

# How can digital twins optimize the air cargo industry?

## A combination of operational research and machine learning techniques

### Digital Twins - What is it?

A digital twin is a virtual replication of a **physical process** that is completely synchronized with its counterpart thanks to the combination of a **physical-to-virtual connection** with a virtual-to-physical one that allows constant real-time information exchange between both entities. It can be used for various **virtual processes** as monitoring, optimization, prediction, or decision-making support.

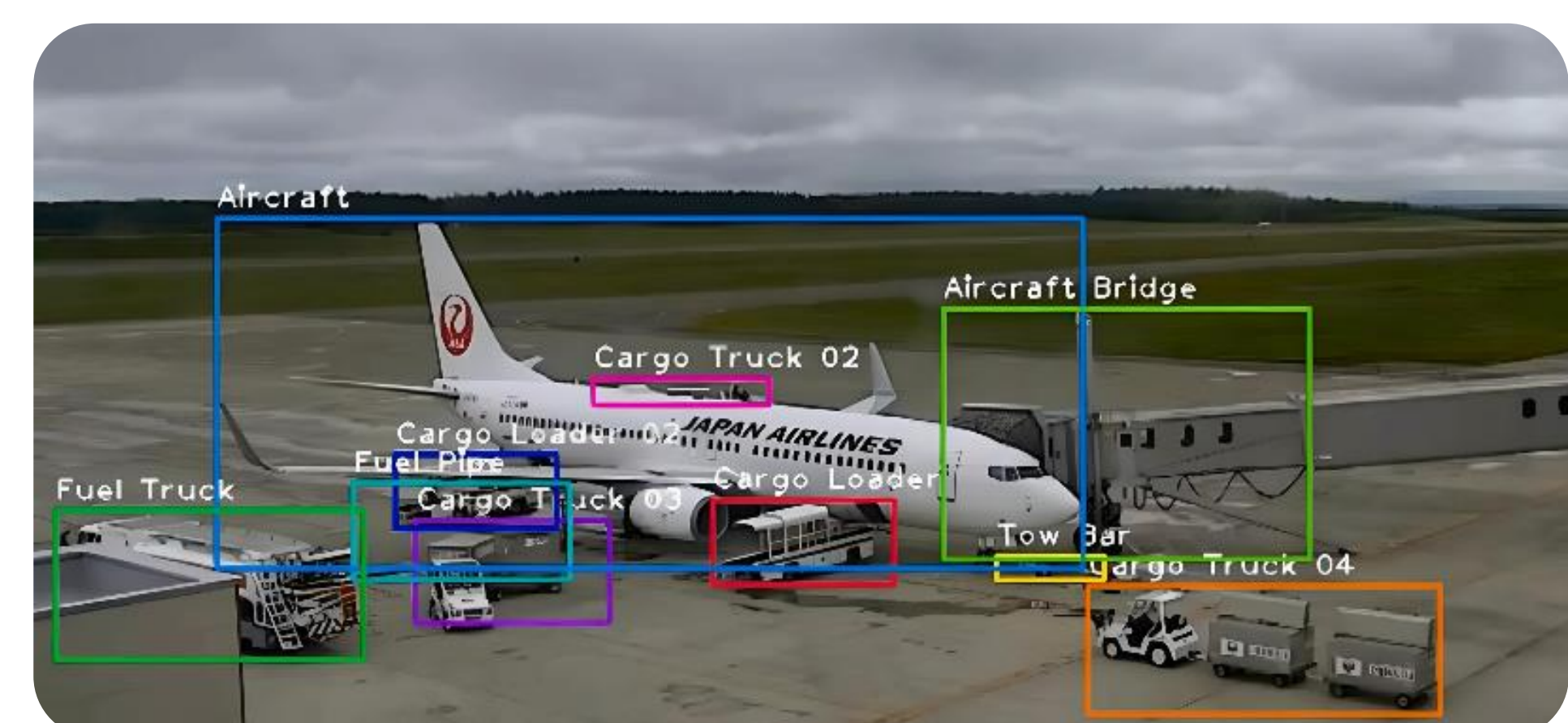
### Physical process Air cargo ground operations

- ▶ **Ground operations:** Logistical activities that take place between the time an aircraft lands and takes off again.
- ▶ Physical process where many challenges need to be overcome.
- ▶ Air transportation has a significant role in e-commerce and flight delays result in reduced customer satisfaction, financial burden and environmental damage.



### Physical-to-virtual connection Computer vision

- ▶ Virtual identification and monitoring of physical ground service vehicles based on real-time video surveillance data.

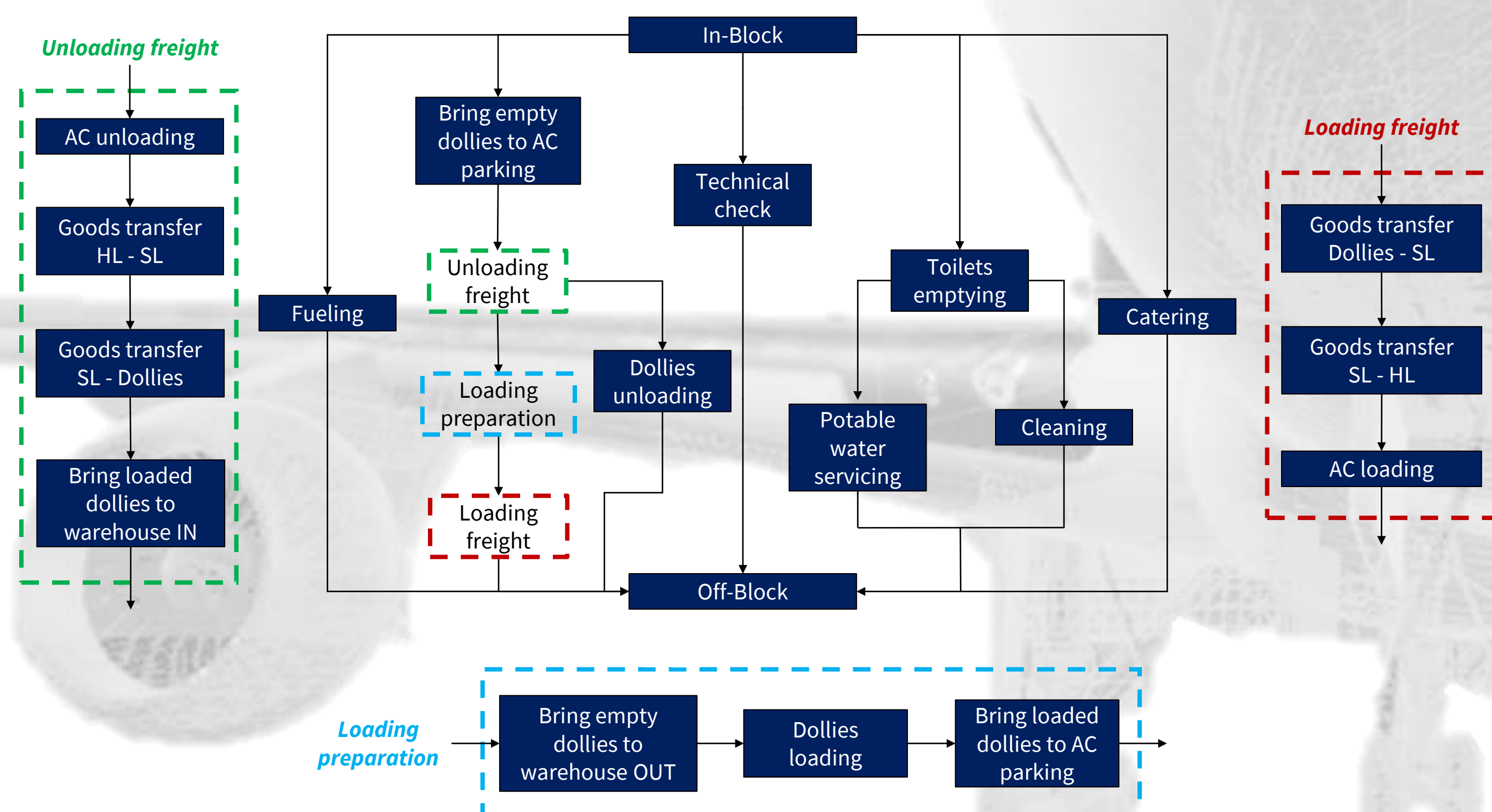


Phat et al. (2022)

- ▶ Use of **machine learning** methods for data analysis.
- ▶ Use of 3D synthetic data coming from **LGG virtual replication** for training.

### Virtual process Ground service vehicle coordination

- ▶ **Digital twin objective:** Complete services as soon as possible to produce safety time buffers that could contain any disruptions (maximize responsiveness).
- ▶ Complex problem that requires the use of **operational research** techniques and **business process modeling**.



- ▶ **Problem:** Set of highly interdependent and rich vehicle routing problems with various synchronization constraints.

- ▶ **Solution method:** Client-centered heuristic approach with recursive procedures.
- ▶ **Numerical experiment:** 18 instances generated based on LGG data (24-hour time horizon).
- ▶ **Results:** The algorithm is responsive, efficient, and fast.
  - Mean service time: **01:07:43**
  - Mean safety time buffer: **03:19:48**
  - Number of delayed aircraft: **-89.69%**
  - Mean (max) delay duration: **-53.78% (-88.67%)**
  - Mean computing time: **7.64 sec**
- ▶ **Generalization:** Construction site vehicle planning, post-disaster emergency vehicle management ...
- ▶ **Next step:** Any deviation of the data acquired through the physical-to-virtual connection from the heuristic solution is notified (**digital twin feedback loop**).