COMPLEXICA

Badania naukowe dotyczące budowy systemów wspomagania decyzji opartych na sztucznej inteligencji

Zbigniew Michalewicz
Chief Scientist

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Outline of the talk

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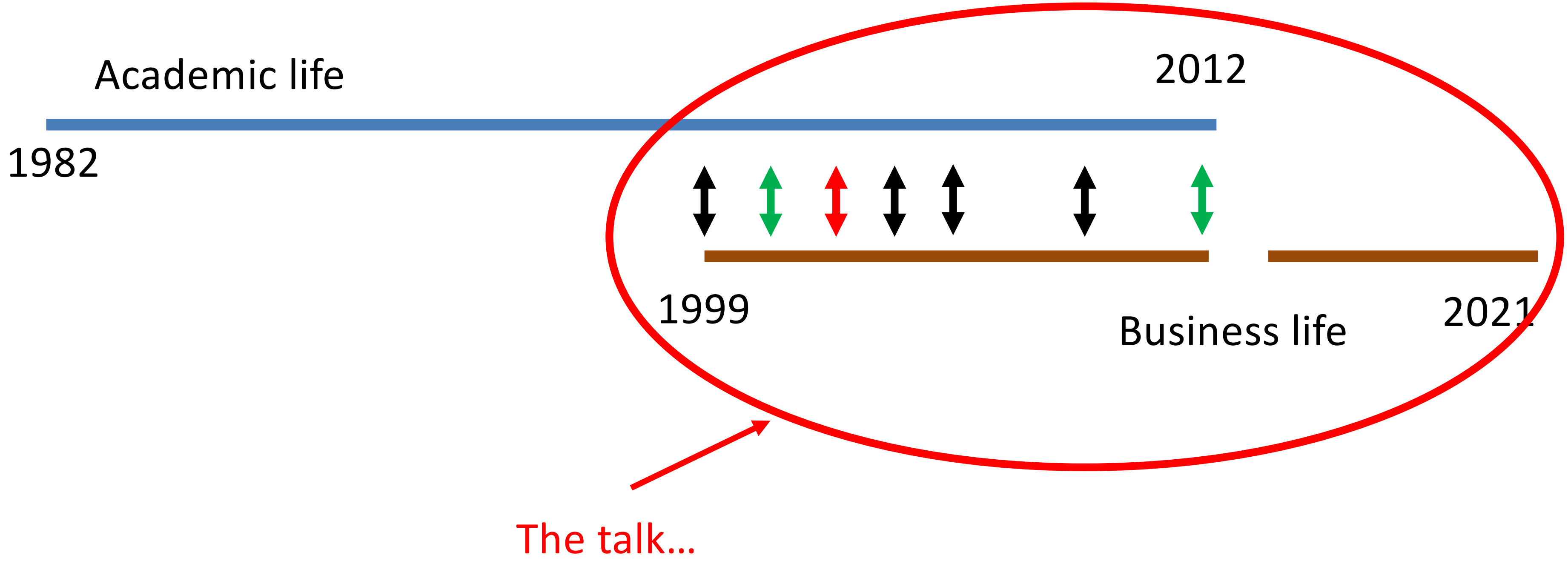
- 1999: NuTech Solutions
- 2005: SolveIT Software
- 2014: Complexica
- Some thoughts on business applications and the EC research

Introduction



Business life

1999 – 2005 NuTech Solutions → Netezza → IBM

2005 – 2012 SolveIT Software → Schneider Electric

2014 – Complexica → ?

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Clients across a broad set of industries

Outline of the talk

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- 2005: SolveIT Software
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NUTECH SOLUTIONS
science for business

1999

Car Distribution System (2001)

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- GMAC (car financial organization) sells 1.2 million off-lease cars each year on various auction sites.
- Every single day, their remarketing team (23 analysts) uses business intelligence tools and reports to decide where to ship 4,000 – 7,000 off lease cars.
- The problem is impacted by demand, depreciation, transportation schedules, cost of capital, risk, changes in market conditions, recent decisions, and the volume effect.

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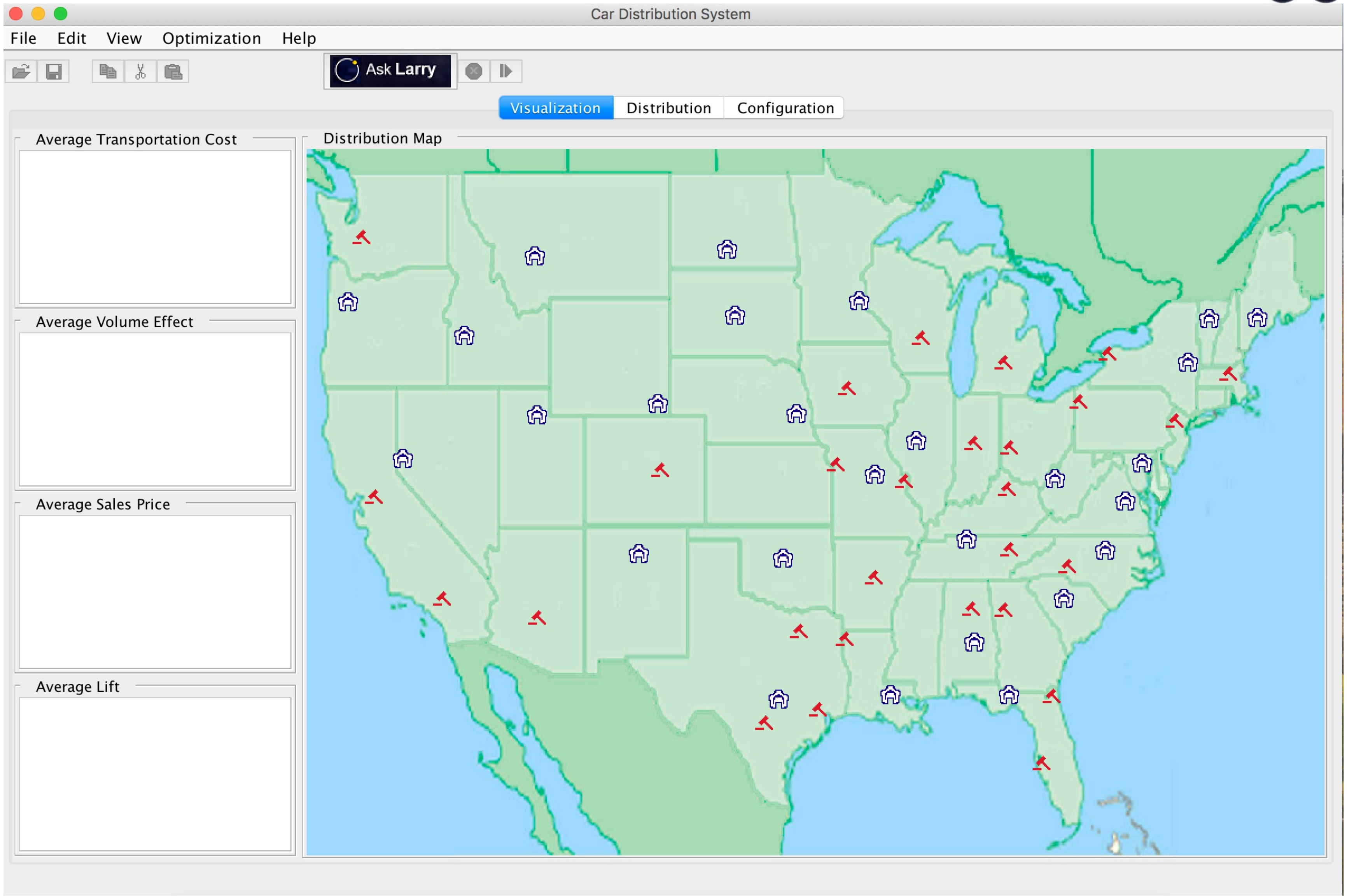
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Visualization
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Average Transportation Cost
Average Volume Effect
Average Sales Price
Average Lift
Distribution Map

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Car Distribution System

File Edit View Optimization Help

Ask Larry

Visualization | Distribution | Configuration

No.	Make	Model	Trim	Year	Distribution Center Location	Auction	Auction Location	Sales Price	Volume Effect	Distance	Transp. Cost	Net Price	Lift
1	Toyota	Tacoma	Deluxe	2004	Albany, NY								
2	Honda	Accord	EX	2003	Albany, NY								
3	Honda	Accord	EX	2003	Albany, NY								
4	Honda	Accord	EX	2003	Albany, NY								
5	Honda	Accord	EX	2003	Albany, NY								
6	Honda	Accord	LX	2003	Albany, NY								
7	Honda	Accord	LX	2001	Albany, NY								
8	Dodge	Dakota	Base	2003	Albany, NY								
9	Jeep	Grand Che...	Limited	2003	Albany, NY								
10	Nissan	Pathfinder	LE	2001	Albany, NY								
11	Toyota	Tacoma	Deluxe	2004	Albany, NY								
12	Honda	Accord	EX	2003	Albany, NY								
13	Honda	Accord	EX	2003	Albany, NY								
14	Honda	Accord	EX	2003	Albany, NY								
15	Honda	Accord	EX	2003	Albany, NY								
16	Honda	Accord	LX	2003	Albany, NY								
17	Honda	Accord	LX	2001	Albany, NY								
18	Dodge	Dakota	Base	2003	Albany, NY								
19	Jeep	Grand Che...	Limited	2003	Albany, NY								
20	Nissan	Pathfinder	LE	2001	Albany, NY								
21	Toyota	Tacoma	Deluxe	2004	Albany, NY								
22	Honda	Accord	EX	2003	Albany, NY								
23	Honda	Accord	EX	2003	Albany, NY								
24	Honda	Accord	EX	2003	Albany, NY								
25	Honda	Accord	EX	2003	Albany, NY								
26	Honda	Accord	LX	2003	Albany, NY								
27	Honda	Accord	LX	2001	Albany, NY								
28	Dodge	Dakota	Base	2003	Albany, NY								
29	Jeep	Grand Che...	Limited	2003	Albany, NY								
30	Nissan	Pathfinder	LE	2001	Albany, NY								
31	Toyota	Tacoma	Deluxe	2004	Albany, NY								
32	Honda	Accord	EX	2003	Albany, NY								
33	Honda	Accord	EX	2003	Albany, NY								
34	Honda	Accord	EX	2003	Albany, NY								
35	Honda	Accord	EX	2003	Albany, NY								
36	Honda	Accord	LX	2003	Albany, NY								
37	Honda	Accord	LX	2001	Albany, NY								
38	Dodge	Dakota	Base	2003	Albany, NY								
39	Jeep	Grand Che...	Limited	2003	Albany, NY								

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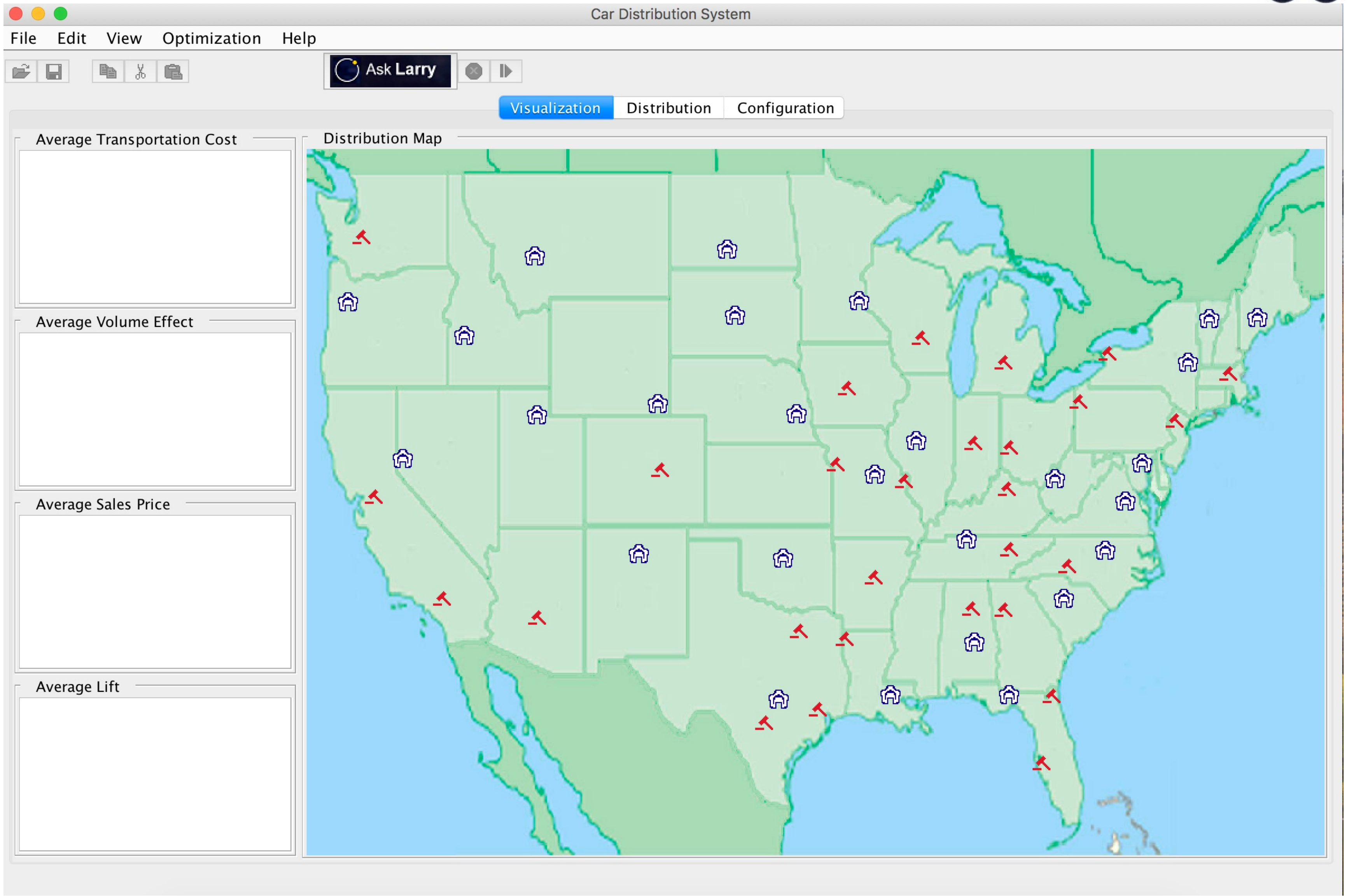
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Average Lift

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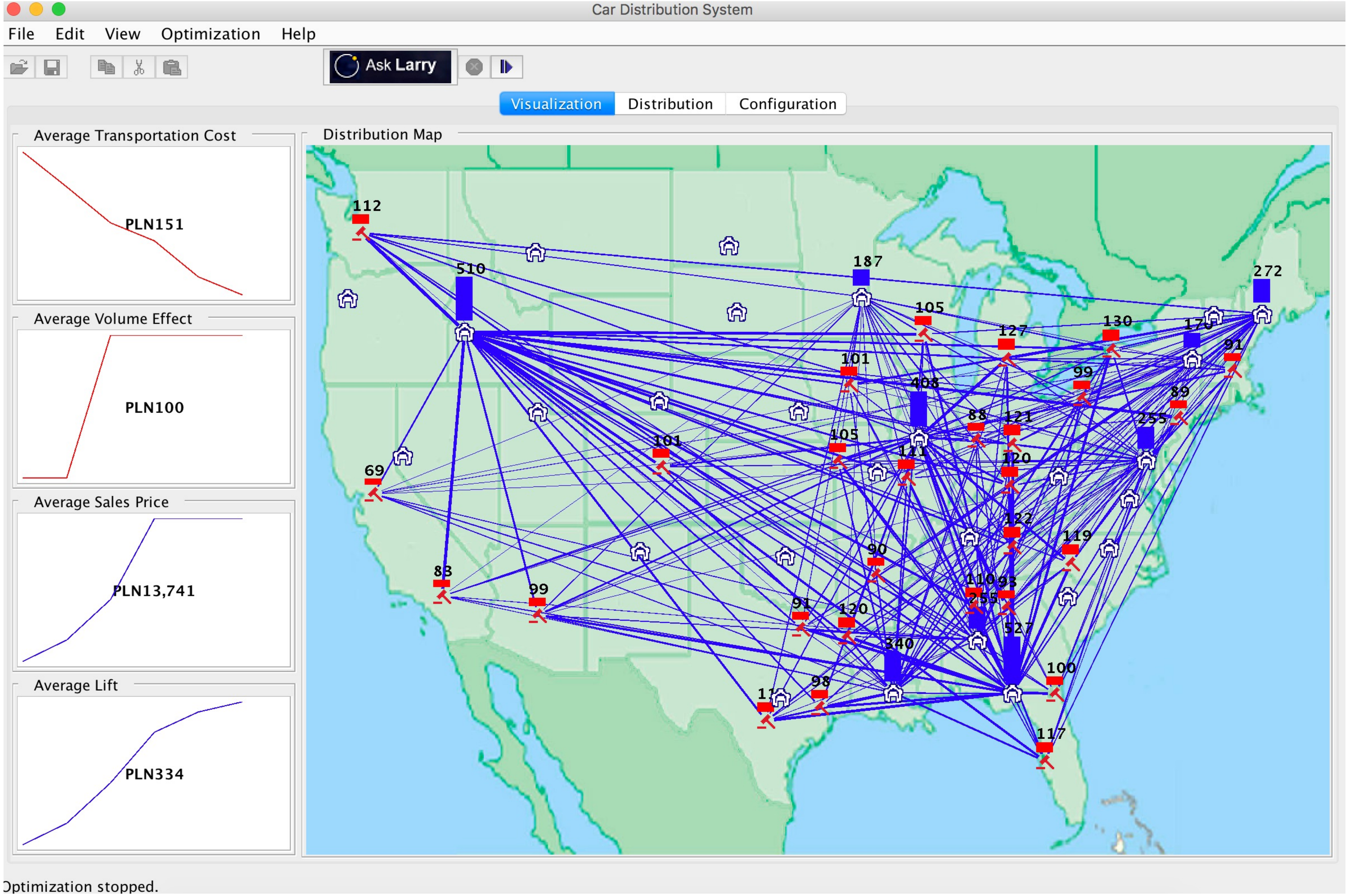
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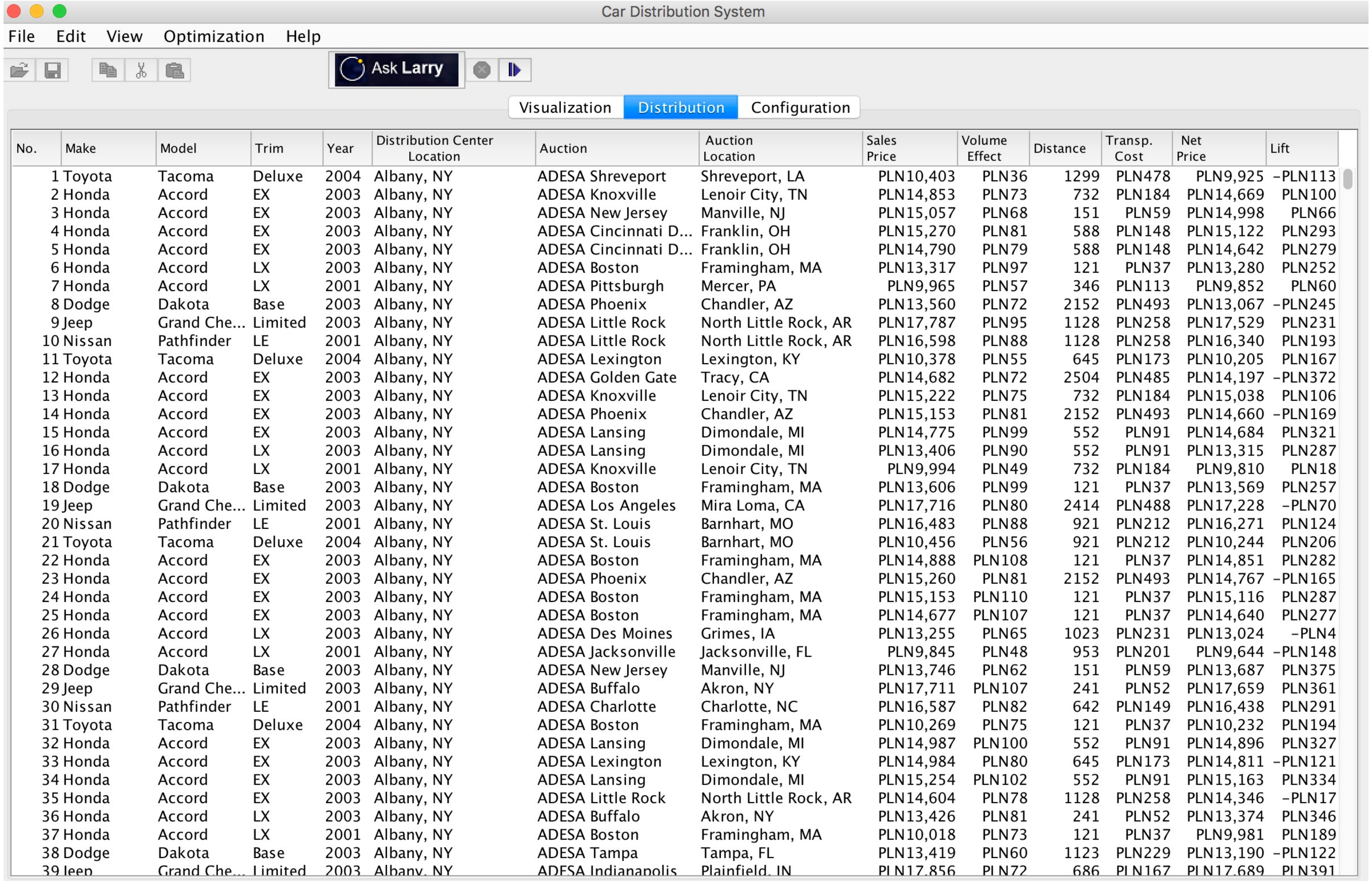

No.	Make	Model	Trim	Year	Distribution Center Location	Auction	Auction Location	Sales Price	Volume Effect	Distance	Transp. Cost	Net Price	Lift
1	Toyota	Tacoma	Deluxe	2004	Albany, NY	ADESA Shreveport	Shreveport, LA	PLN10,403	PLN36	1299	PLN478	PLN9,925	-PLN113
2	Honda	Accord	EX	2003	Albany, NY	ADESA Knoxville	Lenoir City, TN	PLN14,853	PLN73	732	PLN184	PLN14,669	PLN100
3	Honda	Accord	EX	2003	Albany, NY	ADESA New Jersey	Manville, NJ	PLN15,057	PLN68	151	PLN59	PLN14,998	PLN66
4	Honda	Accord	EX	2003	Albany, NY	ADESA Cincinnati D...	Franklin, OH	PLN15,270	PLN81	588	PLN148	PLN15,122	PLN293
5	Honda	Accord	EX	2003	Albany, NY	ADESA Cincinnati D...	Franklin, OH	PLN14,790	PLN79	588	PLN148	PLN14,642	PLN279
6	Honda	Accord	LX	2003	Albany, NY	ADESA Boston	Framingham, MA	PLN13,317	PLN97	121	PLN37	PLN13,280	PLN252
7	Honda	Accord	LX	2001	Albany, NY	ADESA Pittsburgh	Mercer, PA	PLN9,965	PLN57	346	PLN113	PLN9,852	PLN60
8	Dodge	Dakota	Base	2003	Albany, NY	ADESA Phoenix	Chandler, AZ	PLN13,560	PLN72	2152	PLN493	PLN13,067	-PLN245
9	Jeep	Grand Che...	Limited	2003	Albany, NY	ADESA Little Rock	North Little Rock, AR	PLN17,787	PLN95	1128	PLN258	PLN17,529	PLN231
10	Nissan	Pathfinder	LE	2001	Albany, NY	ADESA Little Rock	North Little Rock, AR	PLN16,598	PLN88	1128	PLN258	PLN16,340	PLN193
11	Toyota	Tacoma	Deluxe	2004	Albany, NY	ADESA Lexington	Lexington, KY	PLN10,378	PLN55	645	PLN173	PLN10,205	PLN167
12	Honda	Accord	EX	2003	Albany, NY	ADESA Golden Gate	Tracy, CA	PLN14,682	PLN72	2504	PLN485	PLN14,197	-PLN372
13	Honda	Accord	EX	2003	Albany, NY	ADESA Knoxville	Lenoir City, TN	PLN15,222	PLN75	732	PLN184	PLN15,038	PLN106
14	Honda	Accord	EX	2003	Albany, NY	ADESA Phoenix	Chandler, AZ	PLN15,153	PLN81	2152	PLN493	PLN14,660	-PLN169
15	Honda	Accord	EX	2003	Albany, NY	ADESA Lansing	Dimondale, MI	PLN14,775	PLN99	552	PLN91	PLN14,684	PLN321
16	Honda	Accord	LX	2003	Albany, NY	ADESA Lansing	Dimondale, MI	PLN13,406	PLN90	552	PLN91	PLN13,315	PLN287
17	Honda	Accord	LX	2001	Albany, NY	ADESA Knoxville	Lenoir City, TN	PLN9,994	PLN49	732	PLN184	PLN9,810	PLN18
18	Dodge	Dakota	Base	2003	Albany, NY	ADESA Boston	Framingham, MA	PLN13,606	PLN99	121	PLN37	PLN13,569	PLN257
19	Jeep	Grand Che...	Limited	2003	Albany, NY	ADESA Los Angeles	Mira Loma, CA	PLN17,716	PLN80	2414	PLN488	PLN17,228	-PLN70
20	Nissan	Pathfinder	LE	2001	Albany, NY	ADESA St. Louis	Barnhart, MO	PLN16,483	PLN88	921	PLN212	PLN16,271	PLN124
21	Toyota	Tacoma	Deluxe	2004	Albany, NY	ADESA St. Louis	Barnhart, MO	PLN10,456	PLN56	921	PLN212	PLN10,244	PLN206
22	Honda	Accord	EX	2003	Albany, NY	ADESA Boston	Framingham, MA	PLN14,888	PLN108	121	PLN37	PLN14,851	PLN282
23	Honda	Accord	EX	2003	Albany, NY	ADESA Phoenix	Chandler, AZ	PLN15,260	PLN81	2152	PLN493	PLN14,767	-PLN165
24	Honda	Accord	EX	2003	Albany, NY	ADESA Boston	Framingham, MA	PLN15,153	PLN110	121	PLN37	PLN15,116	PLN287
25	Honda	Accord	EX	2003	Albany, NY	ADESA Boston	Framingham, MA	PLN14,677	PLN107	121	PLN37	PLN14,640	PLN277
26	Honda	Accord	LX	2003	Albany, NY	ADESA Des Moines	Grimes, IA	PLN13,255	PLN65	1023	PLN231	PLN13,024	-PLN4
27	Honda	Accord	LX	2001	Albany, NY	ADESA Jacksonville	Jacksonville, FL	PLN9,845	PLN48	953	PLN201	PLN9,644	-PLN148
28	Dodge	Dakota	Base	2003	Albany, NY	ADESA New Jersey	Manville, NJ	PLN13,746	PLN62	151	PLN59	PLN13,687	PLN375
29	Jeep	Grand Che...	Limited	2003	Albany, NY	ADESA Buffalo	Akron, NY	PLN17,711	PLN107	241	PLN52	PLN17,659	PLN361
30	Nissan	Pathfinder	LE	2001	Albany, NY	ADESA Charlotte	Charlotte, NC	PLN16,587	PLN82	642	PLN149	PLN16,438	PLN291
31	Toyota	Tacoma	Deluxe	2004	Albany, NY	ADESA Boston	Framingham, MA	PLN10,269	PLN75	121	PLN37	PLN10,232	PLN194
32	Honda	Accord	EX	2003	Albany, NY	ADESA Lansing	Dimondale, MI	PLN14,987	PLN100	552	PLN91	PLN14,896	PLN327
33	Honda	Accord	EX	2003	Albany, NY	ADESA Lexington	Lexington, KY	PLN14,984	PLN80	645	PLN173	PLN14,811	-PLN121
34	Honda	Accord	EX	2003	Albany, NY	ADESA Lansing	Dimondale, MI	PLN15,254	PLN102	552	PLN91	PLN15,163	PLN334
35	Honda	Accord	EX	2003	Albany, NY	ADESA Little Rock	North Little Rock, AR	PLN14,604	PLN78	1128	PLN258	PLN14,346	-PLN17
36	Honda	Accord	LX	2003	Albany, NY	ADESA Buffalo	Akron, NY	PLN13,426	PLN81	241	PLN52	PLN13,374	PLN346
37	Honda	Accord	LX	2001	Albany, NY	ADESA Boston	Framingham, MA	PLN10,018	PLN73	121	PLN37	PLN9,981	PLN189
38	Dodge	Dakota	Base	2003	Albany, NY	ADESA Tampa	Tampa, FL	PLN13,419	PLN60	1123	PLN229	PLN13,190	-PLN122
39	Jeep	Grand Che...	Limited	2003	Albany, NY	ADESA Indianapolis	Plainfield, IN	PLN17,856	PLN72	686	PLN167	PLN17,689	PLN391

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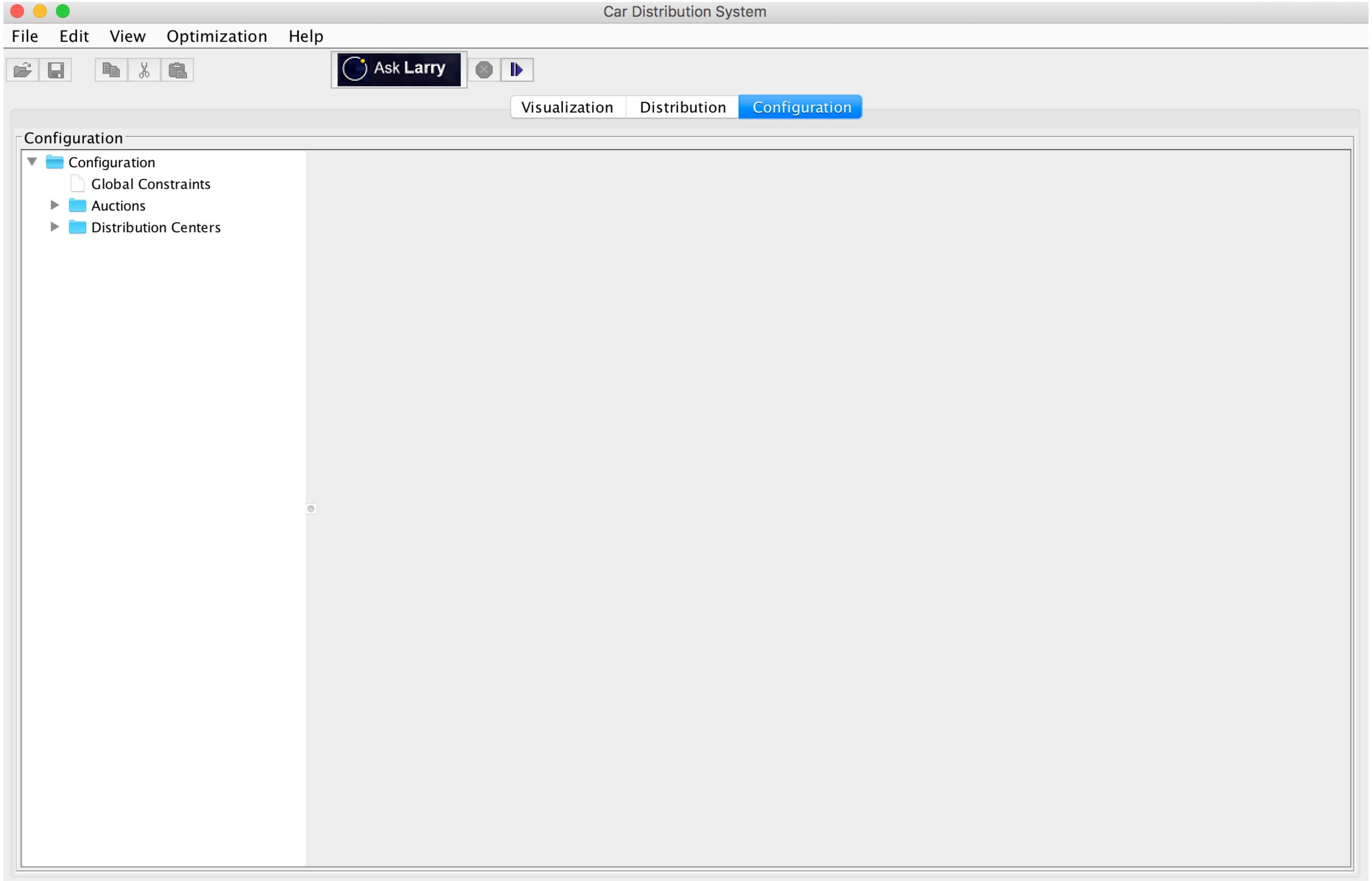
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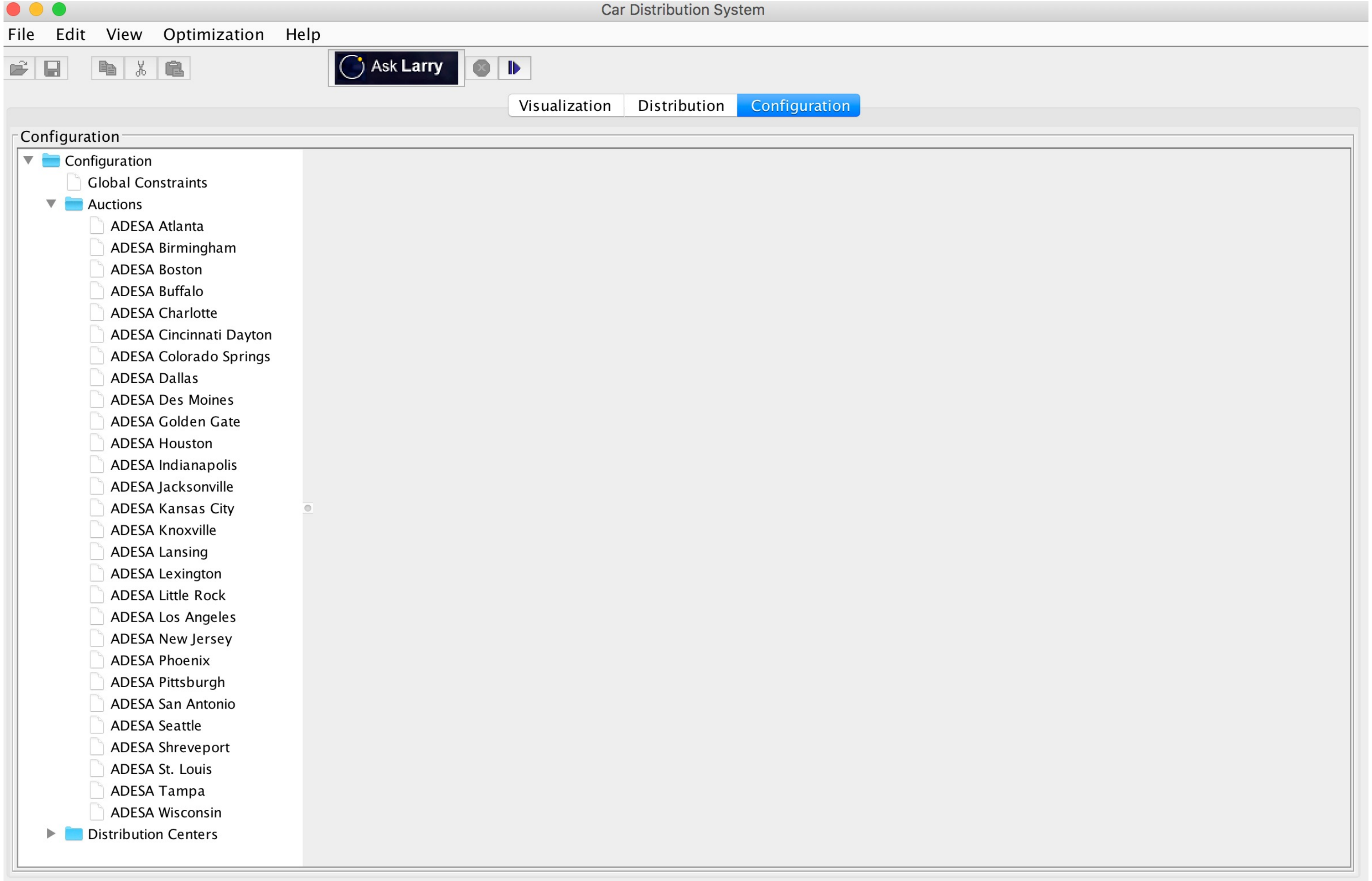

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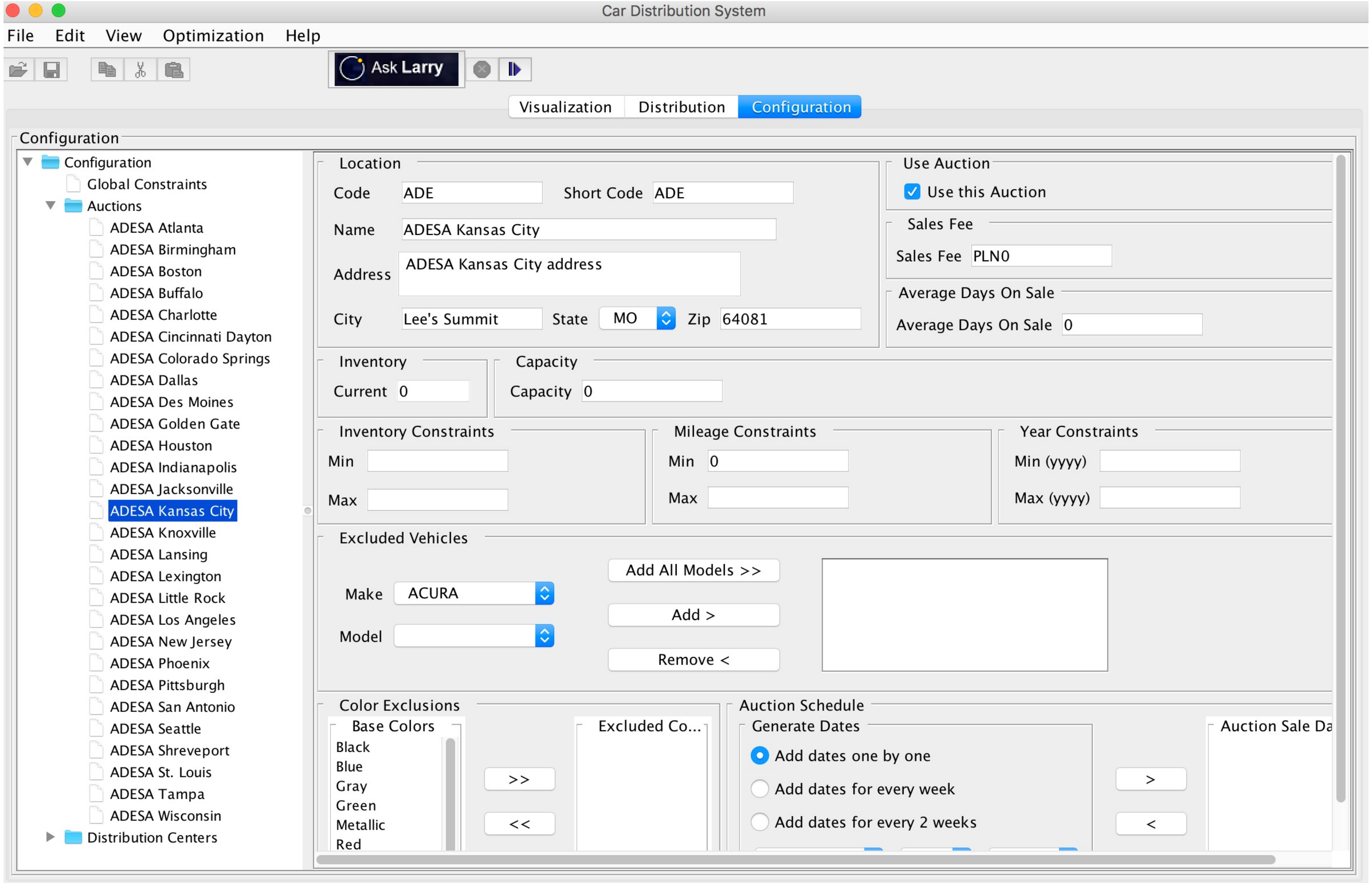

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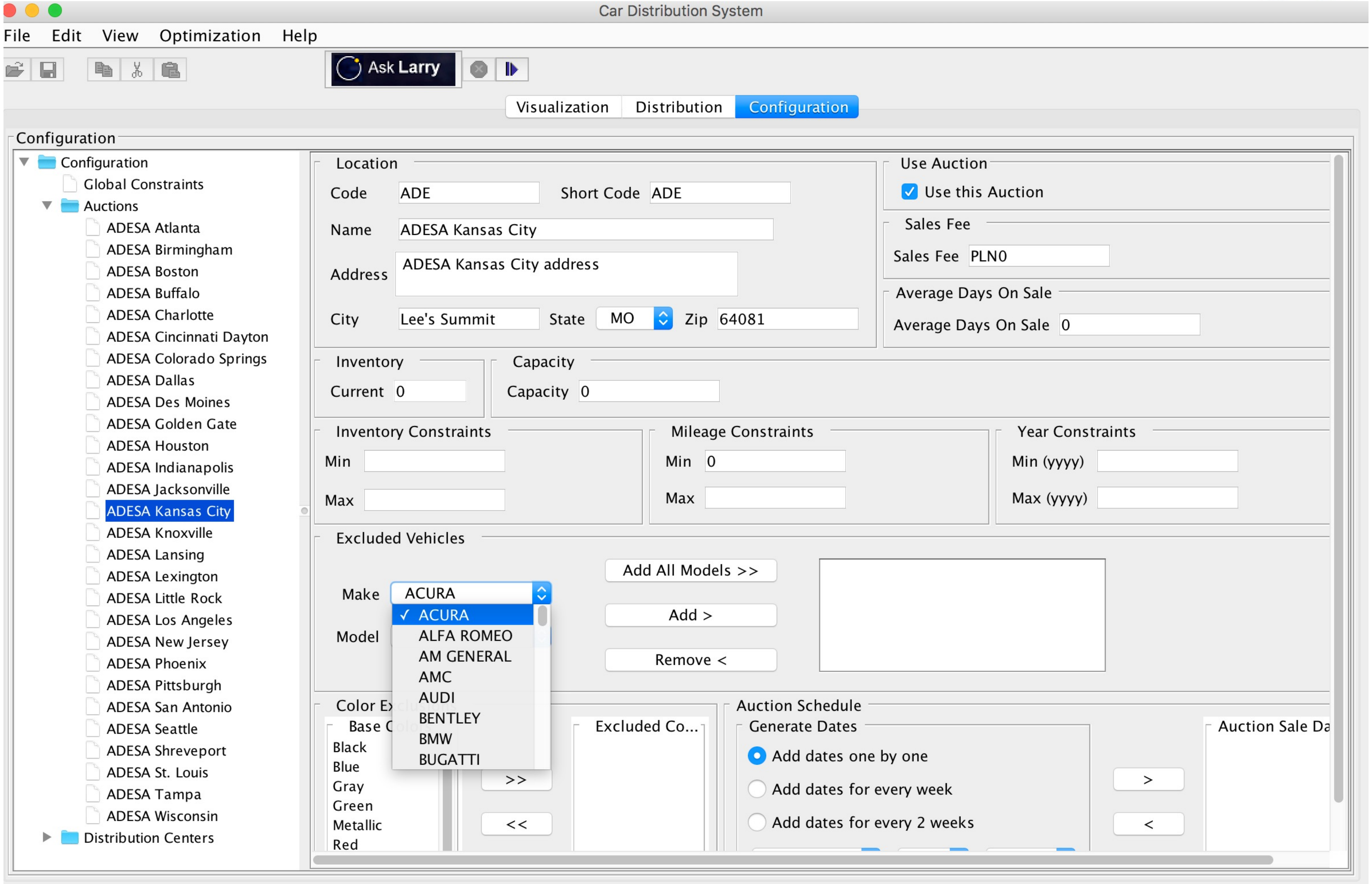
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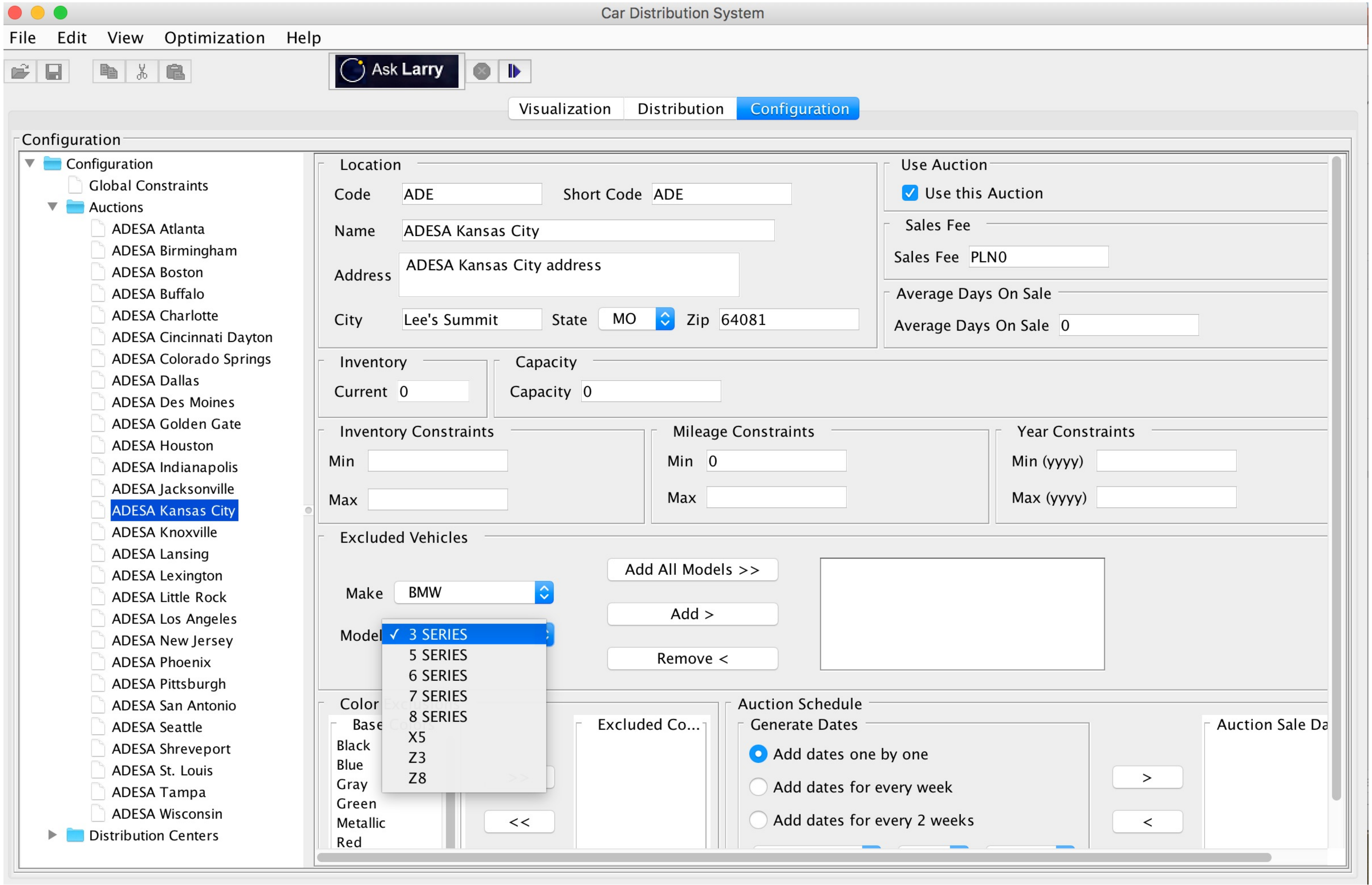

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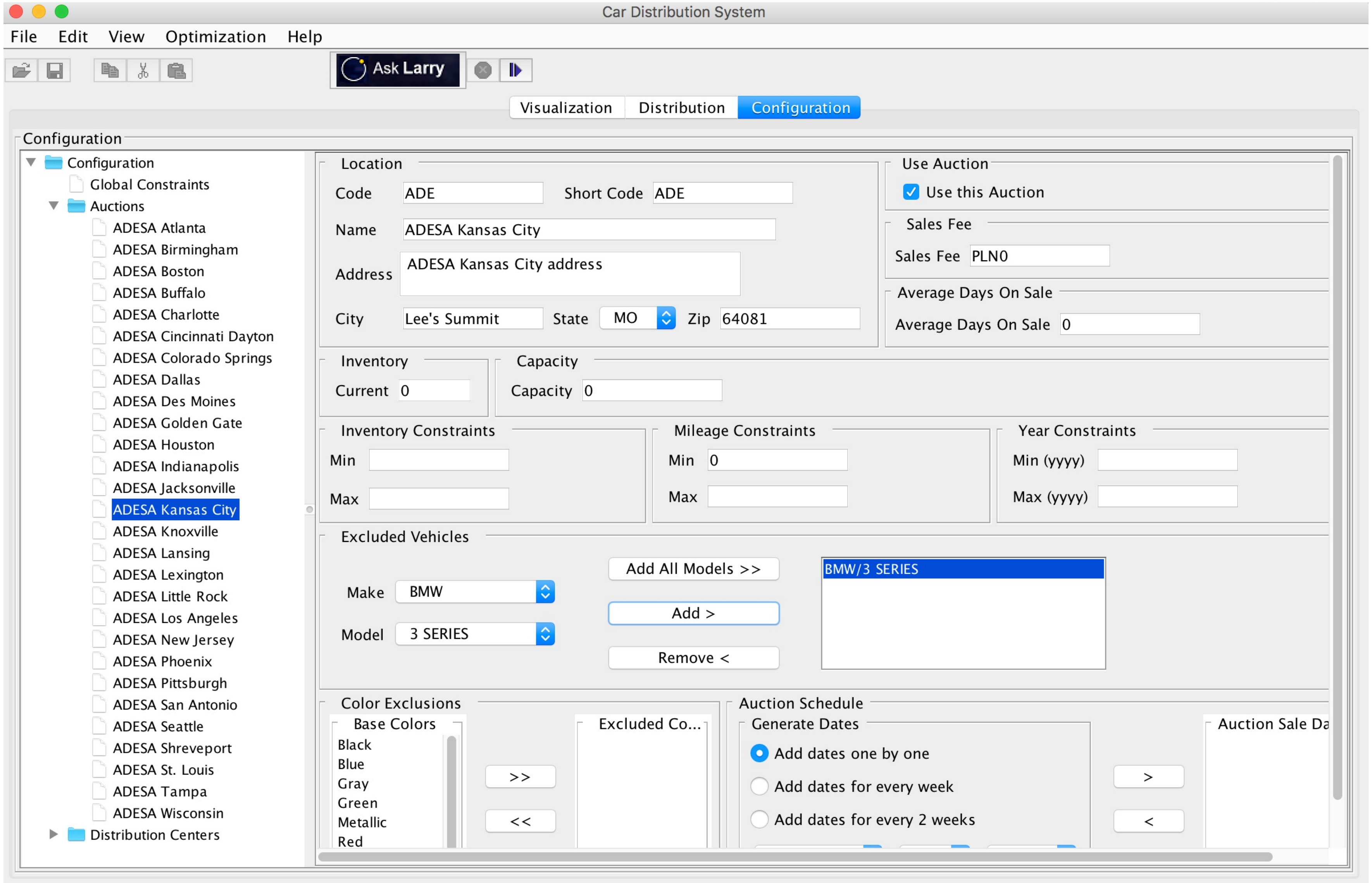
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Results

Better: Net lift of $213/car

Cheaper: 23 people down to 2

Faster: Minutes not man-days

Data-driven decisions that are consistent

Predicted vs. actual comparisons; closed loop for making improvement

Results

Better: Net lift of $213/car

Cheaper: 23 people down to 2

Faster: Minutes not man-days

Data-driven decisions that are consistent

Predicted vs. actual comparisons; closed loop for making improvement

Adaptive Business Intelligence

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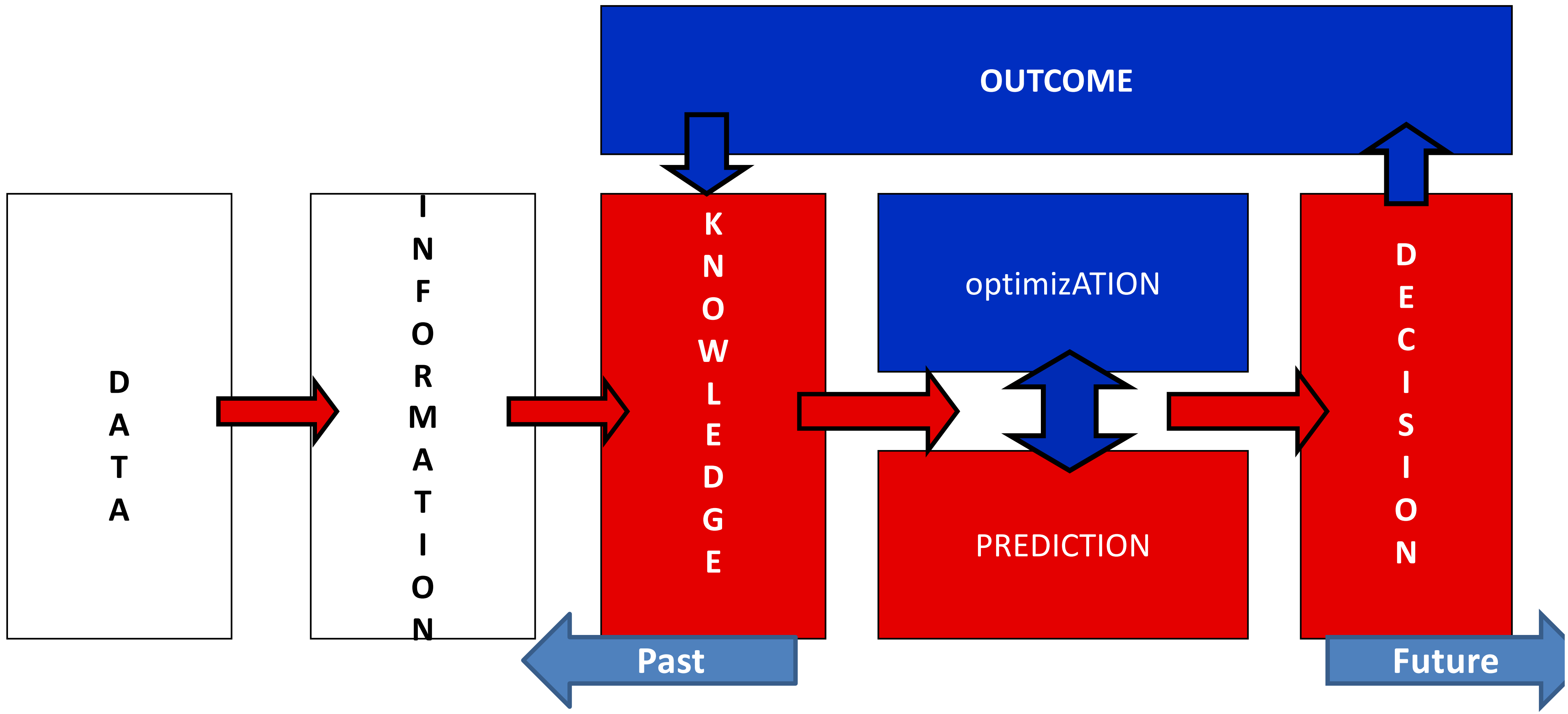
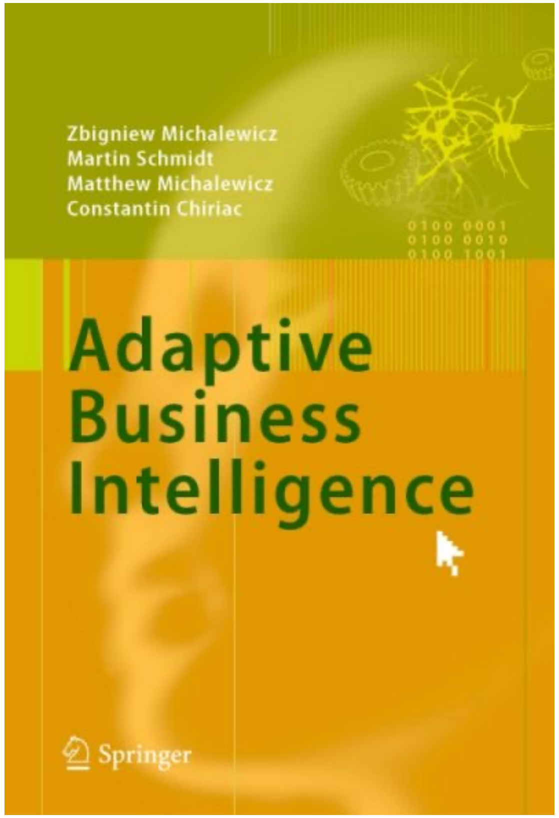


Adaptive Business Intelligence



…how to combine prediction, optimization, and how to close the loop to create truly *intelligent* decision-support systems…

Outline of the talk

- 1999: NuTech Solutions
- 2005: SolveIT Software
- 2014: Complexica
- Some thoughts on business applications and the EC research

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SolveIT Software

2005

Small example

Consider decision support system for delivery of water tanks to farmers in Australia. Delivery decisions (many customers/orders & dealers, due dates, etc.) include:

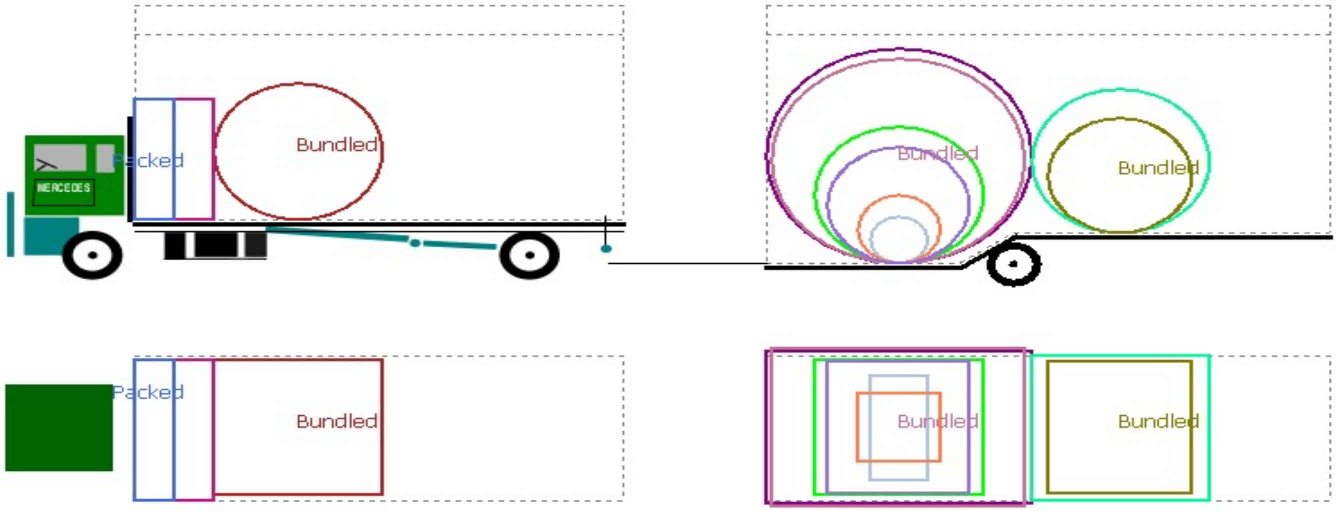
- ✓ selection of trucks / trailers
- ✓ selection of drivers
- ✓ packing (including bundling)
- ✓ routing (including dealers and unbundling sites)
- ✓ etc.

Small example

Each of these problems is hard to solve on its own.

For example, the problem of packing of goods on trucks and trailers cannot be solved with standard 2D or 3D packing algorithms, as different types of tanks can be packed in different ways, e.g. bundled inside each other, on top of each other, taking into account various constraints, in a pyramid stacking configuration, or as loose items.

Small example



Truck: 1 bundles (1 bundled items) 2 packed items; Trailer: 2 bundles (8 bundled items)

Tanks

No.	Transport	Tank	Pyramid	Order No.	Product	Product Group	Product	Height (m)	Width (m)	Depth (m)	Weight (kg)	Unbu
1	Truck	Packed		449746	TP40104	EVEREST K2 ...	RECTAN...	2.077	2.425	0.555	90	ONE STOP WATER SHOP
2	Truck	Packed		449746	TP33977	EVEREST K2 ...	RECTAN...	2.077	2.425	0.555	90	ONE STOP WATER SHOP
3	Truck	Bundle		449752	TP2843	8000L TANK	ROUND	2.325	2.341	2.341	151.75	ONE STOP WATER SHOP
4	Trailer	Bundle		449639	TP3413	22500L SQUA...	ROUND	2.631	3.7	3.7	378.05	ONE STOP WATER SHOP
5	Trailer	Bundle		449639	TP3369	22500L TANK	ROUND	2.72	3.53	3.53	378.25	ONE STOP WATER SHOP
6	Trailer	Bundle		449639	TP2751	8000L TANK	ROUND	2.325	2.341	2.341	151.75	ONE STOP WATER SHOP
7	Trailer	Bundle		449752	TP2621	5400L TANK	ROUND	2.268	1.986	1.986	113.75	ONE STOP WATER SHOP
8	Trailer	Bundle		449752	TP19339	900L TANK	ROUND	1.17	1.16	1.16	30	ONE STOP WATER SHOP
9	Trailer	Bundle		449746	TP19384	MINI-LINE 4	ROUND	1.788	0.788	0.788	26	ONE STOP WATER SHOP
10	Trailer	Bundle		449752	TP2973	9000L TANK	ROUND	2.502	2.475	2.475	176.75	ONE STOP WATER SHOP
11	Trailer	Bundle		448923	TP2690	5400L TANK	ROUND	2.268	1.986	1.986	113.75	ONE STOP WATER SHOP

Small example

Further, many of these problems are connected in the sense that decisions made in one problem may impact some decisions for another problem:

- ✓ The packing and routing problems are intertwined, as the destination locations of items packed on a truck/trailer for a trip determine the final delivery destinations to be visited.
- ✓ Bundled water tanks can be unbundled only at specific agent locations, which has to be done prior to final delivery to customer locations.
- ✓ A decision of using a particular truck with a trailer for a trip may prevent another delivery which requires a driver with appropriate qualifications.

Global vs. silo optimisation

The optimal decision in one problem may prevent finding the overall optimal solution...

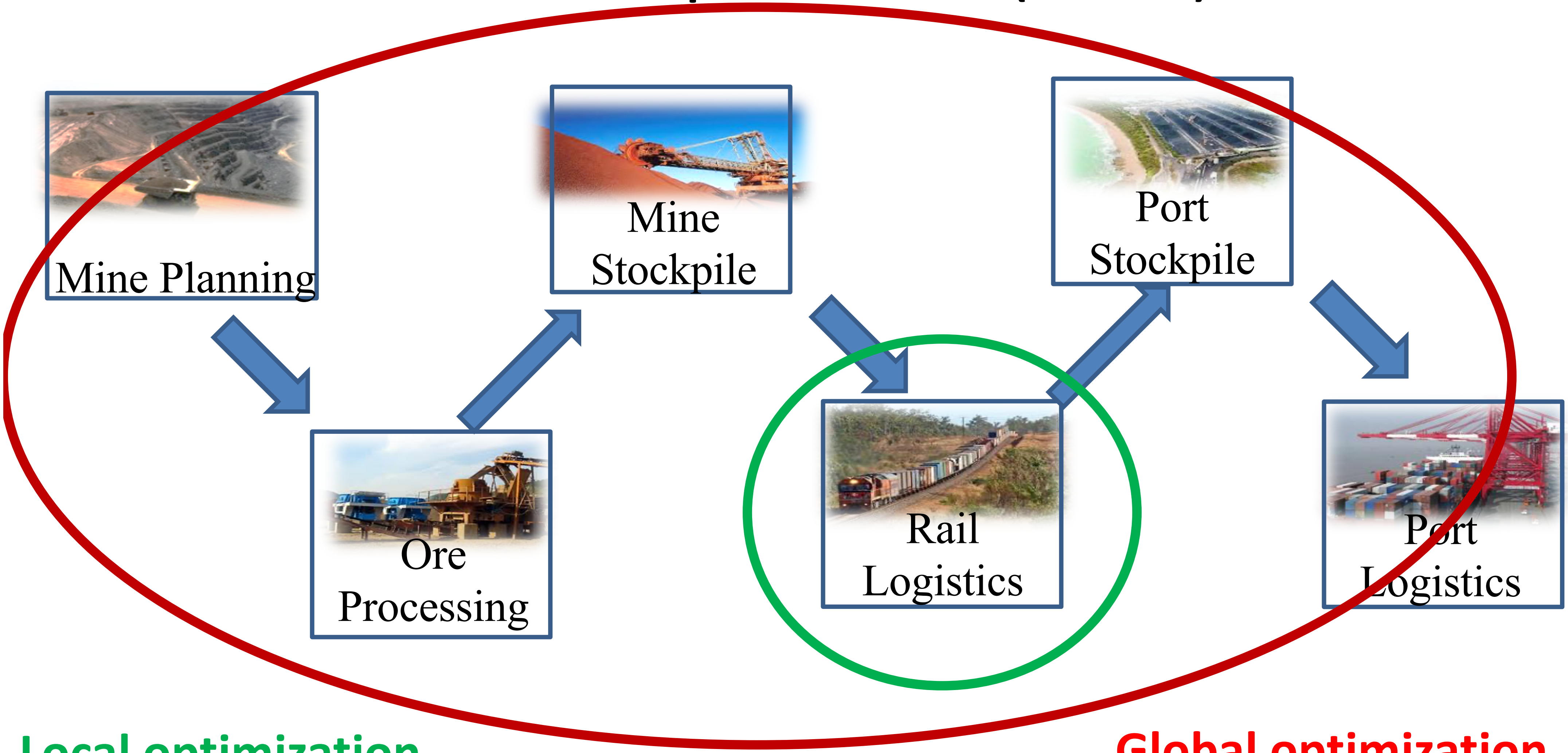
A thought from the past:

“Problems require holistic treatment. They cannot be treated effectively by decomposing them analytically into separate problems to which optimal solutions are sought.”

R. Ackoff, *The Future of OR is Past*, JORS, 1979.

From Mine to Port Operations (2010)

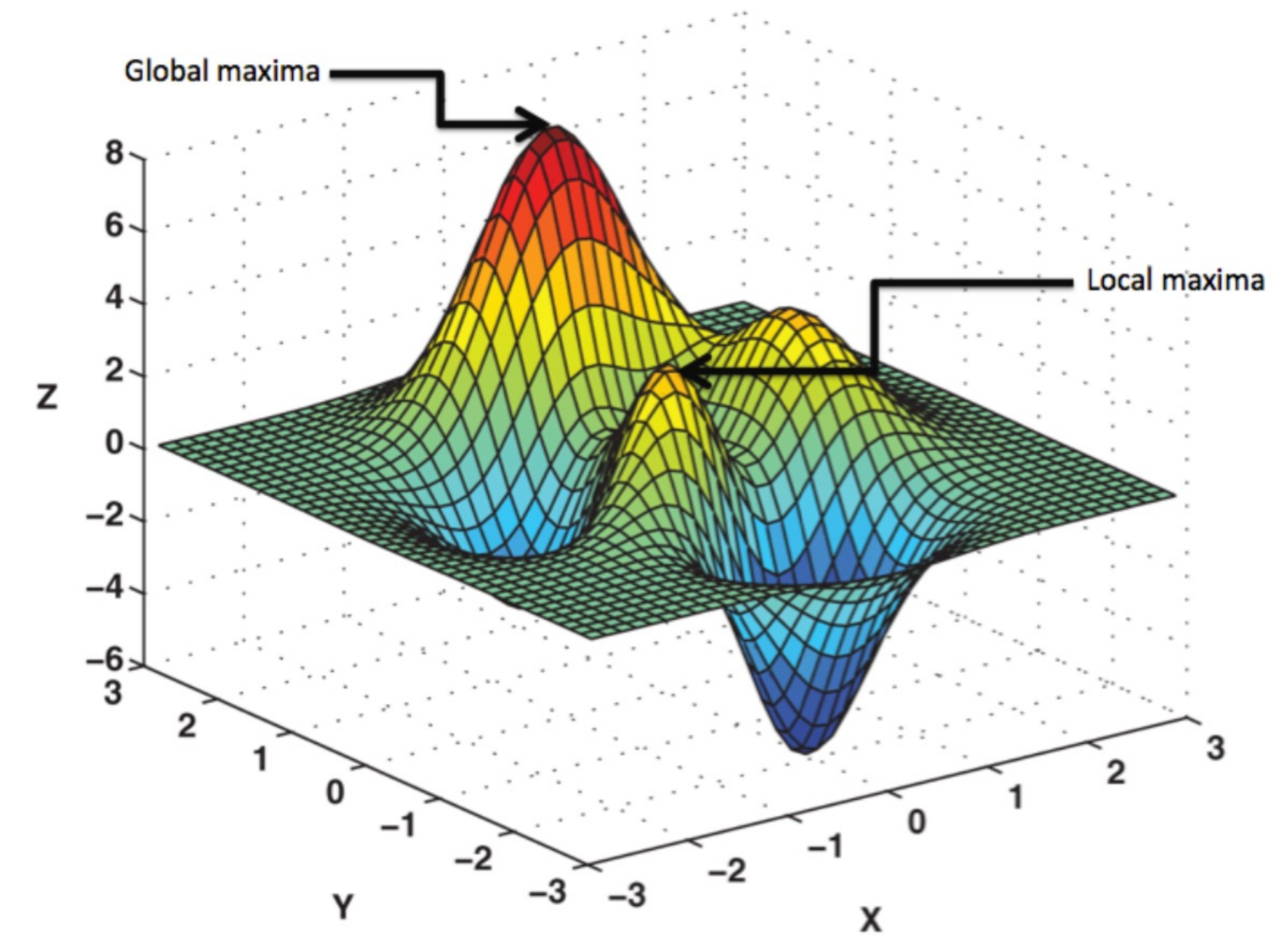
COMPLEXICA

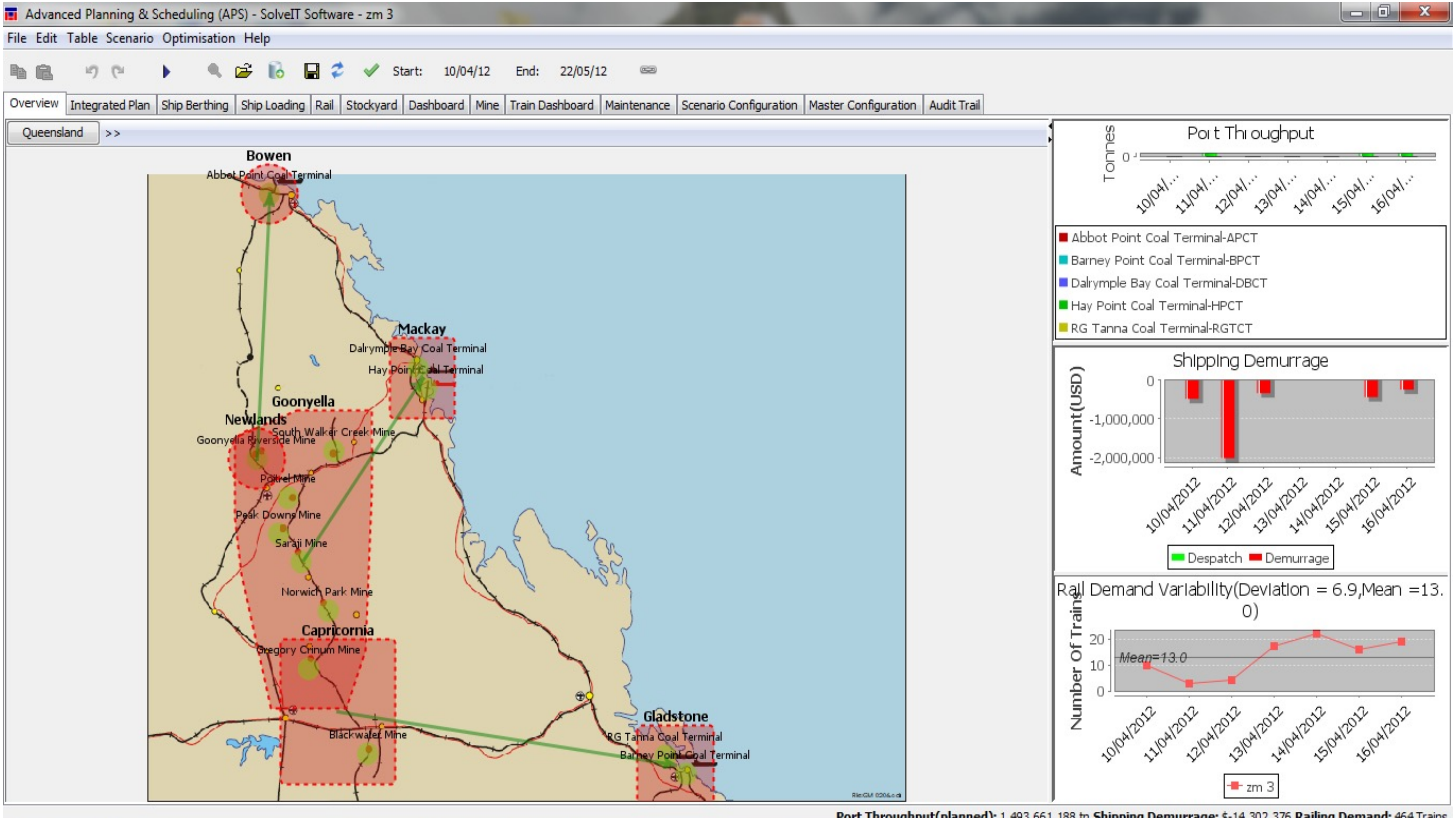


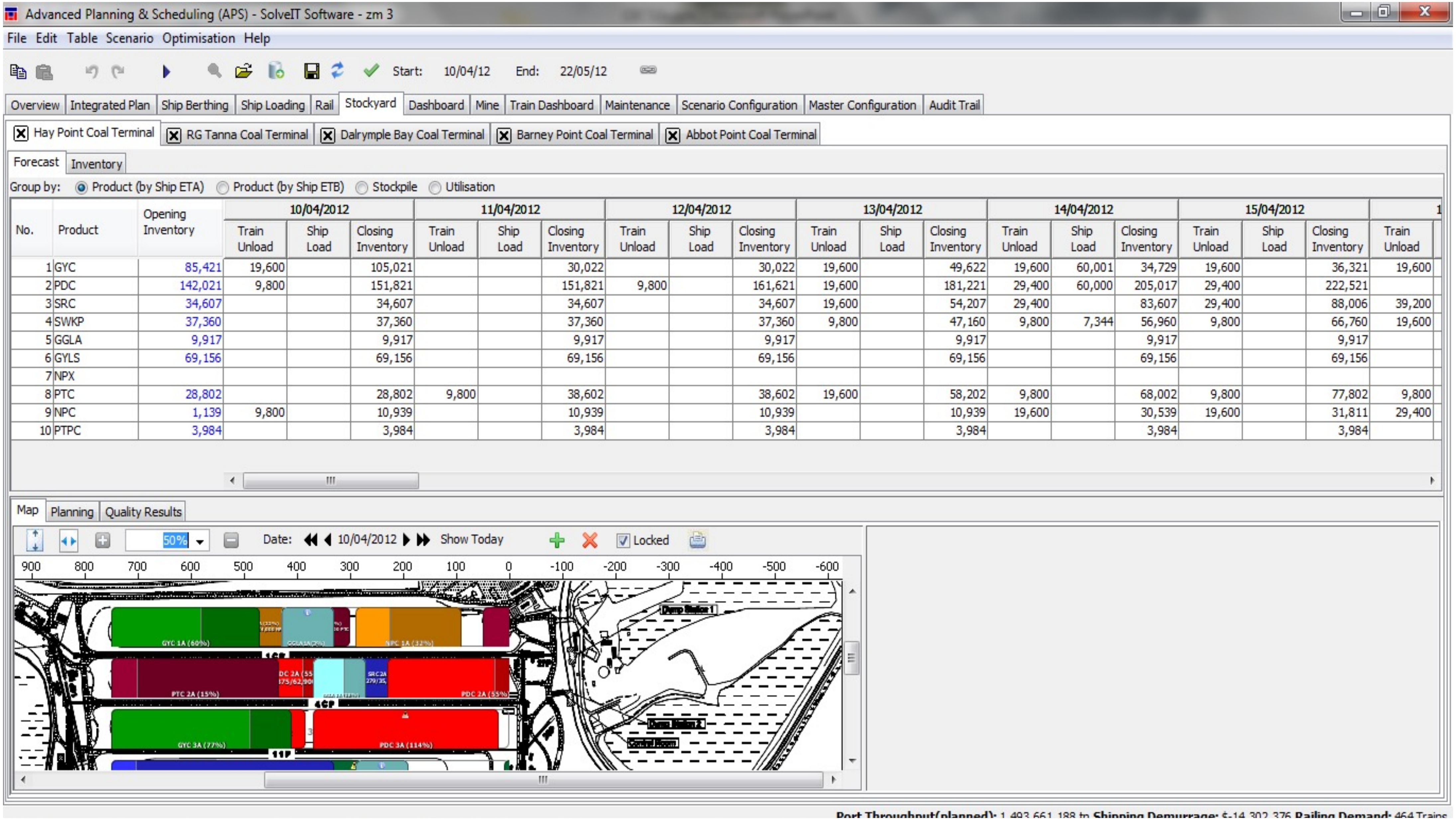
Local optimization

Global optimization

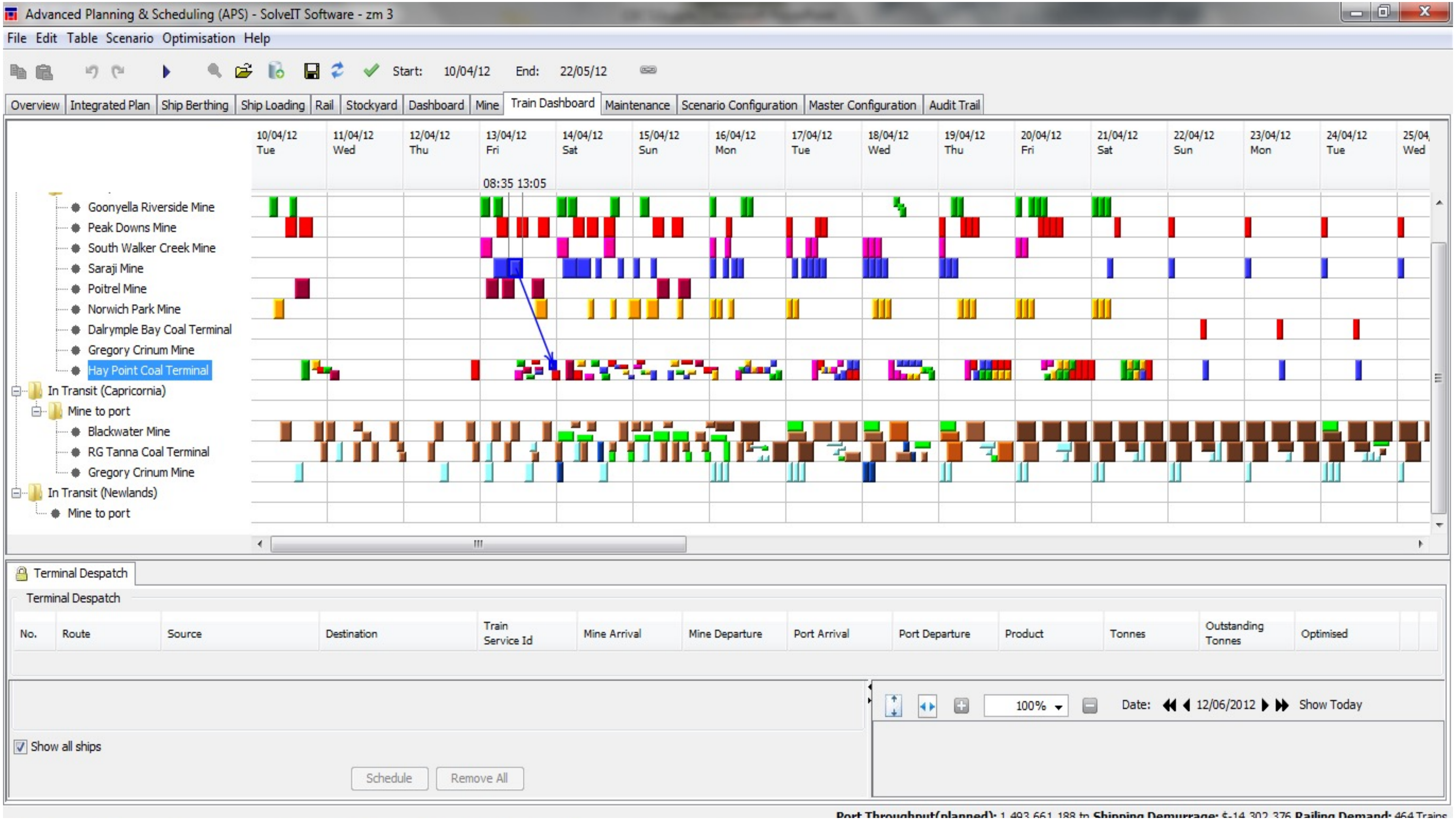
Global vs. Local optimization



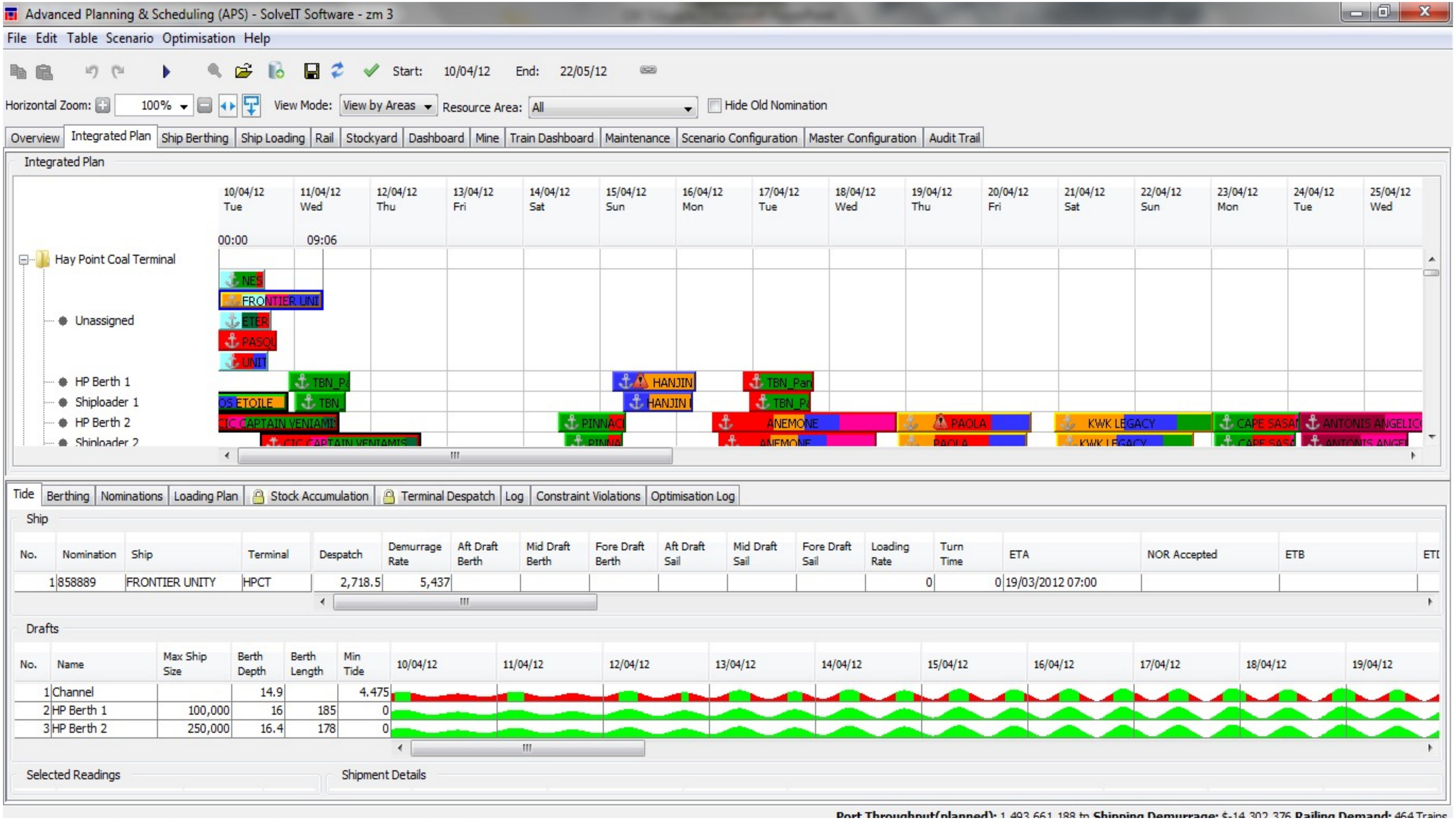

Advanced Planning & Scheduling (APS) - SolveIT Software - zm 3
File Edit Table Scenario Optimisation Help
Start: 10/04/12 End: 22/05/12
Overview
Integrated Plan
Ship Berthing
Ship Loading
Rail
Stockyard
Dashboard
Mine
Train Dashboard
Maintenance
Scenario Configuration
Master Configuration
Audit Trail
Queensland >>
Bowen
Abbot Point Coal Terminal
Mackay
Dalrymple Bay Coal Terminal
Hay Point Coal Terminal
Goonyella
Newlands
South Walker Creek Mine
Goonyella Riverside Mine
Poitrel Mine
Peak Downs Mine
Saraji Mine
Norwich Park Mine
Capricornia
Gregory Crinum Mine
Blackwater Mine
Gladstone
RG Tanna Coal Terminal
Barney Point Coal Terminal
Port Throughput
Tonnes
Abbot Point Coal Terminal-APCT
Barney Point Coal Terminal-BPCT
Dalrymple Bay Coal Terminal-DBCT
Hay Point Coal Terminal-HPCT
RG Tanna Coal Terminal-RGTCT
Shipping Demurrage
Amount (USD)
0
-1,000,000
-2,000,000
10/04/2012
11/04/2012
12/04/2012
13/04/2012
14/04/2012
15/04/2012
16/04/2012
Despatch
Demurrage
Rail Demand Variability(Deviation = 6.9,Mean =13.0)
Number Of Trains
Mean=13.0
20
10
0
zm 3



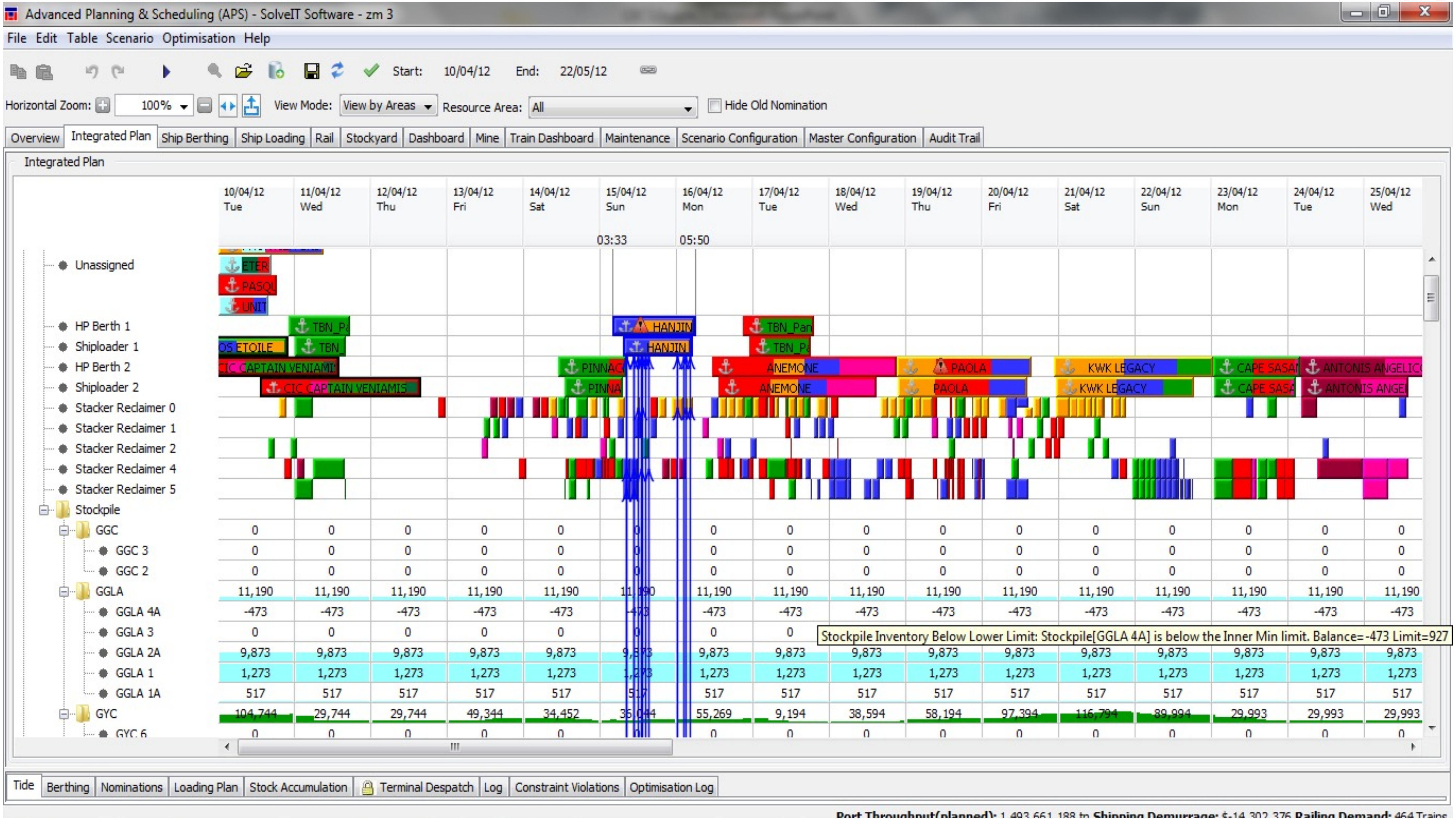
No.	Product	Opening Inventory	10/04/2012			11/04/2012			12/04/2012			13/04/2012			14/04/2012			15/04/2012			1
			Train Unload	Ship Load	Closing Inventory	Train Unload	Ship Load	Closing Inventory	Train Unload	Ship Load	Closing Inventory	Train Unload	Ship Load	Closing Inventory	Train Unload	Ship Load	Closing Inventory	Train Unload	Ship Load	Closing Inventory	Train Unload
1	GYC	85,421	19,600		105,021			30,022			30,022	19,600		49,622	19,600	60,001	34,729	19,600		36,321	19,600
2	PDC	142,021	9,800		151,821			151,821	9,800		161,621	19,600		181,221	29,400	60,000	205,017	29,400		222,521	
3	SRC	34,607			34,607			34,607			34,607	19,600		54,207	29,400		83,607	29,400		88,006	39,200
4	SWKP	37,360			37,360			37,360			37,360	9,800		47,160	9,800	7,344	56,960	9,800		66,760	19,600
5	GGLA	9,917			9,917			9,917			9,917			9,917			9,917			9,917	
6	GYLS	69,156			69,156			69,156			69,156			69,156			69,156			69,156	
7	NPX																				
8	PTC	28,802			28,802	9,800		38,602			38,602	19,600		58,202	9,800		68,002	9,800		77,802	9,800
9	NPC	1,139	9,800		10,939			10,939			10,939			10,939	19,600		30,539	19,600		31,811	29,400
10	PTPC	3,984			3,984			3,984			3,984			3,984			3,984			3,984	



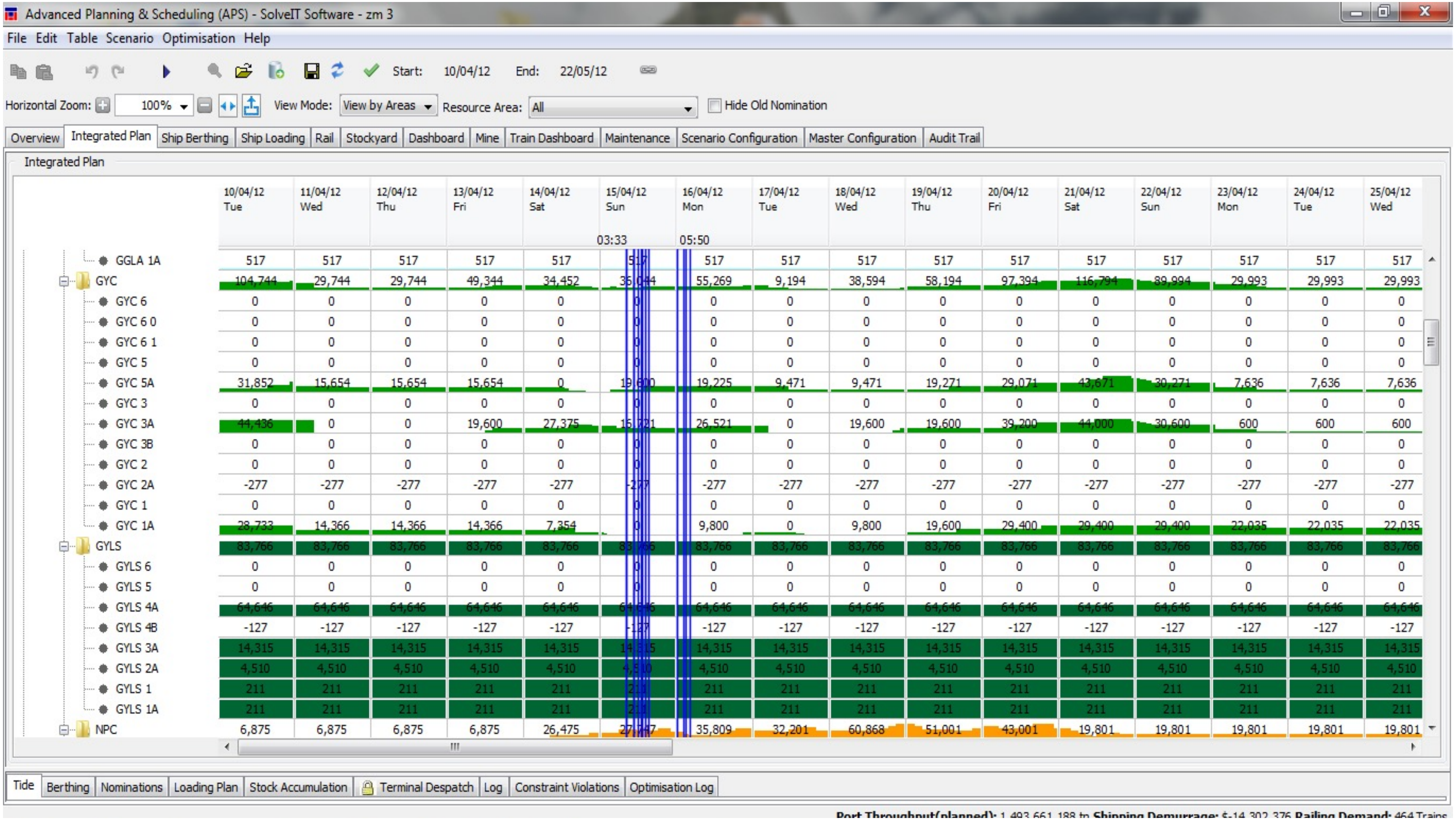
Advanced Planning & Scheduling (APS) - SolveIT Software - zm 3
File Edit Table Scenario Optimisation Help
Start: 10/04/12 End: 22/05/12
Overview | Integrated Plan | Ship Berthing | Ship Loading | Rail | Stockyard | Dashboard | Mine | Train Dashboard | Maintenance | Scenario Configuration | Master Configuration | Audit Trail
10/04/12 Tue
11/04/12 Wed
12/04/12 Thu
13/04/12 Fri
14/04/12 Sat
15/04/12 Sun
16/04/12 Mon
17/04/12 Tue
18/04/12 Wed
19/04/12 Thu
20/04/12 Fri
21/04/12 Sat
22/04/12 Sun
23/04/12 Mon
24/04/12 Tue
25/04 Wed
08:35 13:05
Goonyella Riverside Mine
Peak Downs Mine
South Walker Creek Mine
Saraji Mine
Poitrel Mine
Norwich Park Mine
Dalrymple Bay Coal Terminal
Gregory Crinum Mine
Hay Point Coal Terminal
In Transit (Capricornia)
Mine to port
Blackwater Mine
RG Tanna Coal Terminal
Gregory Crinum Mine
In Transit (Newlands)
Mine to port
Terminal Despatch
Terminal Despatch
No. | Route | Source | Destination | Train Service Id | Mine Arrival | Mine Departure | Port Arrival | Port Departure | Product | Tonnes | Outstanding Tonnes | Optimised
100%
Date: 12/06/2012 Show Today
Show all ships
Schedule
Remove All
Port Throughput(planned): 1 493 661 188 tn Shipping Demurrage: $-14 302 376 Railing Demand: 464 Trains



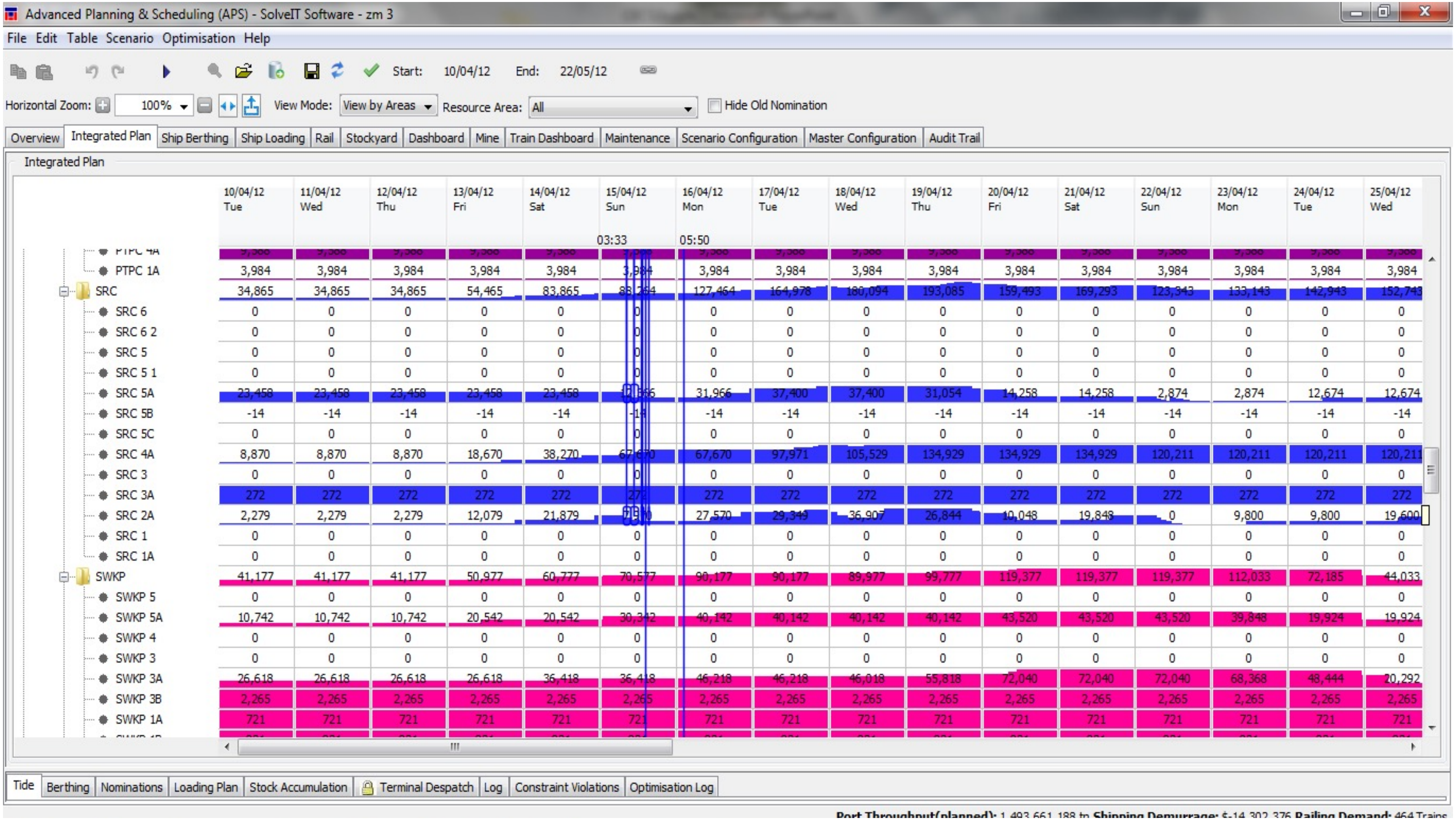
Advanced Planning & Scheduling (APS) - SolveIT Software - zm 3
File Edit Table Scenario Optimisation Help
Start: 10/04/12 End: 22/05/12
Horizontal Zoom: 100%
View Mode: View by Areas
Resource Area: All
Hide Old Nomination
Overview Integrated Plan Ship Berthing Ship Loading Rail Stockyard Dashboard Mine Train Dashboard Maintenance Scenario Configuration Master Configuration Audit Trail
Integrated Plan
10/04/12 Tue 11/04/12 Wed 12/04/12 Thu 13/04/12 Fri 14/04/12 Sat 15/04/12 Sun 16/04/12 Mon 17/04/12 Tue 18/04/12 Wed 19/04/12 Thu 20/04/12 Fri 21/04/12 Sat 22/04/12 Sun 23/04/12 Mon 24/04/12 Tue 25/04/12 Wed
00:00
09:06
Hay Point Coal Terminal
Unassigned
HP Berth 1
Shiploader 1
HP Berth 2
Shiploader 2
FRONTIER UNI
PASQU
UNIT
TBN_Pa
OS ETOILE
TBN
CIC CAPTAIN VENIAMI
HANJIN
PINNAC
ANEMONE
PAOLA
KWK LEGACY
CAPE SASA
ANTONIS ANGELIC
Tide Berthing Nominations Loading Plan Stock Accumulation Terminal Despatch Log Constraint Violations Optimisation Log
Ship
No. Nomination Ship Terminal Despatch Demurrage Rate Aft Draft Berth Mid Draft Berth Fore Draft Berth Aft Draft Sail Mid Draft Sail Fore Draft Sail Loading Rate Turn Time ETA NOR Accepted ETB
1 858889 FRONTIER UNITY HPCT 2,718.5 5,437 0 0 19/03/2012 07:00
Drafts
No. Name Max Ship Size Berth Depth Berth Length Min Tide 10/04/12 11/04/12 12/04/12 13/04/12 14/04/12 15/04/12 16/04/12 17/04/12 18/04/12 19/04/12
1 Channel 14.9 4.475
2 HP Berth 1 100,000 16 185 0
3 HP Berth 2 250,000 16.4 178 0
Selected Readings
Shipment Details



Advanced Planning & Scheduling (APS) - SolveIT Software - zm 3
File Edit Table Scenario Optimisation Help
Start: 10/04/12 End: 22/05/12
Horizontal Zoom: 100%
View Mode: View by Areas
Resource Area: All
Hide Old Nomination
Overview
Integrated Plan
Ship Berthing
Ship Loading
Rail
Stockyard
Dashboard
Mine
Train Dashboard
Maintenance
Scenario Configuration
Master Configuration
Audit Trail
Integrated Plan
10/04/12 Tue
11/04/12 Wed
12/04/12 Thu
13/04/12 Fri
14/04/12 Sat
15/04/12 Sun
16/04/12 Mon
17/04/12 Tue
18/04/12 Wed
19/04/12 Thu
20/04/12 Fri
21/04/12 Sat
22/04/12 Sun
23/04/12 Mon
24/04/12 Tue
25/04/12 Wed
03:33
05:50
Unassigned
HP Berth 1
Shiploader 1
HP Berth 2
Shiploader 2
Stacker Reclaimer 0
Stacker Reclaimer 1
Stacker Reclaimer 2
Stacker Reclaimer 4
Stacker Reclaimer 5
Stockpile
GGC
GGC 3
GGC 2
GGLA
GGLA 4A
GGLA 3
GGLA 2A
GGLA 1
GGLA 1A
GYC
GYC 6
ETER
PASQL
UNIT
TBN_Pa
TBN
OS ETOILE
CIC CAPTAIN VENIAMI
CIC CAPTAIN VENIAMIS
HANJIN
TBN_Pan
PINNAC
PINNA
ANEMONE
PAOLA
KWK LEGACY
CAPE SASA
ANTONIS ANGELIC
ANTONIS ANGEL
11,190
-473
9,873
1,273
517
104,744
29,744
49,344
34,452
55,269
9,194
38,594
58,194
97,394
116,794
89,994
29,993
Stockpile Inventory Below Lower Limit: Stockpile[GGLA 4A] is below the Inner Min limit. Balance=-473 Limit=927
Tide
Berthing
Nominations
Loading Plan
Stock Accumulation
Terminal Despatch
Log
Constraint Violations
Optimisation Log
Port Throughput(planned): 1,493,661,188 tn Shipping Demurrage: $-14,302,376 Railing Demand: 464 Trains



	10/04/12 Tue	11/04/12 Wed	12/04/12 Thu	13/04/12 Fri	14/04/12 Sat	15/04/12 Sun	16/04/12 Mon	17/04/12 Tue	18/04/12 Wed	19/04/12 Thu	20/04/12 Fri	21/04/12 Sat	22/04/12 Sun	23/04/12 Mon	24/04/12 Tue	25/04/12 Wed
GGLA 1A	517	517	517	517	517	517	517	517	517	517	517	517	517	517	517	517
GYC	104,744	29,744	29,744	49,344	34,452	36,044	55,269	9,194	38,594	58,194	97,394	116,794	89,994	29,993	29,993	29,993
GYC 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GYC 6 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GYC 6 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GYC 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GYC 5A	31,852	15,654	15,654	15,654	0	19,600	19,225	9,471	9,471	19,271	29,071	43,671	30,271	7,636	7,636	7,636
GYC 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GYC 3A	44,436	0	0	19,600	27,375	16,721	26,521	0	19,600	19,600	39,200	44,000	30,600	600	600	600
GYC 3B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GYC 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GYC 2A	-277	-277	-277	-277	-277	-277	-277	-277	-277	-277	-277	-277	-277	-277	-277	-277
GYC 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GYC 1A	28,733	14,366	14,366	14,366	7,354	0	9,800	0	9,800	19,600	29,400	29,400	29,400	22,035	22,035	22,035
GYLS	83,766	83,766	83,766	83,766	83,766	83,766	83,766	83,766	83,766	83,766	83,766	83,766	83,766	83,766	83,766	83,766
GYLS 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GYLS 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GYLS 4A	64,646	64,646	64,646	64,646	64,646	64,646	64,646	64,646	64,646	64,646	64,646	64,646	64,646	64,646	64,646	64,646
GYLS 4B	-127	-127	-127	-127	-127	-127	-127	-127	-127	-127	-127	-127	-127	-127	-127	-127
GYLS 3A	14,315	14,315	14,315	14,315	14,315	14,315	14,315	14,315	14,315	14,315	14,315	14,315	14,315	14,315	14,315	14,315
GYLS 2A	4,510	4,510	4,510	4,510	4,510	4,510	4,510	4,510	4,510	4,510	4,510	4,510	4,510	4,510	4,510	4,510
GYLS 1	211	211	211	211	211	211	211	211	211	211	211	211	211	211	211	211
GYLS 1A	211	211	211	211	211	211	211	211	211	211	211	211	211	211	211	211
NPC	6,875	6,875	6,875	6,875	26,475	27,747	35,809	32,201	60,868	51,001	43,001	19,801	19,801	19,801	19,801	19,801


Advanced Planning & Scheduling (APS) - SolveIT Software - zm 3

File Edit Table Scenario Optimisation Help

Start: 10/04/12 End: 22/05/12

Horizontal Zoom: 100% View Mode: View by Areas Resource Area: All Hide Old Nomination

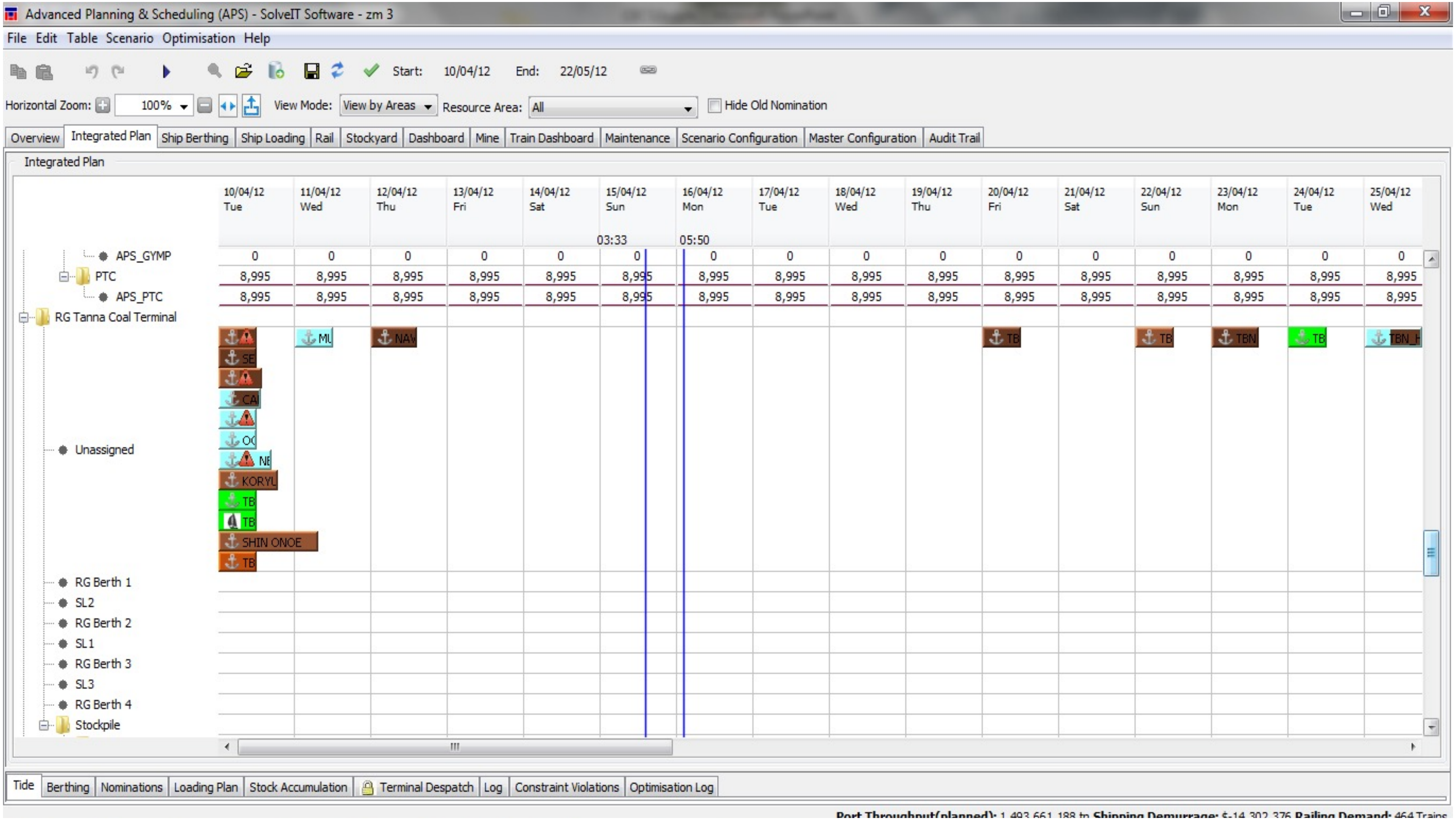
Overview | Integrated Plan | Ship Berthing | Ship Loading | Rail | Stockyard | Dashboard | Mine | Train Dashboard | Maintenance | Scenario Configuration | Master Configuration | Audit Trail

Integrated Plan

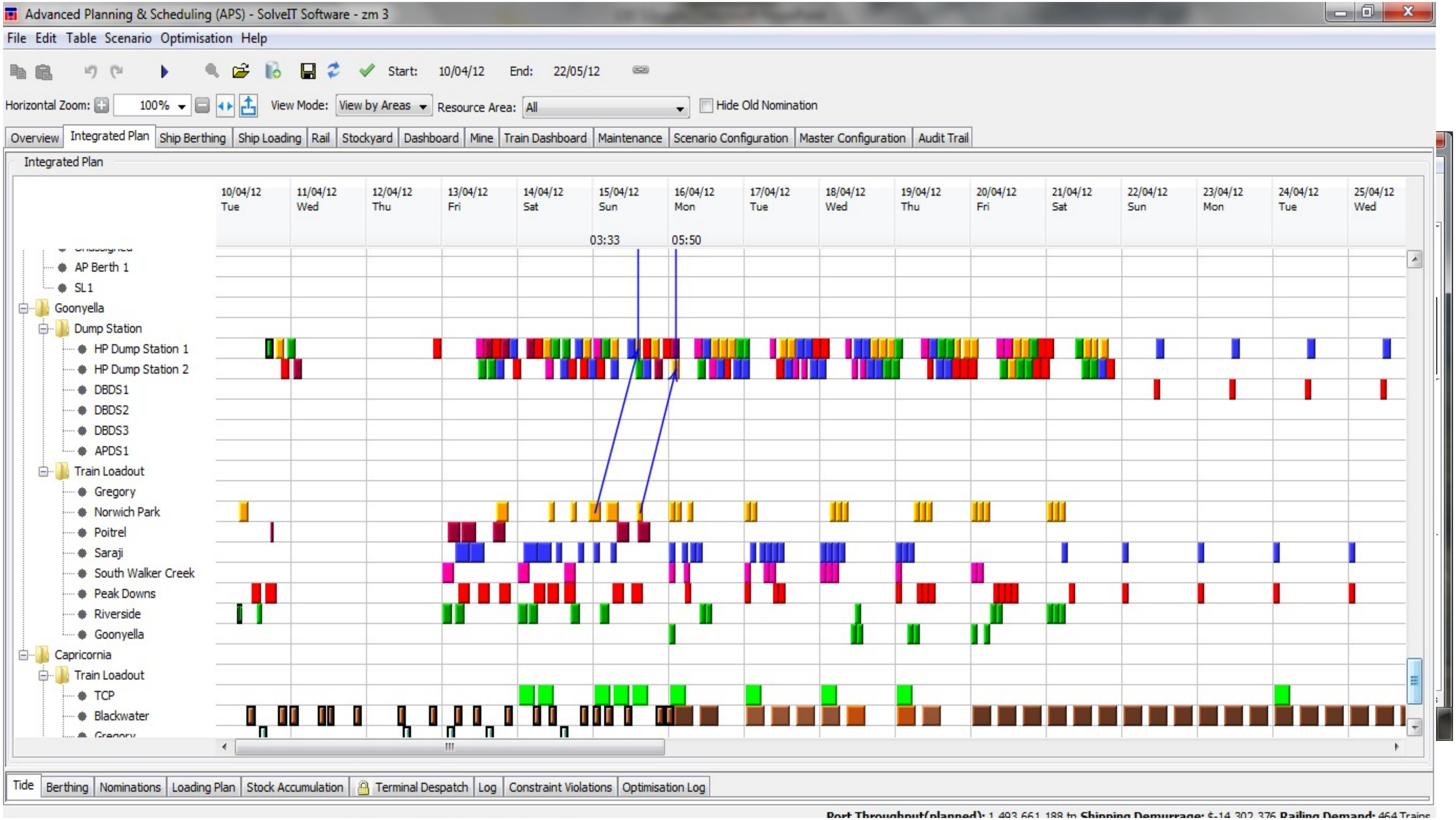
	10/04/12 Tue	11/04/12 Wed	12/04/12 Thu	13/04/12 Fri	14/04/12 Sat	15/04/12 Sun 03:33	16/04/12 Mon 05:50	17/04/12 Tue	18/04/12 Wed	19/04/12 Thu	20/04/12 Fri	21/04/12 Sat	22/04/12 Sun	23/04/12 Mon	24/04/12 Tue	25/04/12 Wed
PTPC 4A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PTPC 1A	3,984	3,984	3,984	3,984	3,984	3,984	3,984	3,984	3,984	3,984	3,984	3,984	3,984	3,984	3,984	3,984
SRC	34,865	34,865	34,865	54,465	83,865	88,264	127,464	164,978	180,094	193,085	159,493	169,293	123,343	133,143	142,943	152,743
SRC 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRC 6 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRC 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRC 5 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRC 5A	23,458	23,458	23,458	23,458	23,458	[illegible]	31,966	37,400	37,400	31,054	14,258	14,258	2,874	2,874	12,674	12,674
SRC 5B	-14	-14	-14	-14	-14	-14	-14	-14	-14	-14	-14	-14	-14	-14	-14	-14
SRC 5C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRC 4A	8,870	8,870	8,870	18,670	38,270	67,670	67,670	97,971	105,529	134,929	134,929	134,929	120,211	120,211	120,211	120,211
SRC 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRC 3A	272	272	272	272	272	272	272	272	272	272	272	272	272	272	272	272
SRC 2A	2,279	2,279	2,279	12,079	21,879	[illegible]	27,570	29,349	36,907	26,844	10,048	19,848	0	9,800	9,800	19,600
SRC 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SRC 1A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SWKP	41,177	41,177	41,177	50,977	60,777	70,577	90,177	90,177	89,977	99,777	119,377	119,377	119,377	112,033	72,185	44,033
SWKP 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SWKP 5A	10,742	10,742	10,742	20,542	20,542	30,342	40,142	40,142	40,142	40,142	43,520	43,520	43,520	39,848	19,924	19,924
SWKP 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SWKP 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SWKP 3A	26,618	26,618	26,618	26,618	36,418	36,418	46,218	46,218	46,018	55,818	72,040	72,040	72,040	68,368	48,444	20,292
SWKP 3B	2,265	2,265	2,265	2,265	2,265	2,265	2,265	2,265	2,265	2,265	2,265	2,265	2,265	2,265	2,265	2,265
SWKP 1A	721	721	721	721	721	721	721	721	721	721	721	721	721	721	721	721

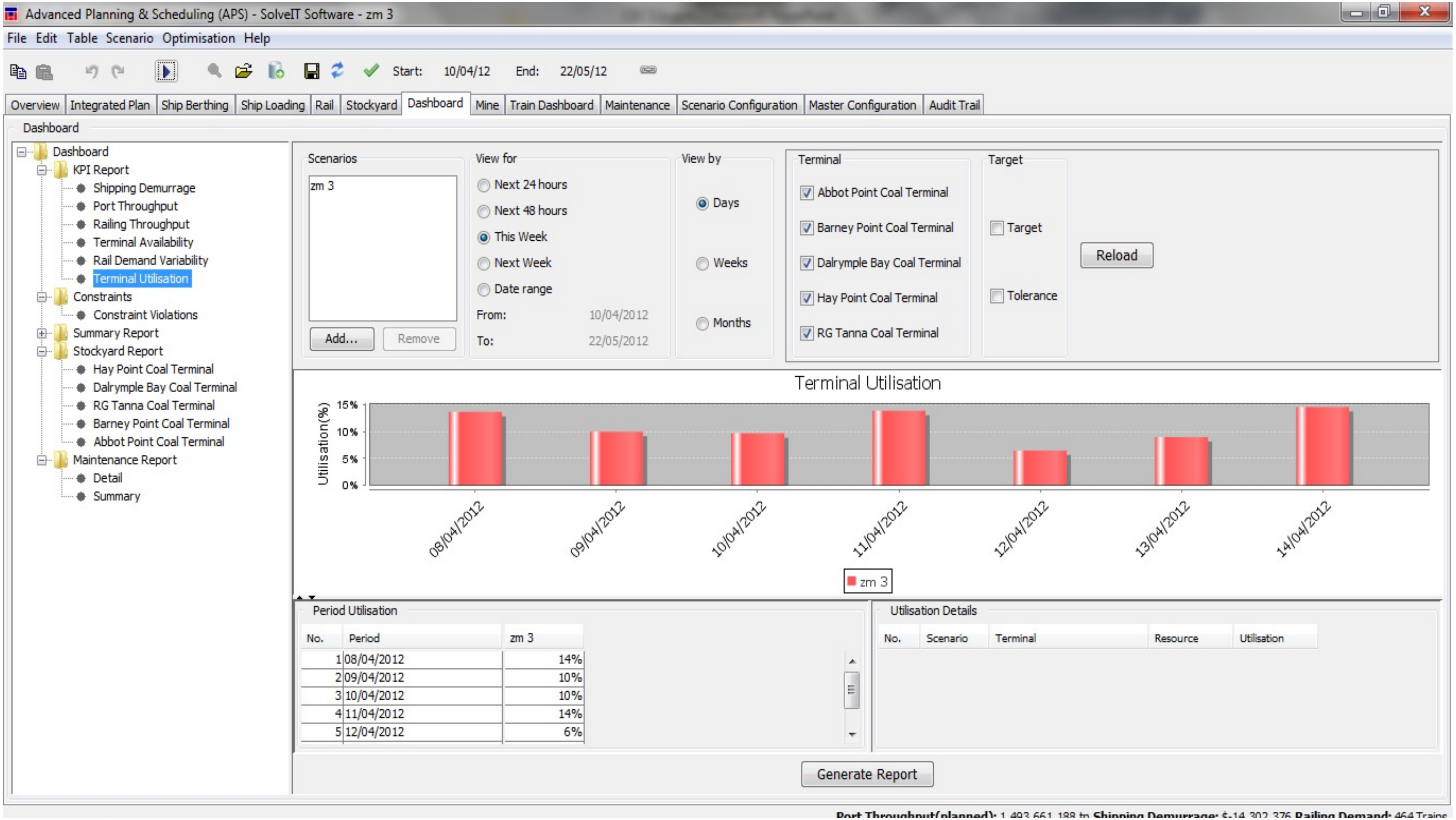
Tide | Berthing | Nominations | Loading Plan | Stock Accumulation | Terminal Despatch | Log | Constraint Violations | Optimisation Log

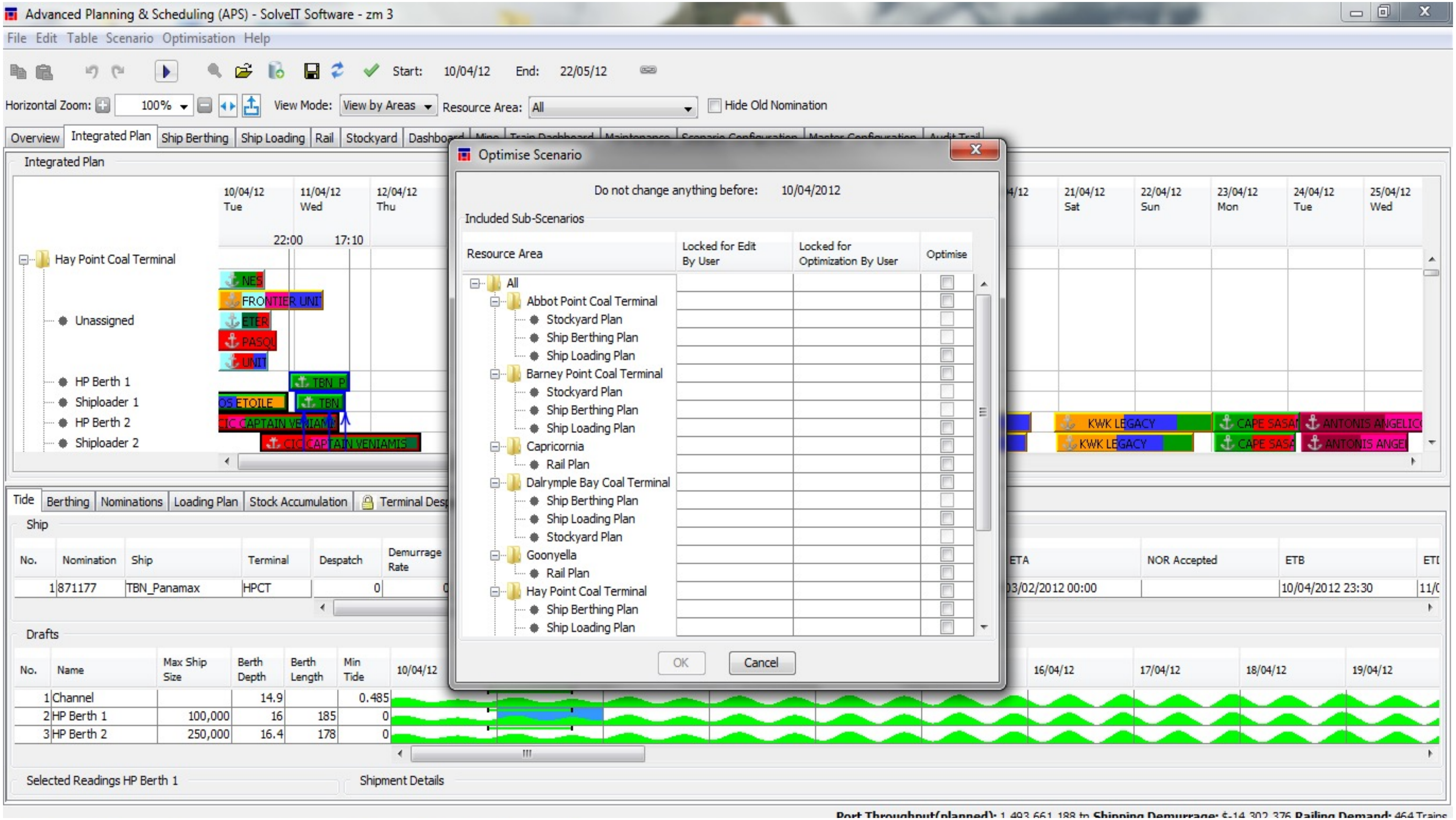
Port Throughput(planned): 1,493,661,188 tn **Shipping Demurrage:** $-14,302,376 **Railing Demand:** 464 Trains



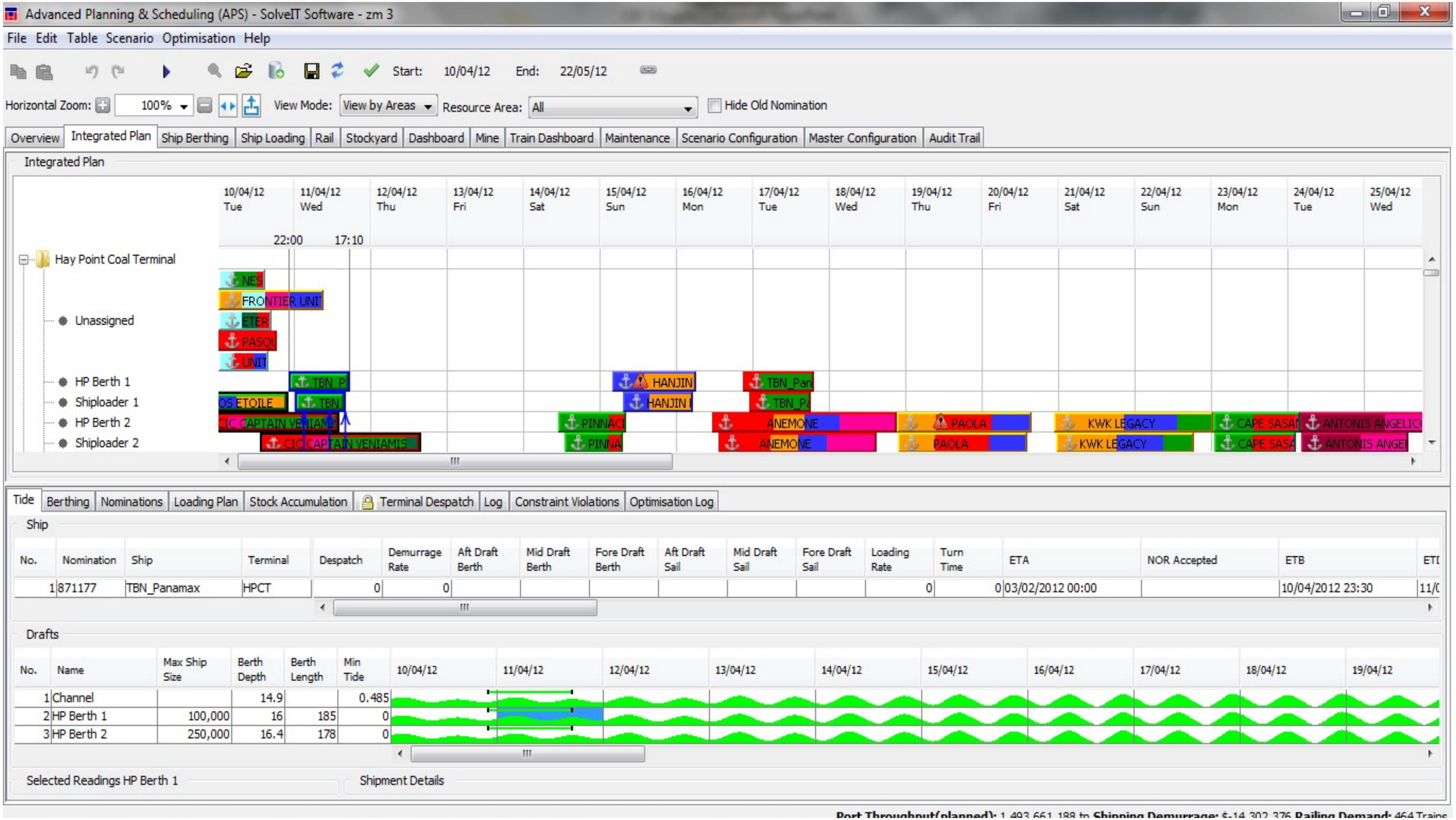
Advanced Planning & Scheduling (APS) - SolveIT Software - zm 3
File Edit Table Scenario Optimisation Help
Start: 10/04/12 End: 22/05/12
Horizontal Zoom: 100% View Mode: View by Areas Resource Area: All Hide Old Nomination
Overview Integrated Plan Ship Berthing Ship Loading Rail Stockyard Dashboard Mine Train Dashboard Maintenance Scenario Configuration Master Configuration Audit Trail
Integrated Plan
10/04/12 Tue 11/04/12 Wed 12/04/12 Thu 13/04/12 Fri 14/04/12 Sat 15/04/12 Sun 16/04/12 Mon 17/04/12 Tue 18/04/12 Wed 19/04/12 Thu 20/04/12 Fri 21/04/12 Sat 22/04/12 Sun 23/04/12 Mon 24/04/12 Tue 25/04/12 Wed
03:33
05:50
APS_GYMP 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
PTC 8,995 8,995 8,995 8,995 8,995 8,995 8,995 8,995 8,995 8,995 8,995 8,995 8,995 8,995 8,995 8,995
APS_PTC 8,995 8,995 8,995 8,995 8,995 8,995 8,995 8,995 8,995 8,995 8,995 8,995 8,995 8,995 8,995 8,995
RG Tanna Coal Terminal
Unassigned
KORYU
SHIN ONOE
TBN
RG Berth 1
SL2
RG Berth 2
SL1
RG Berth 3
SL3
RG Berth 4
Stockpile
Tide Berthing Nominations Loading Plan Stock Accumulation Terminal Despatch Log Constraint Violations Optimisation Log

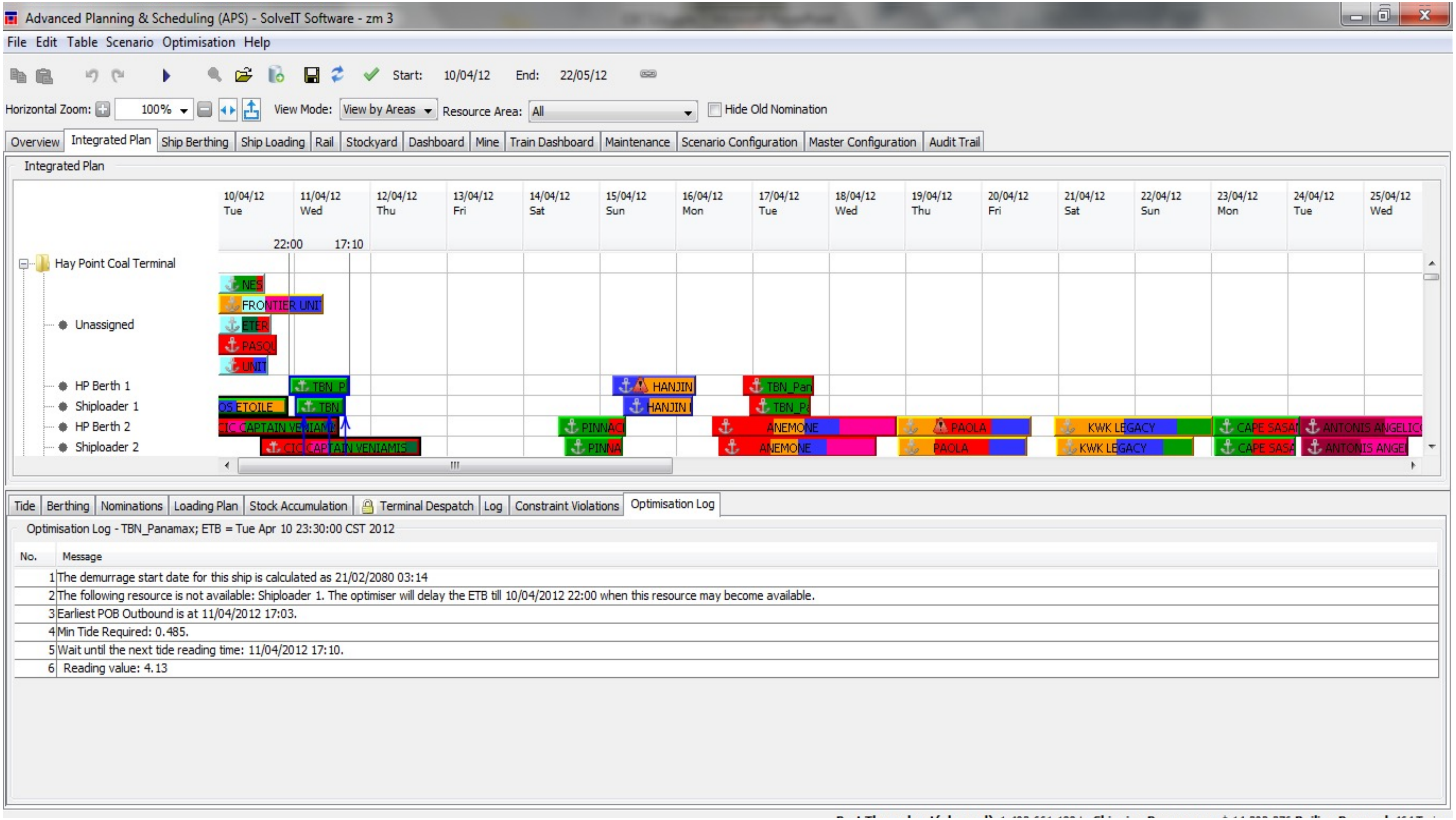

Advanced Planning & Scheduling (APS) - SolveIT Software - zm 3
File Edit Table Scenario Optimisation Help
Start: 10/04/12 End: 22/05/12
Horizontal Zoom: 100%
View Mode: View by Areas
Resource Area: All
Hide Old Nomination
Overview
Integrated Plan
Ship Berthing
Ship Loading
Rail
Stockyard
Dashboard
Mine
Train Dashboard
Maintenance
Scenario Configuration
Master Configuration
Audit Trail
Integrated Plan
10/04/12 Tue
11/04/12 Wed
12/04/12 Thu
13/04/12 Fri
14/04/12 Sat
15/04/12 Sun
16/04/12 Mon
17/04/12 Tue
18/04/12 Wed
19/04/12 Thu
20/04/12 Fri
21/04/12 Sat
22/04/12 Sun
23/04/12 Mon
24/04/12 Tue
25/04/12 Wed
03:33
05:50
AP Berth 1
SL1
Goonyella
Dump Station
HP Dump Station 1
HP Dump Station 2
DBDS1
DBDS2
DBDS3
APDS1
Train Loadout
Gregory
Norwich Park
Poitrel
Saraji
South Walker Creek
Peak Downs
Riverside
Goonyella
Capricornia
Train Loadout
TCP
Blackwater
Tide
Berthing
Nominations
Loading Plan
Stock Accumulation
Terminal Despatch
Log
Constraint Violations
Optimisation Log


Advanced Planning & Scheduling (APS) - SolveIT Software - zm 3
File Edit Table Scenario Optimisation Help
Start: 10/04/12 End: 22/05/12
Overview
Integrated Plan
Ship Berthing
Ship Loading
Rail
Stockyard
Dashboard
Mine
Train Dashboard
Maintenance
Scenario Configuration
Master Configuration
Audit Trail
Dashboard
KPI Report
Shipping Demurrage
Port Throughput
Railing Throughput
Terminal Availability
Rail Demand Variability
Terminal Utilisation
Constraints
Constraint Violations
Summary Report
Stockyard Report
Hay Point Coal Terminal
Dalrymple Bay Coal Terminal
RG Tanna Coal Terminal
Barney Point Coal Terminal
Abbot Point Coal Terminal
Maintenance Report
Detail
Summary
Scenarios
zm 3
Add...
Remove
View for
Next 24 hours
Next 48 hours
This Week
Next Week
Date range
From: 10/04/2012
To: 22/05/2012
View by
Days
Weeks
Months
Terminal
Abbot Point Coal Terminal
Barney Point Coal Terminal
Dalrymple Bay Coal Terminal
Hay Point Coal Terminal
RG Tanna Coal Terminal
Target
Target
Tolerance
Reload
Terminal Utilisation
Utilisation(%)
15%
10%
5%
0%
08/04/2012
09/04/2012
10/04/2012
11/04/2012
12/04/2012
13/04/2012
14/04/2012
zm 3
Period Utilisation
No. Period zm 3
1 08/04/2012 14%
2 09/04/2012 10%
3 10/04/2012 10%
4 11/04/2012 14%
5 12/04/2012 6%
Utilisation Details
No. Scenario Terminal Resource Utilisation
Generate Report



Advanced Planning & Scheduling (APS) - SolveIT Software - zm 3
File Edit Table Scenario Optimisation Help
Start: 10/04/12 End: 22/05/12
Horizontal Zoom: 100%
View Mode: View by Areas
Resource Area: All
Hide Old Nomination
Overview
Integrated Plan
Ship Berthing
Ship Loading
Rail
Stockyard
Hay Point Coal Terminal
Unassigned
HP Berth 1
Shiploader 1
HP Berth 2
Shiploader 2
Optimise Scenario
Do not change anything before: 10/04/2012
Included Sub-Scenarios
Resource Area
Locked for Edit By User
Locked for Optimization By User
Optimise
All
Abbot Point Coal Terminal
Stockyard Plan
Ship Berthing Plan
Ship Loading Plan
Barney Point Coal Terminal
Stockyard Plan
Ship Berthing Plan
Ship Loading Plan
Capricornia
Rail Plan
Dalrymple Bay Coal Terminal
Ship Berthing Plan
Ship Loading Plan
Stockyard Plan
Goonyella
Rail Plan
Hay Point Coal Terminal
Ship Berthing Plan
Ship Loading Plan
OK
Cancel
Tide
Berthing
Nominations
Loading Plan
Stock Accumulation
Ship
No.
Nomination
Ship
Terminal
Despatch
Demurrage Rate
ETA
NOR Accepted
ETB
1
871177
TBN_Panamax
HPCT
0
10/04/2012 23:30
Drafts
No.
Name
Max Ship Size
Berth Depth
Berth Length
Min Tide
1 Channel 14.9 0.485
2 HP Berth 1 100,000 16 185 0
3 HP Berth 2 250,000 16.4 178 0
Selected Readings HP Berth 1
Shipment Details


Advanced Planning & Scheduling (APS) - SolveIT Software - zm 3
File Edit Table Scenario Optimisation Help
Start: 10/04/12 End: 22/05/12
Horizontal Zoom: 100% View Mode: View by Areas Resource Area: All Hide Old Nomination
Overview Integrated Plan Ship Berthing Ship Loading Rail Stockyard Dashboard Mine Train Dashboard Maintenance Scenario Configuration Master Configuration Audit Trail
Integrated Plan
10/04/12 Tue 11/04/12 Wed 12/04/12 Thu 13/04/12 Fri 14/04/12 Sat 15/04/12 Sun 16/04/12 Mon 17/04/12 Tue 18/04/12 Wed 19/04/12 Thu 20/04/12 Fri 21/04/12 Sat 22/04/12 Sun 23/04/12 Mon 24/04/12 Tue 25/04/12 Wed
22:00 17:10
Hay Point Coal Terminal
Unassigned
HP Berth 1
Shiploader 1
HP Berth 2
Shiploader 2
NES
FRONTIER UNI
ETER
PASQU
UNIT
TBN_P
TBN
OS ETOILE
CIC CAPTAIN VENIAMIS
HANJIN
TBN_Pan
PINNACI
ANEMONE
PAOLA
KWK LEGACY
CAPE SASA
ANTONIS ANGELIC
Tide Berthing Nominations Loading Plan Stock Accumulation Terminal Despatch Log Constraint Violations Optimisation Log
Ship
No. Nomination Ship Terminal Despatch Demurrage Rate Aft Draft Berth Mid Draft Berth Fore Draft Berth Aft Draft Sail Mid Draft Sail Fore Draft Sail Loading Rate Turn Time ETA NOR Accepted ETB
1 871177 TBN_Panamax HPCT 0 0 0 0 03/02/2012 00:00 10/04/2012 23:30
Drafts
No. Name Max Ship Size Berth Depth Berth Length Min Tide
1 Channel 14.9 0.485
2 HP Berth 1 100,000 16 185 0
3 HP Berth 2 250,000 16.4 178 0
10/04/12 11/04/12 12/04/12 13/04/12 14/04/12 15/04/12 16/04/12 17/04/12 18/04/12 19/04/12
Selected Readings HP Berth 1
Shipment Details
Port Throughput(planned): 1,493,661,188 tn Shipping Demurrage: $-14,302,376 Railing Demand: 464 Trains


Advanced Planning & Scheduling (APS) - SolveIT Software - zm 3
File Edit Table Scenario Optimisation Help
Start: 10/04/12 End: 22/05/12
Horizontal Zoom: 100% View Mode: View by Areas Resource Area: All Hide Old Nomination
Overview Integrated Plan Ship Berthing Ship Loading Rail Stockyard Dashboard Mine Train Dashboard Maintenance Scenario Configuration Master Configuration Audit Trail
Integrated Plan
10/04/12 Tue 11/04/12 Wed 12/04/12 Thu 13/04/12 Fri 14/04/12 Sat 15/04/12 Sun 16/04/12 Mon 17/04/12 Tue 18/04/12 Wed 19/04/12 Thu 20/04/12 Fri 21/04/12 Sat 22/04/12 Sun 23/04/12 Mon 24/04/12 Tue 25/04/12 Wed
22:00 17:10
Hay Point Coal Terminal
Unassigned
HP Berth 1
Shiploader 1
HP Berth 2
Shiploader 2
NES
FRONTIER UNI
ETER
PASQU
UNIT
TBN_P
OS ETOILE
TBN
CIC CAPTAIN VENIAMIS
HANJIN
TBN_Pan
PINNACI
PINNA
ANEMONE
PAOLA
KWK LEGACY
CAPE SASA
ANTONIS ANGELICO
Tide Berthing Nominations Loading Plan Stock Accumulation Terminal Despatch Log Constraint Violations Optimisation Log
Optimisation Log - TBN_Panamax; ETB = Tue Apr 10 23:30:00 CST 2012
No. Message
1 The demurrage start date for this ship is calculated as 21/02/2080 03:14
2 The following resource is not available: Shiploader 1. The optimiser will delay the ETB till 10/04/2012 22:00 when this resource may become available.
3 Earliest POB Outbound is at 11/04/2012 17:03.
4 Min Tide Required: 0.485.
5 Wait until the next tide reading time: 11/04/2012 17:10.
6 Reading value: 4.13

Global optimization – consequences

- SolveIT Software was the first company to offer "global solutions" for supply chain problems (including what-ifs, optimization)
- SolveIT Software won **every** mining tender: Billiton Mitsubishi Alliance, Rio Tinto, Xstrata, Fortescue, BHP Iron Ore, Hancock, PNC, QR, etc.
- SolveIT Software was acquired by Schneider Electric in August 2012

Outline of the talk

- ➢ 1999: NuTech Solutions
- ➢ 2005: SolveIT Software
- ➢ 2014: Complexica
- ➢ Some thoughts on business applications and the EC research

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2014

Promotional planning (2018)

We’ve all experienced product promotions, e.g.:

Sale! 50% off!

Buy one, get one free!

which manufacturers and retailers use to

- ✓ drive foot traffic into stores
- ✓ increase volume and market share
- ✓ build awareness for new products

These promotional activities are typically funded by both the retailer and participating manufacturer and can account for almost 20% of the revenue of fast-moving consumer goods (FMCG) companies.

Promotional planning

Retailer:	Mary's Market
State:	NSW
Category:	Snacks

A retailer with 500 stores across the country

	WK 1	WK 2	WK 3	WK 4	WK 5	WK 6	...	WK 51	WK 52
Product 1	Y	Y		Y	Y				
Product 2	Y		Y		Y	Y			Y
Product 3	Y		Y		Y	Y			Y
Product 4			Y						
Product 5	Y			Y					
Product 6	Y	Y		Y					
...									
Product 100	Y			Y	Y			Y	Y

Promotional planning

Retailer:	Mary's Market
State:	NSW
Category:	Snacks

	WK 1	WK 2	WK 3	WK 4	WK 5	WK 6	...	WK 51	WK 52
Product 1	Y	y		y	Y				
Product 2	y		y		y				y
Product 3	Y		y		y	Y			y
Product 4			Y			y			
Product 5	Y			Y					
Product 6	Y	y		y					
...									
Product 100	Y			y	Y			Y	

Promotion Type	In store
Promotional Price	$19.00
Shelf Price	$23.50
Discount	$4.50
Margin	35%
Retailer Margin	33%
Min/Max Frequencies	13/26 Weeks
Min/Max Sell Price	$12/20
Min/Max Promo Gap	2/6 Weeks

Promotional planning

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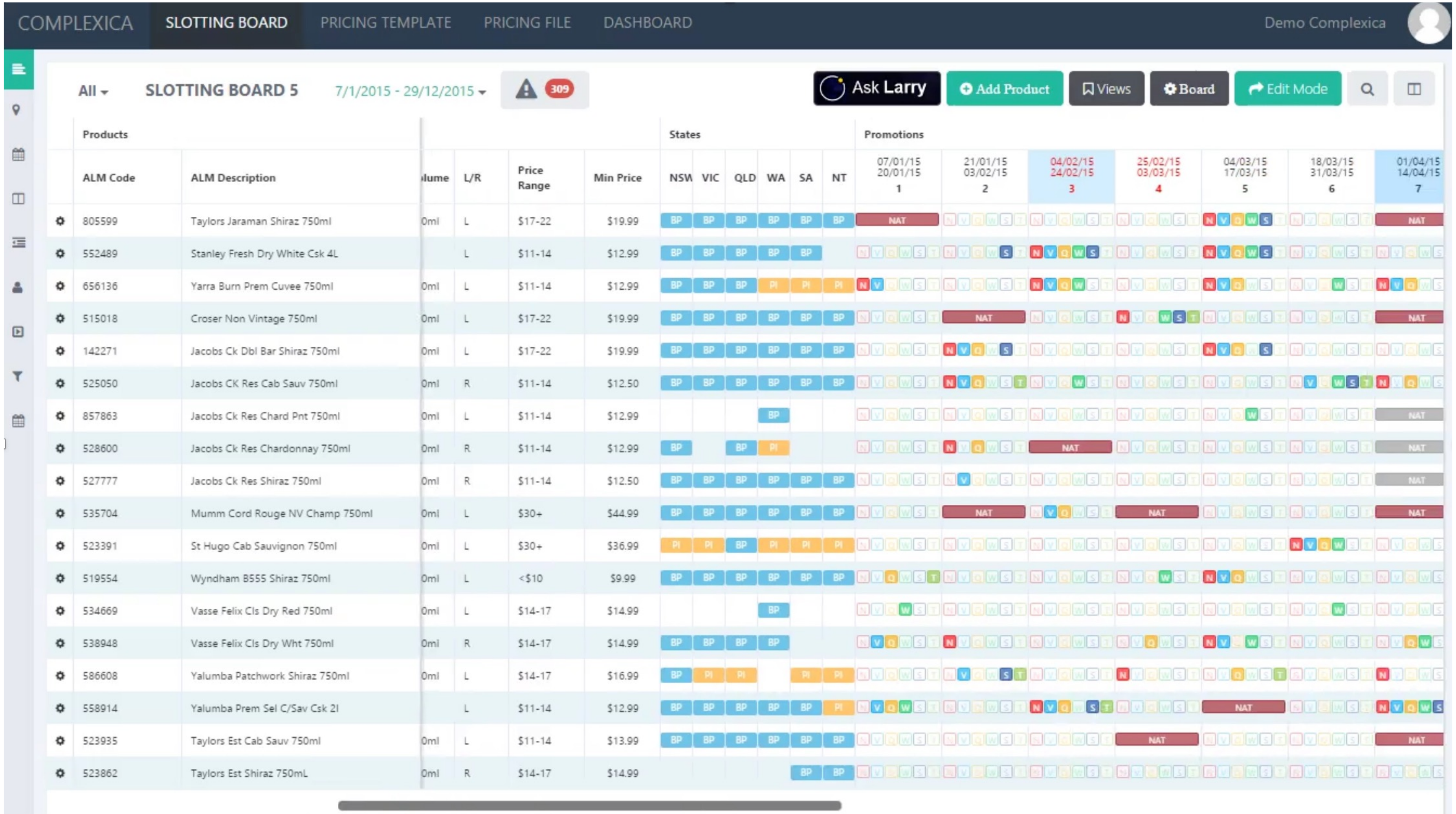
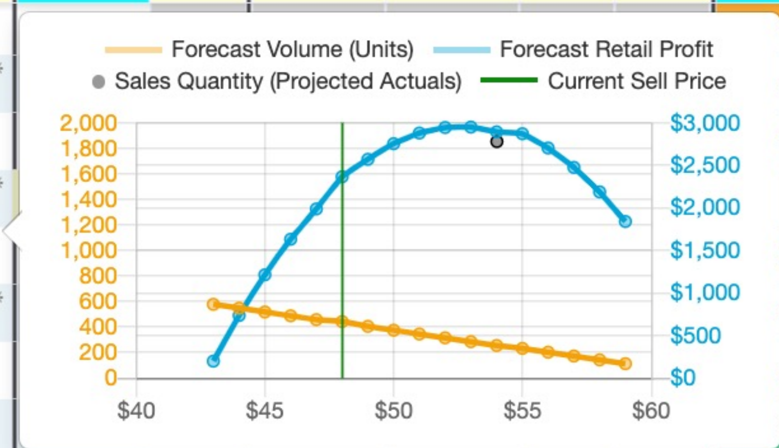


Discount Elasticities & Volume Predictions

Products ☐ Expand Ranges to Products

Group	I/S	Code	Supplier Description	Company Description	Source		Scan Deal: Company Scan State	Scan Deal: GP$	Multi: Multi	Multi: Price	Multi: GP%	Multi: GP$	Advertising: Program
	I	505165	BOAGS PREMIUM LGR BTL 375ML	BOAGS PREMIUM LGR BTL 24*375ML	Direct								
	I	518346	BOAGS PREMIUM LGR BTL 24*375ML	BOAGS PREMIUM LGR BTL 24*375ML	Direct								
	I	512544	BOAGS PREMIUM LGR BTL 6*375ML	BOAGS PREMIUM LGR BTL 6*375ML	Direct								
	I	584169	CARLTON MID CAN 30PK 375ML	CARLTON MID CAN 30PK 375ML	Direct								
	I	504703	COOPERS SPK ALE BTL 375ML	COOPERS SPK ALE 375ML	ALM								
	I	517895	COOPERS SPK ALE BTL 24*375ML	COOPERS SPK ALE BTL 24*375ML	ALM								
	I	513689	COOPERS SPK ALE BTL 6*375ML	COOPERS SPK ALE BTL 6*375ML	ALM								
	I	728404	COOPERS SPK ALE CAN 375ML	COOPERS SPK ALE CAN 375ML	ALM								



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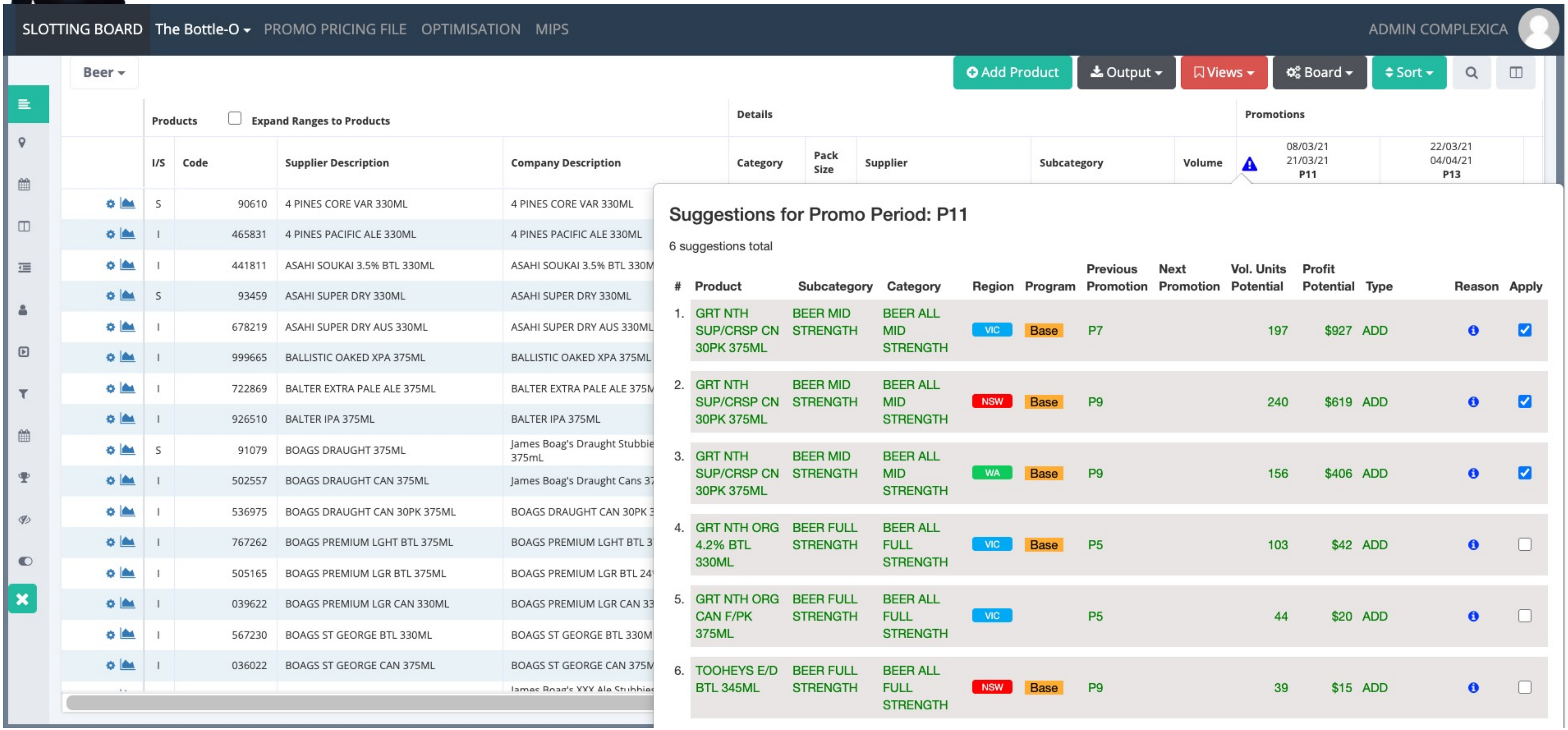
Optimized Recommendations

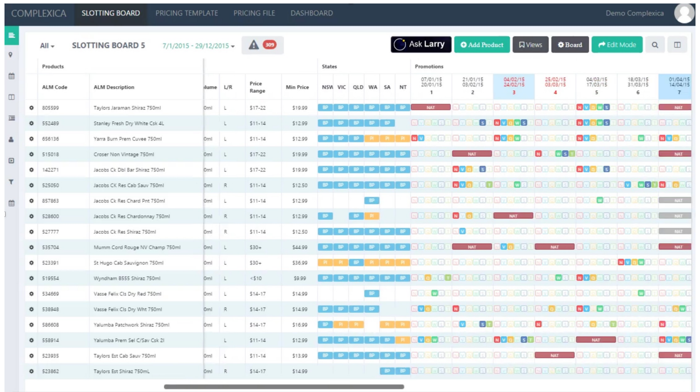


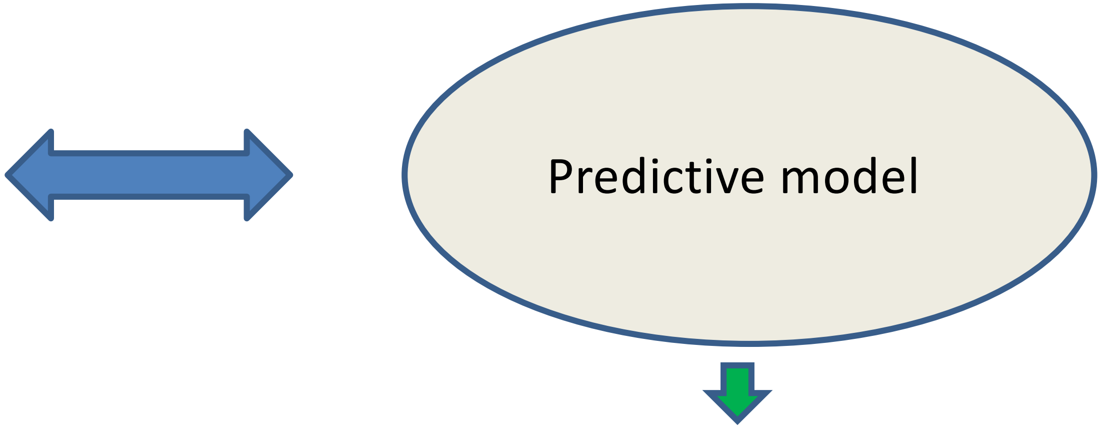
Promotional planning

Predictive model should take into account:

- *Promotion mechanics* (e.g. two-for-one, % off)
- *Off-location* for the product
- *Shelf price and discount* of different products
- *Catalogue entry* (if any)
- *Price elasticity* of different products
- *Pack-size cannibalization* among products
- *Sub-category cannibalization* among products
- *Cross-category cannibalization* among products
- *Delayed cannibalization*
- *Seasonality, including key selling periods*
- *Cross-retailer cannibalization*

Promotional planning

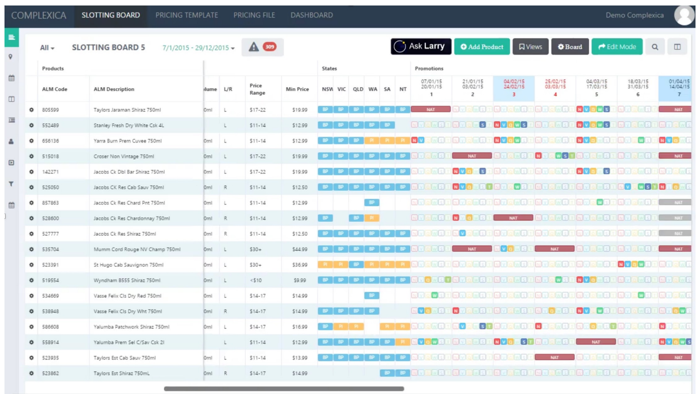




- *Volume*:
- *Net revenue*:
- *Retailer gross profit*:
- *Manufacturer gross profit*:

and values for many constraints…

Promotional planning



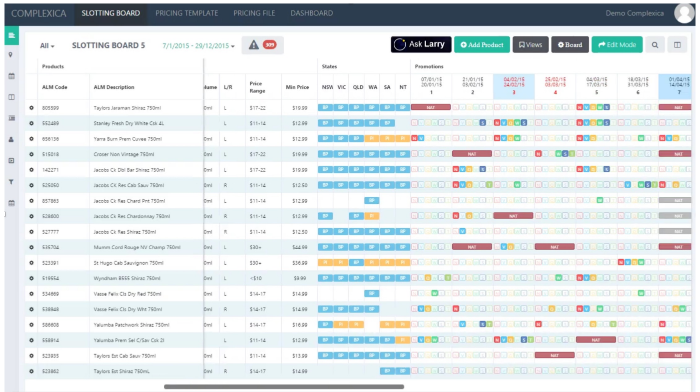
Predictive model

- *Volume*:
- *Net revenue*:
- *Retailer gross profit*:
- *Manufacturer gross profit*:

and values for many constraints…

New data coming in (sometimes daily)

Promotional planning



comparisons predicted vs. actuals

Predictive model

- *Volume*:
- *Net revenue*:
- *Retailer gross profit*:
- *Manufacturer gross profit*:

and values for many constraints…

New data coming in (sometimes daily)

Outline of the talk

- 1999: NuTech Solutions
- 2005: SolveIT Software
- 2014: Complexica
- Some thoughts on business applications and the EC research

The Problem to Decision Pyramid

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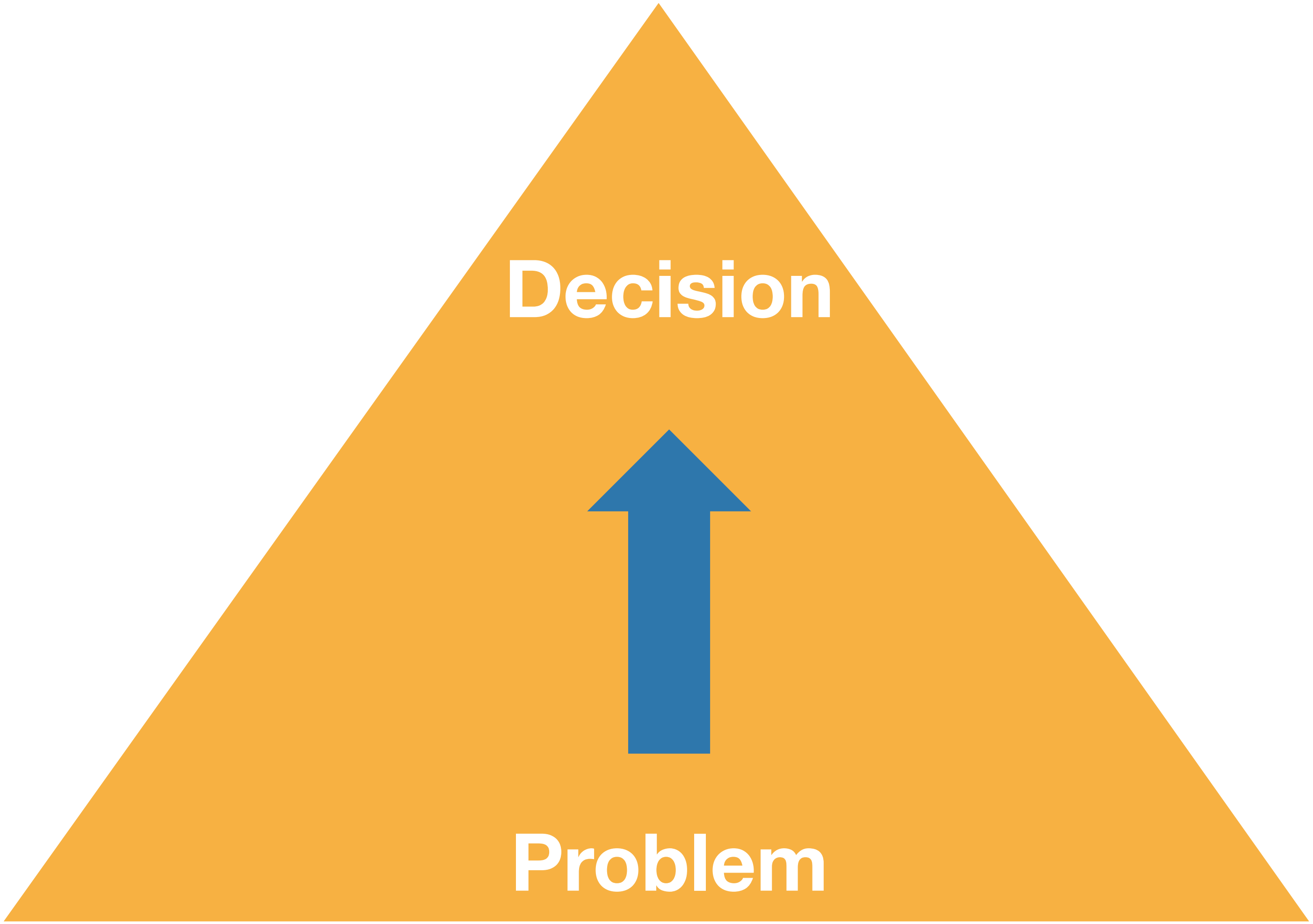
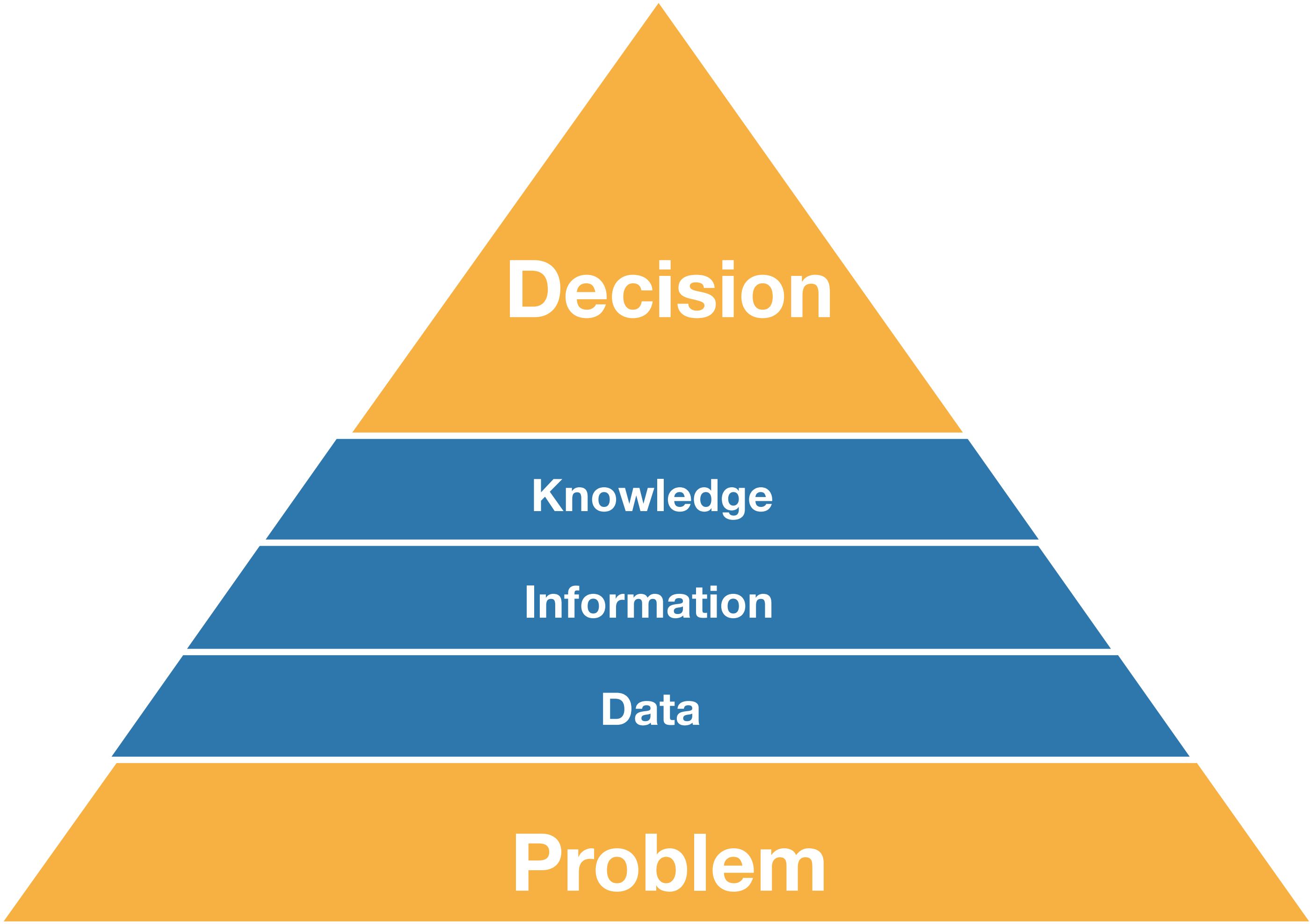


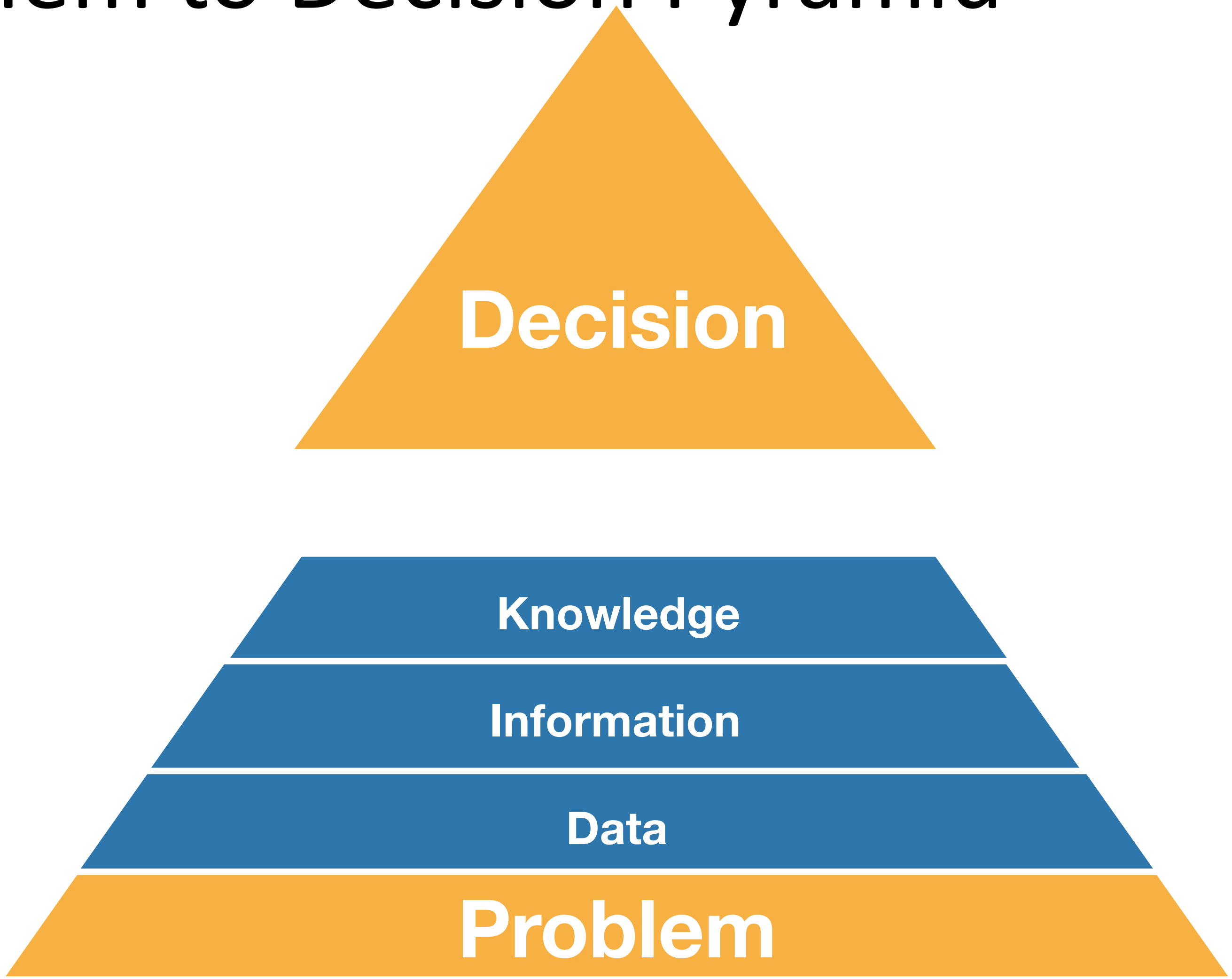
The Problem to Decision Pyramid

COMPLEXICA



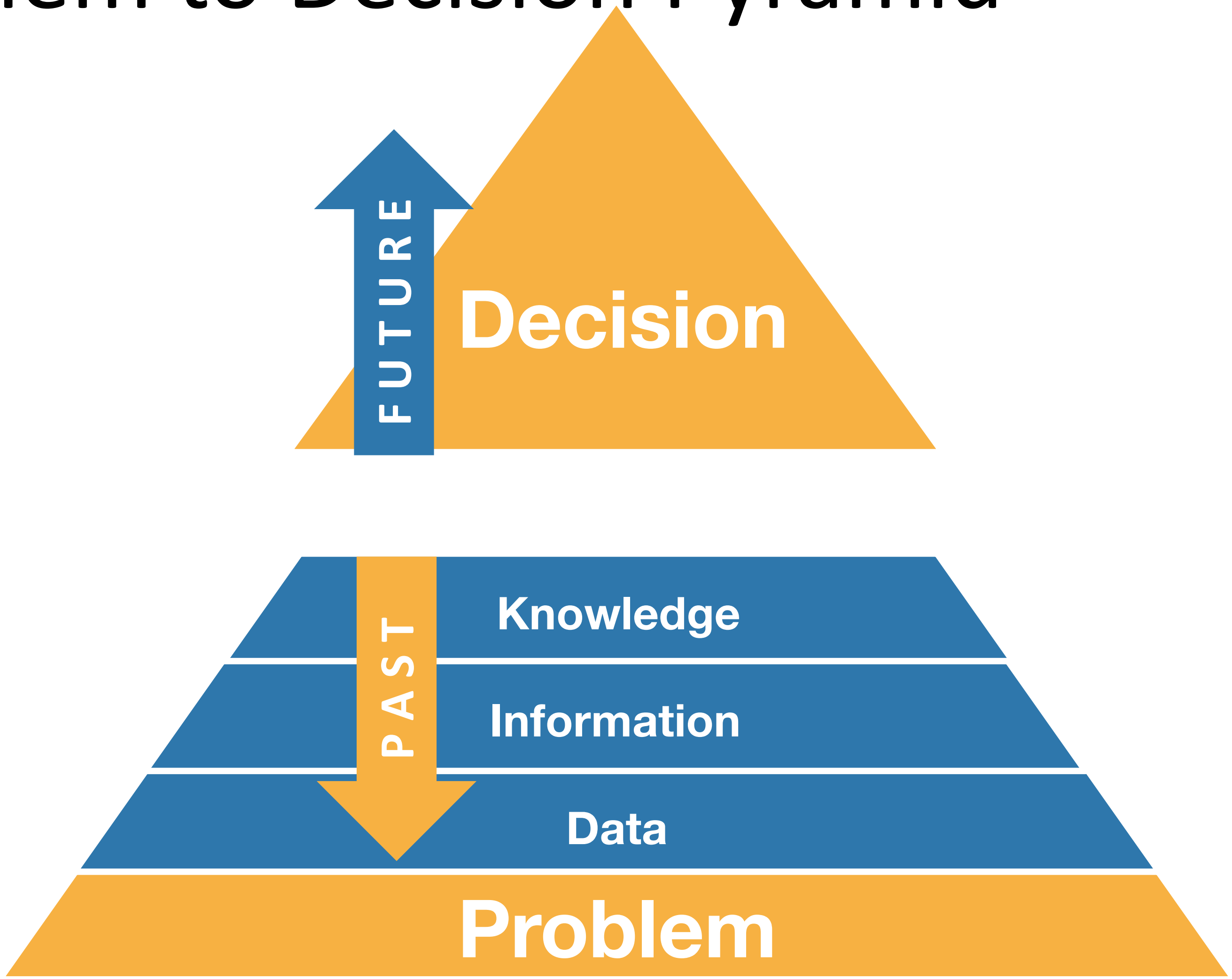
The Problem to Decision Pyramid

COMPLEXICA



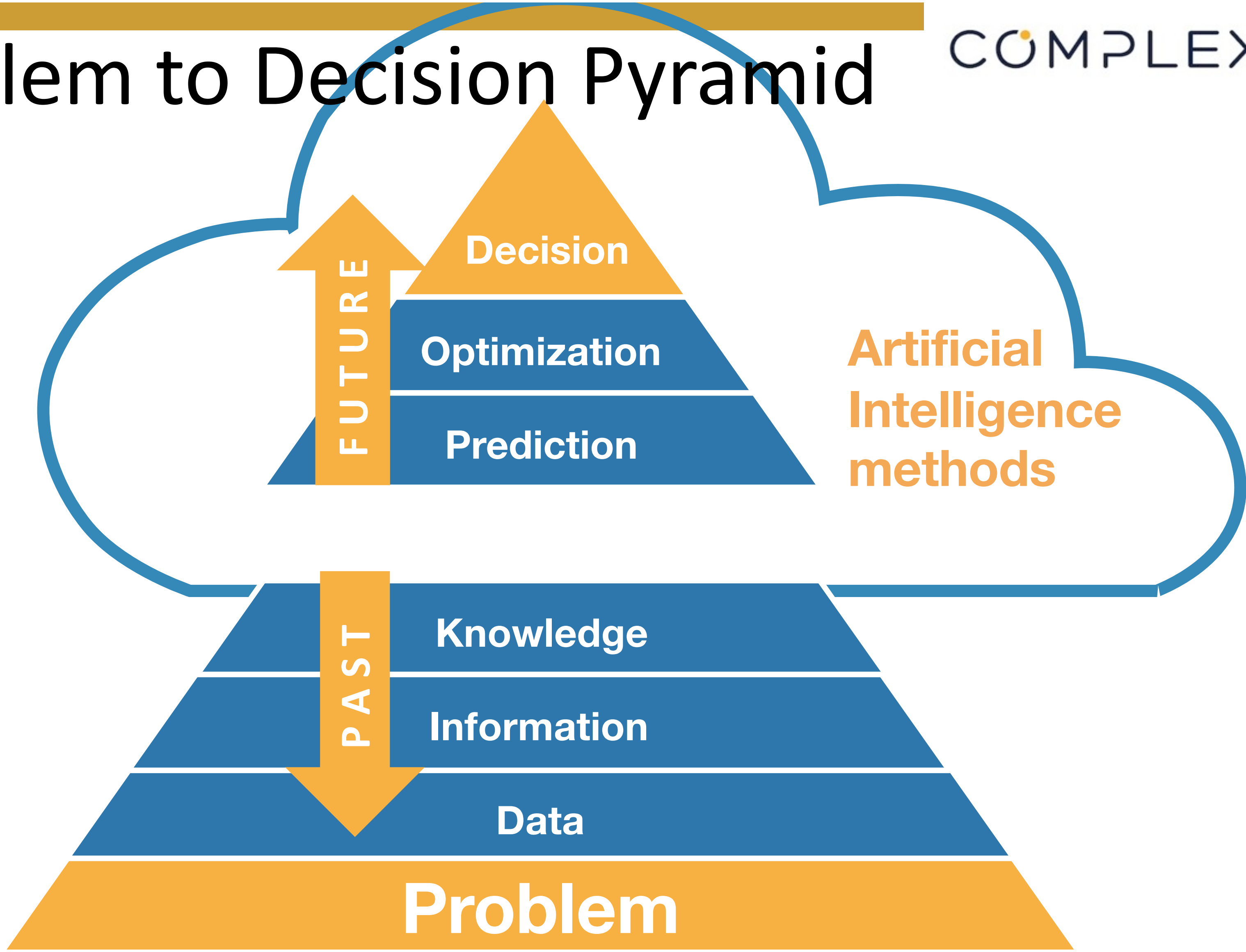
The Problem to Decision Pyramid

COMPLEXICA

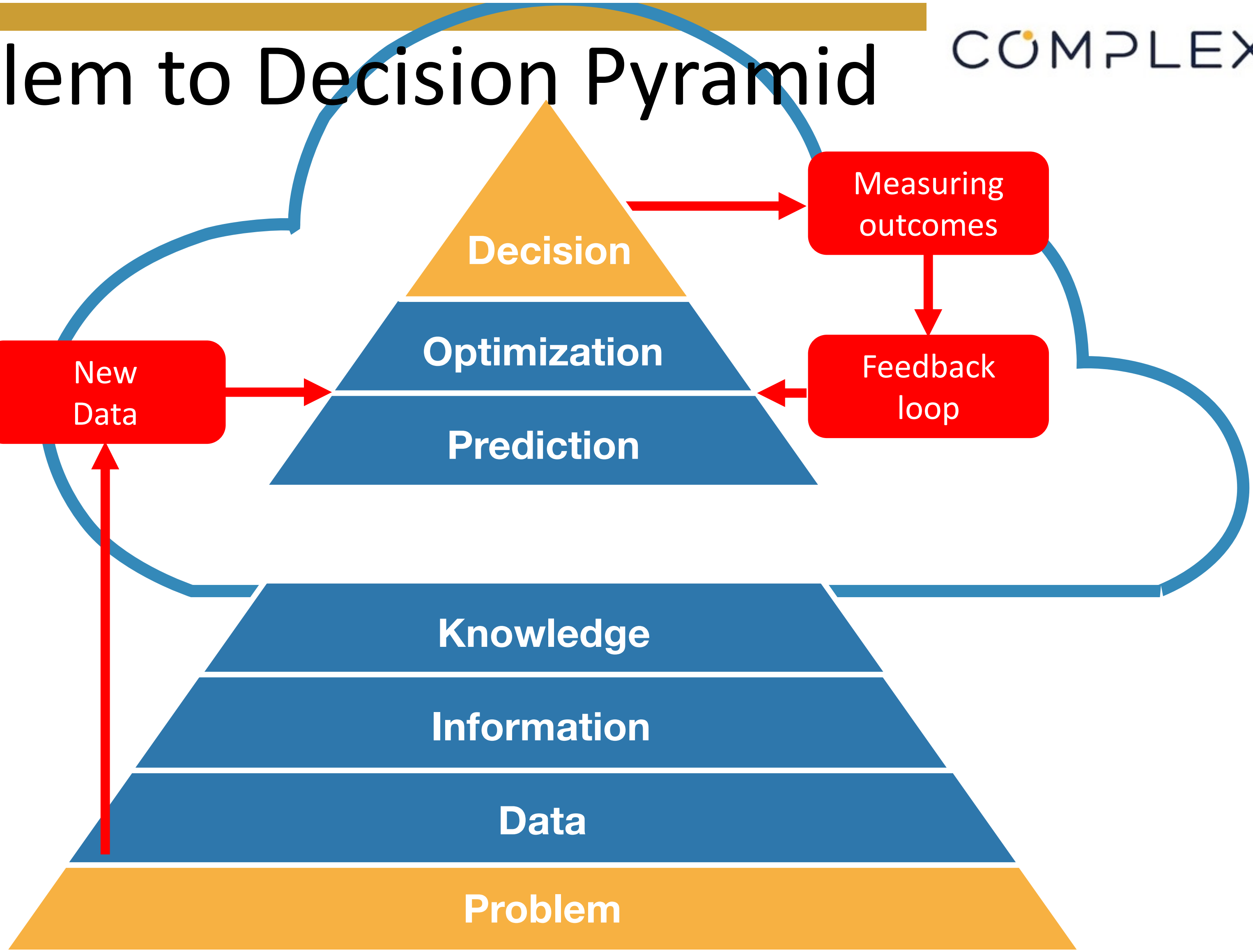


The Problem to Decision Pyramid

COMPLEXICA



The Problem to Decision Pyramid



Some thoughts…

1) Continuous vs. discrete optimization problems
2) Single-objective vs. multi-objective problems
3) Global optimization; multi-component problems
4) Explanatory features of the optimizers
5) The nature of dynamic environments; the key importance of predictive models: their accuracy, updates, self-learning capabilities and some consequences

1) Continuous vs. discrete optimization problems

In 20+ years working on a variety of business applications, I have never encountered a continuous optimization problem… ☹

2) Single-objective vs. multi-objective problems

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Most optimization-oriented business applications have several objectives…

However, it seems that the most meaningful arrangement for the end-user is to create a scenario, where one leading objective is defined, and other objectives are converted into constraints (thresholds), resulting in a “scenario” that is investigated.

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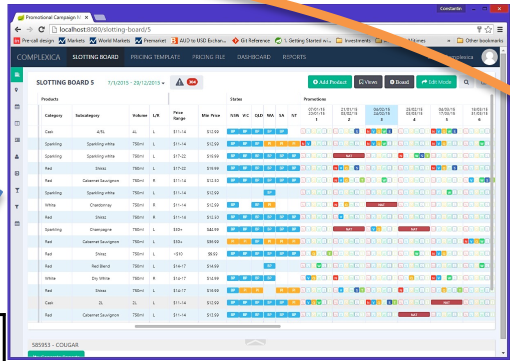
A Scenario

Input



	Target Name	Current Plan	New Value
	Volume		
□	Minimum Volume Outcome (Litres)	12,000	
■	Minimum Volume Growth on Last Year (%)	10	5
■	Minimum Volume Share Outcome in Market (%)	15	20
	Net Sales Revenue (NSR)		
■	Minimum NSR Outcome ($)	3,000	2,500
□	Minimum NSR Growth on Last Year (%)	12	
■	Minimum NSR CPL (%)	10	10
	Customer Margin		
□	Minimum Customer Margin $	5,000	
■	Minimum Customer Growth on Last Year (%)	10	5
□	Minimum Customer Margin (%)	10	
■	Minimum GM CPL (%)	5	4
	Maximum Number of Changes		10

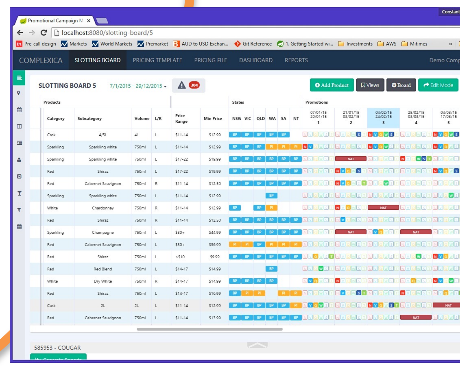
Objectives

Maximise Volume

- ● Volume Outcome (Litres)
- ○ Volume Growth on Last Year (%)
- ○ Volume Share Outcome in Market (%)

Maximise Net Sales Revenue (NSR)

- ○ NSR Outcome ($)
- ○ NSR Growth on Last Year (%)
- ○ NSR CPL (%)



Output

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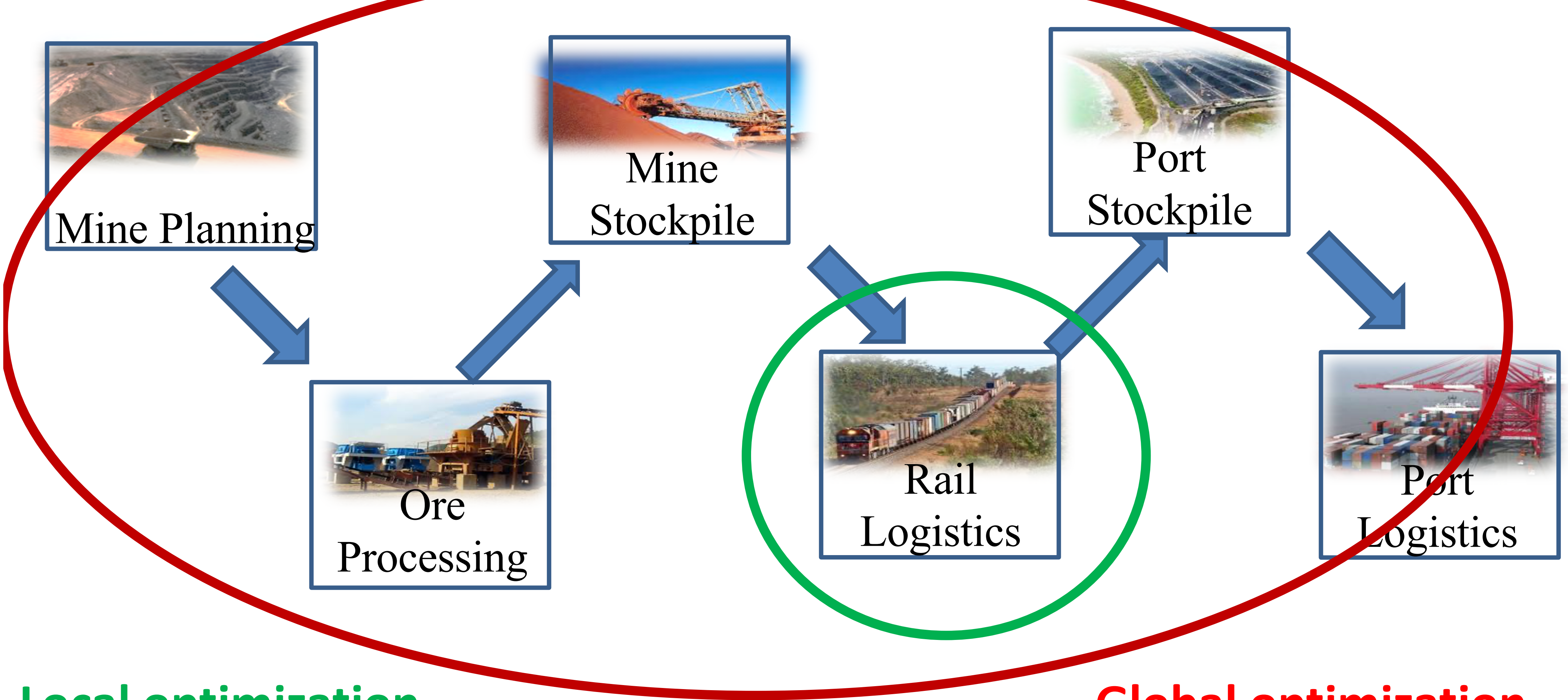
3) Global optimization: multi-component problems



Local optimization

Global optimization

An article ☺

Bonyadi, M.R., Michalewicz, Z., and Barone, L., *Travelling Thief Problem: the first step in transition from theoretical problems to realistic problems*, Proceedings of the 2013 IEEE Congress on Evolutionary Computation, Cancun, Mexico, June 20 - 23, 2013.

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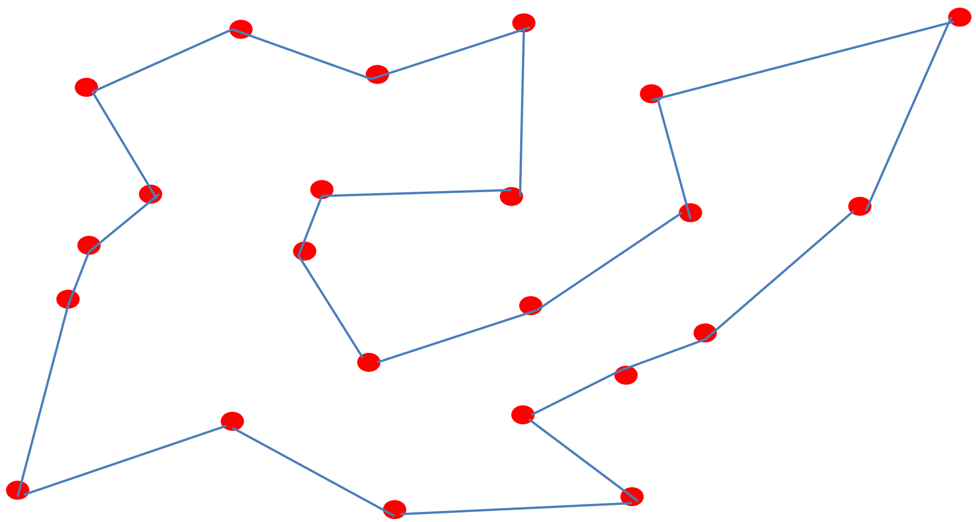
Travelling salesman problem

Given a list of cities and all costs of moving between them, find a cycle that visits each city precisely once and minimizes the total cost…



- Thousands of research papers
- Many books
- Hundreds of algorithms
- Very active research area

Knapsack problem

Given a list of items, each with a value V and a weight W, select a number of items to maximize the total value but not exceed the threshold weight (capacity).

Again:

- Thousands of research papers
- Many books
- Hundreds of algorithms
- Very active research area…

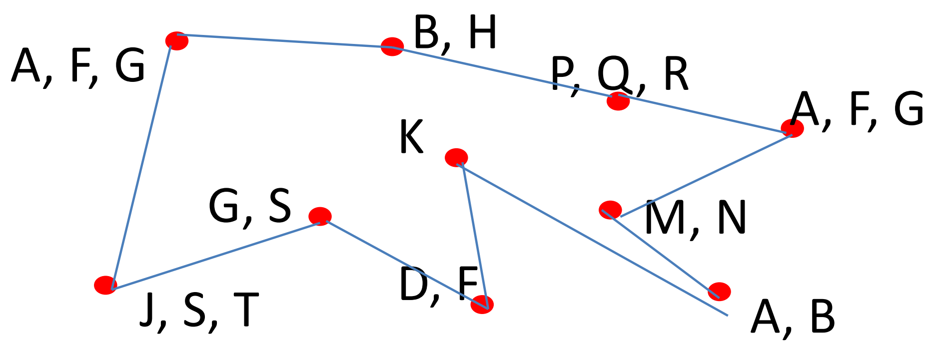
Travelling thief problem

Given a list of cities and items available in these cities, find a cycle that visits each city precisely once, collect some items available in these cities, to

(1) minimize the total cost of the travel, and

(2) maximize the value.

Note, that the cost of travel is a function of the current load…



4) Explanatory feature of the optimizers and constraint-handling

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Working on a variety of (academic) optimization problems I have never thought about any need to "justify" optimal solution that was found – simply because the evaluation score was "the best"…

However, this is not the case for business application – the end user needs to be convinced…. You hear very often: *I would never do that the recommended way*…

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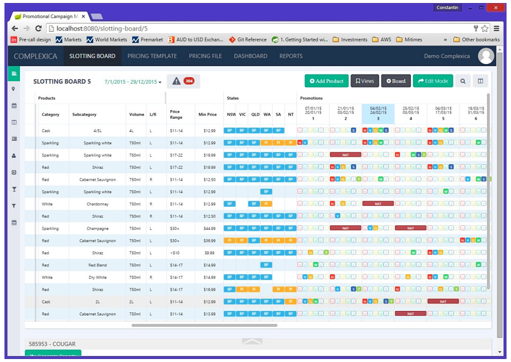

Target Name	Current Plan	New Value
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Minimum NSR CPL (%)	10	10
Customer Margin		
Minimum Customer Margin $	5,000	
Minimum Customer Growth on Last Year (%)	10	5
Minimum Customer Margin (%)	10	
Minimum GM CPL (%)	5	4
Maximum Number of Changes		10

Objectives

Maximise Volume

- Volume Outcome (Litres)
- Volume Growth on Last Year (%)
- Volume Share Outcome in Market (%)

Maximise Net Sales Revenue (NSR)

- NSR Outcome ($)
- NSR Growth on Last Year (%)
- NSR CPL (%)

Very important!

4) Explanatory feature of the optimizers and constraint-handling

So, number of changes made to the initial solution might be useful.

Also, constraints could be used to justify the proposed solution:

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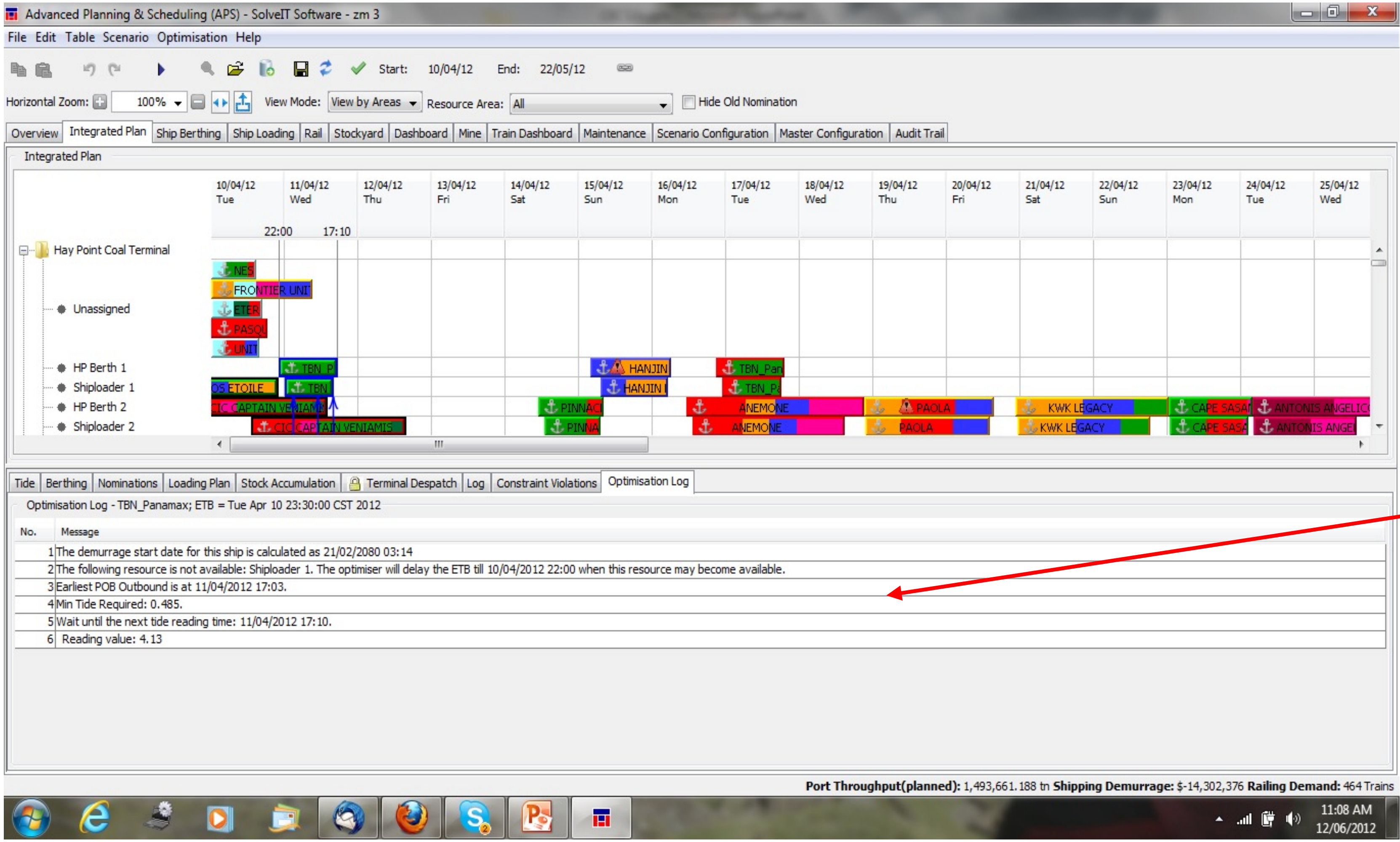

Some explanations…

Additional comment on constraints:

Very often (always?) in a real-world optimization problem, the optimal solution lies on the boundary between feasible and infeasible areas of the search space…

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Some papers from 25 years ago…

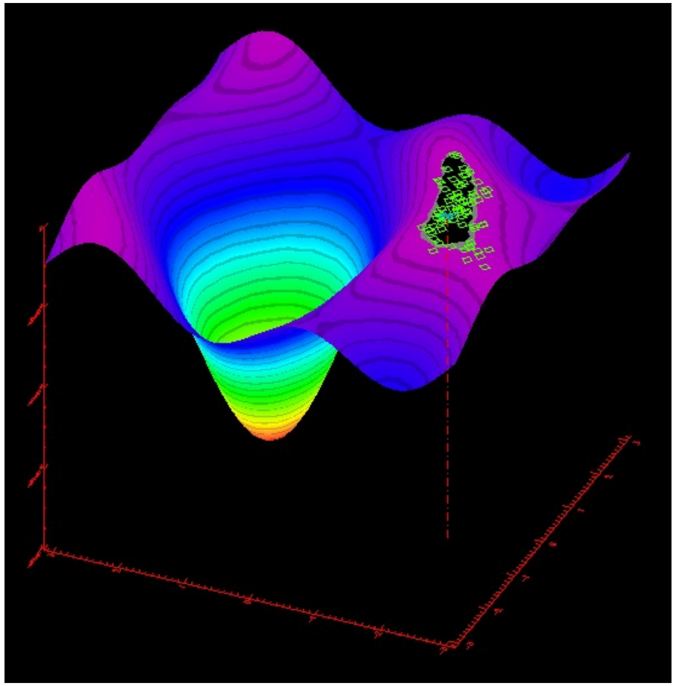
Schoenauer, M. and Michalewicz, Z., *Boundary Operators for Constrained Parameter Optimization Problems*, Proceedings of the 7th International Conference on Genetic Algorithms, East Lansing, Michigan, July 19 – 23, 1997, pp.320 – 329.

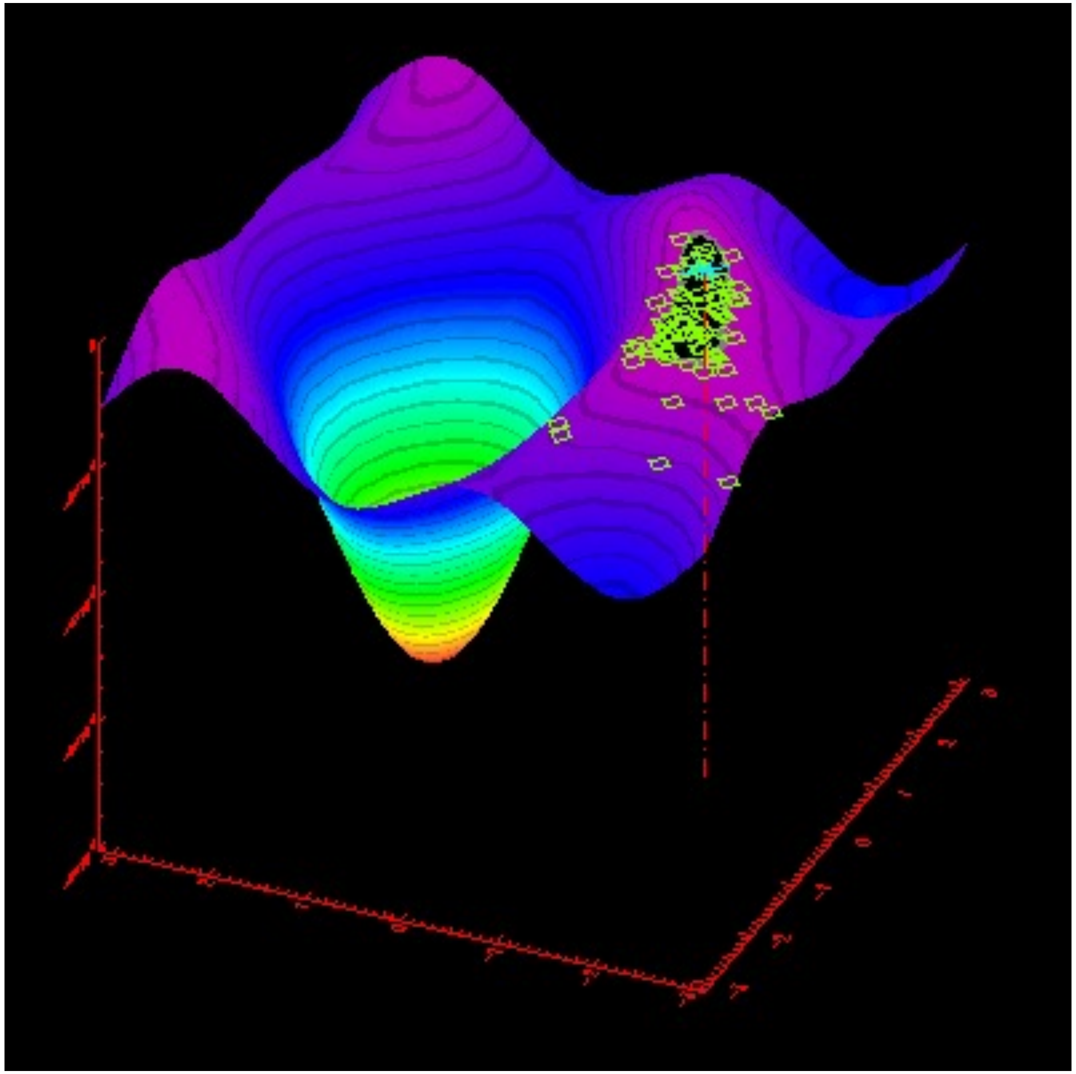
Schoenauer, M. and Michalewicz, Z., *Evolutionary Computation at the Edge of Feasibility*, Proceedings of the 4th Parallel Problem Solving from Nature, H.-M. Voigt, W. Ebeling, I. Rechenberg, and H.-P. Schwefel (Editors), September 22 – 27, 1996, Springer, Lecture Notes in Computer Science, Vol.1141, pp.245 – 254.

Additional comments on constraints:

- Very often (always?) in a real-world optimization problem, the optimal solution lies on the boundary between feasible and infeasible areas of the search space…
- Classification of constraints into hard/soft represents a huge simplification
- Regardless whether a constraint is hard or soft, the users are interested what is a potential reward for violating it…
- Constraints can be used for additional explanations…

5) The nature of dynamic environments; the key importance of predictive models: their accuracy, updates, self-learning capabilities and some consequences





Predictive Model & Optimization

generate a solution

check feasibility of the solution (constraints)

evaluate the solution

repeat

    apply variation operator to the current solution to generate a new solution

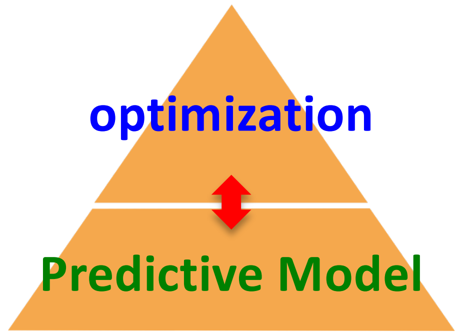
    check feasibility of the new solution

    evaluate new solution

    select one solution for further processing

end

report results



Predictive Model & optimization

generate a solution

check feasibility of the solution (requires definitions of constraints)

evaluate the solution

repeat

  apply variation operator to the current solution to generate a new solution

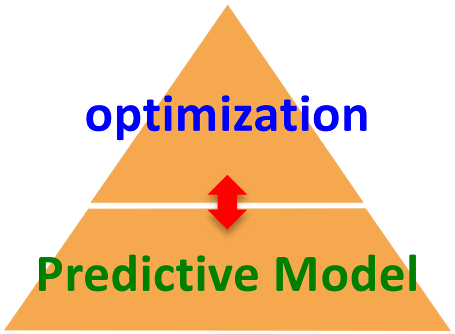
  check feasibility of the new solution

  evaluate new solution

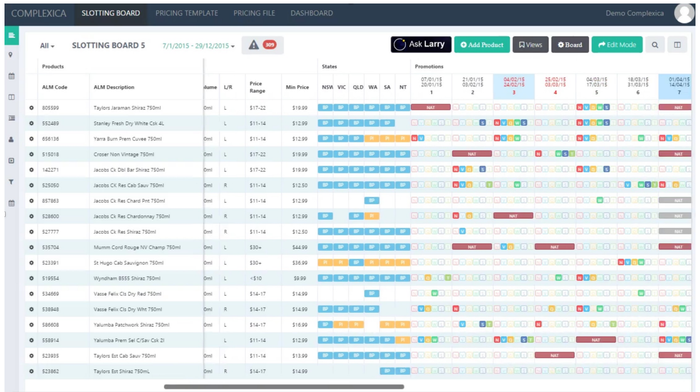
  select one solution for further processing

end

report results (e.g., trade-offs)



Example: Promotional planning



comparisons predicted vs. actuals

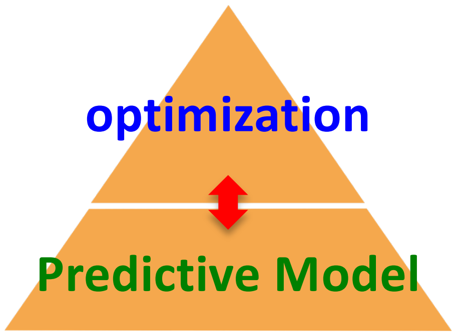
Predictive model

- *Volume*:
- *Net revenue*:
- *Retailer gross profit*:
- *Manufacturer gross profit*:

and values for many constraints…

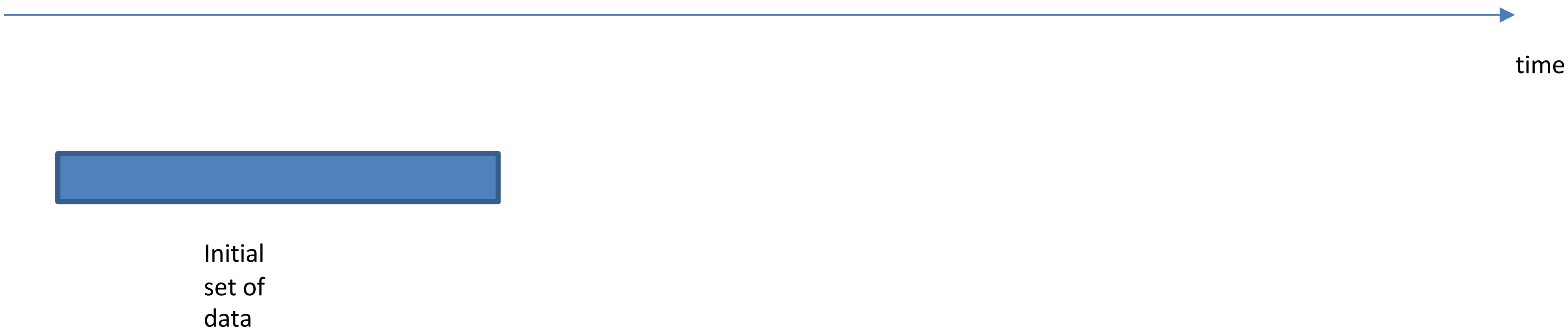
New data coming in (sometimes daily)

Some thoughts on development of a predictive model, its updates, feedback, learning, and adaptability

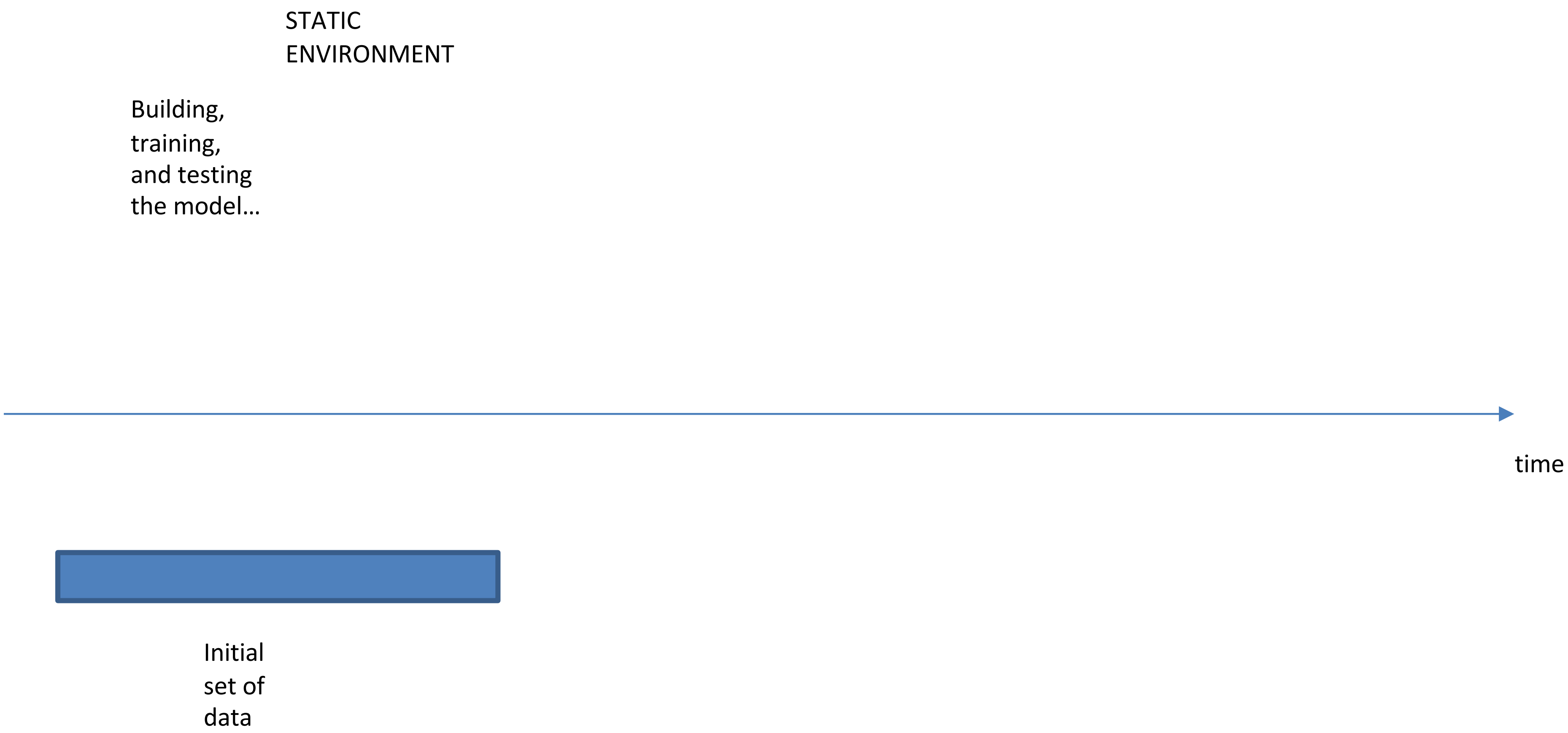


Understanding "dynamic environments"

MODELS AND ADAPTABILITY



MODELS AND ADAPTABILITY



MODELS AND ADAPTABILITY

STATIC
ENVIRONMENT

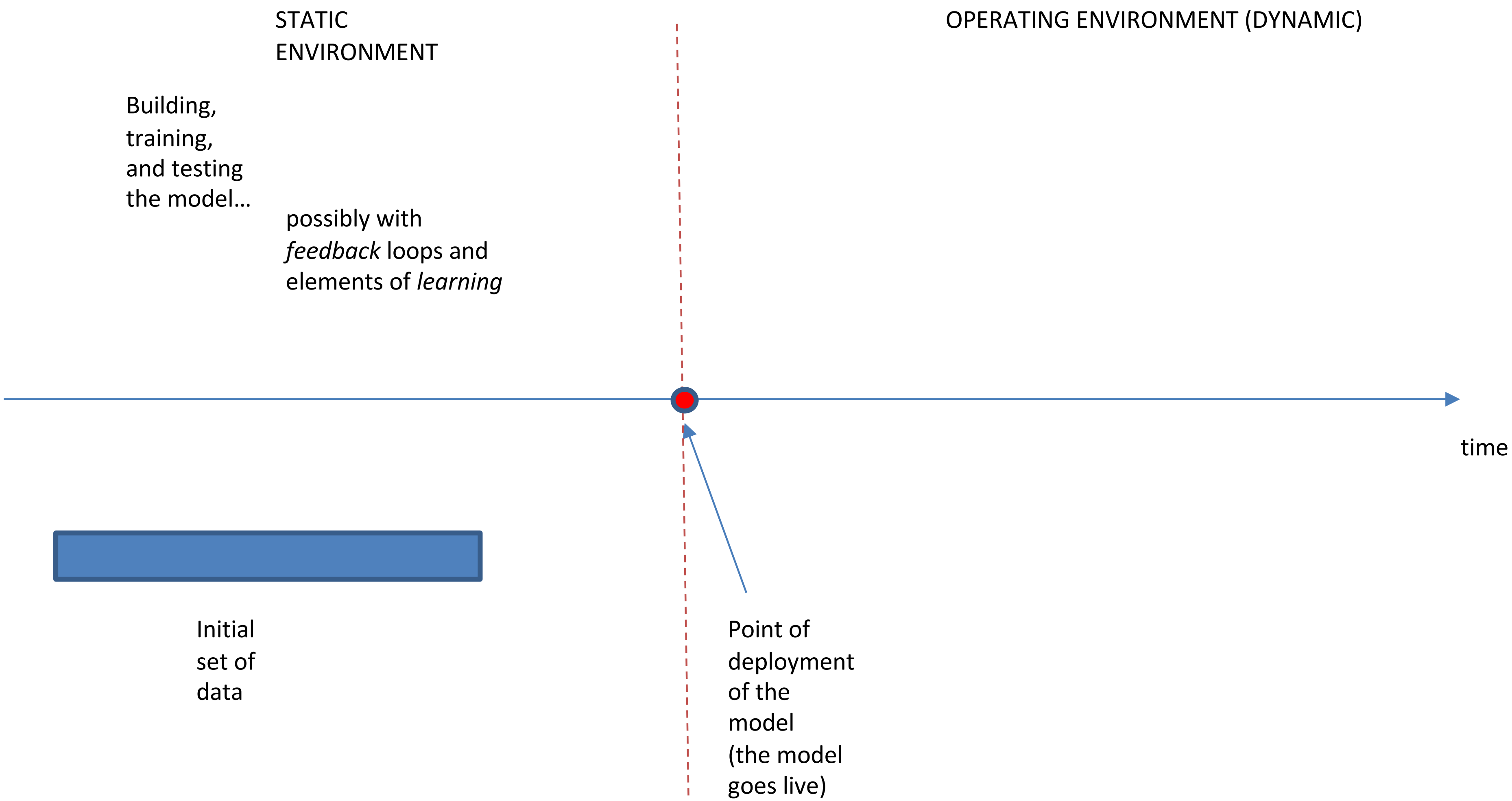
Building,
training,
and testing
the model…

possibly with
feedback loops and
elements of *learning*

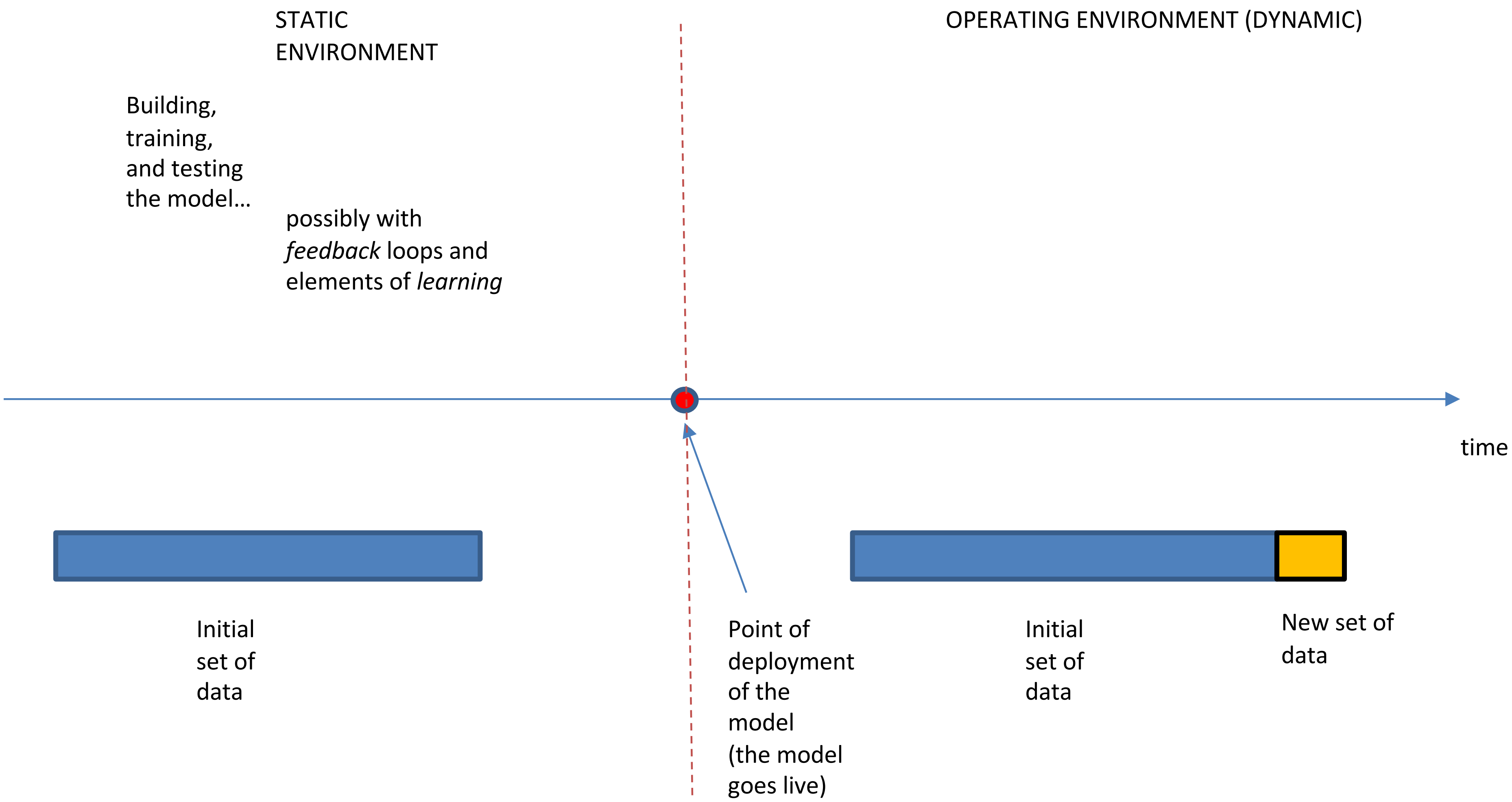
time

Initial
set of
data

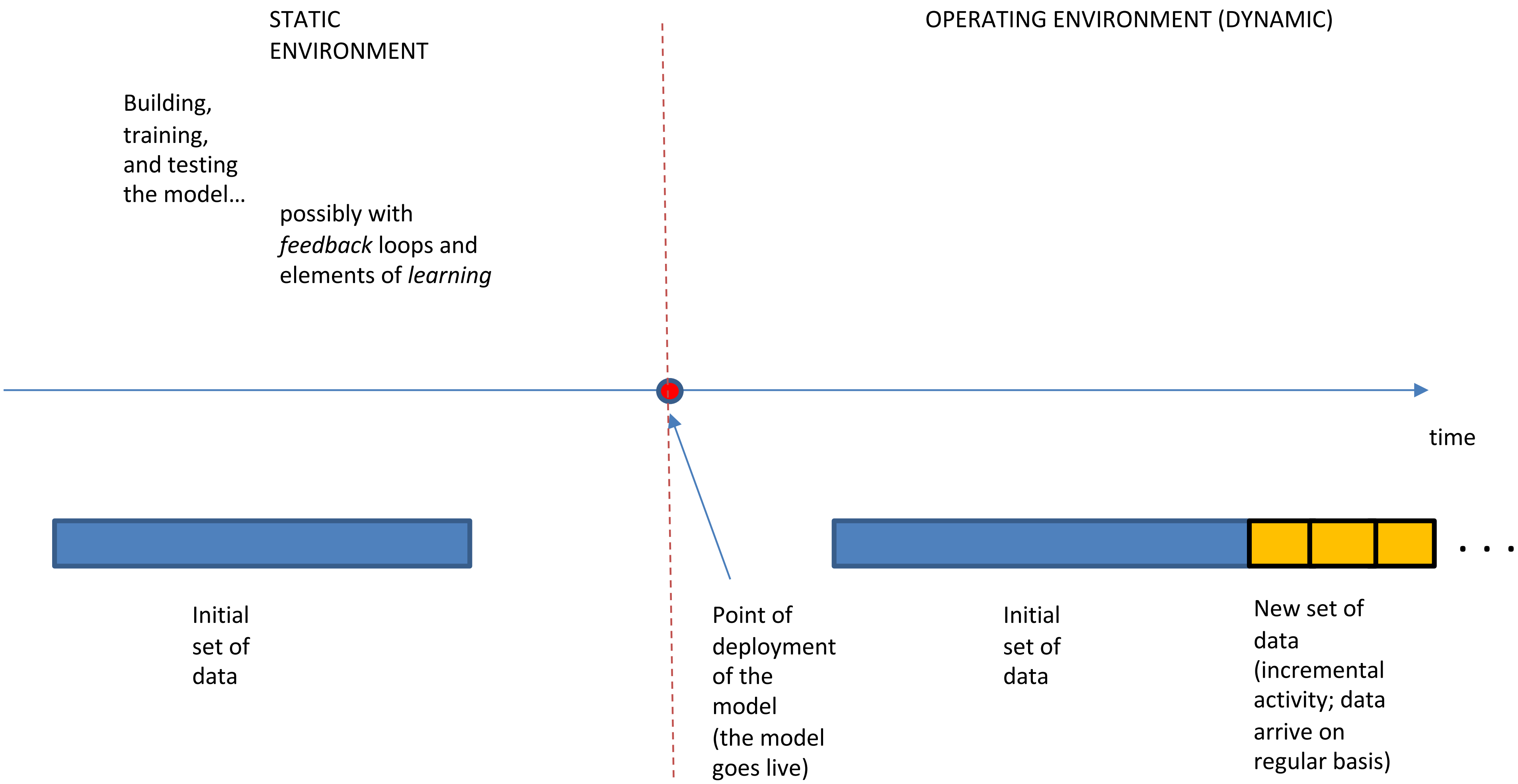
MODELS AND ADAPTABILITY



MODELS AND ADAPTABILITY



MODELS AND ADAPTABILITY



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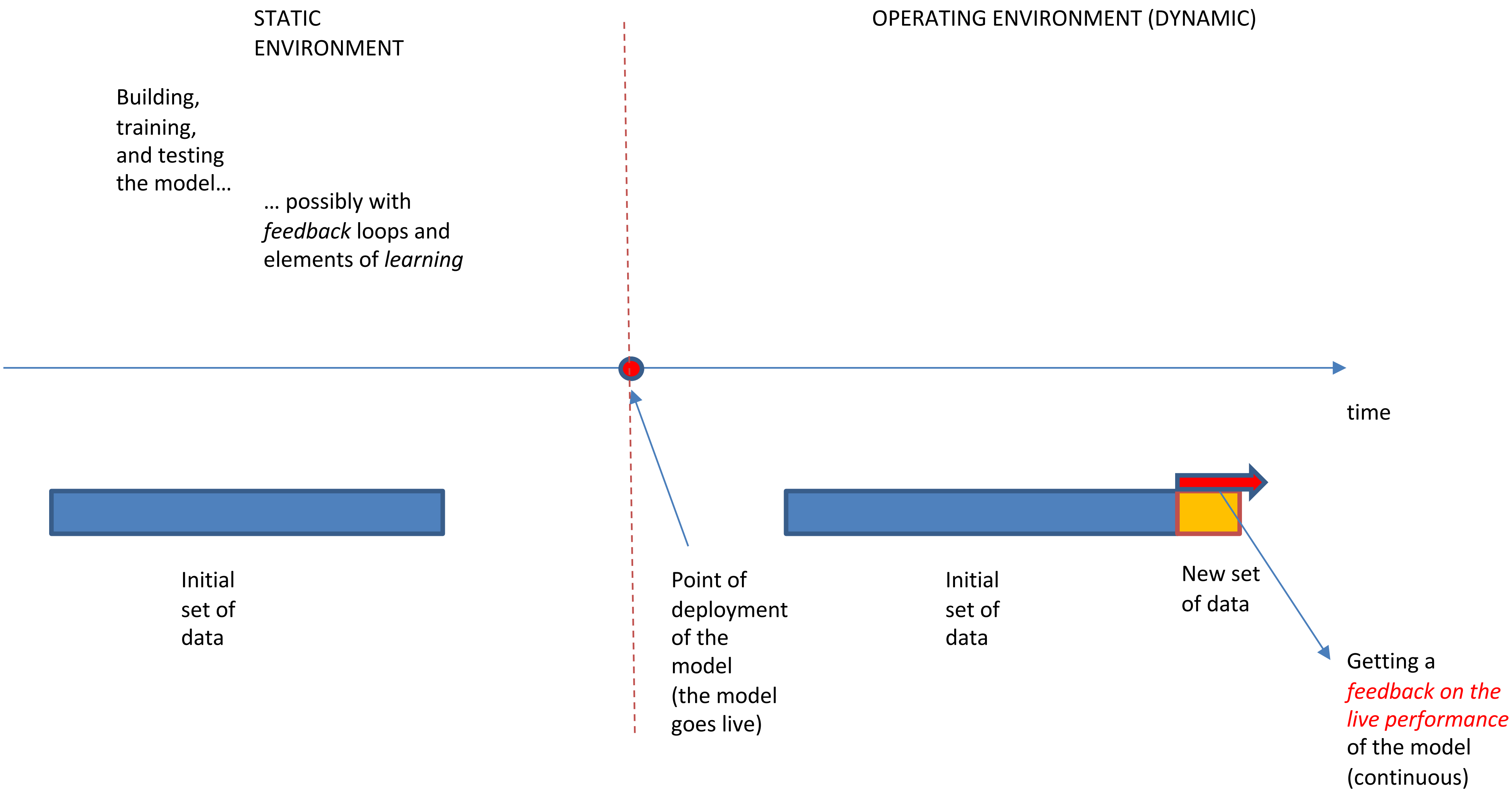
MODELS AND ADAPTABILITY



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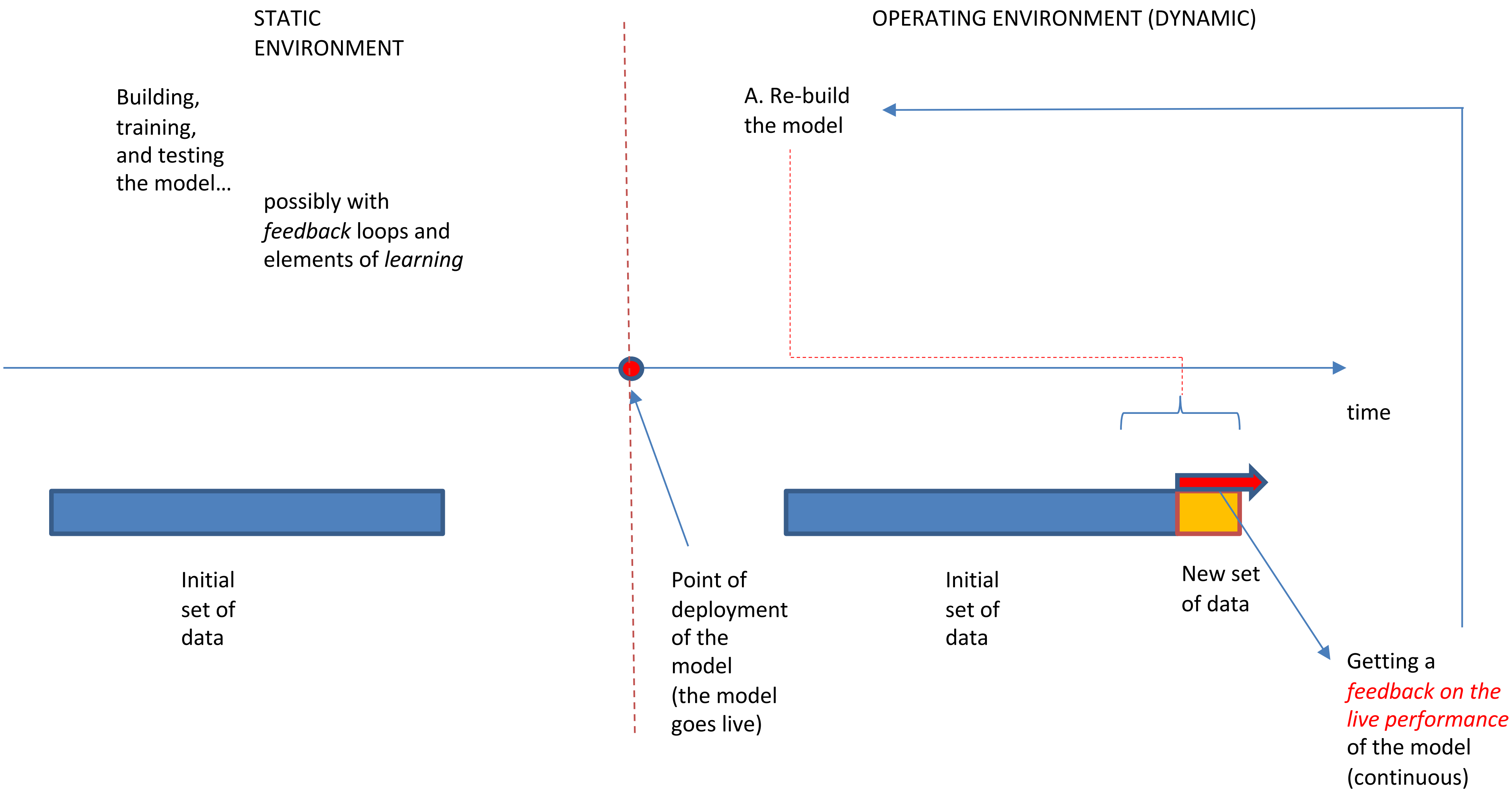
MODELS AND ADAPTABILITY



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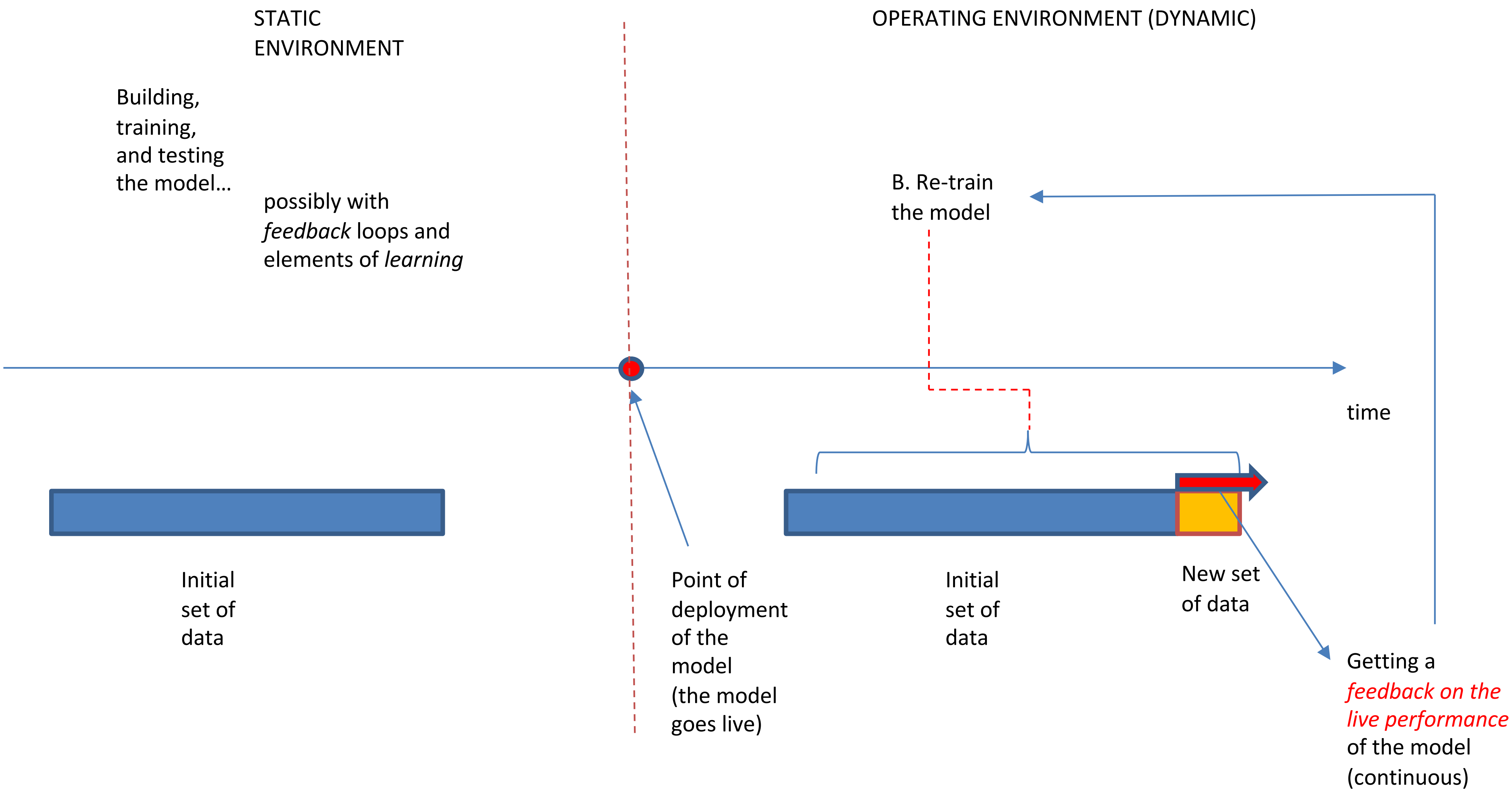
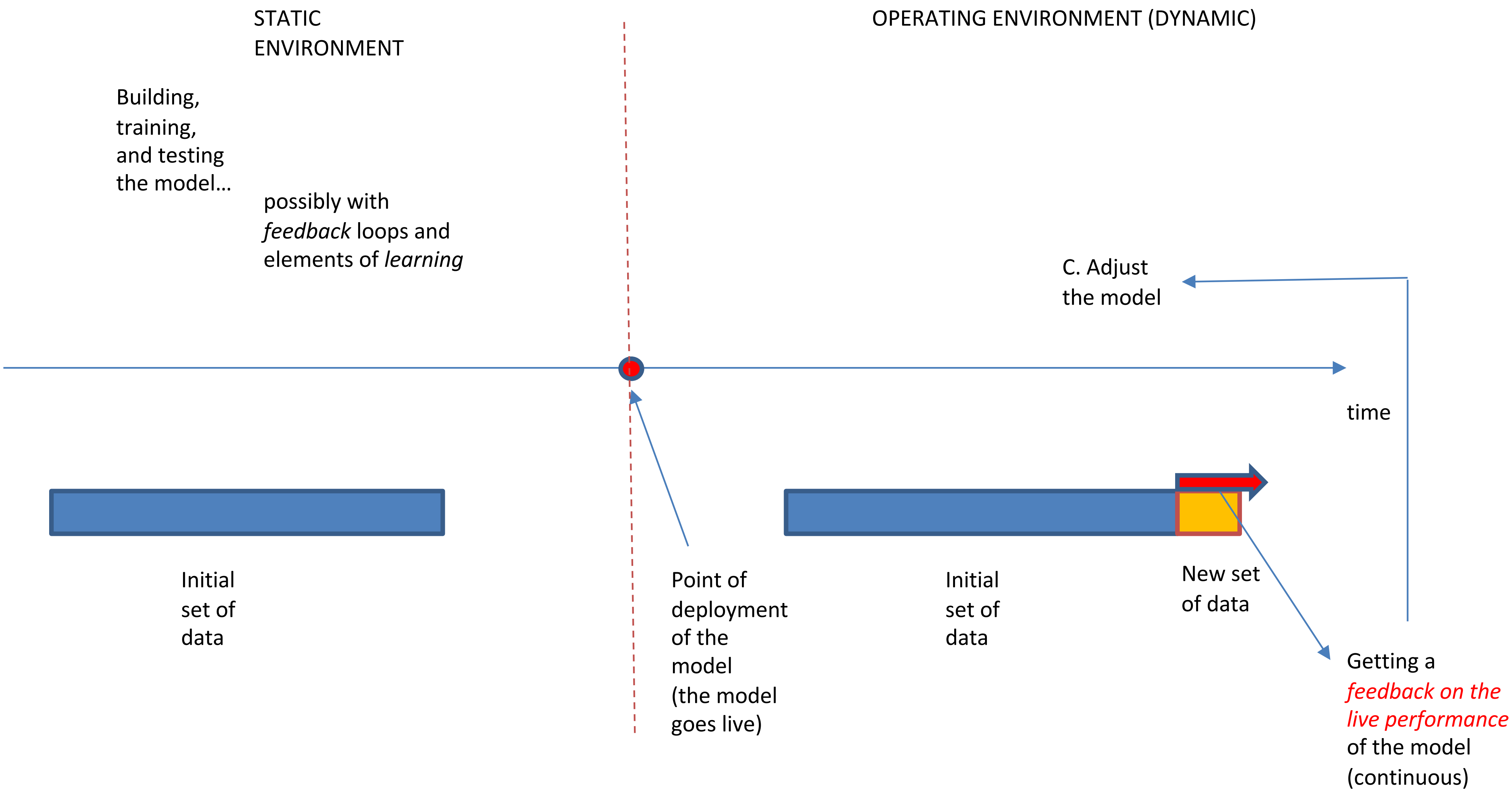
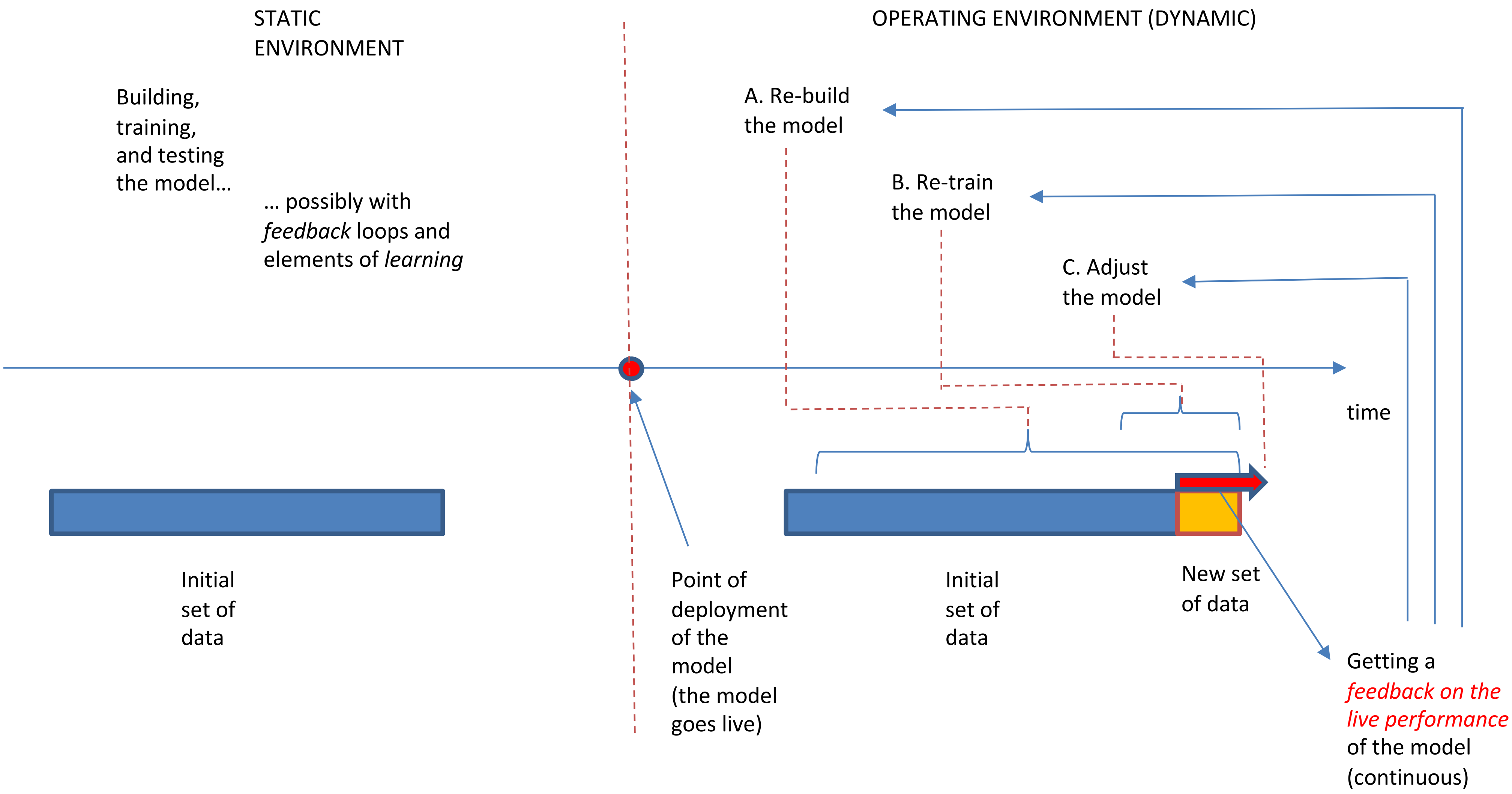
MODELS AND ADAPTABILITY



MODELS AND ADAPTABILITY



MODELS AND ADAPTABILITY



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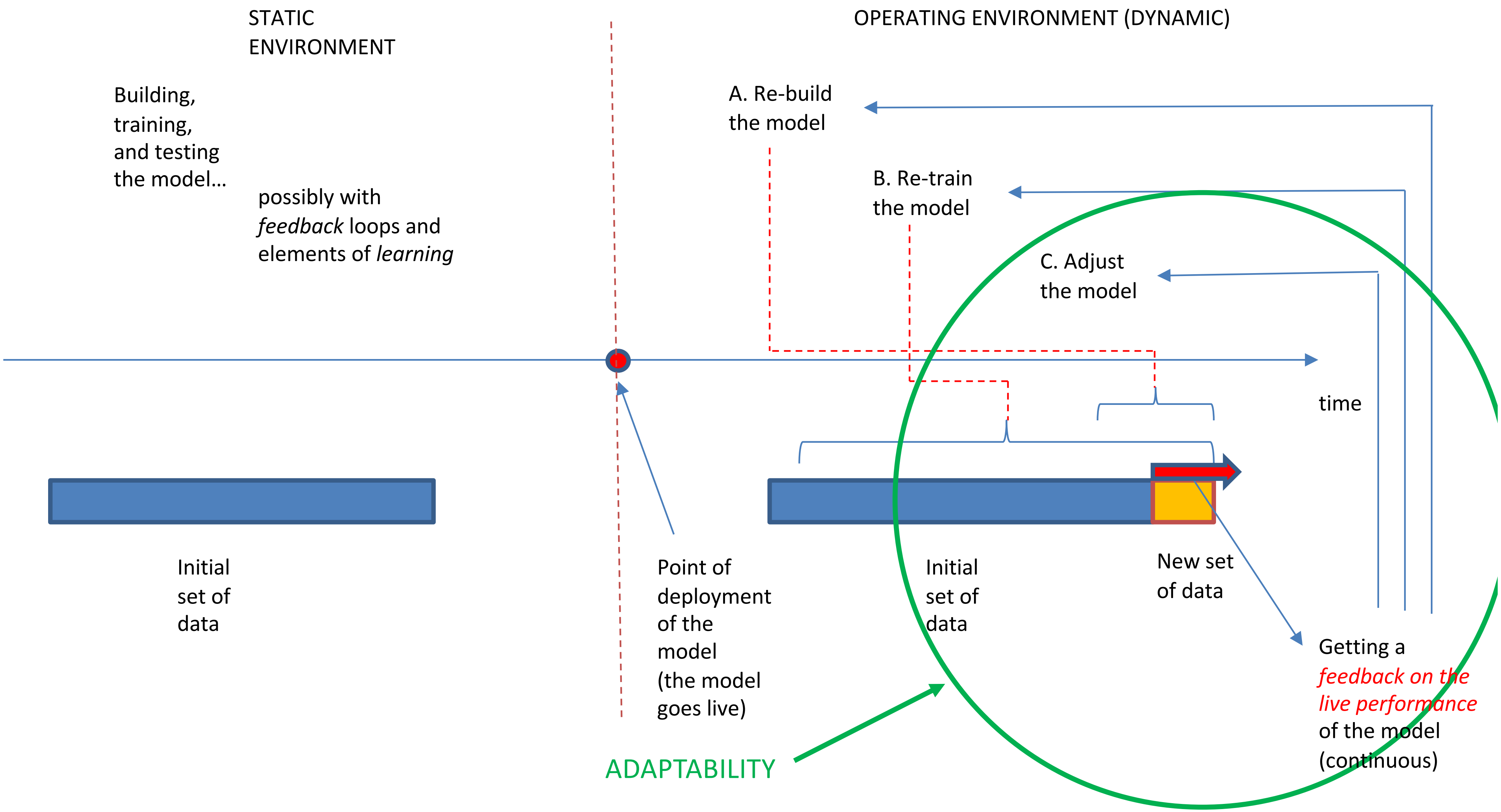
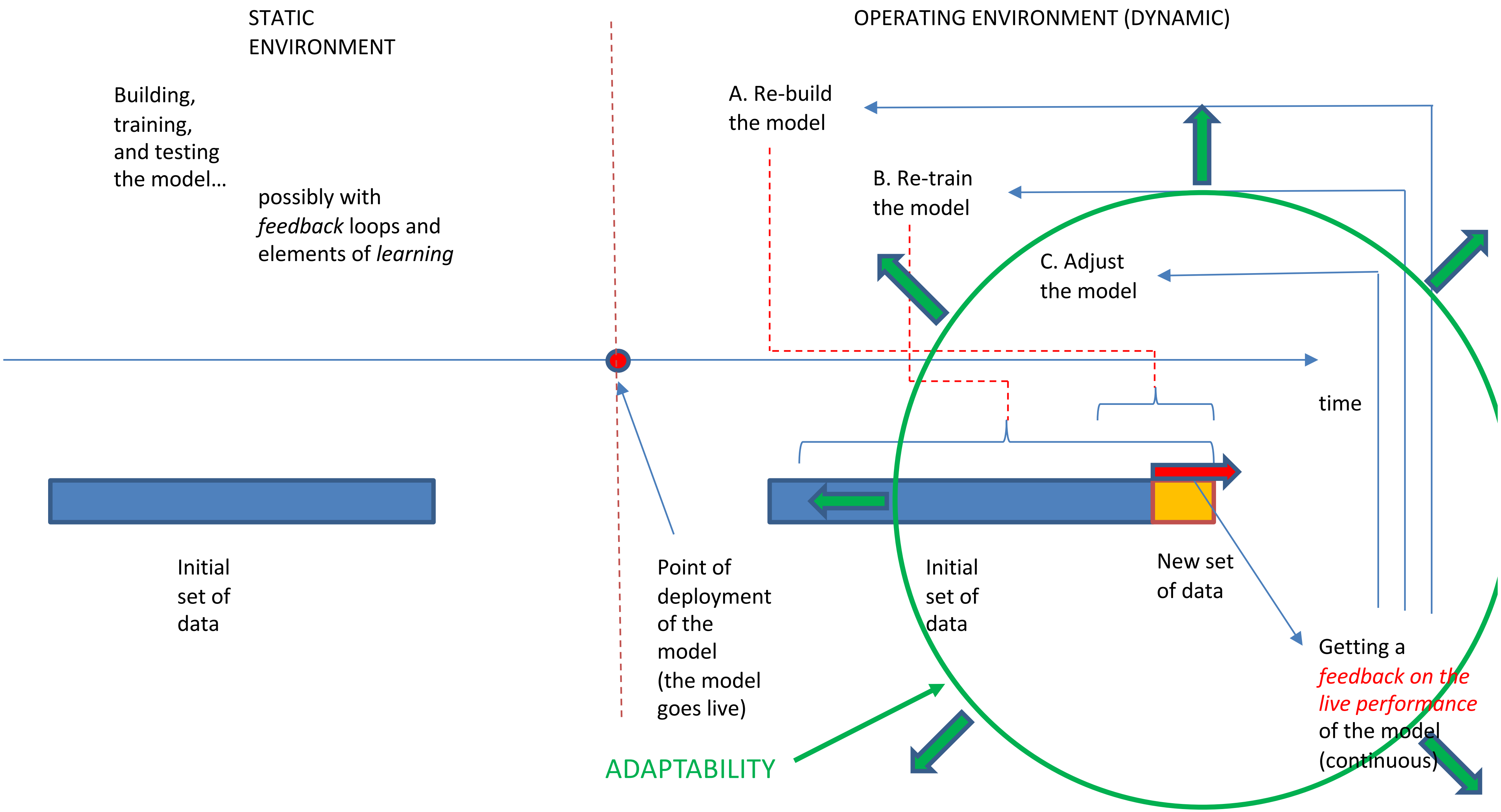
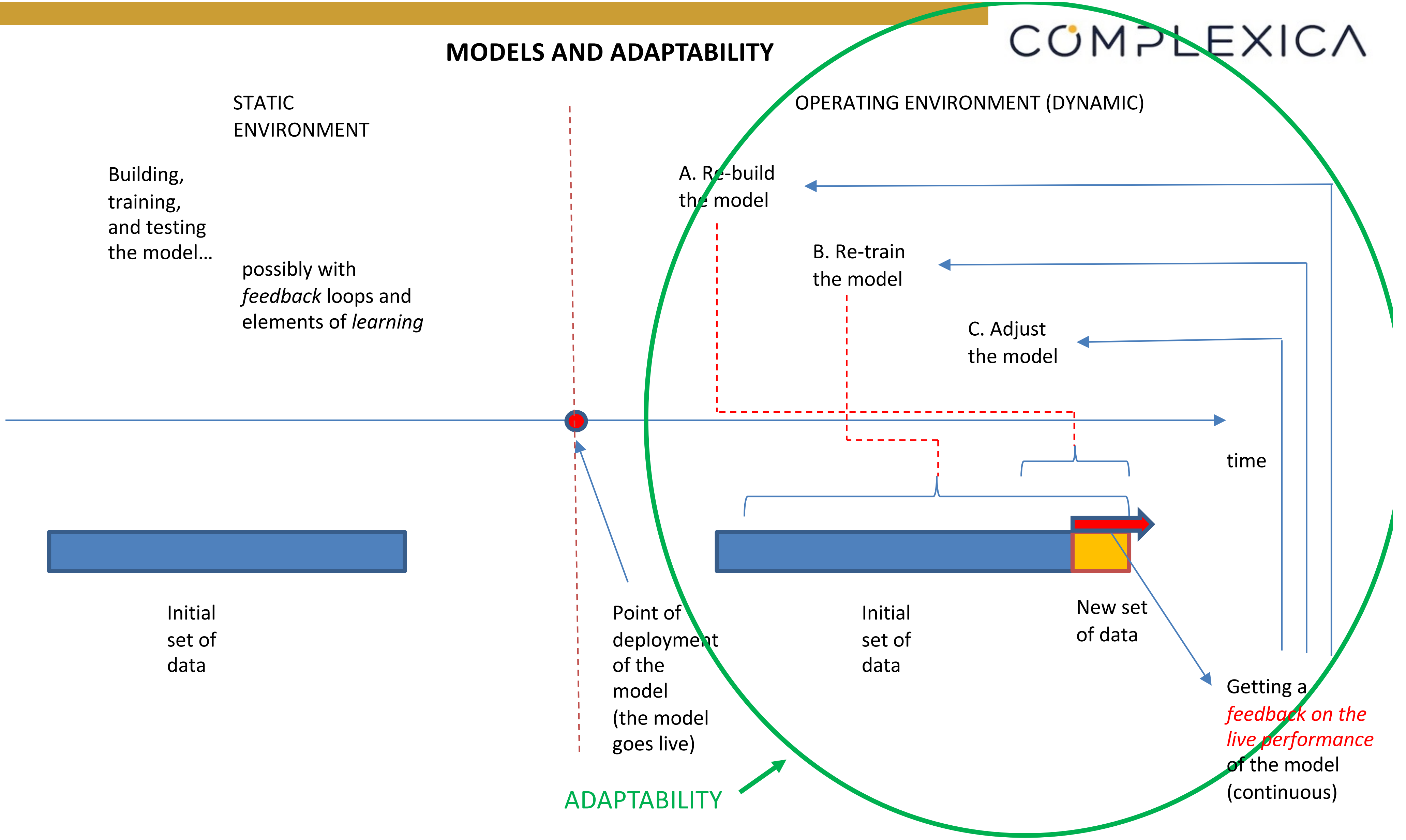
MODELS AND ADAPTABILITY

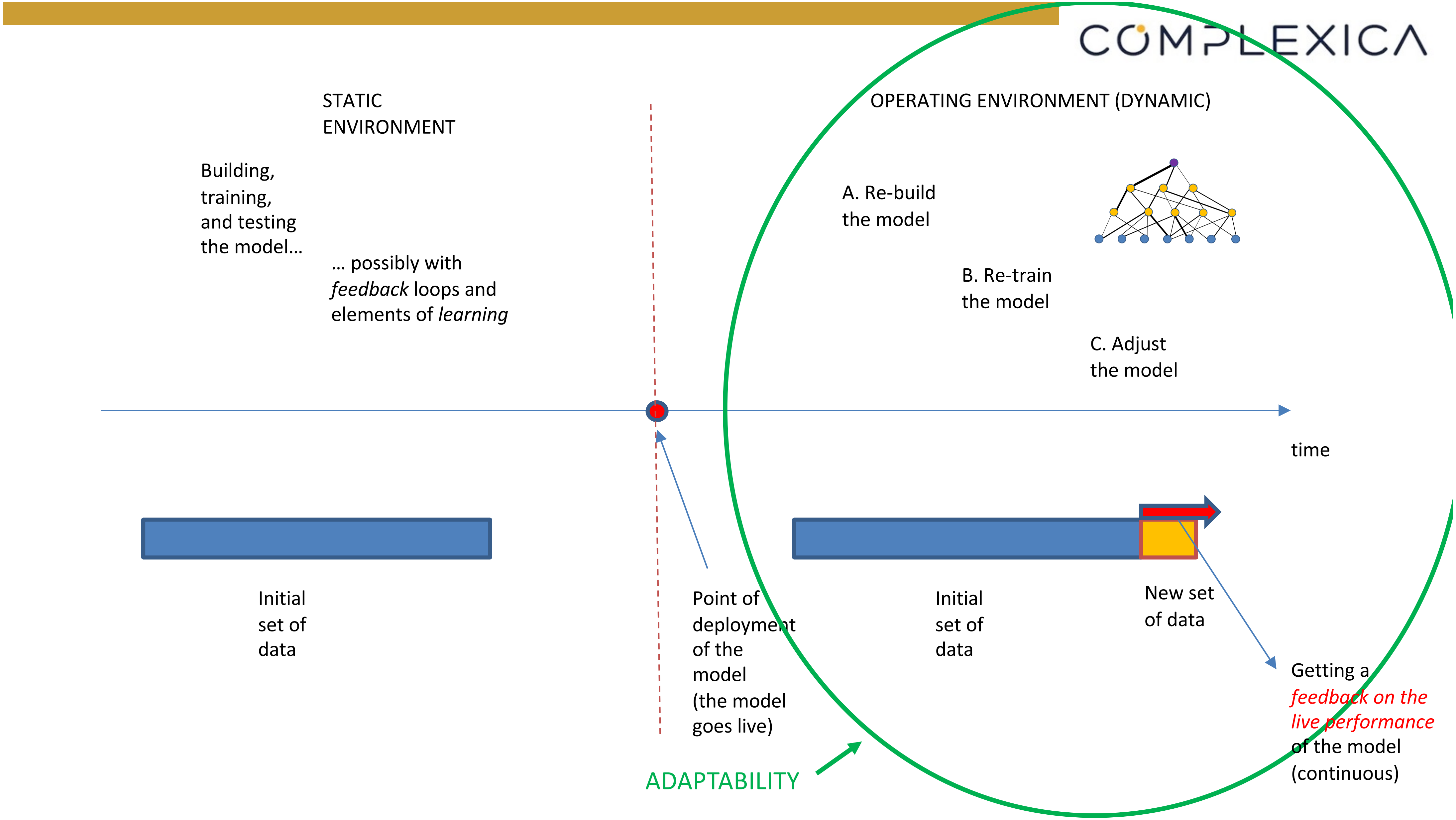


MODELS AND ADAPTABILITY



MODELS AND ADAPTABILITY

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STATIC ENVIRONMENT
OPERATING ENVIRONMENT (DYNAMIC)
Building, training, and testing the model…
… possibly with *feedback* loops and elements of *learning*
A. Re-build the model
B. Re-train the model
C. Adjust the model
time
Initial set of data
Point of deployment of the model (the model goes live)
Initial set of data
New set of data
Getting a *feedback on the live performance* of the model (continuous)
ADAPTABILITY

MODELS AND ADAPTABILITY

	High No. of Moderate Errors	Low No. of Moderate Errors
High No. of Significant Errors		
Low No. of Significant Errors		All good

MODELS AND ADAPTABILITY

	High No. of Moderate Errors	Low No. of Moderate Errors
High No. of Significant Errors	Model is out-dated	New “things” are introduced
Low No. of Significant Errors	Natural market growth	All good

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MODELS AND ADAPTABILITY

Option A:
re-building

Option C:
adjusting

	High No. of Moderate Errors	Low No. of Moderate Errors
High No. of Significant Errors	Model is outdated	New “things” are introduced
Low No. of Significant Errors	Natural market growth	All good

Option B:
re-training

No need to change

MODELS AND ADAPTABILITY

COMPLEXICA

Option A: re-building

Option C: adjusting

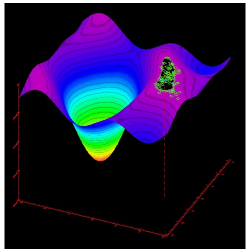
	High No. of Moderate Errors	Low No. of Moderate Errors
High No. of Significant Errors	Model is outdated	New "things" are introduced
Low No. of Significant Errors	Natural market growth	All good

Option B: re-training

No need to change

- **Option A:** *Re-building.* Discard the old model, use all available data, old (possibly to some extend) and new, to re-build the model
- **Option B**: *Re-training*. Keep the old model, use all new data to train a separate (new) model. Both models (old and new) model work together (bagging strategy)
- **Option C**: *Adapting*. Keep the old model, use only the significant error cases to train a separate (new) model. Both models (old and new) work together (boosting strategy)

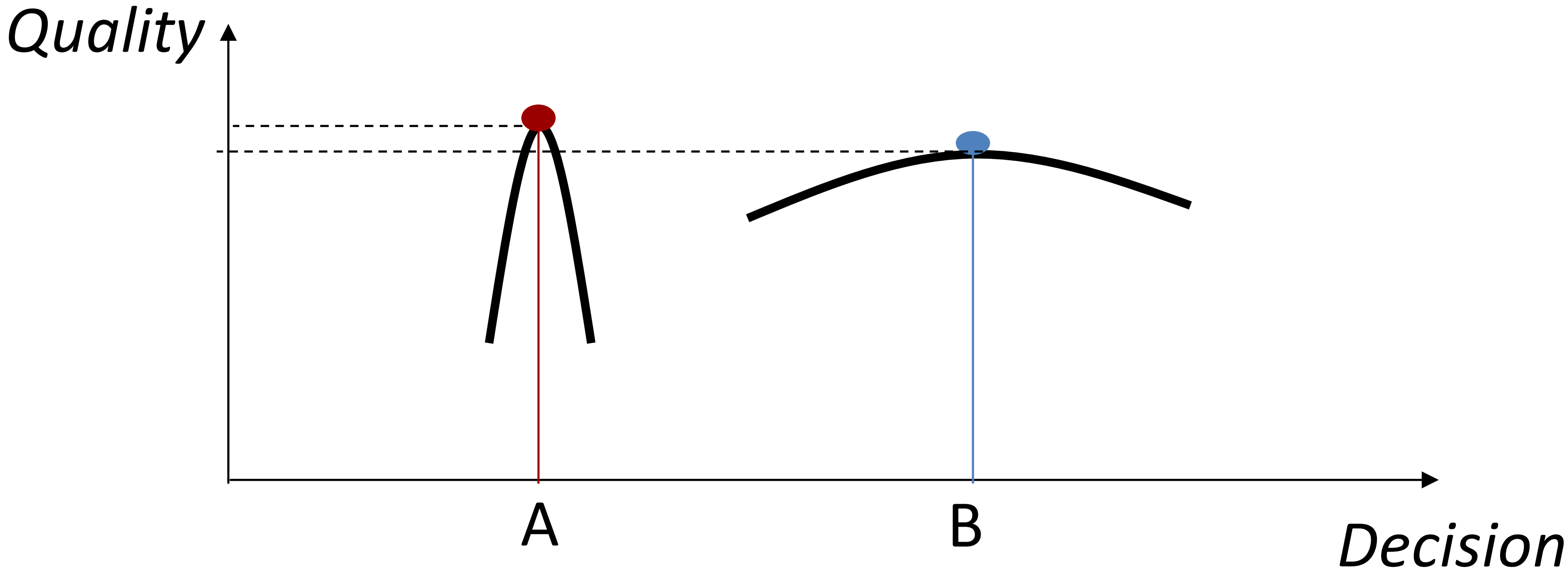
5) The nature of dynamic environments: predictive model as the evaluation function



- How to handle updates: arrival of new data (on regular basis)?
- How to handle the feedback on the accuracy of prediction?
- Does the system learn?
- Should we forget the past? If yes, under what circumstances?
- Should we measure the dynamics of the environment?
- Should we introduce a mechanism by which the end user may influence the predictive model?

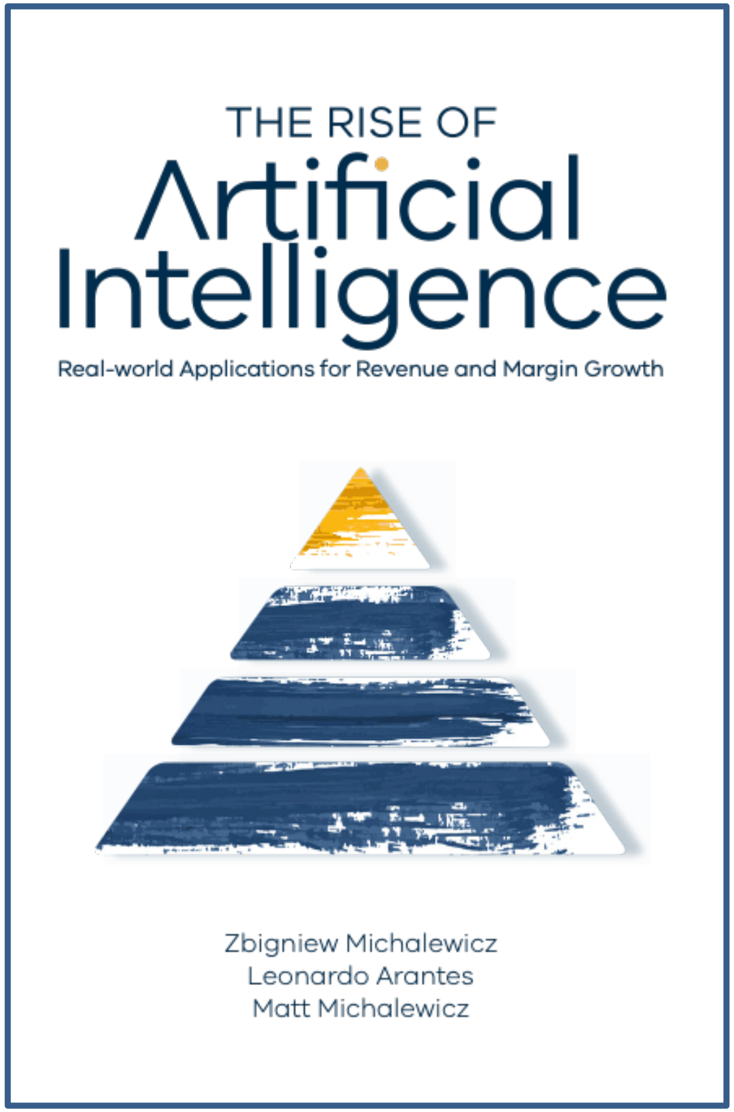
Variability and Risk

Without considering variability, some decisions will be “risker” than others



Additional information

The talk was based on my new book which was just published (April 2021)



Real World Problems vs. Research…

Adaptive Business Intelligence

Puzzle-based Learning

Constraint Handling Methods

Global Optimisation for Multi-component Problems

Partial Optimisation

Time Horizons, Variability, and Risk

Explanatory Features

Closing remarks

"Look at the last section [of some paper], where there were always some 'open problems.' Pick one, and work on it, until you are able to make a little progress. Then write a paper of your own about your progress, and don't forget to include an 'open problems' section, where you put in everything you were unable to do."

Jeff Ullman, 2009

Closing remarks

*"Unfortunately this approach, still widely practiced today, encourages mediocrity. […] It almost guarantees that after a while, the work is driven by what **can** be solved, rather than what **needs** to be solved."*

"People write papers, and the papers get accepted because they are reviewed by the people who wrote the papers being improved incrementally, but the influence beyond the world of paper-writing is minimal."

Jeff Ullman, 2009

Two essays

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1. Michalewicz, Z., *Quo Vadis, Evolutionary Computation? On a growing gap between theory and practice*, Springer LNCS State-of-the-Art Survey, J. Liu, C. Alippi, B. Bouchon-Meunier, G. Greenwood, H. Abbass (Editors), 2012.

2. Michalewicz, Z., *The Emperor is Naked: Evolutionary Algorithms for Real-World Applications*, ACM Ubiquity, November 2012, pp. 1 - 13.

Final observation…

"Luck plays a big role. Yes, I'd like to publicly acknowledge the power of luck. Athletes get lucky, poets get lucky, businesses get lucky. Hard work is critical, a good team is essential, brains and determination are invaluable, but luck may decide the outcome."

Phil Knight, *Shoe Dog*

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Thank you...