
# High Frequency Bus Route Optimiza Bunching

Transportation Road Traffic

## Problem:

Bus bunching was hurting service reliability in Quebec City, leading to long waits, crowded buses, and a frustrating experience for both riders and drivers.

## Solution:

SimWell built a simulation model using real data

- ✓ Compared different dispatching and headway management approaches.
- ✓ Provided decision-makers with a clear, visual way to understand trade-offs.
- ✓ Laid the groundwork for future tools like controller training and digital twins.

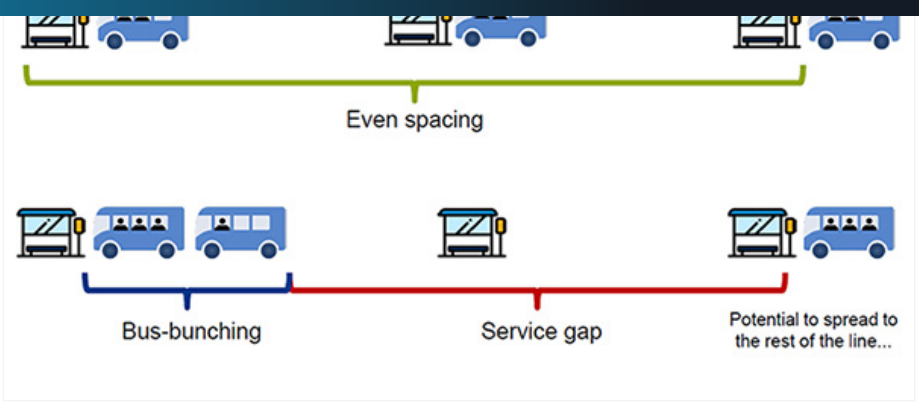
RTC is the public transit agency for Quebec City, Canada. It ensures the mobility of people in the urban agglomeration of Quebec City by offering public transport and promoting the integration of different transportation solutions.

In search of a data-driven solution to bus bunching, RTC turned to SimWell - an industrial engineering company supporting business decisions with simulation, data science, and optimization, based in US and Canada. SimWell's solution to the bus bunching problem involved simulation modeling with AnyLogic.

## Problem

Bus bunching is a problem faced by transport authorities around the world and for RTC there is no exception.

In a perfect world, every bus would arrive at a stop according to planned frequency to efficiently serve customers. In reality, several problems can occur and breakdown any well-thought plans: traffic congestion, schedule gaps, mechanical failures, unexpected demand leading to overcrowding and uneven loads, etc. All of these create problems for customers and




Bus bunching problem diagram (click to enlarge)

The objective of this project was to improve service quality for the customers while maintaining or improving the quality of work for bus drivers. Using a simulation model, engineers wanted to test solutions and see their potential impact and risk for customers and bus drivers before deployment into the real world.

# Solution

## Why AnyLogic?

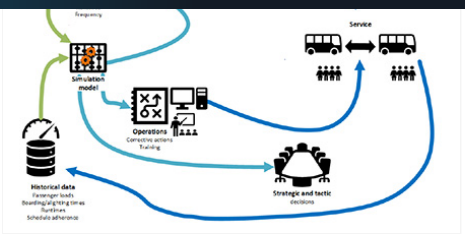
One of the main goals of using the simulation model for transportation system analysis was to figure out the best solution to solve the bus bunching problem. Another goal was to allow stakeholders and decision-makers to witness experimentation and see how solutions physically operate and not just with tables and statistics. AnyLogic's UI and 2D and 3D animation capabilities fully covered these requirements, providing multiple views and strong features.

Implementation flexibility thanks to JAVA extensibility and the ability to package the model as the standalone

actions. The long-term decisions are modeled by changing the input data.

The historical data used to calibrate the model was taken from bus information systems:

- GPS locations and runtimes from Automatic vehicle location system
- Destinations
- Automatic passengers counter
- Capacity
- Travel time




Solution infrastructure (click to enlarge)

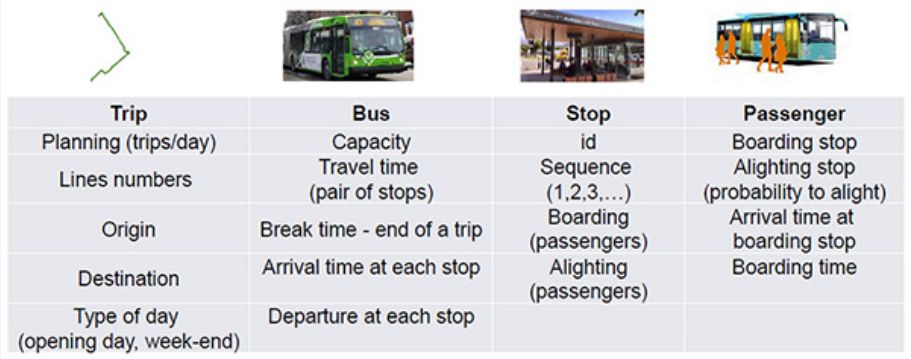
The information helps reproduce all components of the trip processes and bus capabilities. Different sorts of variability are also captured in the historical data, such as traffic congestion, traffic lights, seasonal factors, overcrowding, etc.

The model is fed from historical data extracted from RTC data warehouse. It allows calibration of different functions of the model, such as travel times, driver behaviors, ridership at the various stops, etc. Then, to test bus frequencies and schedule runtimes, schedules are taken from the RTC planning software.

The simulation model provides visualization and information that can be used in decision making. The

For the reference scenario, engineers used the data from 2018 and 2019 – before the pandemic, to give a baseline. The team included various data for analysis:

1. Bus time at each stop (open doors duration, alighting and boarding time, additional constant time (e.g. fare), traffic lights).
2. Passenger arrival rate at a bus stop.
3. Passenger destination probability (how many people board and alight on the different stops on the line).
4. Running time (based on the Markov chains principle, the time for each next pair of stops depends on the previous one).



| Trip | Bus | Stop | Passenger |
|---|---|---|---|
| Planning (trips/day) | Capacity | id | Boarding stop |
| Lines numbers | Travel time (pair of stops) | Sequence (1,2,3,...) | Alighting stop (probability to alight) |
| Origin | Break time - end of a trip | Boarding (passengers) | Arrival time at boarding stop |
| Destination | Arrival time at each stop | Alighting (passengers) | Boarding time |
| Type of day (opening day, week-end) | Departure at each stop | | |

Summary of available data (click to enlarge)

## Key Performance Indicators

There were no existing KPI that represent what customers and bus drivers experience in a high frequency environment. Now, with simulation modeling, it is possible to calculate several indicators and compare them to real life data:

# Result

Model window (click to enlarge)

The simulation model, created by SimWell for RTC, allows experimentation based on input data, and the assessment of multiple ideas and combinations in the search for better solutions to bus bunching.

Engineers are currently planning the next phases and may include a gaming module for training operation controllers. Another possibility is the addition of transportation optimization of the next days' frequencies and schedules, based on resource availability and runtime predictions.

Additionally, there is a possibility to create a digital twin that could be used to trigger action suggestions for drivers to apply preventive or correcting action to prevent bus-bunching.

The case study was presented by Pierre-Olivier Bédard and Nomessi Kokutse, of RTC, and Denis Matarangas, of SimWell, at the AnyLogic Conference 2021.

The slides are available as a PDF >>

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