Combining a Digital Twin and Collaborative Design at the Montreal International Airport to Create a Smart Baggage Handling System (BHS)

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anylogic® conference 2021

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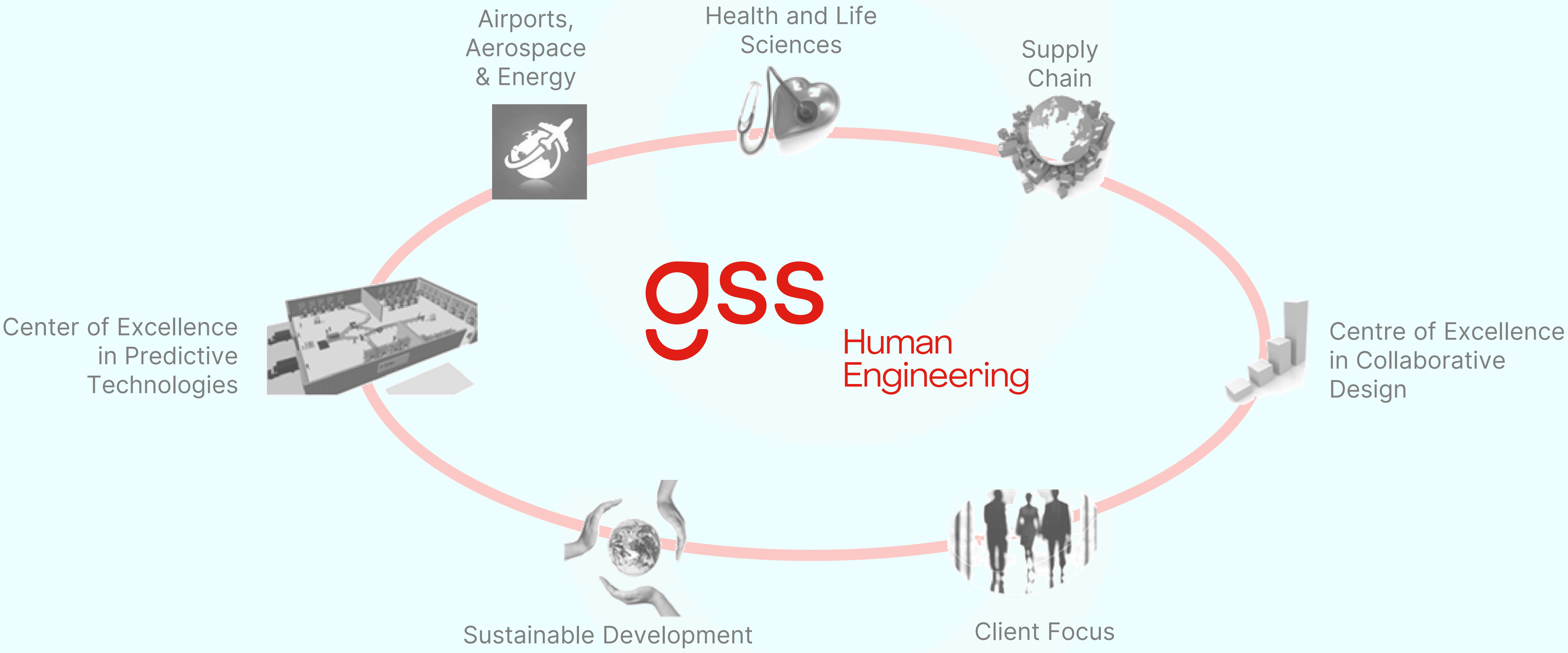
YUL Aéroport International Montréal-Trudeau

Company Profile



Company Profile

- International Diabetes Federation
- OLYMPUS
- TELUS — the future is friendly®
- Urgences-santé Québec — Laval Montréal
- Hôpital général juif / Jewish General Hospital
- axis
- Thomas&Betts
- Johnson&Johnson
- cmc electronics
- Nikon
- SNC·LAVALIN
- YUL Montréal-Trudeau International Airport
- engie
- R3D Conseil inc.
- International Airport Authority / Administration de l'aéroport international — Ottawa
- Santé Canada / Health Canada
- CFIA·ACIA
- Hudson's Bay Co. — Since 1670 Depuis
- SANDOZ
- YQB Québec City Jean Lesage International Airport
- DESSAU
- ABB
- BOMBARDIER
- pharma science
- Canadian Intellectual Property Office
- essilor
- Centre universitaire de santé McGill / McGill University Health Centre
- bostonlogan

YUL Montréal-Trudeau International Airport

Montreal International Airport

- #11 in North America in terms of total volume of passengers.
- 148 direct destinations, 89 of them international, handled by 34 airlines.
- Connections account for 22% of passenger traffic.
- 20.3 millions passengers in 2019.
- Increase in passenger traffic of 38% from 2014 to 2019.

Forecast Traffic

- As all airports around the world, the passenger traffic has been affected by the pandemic.
- Right now, ADM is starting to ramp up the traffic, hopefully in the next years the growth will be as high as before, with a constant growth rate of 4% or more.
- The current project is part of the preparation for the future growth.

Agenda

1/ Baggage Handling System (BHS)

2/ Business Challenge

3/ HLC Concept

4/ Simulation Model

5/ Results

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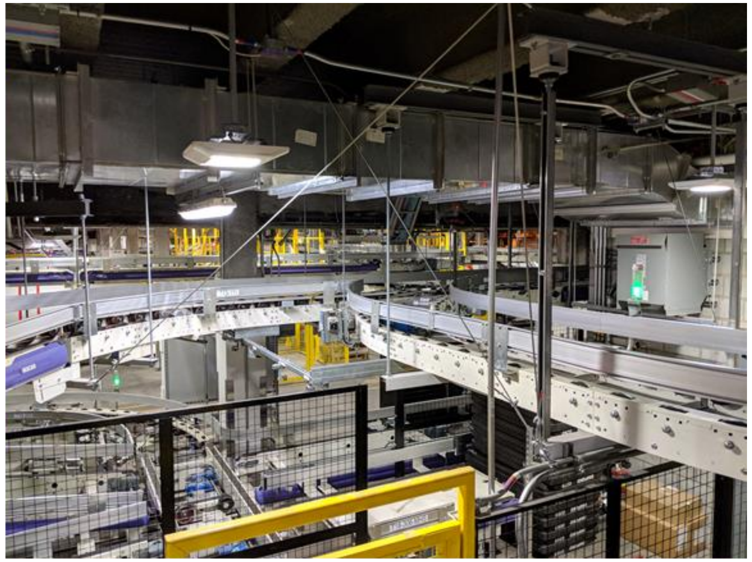
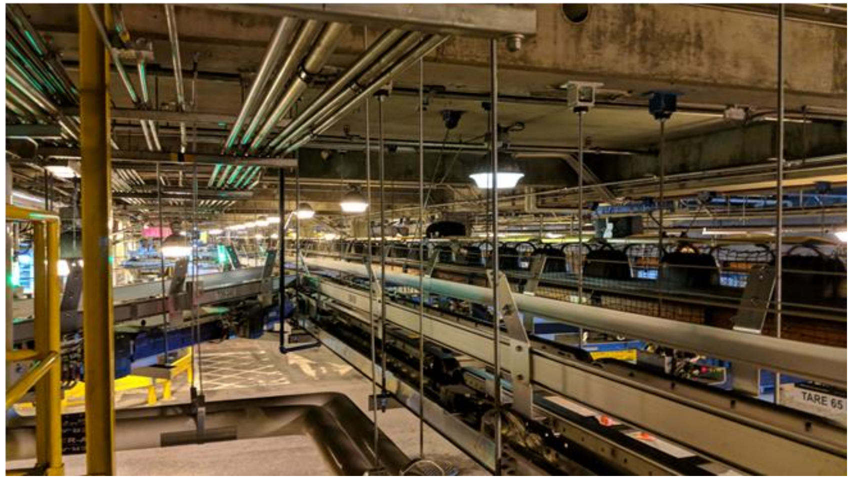
Baggage Handling System

Baggage Handling System

- A Baggage Handling System (BHS) is a combination of conveyors, screening equipment, automation components and stations to transport and process bags from different entry points, and going towards multiple destinations.
- Thousands of interconnected elements.
- Complex System.
- High throughput and variability.





Baggage Handling System

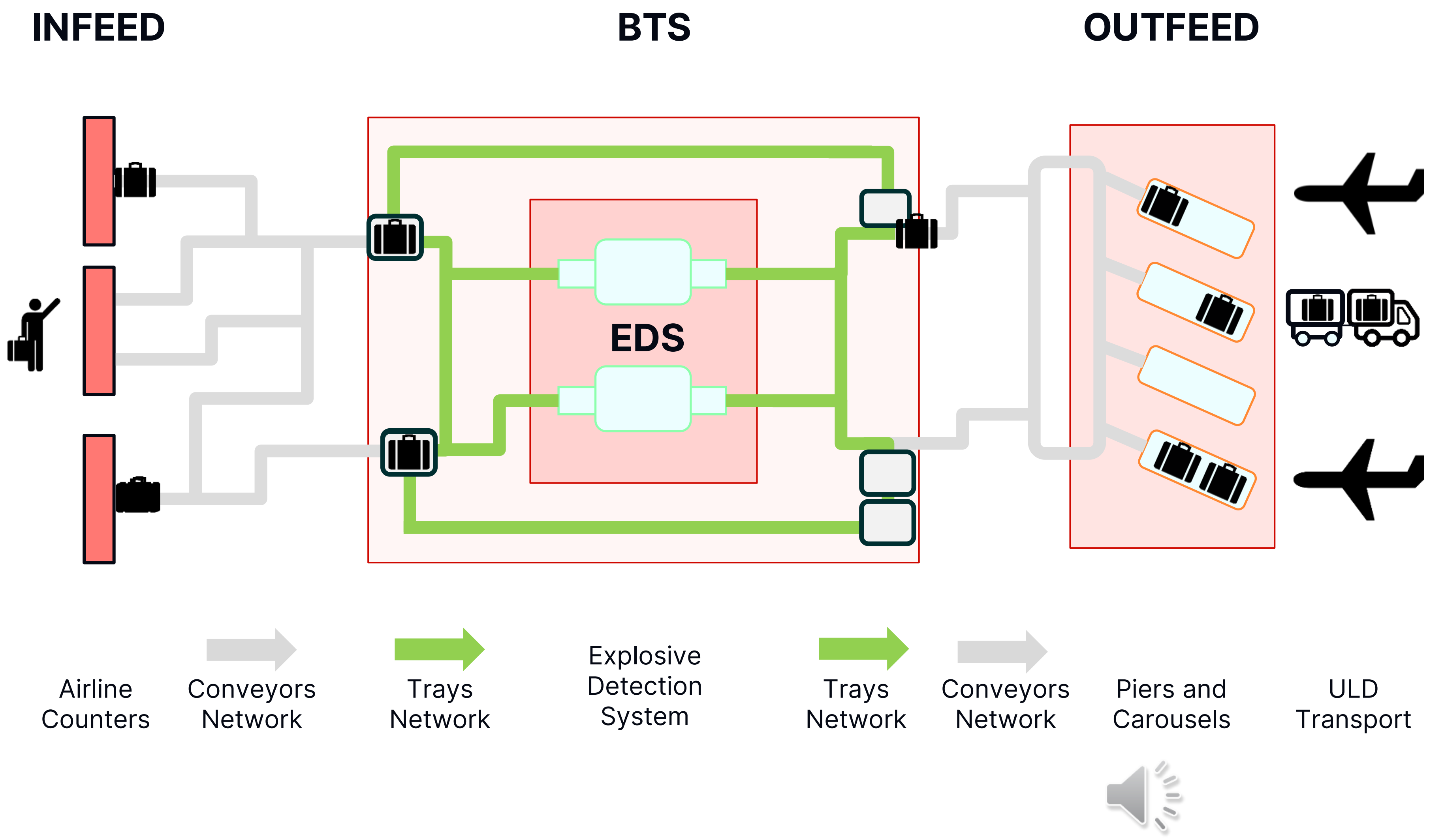
- 1000+ Conveyor
- 100+ Decision Points
- 2.8M+ Daily Decisions

Type of Decision:

- Start / Stop
- Points of Divergence
- Drop Bags

Decision Variables:

- # of Trays in Segment
- # of Bags in Segment
- Status of Segment (available, failure, dieback)
- Status of Trays
- Destination
- X-Ray Status



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Business Challenge

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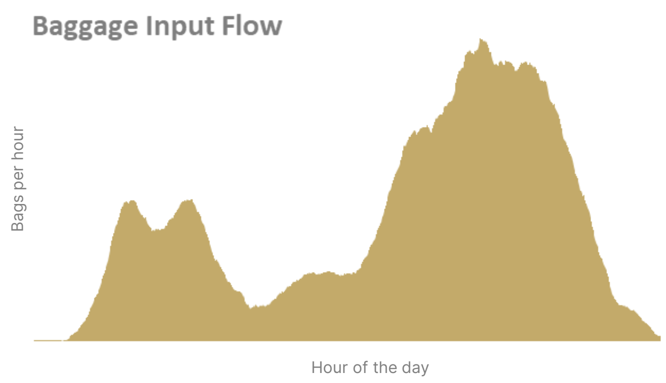
Business Challenge

- Operational reality: flight departures are concentrated in specific periods of the day, the design has to support the peak time without affecting the customer service level, and random operational events.
- Given space constraints, the implementation of the bag tray system (BTS) was successful from a mechanical viewpoint, but the flow management system (FMS) presented many improvement opportunities.
- Main business challenges:
  - Flights delayed,
  - Customer experience affected at counters and transit drop-off belts,
  - Practical capacity not used at its full potential.
- Need for a robust and dynamic system architecture to support the implementation of a smart control automation approach (Digital Twin, HLC).
  - Operational improvements and infrastructure evolution.
- Need for a strong partnership between key community stakeholders (security agencies, airport authority, BHS operator, airlines and engineering companies), to accurately represent the system operations (Collaborative Design)



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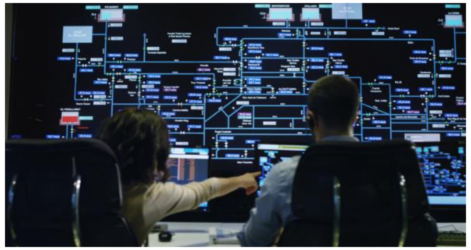
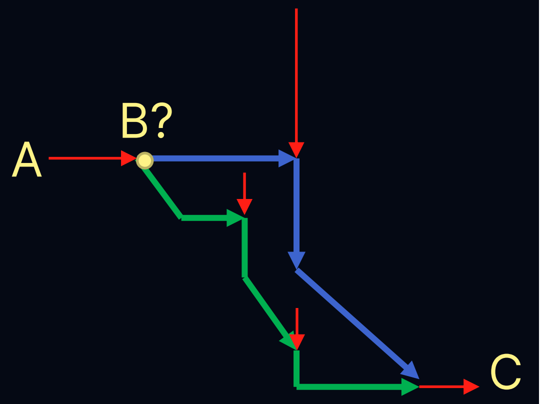
HLC Concept

High-Level Control (HLC) Approach

- Initially, the decisions were made based on local variables (PLC traditional approach).
- A High-Level Control (HLC) uses system thinking to take proactive and dynamic decisions based on multiple conditions.
  - A tray may change its destination based on new demand information, changes in the availability of trays in parking areas and degraded modes.
- Change of paradigm: need to test thousands of What-If scenarios to design a robust logic, Lean and agile principles in the design process to simplify the logic.
- Multiple scenario analysis combined with a multi-criterion optimization algorithm, resulting in a consolidated set of rules (that may evolve over time – winter is different from spring…).





Example: going from A to C, decision point B.

Local approach considers only status of green and blue lines, whereas the HLC approach considers the upstream demand and equipment availability downstream (VISIBILITY requires an IT layer and simulation).

Example of a rule:

- Decision point P1 (T29115A): Continue to Sector 1 (straight) or Sector 2 (divert).
- **Logic for empty trays:**
  IF (Bufer1 + Buffer2) < 5 , THEN Sector 1
  ELSE IF (UtilizationComponent1) < 50%, THEN Sector 1
  ELSE IF (Buffer1/Buffer3 < 0.5), THEN Sector 1
  ELSE Sector 2

Human reads

System reads

SCADA reads

- **Decision Rule:**

ID	Condition Straight	E_01	E_02	E_03
T29115A	status_empty and E_01 and E_02 and E_03	Buffer1 + Buffer2<5	UtilizationComponent1<0.5	Buffer1/Buffer3<0.5

Simulation Decision Platform helps with the design and test of High-Level Control rules.

Modelling is a principal –perhaps the primary- tool for studying the behaviour of large complex systems.

Herbert A. Simon

Nobel Prize in Economics in 1978 and the Turing Award in 1975

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Simulation Model

Simulation Model – Why AnyLogic?

- The solution requires a dynamic architecture
- Flexible software
- Agent-Based Approach
- Custom-Design elements (physical components)
- Combination of Material Handling + Process Modeling Library (GSS BHS library)
- Possibility of integration with external libraries and multiple data-sources

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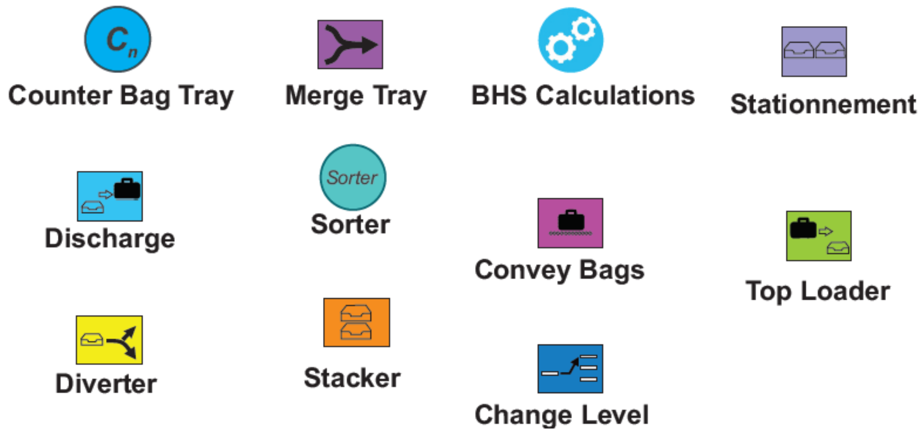
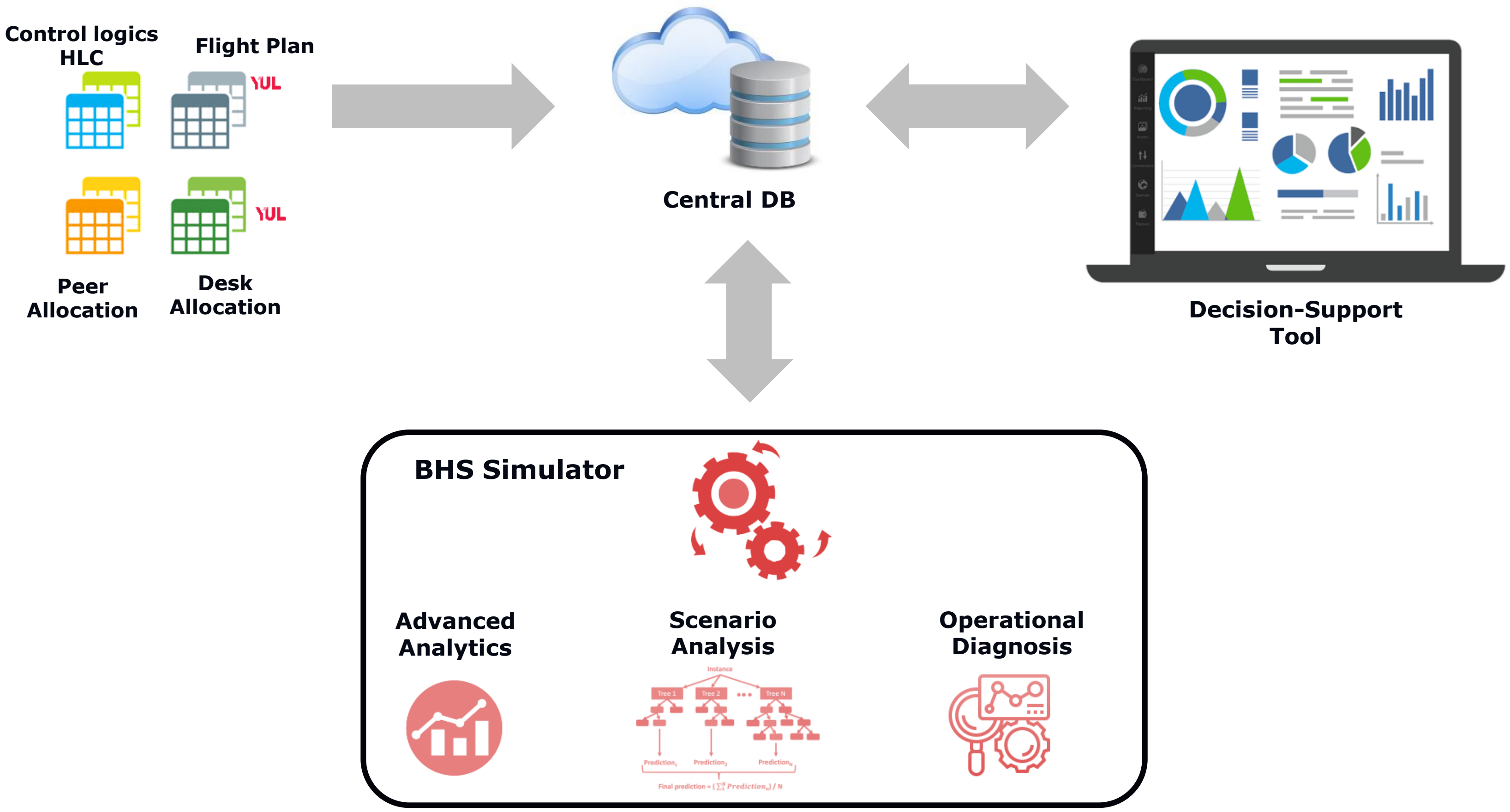
Process Modeling

Material Handling



Simulation Model - Architecture



Strategic:

- Ability to integrate with operations,
- Planning support tool,
- Rapid assessment of operational improvements and system logic,
- Predictive assessment of infrastructure evolution,
- Continuous protection of customer operations (operational risk reduction).

Technical:

- Modular architecture, which increases development speed,
- Ability to easily isolate subsystems for multiple simulations,
- Standard components created by GSS to reproduce the detailed behavior of system components,
- Ease of rapid modification of control logic (tie-in with the BHS system language).

Simulation Model - Development Phases

BHS Library

Design of custom elements according to the mechanical behaviour and physical constraints.

Implementation

Model assembly representing each component of the system.

Calibration

Real operational data used to calibrate the model.

What-If

Scenario analysis using the simulation tool (flight allocation changes, equipment failures, etc.)

Infrastructure

Validation of infrastructure investment decisions

One-Way

BHS Simulator as planning and operational decision-making tool

Digital Twin

Two-way communication between the BHS and the simulator

Current Phase

Simulation Model - Video

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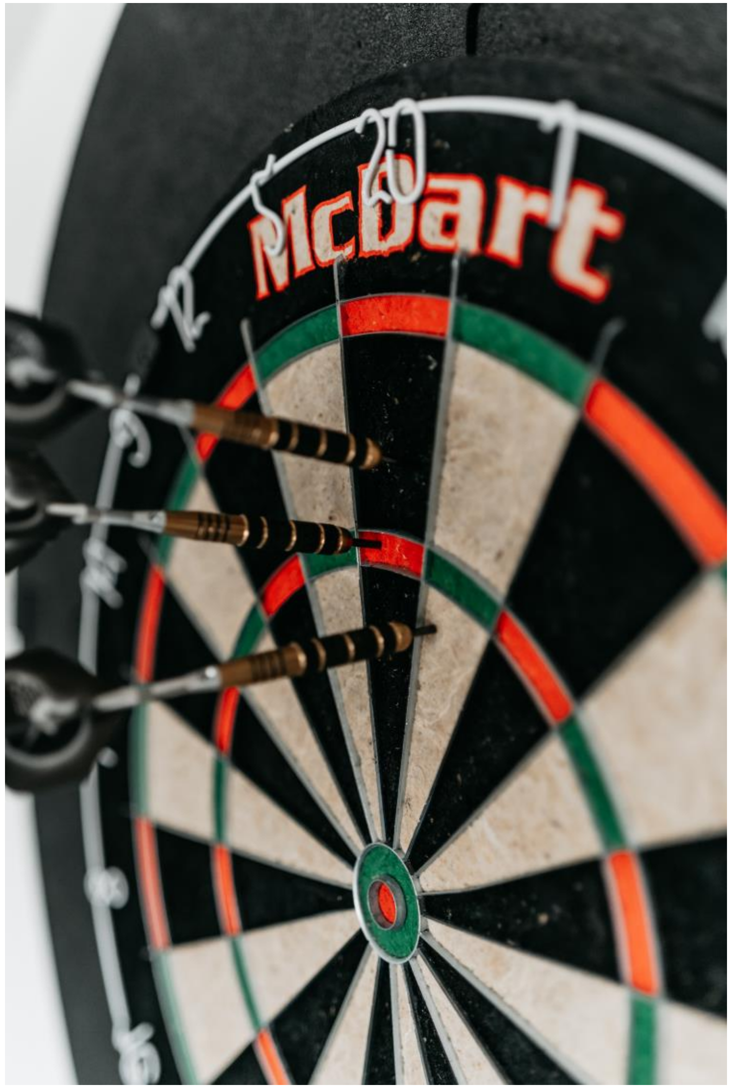
Results

- **Target practical capacity reached on a consistent basis (physical tests ran by the airport).**
- The airport is ready to handle the recovery phase.
- 2 products successfully implemented:
  - High-level control (HLC) strategy,
  - Simulation platform with flexible architecture.
- Added value of the simulation platform:
  - Rapid decision-making support tool for operations planning and improvement,
  - Support in identifying and communicating bottleneck issues,
  - Infrastructure decision support: adding lines, equipment, changes of layout, etc.,
  - Increase of service levels (Airport and Airlines), which is translates into passenger satisfaction,
  - Contingency plan design and improvement,
  - Efficiency gains.
- Digital Twin Phase 1.0 on-going, next step: consolidation of Digital Twin for real-time support to operations.



Thank you.

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