WHITEPAPER

Locus

Sensitivity Analysis in Supply Chains: Future-Proofing Logistics Networks Against Disruption

Executive Summary

This paper explores the world of supply chain simulations through sensitivity analysis, It presents the benefits of simulating scenario based business expectations or expansion. This concept of sensitivity analysis is used in crafting Go-to-market strategy in terms of building infrastructures, hiring workforce and also the cost implications for each factor.

Businesses who need to tech enable their logistics should look at the capability of the system which can act as a simulator in experimenting with different market conditions.

With technologies like AI, this piece of analysis can be quicker and more accurate and help make faster decisions amidst the chaos in the market, customer expectations, environmental regulations and policies.

Introduction

Businesses are under increasing pressure to reduce cost across the value chain while continuing to keep up with the customer expectations. The e-commerce hype in the last decade has fundamentally changed the way customers purchase and consume products, and the expectations for delivery have changed over the years.

When you want to balance all the factors in a situation, it is rarely straightforward. It needs careful consideration of both the business and operational constraints and finding a middle ground.

Customers are looking for multiple options across searching, investigating and placing an order. Which is enabled by business through omni channel strategies.

While you are designing strategies to fulfill the customer needs through different digital and offline channels, simulation-led sensitivity analysis becomes a critical decision tool, helping teams stress-test plans before peak events, expansion or disruption.

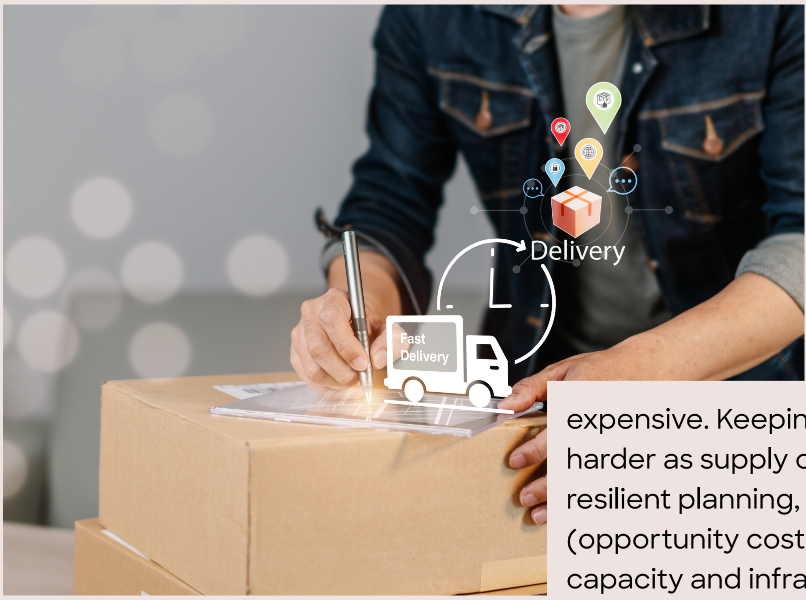
What is sensitivity analysis ?

It is a scenario building activity in order to assess different market conditions, Policy changes, constraints changes in the supply chain.

For example: during a quarter-end sale or a large marketplace mega-sale event, warehouse and regional distribution centre volumes spike. But how do you estimate how many vehicles/drivers, pickers, and packers are required?

Sensitivity analysis enables it, while you do not need to implement everything on the ground, but put the on ground knowledge into the model. That closes the loop between strategy and execution, rather than optimising on paper alone.
In essence it provides **"what if?"** scenarios for you to decide the best strategy while keeping costs in check and disruptions far from your network.

Problem Statement



Some businesses still rely on static planning for their last-mile delivery, or operate rigid networks that cannot honor customer promises. This leads to high costs that are hard to observe and are eventually passed on to customers, either through higher shipping charges or lower service quality.

Customers will move to a competitor when delivery is inconvenient, unreliable, or expensive. Keeping delivery networks flexible has become harder as supply chains face more frequent disruption. Without resilient planning, organisations lose revenue opportunities (opportunity cost) and may also lose on investments made into capacity and infrastructure.

In this paper, we restrict the discussion to sensitivity analysis for **(1) last-mile delivery and (2) network optimisation.**

Locus

Proposed Solution

Sensitivity analysis in Last mile delivery

Last mile deliveries, which incur about 50% of the costs among all the tiers of the supply chain, would certainly need to adapt quickly to the market changes. And these market changes can be predicted through sensitivity analysis by changing the factors which will impact the resource allocation, cost and expectations. Simulation helps quantify how robust (or fragile) the current delivery structure is under changing conditions, and what trade-offs are required to meet service goals. The last mile involves a large number of operational and business constraints. Here, we focus on 5-6 high-priority factors (illustrative):

demand/volume, delivery windows & SLA targets, fleet capacity, driver shift rules, service time per stop, and hub/route constraints.

It's important for you to determine the objectives of optimisation first and then tweak the constraints accordingly.

For example: do you want 100% on-time deliveries, even if it requires more vehicles, or are you optimising fleet utilisation while maintaining, say, 95% on-time delivery?

While comparing "to-be" and "as-is" networks is useful, it is equally important to maximise the efficiency and practicality of the "to-be" network.

Our aim is to determine an implementable resource plan (fleet, driver capacity, and routing strategy) that meets service targets at the lowest feasible cost.

Once we identify the optimal last mile network, we test the network with varying factors.

Results can be read as follows:

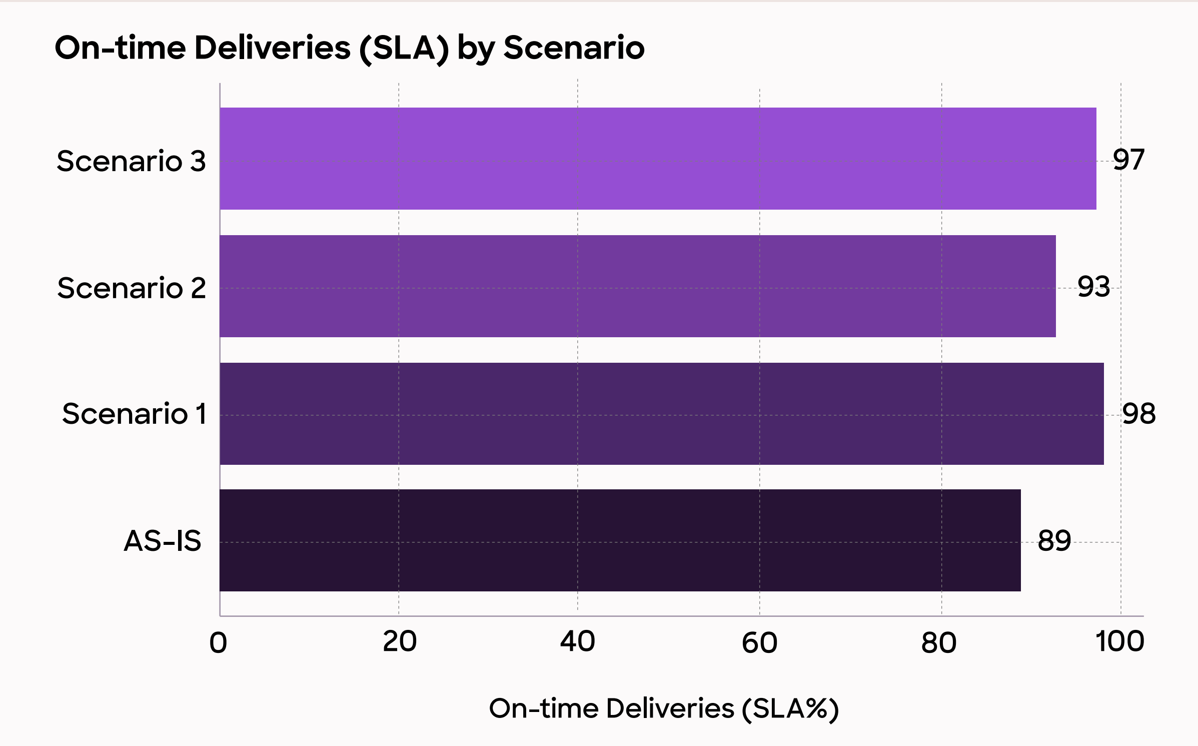
- **AS-IS:** Current network
- **TO-BE 1:** SLA prioritised over vehicle optimisation
- **TO-BE 2:** Vehicle optimisation prioritised over SLA and distance
- **TO-BE 3:** "What if?" scenario with **15% volume increase**

Note : Organisations will choose the scenario to be implemented based on their business priorities

Particulars	AS-IS Scenario	TO-BE Scenario 1	TO-BE Scenario 2	TO-BE Scenario 3
Number of Customers	3240	3240	3240	3726
Number of Vehicles	100	95	90	110
Total Distance (KM)	7000	6600	6500	7200
On-time Deliveries (SLA)	89%	98%	93%	97%
Driver Shift Utilisation	105%	96%	97%	98%

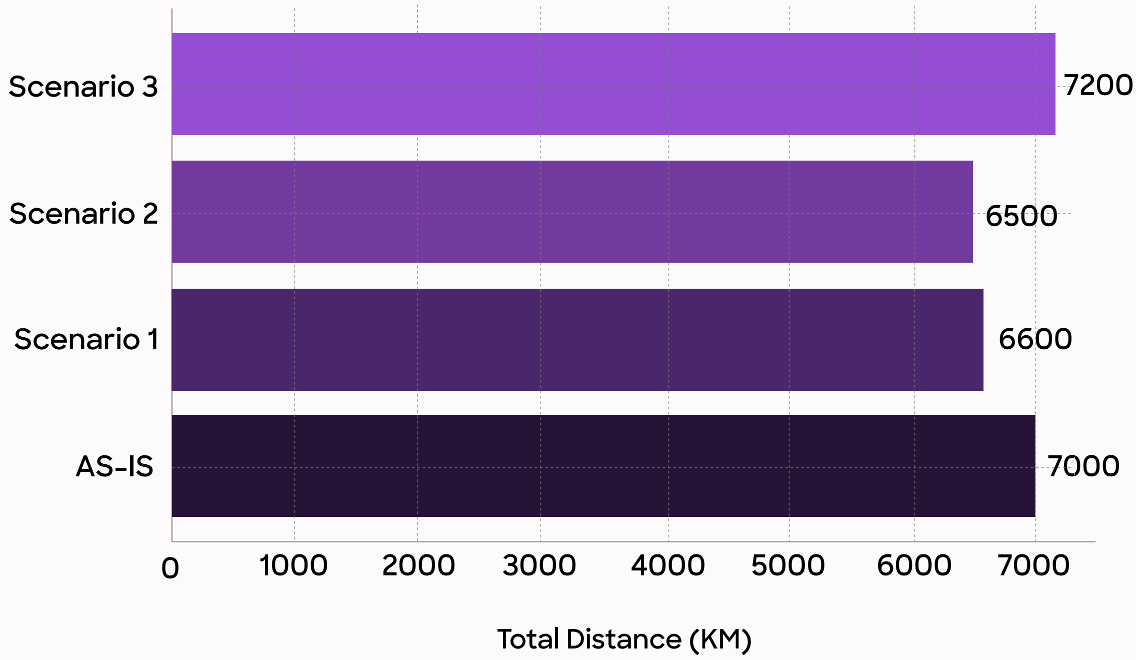
Note: Values are illustrative (assumed parameters) to demonstrate how scenario outputs can be compared. >100% indicates shift rule violations or overtime.

These outputs can also be visualized using charts (for example, vehicles vs. SLA, distance, and utilization).

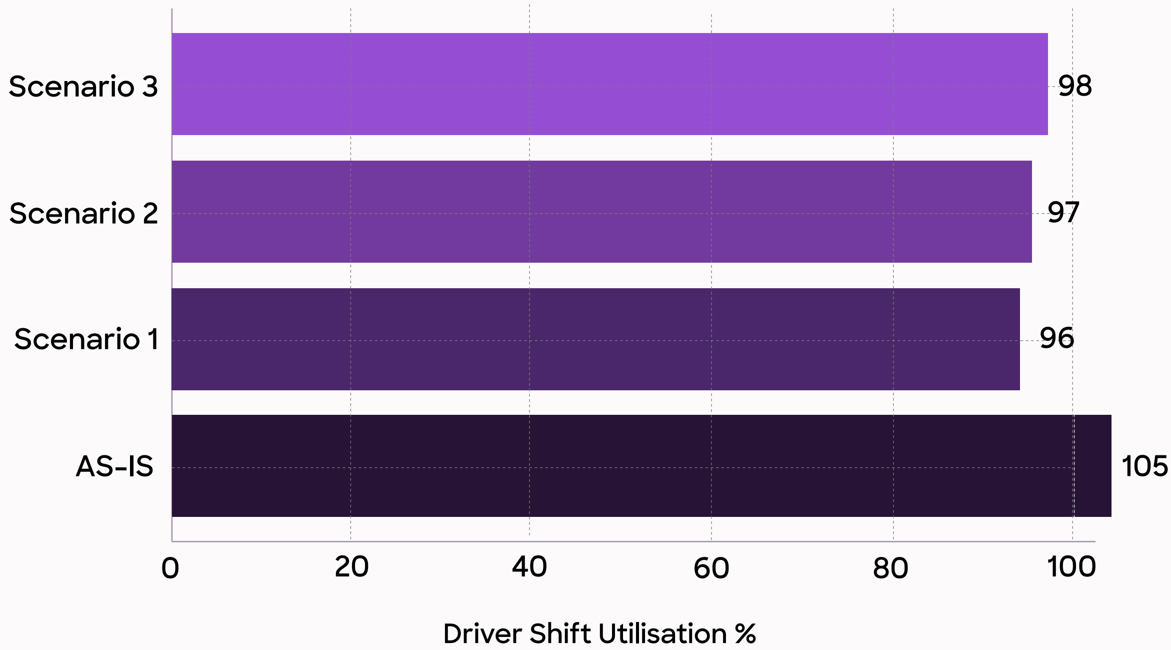


Locus

Total Distance by Scenario



Driver Shift Utilisation by Scenario



Example from a use case

This study explores the impact of introducing a last-mile transportation system in a high-density residential area in Sejong, South Korea, where public transportation usage is low (5%). The study focuses on the potential benefits of a minibus service with non-fixed routes to improve access to local bus services. The minibuses are designed to operate in small residential areas with demand-responsive schedules. Using MATSim, an agent-based model, the study compares different transportation modes (car, walking, and minibus) and examines their effect on public transportation ridership.

By testing multiple simulated scenarios, the study shows how service design choices shift ridership and access outcomes, illustrating the practical value of scenario-based simulation for planning.

By testing multiple simulated scenarios, the study shows how service design choices shift ridership and access outcomes—illustrating the practical value of scenario-based simulation for planning.

Case study link: https://www.sciencedirect.com/science/article/pii/S187705091930482X

Sensitivity analysis in Network Optimisation

Network optimisation which is strategic in nature, helps design the optimal network for the entire supply chain, first mile, mid-mile and last mile. Since this is a capital intensive and time consuming activity, it is very important to get it right the first time.

Analyzing how fluctuations in supply and demand, shipping costs, or lead times affect inventory levels, distribution centers, or flow of goods through the network is the primary objective.

This involves testing the robustness of the solution when parameters such as capacity, demand, or supply vary. The goal is to identify the critical parameters that materially change the optimal solution, for example, when transportation cost or capacity thresholds shift enough to change facility selection, routes, or service commitments.

As in last-mile planning, comparing “to-be” vs “as-is” is useful, but the “to-be” must also be efficient and implementable.

Our aim is to determine the optimal locations and configuration of warehouses and regional DCs relative to customer demand, and then test that network under varying conditions.

Definition of Scenarios are as follows.

- **AS-IS:** Current network
- **TO-BE 1:** SLAs prioritised over vehicles
- **TO-BE 2:** Vehicle optimisation prioritised over SLA and distance
- **TO-BE 3:** "What if?" scenario with **15% volume increase**

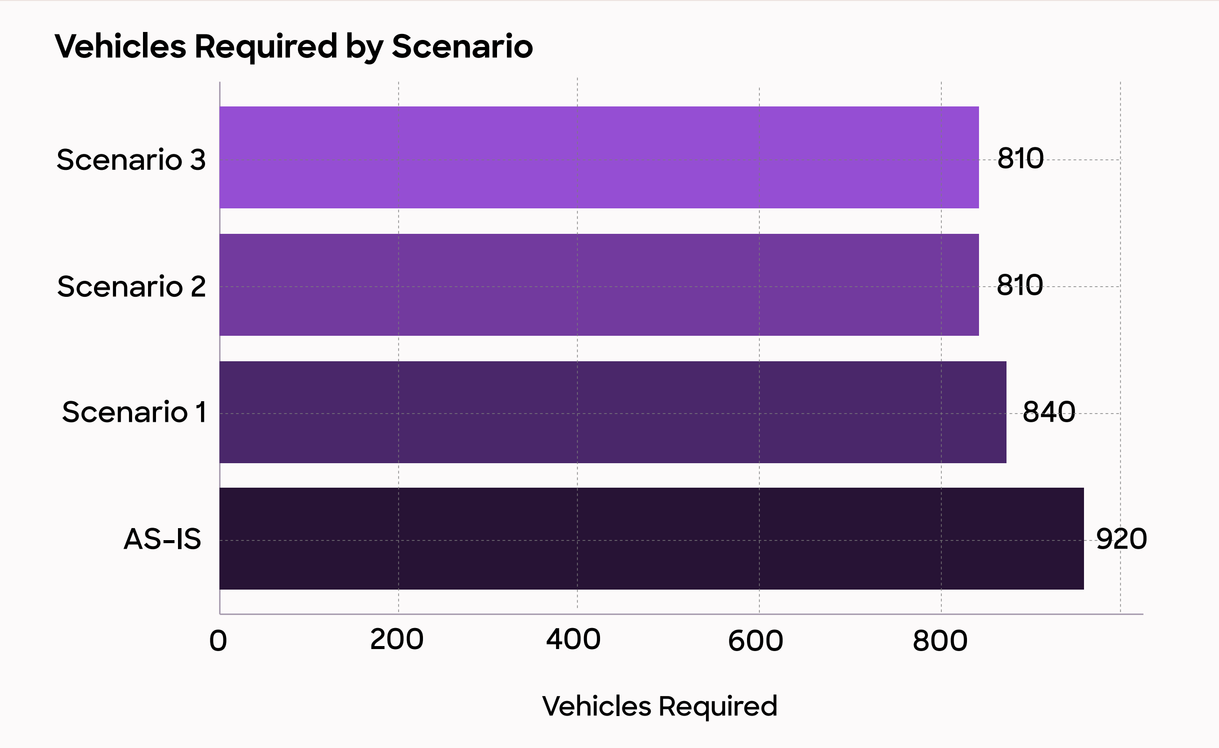
Results can be viewed here:

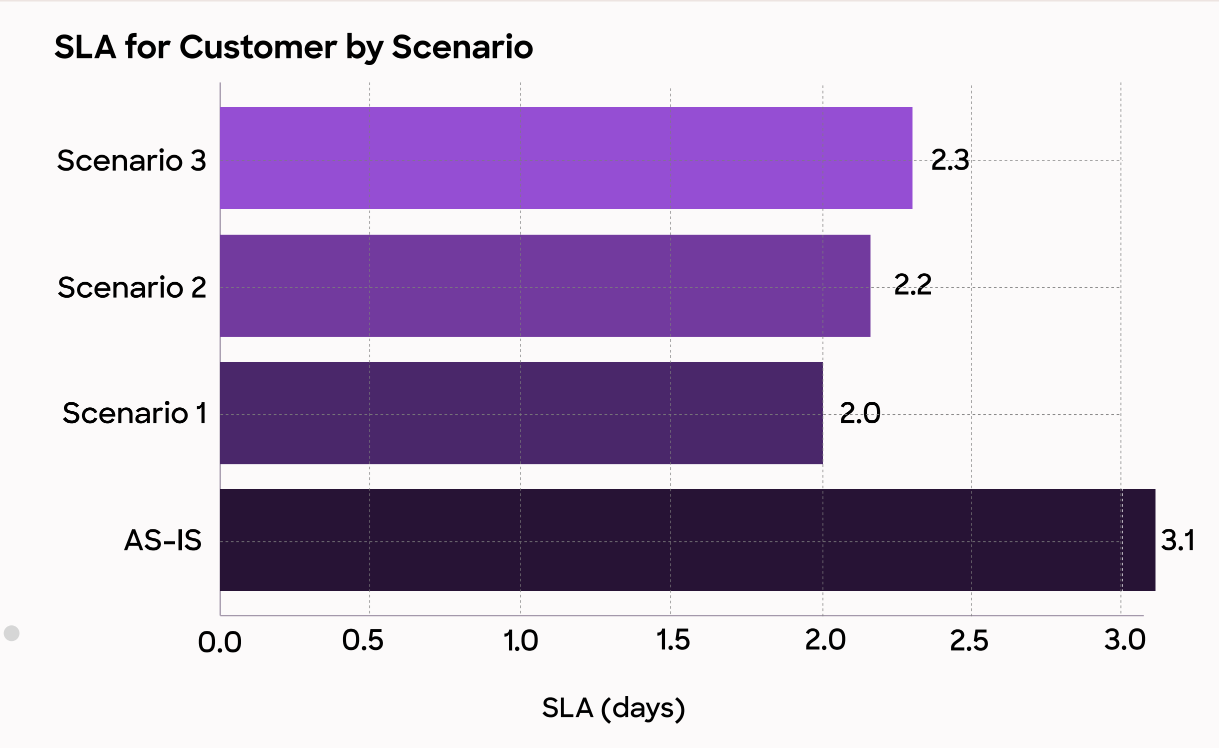
Particulars	AS-IS Scenario	TO-BE Scenario 1	TO-BE Scenario 2	TO-BE Scenario 3
Number of Customers	31,240	31,240	31,240	35,926
Warehouses to be Open	2	2	2	2
Regional DCs	10	6	7	7
New Warehouses Required	——	3	2	3
Vehicles Required	920	840	810	810
SLA for the Customers	3.1 days	2 days	2.2 days	2.3 days
Total Cost ($)	2.9	2.35	2.25	2.25
Savings %	——	18.97%	22.41%	22.41%

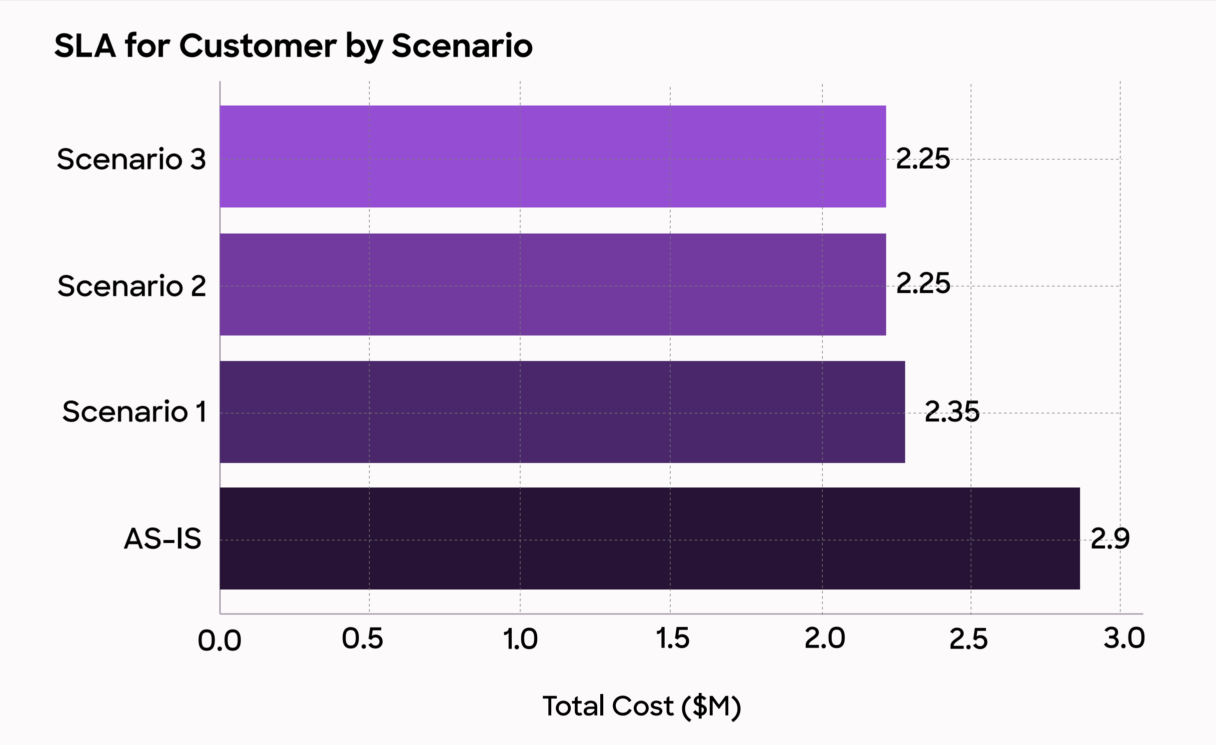
Note: Values are illustrative to demonstrate scenario comparison.

These numbers are representational/illustration only, not based on any use case, and based on assumed parameters as discussed in the previous paragraph.

The charts below visualize key metrics from the table: Vehicles Required, Customer SLA, and Total Cost.







The numbers in the table are graphically represented below for Vehicle required, SLA and Total cost.

Example from a use case

This paper addresses the growing challenges in logistics networks due to the rapid growth of e-commerce. It proposes a resilient capacity deployment approach for open-access logistics hubs within hyperconnected transportation networks, focusing on how these hubs can handle demand uncertainty and disruptions (such as natural disasters, labor strikes, or power outages). The model aims to improve delivery timeliness, network resilience, and cost-effectiveness while minimizing hub setup and fleet costs.

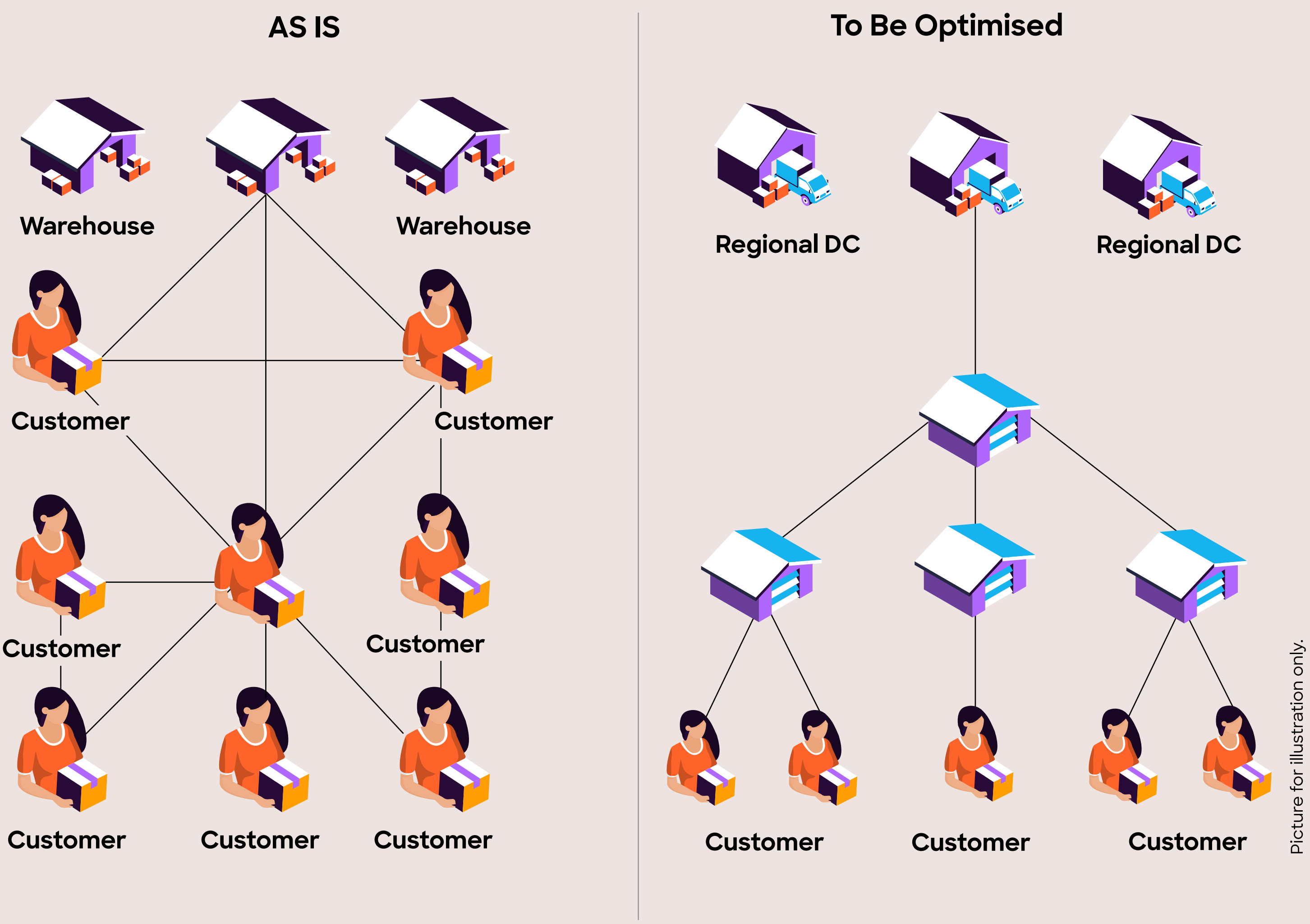
Uncertainty Scenarios: the model accounts for demand fluctuations and disruption risks to optimise hub configuration. It is applied to a vehicle delivery network in the Southeast U.S.

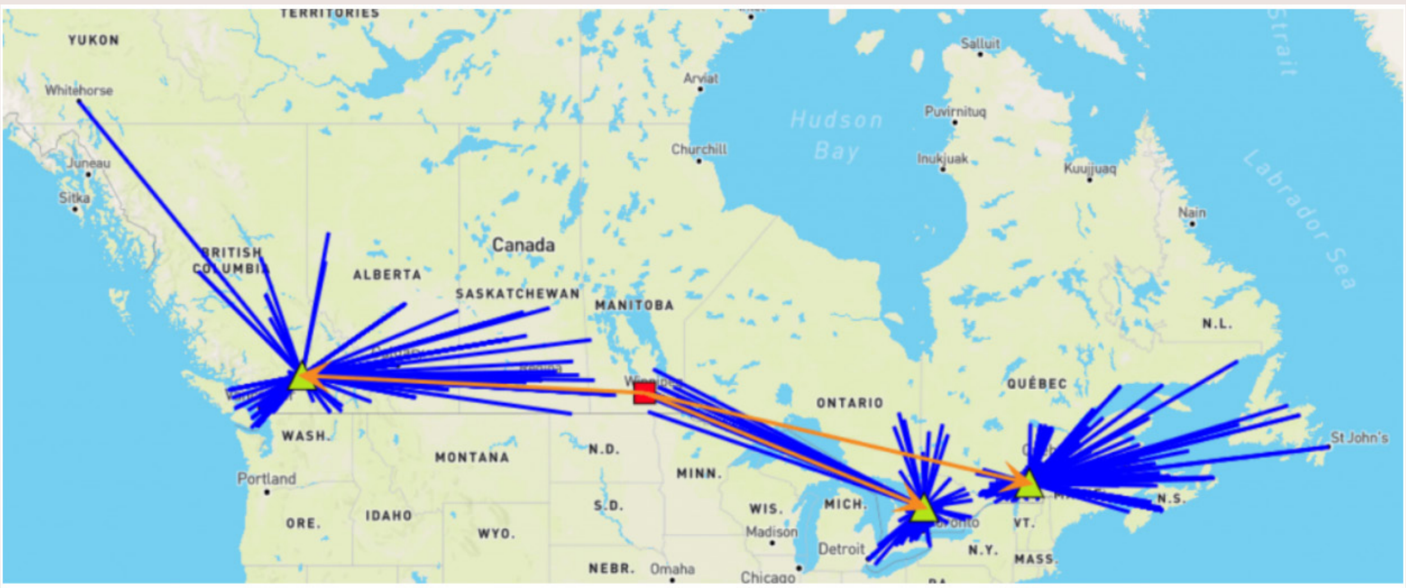
- Methodology: simulation-based stress testing across four scenario types1. Deterministic demands, no disruptions.
- Uncertain demand, no disruptions
- Random disruptions, fixed demand
- Both demand uncertainty and disruptions

The model is tested on a real automotive delivery network dataset, evaluating performance in terms of hub capacity, network resilience, delivery timeliness, and cost.

Case study link: https://arxiv.org/abs/2402.0622

Locus





Example for a Network optimisation : Picture for illustration only.

Benefits and Value

Sensitivity analysis impacts both quantitative KPIs (cost, distance, utilisation, SLA) and qualitative outcomes (agility, planning confidence, customer trust). Examples below.

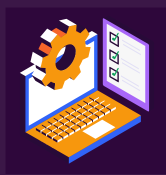
Key performance Indicators : Impact of Metric

LAST MILE

Cost reduction:
fewer vehicles where feasible, lower fuel spend, and reduced total distance

Time savings:
optimised travel time and improved route efficiency

On-time delivery (SLA):
higher reliability improves customer satisfaction and retention

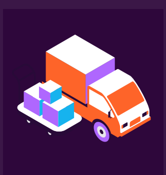


Operational agility:
better ability to respond to disruptions (volume spikes, capacity shortfalls, route constraints

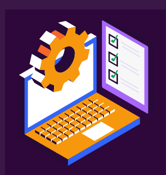
NETWORK DESIGN

Cost reduction:
optimising facility footprint can reduce fixed and variable costs

Customer service:
improved service levels aligned to delivery promises



Capacity utilisation:
better throughput planning and higher utilisation of facilities



Operational agility:
more resilient networks under disruption and demand variability

Conclusion

Businesses today must make swift and well-informed decisions, and this is only possible through technologies capable of processing hundreds of complex constraints and delivering actionable insights rapidly. To maximise ROI, it is crucial not only to identify an optimal network, but also to ensure it is implementable, sustainable, and adaptable to future market dynamics.

Locus

Locus is a leading-edge technology company dedicated to solving the most challenging last-mile problems in global logistics.

1.5B+

Total deliveries optimized

17M+ kgs

Reduction in GHG emissions

$320M+

Savings in logistics costs

GROWTH, DELIVERED.

Know more

www.locus.sh