DEVELOPMENT OF AN USER-FRIENDLY INTERFACE USING GAMS AND GAMS MIRO.

Final presentation | Advanced Data & Business Analytics

Lehrstuhl für Data and Business Analytics | RWTH AACHEN UNIVERSITY

GAMS

USER-FRIENDLY INTERFACE FOR MATHEMATICAL MODELS USING GAMS AND GAMS MIRO.

01
What was the project’s goal and what was the motivation behind it?

Motivation & project framework

02
How is the optimization model for the network design problem build?

Optimization model

03
What does the final dashboard look like and what steps did we take to get there?

Implementation & Dashboard

04
What hurdles did we face during implementation?

Problems & challenges

05
What lessons have we learned and where is there still a need for future optimization?

Conclusion and outlook

Motivation & project framework

„What was the project's goal and what was the motivation behind it?"

VISUALIZATION OF OPTIMIZATION MODELS: UNLOCKING NUMEROUS BENEFITS AND ENHANCED INSIGHTS.

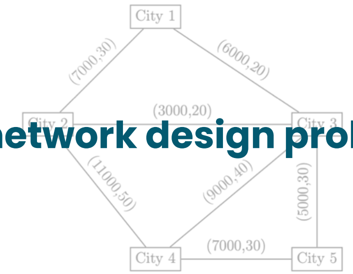
"Develop an user-friendly interface for a given mathematical optimization model."

Optimization Model — **Solver code** — **Visualization** (New) — **Interactive** (New)

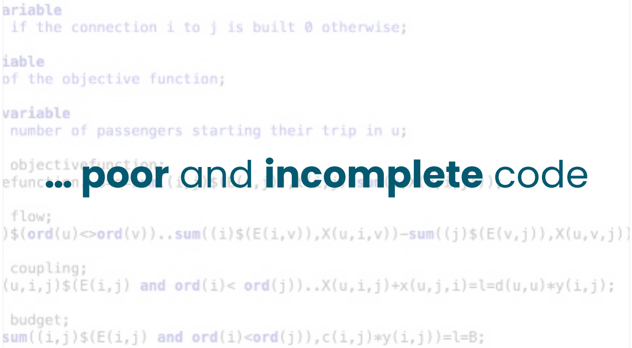
Adding **visualization** and **interactive components** to an optimization model **enables several advantages …**

- ✓ *Better interpretability*
- ✓ *Efficient*
- ✓ *Improved learning*
- ✓ *Interactive Analysis*
- ✓ *Enhanced Understanding*
- ✓ *Increased Accessibility*
- ✓ *More fun ☺*

The following were provided …



… network design problem



… poor and **incomplete** code

… missing **visualizations** and **interactive components**

GAMS | Lehrstuhl für Data and Business Analytics | RWTH AACHEN UNIVERSITY

GAMS AND GAMS MIRO COMBINE THE FUNCTIONS OF OPTIMIZATION AND VISUALIZATION SOFTWARE INTO A SINGLE TOOL.

Optimization & modeling software

- **Creation and optimization** of real-world problems in a software environment.
- Uses **optimization algorithms** such as LP, MILP, NLP to find the best values for decision variables.
- It is applied in **many industry areas.**

Visualization software

- Enables the **representation of data in graphical form**, such as charts, graphs, and interactive dashboards.
- Aids in **identifying patterns, trends, and anomalies** in large datasets.

✓ Both tools within a **single software**.

✓ **Popularity in the industry** is steadily increasing.

Different software for … … different applications.

FROM INITIAL STATE TO VISION: SETTING OUR TARGET OBJECTIVES AND GENERATION OF A TARGET IMAGE.

Initial Situation

- ✓ **Mathematical Model** with incomplete **code base**
- ✗ **Missing Dashboard**
- ✗ **Lack of Real-World Relevance**
- ✗ **No Scenario Planning**
- ✗ **No Visualizations**

Establish
Real-World Relevance

Nod Selection as
real **German Cities**

Vision

Create an **Intuitive** and **User-Friendly Dashboard**

Integrate predefined
Scenarios

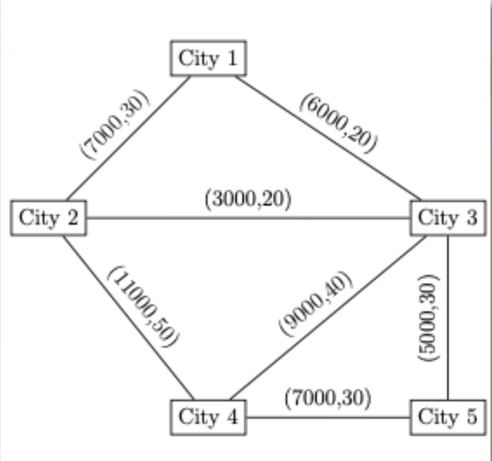
Train Network with
different **Train Types**

Introduction of the the network design problem

„What is the network design problem and how is the optimization model built?"

THE NETWORK DESIGN PROBLEM AIMS TO MINIMIZE PASSENGER TRAVEL TIME WHILE ADHERING TO OPERATIONAL RESTRICTIONS.

Initial Network



Mathematical Model

$$\text{Minimize } G = \sum_{i,j \in E} t_{ij} \sum_{u \in V} x_{uij}$$

$$\sum_{(i,v) \in E} x_{uiv} - \sum_{(v,j) \in E} x_{uvj} = d_{uu} \qquad \forall i, v \in V \,|\, u \neq v$$

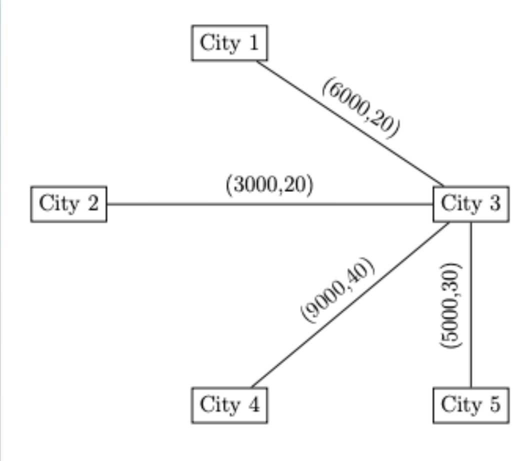
$$x_{uij} + x_{uji} \leq d_{uu} \times y_{ij} \qquad \forall u \in V, (i,j) \in E$$

$$\sum_{(i,j) \in E | i<j} c_{ij} \times y_{ij} \leq B \qquad \forall u \in V, (i,j) \in E \,|\, i < j$$

$$x_{uij} \geq 0 \qquad \forall u \in V, (i,j) \in E$$

$$y_{ij} \in \{0,1\} \qquad \forall (i,j) \in E \,|\, i < j$$

Optimal Solution



Input

V : cities

E : connections

---

c_{ij}: construction costs

B: budget

t_{ij}: travel time

d_{uv}: expected number of passengers

Mathematical optimization

Objective Function

- Minimize total travel time

Constraints

Output

y_{ij}: 1, if edge is built (0, otherwise)

x_{uij}: number of passengers starting trip in u and traveling from i to j

A FUNDAMENTAL UNDERSTANDING OF THE OPTIMIZATION MODEL IS KEY TO INTERACTIVE APPLICATIONS.

Sets

V : sorted nodes (indices: i, j, u, v)
E : edges; with edge $[i, j] \in E$, where $i < j$

Variables

y_{ij} : 1, if edge$[i, j]$is built (0, otherwise) sorted nodes (indices: i, j, u, v) if edge
x_{uij} : number of passengers starting their trip in node u and traveling from i to j

$$Minimize\ G = \sum_{i,j \in E} t_{ij} \sum_{u \in V} x_{uij}$$

$$\sum_{(i,v) \in E} x_{uiv} - \sum_{(v,j) \in E} x_{uvj} = d_{uu} \qquad \forall i, v \in V \mid u \neq v$$

$$x_{uij} + x_{uji} \leq d_{uu} \times y_{ij} \qquad \forall u \in V, (i,j) \in E$$

$$\sum_{(i,j) \in E \mid i<j} c_{ij} \times y_{ij} \leq B \qquad \forall u \in V, (i,j) \in E \mid i < j$$

$$x_{uij} \geq 0 \qquad \forall u \in V, (i,j) \in E$$

$$y_{ij} \in \{0,1\} \qquad \forall (i,j) \in E \mid i < j$$

A FUNDAMENTAL UNDERSTANDING OF THE OPTIMIZATION MODEL IS KEY TO INTERACTIVE APPLICATIONS.

Sets

V : sorted nodes (indices: i, j, u, v)
E : edges; with edge $[i, j] \in E$, where $i < j$

Variables

y_{ij} : 1, if edge$[i, j]$is built (0, otherwise) sorted nodes (indices: i, j, u, v) if edge
x_{uij} : number of passengers starting their trip in node u and traveling from i to j

$$Minimize\ G = \sum_{i,j \in E} \boxed{t_{ij}} \sum_{u \in V} x_{uij}$$

Travel time between nodes

$$\sum x_{uiv} - \sum x_{uvj} = d_{uu} \qquad \forall i, v \in V \mid u \neq v$$

Minimizes the total travel time for all passengers

$$x_{uij} + x_{uji} \leq d_{uu} \times y_{ij} \qquad \forall u \in V, (i,j) \in E$$

$$\sum_{(i,j) \in E | i<j} c_{ij} \times y_{ij} \leq B \qquad \forall u \in V, (i,j) \in E | \ i < j$$

$$x_{uij} \geq 0 \qquad \forall u \in V, (i,j) \in E$$

$$y_{ij} \in \{0,1\} \qquad \forall (i,j) \in E \mid i < j$$

A FUNDAMENTAL UNDERSTANDING OF THE OPTIMIZATION MODEL IS KEY TO INTERACTIVE APPLICATIONS.

Sets

V : sorted nodes (indices: i, j, u, v)
E : edges; with edge $[i, j] \in E$, where $i < j$

Variables

y_{ij} : 1, if edge$[i, j]$is built (0, otherwise) sorted nodes (indices: i, j, u, v) if edge
x_{uij} : number of passengers starting their trip in node u and traveling from i to j

$$\text{Minimize } G = \sum_{i,j \in E} t_{ij} \sum_{u \in V} x_{uij}$$

expected number of passengers traveling from node u to node v, with $v \neq u$

$$\sum_{(i,v) \in E} x_{uiv} - \sum_{(v,j) \in E} x_{uvj} = \boxed{d_{uu}} \qquad \forall i, v \in V \,|u \neq v$$

$$x_{uij} + x_{uji} \leq d_{uu} \times y_{ij} \qquad \forall u \in V, (i,j) \in E$$

$$\sum_{(i,j) \in E|i<j} c_{ij} \times y_{ij} \leq B \qquad \forall u \in V, (i,j) \in E|i<j$$

Flow balance constraint: ensures the number of passengers leaving a node equals the number arriving, accounting for the expected demand

$$x_{uij} \geq 0 \qquad \forall u \in V, (i,j) \in E$$

$$y_{ij} \in \{0,1\} \qquad \forall (i,j) \in E \,|\, i < j$$

A FUNDAMENTAL UNDERSTANDING OF THE OPTIMIZATION MODEL IS KEY TO INTERACTIVE APPLICATIONS.

Sets

V : sorted nodes (indices: i, j, u, v)
E : edges; with edge $[i, j] \in E$, where $i < j$

Variables

y_{ij} : 1, if edge$[i, j]$is built (0, otherwise) sorted nodes (indices: i, j, u, v) if edge
x_{uij} : number of passengers starting their trip in node u and traveling from i to j

$$Minimize\ G = \sum_{i,j \in E} t_{ij} \sum_{u \in V} x_{uij}$$

$$\sum_{(i,v) \in E} x_{uiv} - \sum_{(v,j) \in E} x_{uvj} = d_{vu} \qquad \forall i, v \in V \mid u \neq v$$

1 if connection has been built and 0 otherwise

$$x_{uij} + x_{uji} \leq d_{uu} \times \boxed{y_{ij}} \qquad \forall u \in V, (i,j) \in E$$

Passenger flow constraint: ensures passenger flow on an edge does not exceed the demand if the edge is built

$$\sum_{(i,j) \in E | i<j} c_{ij} \times y_{ij} \leq B$$

$$x_{uij} \geq 0 \qquad \forall u \in V, (i,j) \in E$$

$$y_{ij} \in \{0,1\} \qquad \forall (i,j) \in E \mid i < j$$

A FUNDAMENTAL UNDERSTANDING OF THE OPTIMIZATION MODEL IS KEY TO INTERACTIVE APPLICATIONS.

Sets

V : sorted nodes (indices: i, j, u, v)
E : edges; with edge $[i, j] \in E$, where $i < j$

Variables

$\boldsymbol{y_{ij}}$: 1, if edge$[i, j]$is built (0, otherwise) sorted nodes (indices: i, j, u, v) if edge
$\boldsymbol{x_{uij}}$: number of passengers starting their trip in node u and traveling from i to j

$$Minimize\ G = \sum_{i,j \in E} t_{ij} \sum_{u \in V} x_{uij}$$

$$\sum_{(i,v) \in E} x_{uiv} - \sum_{(v,j) \in E} x_{uvj} = d_{uu} \quad \forall i, v \in V \mid u \neq v$$

$$x_{uij} + x_{uji} \leq d_{uu} \times y_{ij} \quad \forall u \in V, (i,j) \in E$$

Budget for constructing edges

$$\sum_{(i,j) \in E | i<j} c_{ij} \times y_{ij} \leq \boxed{B} \quad \forall u \in V, (i,j) \in E |\ i\ < j$$

Budget constraint: ensures the total construction cost does not exceed the budget

$$x_{uij} \geq 0 \quad \forall u \in V, (i,j) \in E$$

$$y_{ij} \in \{0,1\} \quad \forall (i,j) \in E \mid i < j$$

A FUNDAMENTAL UNDERSTANDING OF THE OPTIMIZATION MODEL IS KEY TO INTERACTIVE APPLICATIONS.

Sets

V : sorted nodes (indices: i, j, u, v)
E : edges; with edge $[i, j] \in E$, where $i < j$

Variables

y_{ij} : 1, if edge$[i, j]$is built (0, otherwise) sorted nodes (indices: i, j, u, v) if edge
x_{uij} : number of passengers starting their trip in node u and traveling from i to j

$$Minimize\ G = \sum_{i,j \in E} t_{ij} \sum_{u \in V} x_{uij}$$

$$\sum_{(i,v) \in E} x_{uiv} - \sum_{(v,j) \in E} x_{uvj} = d_{uu} \qquad \forall i, v \in V \mid u \neq v$$

$$x_{uij} + x_{uji} \leq d_{uu} \times y_{ij} \qquad \forall u \in V, (i,j) \in E$$

$$\sum_{(i,j) \in E \mid i<j} c_{ij} \times y_{ij} \leq B \qquad \forall u \in V, (i,j) \in E \mid i < j$$

$$x_{uij} \geq 0 \qquad \forall u \in V, (i,j) \in E$$

Non-negativity constraint: ensures the number of passengers on any edge is non-negative

GAMS | Lehrstuhl für Data and Business Analytics | RWTH AACHEN UNIVERSITY

A FUNDAMENTAL UNDERSTANDING OF THE OPTIMIZATION MODEL IS KEY TO INTERACTIVE APPLICATIONS.

Sets

V : sorted nodes (indices: i, j, u, v)
E : edges; with edge $[i, j] \in E$, where $i < j$

Variables

y_{ij} : 1, if edge$[i, j]$is built (0, otherwise) sorted nodes (indices: i, j, u, v) if edge
x_{uij} : number of passengers starting their trip in node u and traveling from i to j

$$Minimize\ G = \sum_{i,j \in E} t_{ij} \sum_{u \in V} x_{uij}$$

$$\sum_{(i,v) \in E} x_{uiv} - \sum_{(v,j) \in E} x_{uvj} = d_{uu} \qquad \forall i, v \in V \mid u \neq v$$

$$x_{uij} + x_{uji} \leq d_{uu} \times y_{ij} \qquad \forall u \in V, (i,j) \in E$$

$$\sum_{(i,j) \in E \mid i<j} c_{ij} \times y_{ij} \leq B \qquad \forall u \in V, (i,j) \in E \mid i < j$$

$$x_{uij} \geq 0 \qquad \forall u \in V, (i,j) \in E$$

$$y_{ij} \in \{0,1\} \qquad \forall (i,j) \in E \mid i < j$$

Binary constraint: ensures that an edge is either built (1) or not built (0)

GAMS Lehrstuhl für Data and Business Analytics RWTH AACHEN UNIVERSITY

Implementation & Dashboard

„What does the final dashboard look like and what steps did we take to get there?“

USER-FRIENDLY INTERFACE FOR MATHEMATICAL MODELS USING GAMS AND GAMS MIRO.

WP1: Comprehensive GAMS MIRO Research

- ✓ *Familiarization with GAMS and MIRO*
- ✓ *Analyzing the possibilities in MIRO*
- ✓ *Planning possible dashboard options*

WP2: Code Base Adaption in GAMS

- ✓ *Adjustment of Input Data and Node Set*
- ✓ *Enabling Selection Options for Users*
- ✓ *Transfer of Parameters to GAMS MIRO*

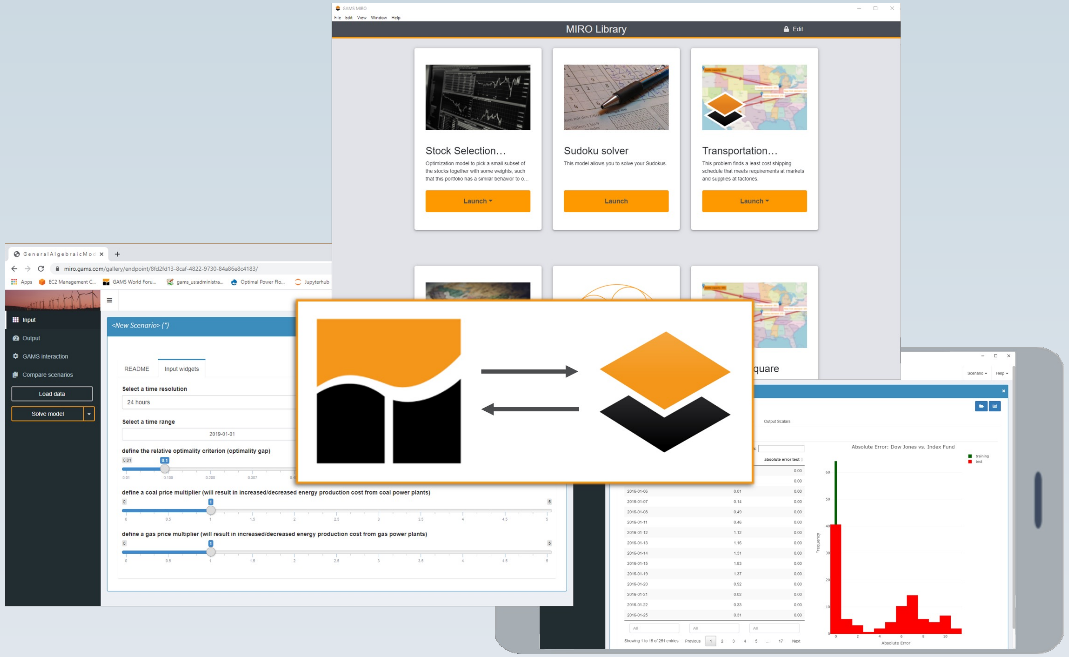
WP3: Dashboard setup in MIRO

- ✓ *Setting up input option for user*
- ✓ *Creating visualization graphics for output*
- ✓ *Structuring of output graphics*

WP4: Defining and creating scenarios

- ✓ *Defining degrees of freedom*
- ✓ *Establishing interesting characteristics*
- ✓ *Simulating all scenarios*

THE GAMS MIRO DOCUMENTATION IS A HELPFUL SUPPORT AND DEMONSTRATES THE DIVERSE POSSIBILITIES OF THE TOOL.



- **Read the documentation** of GAMS and GAMS Miro and **familiarized with the functions**.
- Went through the **provided example dashboards**.
- Analyzed **further implementation steps**.

- GAMS MIRO offers a **variety of customization options** and the ability to build **an interactive dashboard** according to our requirements

- The provided GAMS code **needs significant adjustments**.

THE FOUNDATION OF THE CODE MUST BE ADJUSTED TO CREATE REALISM AND ENABLE THE INTERACTIVITY OF THE DASHBOARD.

Defining the nodes to be simulated through real city selection

Example

```
Set v /Aachen, Berlin, Bremen, Chemnitz, Dortmund,
Dresden, Duesseldorf, Erfurt, Frankfurt, Freiburg,
Goettingen, Hamburg, Hannover, Karlsruhe, ... ;

Set E(v, v);

E(v, i) = yes;
```

- **Expand the number of nodes** to be optimized.
- Include up to **largest cities** in the **16 federal states**.
- Use real **geographic coordinates**.

Adjust the input data and establish a connection to reality

Real World Assumtion

Gravety_Model.gms

- Adjust construction costs [*c(v,v)*] and travel times [*t(v,v)*] using **more realistic values** through appropriate assumptions and simplifications.
  - ***Example***: *City distance * train speed = travel time.*
- Modeling traffic between cities by previously **incorporating a gravity model**.

THE FOUNDATION OF THE CODE MUST BE ADJUSTED TO CREATE REALISM AND ENABLE THE INTERACTIVITY OF THE DASHBOARD.

Enable input selection by the user

Example

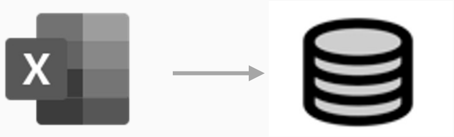
```
If (Subcityselction('East'),
     v_subset('Berlin') = yes;
     v_subset('Potsdam') = yes;
     v_subset('Magdeburg') = yes;
     v_subset('Leipzig') = yes;
     v_subset('Erfurt') = yes;
);
```

- Making the GAMS **code more flexible**.
- Enable external input through **dynamic quantities** and **adjustable parameters**.

Linking with a GDX file for data transfer

Example

```
$GDXIN data_general.gdx
$LOAD long, lat, ...
$GDXIN
```



- Input data is **transferred via a GDX file** and not embedded in the code itself.
- Enables **larger datasets** and more **flexible adjustments** during the coding phase.

Linking GAMS MIRO and GAMS for mutual data exchange

Example

```
$OnExternalInput
Parameter B /1000/;
$OffExternalInput

$OnExernalOutput
Table      map(v,i, mapHdr);
Parameter totalcost;
$OffExternalOutput
```

- Creating **transparent code blocks**.
- Ensuring **data exchange for input and output data**.

GAMS | Lehrstuhl für Data and Business Analytics | RWTH AACHEN UNIVERSITY

UNLOCK FULL POTENTIAL FOR THE END USER WITH INTUITIVE INPUT AND OUTPUT VISUALIZATIONS.

Initial Situation Input

Global Info	Budget	Number of Passengers	Fixed Costs	Travel Time

Final Situation Input

Global Information	User Input		
	Budget	Train Type	Region

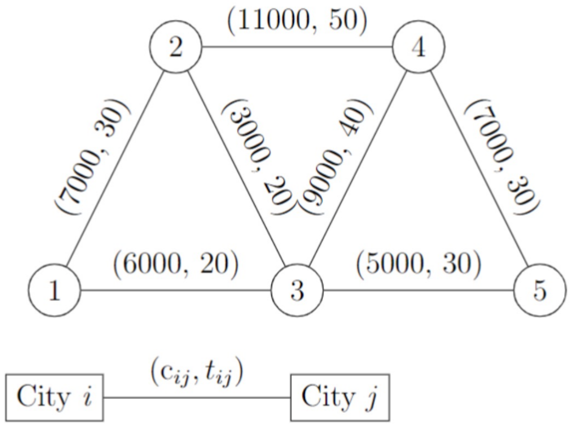
WP3

UNLOCK FULL POTENTIAL FOR THE END USER WITH INTUITIVE INPUT AND OUTPUT VISUALIZATIONS.

Initial Situation Input

Old

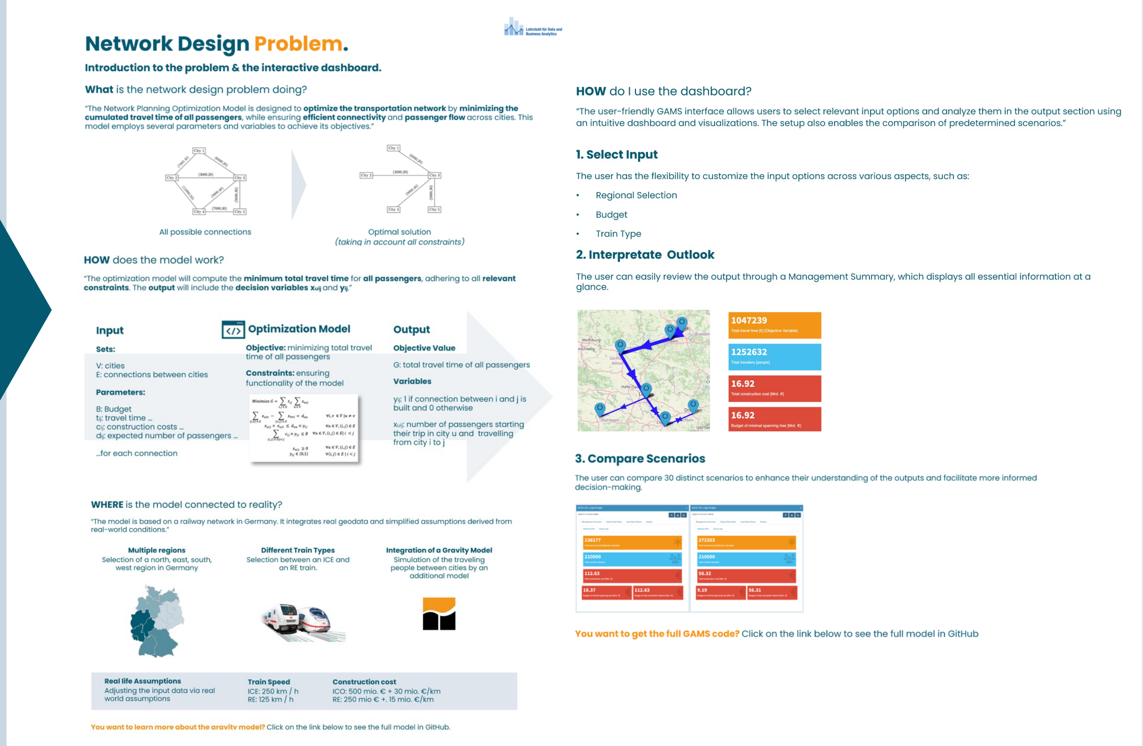
Global Info | Budget | Number of Passengers | Fixed Costs | Travel Time



Final Situation Input

Revised

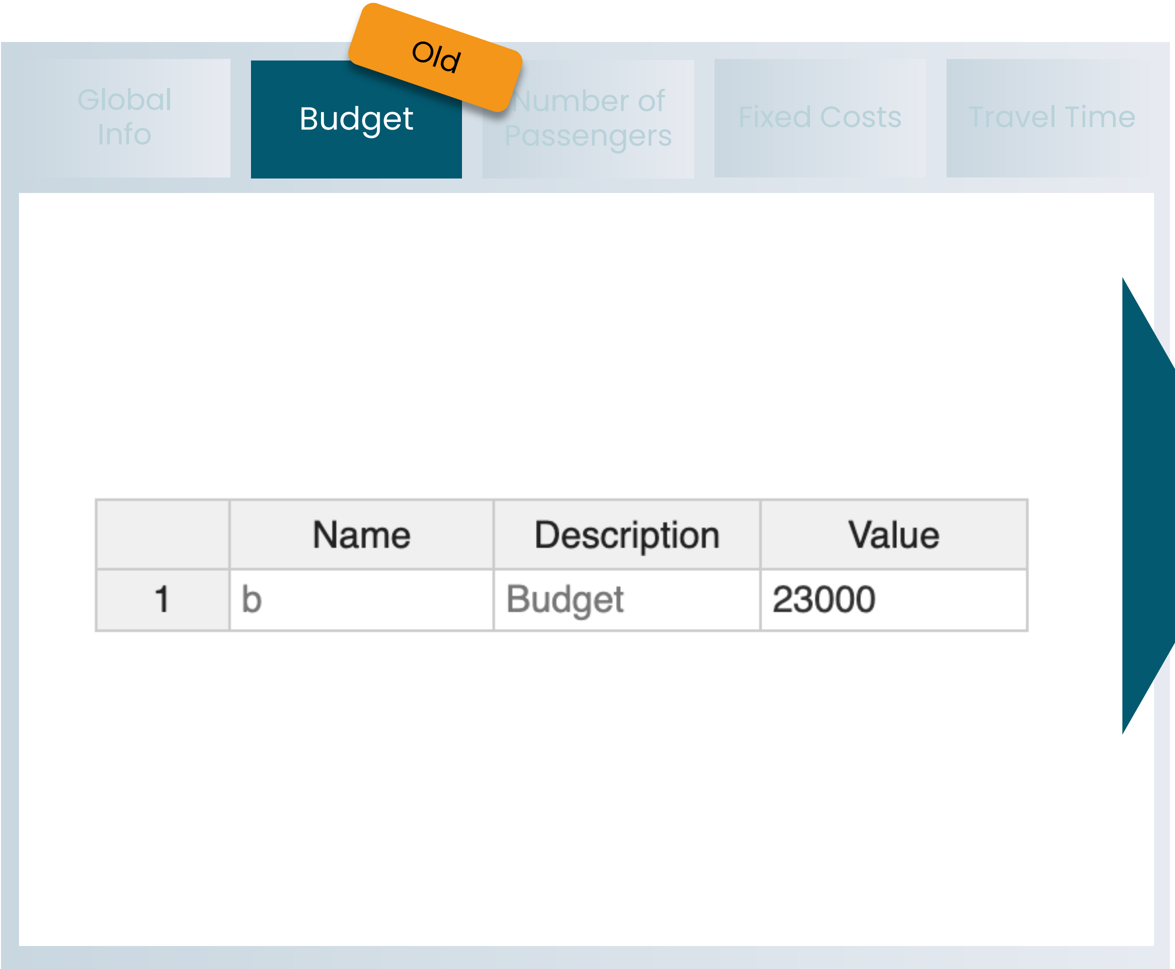
Global Information | User Input: Budget | Train Type | Region



GAMS | Lehrstuhl für Data and Business Analytics | RWTH AACHEN UNIVERSITY

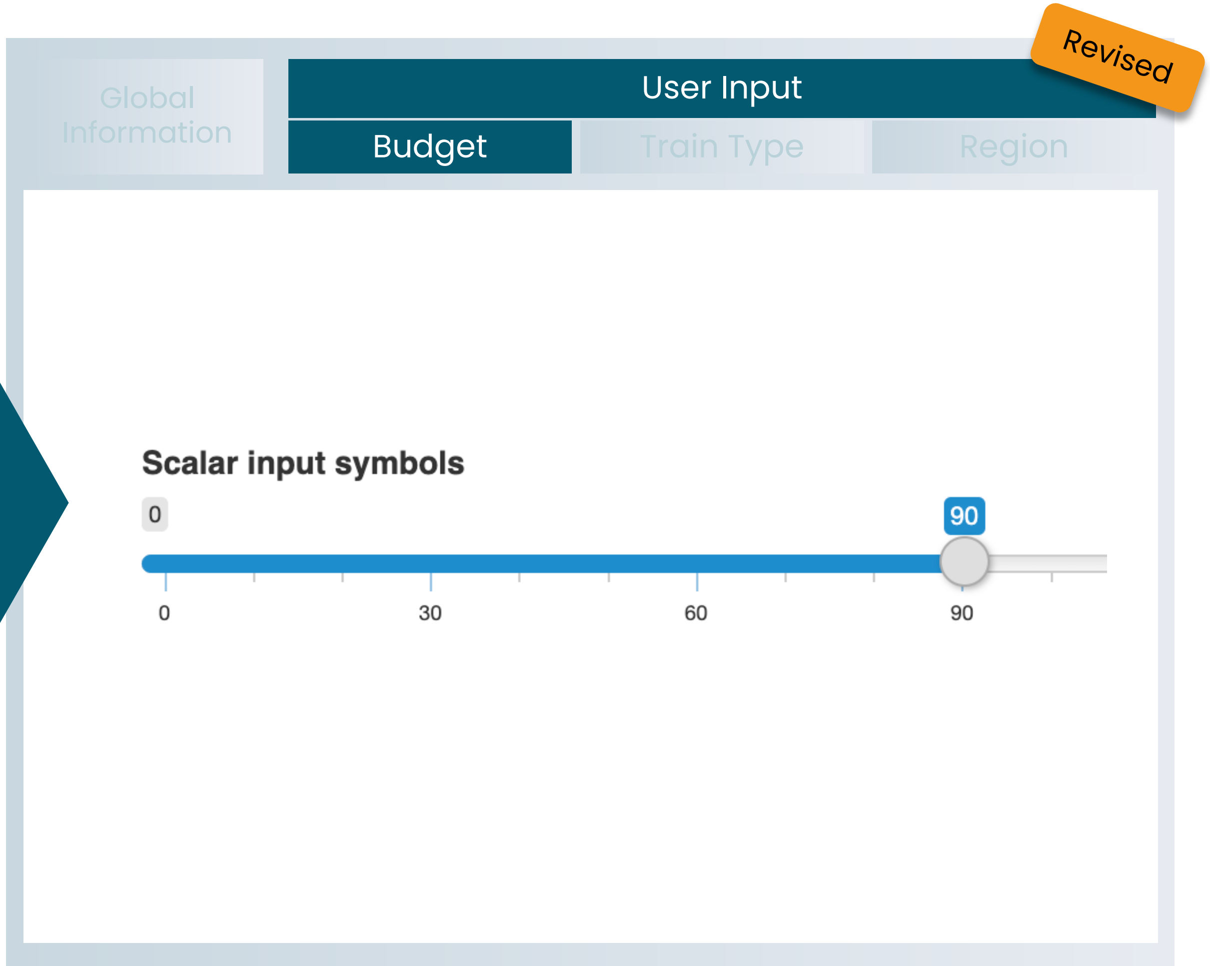
UNLOCK FULL POTENTIAL FOR THE END USER WITH INTUITIVE INPUT AND OUTPUT VISUALIZATIONS.

Initial Situation Input



	Name	Description	Value
1	b	Budget	23000

Final Situation Input



GAMS

Lehrstuhl für Data and Business Analytics

RWTH AACHEN UNIVERSITY

UNLOCK FULL POTENTIAL FOR THE END USER WITH INTUITIVE INPUT AND OUTPUT VISUALIZATIONS.

Initial Situation Input

Global Info | Budget | Number of Passengers (Removed) | Fixed Costs (Removed) | Travel Time (Removed)

Number of Passengers travelling from city u to v

	city u	city 1	city 2	city 3	city 4	city 5
1	city1	900.00	250.00	400.00	100.00	150.00
2	city2	250.00	1400.00	500.00	250.00	400.00
3	city3	400.00	500.00	1300.00	300.00	100.00

Fixed Costs

	city u	city v	fixed cost
1	city1	city2	7000.00
2	city1	city3	6000.00
3	city2	city1	7000.00

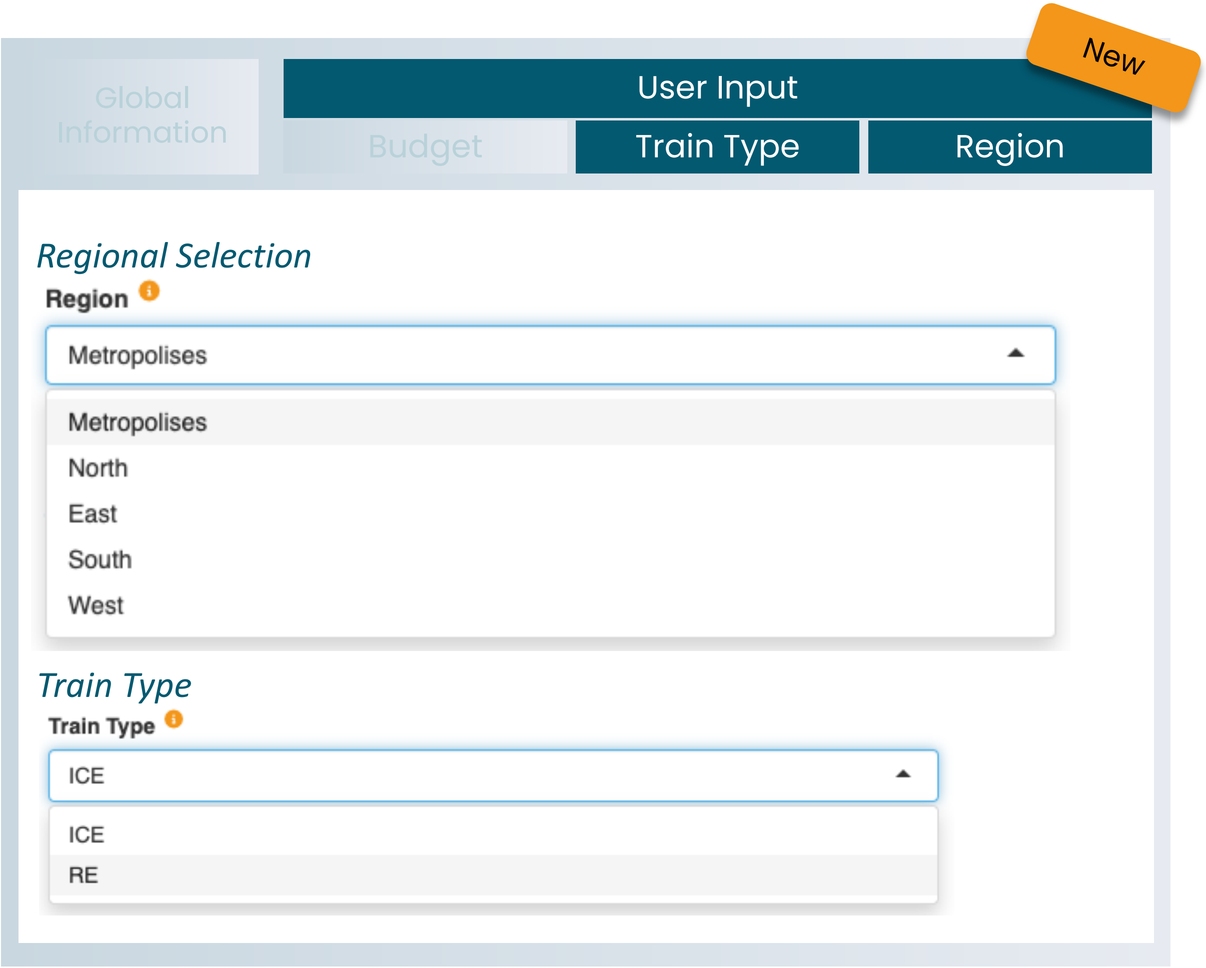
Travel Time

	trip i	trip j	value of travel time for the direct trip from i to j
1	city1	city2	30.00
2	city1	city3	20.00
3	city2	city1	30.00
4	city2	city3	20.00

```
$gdxIn data.gdx
$load long, lat, inhabitants t_subset, c_subset, d_subset
$GDXIN
```

UNLOCK FULL POTENTIAL FOR THE END USER WITH INTUITIVE INPUT AND OUTPUT VISUALIZATIONS.

Final Situation[Input]



UNLOCK FULL POTENTIAL FOR THE END USER WITH INTUITIVE INPUT AND OUTPUT VISUALIZATIONS.

Initial Situation Output

Connections	Number Passengers starting trip in	Objective Value

Final Situation Output

Management Summary		Input Data (Costs, Travel time, All Passengers)	Output Data (Travelling Passengers, Connection built)
Route Map	KPIs		

UNLOCK FULL POTENTIAL FOR THE END USER WITH INTUITIVE INPUT AND OUTPUT VISUALIZATIONS.

Initial Situation Output

Old

Connections | Number Passengers starting trip in | Objective Value

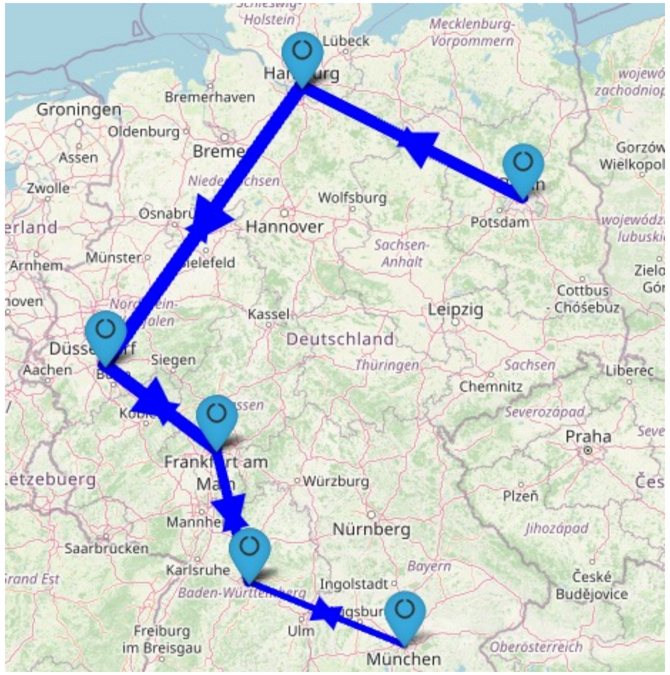
city j	city j	Header	value
city1	city3	level	1.00
		lower	0.00
		marginal	0.00
		scale	1.00
		upper	1.00

Final Situation Output

Revised

Management Summary | Input Data (Costs, Travel time, All Passengers) | Output Data (Travelling Passengers, Connection built)

Route Map | KPIs



UNLOCK FULL POTENTIAL FOR THE END USER WITH INTUITIVE INPUT AND OUTPUT VISUALIZATIONS.

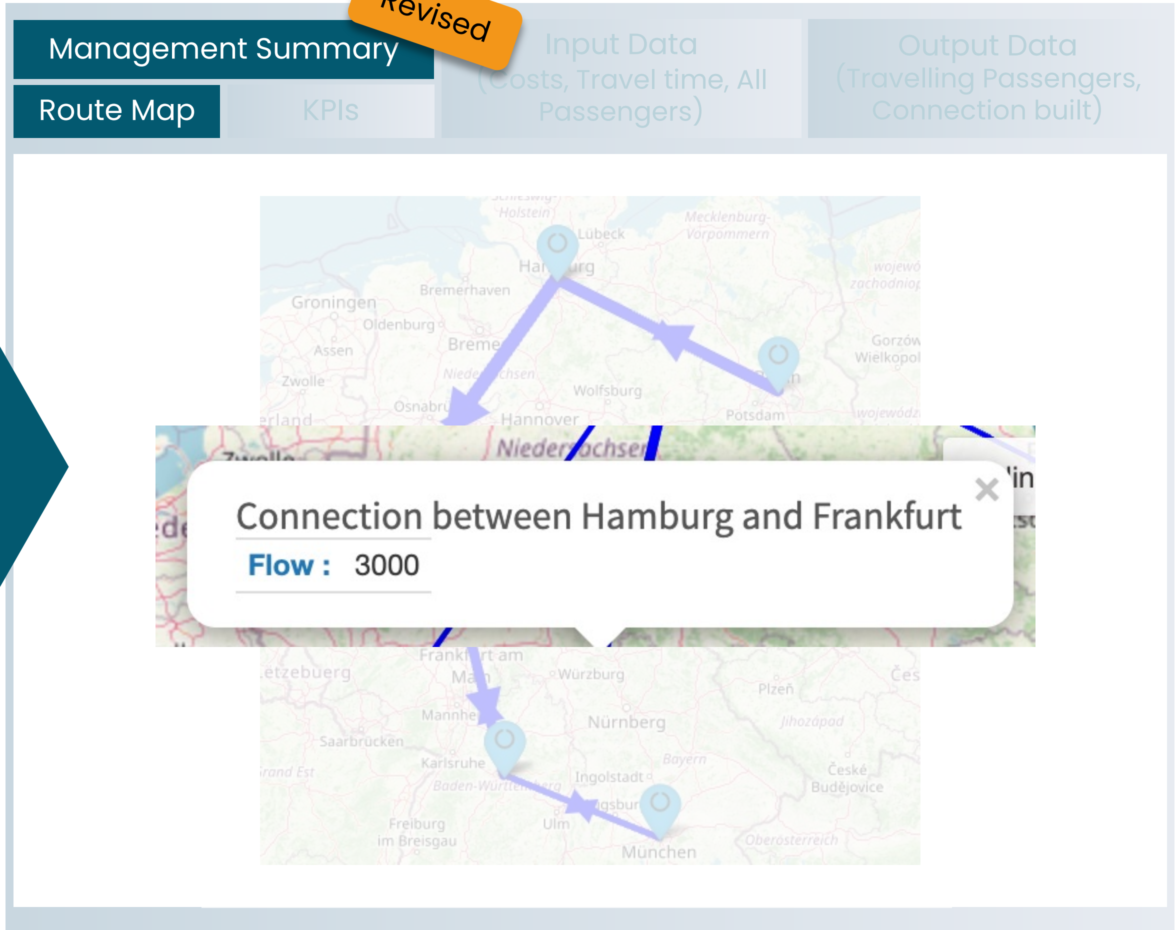
Initial Situation Output

Old

Connections | Number Passengers starting trip in | Objective Value

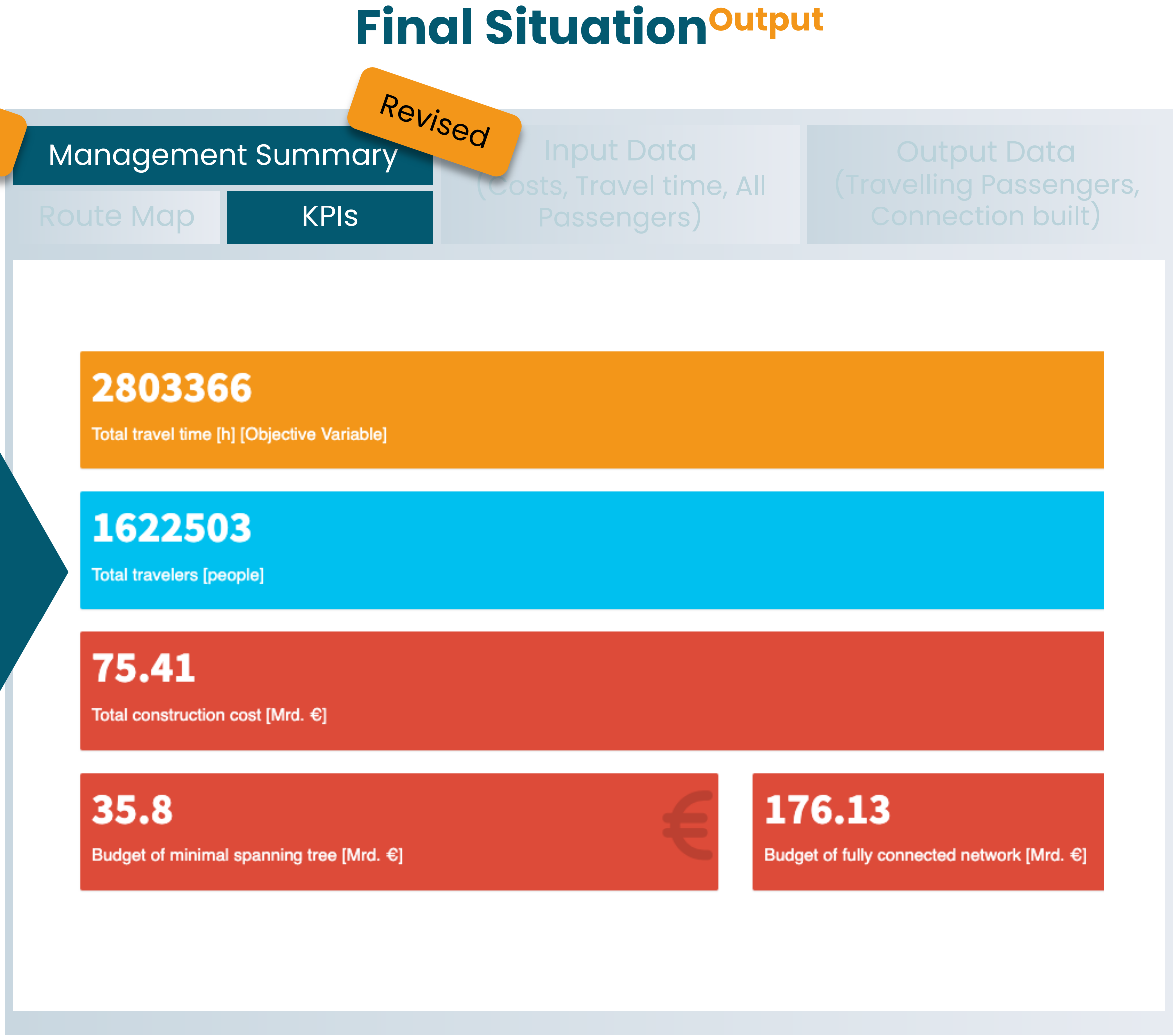
city j	city j	Header	value
city1	city3	level	1.00
		lower	0.00
		marginal	0.00
		scale	1.00
		upper	1.00

Final Situation Output



GAMS | Lehrstuhl für Data and Business Analytics | RWTH AACHEN UNIVERSITY

UNLOCK FULL POTENTIAL FOR THE END USER WITH INTUITIVE INPUT AND OUTPUT VISUALIZATIONS.



UNLOCK FULL POTENTIAL FOR THE END USER WITH INTUITIVE INPUT AND OUTPUT VISUALIZATIONS.

Final Situation Output

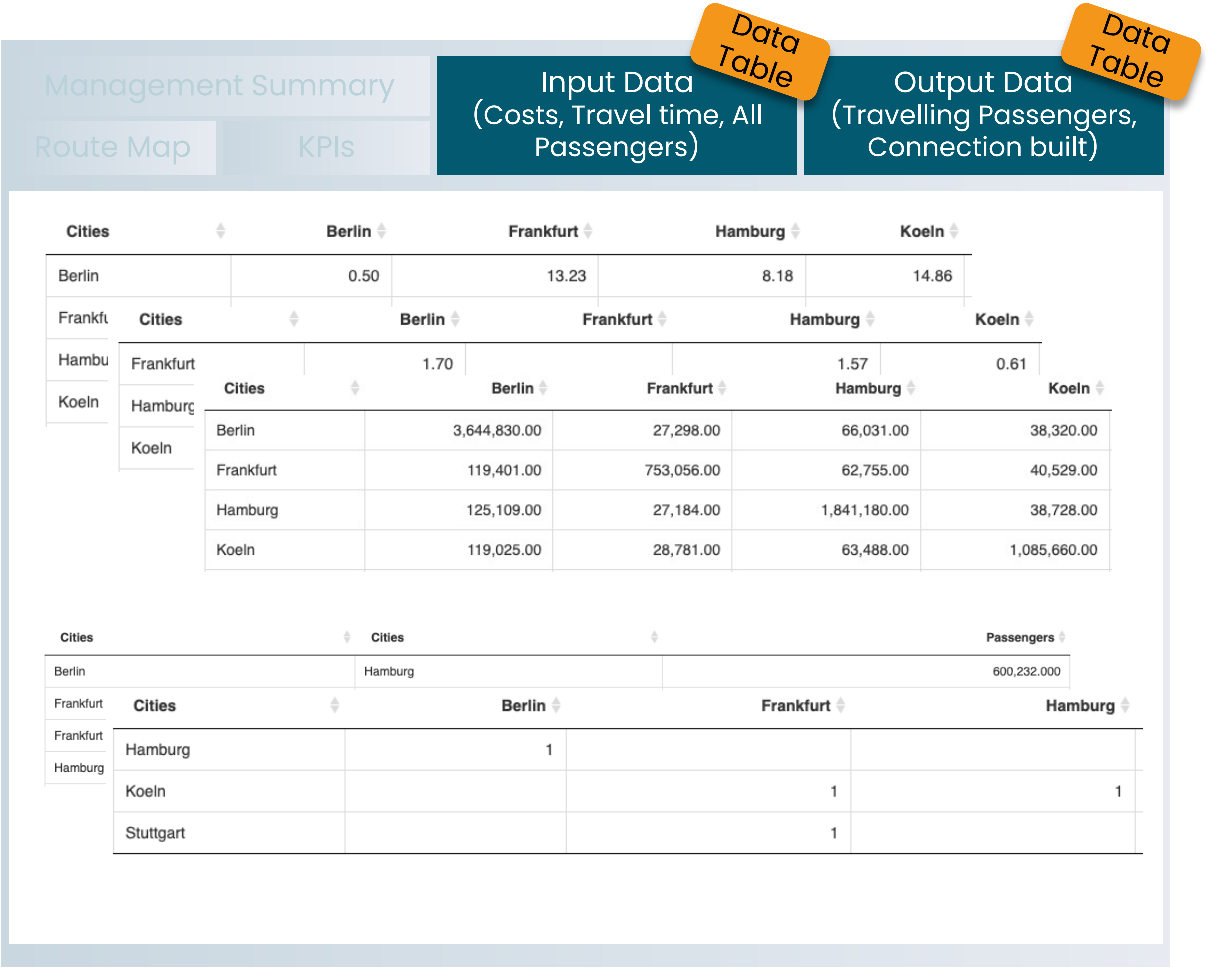
Data Tables

Input Data :

Predetermined parameters including construction costs, travel time, and passenger volume for each connection

Output Data

Provides the user with an option to view detailed data of consolidated data in the management summary if desired



Cities	Berlin	Frankfurt	Hamburg	Koeln
Berlin	0.50	13.23	8.18	14.86

Cities	Berlin	Frankfurt	Hamburg	Koeln
Frankfurt	1.70		1.57	0.61

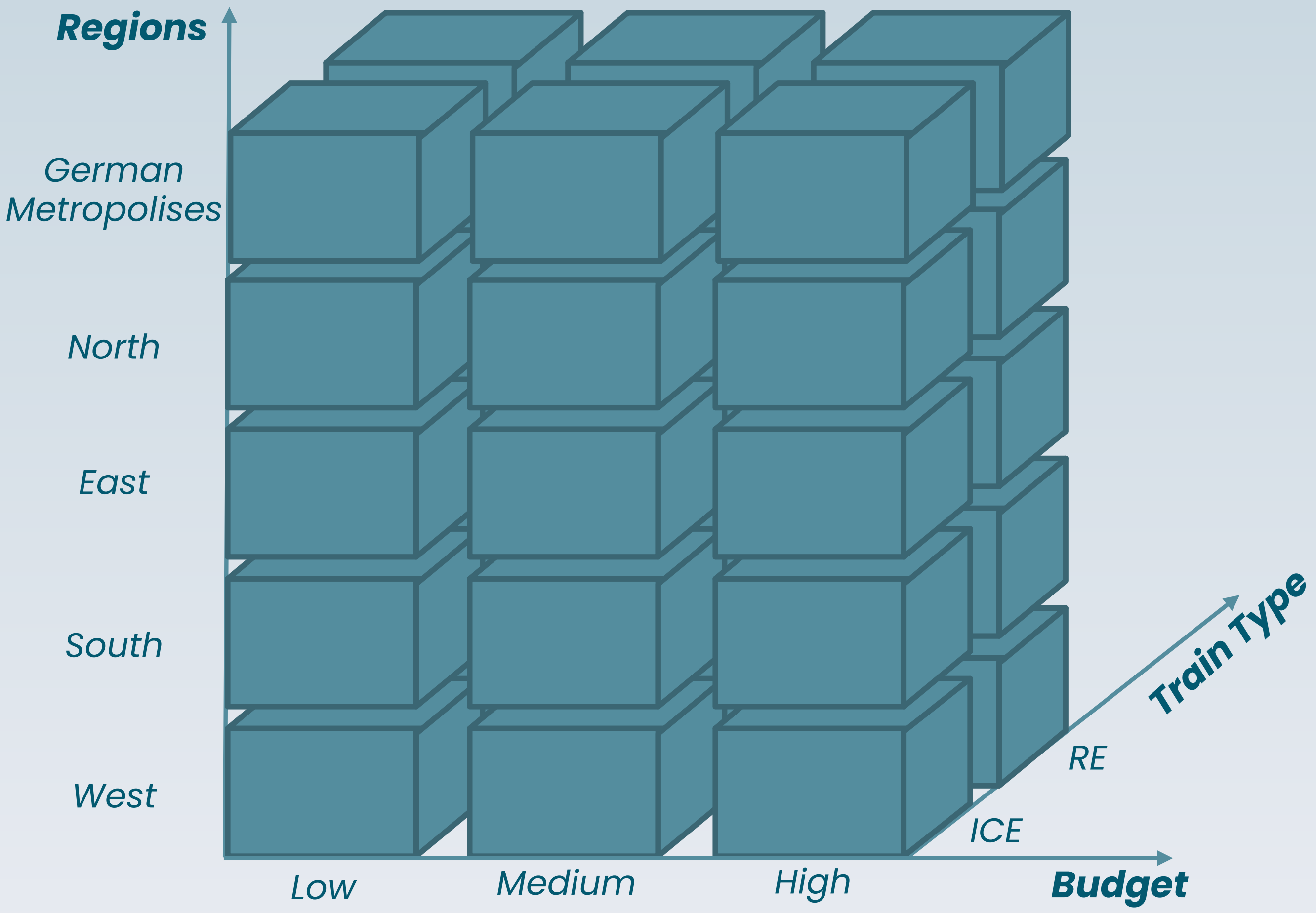
Cities	Berlin	Frankfurt	Hamburg	Koeln
Berlin	3,644,830.00	27,298.00	66,031.00	38,320.00
Frankfurt	119,401.00	753,056.00	62,755.00	40,529.00
Hamburg	125,109.00	27,184.00	1,841,180.00	38,728.00
Koeln	119,025.00	28,781.00	63,488.00	1,085,660.00

Cities	Cities	Passengers
Berlin	Hamburg	600,232.000

Cities	Berlin	Frankfurt	Hamburg
Hamburg	1		
Koeln		1	1
Stuttgart		1	

GAMS
Lehrstuhl für Data and Business Analytics
RWTH AACHEN UNIVERSITY

ENABLE USER-FRIENDLY SCENARIO COMPARISONS WITH REAL-WORLD CONTEXTUALIZATION.



- **30 Predefined Scenarios:** Automatically generated from three key dimensions—Regions, Budget, and Train Type.
- **Comparative Opportunities:** Allows users to easily compare scenarios to streamline decision-making.
- **User-Friendly Analysis:** Simplifies results analysis by providing ready-made scenarios, reducing user workload.

Problems & challenges

„What hurdles did we face during implementation?

ON THE WAY TO THE FINAL INTERFACE, THERE WERE CHALLENGES THAT COULD BE RESOLVED WITH THE APPROPRIATE SUPPORT.

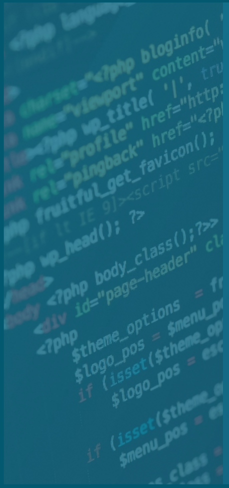
Balance realism and simplicity

Restrictive city selection

Greenfield network planning

Costs and travel times

Making **simplified but realistic assumptions**



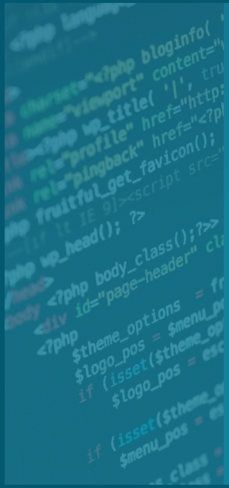
Unexpectedly high coding proportion

City expansion

Creating interactivity

Code architecture for large datasets

Learning GAMS MIRO **and GAMS code**



Implementation difficulties in coding

Calculation Minimum Spanning Tree

Integration Gravity Model

Quick and effective support from Lorena

Bugs due to MIRO development stage

Map display

Live display in configuration mode

Management summary

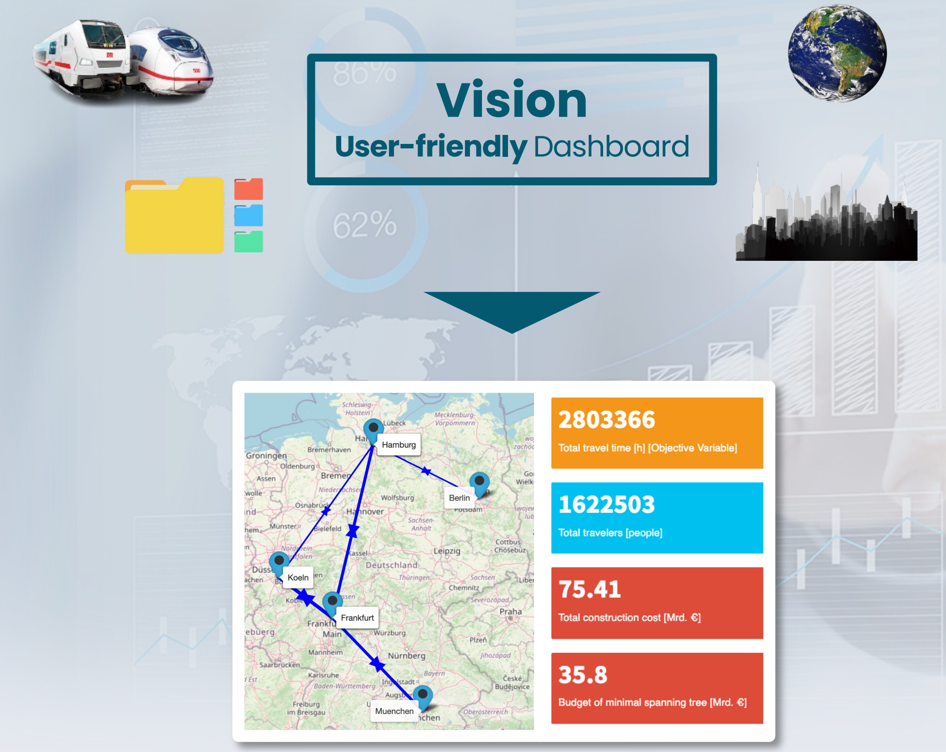
Quick and efficient support from the GAMS and GAMS MIRO team

Conclusion and outlook

“What lessons have we learned and where is there still a need for future optimization?”

PROJECT ACHIEVEMENTS AND FUTURE POTENTIALS FOR IMPROVEMENTS OF THE DEVELOPED GAMS INTERFACE.

“Develop an user-friendly interface for a given mathematical optimization model.”



… but there still are potentials for further development

- Possibility to **combine ICE** and **RE** tracks.
- Increased **realism** by considering **building restrictions**
- Enhance efficiency and accessibility through the **integration** of **various modes** of **transport** such as **rail**, **road**, and **boat**
- Model application on **established Networks** to optimize and enhance the performance of **existing transportation** networks.

Thank you for your Attention are there any questions?

Feel free to contact us anytime for a live demo in GAMS MIRO or the GitHub file.

David Sanders
Industrial Engineer B. Sc.

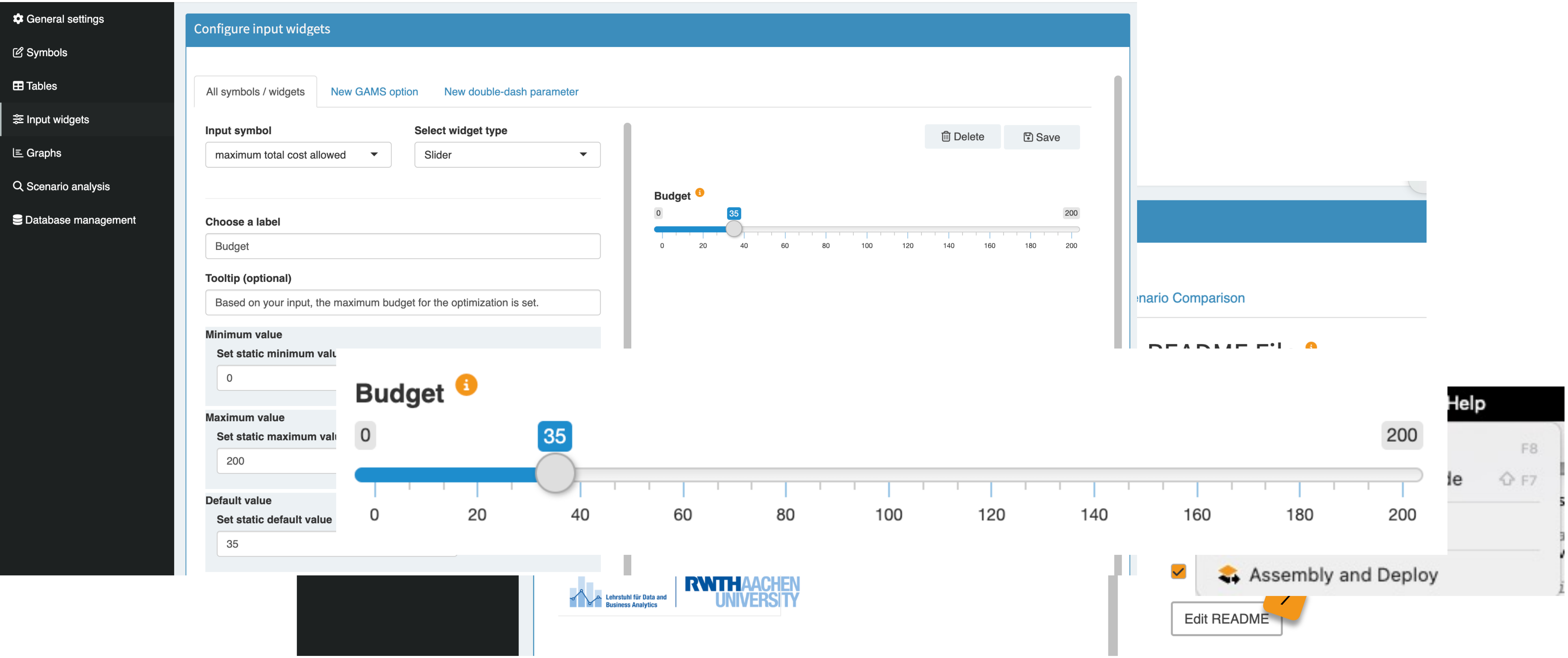
+49 (0) 157 83297845
david.sanders@rwth-aachen.de

Noah Schuster
Industrial Engineer B. Sc.

+49 (0) 160 2531844
noah.schuster@rwth-aachen.de

Dr. Lorena Silvana Reyes Rubiano
Associate Postdoctoral Researcher

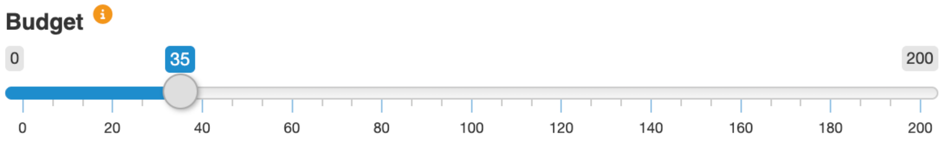
reyes@analytics.rwth-aachen.de


General settings
Symbols
Tables
Input widgets
Graphs
Scenario analysis
Database management
Configure input widgets
All symbols / widgets
New GAMS option
New double-dash parameter
Input symbol
maximum total cost allowed
Select widget type
Slider
Delete
Save
Choose a label
Budget
Tooltip (optional)
Based on your input, the maximum budget for the optimization is set.
Minimum value
Set static minimum valu
0
Maximum value
Set static maximum valu
200
Default value
Set static default value
35
Budget
0
35
200
0 20 40 60 80 100 120 140 160 180 200
nario Comparison
Help
F8
F7
Assembly and Deploy
Edit README

££

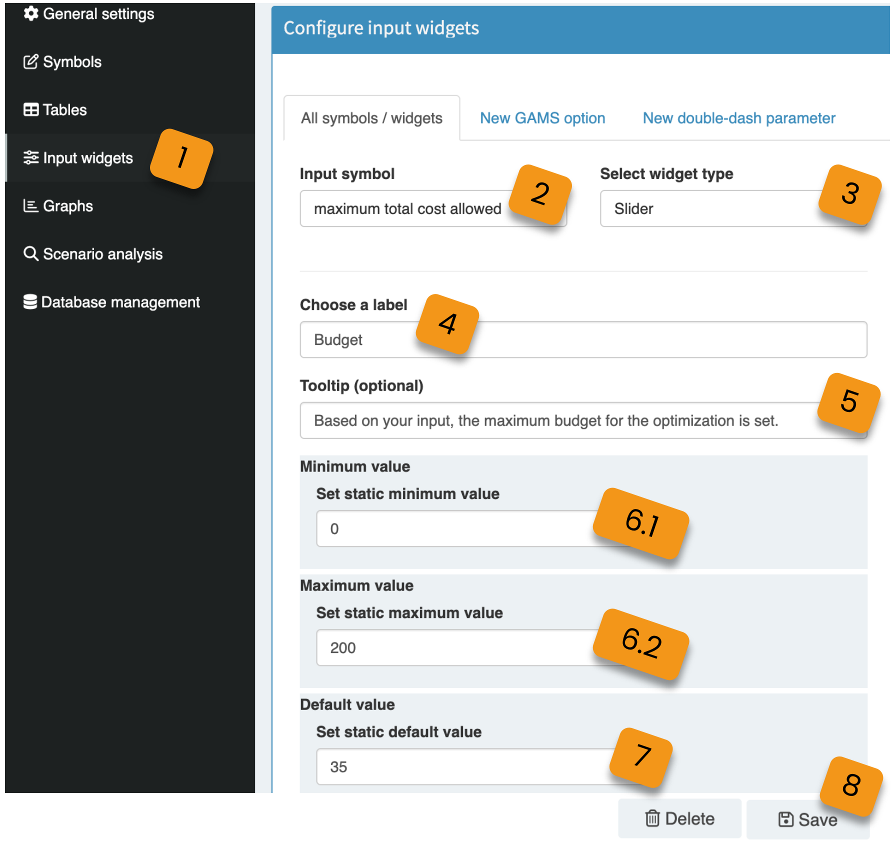
5

6



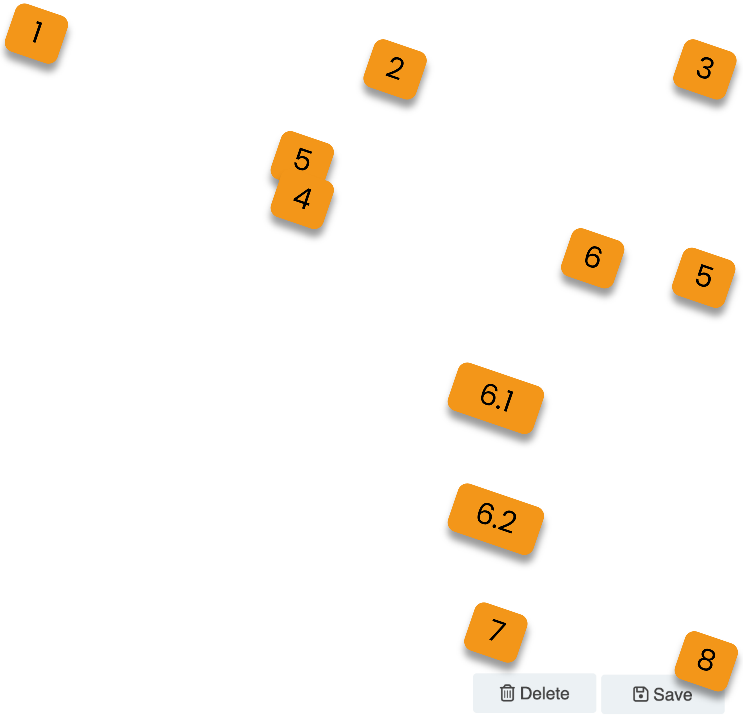
7

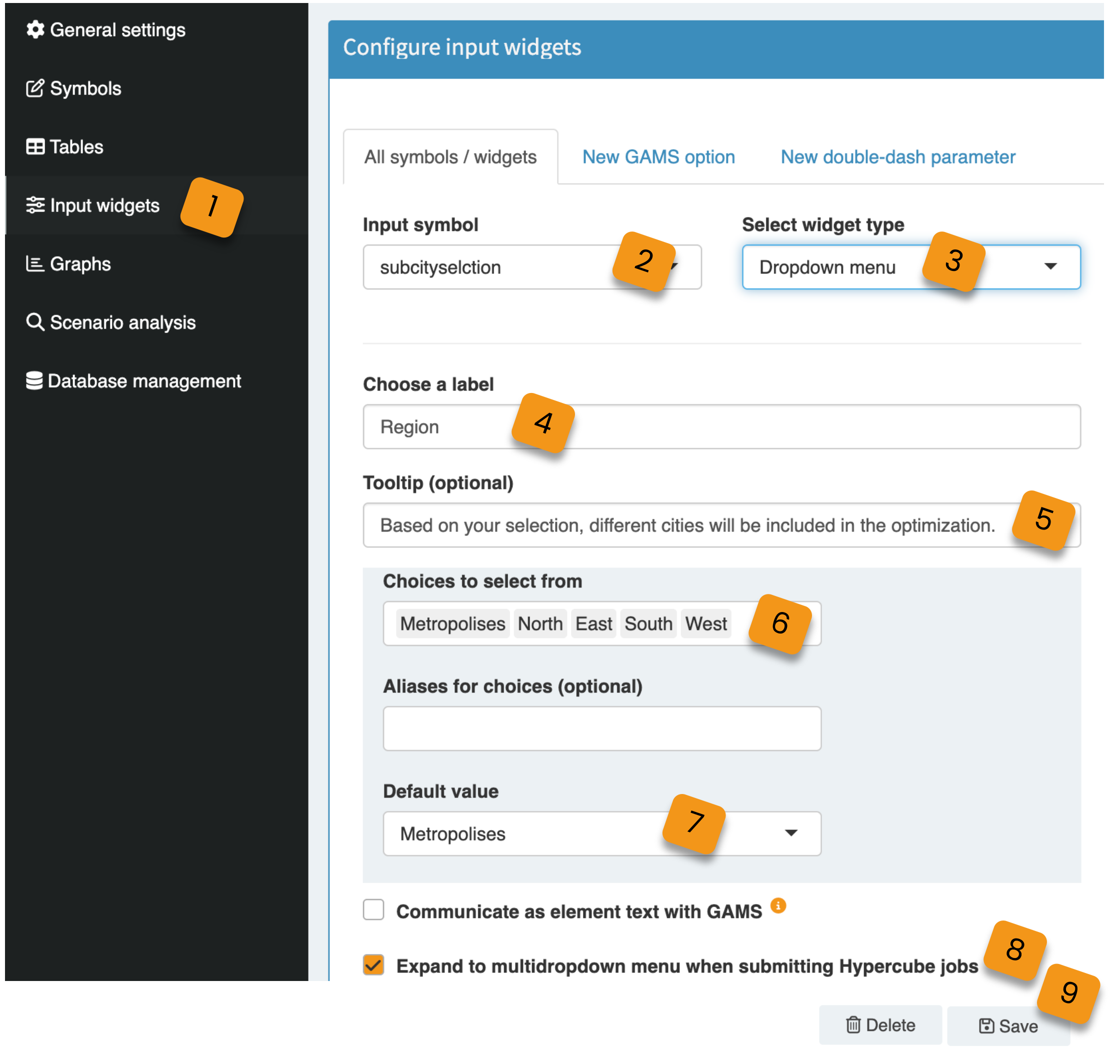
££

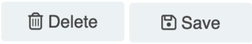


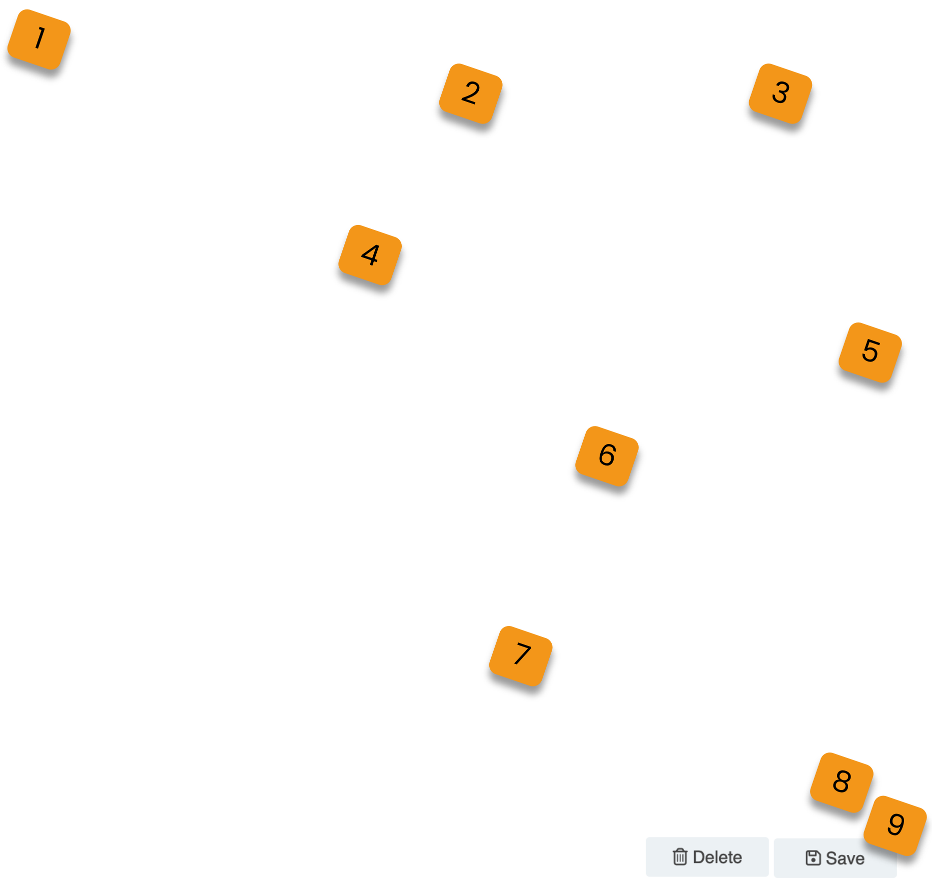
General settings
Symbols
Tables
Input widgets
1
Graphs
Scenario analysis
Database management
Configure input widgets
All symbols / widgets
New GAMS option
New double-dash parameter
Input symbol
maximum total cost allowed
2
Select widget type
Slider
3
Choose a label
4
Budget
Tooltip (optional)
5
Based on your input, the maximum budget for the optimization is set.
Minimum value
Set static minimum value
0
6.1
Maximum value
Set static maximum value
200
6.2
Default value
Set static default value
35
7
8
Delete
Save

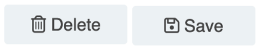
££

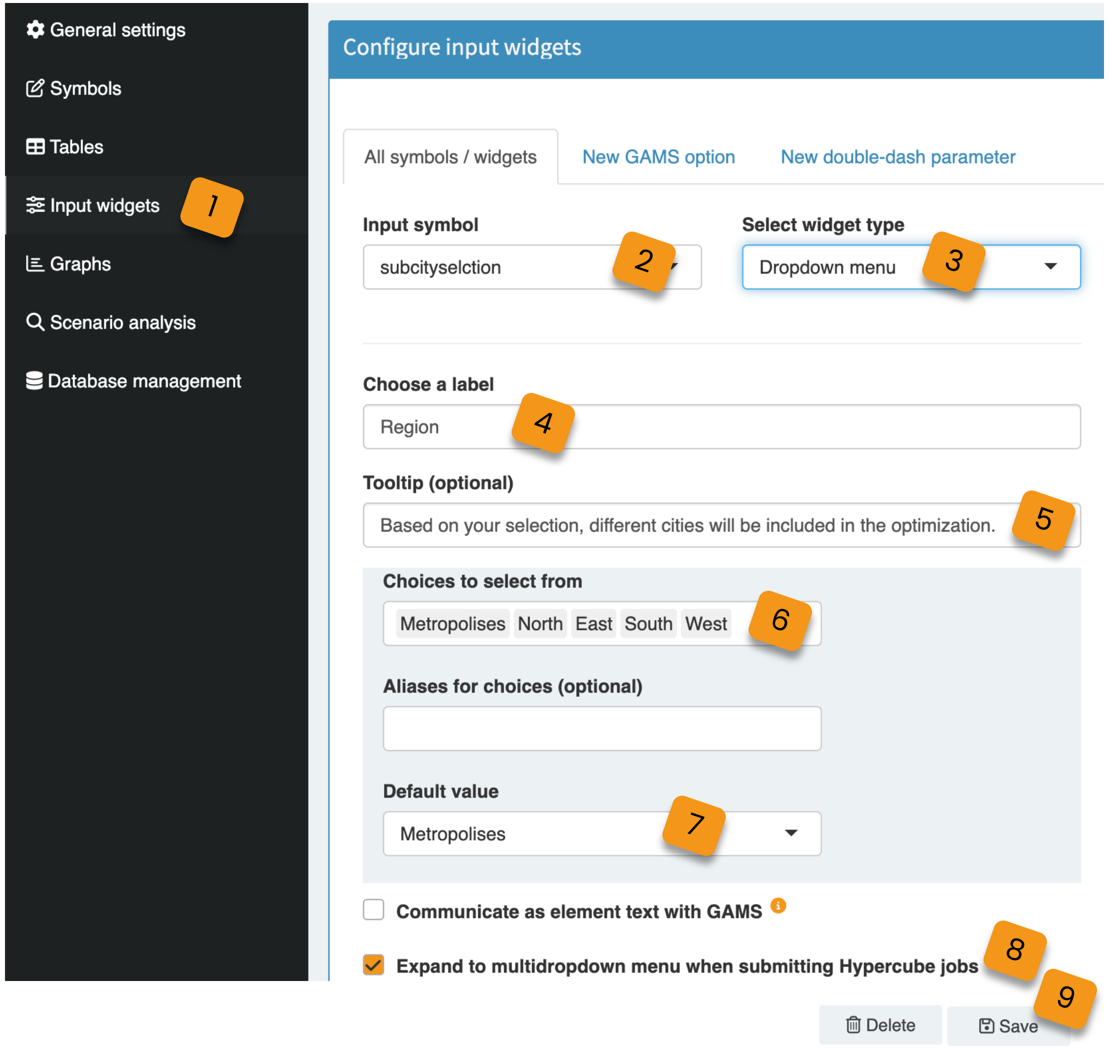

1
2
3
5
4
6
5
6.1
6.2
7
8
Delete
Save


General settings
Symbols
Tables
Input widgets
Graphs
Scenario analysis
Database management
Configure input widgets
All symbols / widgets
New GAMS option
New double-dash parameter
Input symbol
subcityselction
Select widget type
Dropdown menu
Choose a label
Region
Tooltip (optional)
Based on your selection, different cities will be included in the optimization.
Choices to select from
Metropolises North East South West
Aliases for choices (optional)
Default value
Metropolises
Communicate as element text with GAMS
Expand to multidropdown menu when submitting Hypercube jobs
Delete
Save
1
2
3
4
5
6
7
8
9

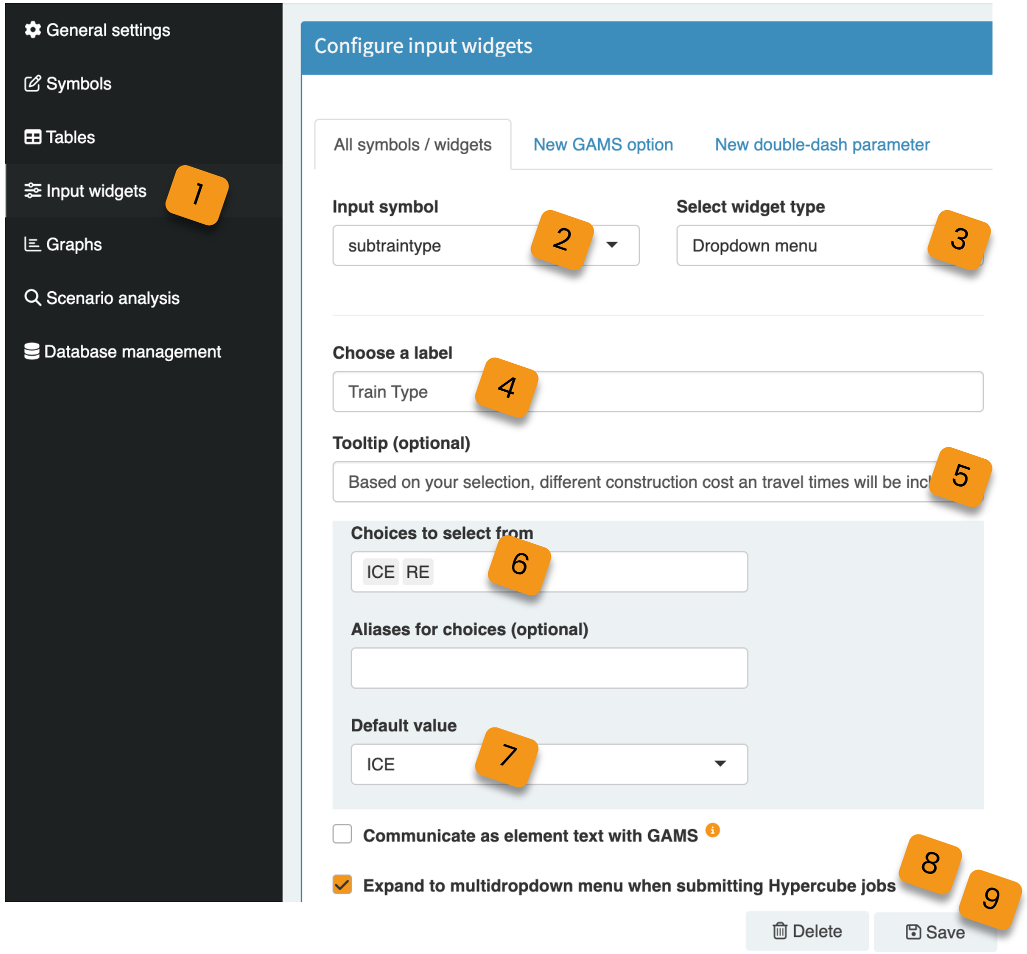

Delete
Save


1
2
3
4
5
6
7
8
9
Delete
Save


Delete
Save


General settings
Symbols
Tables
Input widgets
Graphs
Scenario analysis
Database management
Configure input widgets
All symbols / widgets
New GAMS option
New double-dash parameter
Input symbol
subcityselction
Select widget type
Dropdown menu
Choose a label
Region
Tooltip (optional)
Based on your selection, different cities will be included in the optimization.
Choices to select from
Metropolises North East South West
Aliases for choices (optional)
Default value
Metropolises
Communicate as element text with GAMS
Expand to multidropdown menu when submitting Hypercube jobs
Delete
Save
1
2
3
4
5
6
7
8
9


Delete
Save


General settings
Symbols
Tables
Input widgets
Graphs
Scenario analysis
Database management
Configure input widgets
All symbols / widgets
New GAMS option
New double-dash parameter
Input symbol
subtraintype
Select widget type
Dropdown menu
Choose a label
Train Type
Tooltip (optional)
Based on your selection, different construction cost an travel times will be incl
Choices to select from
ICE RE
Aliases for choices (optional)
Default value
ICE
Communicate as element text with GAMS
Expand to multidropdown menu when submitting Hypercube jobs
Delete
Save
1
2
3
4
5
6
7
8
9

Delete
Save