COSMO TECH
Find Your Forward

Inventory management demo

Bonsai & Cosmo Tech

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At a glance

COSMOTECH
Find Your Forward

Cosmo Tech is a global software vendor of Simulation Digital Twins solutions.

Our technology predicts all possible futures of an organization to dramatically improve the capabilities and decision-making efficiency of complex organizations.

KEY FACTS

2010
Founded

$5.2 M
Series A 2014

$21 M
Series B 2018

COSMOTECH
Find Your Forward

2010

Cosmo Tech founded as a spin off of an academic program

20 years

Cosmo Tech proprietary modelling language grounded on Academics research.

Unique 360° simulation and modeling language of complex systems.

Cosmo Tech's solutions are based on Cosmo Tech proprietary modelling language, the result of more than 20 years of academic research, as well as a unique methodology developed over more than a decade.
This unique approach can identify all system's critical variables, interactions and interdependent tasks and predict the effects of change with strong accuracy for the short, medium and long term.

Cosmo Tech Product Unique Value Proposition relies on two pillars:

360° Simulation and Prescriptive Analytics

- **Core** CoSML Modeling Language
- **Studio** for simulation authoring and packaging
- **CoMETS**: Hybrid AI native capabilities

Models the full system

Optimizes across different time scales

Simulates the dynamics

Packaging of 3rd party vendors

Easy to use implement and scale

Cloud-Native Simulation Orchestration

- **Scale easily simulation in the cloud**
- **Native access** to cloud services
- **Assemble and run** experiments
- **Agnostic** to simulation technology

Connectors

Organisation management

Interactive scenario workflows

APIs

Security

Model Ops

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Modeling language and Studio

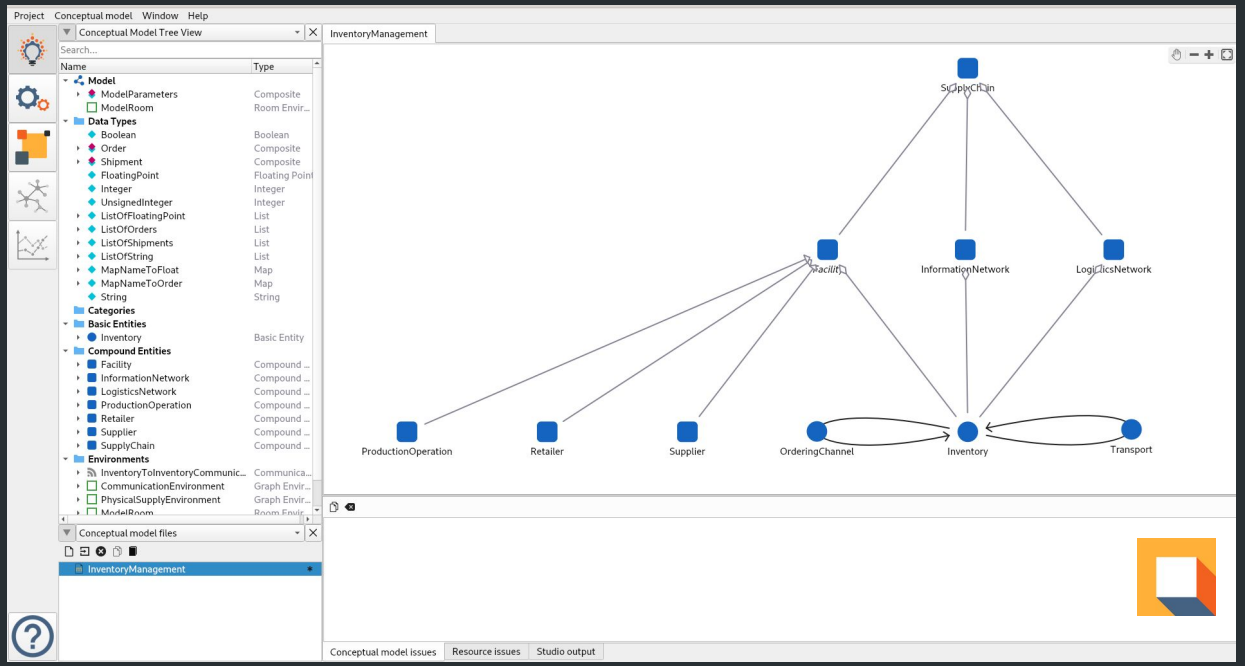
In the Studio, modelers can create their own domain model to capitalize on their expertise, build reusable models for their customers or build bespoke solutions for their very unique organizations.

Complex hierarchies

Dynamic couplings

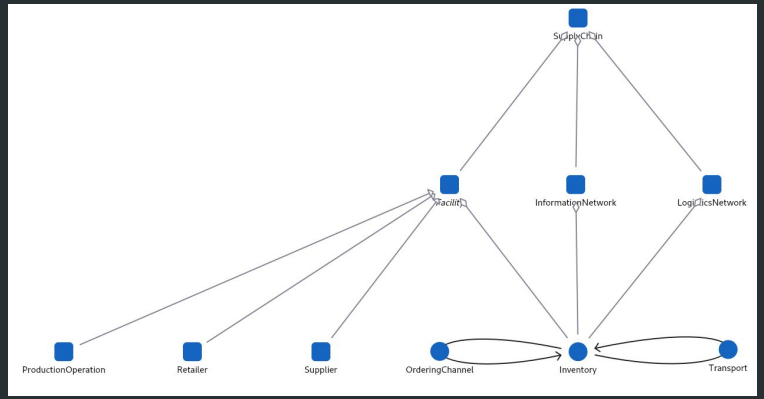
Meta-modeling

A reinforcement learning ready supply chain model in the Studio

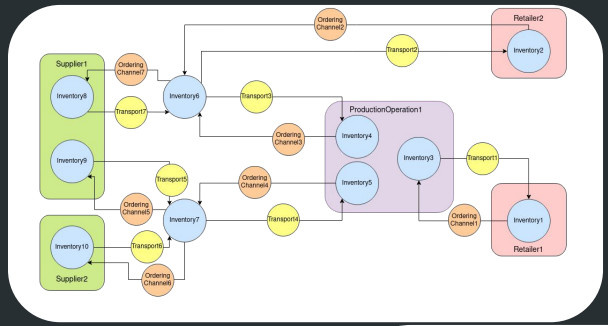


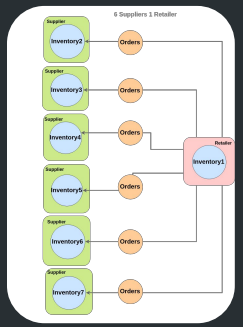
One generic model for unlimited instances

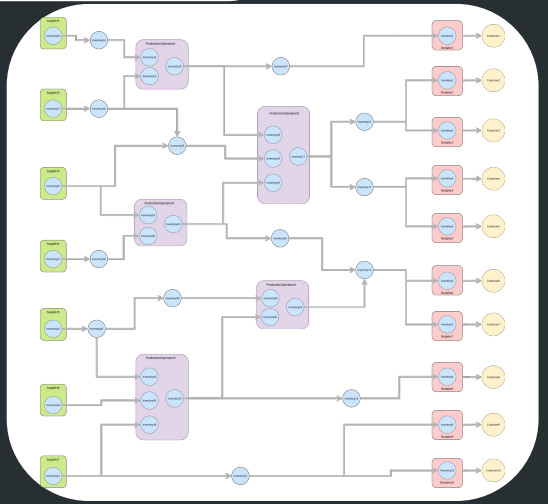
One “meta model” can be used to build, simulate and optimize an unlimited number of structures and dynamics.



Generic concept of a Supply Chain







Examples of different supply chain digital twins created from the meta model by simply importing data from a database

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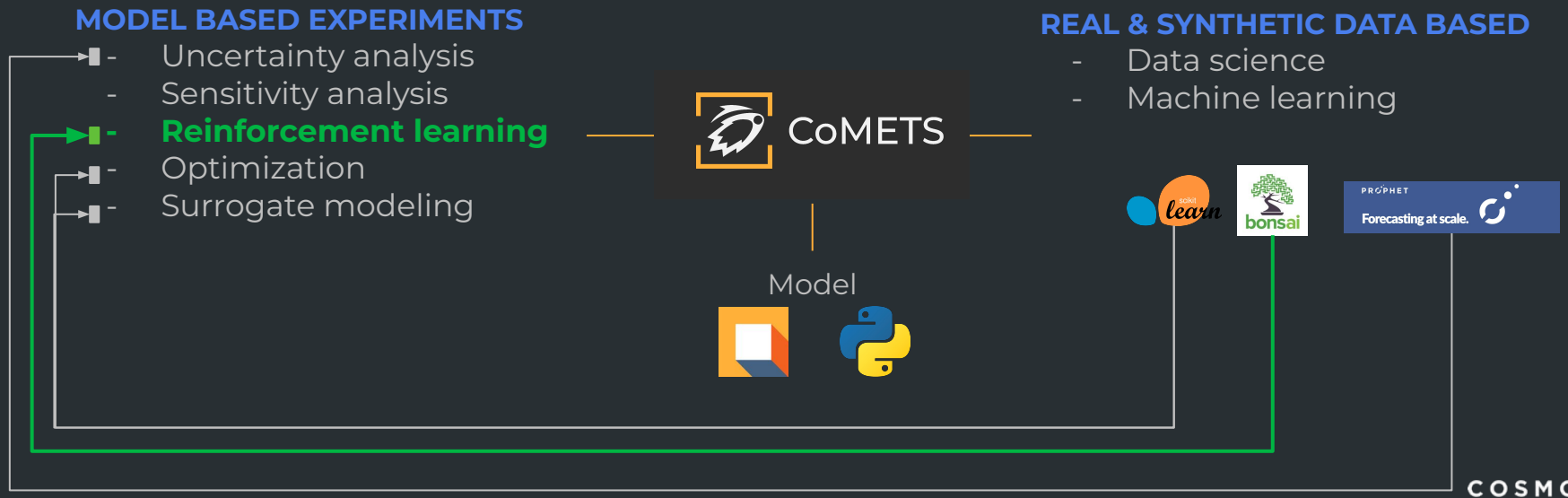
Advanced experiment and Hybrid AI

Cosmo Tech is a pioneer in hybrid AI, the combination of simulation with optimization and machine learning.

With Cosmo Tech **platform** and the **low code CoMETS Python** library you can run and **orchestrate advanced experiments** with any model to serve **prescriptive** analytics to your end customers.



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About the Cosmo Tech Bonsai sample

This Cosmo Tech Bonsai sample illustrates that even in a seemingly simple supply chain with a few nodes, uncertainties and capacity constraints make its behavior complex.

Adding competing objectives to this, its daily operation by a supply chain manager can become very hard.

A Simulation Digital Twin is therefore an appropriate solution to train an autonomous Brain agent with reinforcement learning for discovering adapted decision policies able to cope with this complex dynamics.

Use case

As a Supply Chain Manager, you need to manage inventories in order to serve an uncertain and fluctuating demand.

Your goal is to maximize the profit, taking into account transport costs, storage costs and constraints, and income from sold products.

The Supply Chain structure is depicted in the next slide.
It consists of different nodes and transport modes and routes:

One supplier

Two retailers

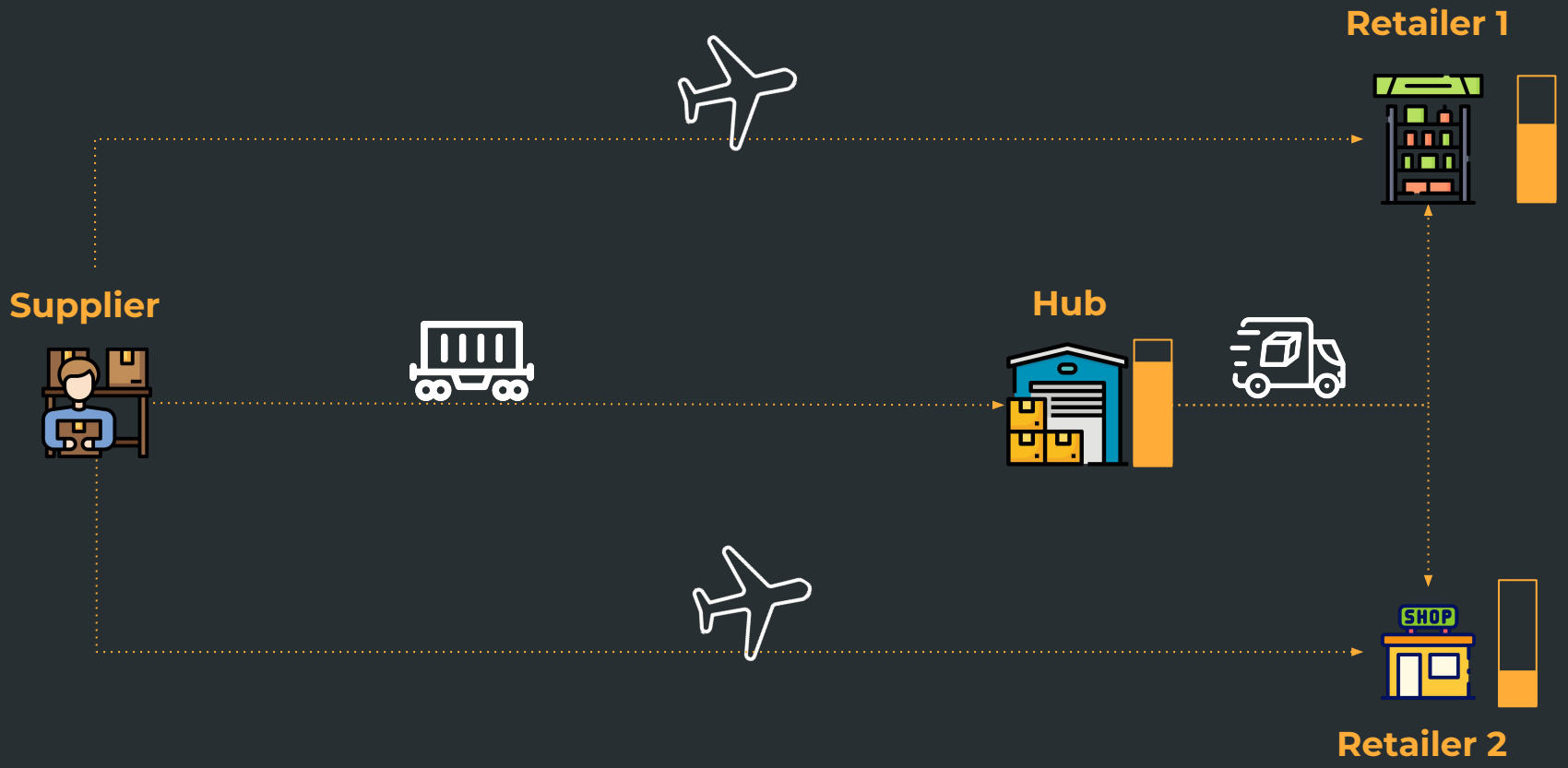
One central hub

Air routes (mainly)
from the supplier to the retailers

Train route
from the supplier to the hub

Truck routes
from the hub to the suppliers

Supply chain structure



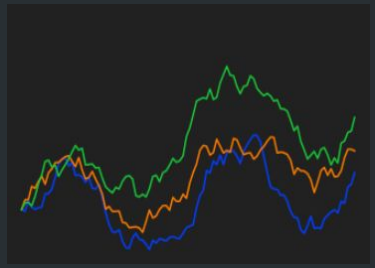
Volatile demand

One supplier
with a limited capacity

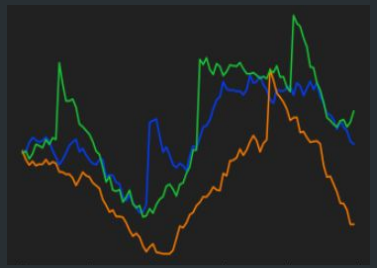
Two retailers
with highly variable demands
with their specific patterns and
important stock limitations

One central hub with large
and cost effective storage

Retailer 1 typical demands



Retailer 2 has **higher demands with sudden peaks**



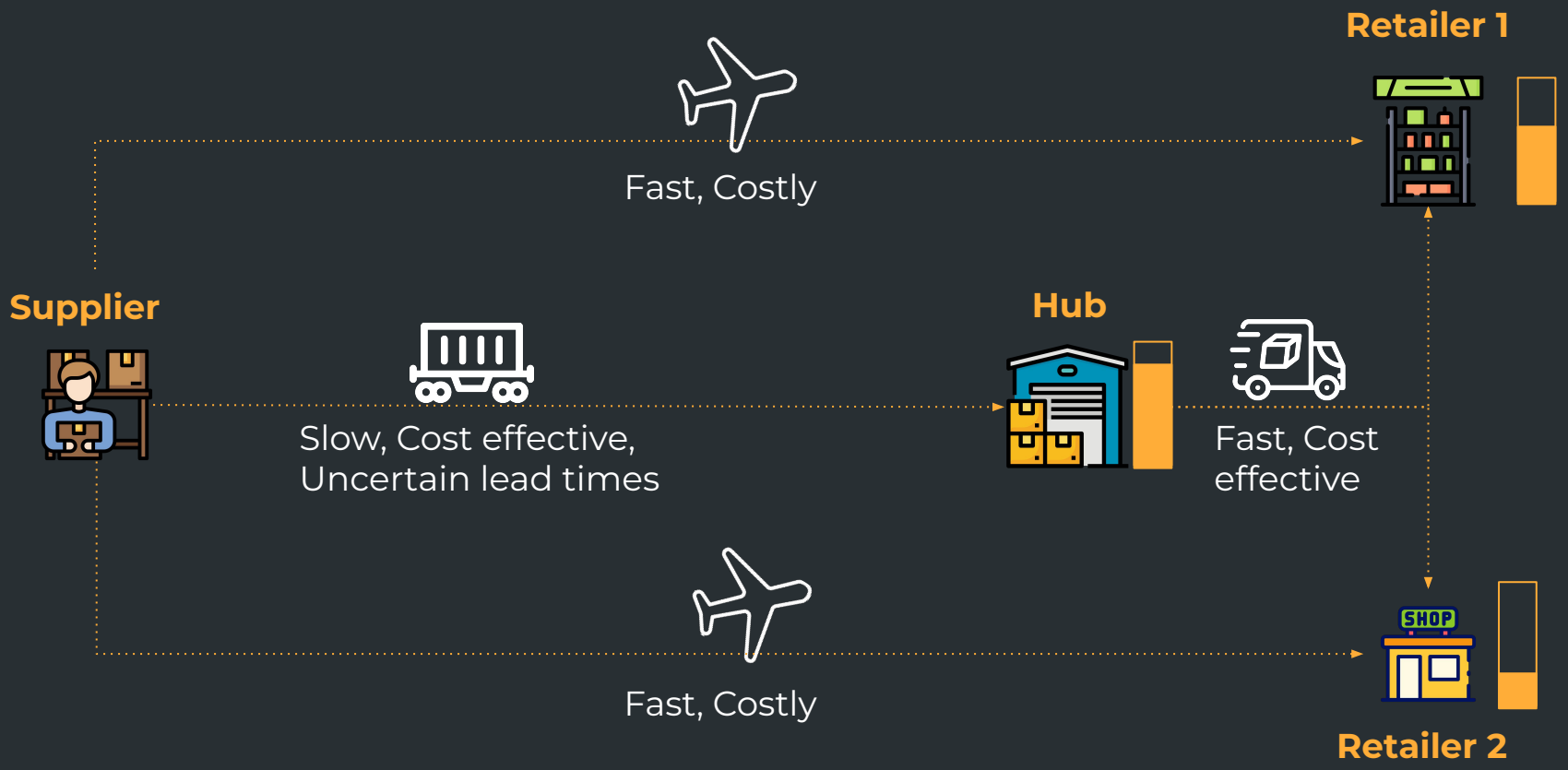
Transport characteristics

Two direct, **fast and costly**, **air routes** from the supplier to each retailers

One **slow but economic and uncertain** **train route** from the supplier to the hub

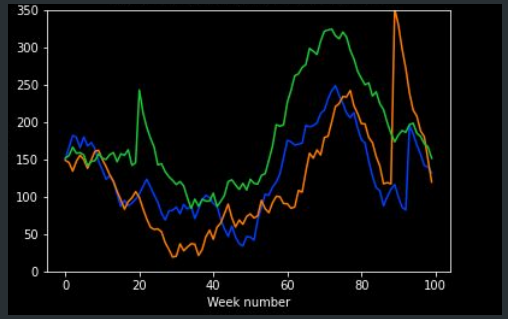
Two **fast** **truck routes** from the hub to each suppliers

Supply chain structure



Overview

- The demand received by the retailers **fluctuates** and **unpredictable peaks** can occur.



- Inventories at each retailer must decide **how much to order each week and the sourcing**, *i.e.* what percentage of these orders must be sent directly to the supplier to be received **quickly by plane**, and what percentage can be ordered to the **central hub and received by truck**.

- The central hub sends orders to the supplier and can **store large quantities**, it is located near the retailers so that shipments can be delivered quickly by truck.

- Shipments from the supplier to the hub are sent **by train and the travel time is longer and uncertain**.

- Plane shipping is much **more expensive but it is received faster to avoid backlog penalties**.

Use case

Each week you need to decide:

- *how many products need to be shipped indirectly by train from your supplier through the central hub*
- *how many products need to be shipped directly from your supplier to the retailers by plane*
- *how many products need to be shipped from the hub to the retailers by truck*

Weekly decisions for the global supply chain manager

Retailer 1

- **Total quantity ordered each week:** “Order_Inventory1”
- **Sourcing allocation (%):** “Inventory1_AllocateToHub”

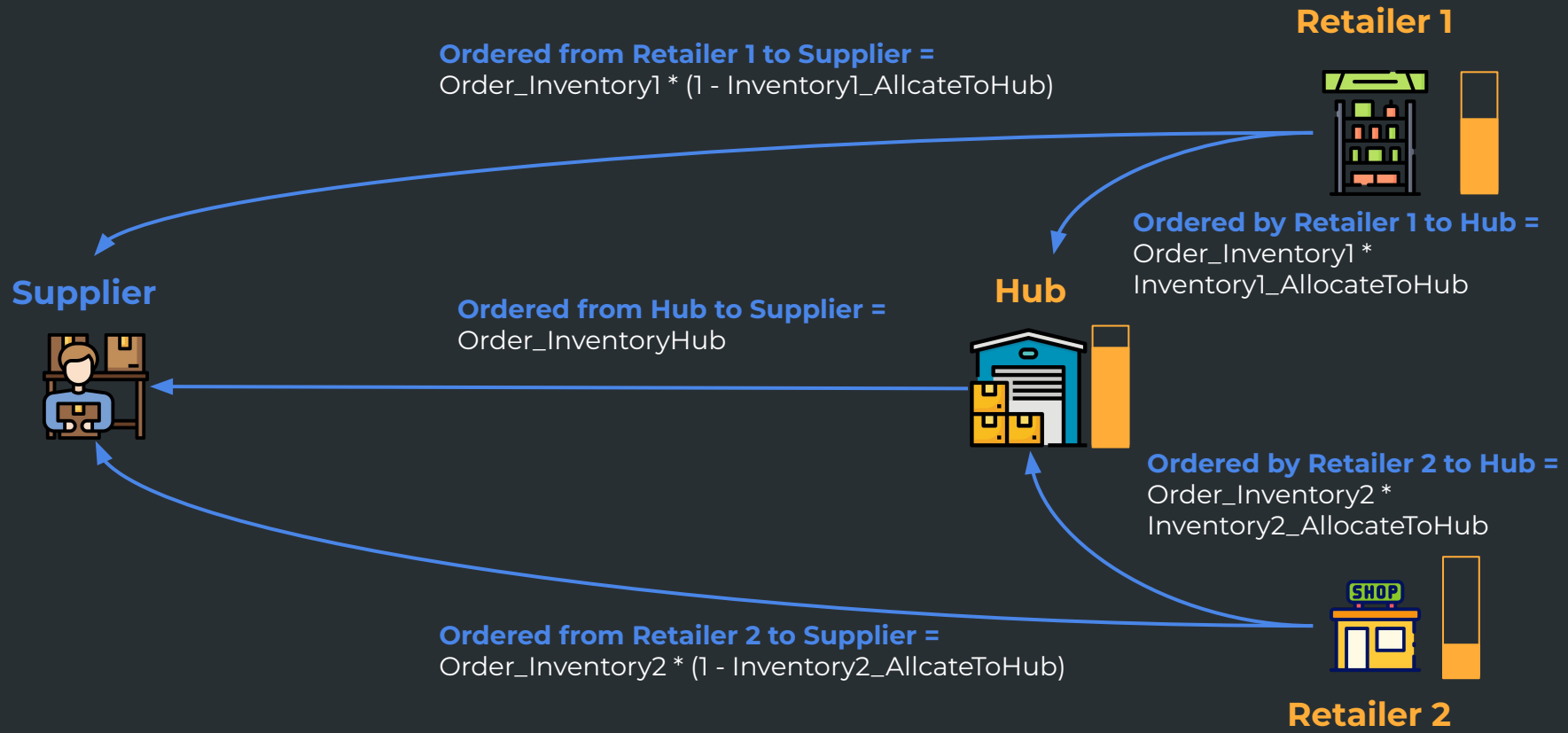
Retailer 2

- **Total quantity ordered each week:** “Order_Inventory2”
- **Sourcing allocation (%):** “Inventory2_AllocateToHub”

Hub

- **Total quantity ordered each week:** “Order_InventoryHub”

Weekly decisions for the global supply chain manager



Your goal is to maximize the profit, taking into account transport costs, storage costs and constraints, and income from sold products.

Profit = Income - Inventory holding costs - transport costs - % backlog penalty

Trade-offs:

- High inventory levels increase sales income but increases holding costs
- Ordering by plane is faster and responsive to demand fluctuations but increases transport costs

Restrictions:

- Storage constraints limit the amount of inventory that can be kept in different inventories
- Retailers compete for hub stock, if one retailer orders to hub it restricts the availability for the other one

Why is it complex?

- Making optimal decisions in such setting is very hard:
  - capacity constraints
  - trade-offs (speed vs cost of delivery, product reserve vs stock costs and limitation)
  - uncertainties (transport time and demand)

  make the impact of any action very difficult to predict.

- ☑ Constraints
- ☑ Trade-offs
- ☑ Randomness
- ☑ Coupled, sequential decisions

- Moreover, the (varying) delay between a decision (order) and its benefit adds another level of complexity: when the income is increased, we can't easily attribute the benefit to the right decision.
- Actually, it is the succession of decisions which makes the result: their respective impacts are not separable.
- Put another way, **whether a decision is good or bad, depends on the following (future) ones: decisions are all coupled in time**.

This is a perfect situation where deep reinforcement learning and machine teaching can help because, when properly trained with the right simulation digital twin, it is able to **autonomously uncover those correlations and profit from them** more than any other technique.

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Use the Brain with Cosmo Tech

I want to maximize the profit, but

- *I also have stock constraints!*
- *and I need to retain customers with in time delivery!*
- *and the cost of shipments by plane have just increased!*

With the provided Inkling file, you can “play”, with different settings to see what’s the best strategy that the Brain would discover in each case and the associated performance:

- **Goal and conflicting objectives:**
  - Add stock constraints (“avoid” statements)
  - Add a minimal service level (“drive” statement)

- **Supply chain configuration**
  - Change the strength of the stock constraints
  - Increase the cost of shipments by plane

I also have stock constraints!

Optional stock conflicting objective

Two scenarios are available for Brain training concerning storage:

1. No restrictions, Brain actions can be chosen to build unlimited stocks levels
2. Restrict Brain actions to avoid very high stocking quantities

I also have stock constraints!

Optional stock conflicting objective

Two scenarios are available for Brain training concerning storage:

1. No restrictions, Brain actions can be chosen to build unlimited stocks levels
2. Restrict Brain actions to avoid very high stocking quantities

You can switch between each scenario in the provided Inkling file:

```
goal(State: SimState)
{
    maximize InstantaneousProfit: State.IncrementProfit in Goal.RangeAbove(10000)
    # You can comment the following lines to train a brain without respecting stock constraints
    # to compare the results to those obtained when respecting them.
    avoid HighHubStock: State.OnHandInventory_Hub in Goal.RangeAbove(MaxHubStock)
    avoid HighRetailer1Stock: State.OnHandInventory_1 in Goal.RangeAbove(MaxRetailerStock)
    avoid HighRetailer2Stock: State.OnHandInventory_2 in Goal.RangeAbove(MaxRetailerStock)
}
```

I also have stock constraints!

Optional stock conflicting objective

Two scenarios are available for Brain training concerning storage:

1. No restrictions, Brain actions can be chosen to build unlimited stocks levels
2. Restrict Brain actions to avoid very high stocking quantities

You can also modify the strength of the constraints (lines 128 and 129):

```
125   ## Weak inventory stock constraints
126   ## Decrease these values if you want to increase the constraints
127   # (for instance, put 0 and uncomment the "avoid" statements of the "goal" - see below - to avoid storage)
128   const MaxHubStock = 1000
129   const MaxRetailerStock = 500
```

and I need to retain customers with in time delivery!

Optional minimal service level to maintain

- You want first and foremost to assure a minimum service level while maximizing profit

and I need to retain customers with in time delivery!

Optional minimal service level to maintain

- You want first and foremost to assure a minimum service level while maximizing profit

You can switch between each scenario in the provided Inkling file:

```
goal(State: SimState)
{
    # You can comment/uncomment the following line to compare results
    # to train a brain to assure a minimum service level while maximizing profit.
    drive ServiceLevel: State.CurrentServiceLevel in Goal.RangeAbove(0.95)
```

and the cost of shipments by plane have just increased!

What if there are higher transport costs?

You can configure the simulator to study different training scenarios concerning costs:

- You want to compare your Brain trained with default costs to extreme cases with much higher transport or holding costs

and the cost of shipments by plane have just increased!

What if there are higher transport costs?

You can configure the simulator to study different training scenarios concerning costs:

- You want to compare your Brain trained with default costs to extreme cases with much higher transport or holding costs

You can switch between each scenario in the provided Inkling file or add your own ones:

```
# You can comment/uncomment the following lines to increase the
# plane transport costs for Retailer 2 by configuring the simulator at each episode start
lesson higher_plane_costs{
    scenario {
        TransportCostPerPiece_Plane2: DefaultTransportCostPerPiece_Plane2*10
    }
}
```

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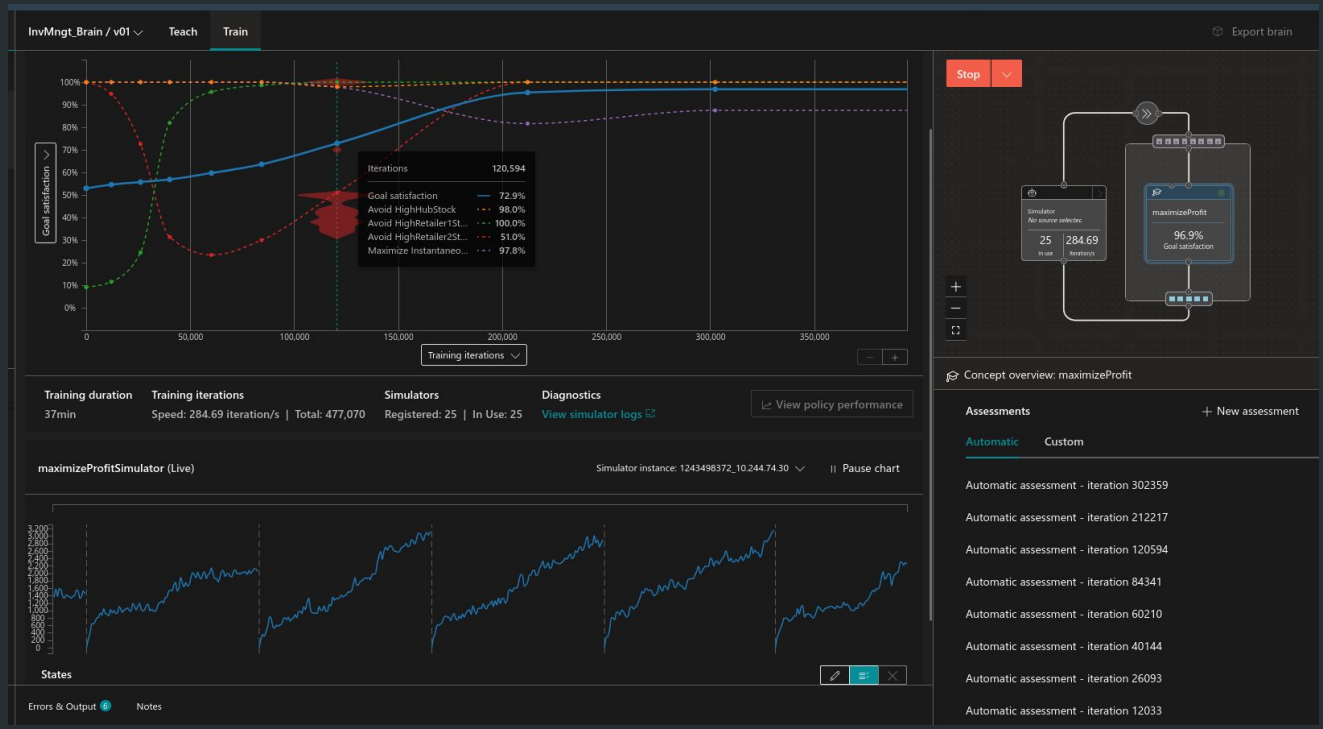
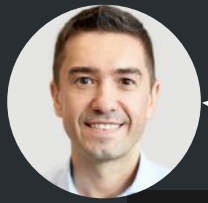
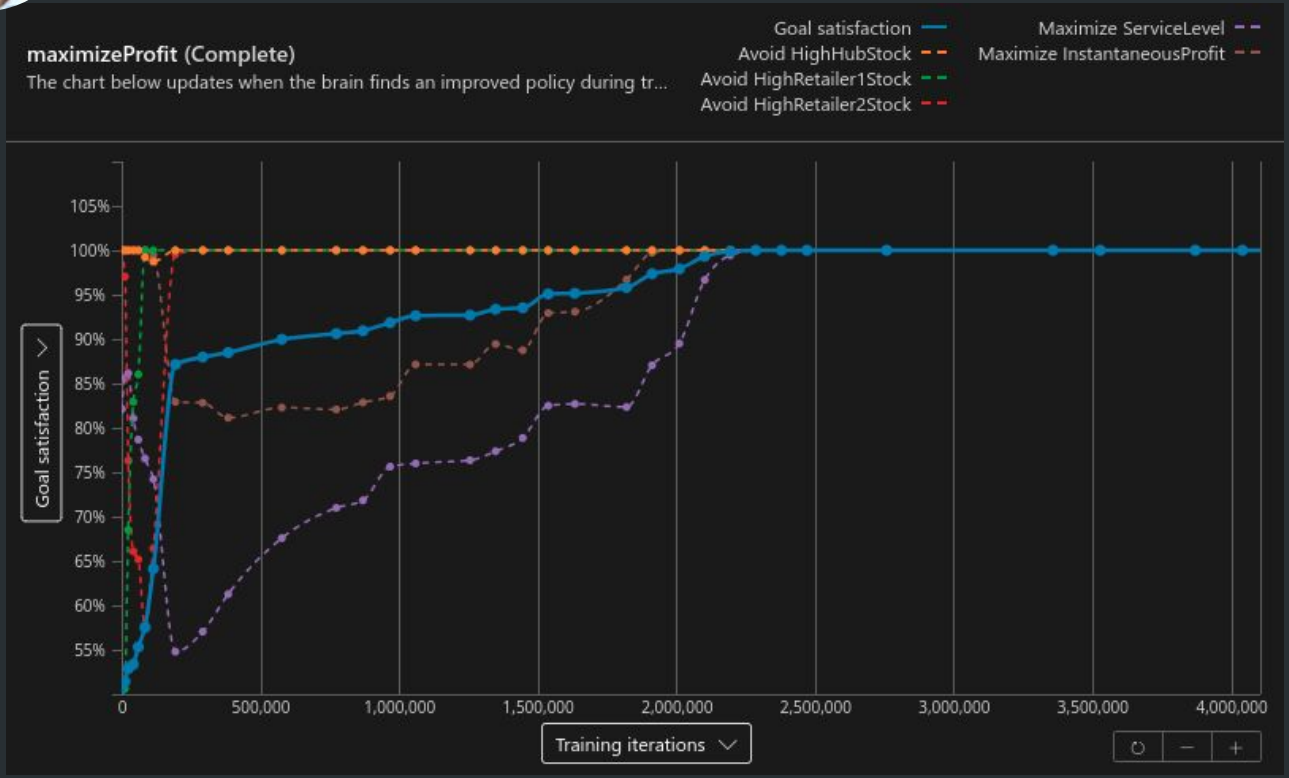
You can test different scenarios





You can test different scenarios



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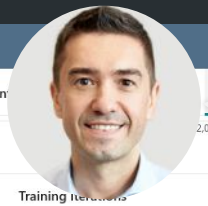


By looking at different indicators, you can analyse the strategy, in different settings, at the beginning of the training or when it is finalized.

InventoryManagemen

Training duration
7hrs 37min

Training iterations
Speed: 311.75 iteration/s | Total: 7,180,482

Simulators
Registered: 25 | In Use: 25

Simulator (Live)

States
CurrentServiceLevel

States
CurrentDemand_2 OnHandInventory_2 QuantityOrderedByPlane_2

Errors & Output 6 Notes

pierre-alexis.gros@cosmotech.com

InventoryManagementSampleTest / v18 Teach Train Export brain

States
IncrementProfit

States
CurrentDemand_2 QuantityOrderedByPlane_2

States
CurrentDemand_1 QuantityOrderedByPlane_1

Errors & Output 6 Notes

Stop

Concept overview: maximizeProfit

Assessments + New assessment

Automatic Custom

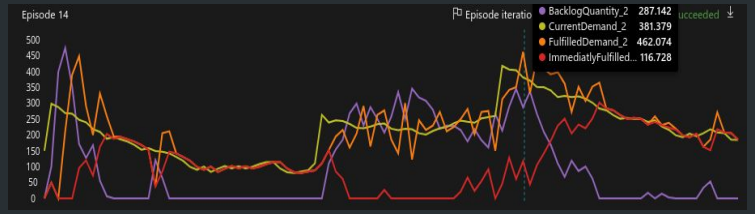
Automatic assessment - iteration 906215
Automatic assessment - iteration 813754
Automatic assessment - iteration 717111
Automatic assessment - iteration 433352
Automatic assessment - iteration 338616
Automatic assessment - iteration 244201
Automatic assessment - iteration 158874
Automatic assessment - iteration 116507

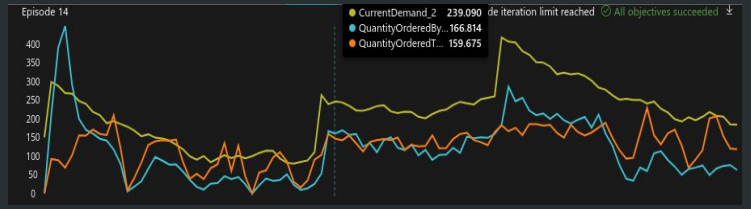
You can test and analyse different scenarios

Maximize Profit and Avoid High Stocks

After the Brain has been trained, you can run an assessment and analyse the results:

- **Are stock restrictions respected?**
- **What is the backlog level in each case?**
- **What is the profit achieved in each case?**
- **What does the Brain decide to do when there are high demand peaks, especially with high stock constraints?**
- **What is the level of service?**





While each training can lead to different discovered strategies, which can be hard to interpret because of the complexity of the supply chain, **in general you should be able to observe that for some extreme situations, the chosen decisions perfectly make sense***.

*Hint: look at the plane shipments to retailer 2 in periods of high demand peaks and low stocks...

You can test and analyse different scenarios

This shows that the Brain, **trained with the right simulation digital twin, is able to autonomously discover valid strategies** (even without any guidance) which are **dynamically** adapted to the exact context (*e.g.* varying and even **sudden** demand peaks)

⇒ You can be confident in its **agility** and its capacity to dynamically react to prescribe actions which **maximize the resilience of the supply chain in all the situations.**

This is the power of AI trained with **Cosmo Tech simulation-based synthetic data**.

In contrast to AI trained on historical data, here AI helps you take the right actions for any of the future, previously unseen, situations.

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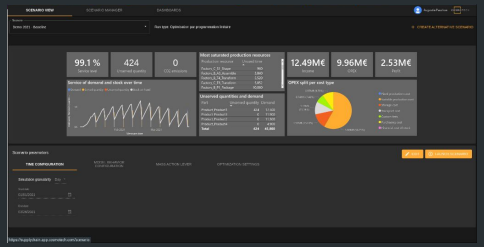
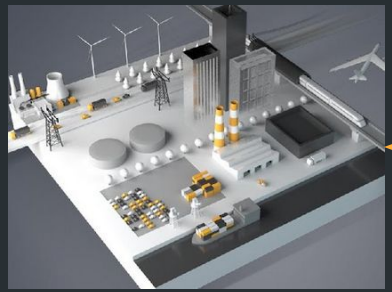
Going further

With Cosmo Tech platform, you can build intuitive web application and deploy the Brain as well as combine it with the simulation digital twin to assess its prescriptions in live.
Operators and business users can therefore run what-if analyses and compare the Brain's recommandations to what they would do or assess the robustness of the decision and its sensitivity to uncertainties



evaluate decisions



Prescription engine

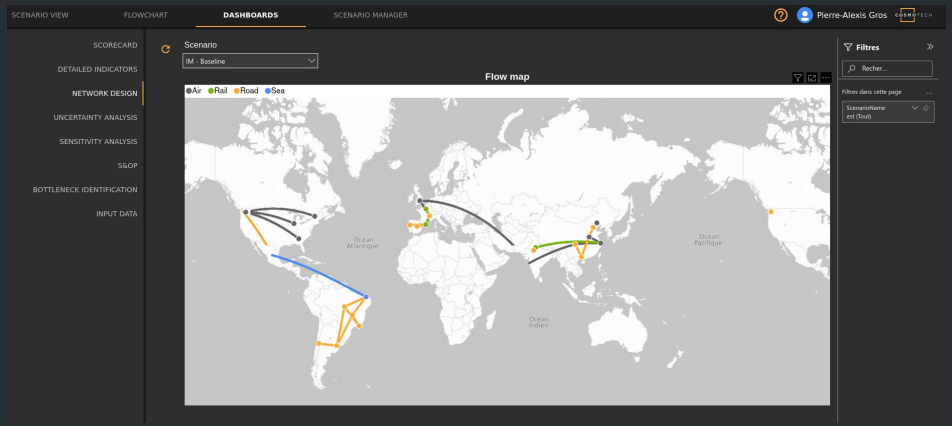
bonsai

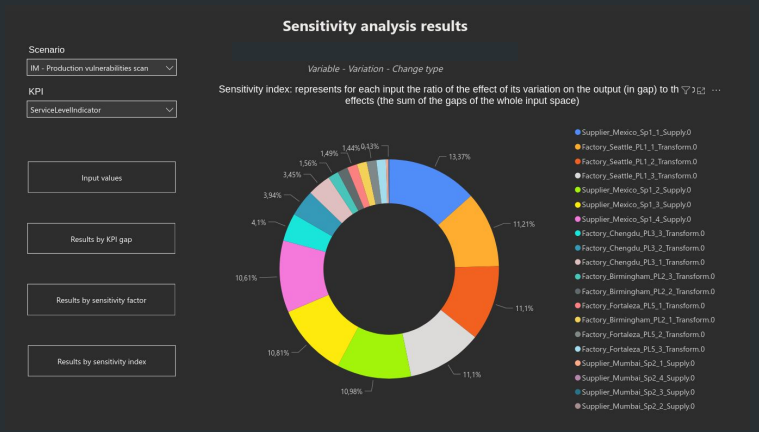
Evaluation engine

bonsai

Cosmo Tech Platform

Going further





More on Cosmo Tech platform
More on CoMETS and Hybrid AI
More on Autonomous and resilient supply chain

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