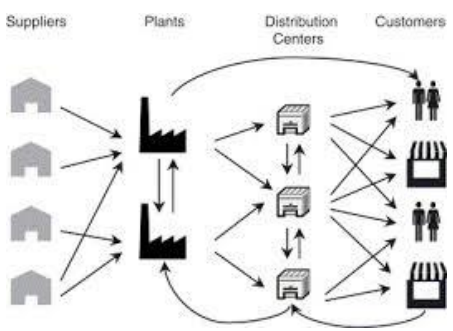
宁波(中国)供应链创新学院
NINGBO CHINA INSTITUTE FOR SUPPLY CHAIN INNOVATION

MIT GLOBAL SCALE NETWORK

Leveraging the CAVE Lab for data-driven decision making in logistics and supply chain management

“Traditional” academic problem solving (in SCM)

Identify a problem → **Develop a model and a solution algorithm** → Obtain a solution and analyze it



How to minimize our distribution costs?

$$minimize\ Z = \sum_{v\in V} FC_v u_v + \sum_{v\in V}\sum_{t\in T} C_v^S y_{vt} + \sum_{l\in L}\sum_{k\in K}\sum_{t\in T} C_{lk}^R f_{lkt} + \sum_{l\in L}\sum_{k\in K}\sum_{t\in T} C^H f_{lkt}$$

Subject to

$$u_v D_t / T_v \geq y_{vt},\quad \forall v \in V, t \in T$$

$$f_{kt}^R + \sum_{l\in L} f_{lkt} = Dem_{kt},\quad \forall k \in K, t \in T$$

$$\sum_{k\in K} f_{lkt} \leq \sum_{v\in V} Q_v\, y_{vt},\quad \forall v \in V, l \in L, t \in T$$

$$u_v, y_{vt} \in INT^+,\quad \forall v \in V, t \in T$$

$$f_{lkt}, f_{kt}^R \geq 0,\quad \forall k \in K, t \in T, l \in L$$

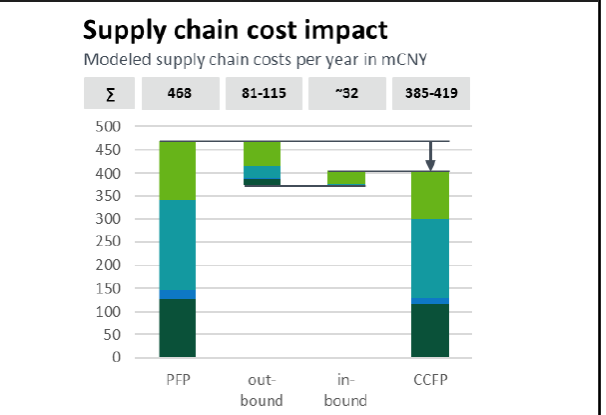
```
z = [None] * numProducts
for p in range(0, numProducts):
    z[p] = list(model.variables.add(types=["B"] * numPlants))
# Create objective function
model.objective.set_sense(model.objective.sense.minimize)

# Create constraint: Charter enough ships
for t in range(0, numPeriods):
    for v in range(0, numVessels):
        model.linear_constraints.add(
            lin_expr=[cplex.SparsePair(ind=[u[v]] + [y[v][t]], val=[int(30
            senses=["G"],
            rhs=[0.0]
        )

# Create constraint: Meet customer demand in each period
for c in range(0, numCustomers):
    for p in range(0, numProducts):
        for t in range(0, numPeriods):
            model.linear_constraints.add(
                lin_expr=[cplex.SparsePair(ind=[x_d[c][p][a][t] for a in r
                senses=["E"],
                rhs=[D[c][p][t]]
            )

# Create constraint: Ensure that vessel capacity is not exceeded
for l in range(0, numLegs):
    for t in range(0, numPeriods):
```

```
Solution status =  101 : Total transportation cost =  33872199.8848
5600.0
5720.0
11582064.0
8235284.803199999
17391964.3856
300000.0
37509313.1888
18581462.3968
```



Academic research (and problem solving) – which often focuses on model development and algorithm design – can be hard to interpret.

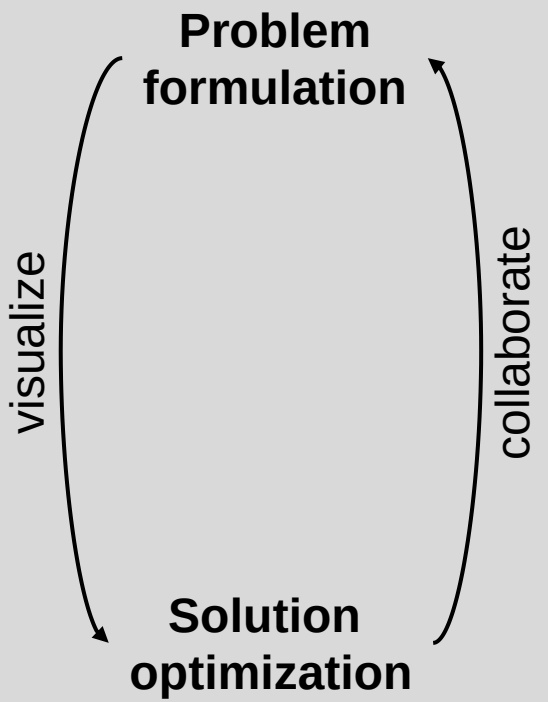
Smarter supply chain design and planning

Multi-stakeholder decision-making process

Intelligence	Collecting data/information and identifying problems and opportunities
Design	Identifying alternatives and selecting assessment criteria
Choice	Evaluating alternatives and choosing optimal solution

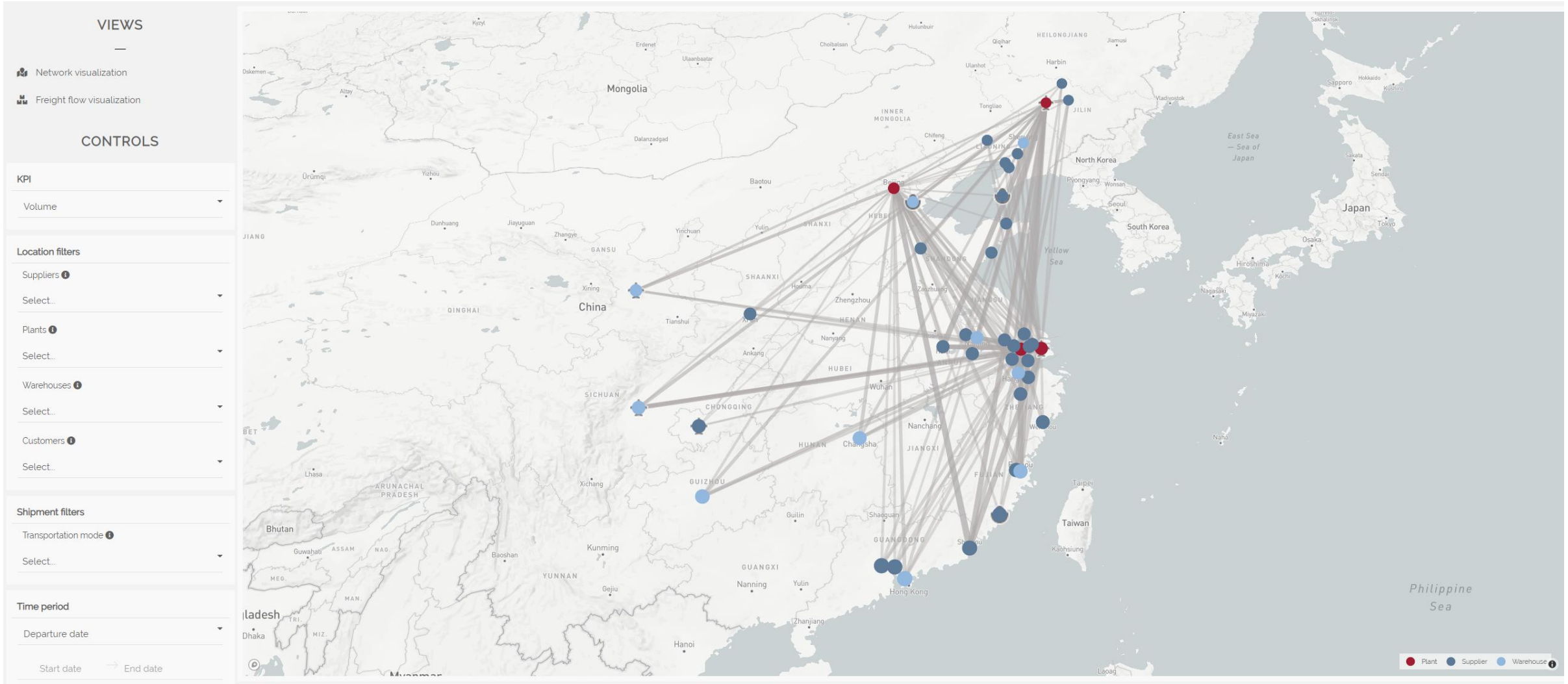
CAVE lab functionalities

- Data visualization & exploration
- Preference elicitation & solution design
- Interactive multi-objective optimization

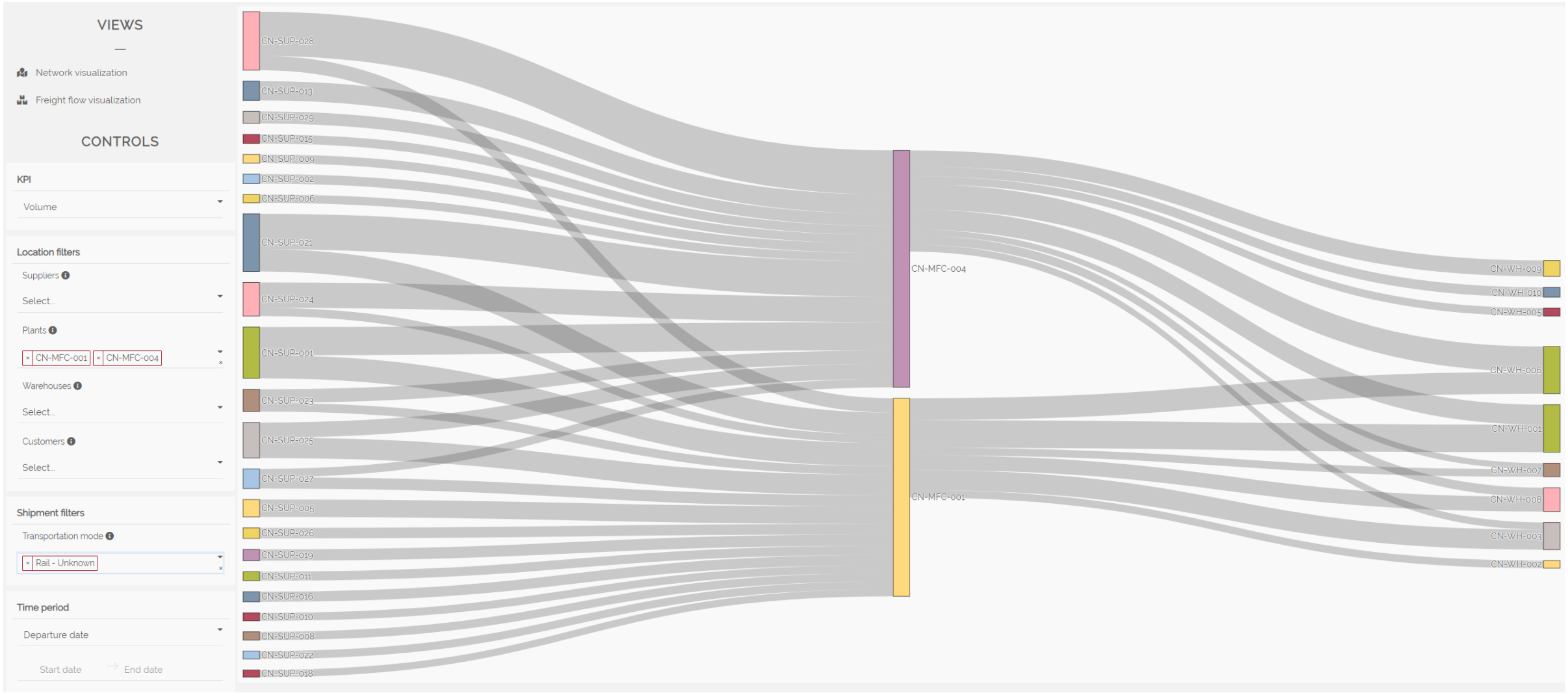


Source: "Interactive visualization to support data-driven supply chain decision and planning decisions", Winkenbach (2021).

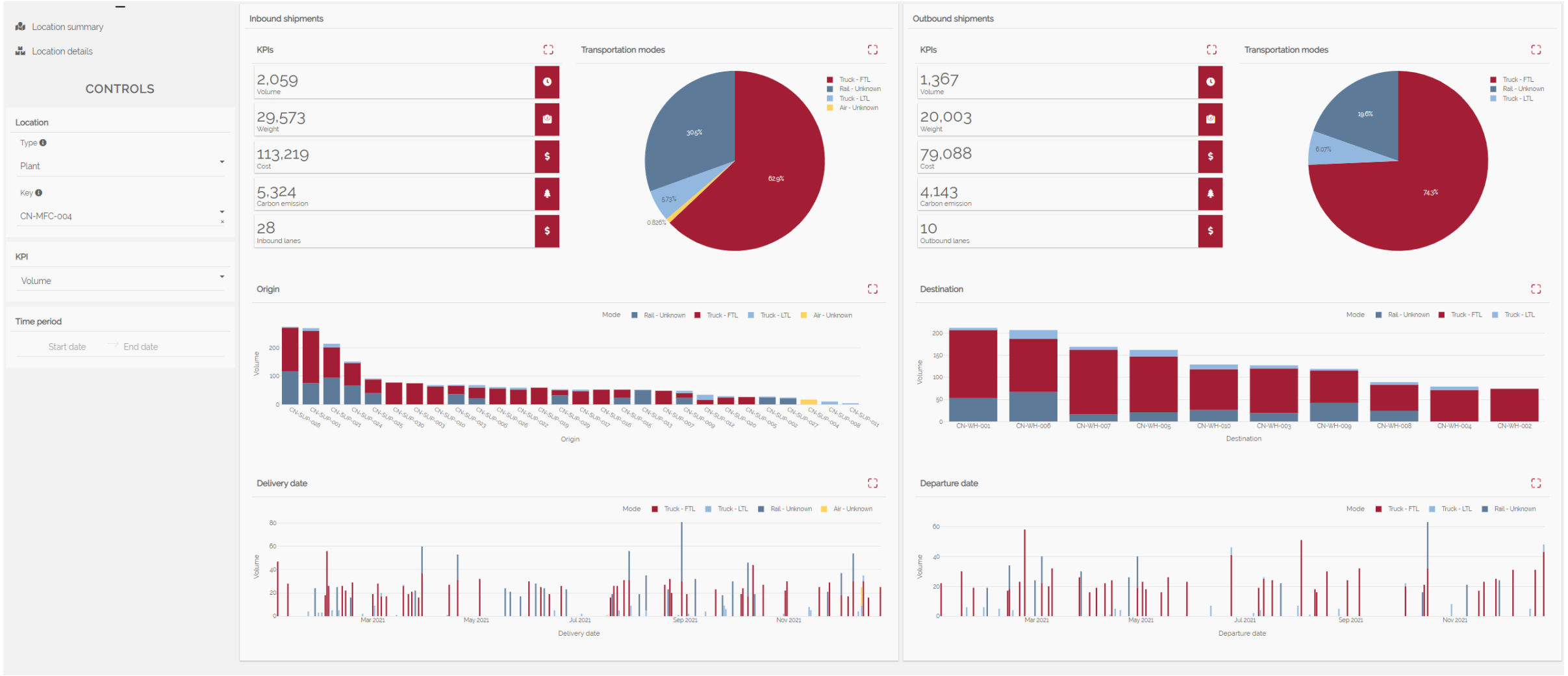
Interactive network design application mockup



Interactive network design application mockup

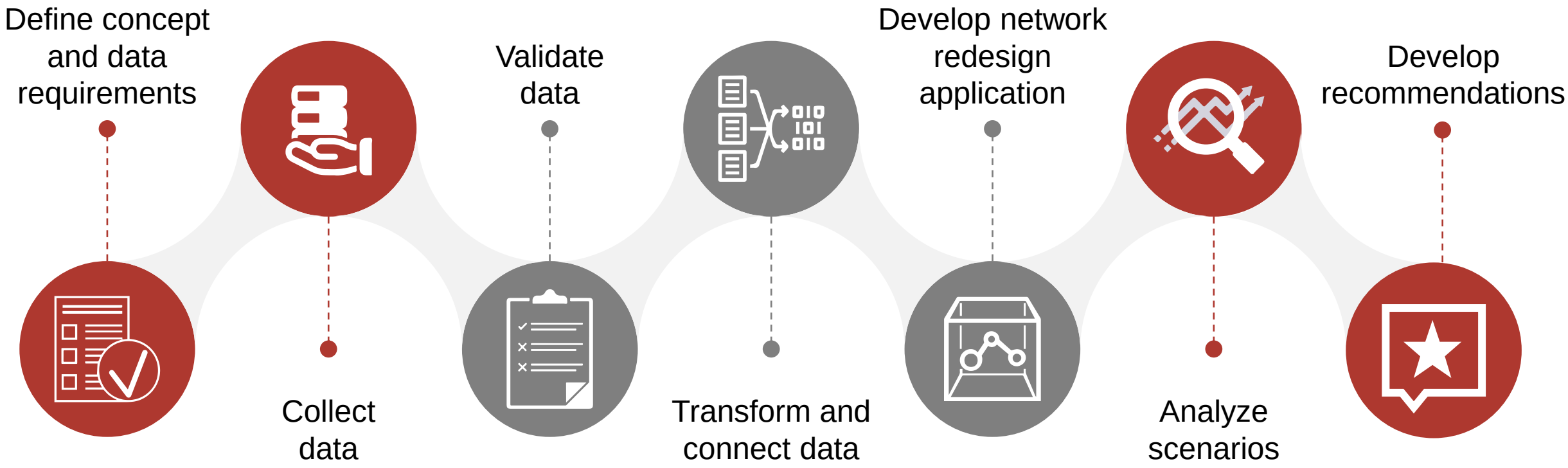


Interactive network design application mockup



Exemplary project approach

CAVE + project partner
CAVE



CAVE Lab advantages

Customization
Tailor-made to the research partner’s specific business requirements instead of a “one size fits all” approach.

Collaboration
CAVE Lab applications foster collaborative decision-making for a wide range of logistics and supply chain planning problems.

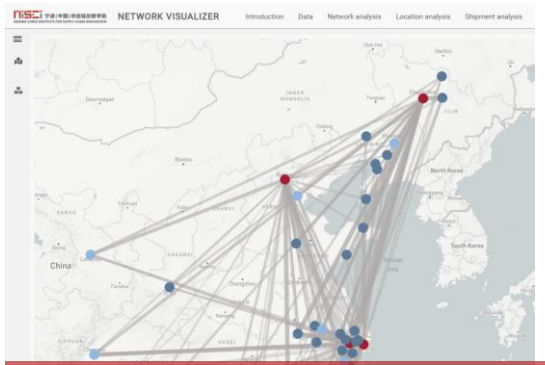
Accessibility
Our tailor-made applications can be deployed on a secure cloud server that ensures accessibility from everywhere at any time.

Platform & device independence
No local installation required. Supply chain design and planning on any device (Desktop PC, Laptop, Tablet, Smartphone, etc.).

Rapid development
Short development and implementation times. Possibility to increase software functionality over time.

CAVE Lab concept is being adopted across the MIT Global SCALE Network

NISCI CAVE Lab applications



NISCI Network Visualizer

Hinterland Network Design

Intermodal Distribution Network for Automobiles

Inbound Truck Scheduling at Warehouses

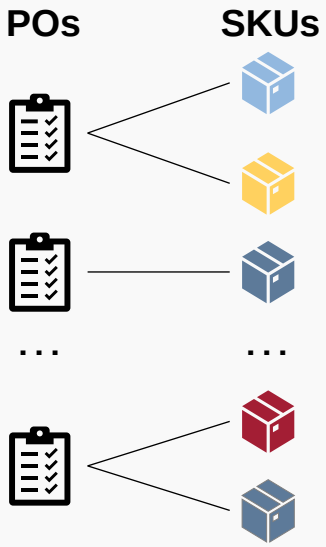
Container Loading Optimization

Case sharing

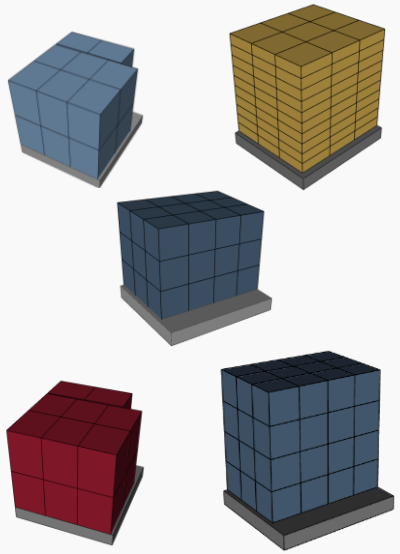
Container Loading Optimization

Overview of the Container Loading Optimization

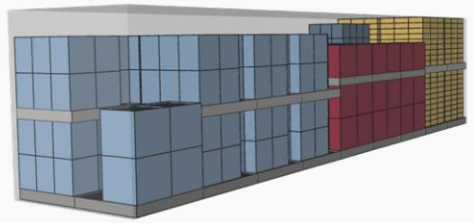
Input



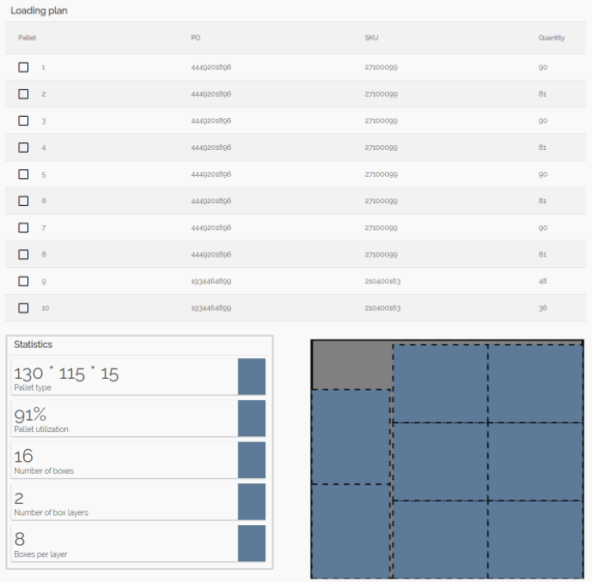
Palletization



Containerization



Loading instructions



Requirements

- Handle heterogenous cargo (weights and dimensions)
- Allow for using various pallet types
- …

- At most one mixed pallet per PO
- **Check for different box orientations**
- Ensure stability
- …

- PO cannot be split among containers
- Relative positioning of cargo
- Ensure weight distribution
- Ensure stackability
- …

- **Interactive**
- Fast
- **Running on smartphones and other mobile devices**

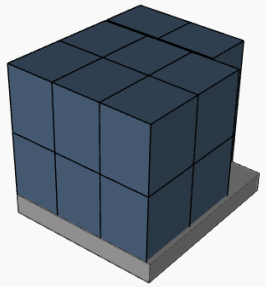
Process

Data upload

Upload of product and pallet data spreadsheets

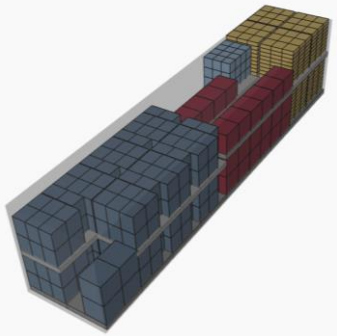
Pallet loading

Identification of ideal pallet loading patterns for all products



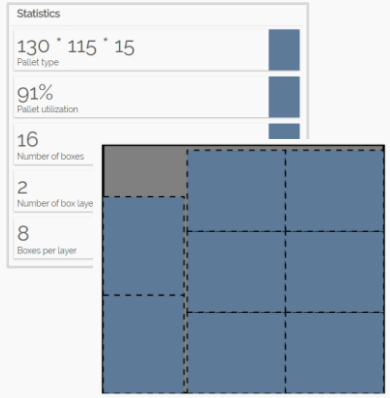
Container loading

Identification of the ideal container loading plans.



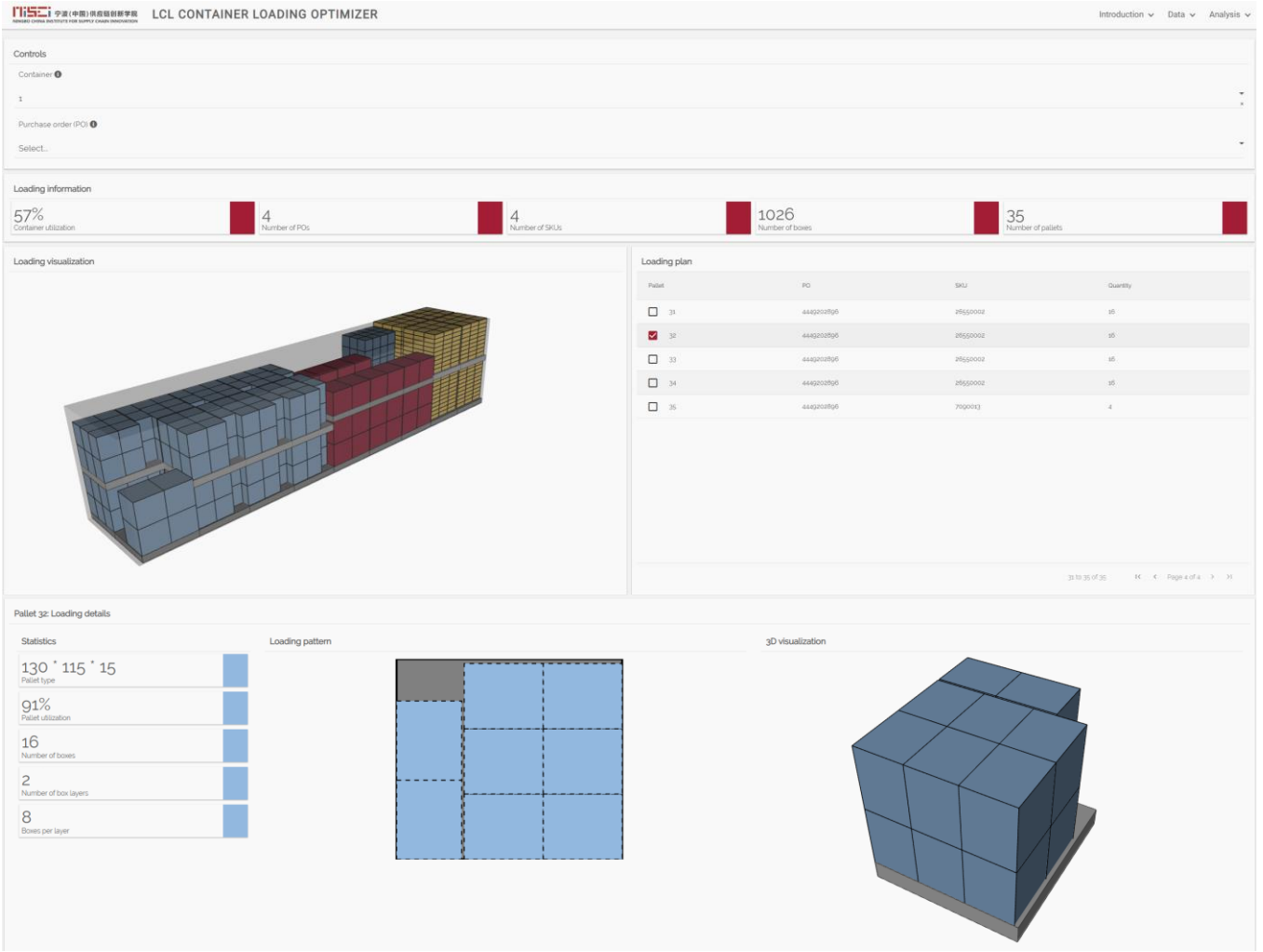
Loading operations

Download of intuitive loading instructions

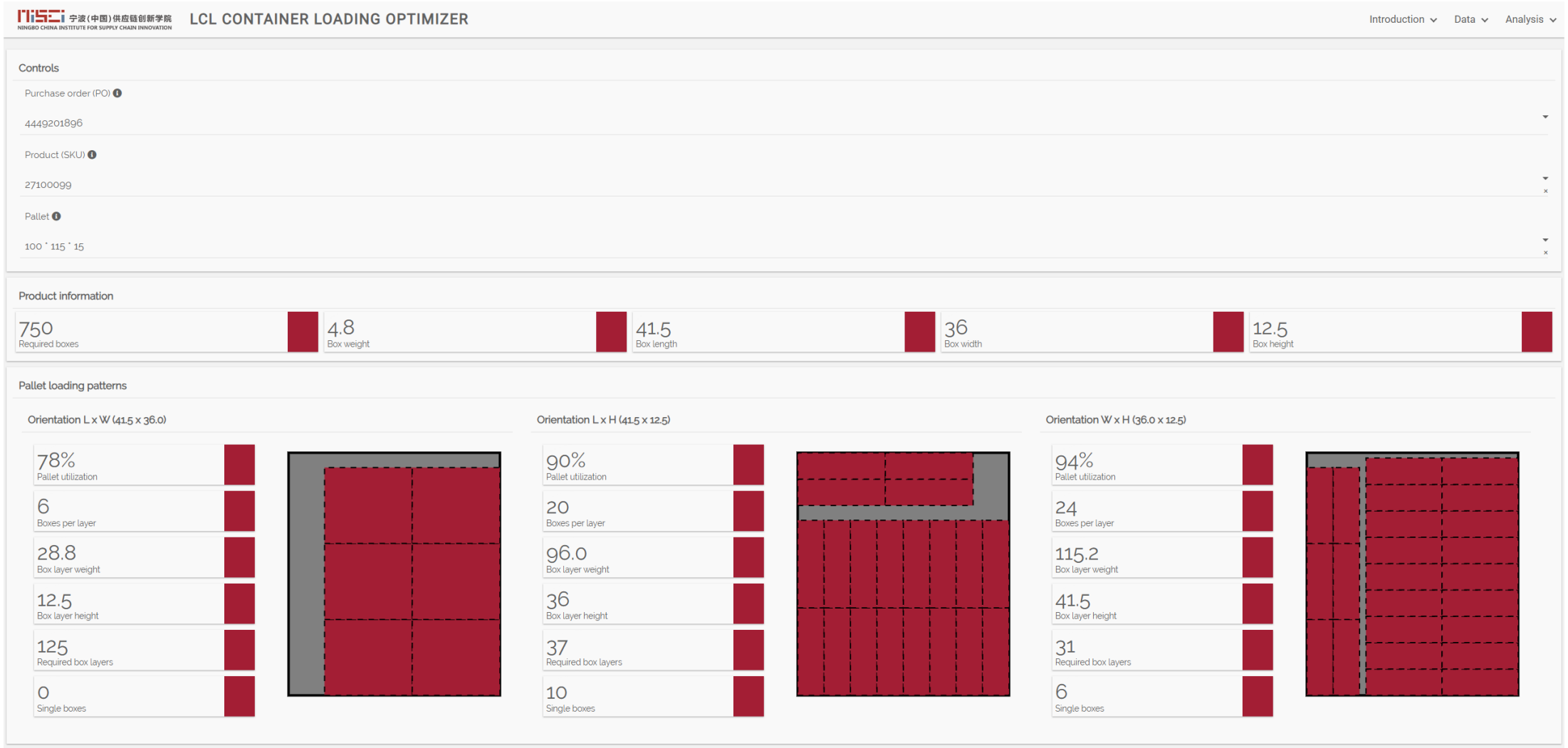


User **Automated**

Application



Application



Thank you! Questions?

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