COOCK
PoA Simulation and Optimization

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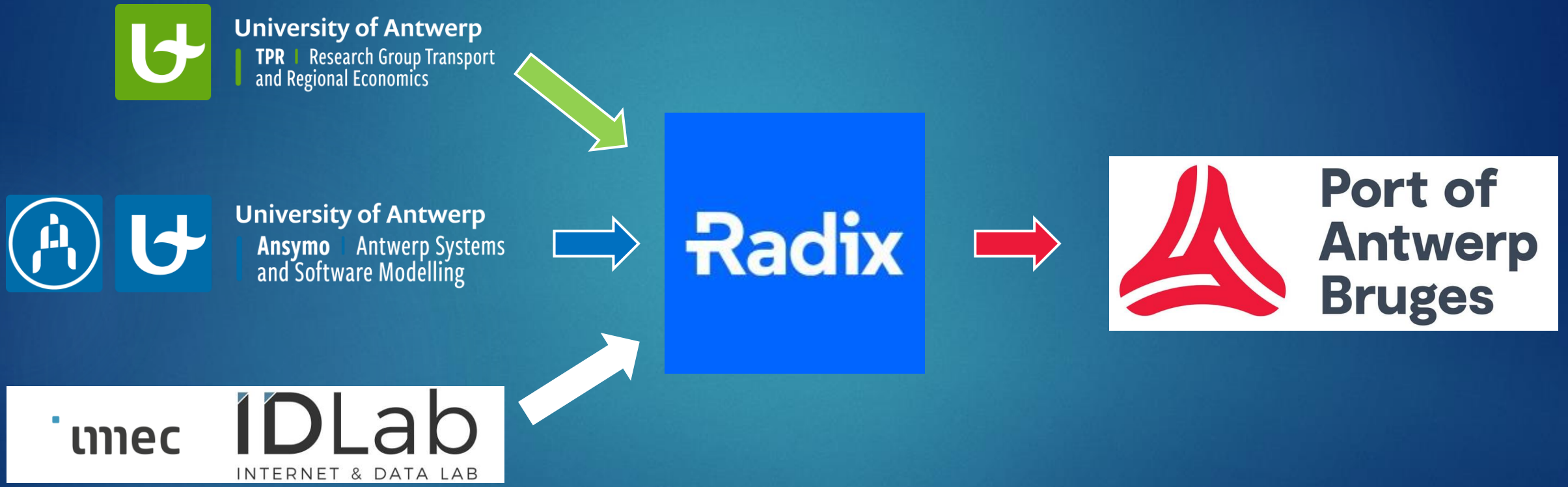
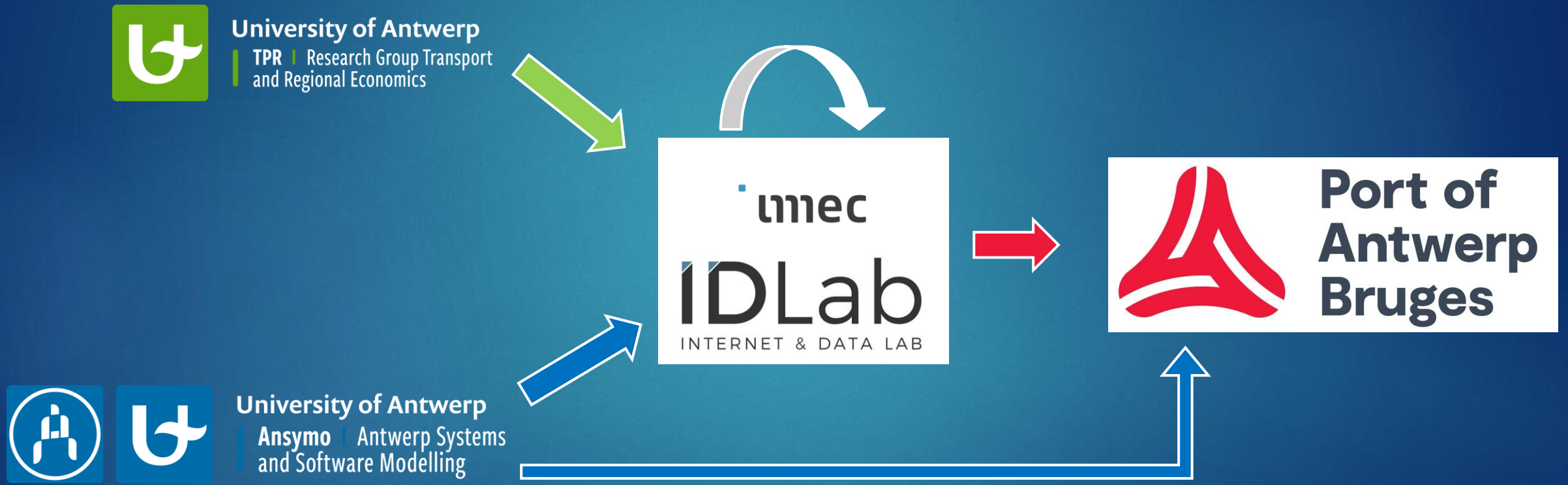
Original Project Setup

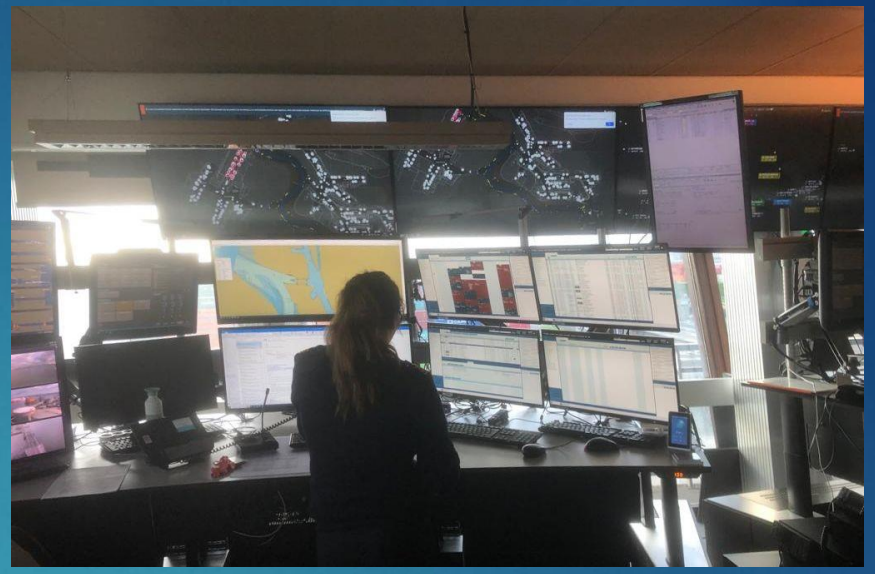


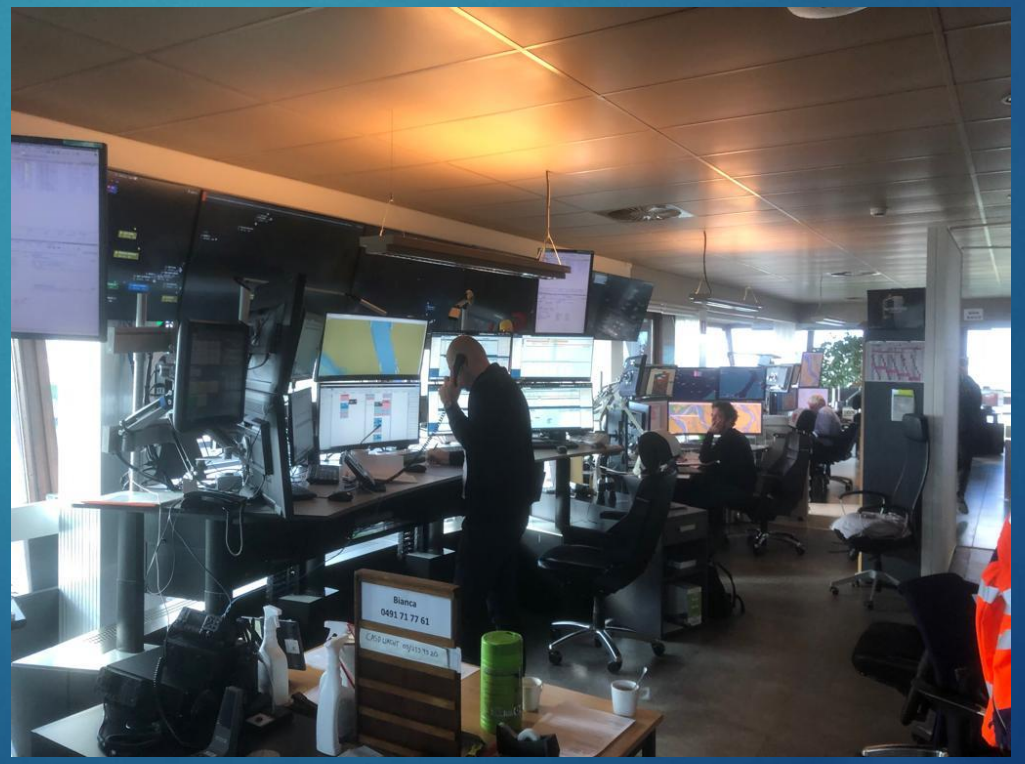
Current Project Setup

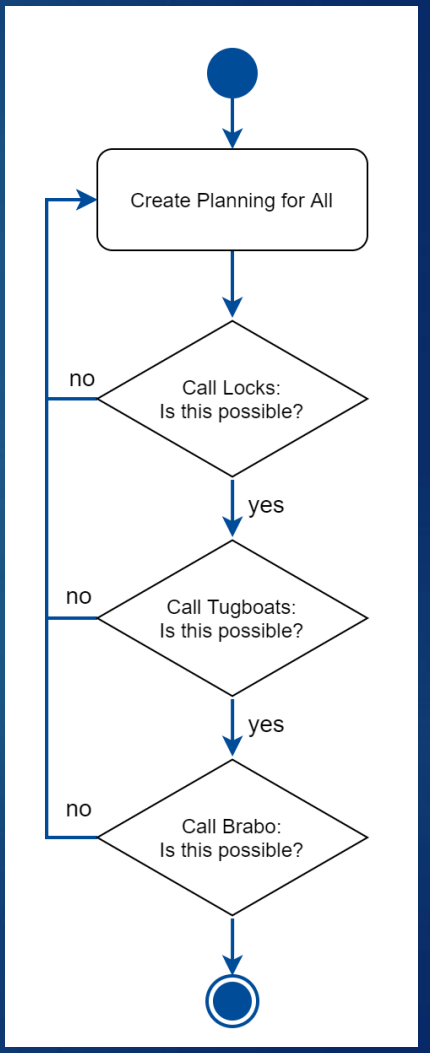


Original Idea

- Optimization and Automation of
  - Pilot Planning
  - Tugboat Planning
  - Boatmen Planning
  - Lock Planning
  - Ship Entry Planning
  - Berthing Planning





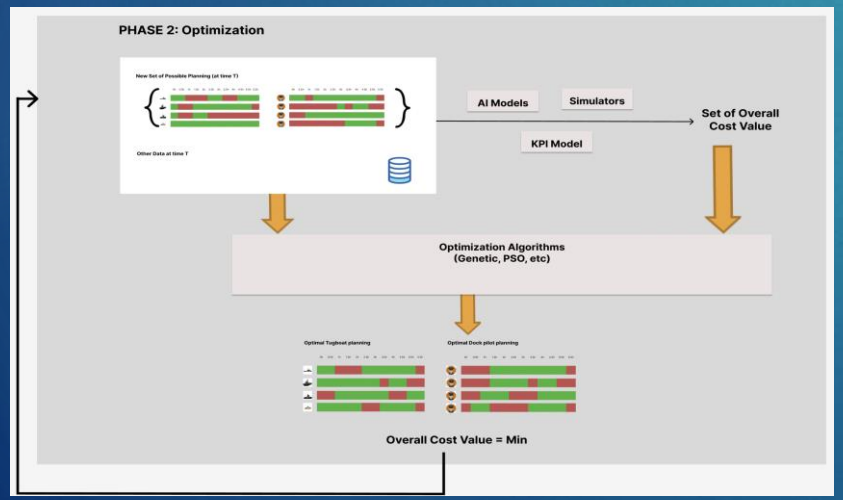


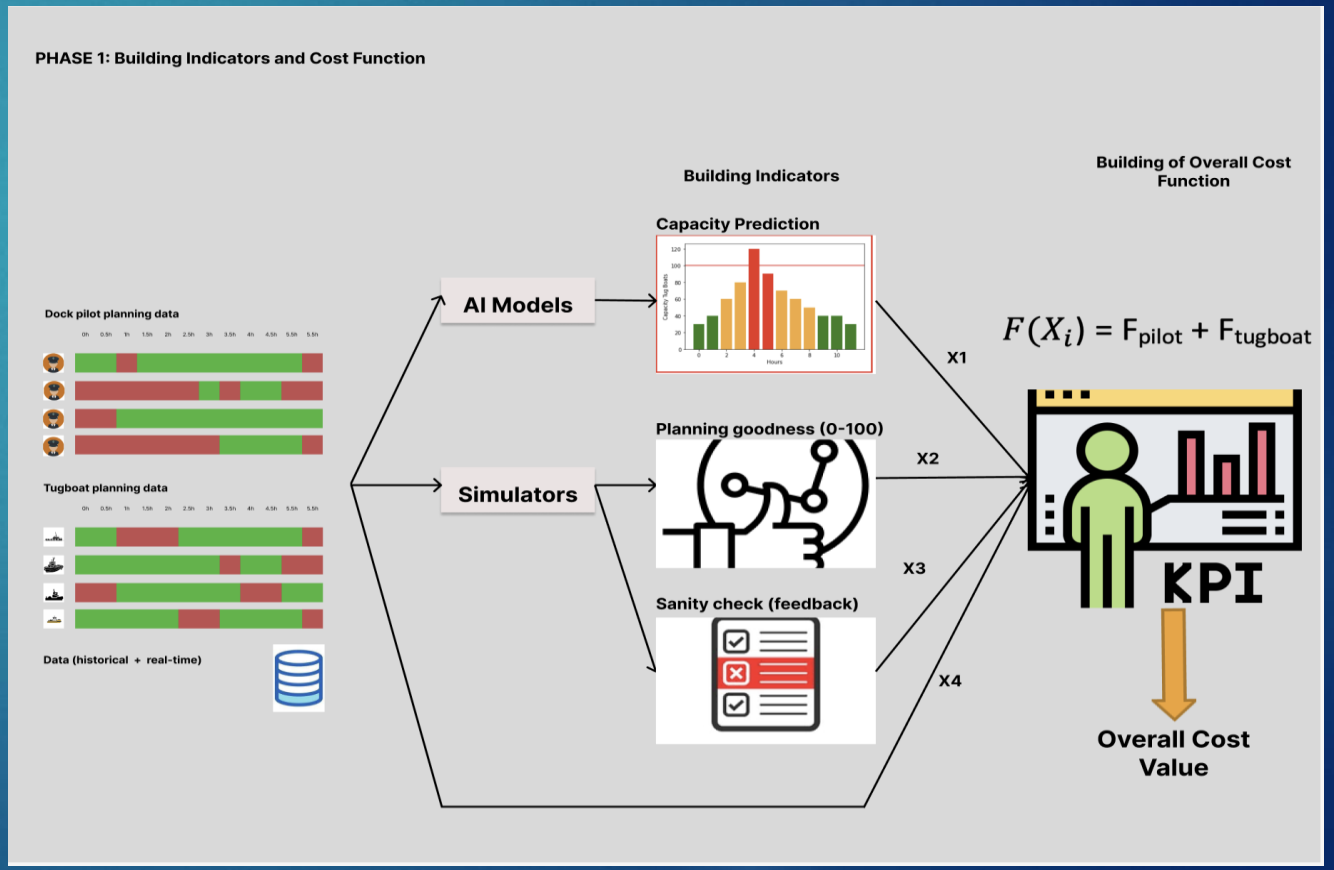
Current Project

imec IDLab INTERNET & DATA LAB

"We can and will only do Capacity Predictions."

- Optimization and Verification of
  - Tugboat Planning
  - (Pilot Planning)
- Academic Project





Datasets

	A	B	C	D	E	F	G	H	I	J	K	
1	Verblijf	Reis	Zeevaart	Aanvang tijd	Aantal besteld	Aantal taken	Afstand	Besteltijd	BT	Dood s	Einde tijd	Geannu
2	V242635	210232615	Ja	2022-01-01 23:30:00.000	1	1	4.06	2022-01-01 20:04:11.0	65148	Nee	2022-01-02 00:30:00.000	NULL
3	V242635	210232615	Ja	2022-01-01 22:54:00.000	1	1	1.55	2022-01-01 22:21:33.0	65148	Nee	2022-01-01 22:57:00.000	NULL
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5	V242635	210232616	Ja	2022-01-06 01:50:00.000	1							
6	V242711	210233671	Ja	2022-01-21 13:00:00.000	1							
7	V242711	210233672	Ja	2022-01-25 17:15:00.000	4							
8	V242711	210233672	Ja	2022-01-25 16:45:00.000	4							
9	V242711	210233672	Ja	2022-01-25 17:15:00.000	4							
10	V242711	210233672	Ja	2022-01-25 16:45:00.000	4							
11	V243304	210246437	Ja	2022-01-16 08:20:00.000	2							
12	V243304	210246437	Ja	2022-01-16 08:30:00.000	2							
13	V243304	210246437	Ja	2022-01-16 06:56:00.000	2							
14	V243304	210246438	Ja	2022-01-16 23:45:00.000	2							
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16	V243304	210246438	Ja	2022-01-16 21:40:00.000	2							
17	V243304	210246438	Ja	2022-01-16 22:45:00.000	2							
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19	V243560	210251518	Ja	2022-01-02 00:30:00.000	1							
20	V243651	210252527	Ja	2022-01-09 01:15:00.000	2							
21	V243651	210252527	Ja	2022-01-09 01:15:00.000	2							
22	V243651	210252528	Ja	2022-01-12 15:00:00.000	1							
23	V243651	210252528	Ja	2022-01-12 13:46:00.000	1							
24	V243750	210254607	Ja	2022-01-11 20:00:00.000	1							
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28	V243807	210256469	Ja	2022-01-01 16:00:00.000	2							
29	V243807	210256469	Ja	2022-01-01 16:00:00.000	2							
30	V243807	210256469	Ja	2022-01-01 14:51:00.000	2							

APICS data – Tugboat Tasks

File: C:\Users\randy\PycharmProjects\PoAB\part-00000-tid-257698335488947142-c2a078b1-adfb-43b6-98b6-947dfaff5eda-5415-1.c000.parquet

File Edit Tools Help

Filter Query (?): WHERE Execute Clear Record Offset: 0 Record Count: 1000

	mmsi	imo	eni	ts	lat	lon	speed	course	heading	rotation	draught	length	width	source_vesselDat	ingestYear
▸	205247890	NULL	NULL	1643196218324	51.18801	4.68166	2.3	287	NULL	NULL	NULL	NULL	NULL	AIS	2022
	205247890	NULL	NULL	1643196632324	51.19064	4.66792	2.4	290	NULL	NULL	NULL	NULL	NULL	AIS	2022
	205247890	NULL	NULL	1643196890324	51.19259	4.65947	2.4	291.5	NULL	NULL	NULL	NULL	NULL	AIS	2022
	205247890	NULL	NULL	1643197106324	51.19469	4.65143	2.3	291.9	NULL	NULL	3	196	12	AIS	2022
	205247890	NULL	6003729	1643197928324	51.19947	4.62389	2.7	293.7	NULL	NULL	3	196	12	AIS	2022
	205247890	NULL	6003729	1643198066324	51.20093	4.61928	2.6	296.8	NULL	NULL	3	196	12	AIS	2022
	205247890	NULL	6003729	1643198231324	51.20265	4.61374	2.6	296.1	NULL	NULL	3	196	12	AIS	2022
	205247890	NULL	6003729	1643198660324	51.20706	4.59994	2.4	297.8	NULL	NULL	3	196	12	AIS	2022
	205247890	NULL	6003729	1643198813324	51.20859	4.59489	2.6	294.9	NULL	NULL	3	196	12	AIS	2022
	205247890	NULL	6003729	1643198900324	51.20948	4.59206	2.5	296.2	NULL	NULL	3	196	12	AIS	2022
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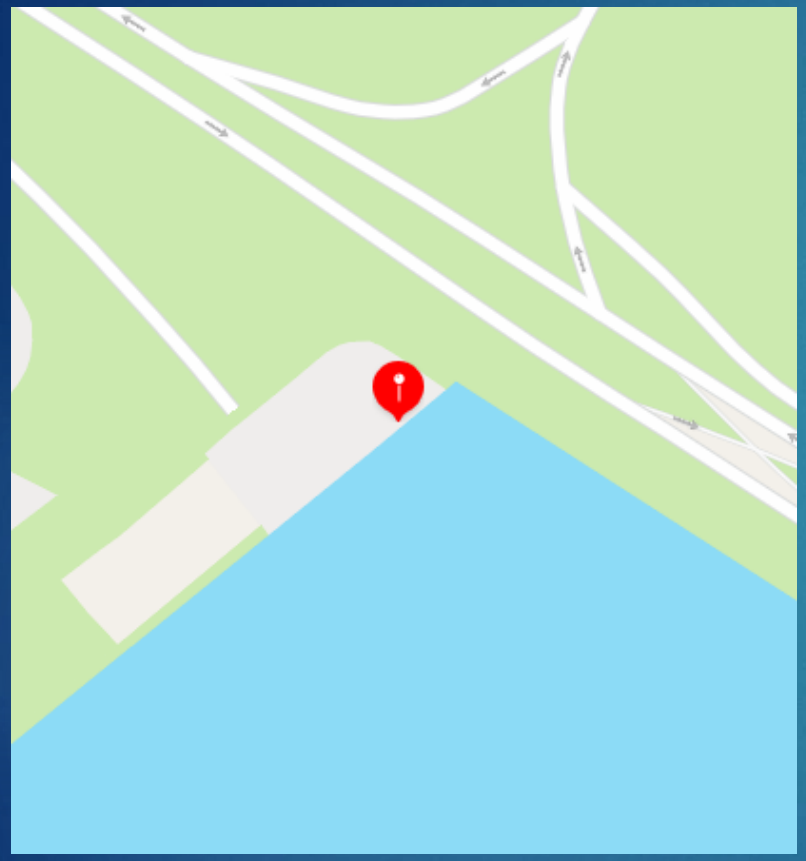
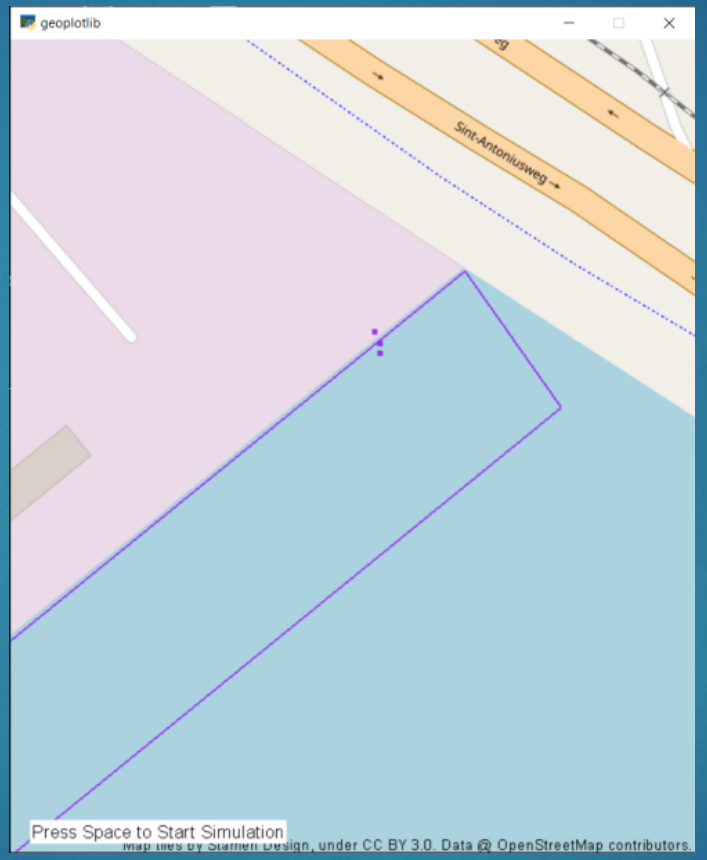
Showing: 1000 Results Loaded: 0 to 1000 Out of: 56524480

IVEF data – Vessel Positions

Data Issues (IVEF)

10 - Achievement Get
Amphibious Ships



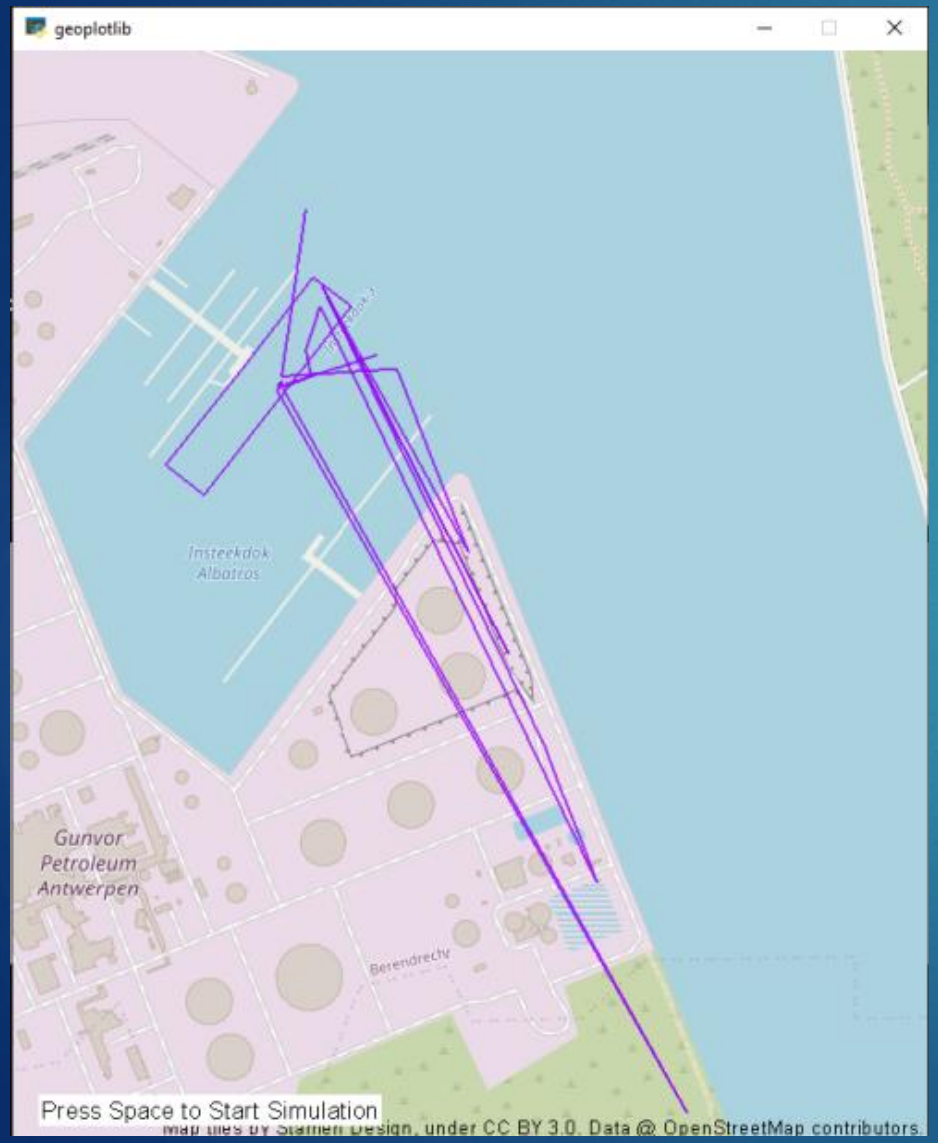


205254890	1641537382324	4.24245	51.27711	0.1
205254890	1641571408324	4.24242	51.27713	0.1
205254890	1641606322324	4.24243	51.2771	0.0

Vessel on land – Likely sensor issue

Data Issues (IVEF)

100 - Achievement Get
Everything Everywhere All at Once



	C1	C2 ▲ 1	C3	C4	C5
1302	205627000	1641074191324	4.29472	51.33883	4.6
1303	205627000	1641074251324	4.29646	51.33891	1.7
1304	205627000	1641074311324	4.297	51.33805	1.7
1305	205627000	1641074371324	4.29754	51.33719	1.7
1306	205627000	1641074407324	4.29533	51.33968	0.0
1307	205627000	1641074437324	4.29813	51.33624	1.7
1308	205627000	1641074467325	4.29533	51.33968	0.0
1309	205627000	1641074497324	4.29867	51.33538	1.7
1310	205627000	1641074527324	4.29893	51.33495	1.7
1311	205627000	1641074557324	4.2992	51.33452	1.7
1312	205627000	1641074587325	4.29947	51.33409	1.7
1313	205627000	1641074617324	4.2953	51.33949	0.0
1314	205627000	1641074647324	4.29509	51.33908	0.2
1315	205627000	1641074677324	4.29518	51.33883	0.5
1316	205627000	1641074707324	4.29475	51.33873	0.9
1317	205627000	1641074737324	4.30082	51.33193	1.7
1318	205627000	1641074779324	4.29465	51.3387	0.0
1319	205627000	1641074839324	4.29473	51.33879	0.1
1320	205627000	1641074899325	4.2947	51.33877	0.0
1321	205627000	1641074959324	4.29469	51.33877	0.0
1322	205627000	1641075019324	4.29468	51.33877	0.0
1323	205627000	1641075079324	4.29468	51.33876	0.0
1324	205627000	1641075139326	4.29467	51.33876	0.0
1325	205627000	1641075199324	4.29467	51.33876	0.0
1326	205627000	1641075259324	4.29475	51.33879	0.0
1327	205627000	1641075319324	4.29474	51.33879	0.0
1328	205627000	1641075379324	4.29474	51.33879	0.0
1329	205627000	1641075439324	4.29467	51.33873	0.0
1330	205627000	1641075499324	4.29467	51.33872	0.0
1331	205627000	1641075559324	4.29467	51.33871	0.0
1332	205627000	1641075619324	4.2947	51.33874	0.0
1333	205627000	1641075679324	4.2947	51.33874	0.0
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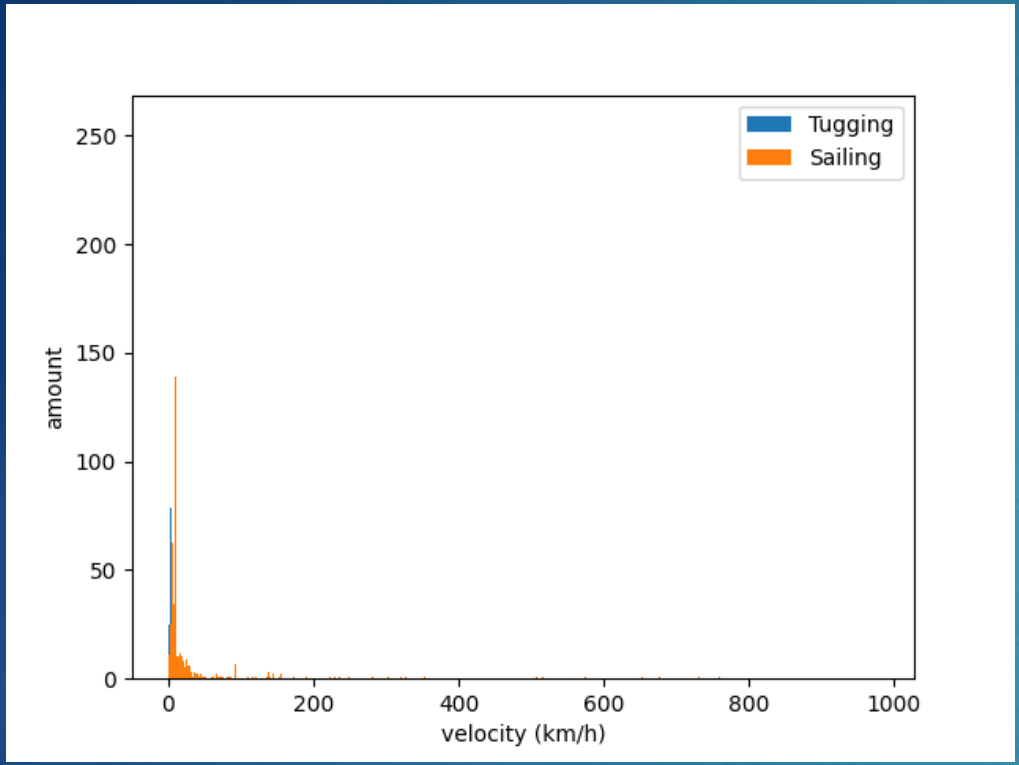
1336	205627000	1641075859324	4.29469	51.33874	0.0
1337	205627000	1641075919324	4.29469	51.33874	0.0

30 minutes

Tugboat is everywhere - Likely a broken sensor

Data Issues (APICS)



100 - Achievement Get
Faster than the speed of sound.

11.77 km in 2 minutes = 353.1 km/h

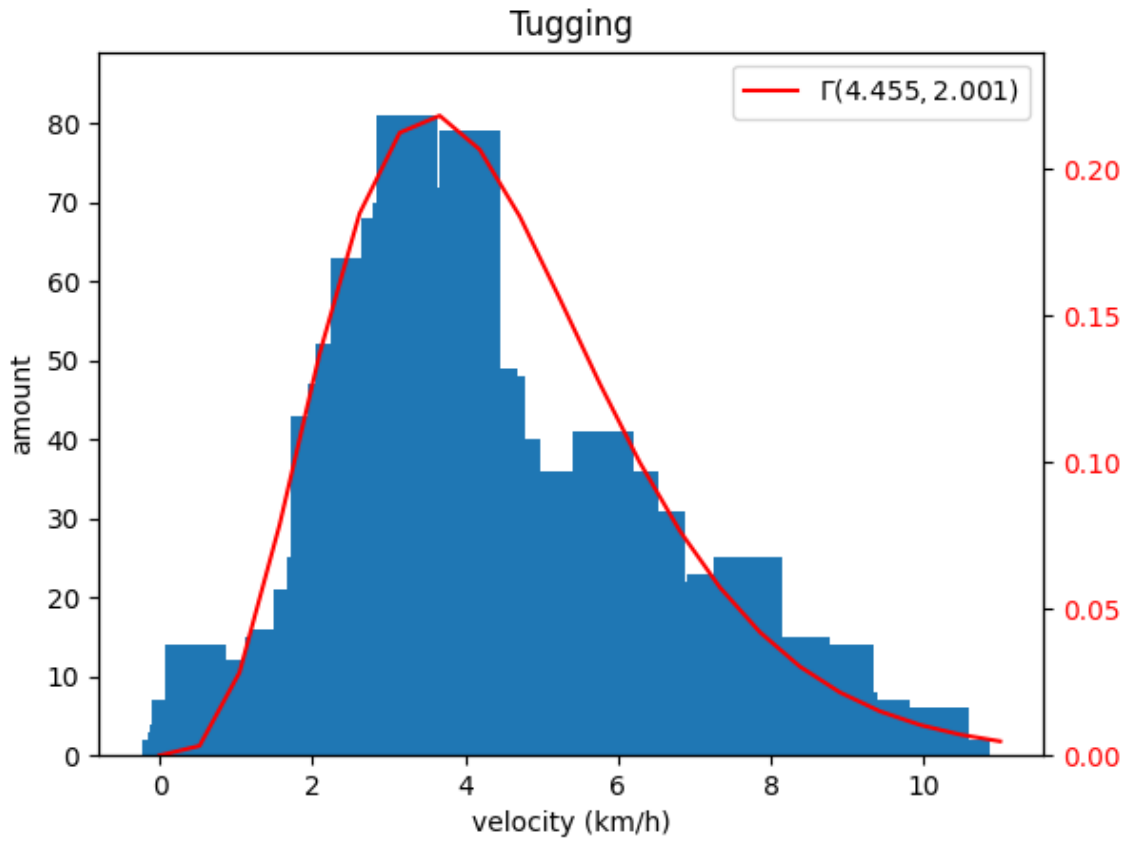
			Aanvang tijd (starting time)			Afstand (distance)					Einde tijd (ending time)					
V245442	210290708	Ja	2022-01-02 01:02:00.000	2	1	4.06	2022-01-01 23:20:25.0(	70853	Nee		2022-01-02 01:02:00.000	NUL	2022-01-0	Agent	Nee	Nee
V245717	210309133	Ja	2022-01-02 01:02:00.000	1	1	0.69	2022-01-02 00:48:12.0(	24634	Nee		2022-01-02 01:02:00.000	NUL	2022-01-0	Agent	Nee	Nee
V245442	210290708	Ja	2022-01-02 01:20:00.000	2	1	3.05	2022-01-01 23:20:32.0(	70853	Nee		2022-01-02 01:20:00.000	NUL	2022-01-0	Agent	Nee	Nee
V245955	210300771	Ja	2022-01-02 02:45:00.000	2	1	11.77	2022-01-02 00:43:53.0(	66399	Nee		2022-01-02 02:47:00.000	NUL	2022-01-0	Agent	Nee	Nee
V244396	210268865	Ja	2022-01-02 02:49:00.000	1	1	1.53	2022-01-02 00:38:21.0(	32825	Nee		2022-01-02 03:30:00.000	NUL	2022-01-0	Agent	Nee	Nee
V246344	210308175	Ja	2022-01-02 02:49:00.000	2	1	3.23	2022-01-02 00:38:44.0(	17858	Nee		2022-01-02 02:50:00.000	NUL	2022-01-0	Agent	Nee	Nee
V245972	210301361	Ja	2022-01-02 03:15:00.000	2	1	7.39	2022-01-02 00:54:27.0(	24167	Nee		2022-01-02 03:15:00.000	NUL	2022-01-0	Agent	Nee	Nee

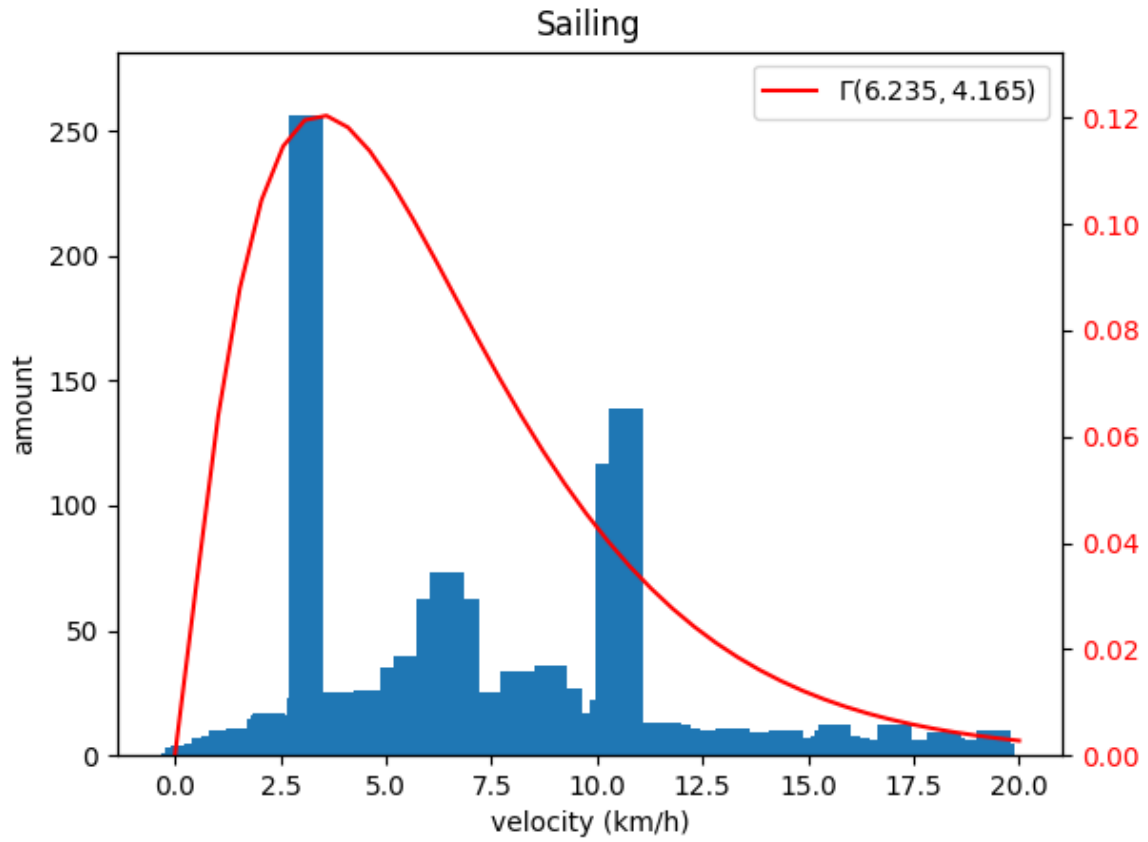
Data Issues (APICS)

100 - Achievement Get
Unusable Data

Task = "slepen"

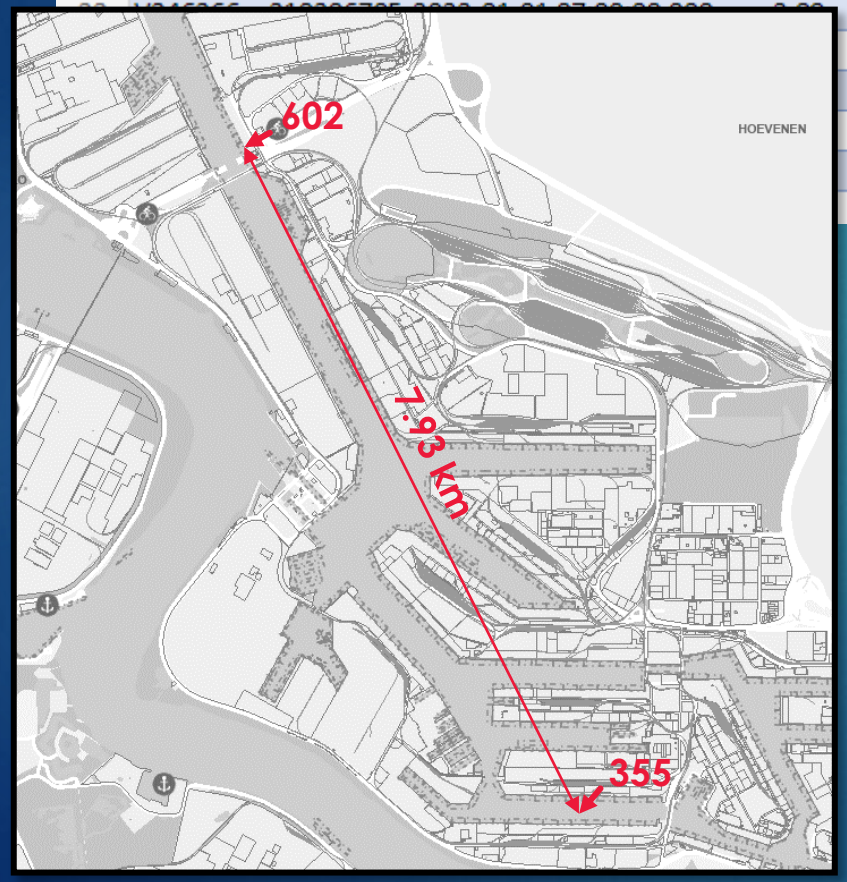
Task = "varen naar"





Data Issues (APICS)

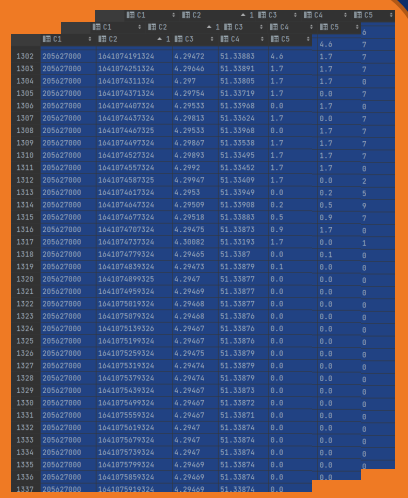
	A	B	D	G	K	Q	R	U	V
1	Verblijf	Reis	Aanvang tijd	Afstand	Einde tijd	Locatie van	Locatie naar	Sleepboot	Taak
4	V245903	210300426	2022-01-01 00:57:00.000	4.74	2022-01-01 02:00:00.000	267A	Boudewijnsluis	32	Varen naar taak
10	V245903	210300426	2022-01-01 02:15:00.000	5.17	2022-01-01 03:30:00.000	Boudewijnsluis	355	32	Slepen
13	V245671	210295221	2022-01-01 03:30:00.000	5.26	2022-01-01 04:30:00.000	602	Boudewijnsluis	32	Varen naar taak
16	V245671	210295221	2022-01-01 04:30:00.000	5.33	2022-01-01 05:20:00.000	Boudewijnsluis	353	32	Slepen
					2022-01-01 07:30:00.000	353	242	32	Varen naar taak
					2022-01-01 08:32:00.000	242	Boudewijnsluis	32	Slepen
					2022-01-01 09:45:00.000	602	412	32	Varen naar taak
					2022-01-01 11:23:00.000	412	Boudewijnsluis	32	Slepen
					2022-01-01 12:00:00.000	Boudewijnsluis	254	32	Varen naar taak
					2022-01-01 13:54:00.000	254	Zandvlietsluis	32	Slepen



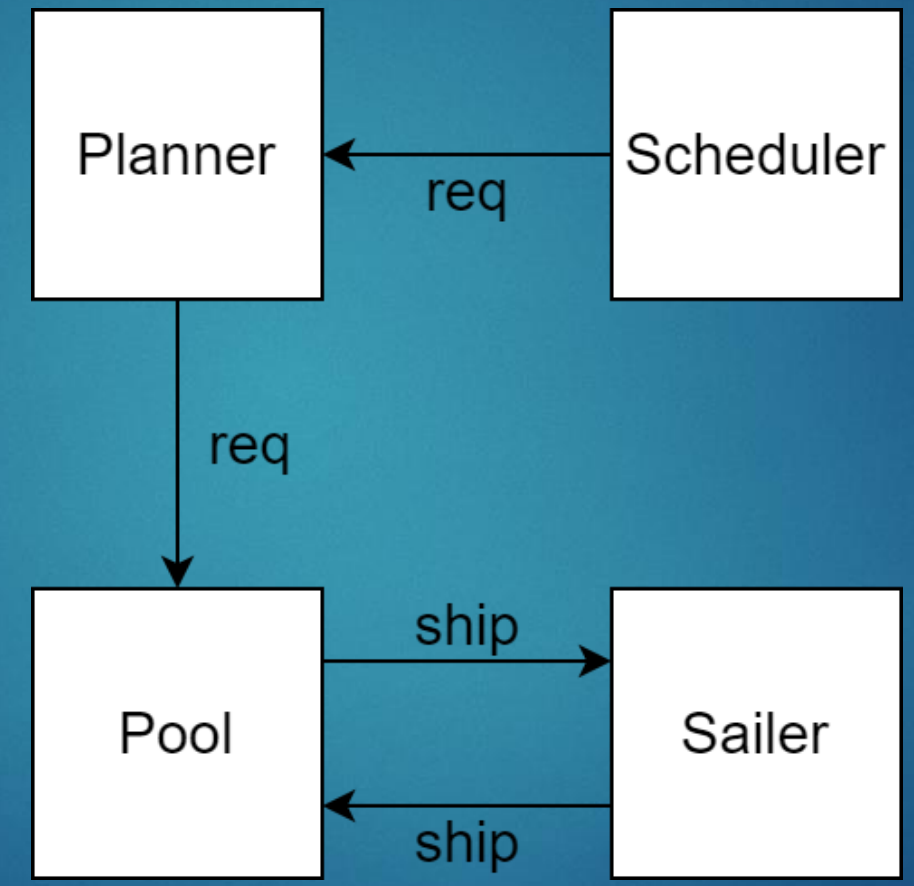
Distance between 355 and 602 = 7.93 km (straight line)
9.28 km (theoretical map)

2nd DEVS Simulation (simplified)

Port Theoretical Map (Graph)



restructured IVEF data



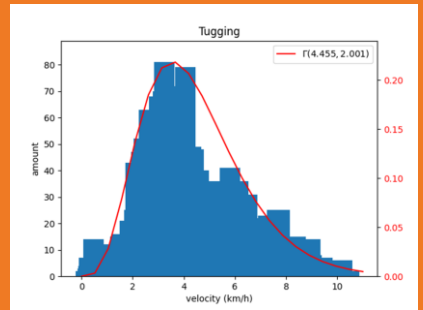
Dummy data

Cost of sailing toward task	Euro/hour
Strong tugboat	150
Average tugboat	100
Weak tugboat	50

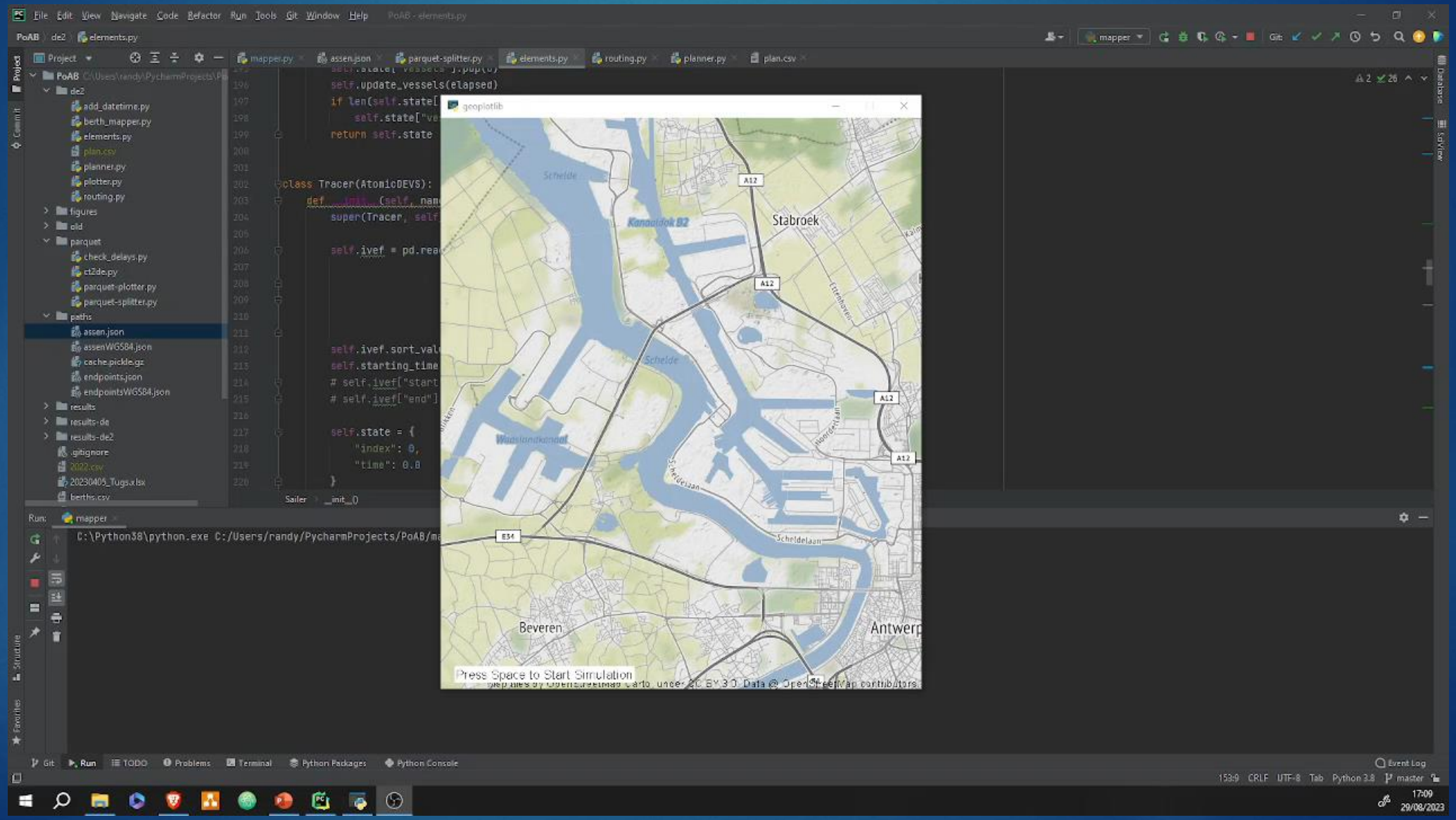
Cost of pushing/pulling ships	Euro/hour
Strong tugboat	200
Average tugboat	133
Weak tugboat	67

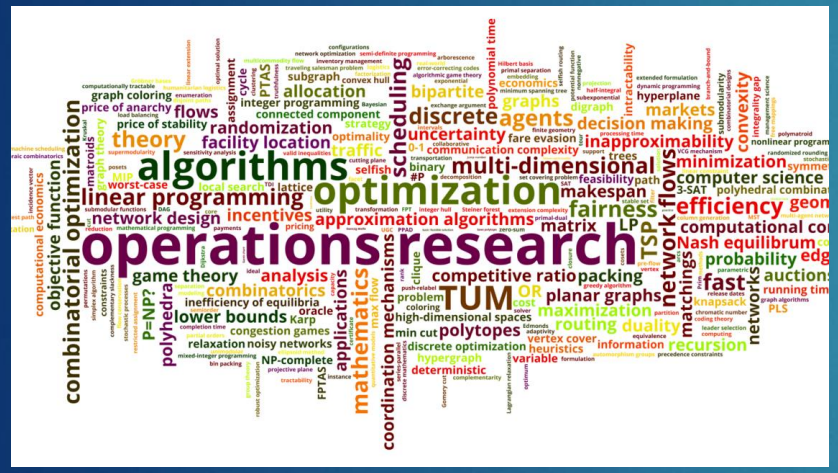
Fixed costs of using tugboat	Euro/day
Strong tugboat	1500
Average tugboat	1000
Weak tugboat	500

Waiting costs before pushing/pulling	Euro/hour
Strong tugboat	100
Average tugboat	67
Weak tugboat	33



2nd DEVS Simulation





Steps:

1. Define the problem of interest and gather relevant data.

2. Formulate a mathematical model to represent the problem.

3. Develop a computer-based procedure for deriving solutions to the problem from the model.

4. Test the model and refine it as needed.

5. Prepare for the ongoing application of the model as prescribed by management.

6. Implement.

Operations Research Applications

For Tugboats

Google OR-Tools

python™

CONSTRAINT PROGRAMMING

Operations Research Applications

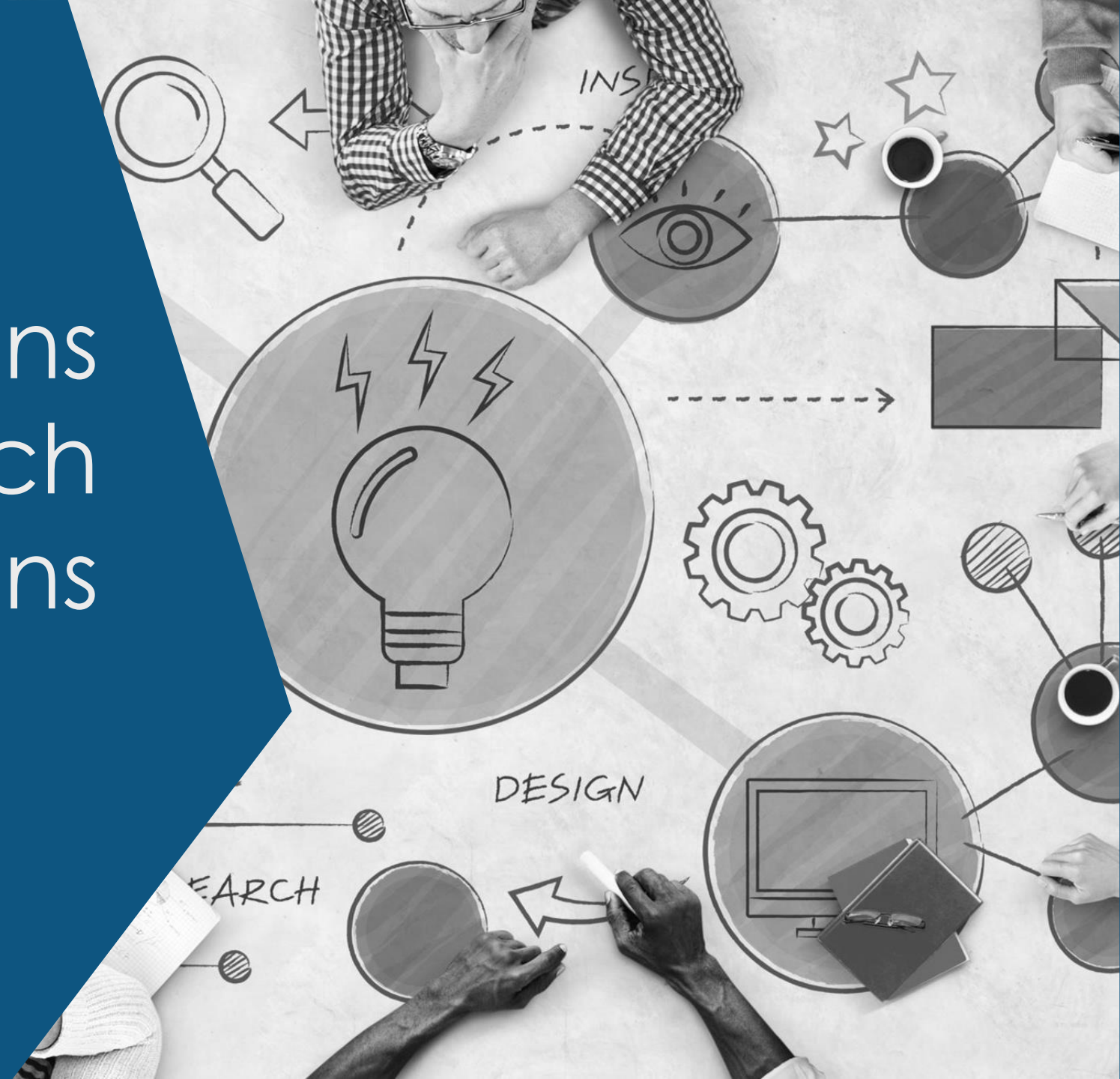
- For Tugboats
- Constraint Programming / Linear Programming
- Goal Function and Constraints

$$f(x) = \sum_{j=1}^{n} c_j x_j$$

$$\sum_{j=1}^{n} a_{ij} x_j \begin{pmatrix} \leq \\ = \\ \geq \end{pmatrix} b_i \quad \forall i = 1, \ldots, m$$

$$x_j \geq 0 \ \forall j = 1, \ldots, n$$

Operations Research Applications



Operations Research Applications

- The Objective Function: How to schedule strong tugboats to provide satisfactory service with the smallest cost?

- Constraints: The number of strong tugboats working during each period must satisfy the minimum requirement in the rightmost column of the Table.

	Time Period Covered (January)					
	Shift					
Time Period	**1**	**2**	**3**	**4**	**5**	**Minimum Number of Strong Tugboats Needed for tugging and sailing**
6:00 A.M. to 8:00 A.M.	X					10
8:00 A.M. to 10:00 A.M.	X	X				8
10:00 A.M. to noon	X	X				38
Noon to 2:00 P.M.	X	X	X			41
2:00 P.M. to 4:00 P.M.		X	X			22
4:00 P.M. to 6:00 P.M.			X	X		12
6:00 P.M. to 8:00 P.M.			X	X		25
8:00 P.M. to 10:00 P.M.				X		14
10:00 P.M. to midnight				X	X	56
Midnight to 6:00 A.M.					X	37
Daily cost per Strong Tugboat	**$272**	**$272**	**$272**	**$272**	**$272**	

The optimal solution for this model is ($x1$, $x2$, $x3$, $x4$, $x5$) = (22,16,6,19,37).
This yields Z = $27200 that is, a total daily cost of $27200

Operations Research Applications

For Tugboat Pilots

PROMETHEE

METHODS

PROMETHEE Methodology

Preference Ranking Organization METHod for Enrichment Evoluation

It is designed to help you to:

Evaluate several possible decisions or items according to multiple often conflicting criteria.

Identify the best possible decision.

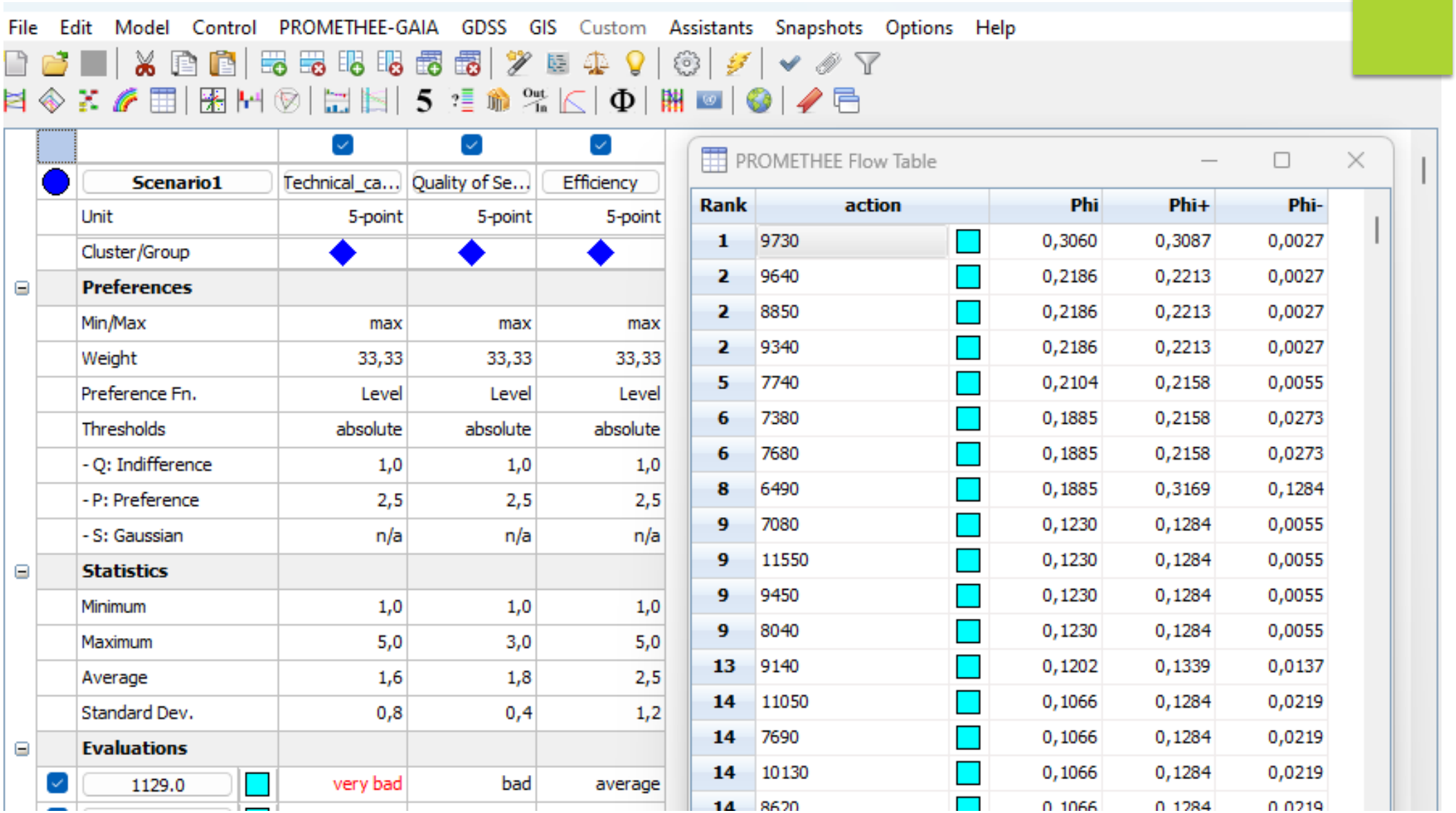
Rank possible decisions

Sort items into predefined classes

Visualize decision or evaluation problems to better understand the difficulties in making good decisions

Achieve consensus decisions when several decision-makers have conflicting points of view

Justify or invalidate decisions based on objective elements.


File Edit Model Control PROMETHEE-GAIA GDSS GIS Custom Assistants Snapshots Options Help
Scenario1 | Technical_ca... | Quality of Se... | Efficiency
Unit | 5-point | 5-point | 5-point
Cluster/Group
Preferences
Min/Max | max | max | max
Weight | 33,33 | 33,33 | 33,33
Preference Fn. | Level | Level | Level
Thresholds | absolute | absolute | absolute
- Q: Indifference | 1,0 | 1,0 | 1,0
- P: Preference | 2,5 | 2,5 | 2,5
- S: Gaussian | n/a | n/a | n/a
Statistics
Minimum | 1,0 | 1,0 | 1,0
Maximum | 5,0 | 3,0 | 5,0
Average | 1,6 | 1,8 | 2,5
Standard Dev. | 0,8 | 0,4 | 1,2
Evaluations
1129.0 | very bad | bad | average
PROMETHEE Flow Table
Rank | action | Phi | Phi+ | Phi-
1 | 9730 | 0,3060 | 0,3087 | 0,0027
2 | 9640 | 0,2186 | 0,2213 | 0,0027
2 | 8850 | 0,2186 | 0,2213 | 0,0027
2 | 9340 | 0,2186 | 0,2213 | 0,0027
5 | 7740 | 0,2104 | 0,2158 | 0,0055
6 | 7380 | 0,1885 | 0,2158 | 0,0273
6 | 7680 | 0,1885 | 0,2158 | 0,0273
8 | 6490 | 0,1885 | 0,3169 | 0,1284
9 | 7080 | 0,1230 | 0,1284 | 0,0055
9 | 11550 | 0,1230 | 0,1284 | 0,0055
9 | 9450 | 0,1230 | 0,1284 | 0,0055
9 | 8040 | 0,1230 | 0,1284 | 0,0055
13 | 9140 | 0,1202 | 0,1339 | 0,0137
14 | 11050 | 0,1066 | 0,1284 | 0,0219
14 | 7690 | 0,1066 | 0,1284 | 0,0219
14 | 10130 | 0,1066 | 0,1284 | 0,0219
14 | 8620 | 0,1066 | 0,1284 | 0,0219