

SUSTAINABLE URBAN LOGISTICS

Integrating VRP Algorithms and Agent-Based Simulation
for Optimized Resource Allocation



SPEAKERS



Ms Anna Bolognesi is a Project Engineer at **STAM**. A graduate of the University of Genoa, she holds a Bachelor's degree in Mechanical Engineering and a Master's degree in Engineering for Strategy and Security. Her expertise centres on developing multi-method simulation models, with a focus on logistics, supply chain, transport, and manufacturing. Anna actively contributes to industrial and research projects.

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Dr Lissa de S. Campos, Project Engineer at **STAM** with a PhD in Mathematical Physics. Skilled in transforming data into actionable insights using advanced data science tools. Focused on the development of machine learning models and optimization algorithms, with hands-on experience in real-world computer vision applications from end to end. Currently contributing expertise to both industrial and research projects.

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Business challenge

The Model

Resource Allocation

Automate & Predict

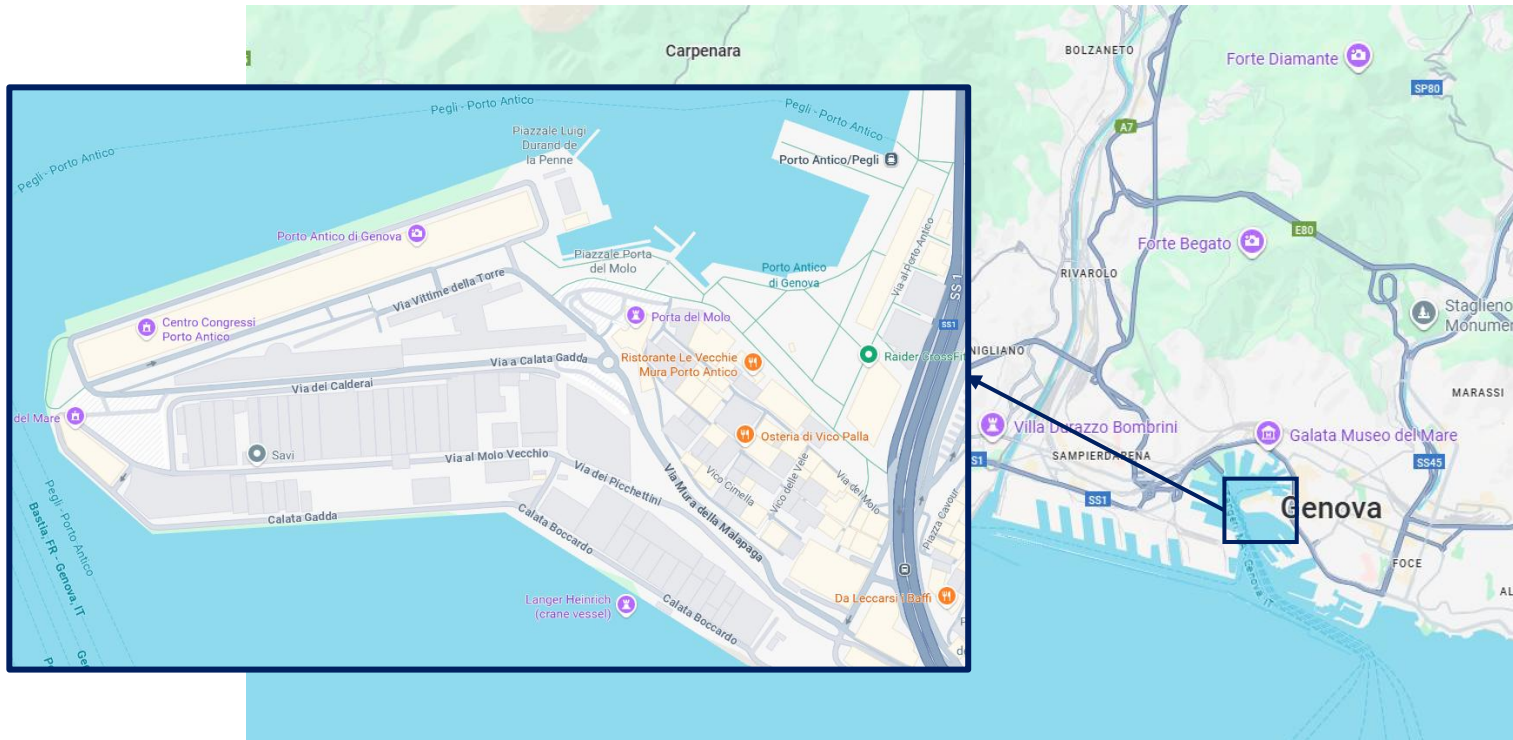
Use-case

An isometric illustration in a light blue and white color scheme. In the center is a large, multi-story building with arched windows and a central entrance. To the left, a winding road with dashed white lines curves around the building. A person stands on the sidewalk holding a box. In the foreground, a person on a bicycle with a box on the back is riding towards the left. Another person stands nearby holding a box. To the right of the building, there are several spherical streetlights on poles. In the bottom right corner, a complex mechanical structure resembling a crane or a large fan with multiple blades is visible. The text "BUSINESS CHALLENGE" is overlaid in the center-right area.

BUSINESS CHALLENGE

URBAN CONTEXT

- Porto Antico: Genoa's historic and multifunctional waterfront
- High pedestrian density, limited access, complex delivery rules



PROJECT GOALS

- To reduce emissions and traffic congestion
- To improve safety and accessibility in Porto Antico
- To test predictive urban logistics
- To enable scalability to other city contexts



The Key Question: *Which and how many carriers is the optimal amount to satisfy the observed demand?*

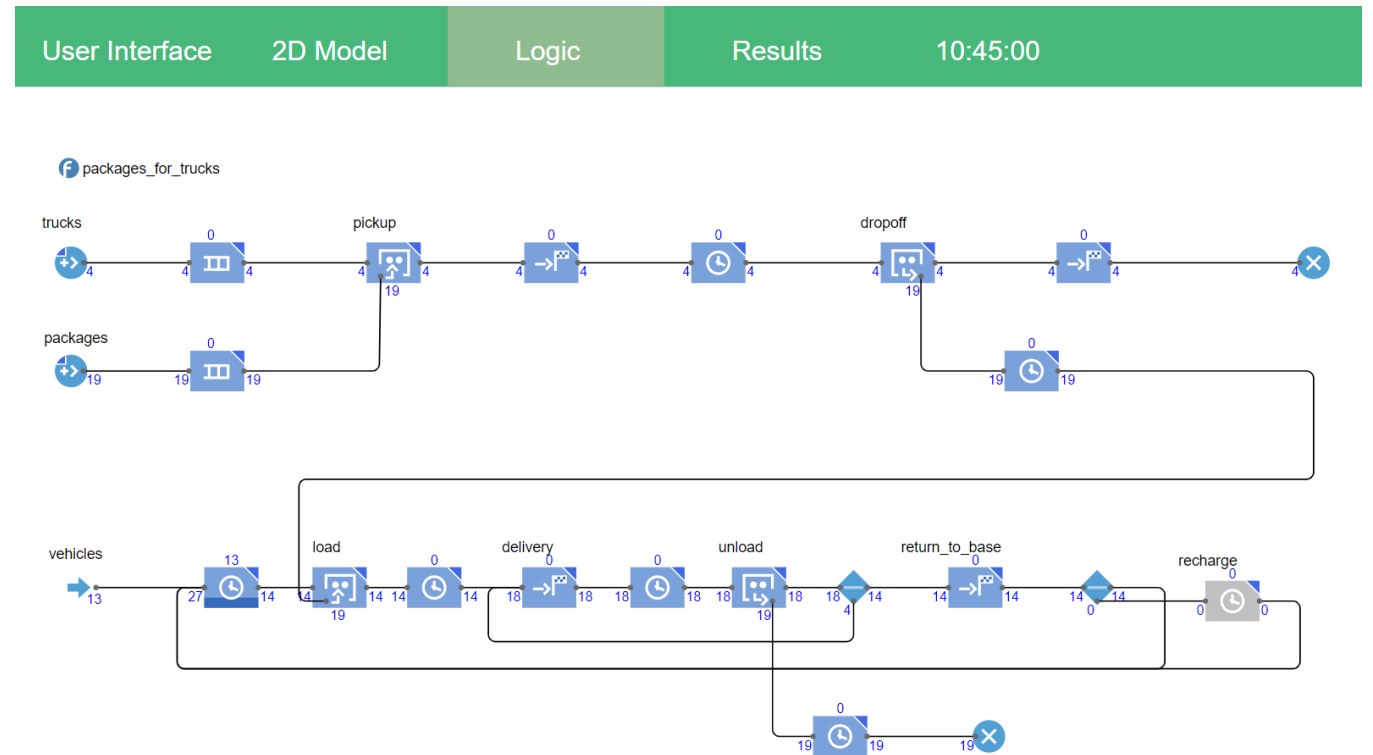
An isometric illustration of a city street scene. In the center is a two-story building with a flat roof and arched windows. To the left, a curved road with dashed white lines leads towards the building. In the foreground, a person stands near a box, a person on a bicycle carries a box, and another person stands with a box. To the right, a road curves away from the building, and a large, complex mechanical structure, possibly a crane or a piece of machinery, is visible. The scene is set against a light orange background with a blue sky and a yellow ground. The text "THE MODEL" is overlaid on the left side of the image.

THE MODEL

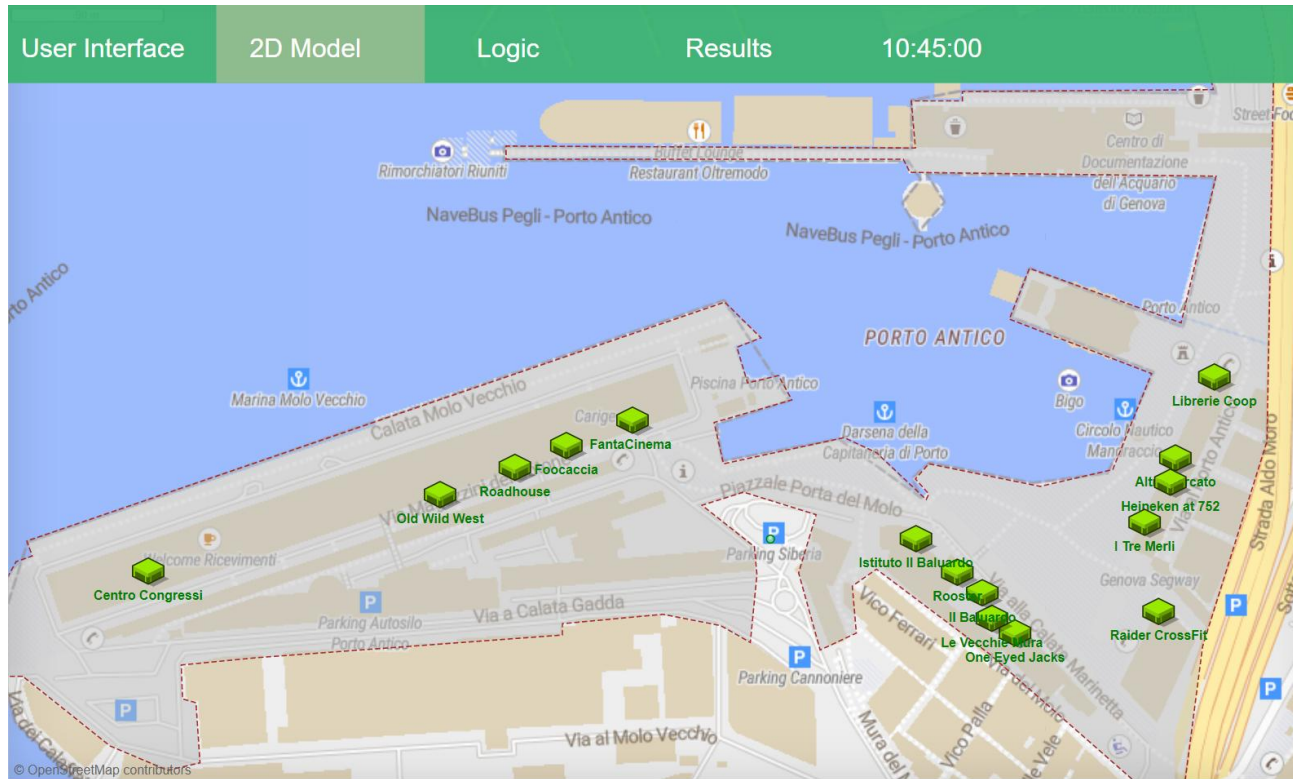
A Hybrid Simulation Approach

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Discrete-Event Simulation (DES) was used to manage delivery timings (pickups, drop-offs, schedules, events).



GIS INTEGRATION



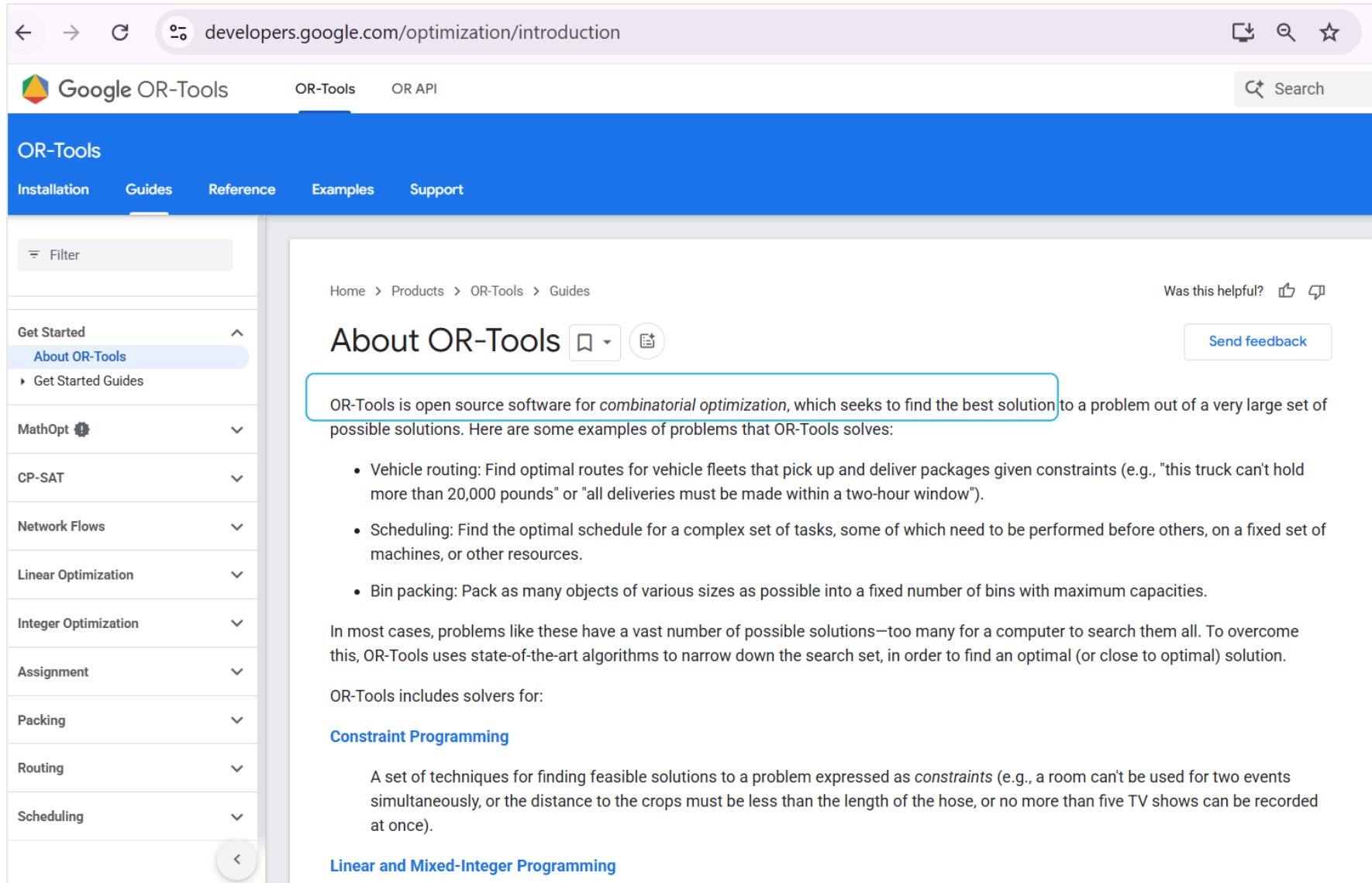
GIS Integration was used to represent the actual road network, pedestrian zones, and restricted areas of Porto Antico.



RESOURCE ALLOCATION

Assigning limited resources to tasks in the best possible way, given a set of constraints, to maximize or minimize an objective.

OR-TOOLS



The screenshot shows the Google OR-Tools website at the URL `developers.google.com/optimization/introduction`. The page has a blue header with the Google OR-Tools logo and navigation links for OR-Tools and OR API. Below the header is a blue navigation bar with links for Installation, Guides, Reference, Examples, and Support. A left sidebar contains a 'Filter' button and a list of categories: Get Started, About OR-Tools, Get Started Guides, MathOpt, CP-SAT, Network Flows, Linear Optimization, Integer Optimization, Assignment, Packing, Routing, and Scheduling. Blue arrows on the left point from the 'OR-TOOLS' title to each of these sidebar items. The main content area is titled 'About OR-Tools' and includes a breadcrumb trail (Home > Products > OR-Tools > Guides), a 'Was this helpful?' feedback link, and a 'Send feedback' button. The text describes OR-Tools as open source software for combinatorial optimization, listing examples like vehicle routing, scheduling, and bin packing. It also mentions that OR-Tools includes solvers for Constraint Programming, Linear and Mixed-Integer Programming, and others.

developers.google.com/optimization/introduction

Google OR-Tools OR-Tools OR API Search

OR-Tools

Installation Guides Reference Examples Support

Filter

Get Started ^

About OR-Tools

Get Started Guides

MathOpt v

CP-SAT v

Network Flows v

Linear Optimization v

Integer Optimization v

Assignment v

Packing v

Routing v

Scheduling v

Home > Products > OR-Tools > Guides

Was this helpful?

Send feedback

About OR-Tools

OR-Tools is open source software for *combinatorial optimization*, which seeks to find the best solution to a problem out of a very large set of possible solutions. Here are some examples of problems that OR-Tools solves:

- Vehicle routing: Find optimal routes for vehicle fleets that pick up and deliver packages given constraints (e.g., "this truck can't hold more than 20,000 pounds" or "all deliveries must be made within a two-hour window").
- Scheduling: Find the optimal schedule for a complex set of tasks, some of which need to be performed before others, on a fixed set of machines, or other resources.
- Bin packing: Pack as many objects of various sizes as possible into a fixed number of bins with maximum capacities.

In most cases, problems like these have a vast number of possible solutions—too many for a computer to search them all. To overcome this, OR-Tools uses state-of-the-art algorithms to narrow down the search set, in order to find an optimal (or close to optimal) solution.

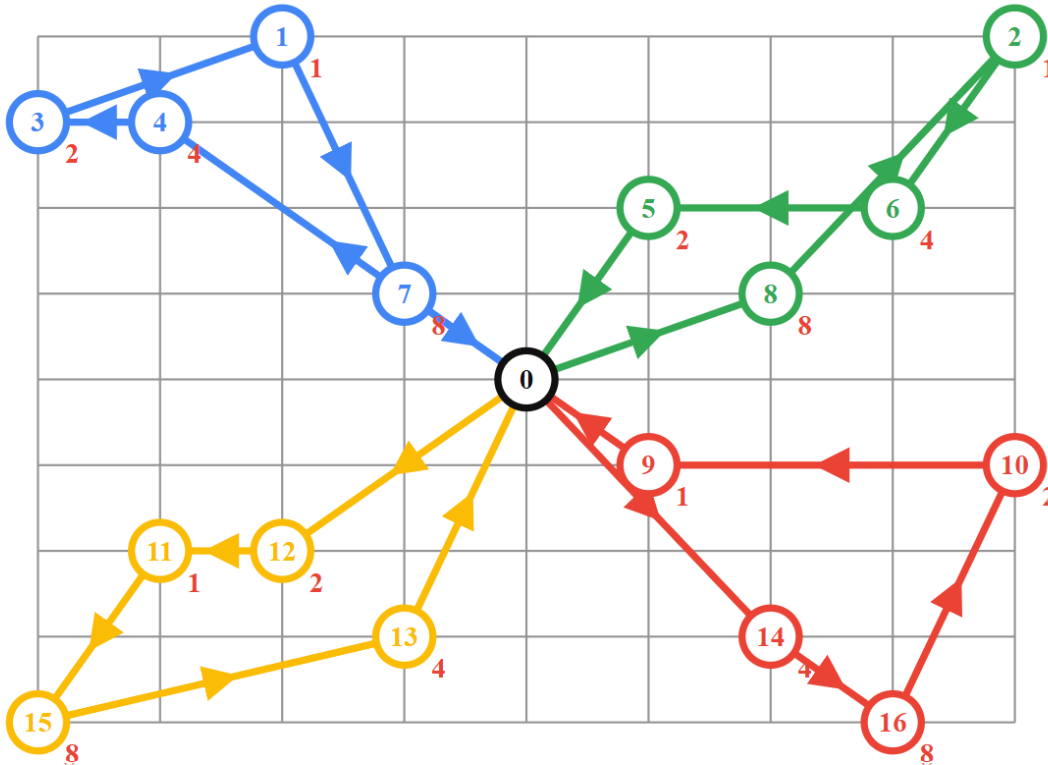
OR-Tools includes solvers for:

Constraint Programming

A set of techniques for finding feasible solutions to a problem expressed as *constraints* (e.g., a room can't be used for two events simultaneously, or the distance to the crops must be less than the length of the hose, or no more than five TV shows can be recorded at once).

Linear and Mixed-Integer Programming

OR-TOOLS: CVRP



Objective: 6208

Route for vehicle 0:

0 Load(0) → 4 Load(4) → 3 Load(2) → 1 Load(1) → 7 Load(7) → 0 Load(15)

Distance of the route: 1552m

Load of the route: 15

Route for vehicle 1:

0 Load(0) → 14 Load(0) → 16 Load(4) → 10 Load(12) → 9 Load(14) → 0 Load(15)

Distance of the route: 1552m

Load of the route: 15

Route for vehicle 2:

0 Load(0) → 12 Load(0) → 11 Load(2) → 15 Load(3) → 13 Load(11) → 0 Load(15)

Distance of the route: 1552m

Load of the route: 15

Route for vehicle 3:

0 Load(0) → 8 Load(0) → 2 Load(8) → 6 Load(9) → 5 Load(13) → 0 Load(15)

Distance of the route: 1552m

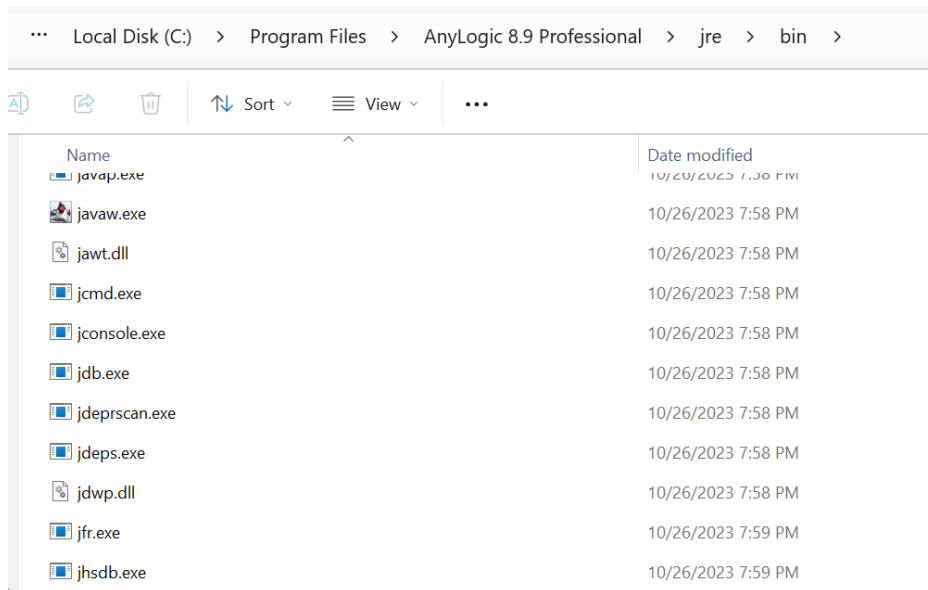
Load of the route: 15

Total Distance of all routes: 6208m

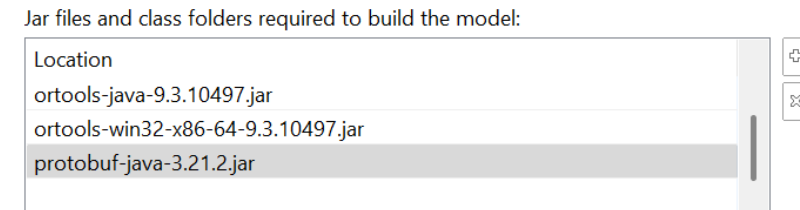
Total Load of all routes: 60

OR-TOOLS: INTEGRATION

Download the C++ files, build the dll and add in:

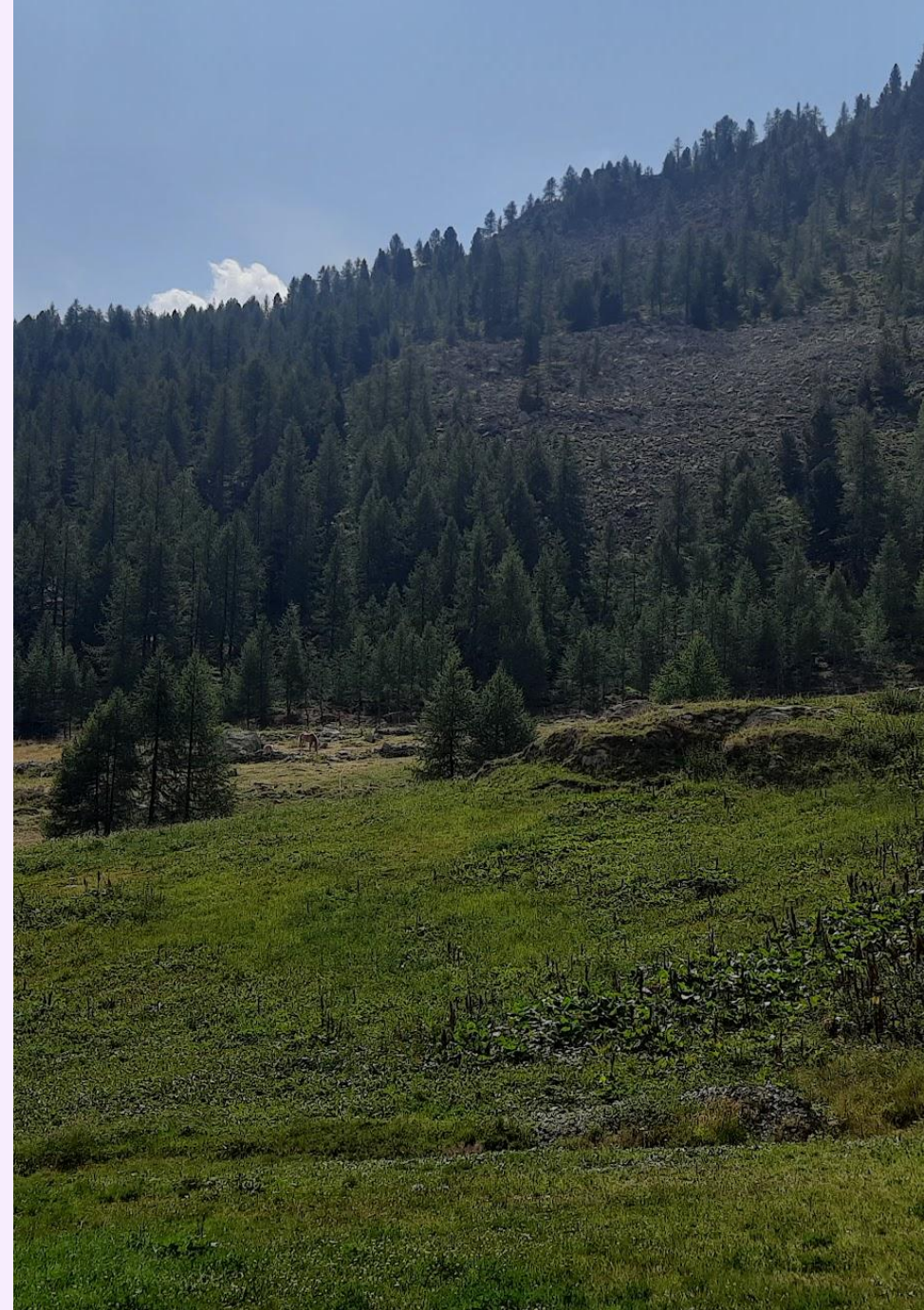


In the Properties tab:

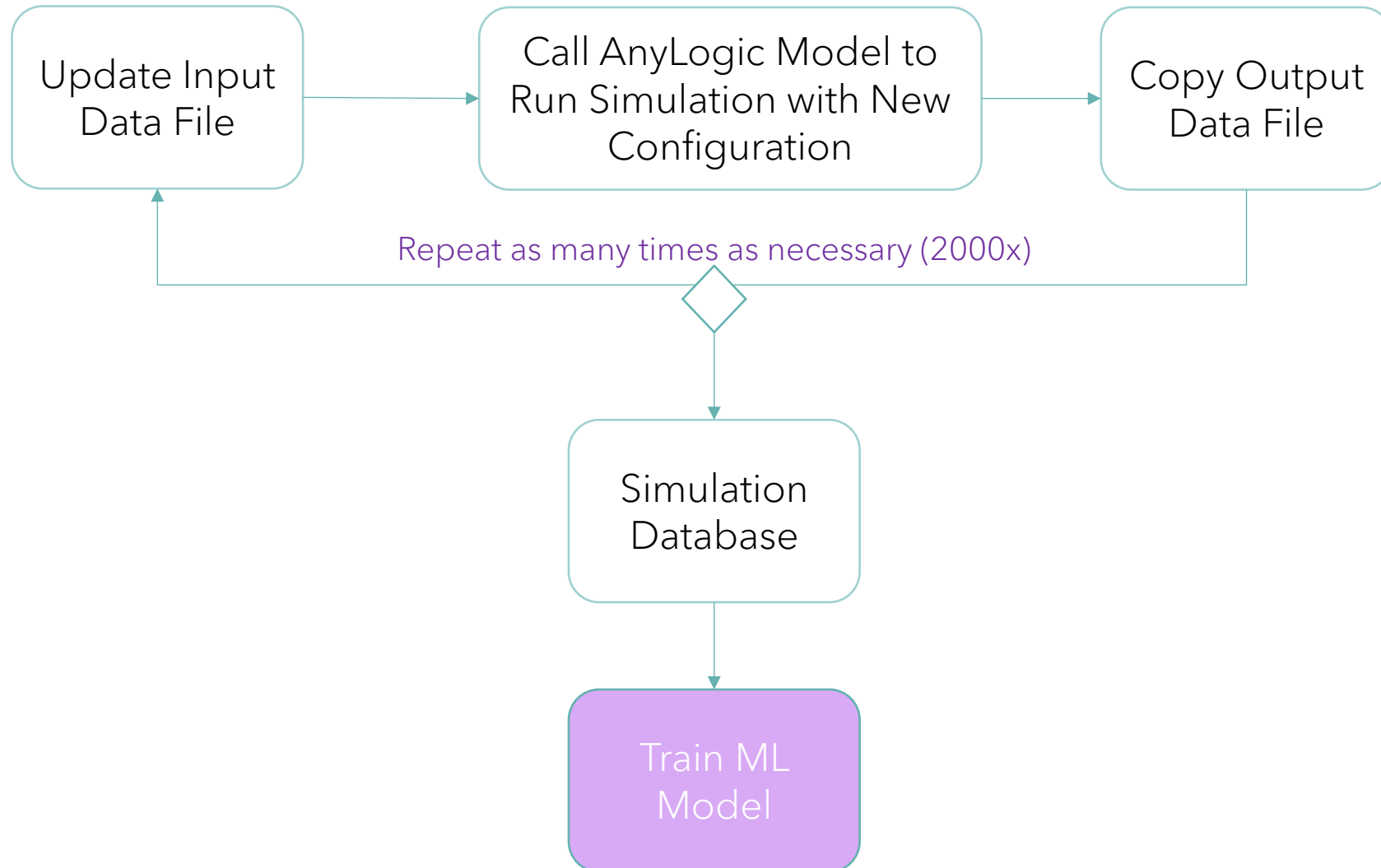


AUTOMATE & PREDICT

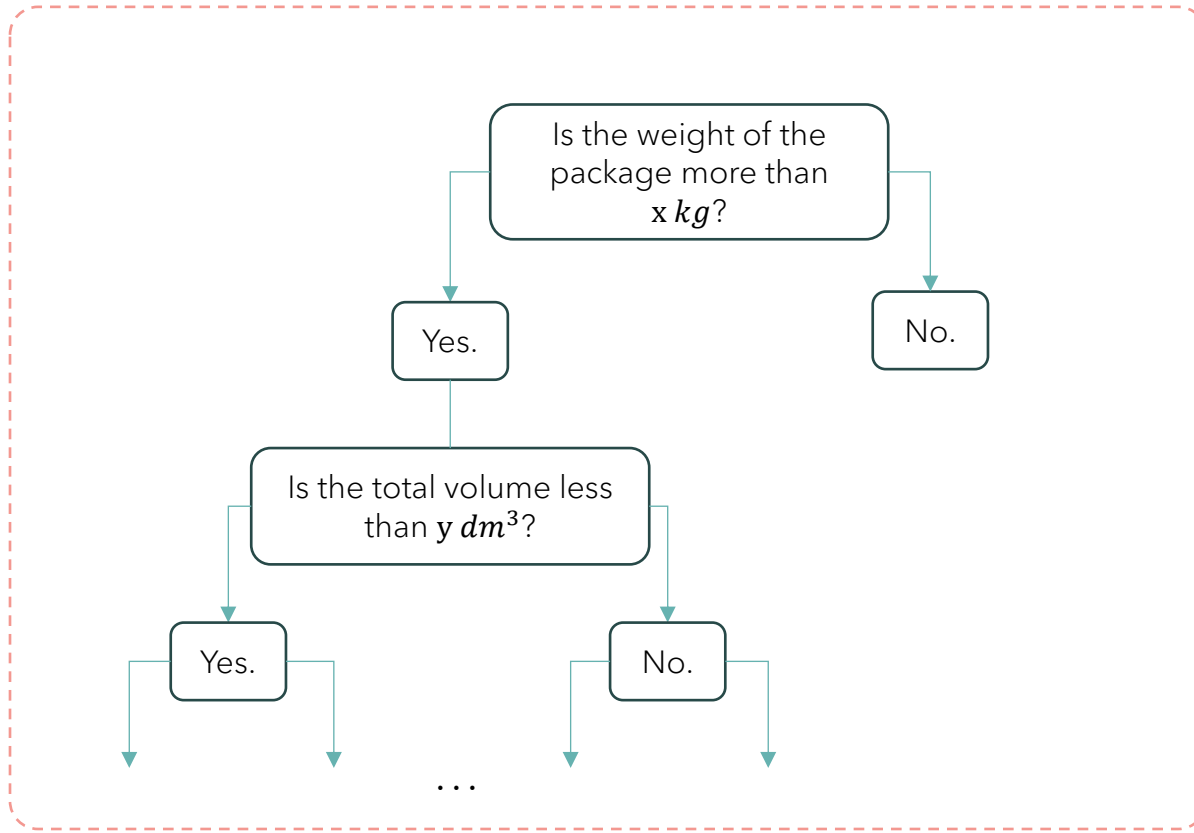
*Bringing Simulation and Machine Learning Together
with Automated Workflows.*



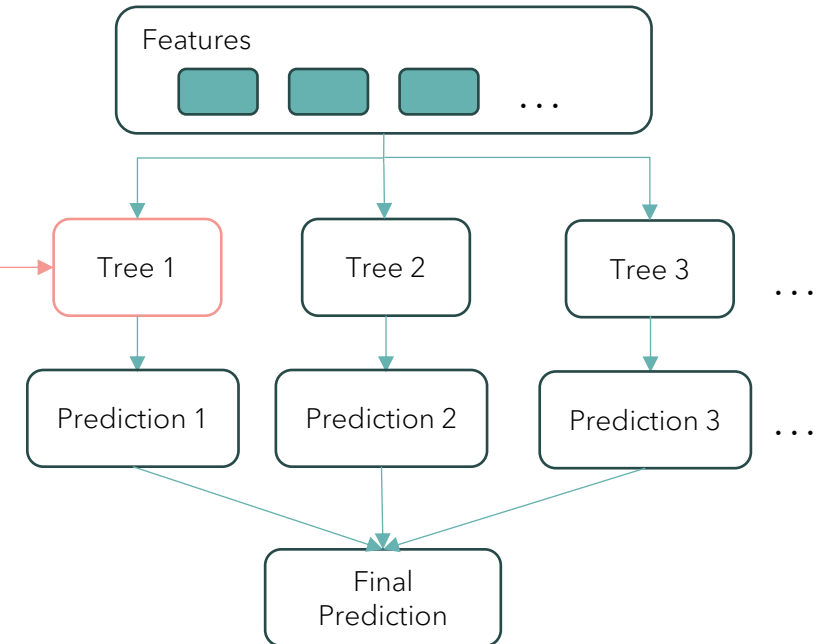
AUTOMATE & PREDICT



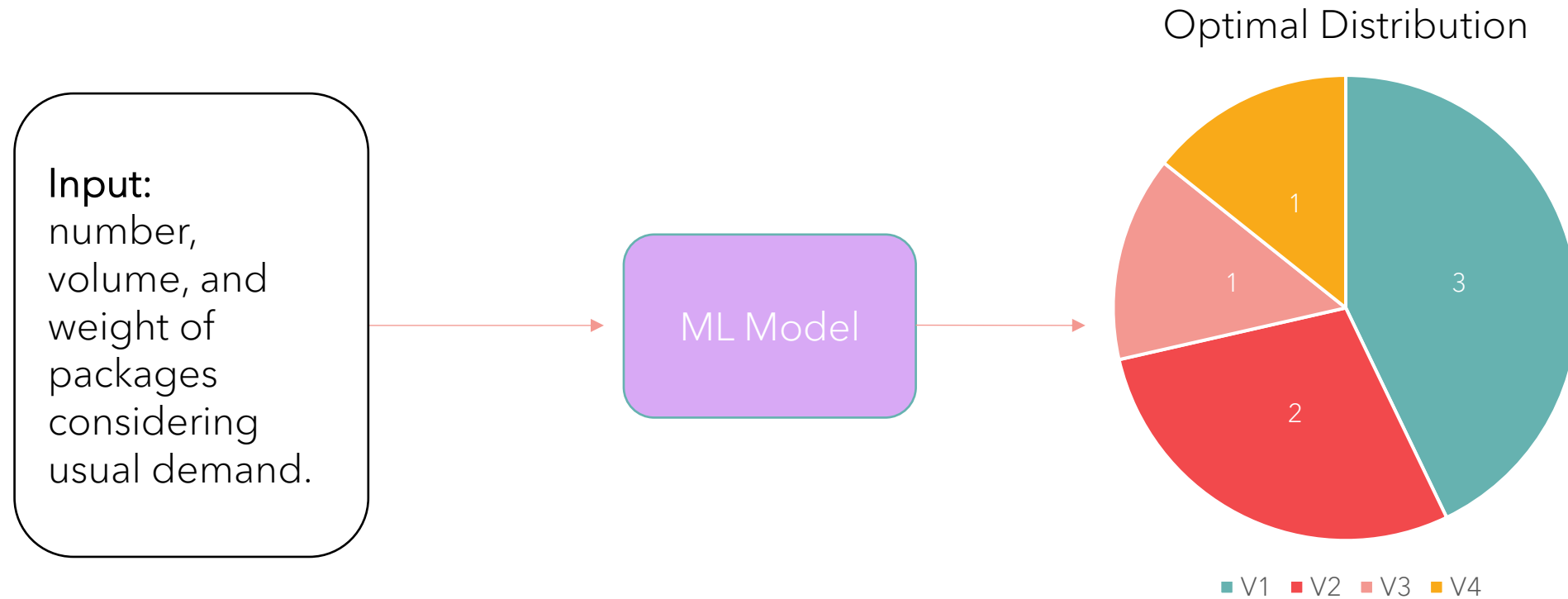
DecisionTree



RandomForestRegressor



ML MODEL



An isometric illustration in a light blue and white color scheme. It depicts a modern, multi-story building with a flat roof and arched windows. A curved road with dashed white lines winds around the building. Several stylized figures are shown: one person standing and holding a box, another person riding a bicycle with a box on the back, and a third person walking and carrying a box. In the foreground, there is a large, stylized fountain with multiple jets of water. The overall scene suggests a modern, eco-friendly urban environment.

ECOLOGIS

Executive summary and video demonstration

VIDEO DEMONSTRATION

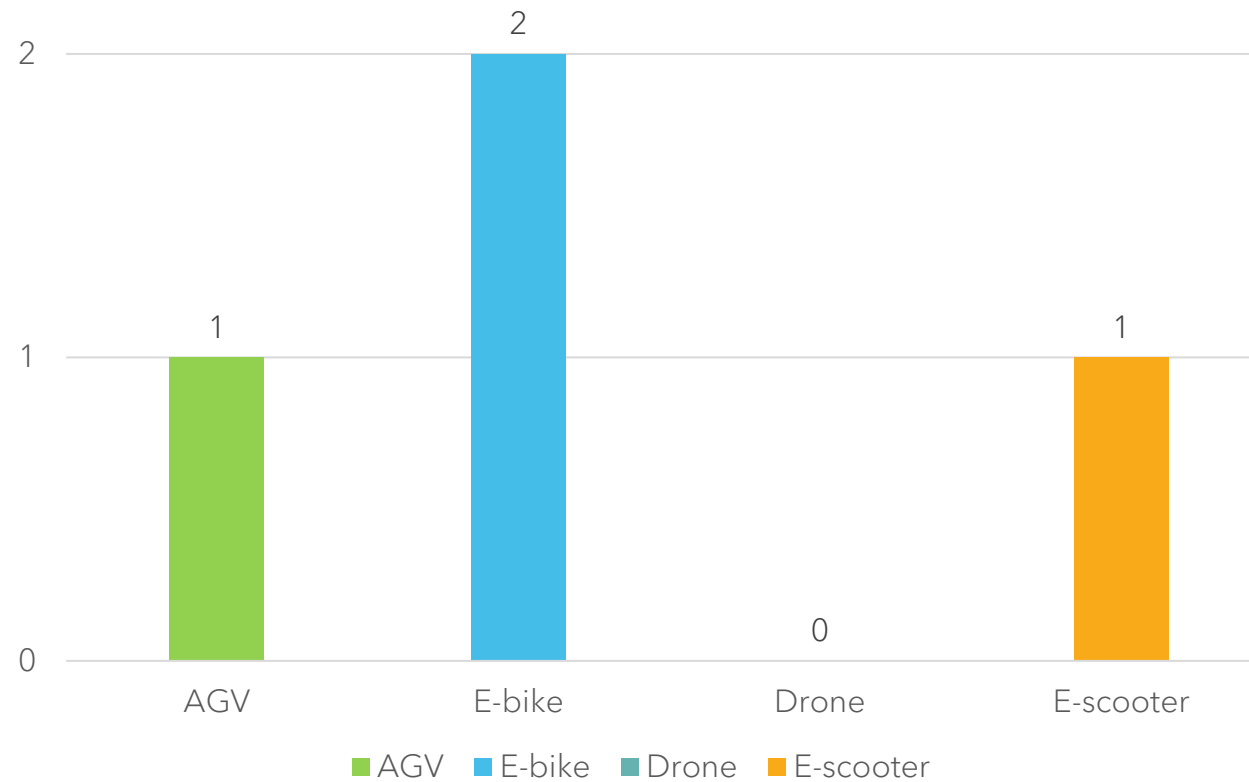
User Interface	2D Model	Logic	Results	08:05:00
<ul style="list-style-type: none">transporters Trasportatore [13]carbikedronecarica 10,000unloadingget_latget_longmove_transporters 180who_loadssaveDatalogToFile		<ul style="list-style-type: none">average_time 0average_load 0set_activitiesCattaneo (5)Marinetta (5)Mandraccio (5)assign_zonesset_destinationsclients Negozio [15]	<ul style="list-style-type: none">pause 42,600schedule 1, next in 3,300delivery_trucks Empty populationentrances {2}compute_distanceMatrixcomputepackages_per_delivery 0 samplesdelivery_time 0 samplestrips_per_transporter 0 samplesdistance_per_transporter 0 samples	

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ECO DELIVERY
Genova Waterfront

BUSINESS CHALLENGE

Which and how many carriers is the optimal amount to satisfy the observed demand?





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