SIMULATION MODEL FOR NETWORK CONFIGURATION AND RAILWAY OPERATIONS IN THE RUMO'S SOUTHERN NETWORK IN BRAZIL

ABOUT US

GENOA

- Genoa is a decision-making support consultancy, with the expertise to streamline and refine business processes and provide dependable and true-to-life outcomes;
- We develop customized solutions to solve the problems of our clients, starting from a thorough understanding of the system's operation;
- Analytics, Big Data, Simulation and Optimization are some of the tools we employ in our solutions;
- We are partners with AnyLogic LATAM.

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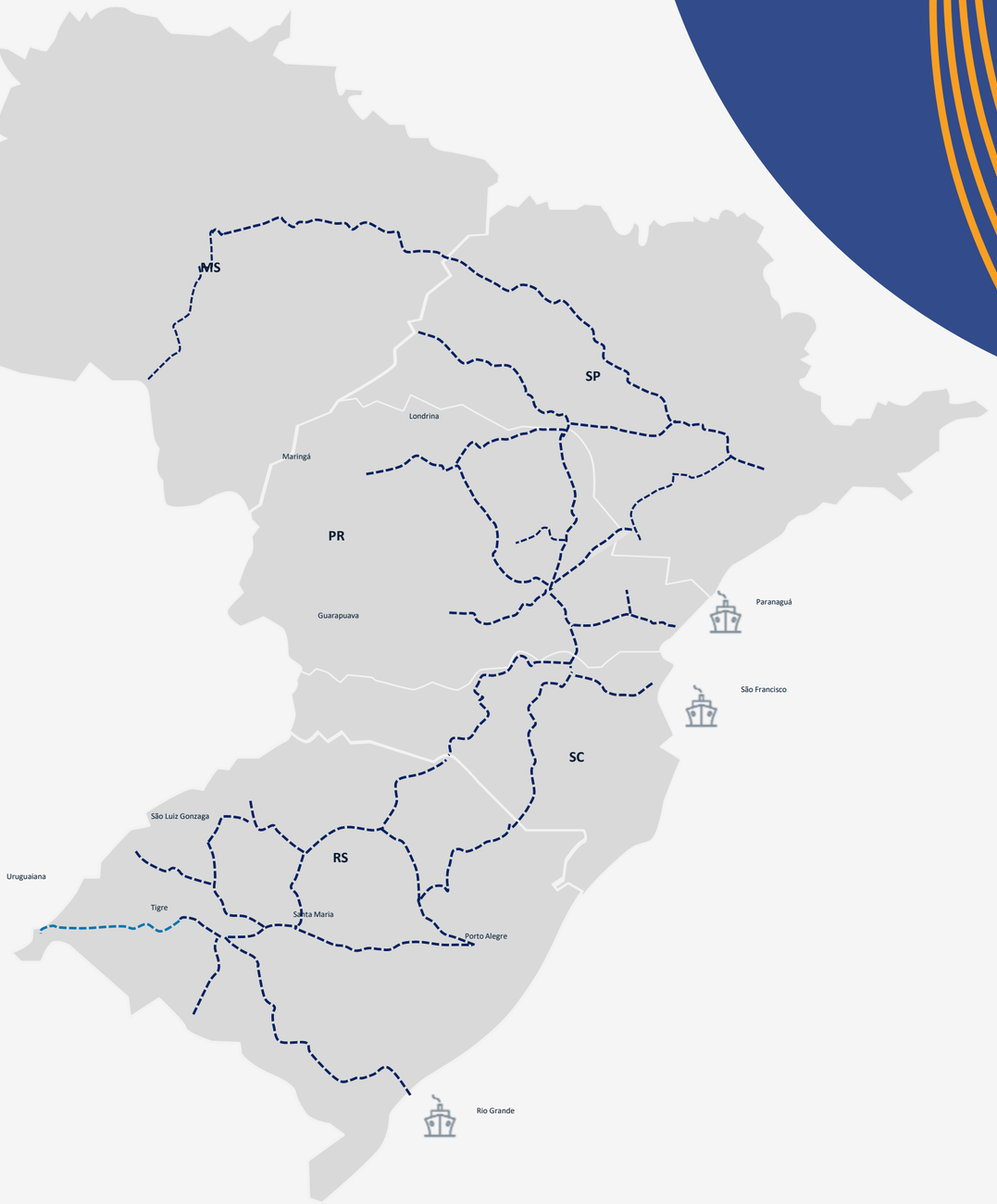
AGENDA

1. *The problem*
2. *Objectives*
3. *Assumptions*
4. *Why AnyLogic?*
5. *Our approach*
6. *Results*
7. *Conclusion*
8. *Questions*



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THE PROBLEM

DESCRIPTION

- The studied system covers the Southern Railway Network, concessioned to Rumo S.A;
- In 2021, the Southern Network transported 12.3 billion TKUs over 7,223 km, serving 150 terminals and 3 Brazilian ports;
- The railway network features the operation of third-party trains, as well as service trains and freight trains;
- About 80% of the goods transported are related to agribusiness.

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THE PROBLEM

DESCRIPTION

- The goal was to evaluate RUMO's quarterly planning, considering the projected demand across different terminals as well as the available infrastructure;
- Each section of the network has specific track characteristics that limit train sizes, maximum loads, and require a minimum number of locomotives;
- The aged and unique railway network requires detailed analysis to optimize transportation;
- The strong seasonality in the agricultural sector directly impacts the volumes and types of transported products;
- Transporting various types of agricultural products during specific times of the year presents logistical challenges.

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THE PROBLEM

DESCRIPTION

- The system encompasses the entire process, including the movement of empty or loaded trains, detailed representation of the railway network and loading and unloading at terminals;
- Trains depart loaded from terminals, bound for ports or other terminals, carrying combinations of various material batches, in accordance with Gross Tonnage (GT) and maximum speed for each track segment, as well as the maximum train composition length;
- Upon being unloaded at their destination, the trains follow the reverse path, loaded or not, traversing the same railway system used for the outbound journey.

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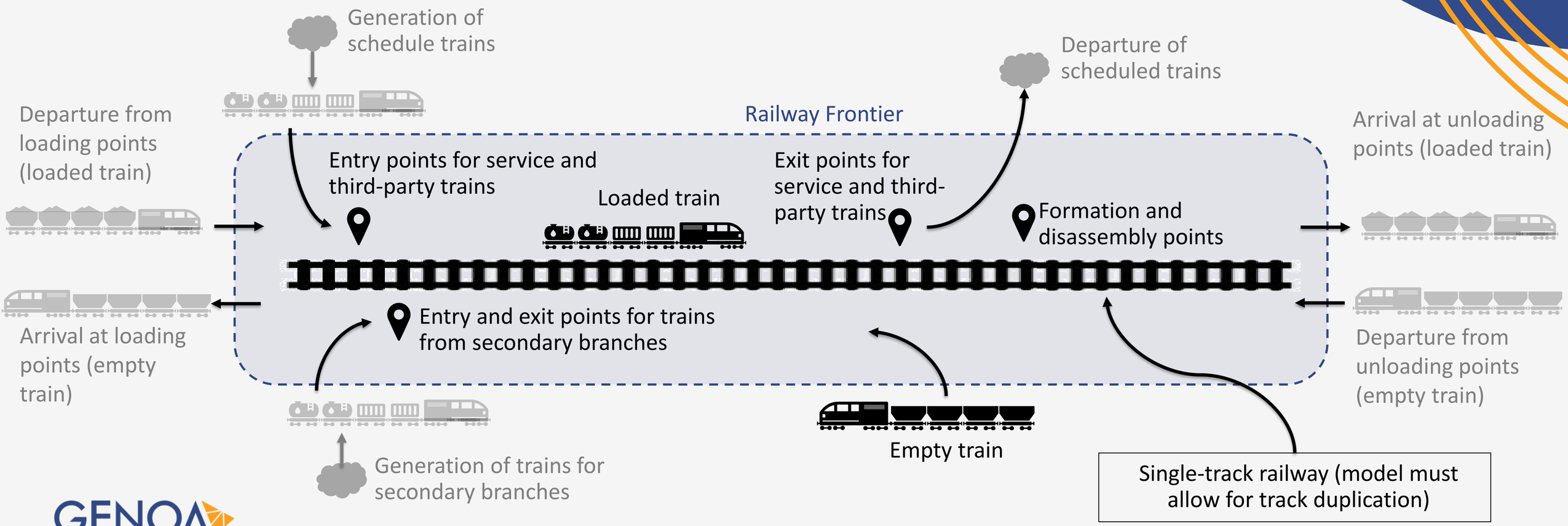
THE PROBLEM

FRONTIER



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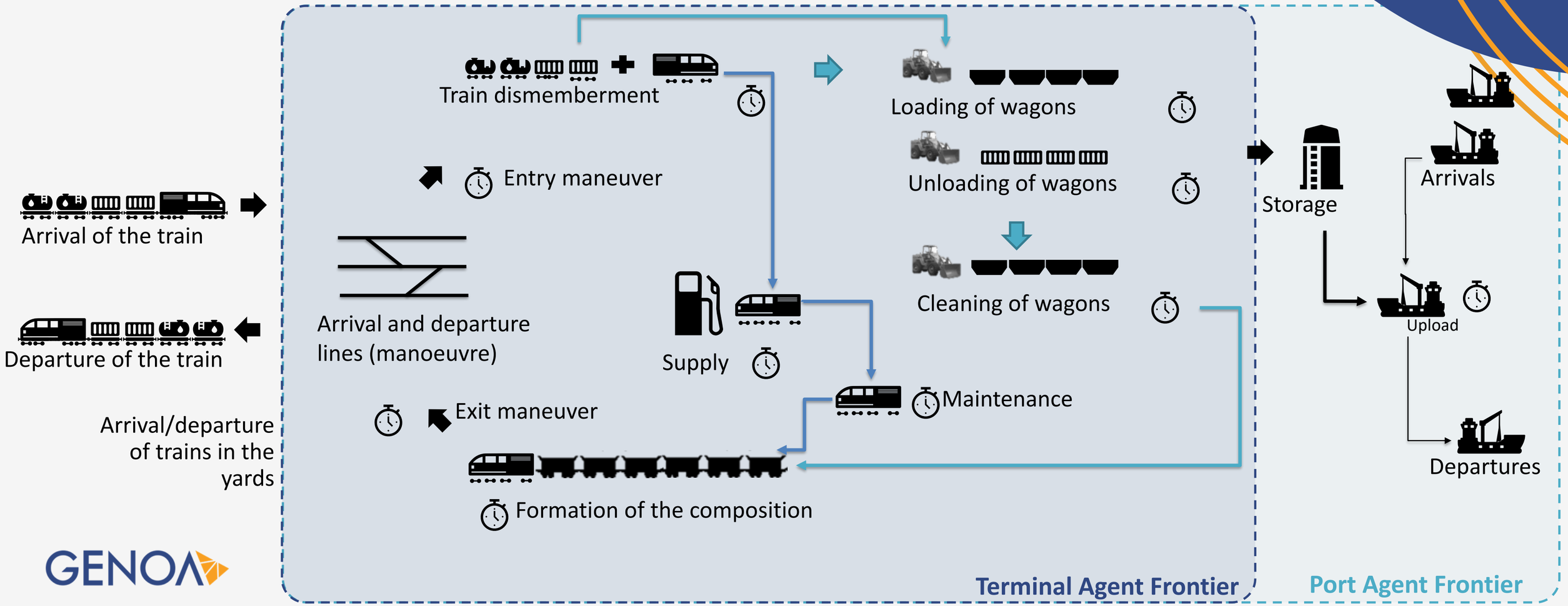
THE PROBLEM

FRONTIER



OBJECTIVES

- **Evaluate the railway network capacity** segment by segment, as a whole, and at terminals/ports, facing different demand scenarios;
- **Estimate the explicit utilization of each segment** and allow **verifying the impact of the most congested segments** in the system, enabling a simulation of these bottlenecks in a single or duplicated line;
- **Assess expansion projects**, not only in terms of handled cargo, but also regarding their dynamic aspects such as loading and/or unloading times, yard areas, retention time etc, in addition to the need for rolling stock, supporting investment decisions in new wagons, locomotives etc;
- **Visualize and understand the operational effects of decisions** through a graphical interface.

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ASSUMPTIONS

- All lines are treated as a set of BSs (Block Sections) and each BS as resources;
- Are considered the UCs (Universal Crossover), in a simplified way, to allow the exchange of a train from one line to another;
- The overtaking of trains only occurs according to priority rules defined by the type of trains;
- In the dynamics of rail circulation, trains can move in two directions in their respective SBs;
- The crossing yards are responsible for enabling the crossing of trains in opposite directions;
- All control of the railroad in the model are carried out through the allocation and deallocation of BSs of lines;
- To ensure that the trains travel each one in its own direction, without there being simultaneous occupation of the same BS by two trains, the process of allocation and deallocation of BS type resources is carried out in a systemic way, according to the priorities in the request queue.

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ASSUMPTIONS

WHY ANYLOGIC?

- Software package dedicated to agent-based modeling;
- Discrete-event simulation framework;
- Easy integration with external libraries;
- GIS already integrated.

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OUR APPROACH

CHALLENGES

- The first challenge of the system is the railway network features complex characteristics due to its age and extensive coverage;
  - The model must check the **train types** for each segment before the train enters that section.
- The secund challenge are the selection of terminals in order to balance the demand of materials;
  - The model calculates a **service gap** to identify the terminals that are lagging behind in terms of demand.

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OUR APPROACH

TRAIN-TYPE

- Along the rail network, different type train formations are required on each corridor, respecting track conditions;
- In this way, the train attaches the cars at the point of origin, moves to the next connection point;
- At these points, the train type is checked for the next segment, so that the train departs with the maximum possible length and GT (Gross Tonnage) capacity, while respecting the minimum blocking;
- If there's a need to attach or detach cars at the connection points, the train is finished, and new trains are formed respecting the train-type configuration.

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OUR APPROACH

SERVICE GAP

- The selection processes of the loading and unloading terminals are carried out considering the lag between the expected volume in the terminals and the volume loaded/unloaded in them (service gap);
- In this way, the service gap, or simply gap, is associated with each route of the Origin-Destination (OD) matrix;
- The gap of a route at any instant t is calculated as follows:

$$gap = \frac{cargo_{exp}^{mov} - cargo_{real}^{mov}}{cargo_{exp}^{mov}},$$

- The load flow algorithm starts with the arrival of empty trains at the loading terminals. Given a point of origin, the algorithm searches for the destination terminal that is most outdated in relation to the gap in order to balance the calls at the discharge terminals;
- The flow of voids begins with the arrival of the loaded trains at the unloading terminals. The algorithm searches for the source terminal most lagging behind the demand for voids in order to ensure that there is a constant flow of empty wagons to the loading terminals

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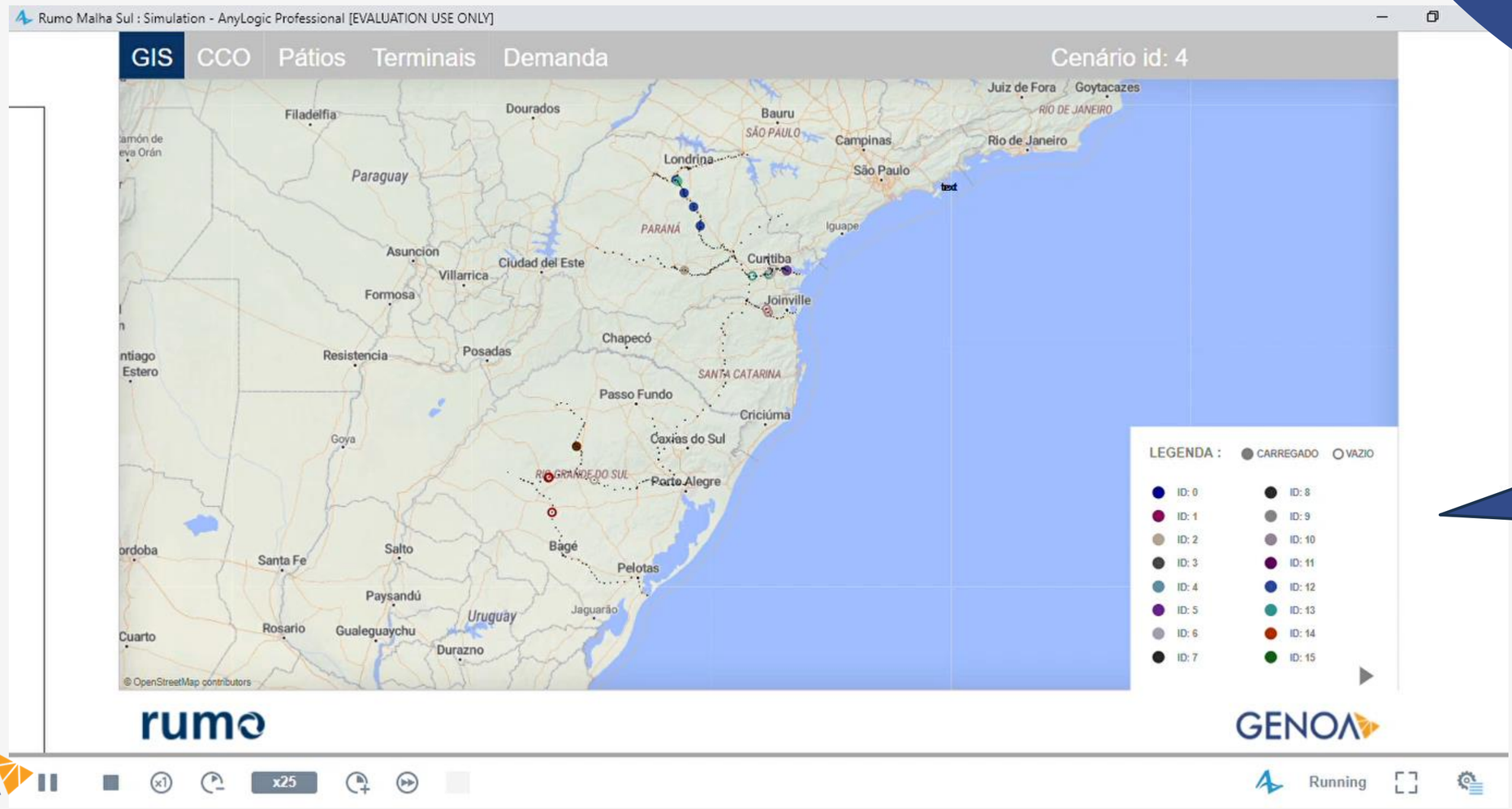
RESULTS

GIS



Loaded train is the filled circle

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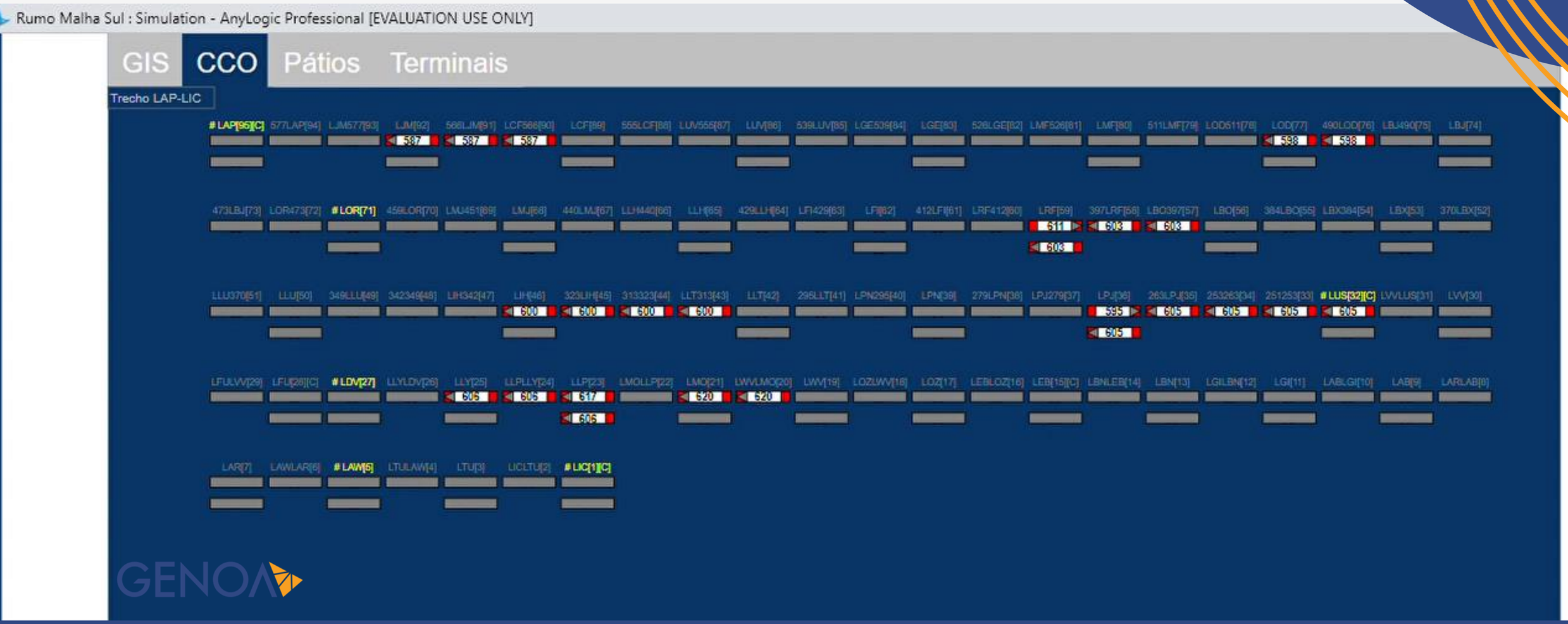
RESULTS

OCC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RESULTS

DASHBOARD

Locomotives

Trains in motion

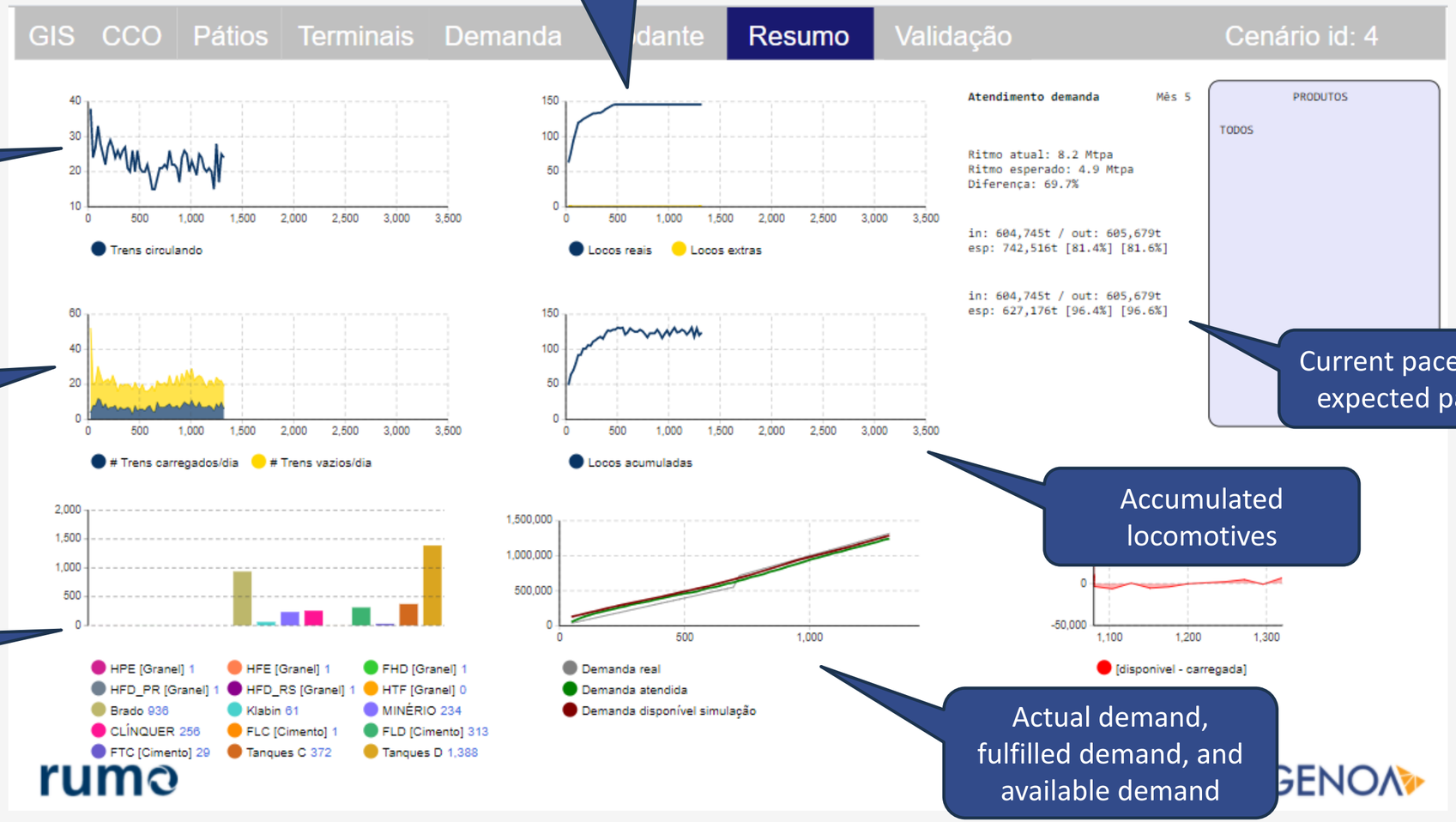
Loaded and Unloaded trains per day

Quantity of materials

Current pace and expected pace

Accumulated locomotives

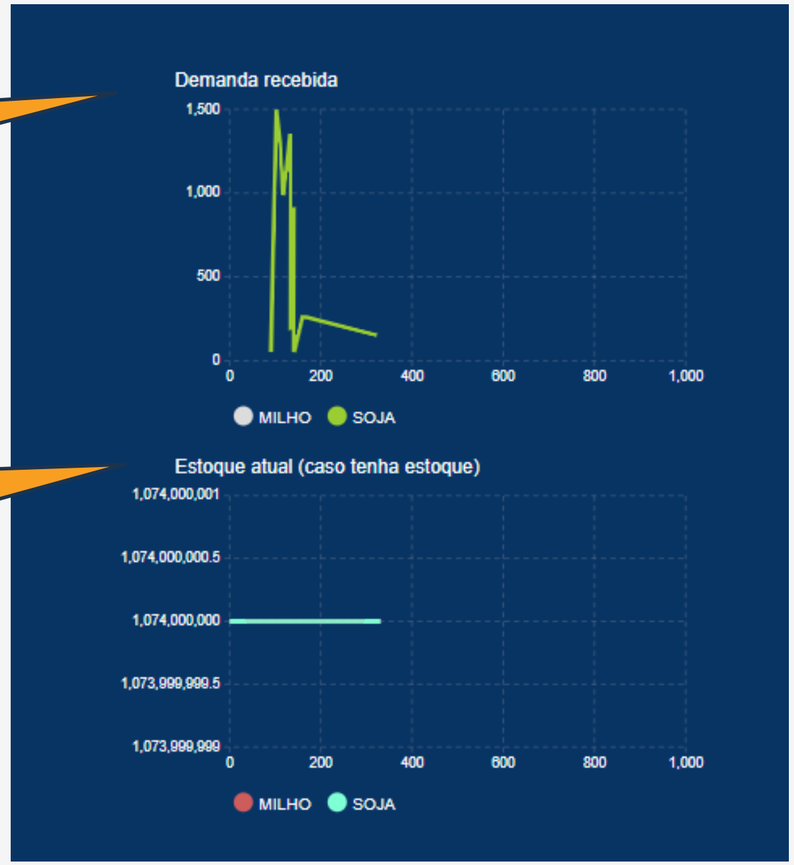
Actual demand, fulfilled demand, and available demand



RESULTS

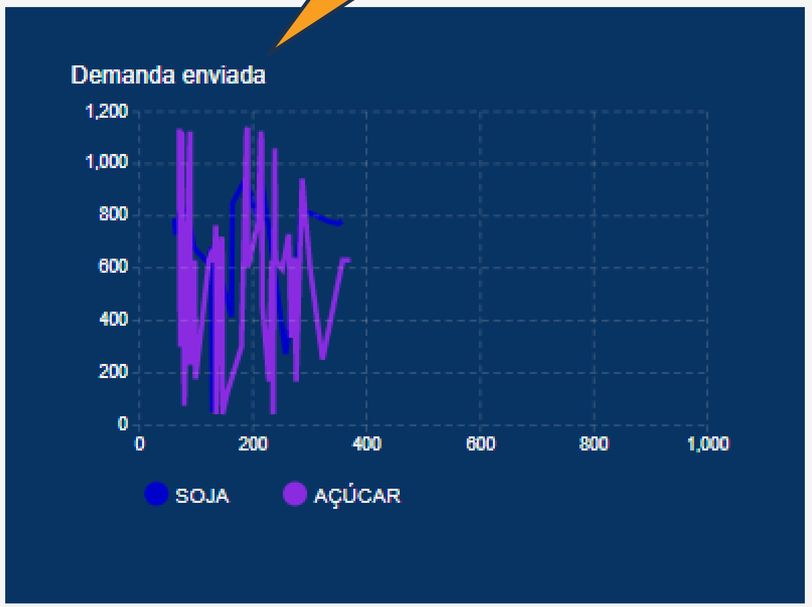
TERMINAL

Received demanda



Current inventory

Dispatched demanda



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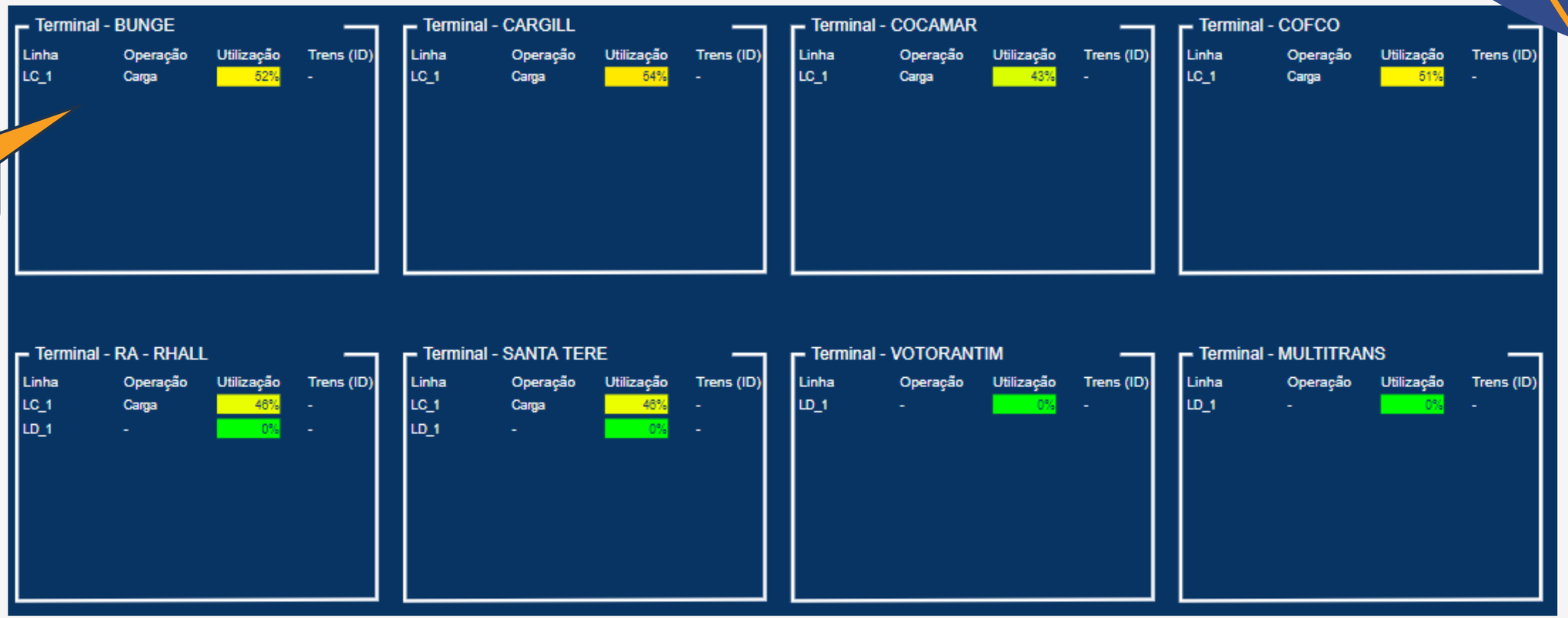
RESULTS

TERMINAL

Utilization of tracks at terminals



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CONCLUSION

- A simulation model was developed to be used by RUMO S.A. in the Southern Railway Network;
- The network infrastructure can be fully customized through an interface, allowing users to design their desired network layout;
- The model heuristically decides on routes, prioritizes loads, and selects appropriate train types to meet the expected demand with the available resources;
- Furthermore, the simulation model include:
  - Characteristics of the track (routes, sections, speeds, etc.);
  - Visualize and understand the operational effects of decisions in a graphical interface;
  - Cargo transshipment terminals and volumes from branches connected to the Southern Network;
  - Rumo's loading and unloading terminals, which can have an impact on capacities;
  - External events affecting the running capacity of trains.
- The model helped RUMO to assess capacity on quarterly bases of the railway network in different scenarios, as well as:
  - Analyze rolling stock utilization;
  - Identify structural bottlenecks within their network.

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THANK YOU!

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