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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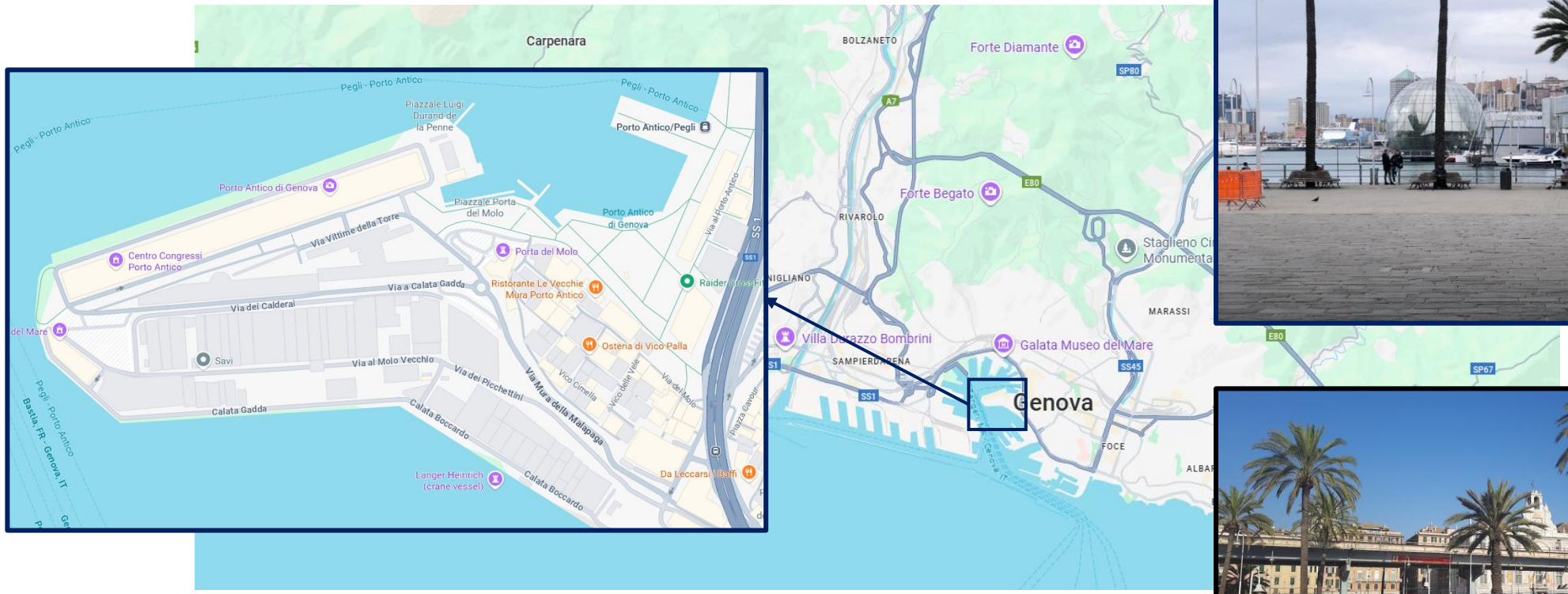
CONTENTS

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?*

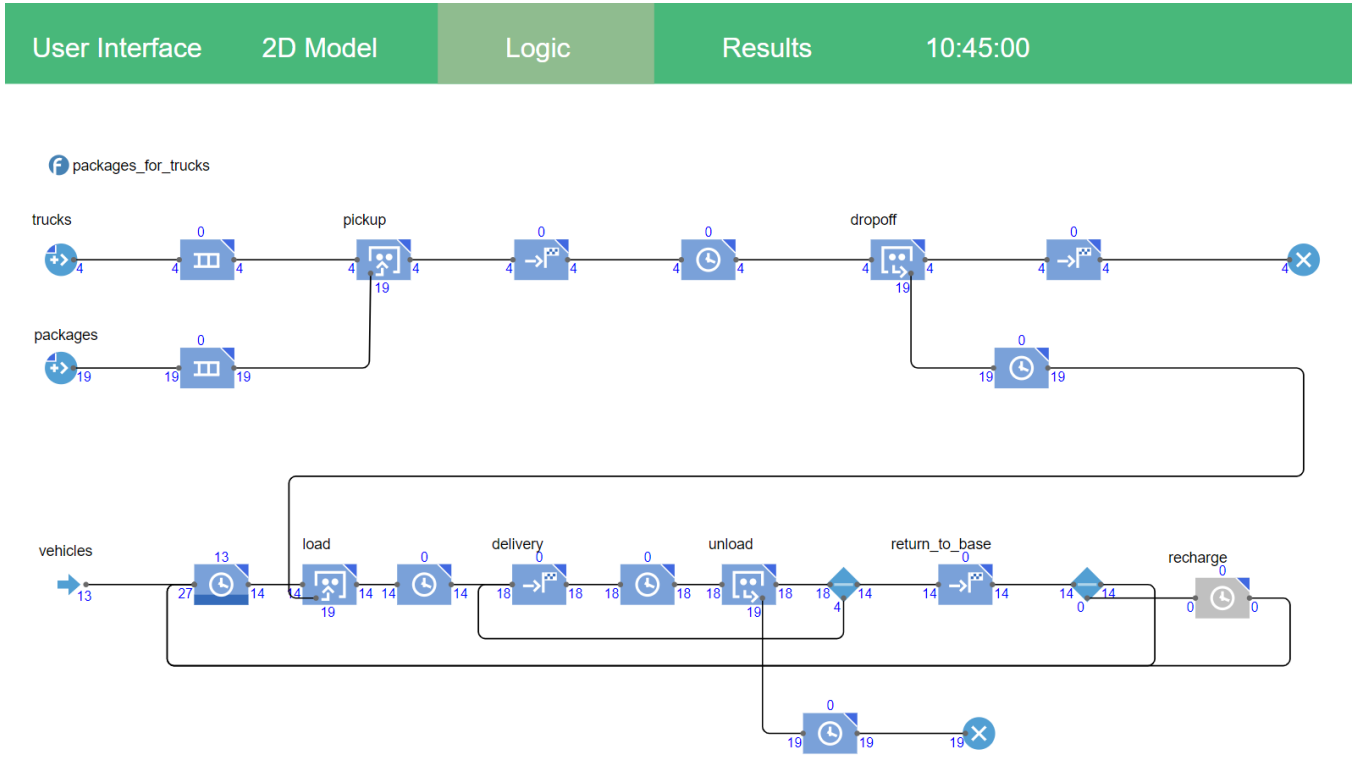
THE MODEL

A Hybrid Simulation Approach

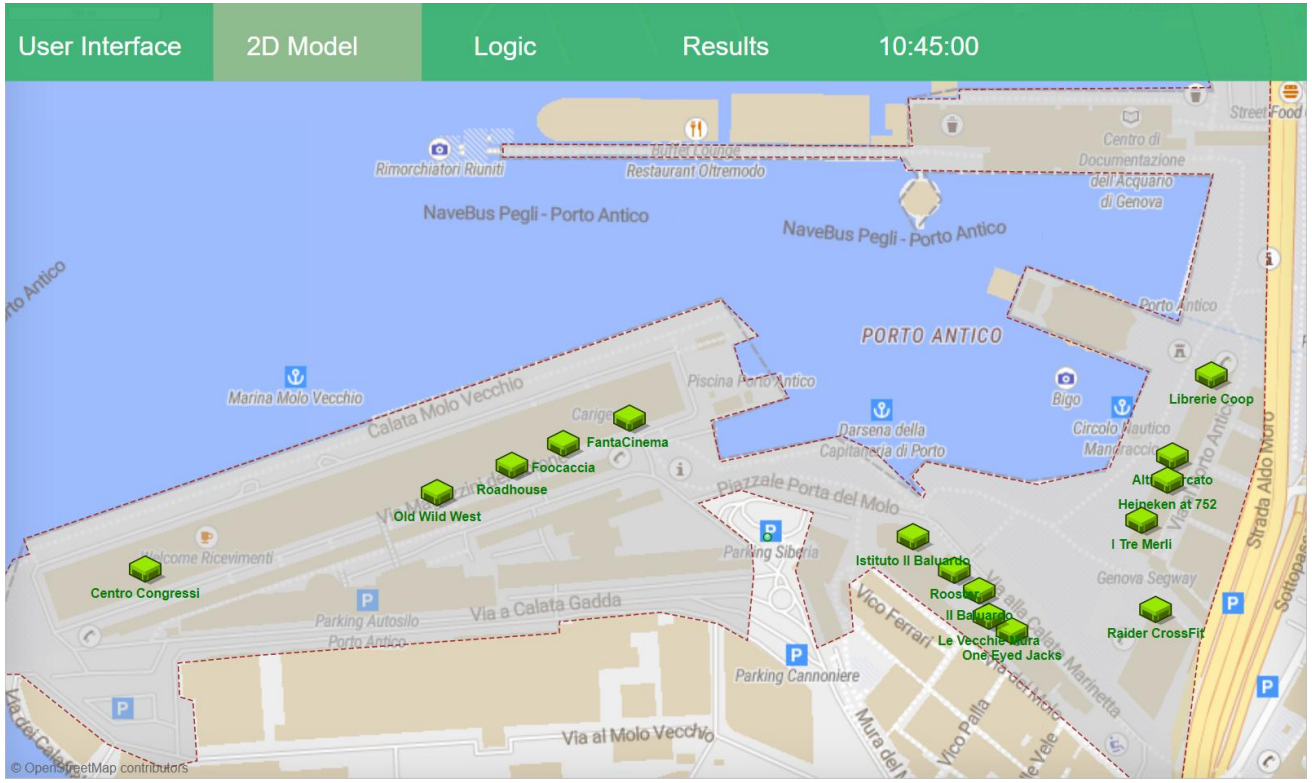
A HYBRID APPROACH

Agent-Based Modeling (ABM) was used to simulate the behavior of individual delivery vehicles, customers, and logistics hubs.

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



GIS INTEGRATION

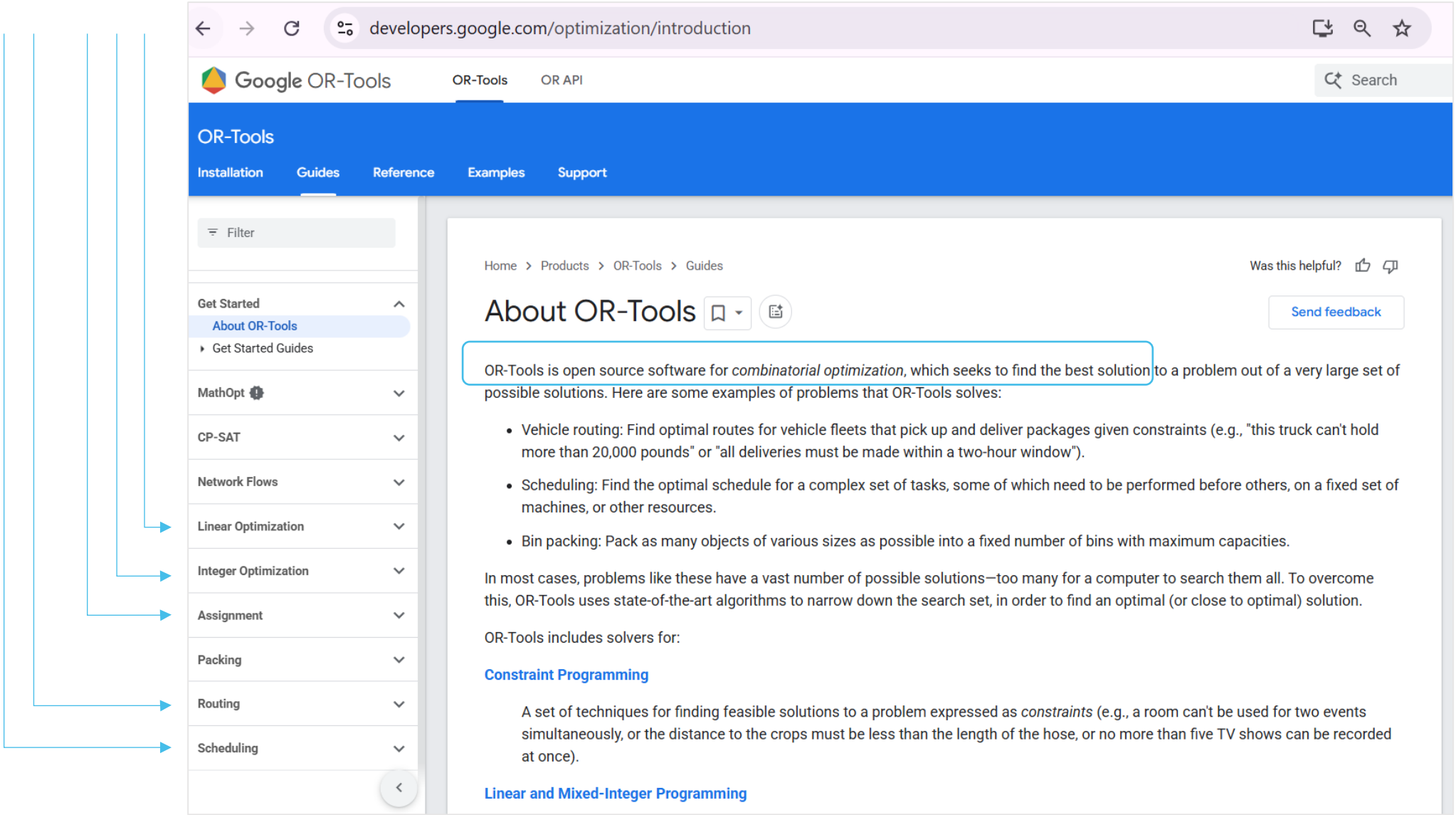


GIS Integration was used to represent the actual road network, pedestrian zones, and restricted areas of Porto Antico.

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


developers.google.com/optimization/introduction
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OR-Tools
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Examples
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About OR-Tools
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MathOpt
CP-SAT
Network Flows
Linear Optimization
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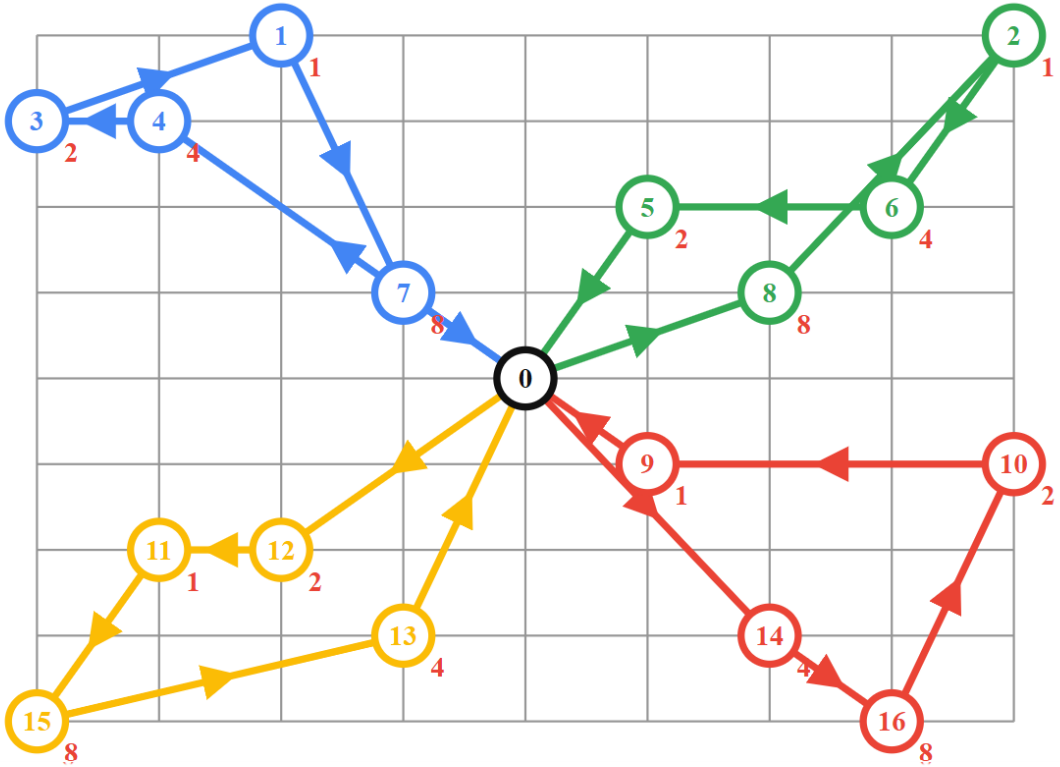
Was this helpful?
About OR-Tools
Send feedback
OR-Tools is open source software for combinatorial optimization, which seeks to find the best solution to a problem out of a very large set of possible solutions. Here are some examples of problems that OR-Tools solves:
Vehicle routing: Find optimal routes 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

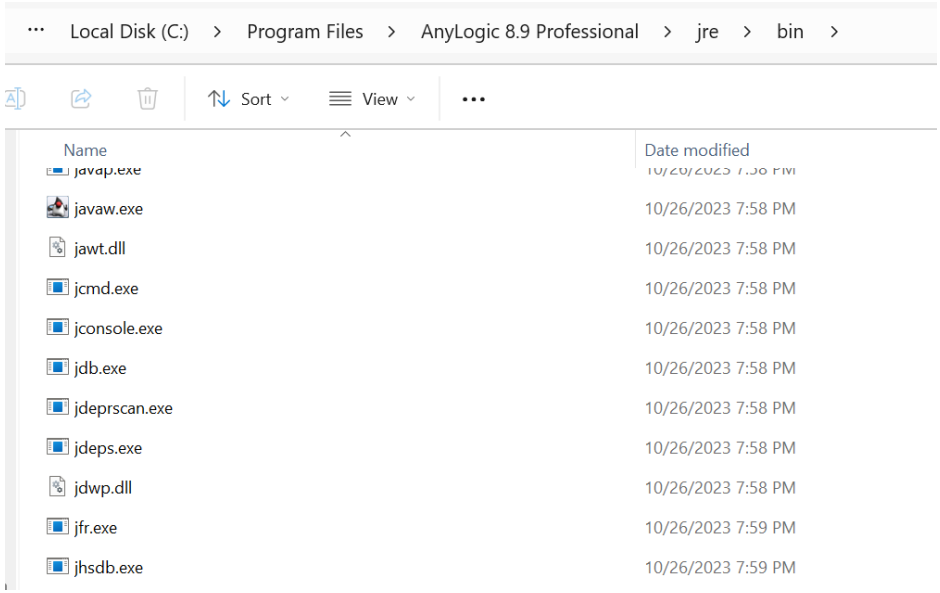



```
Objective: 6208
Route for vehicle 0:
 0 Load(0) ->  4 Load(0) ->  3 Load(4) ->  1 Load(6) ->  7 Load(7) ->  0 Load(15)
Distance of the route: 1552m
Load of the route: 15

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
```

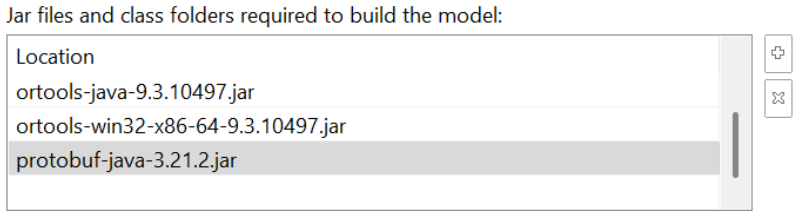
Example from: https://developers.google.com/optimization/routing/cvrp#java_2

OR-TOOLS: INTEGRATION

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



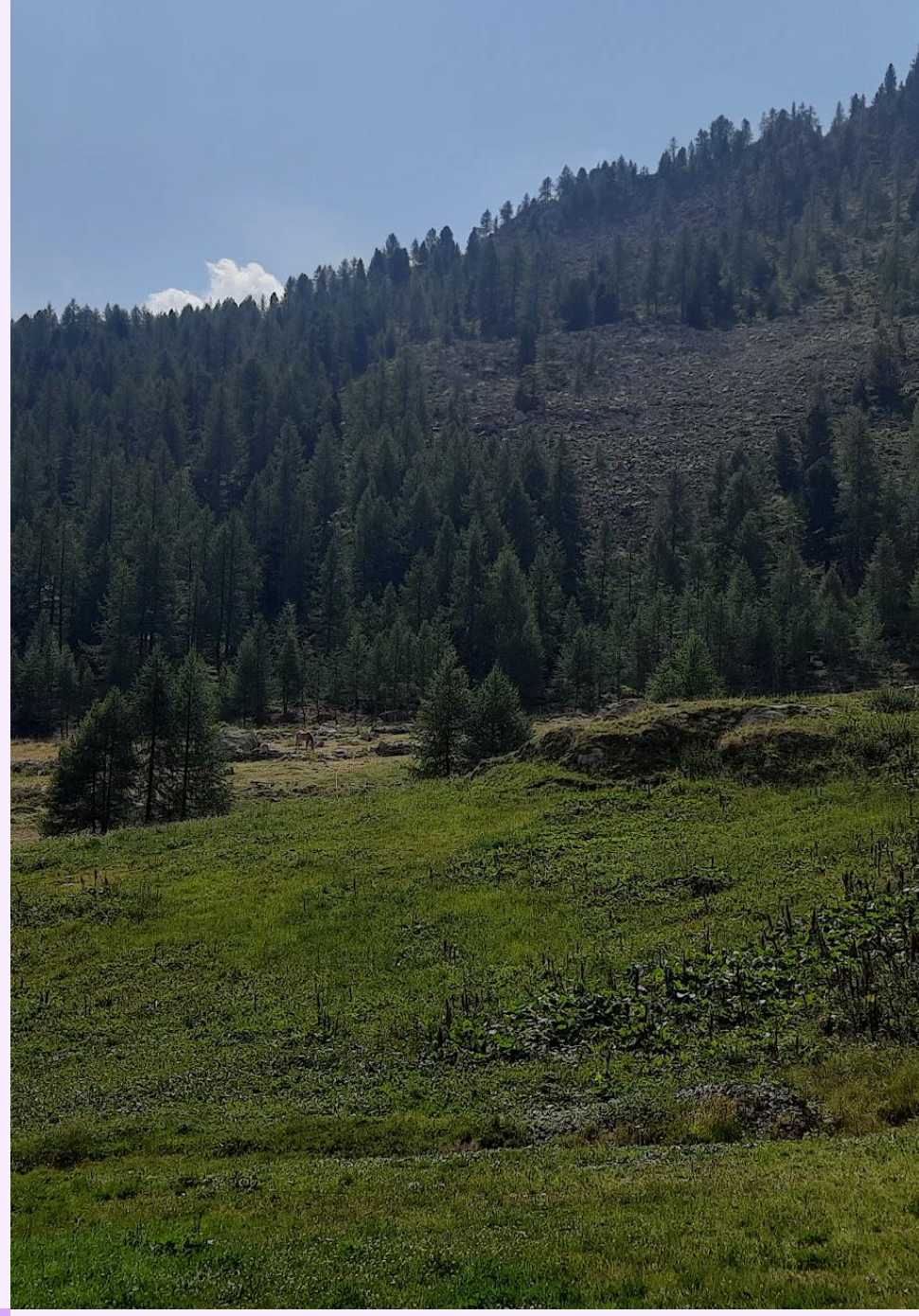
In the Properties tab:



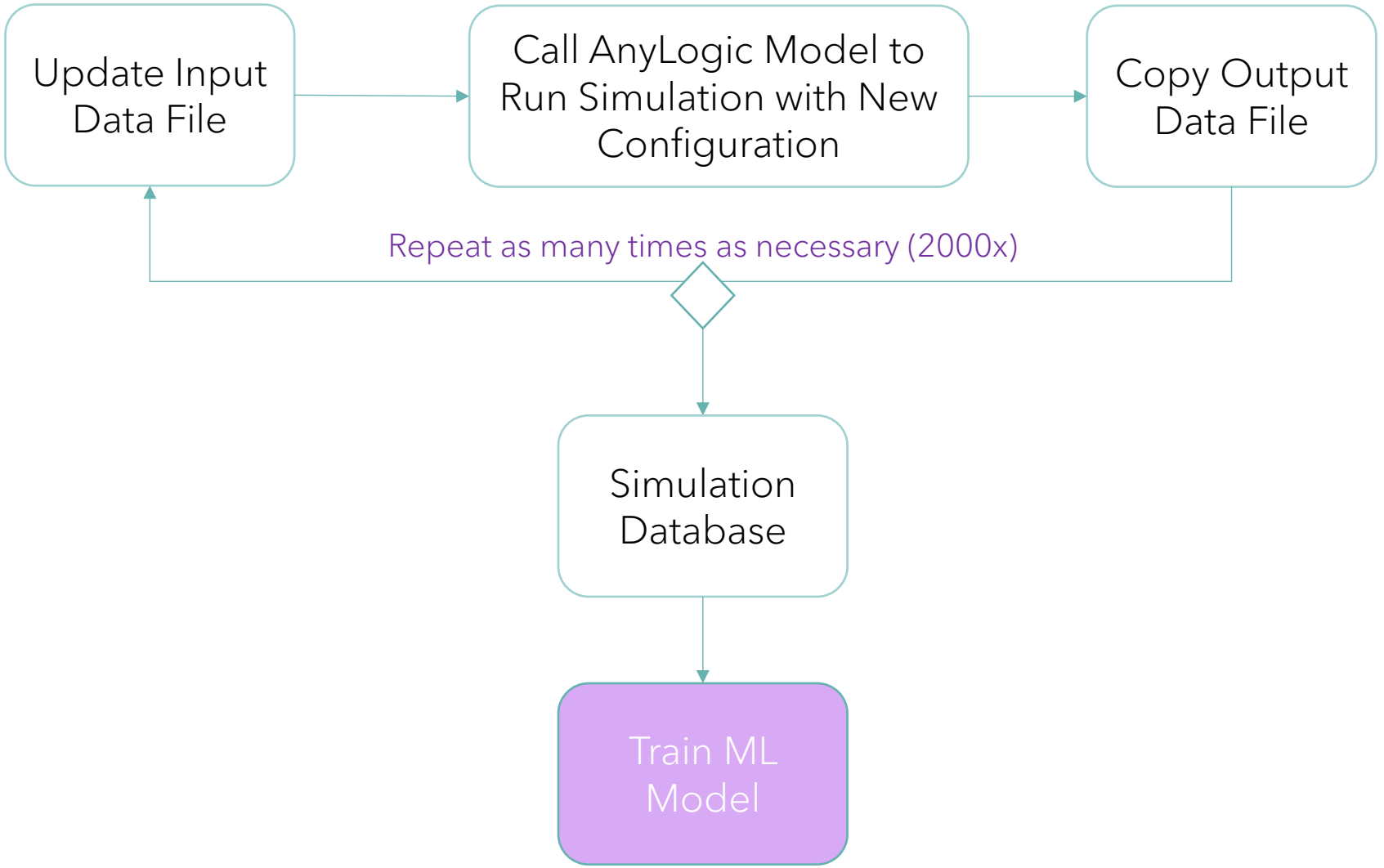
Example online: https://cloud.anylogic.com/model/0caf830a-4b60-4fb4-b41f-2103e15428f0?mode=SETTINGS

AUTOMATE & PREDICT

Bringing Simulation and Machine Learning Together with Automated Workflows.

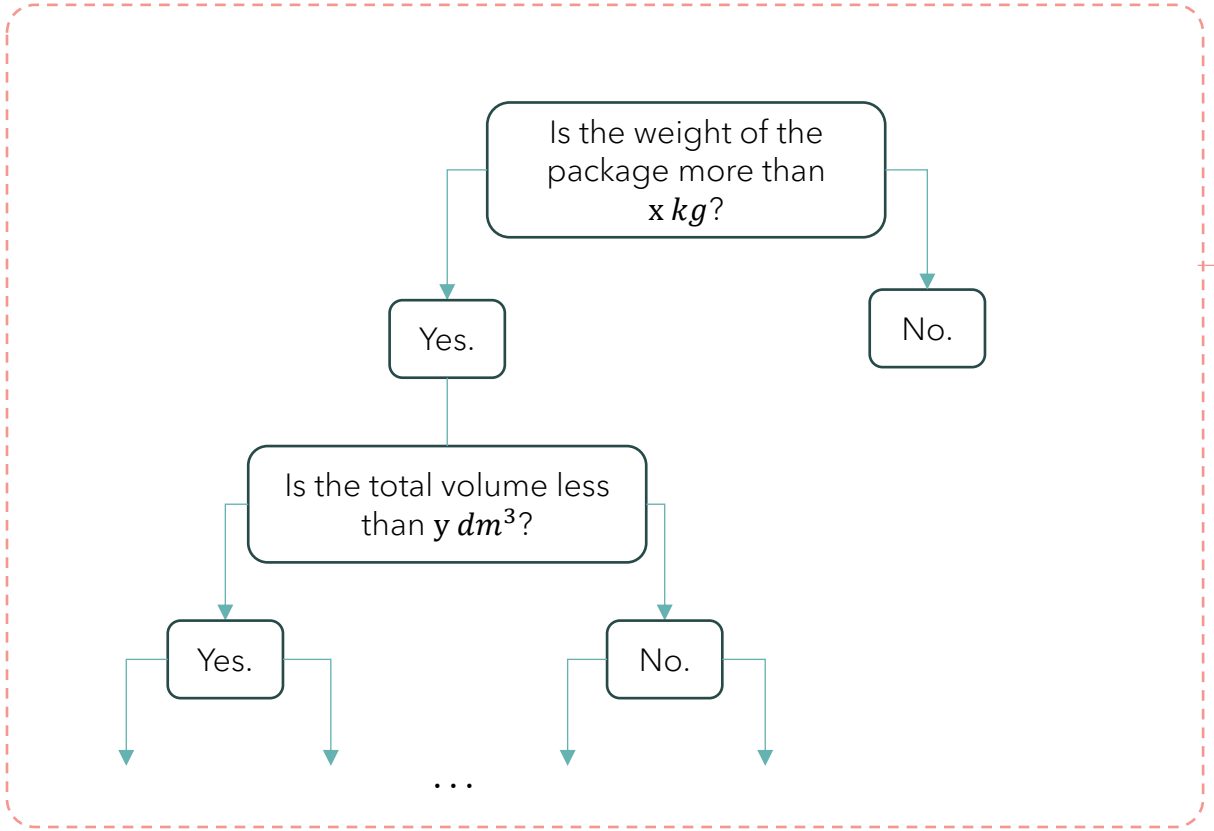


AUTOMATE & PREDICT

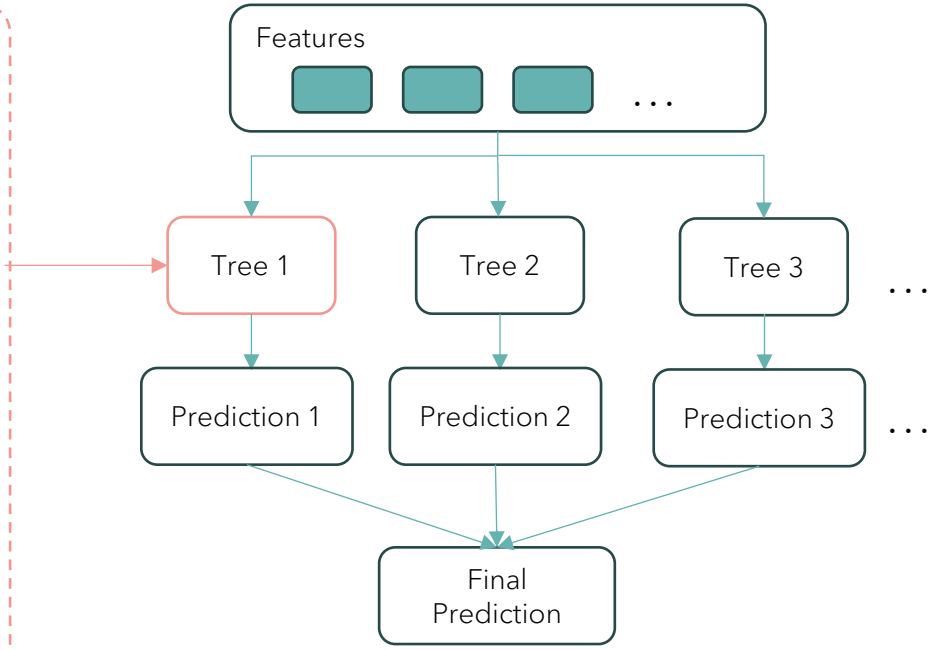


ML MODEL

DecisionTree



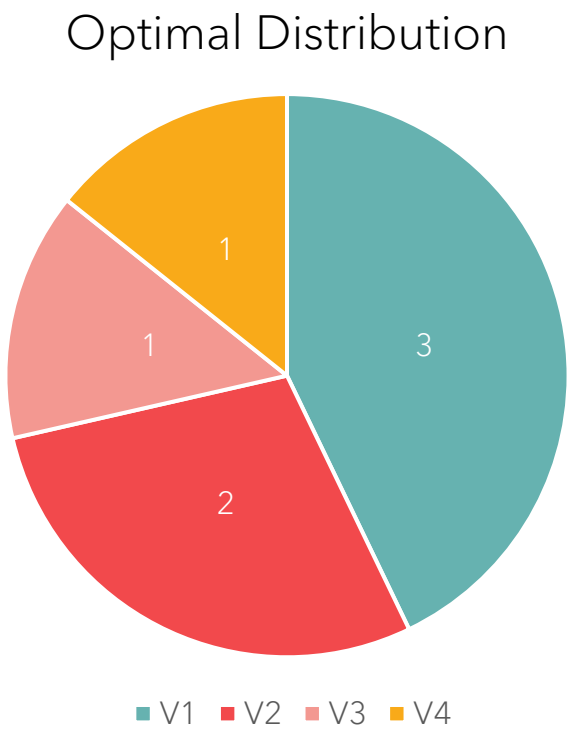
RandomForestRegressor



ML MODEL

Input: number, volume, and weight of packages considering usual demand.

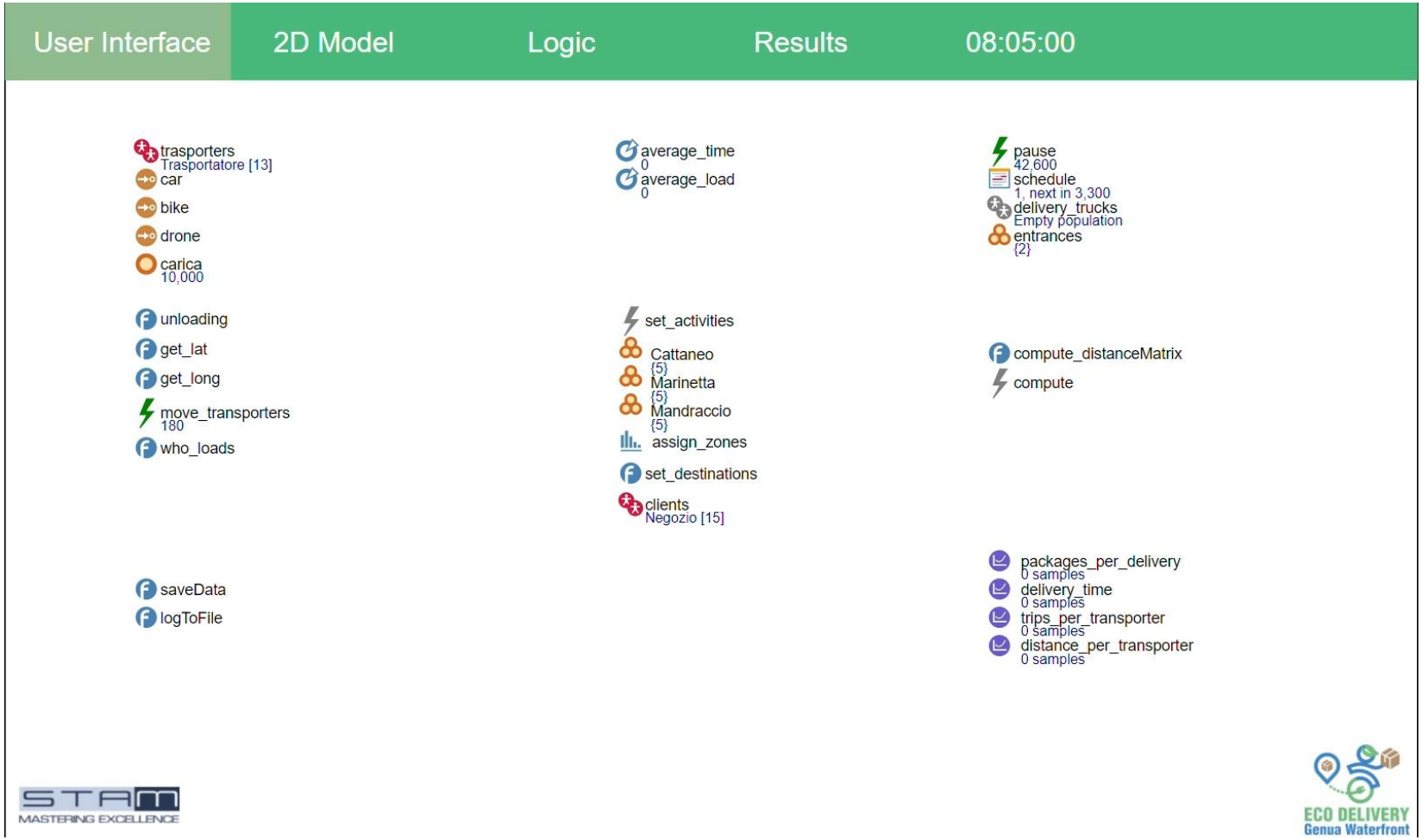
ML Model



ECOLOGIS

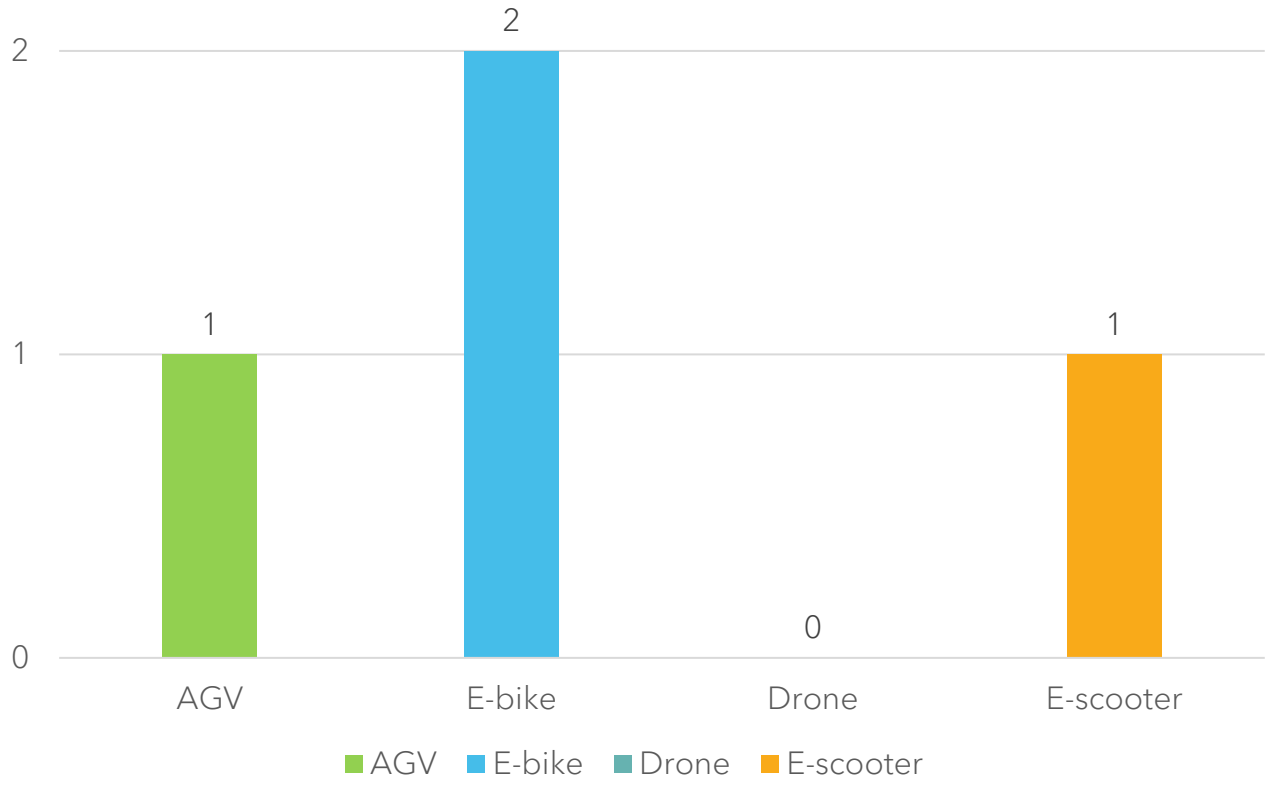
Executive summary and video demonstration

VIDEO DEMONSTRATION



BUSINESS CHALLENGE

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



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