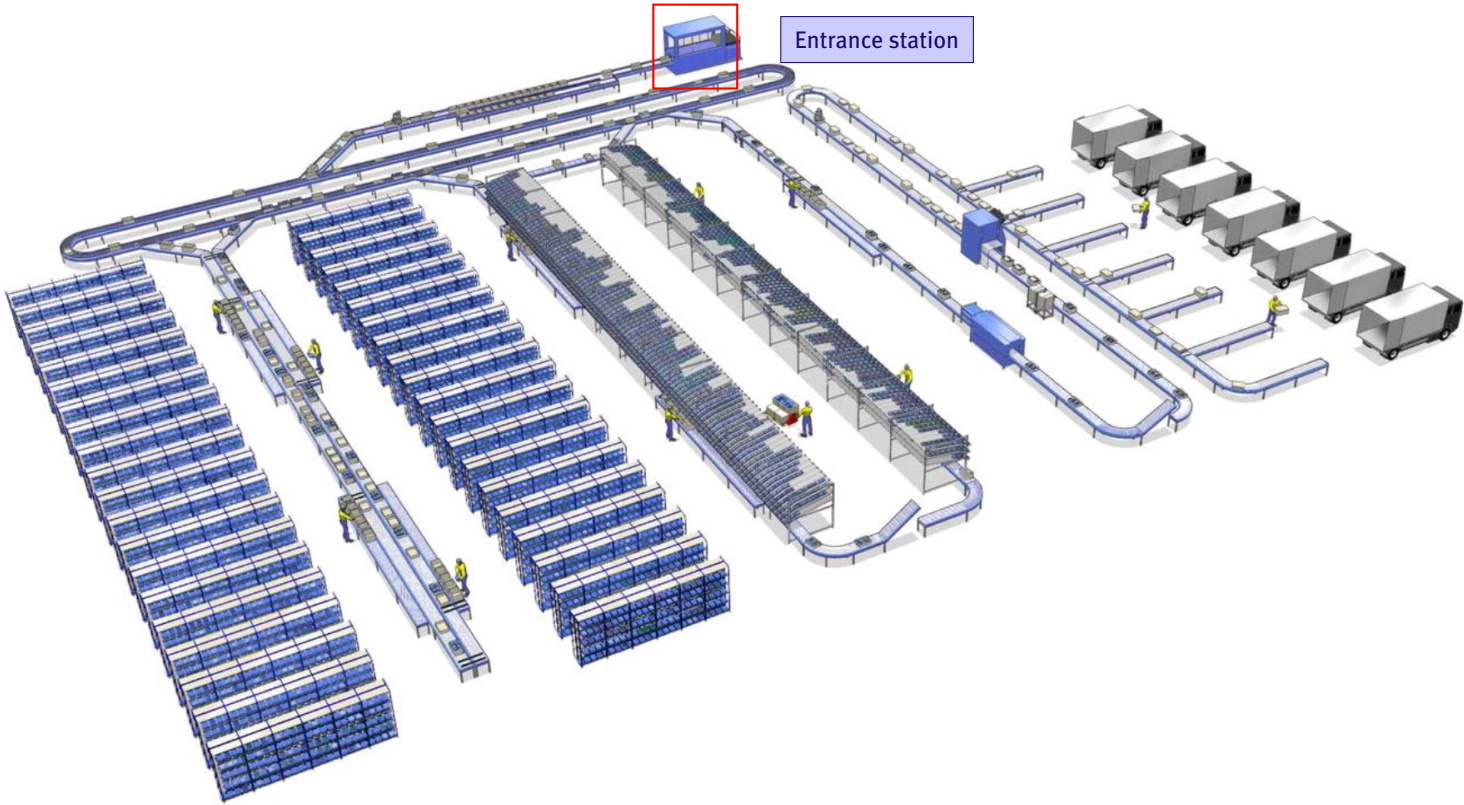

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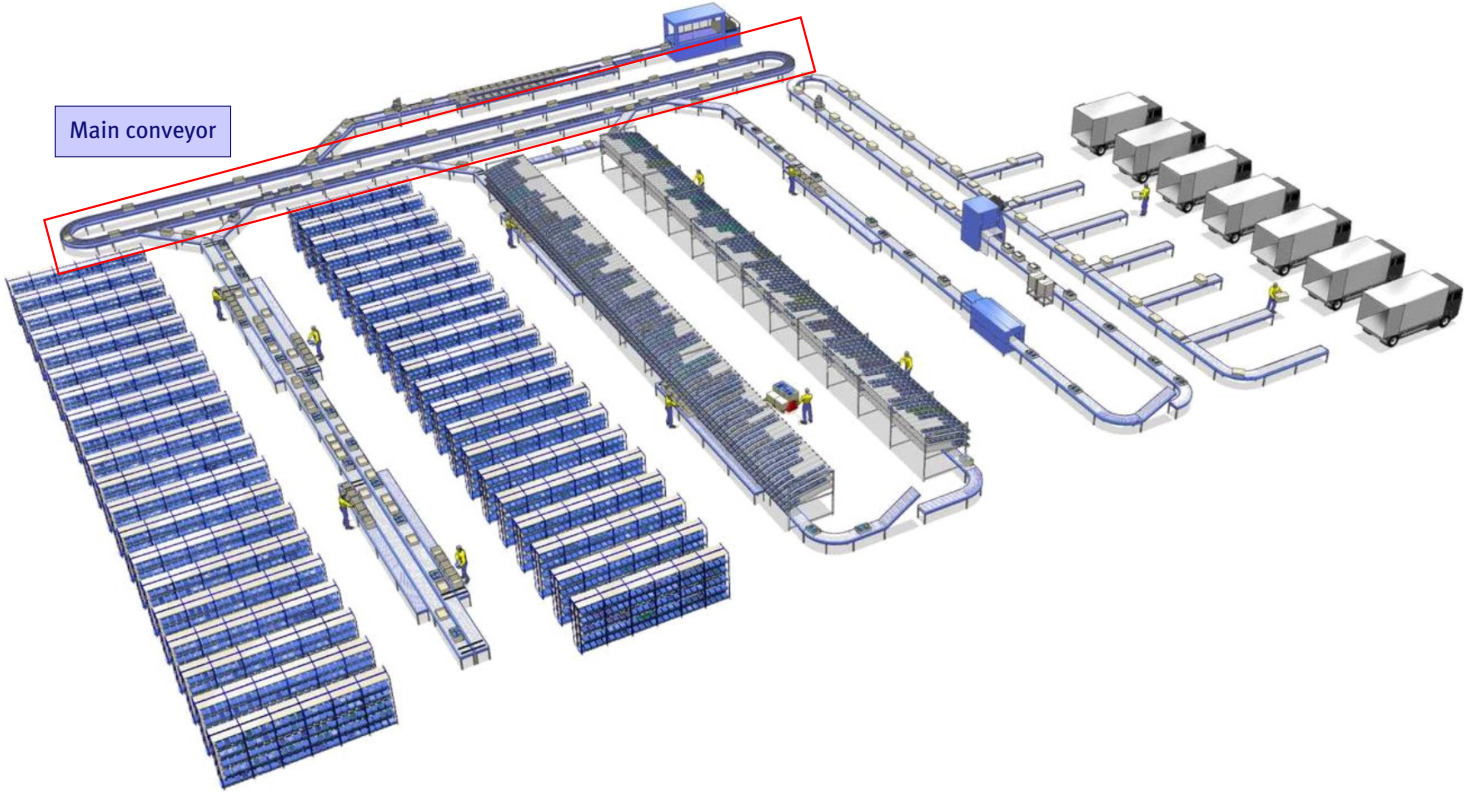

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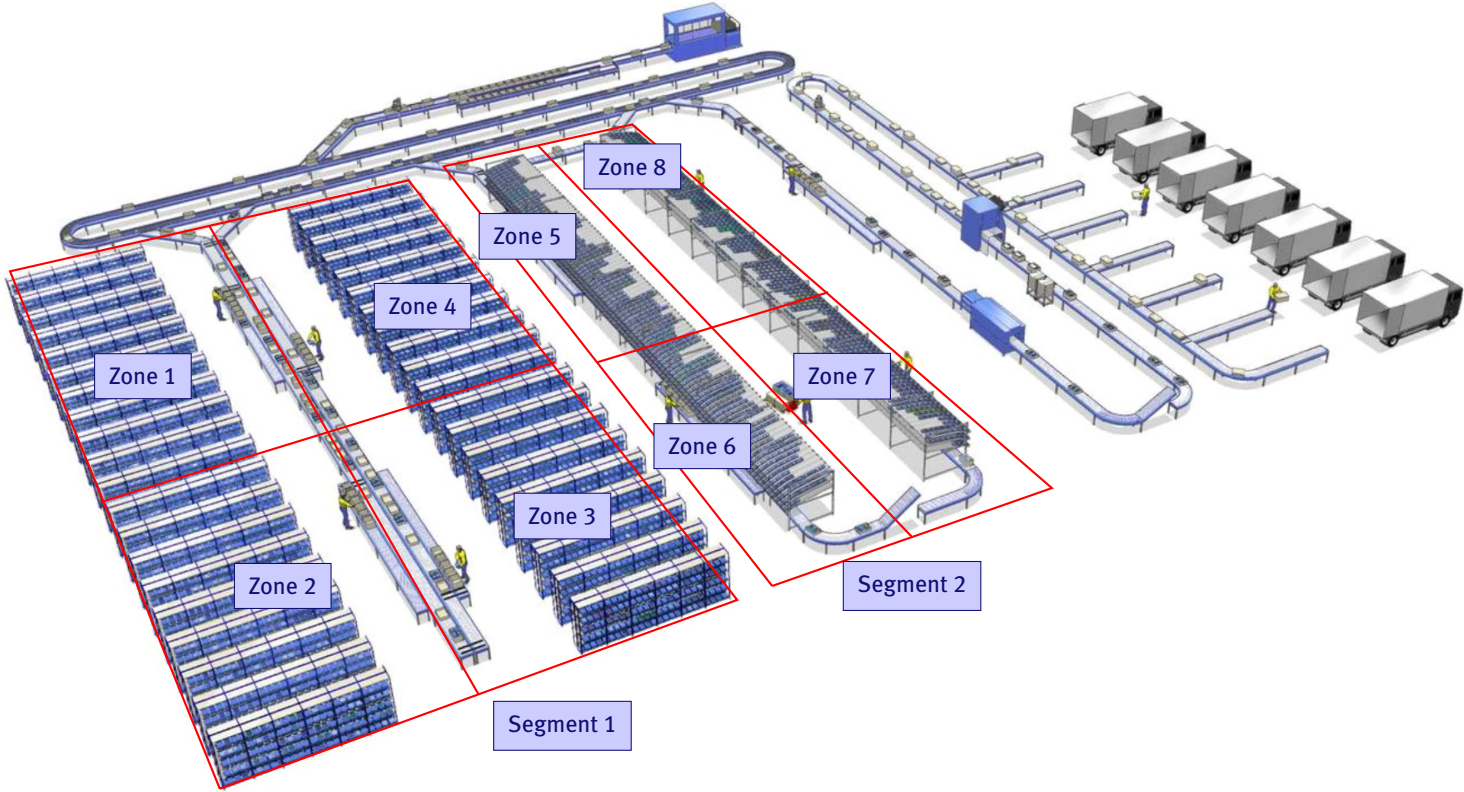

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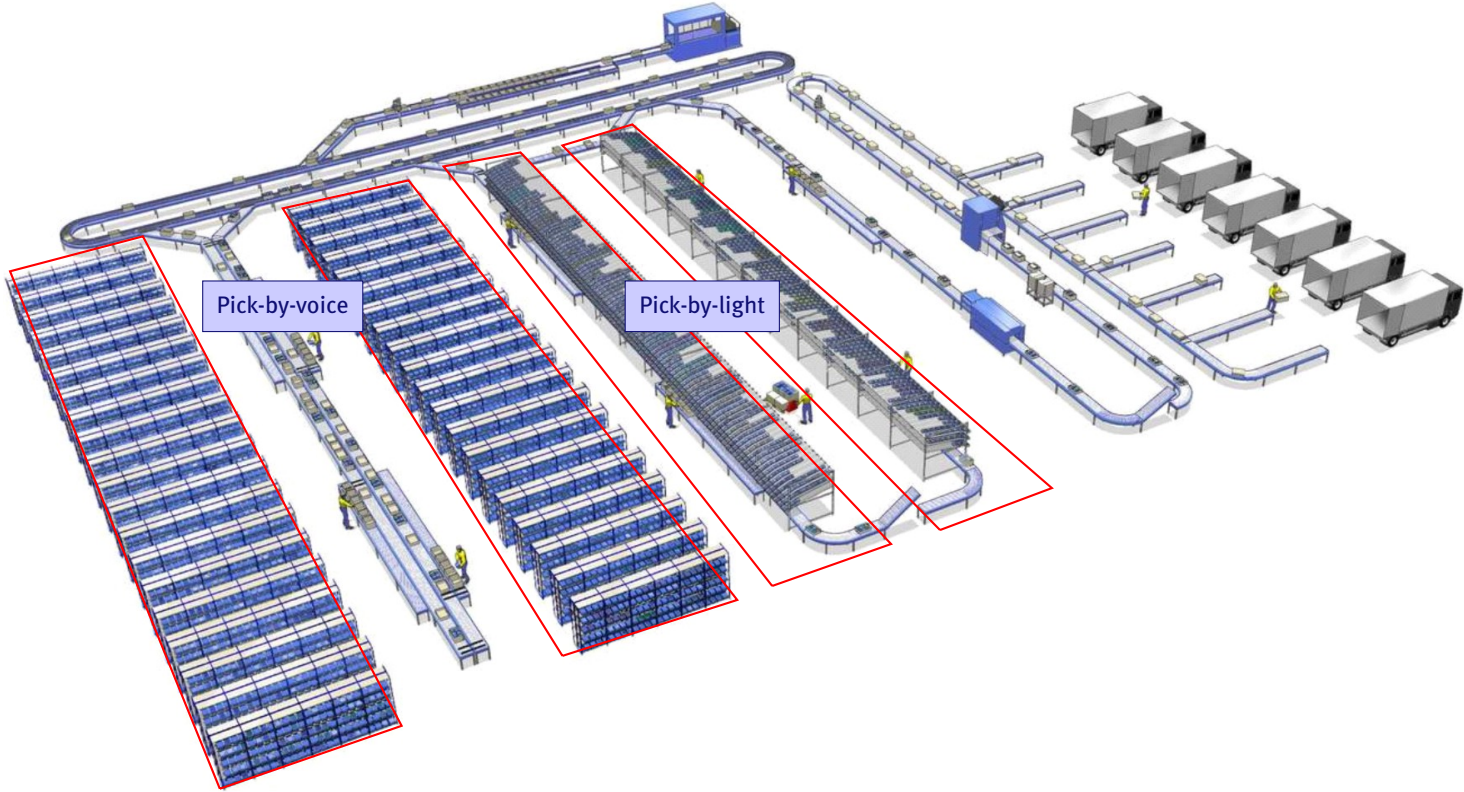

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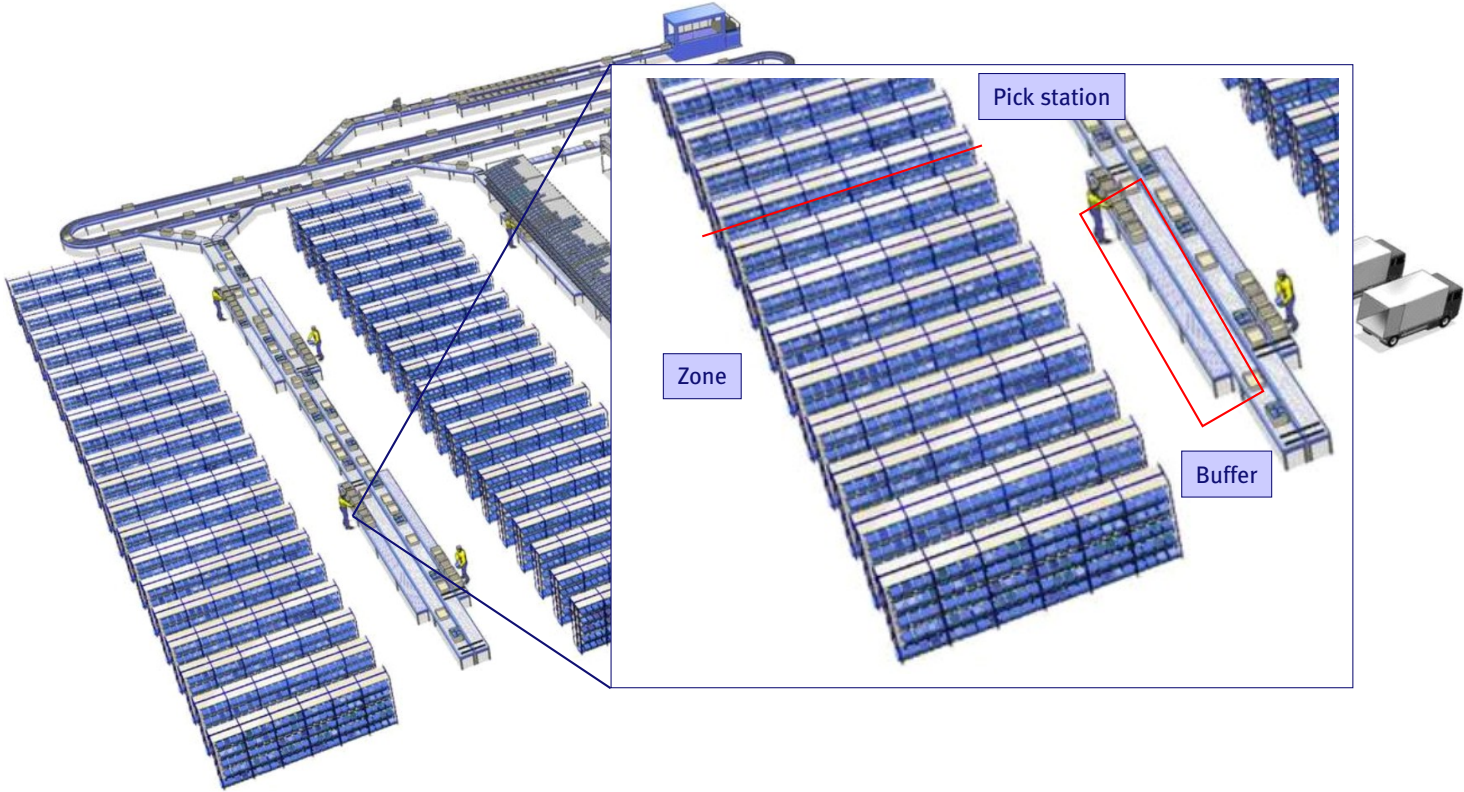

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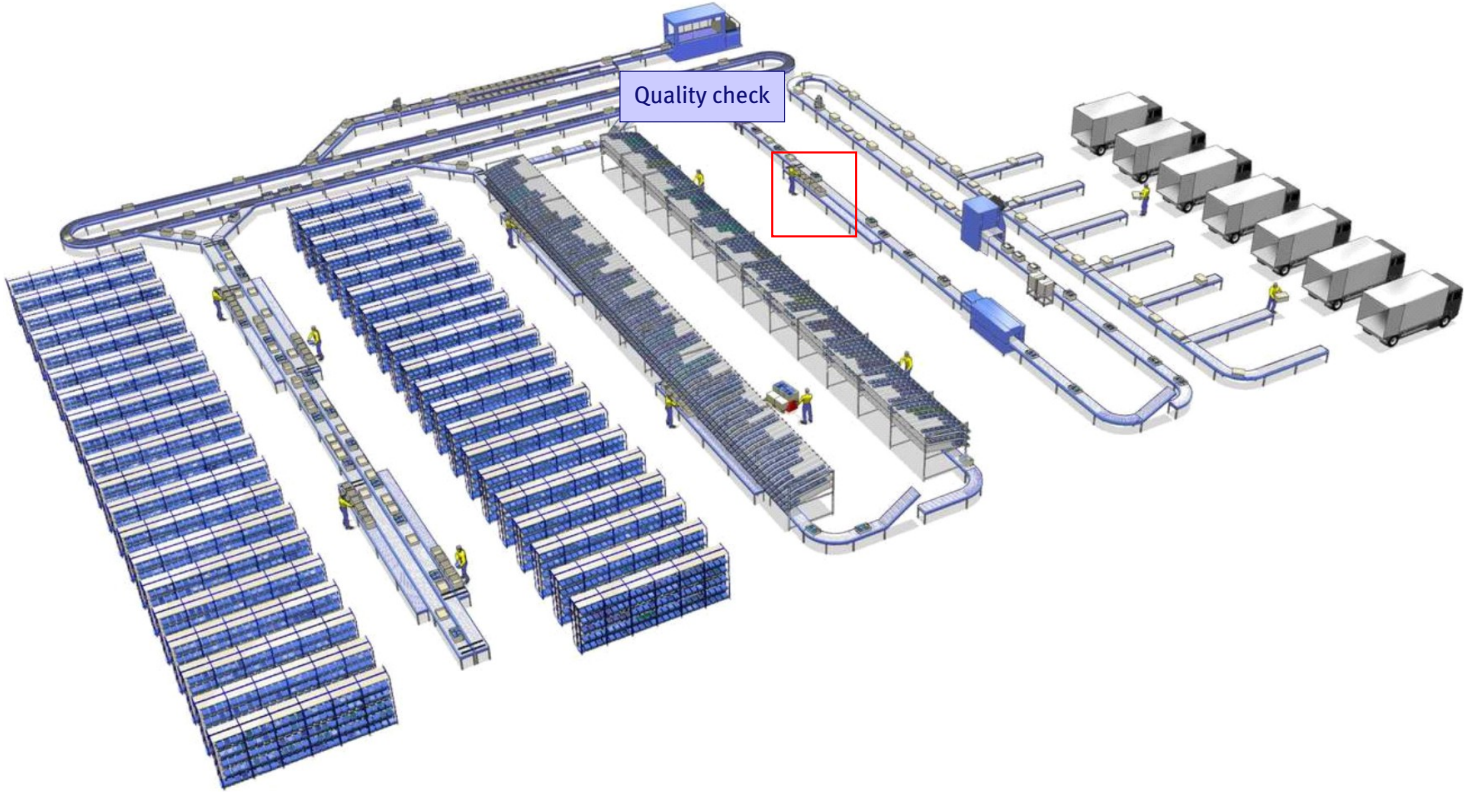

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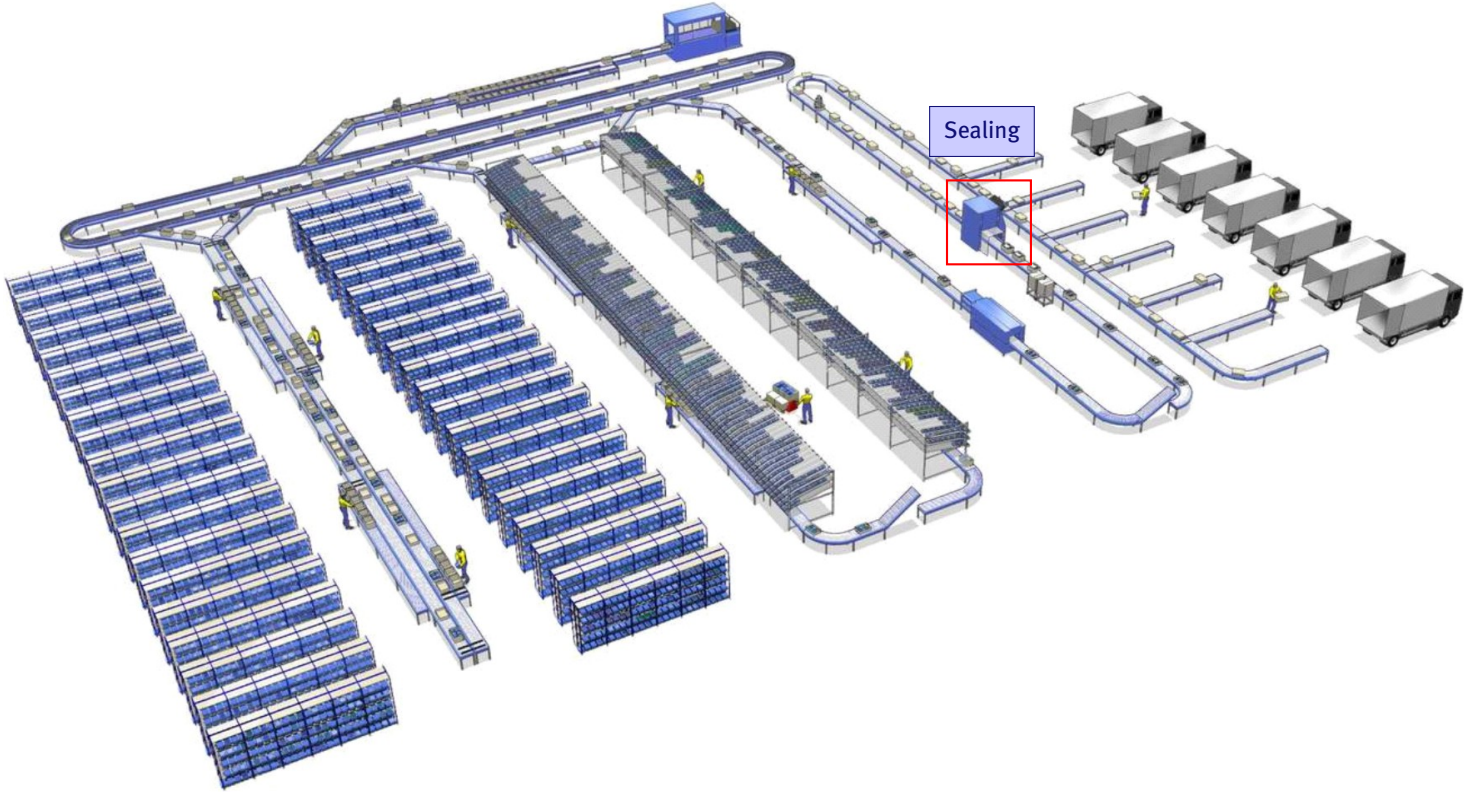

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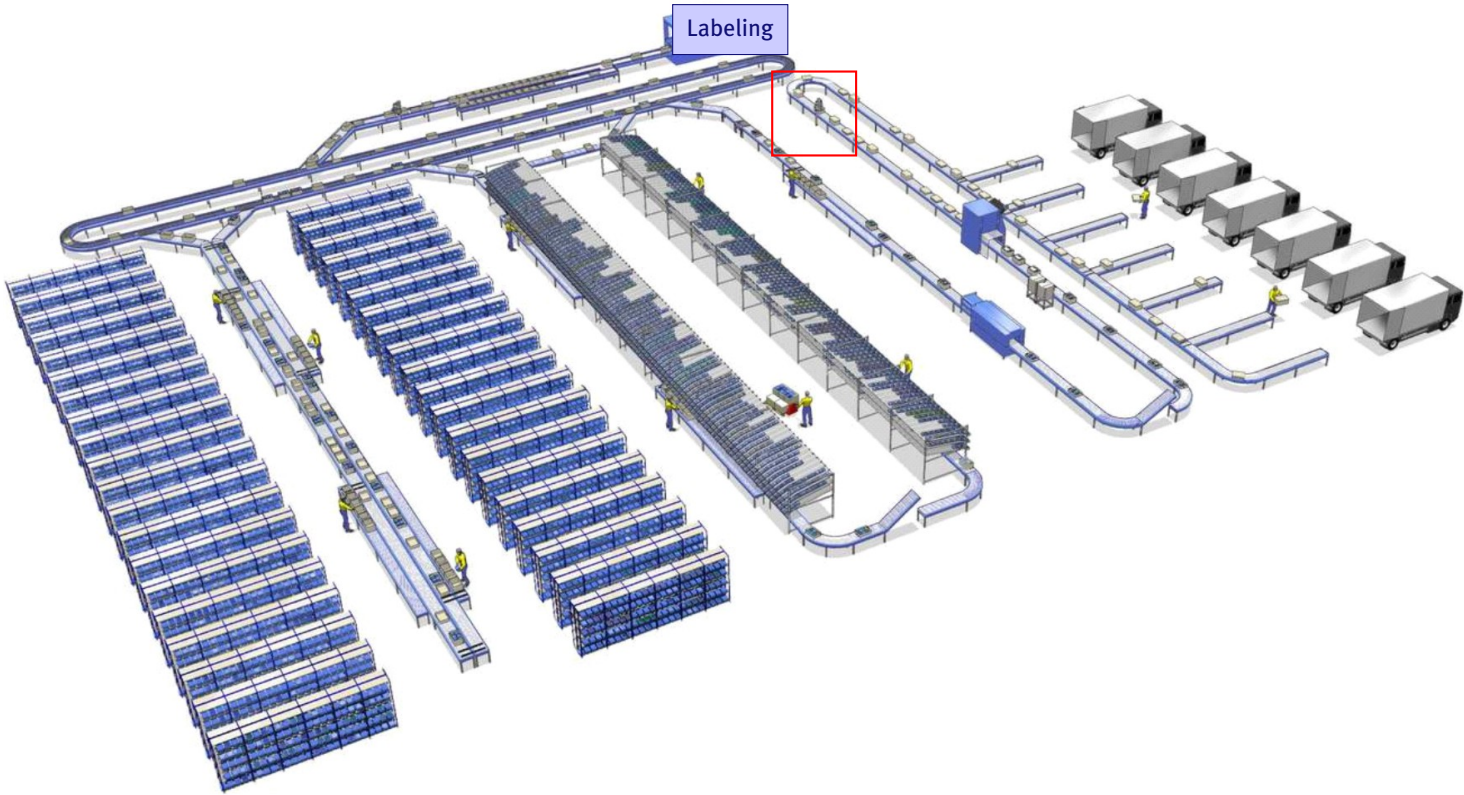

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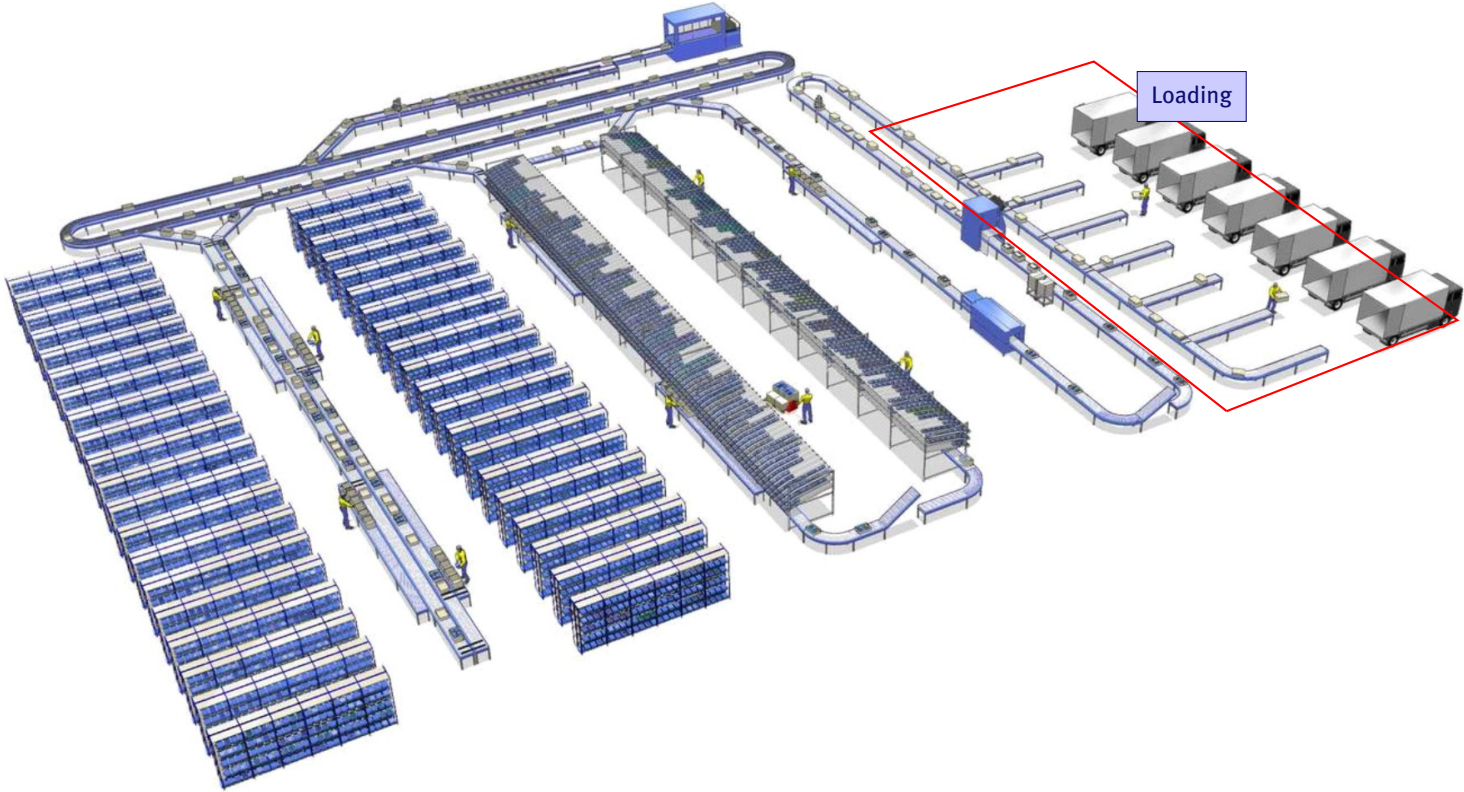

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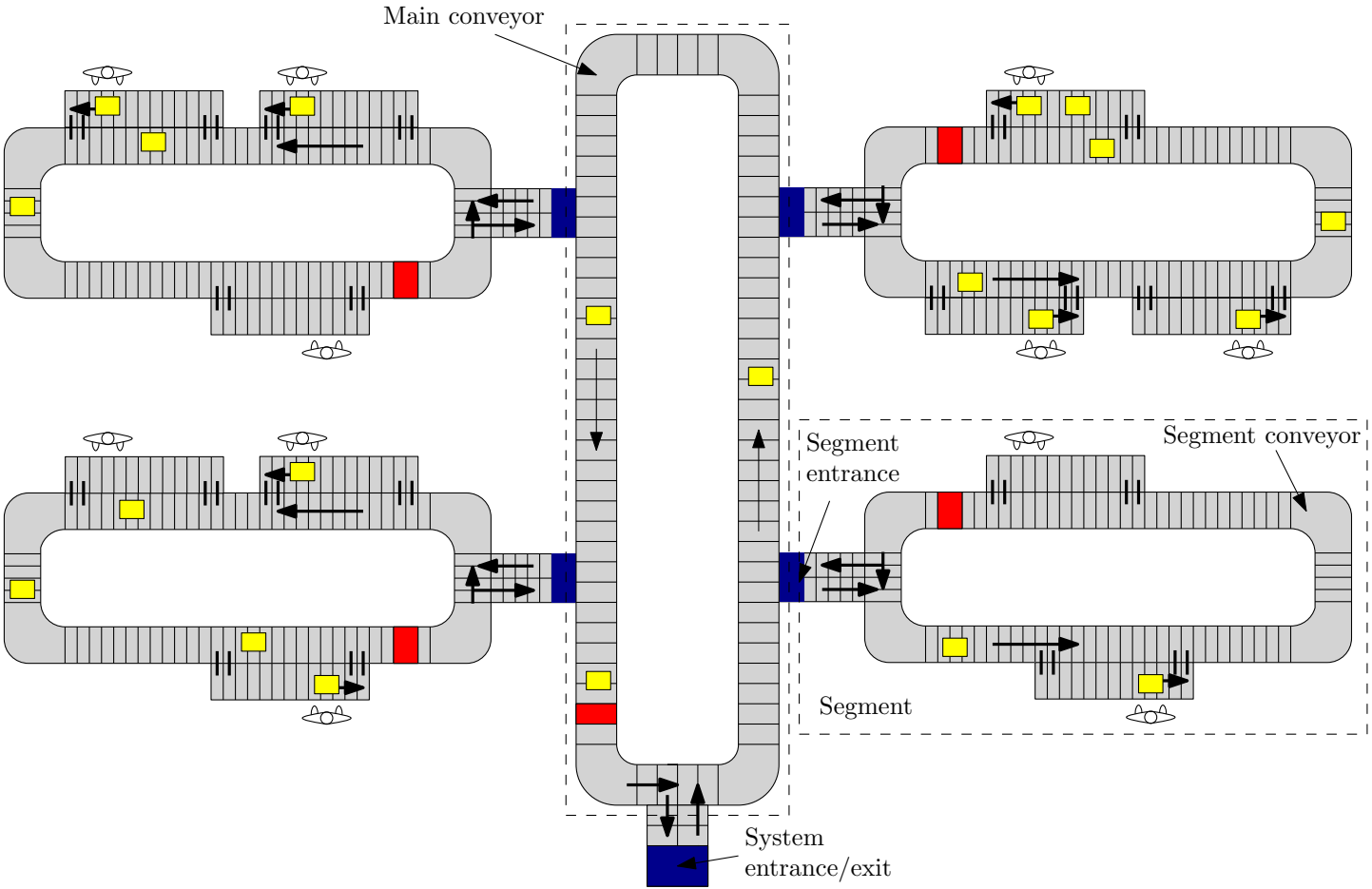
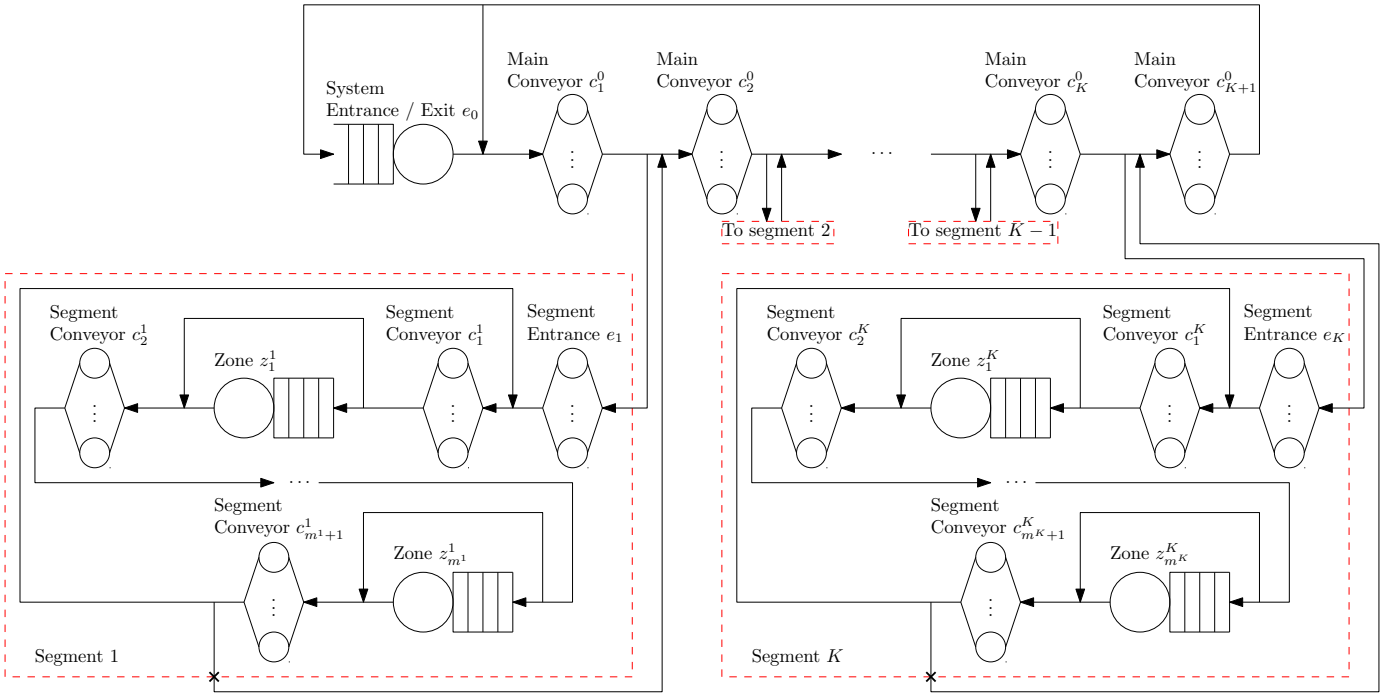


How to design such complex systems?

- What should be the layout of the network?
- Size of zones?
- Where to locate items?
- What number of pickers and zones?
- Required WIP level?

Zone-Picking Systems



Network model: implemented in Java Applet.