

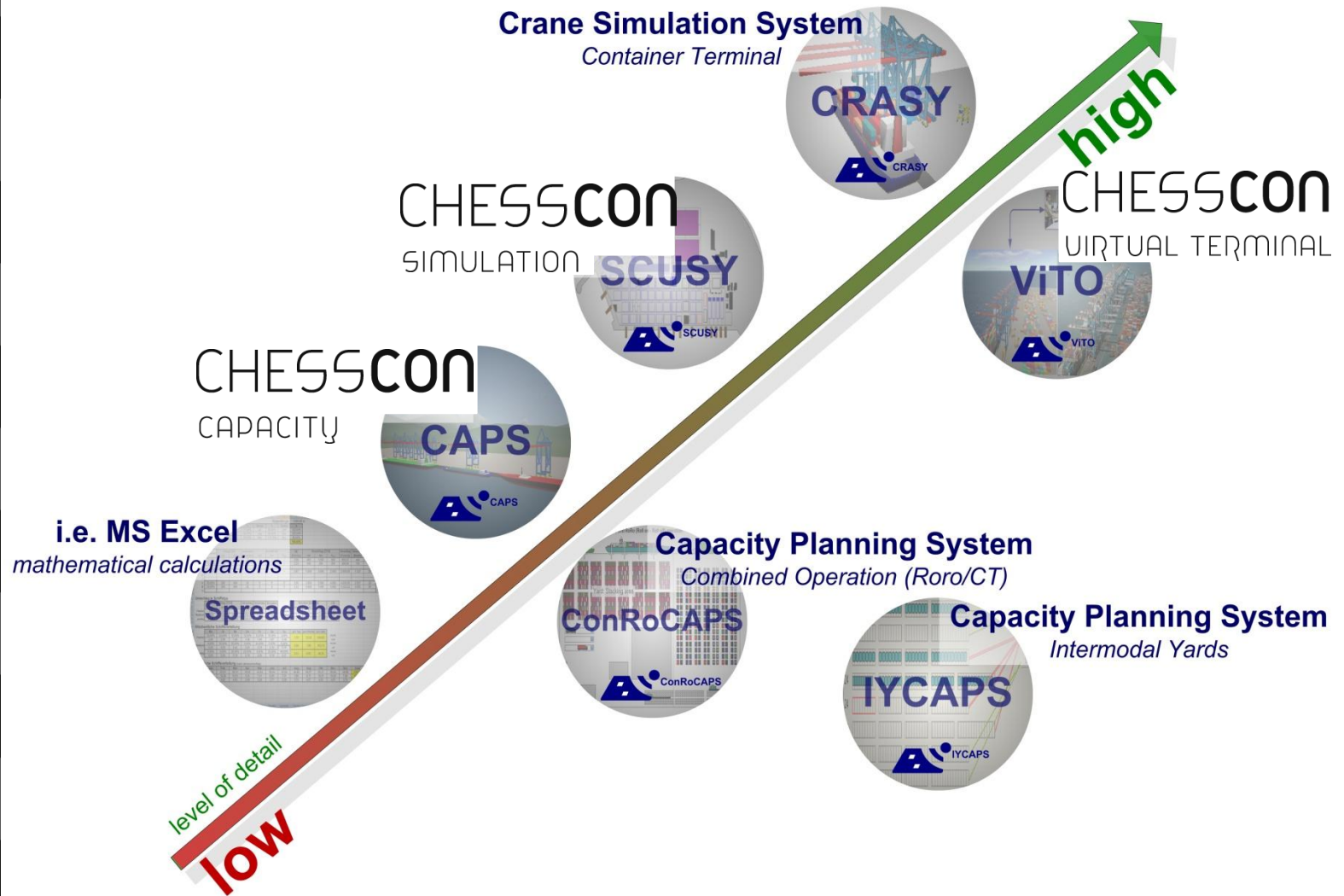
CHESSCON Capacity

Capacity planning for container terminals

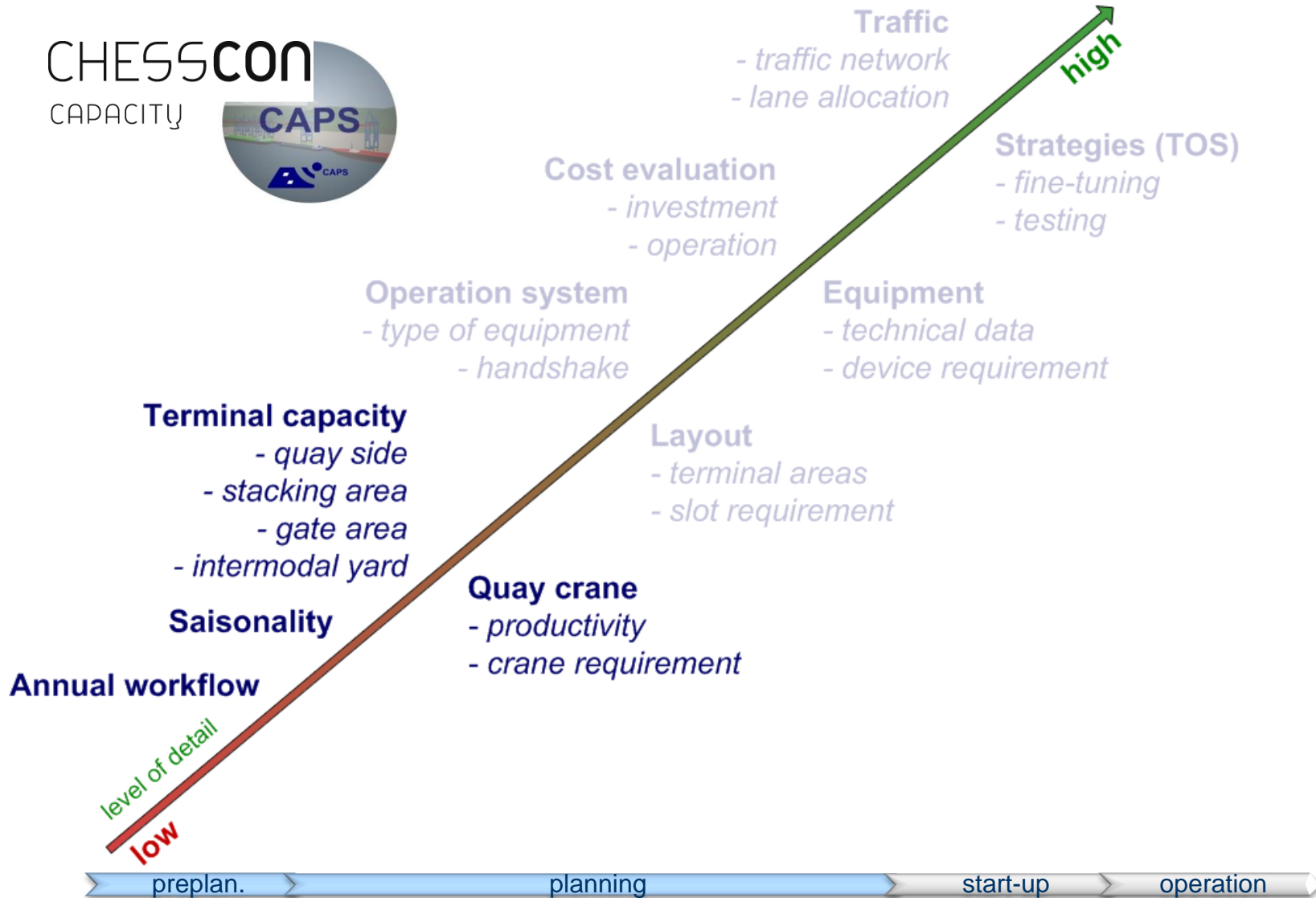


ISL APPLICATIONS GMBH

Simulation tools: Terminal Planning and Optimisation



Terminal planning and optimisation



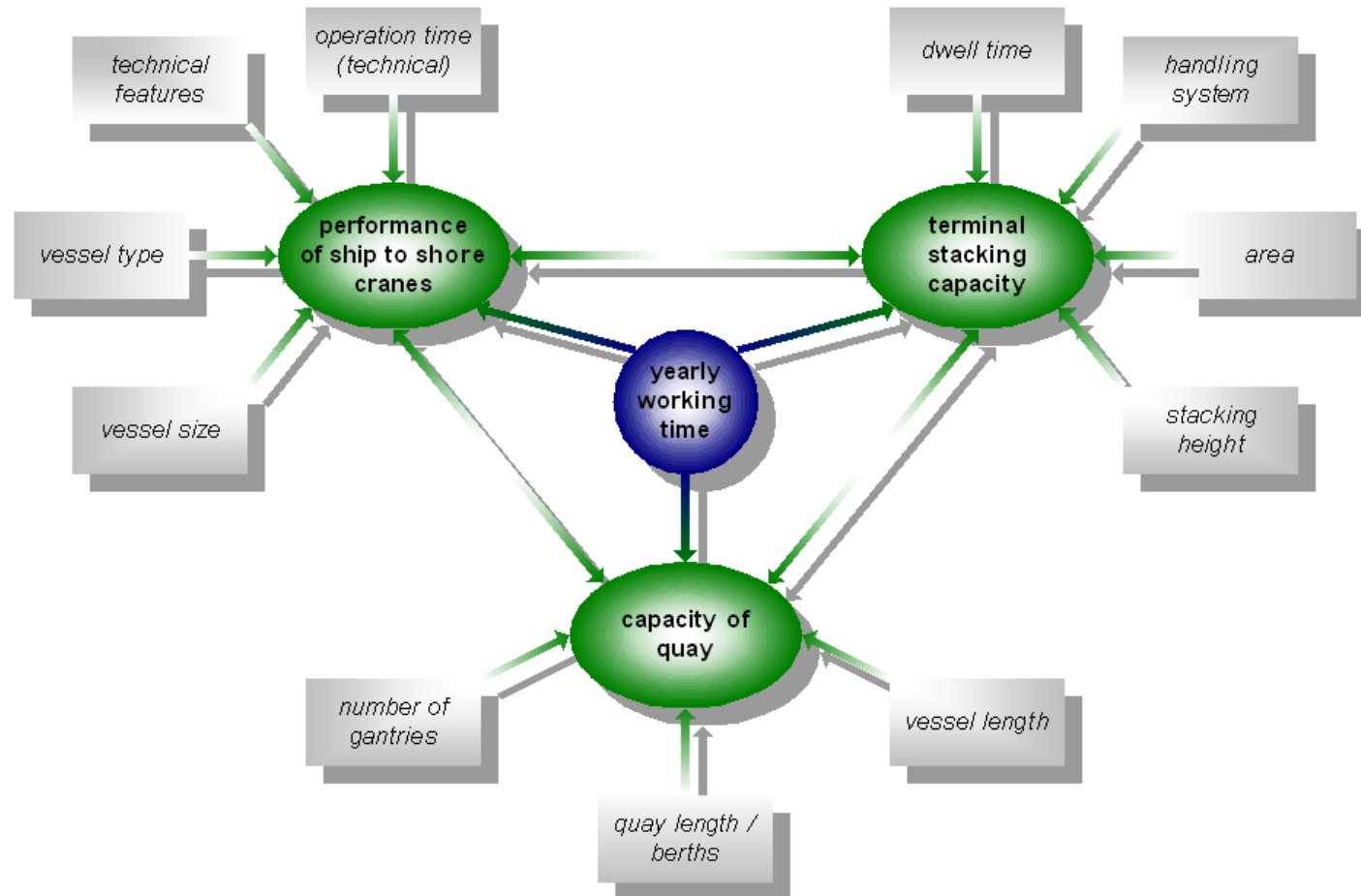
Terminal capacity

- 1,500 m quay length
- 24/7 operation
- Average vessel length 330 m (incl. safety distance)
- Average throughput per vessel 2,300 TEU
- Average service time 24 h
- ~~▪ → Theoretical capacity
 $(1,500 / 330) * 365 * 2,300 \text{ TEU} \sim 3.8 \text{ MTEU pa} \text{ ???}$~~

Static view is insufficient

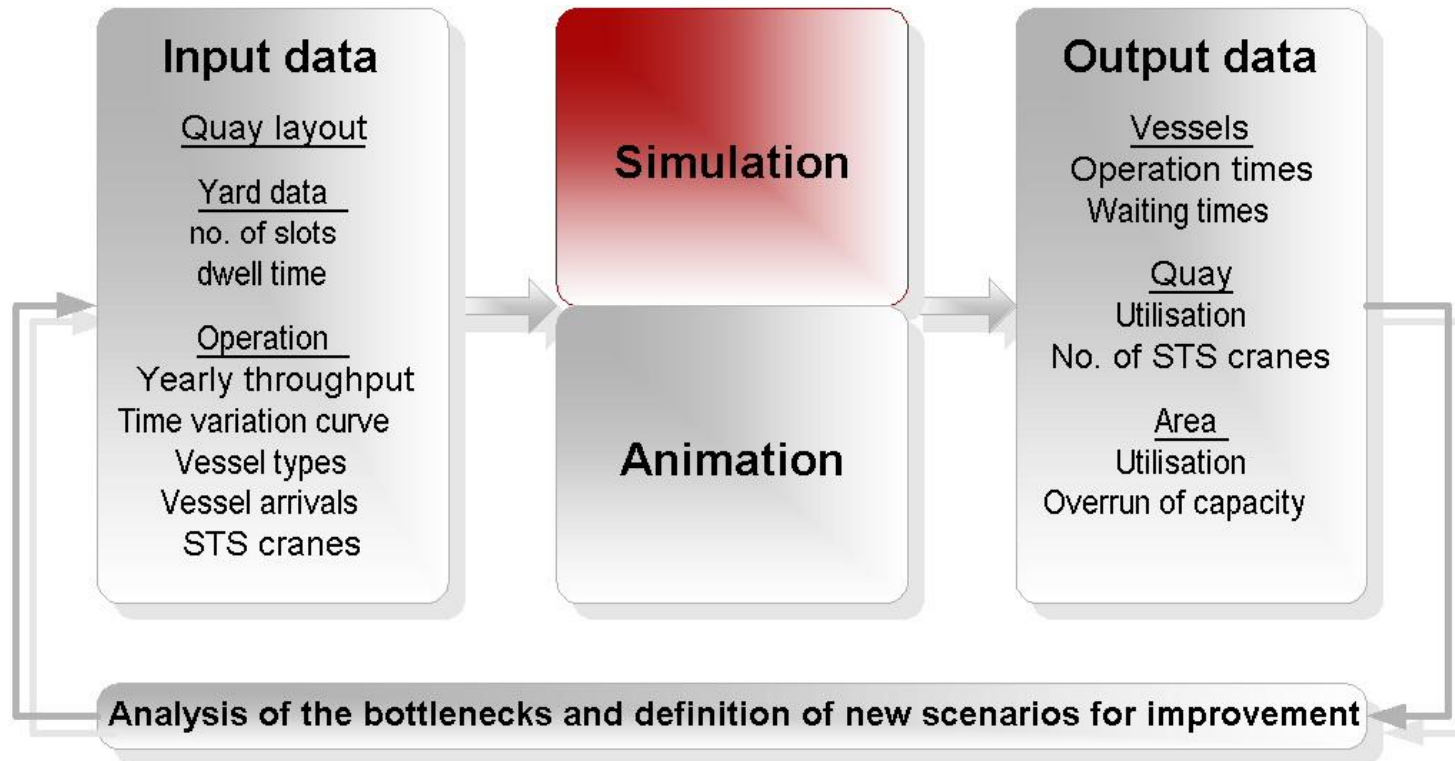
→ Simulation is recommended

Important parameters for container terminal capacity



Source: Burkhard Lemper: Efficiency of the seaport container throughput market of the north range

Main modules



Capacity planning for container terminals

■ Targets

- Where is the bottleneck of the terminal? Quay or stacking area?
- With how much throughput does a terminal cope with the existing capacity?

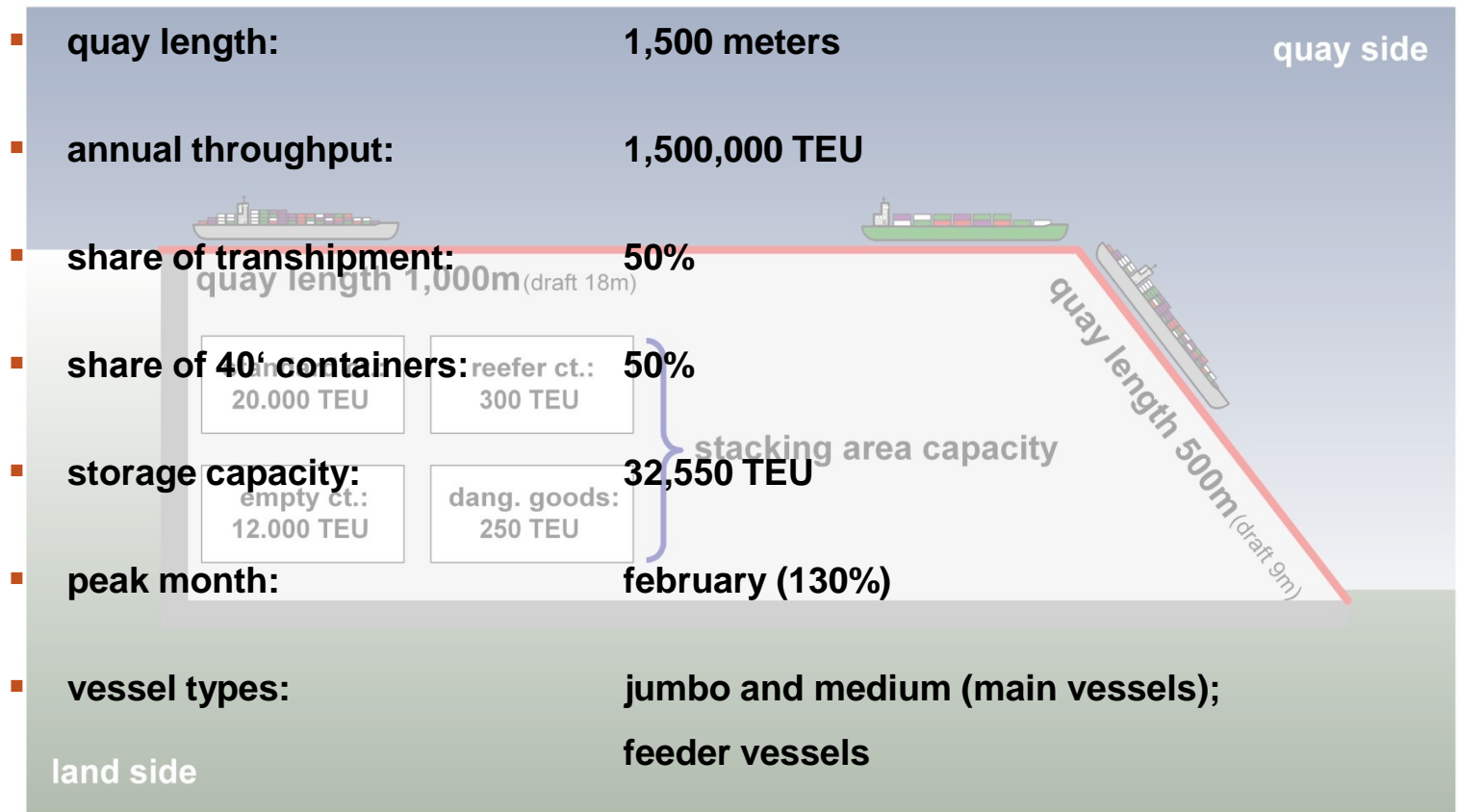
■ Quay evaluation

- Is there sufficient quay length to operate a given container volume?
- What is the utilization of the quay?
- What is the number of quay cranes required to handle the container volume?

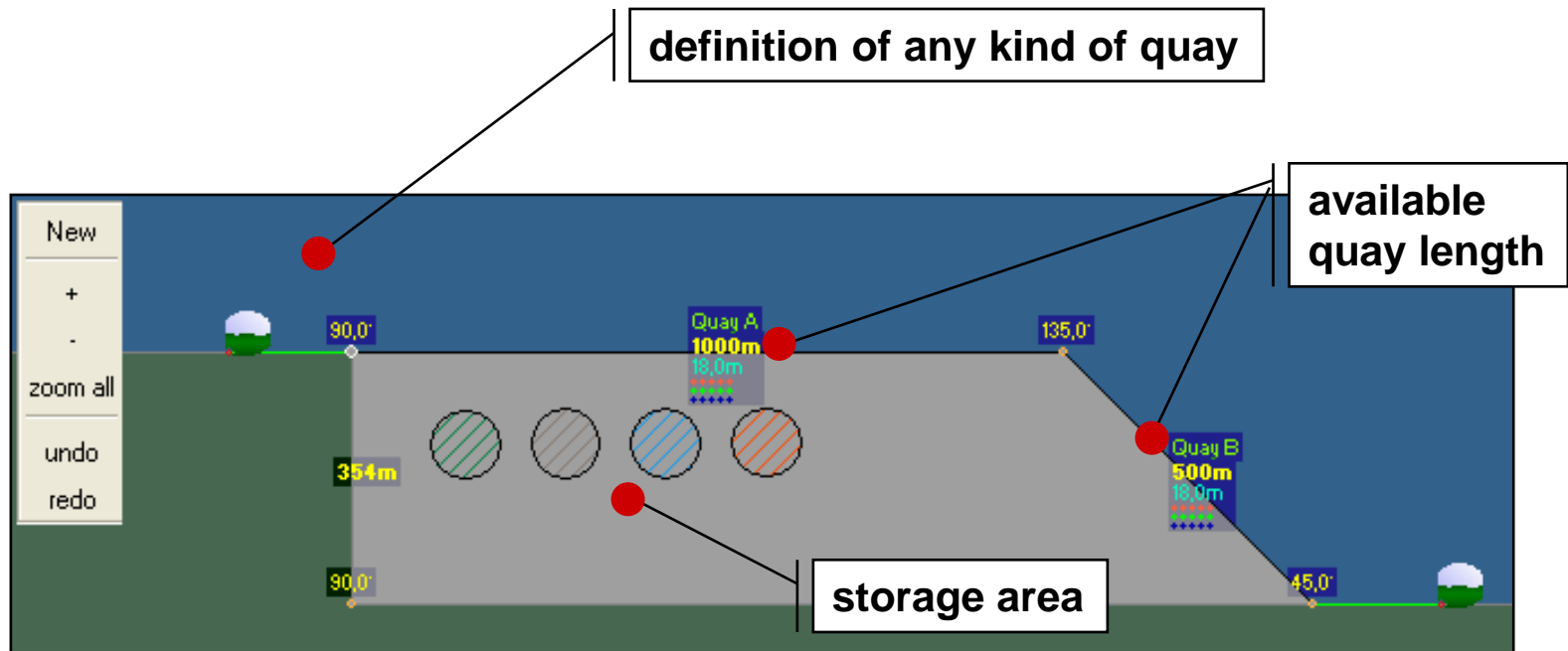
■ Area evaluation

- Is there a sufficient number of stacking slots?
- What is the utilization of the stacking area?

Example of application



Quay definition



Quay crane definition

Ship to shore crane classes

Name	moves/hr	no.
QC	max	15

>> Add >>

Ship to shore cranes

Name	Left	Right	Multi	STSC-Class
QC 1	0	700	no	QC
QC 2	25	725	no	QC
QC 3	50	750	no	QC
QC 4	75	775	no	QC
QC 5	100	800	no	QC
QC 6	200	900	no	QC
QC 7	225	925	no	QC
QC 8	250	950	no	QC
QC 9	275	975	no	QC
QC 10	300	1000	no	QC
QC 11	1000	1400	no	QC
QC 12	1025	1425	no	QC
QC 13	1050	1450	no	QC
QC 14	1075	1475	no	QC
QC 15	1100	1500	no	QC

Add class Delete class

Class name:

time for relocation [sec]:

max moves/hr:

Clone Delete Clear Sort

Name:

op range min.:

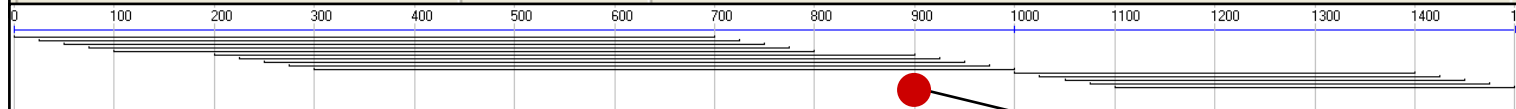
op range max.:

unlimited amount

Assignments

	A	B	C	D	E
Jumbo	X	X	X	X	X
Medium	X	X	X	X	X
Feeder	X	X	X	X	X

0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500

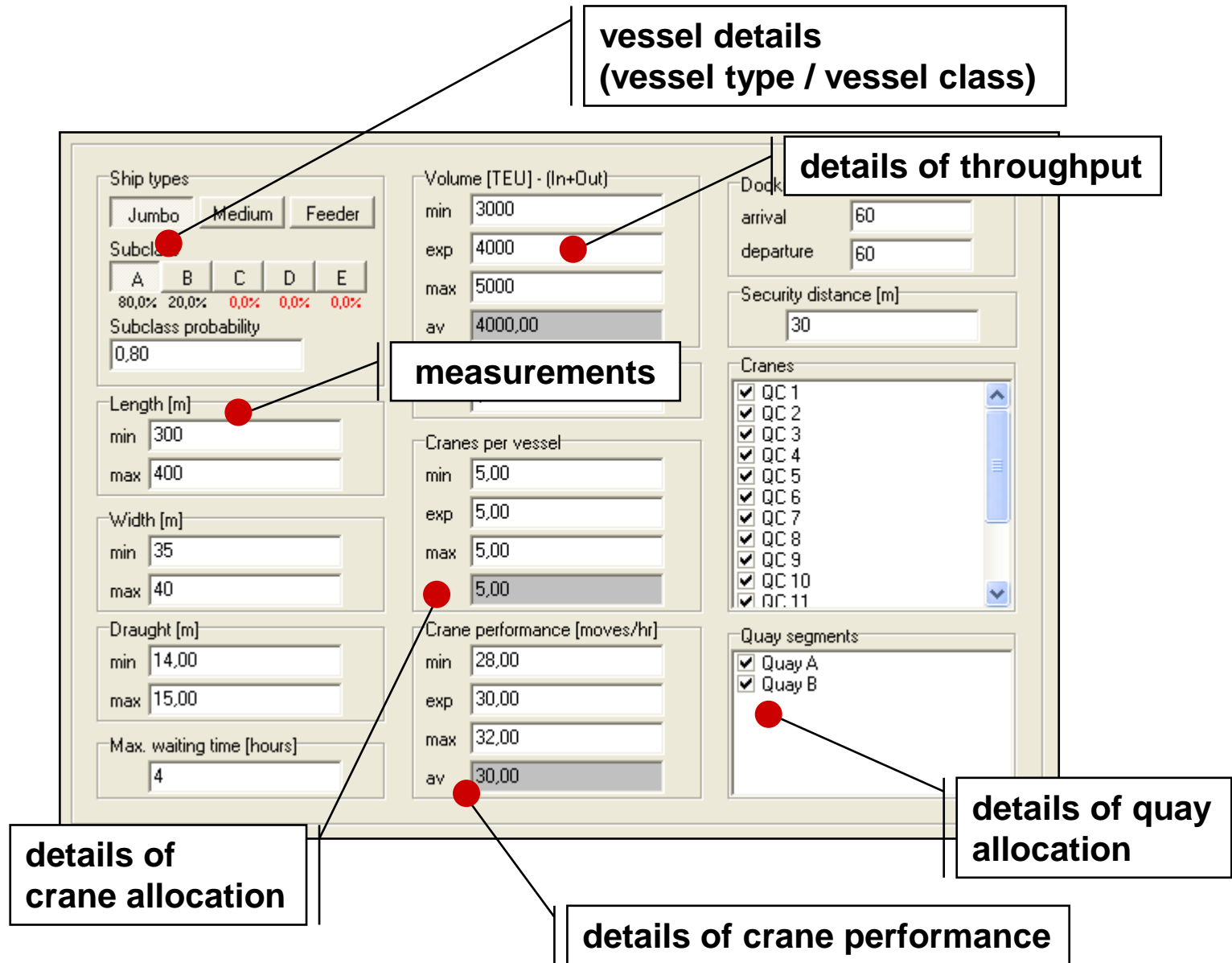


definition of single cranes

quay crane type definition

quay crane ranges

Vessel definition



vessel details (vessel type / vessel class)

details of throughput

measurements

details of crane allocation

details of crane performance

details of quay allocation

Ship types
 Jumbo Medium Feeder

Subclass

A	B	C	D	E
80,0%	20,0%	0,0%	0,0%	0,0%

 Subclass probability: 0,80

Volume [TEU] - (In+Out)
 min: 3000
 exp: 4000
 max: 5000
 av: 4000,00

Length [m]
 min: 300
 max: 400

Width [m]
 min: 35
 max: 40

Draught [m]
 min: 14,00
 max: 15,00

Max. waiting time [hours]
 4

Crane performance [moves/hr]
 min: 28,00
 exp: 30,00
 max: 32,00
 av: 30,00

Crane allocation
 min: 5,00
 exp: 5,00
 max: 5,00
 av: 5,00

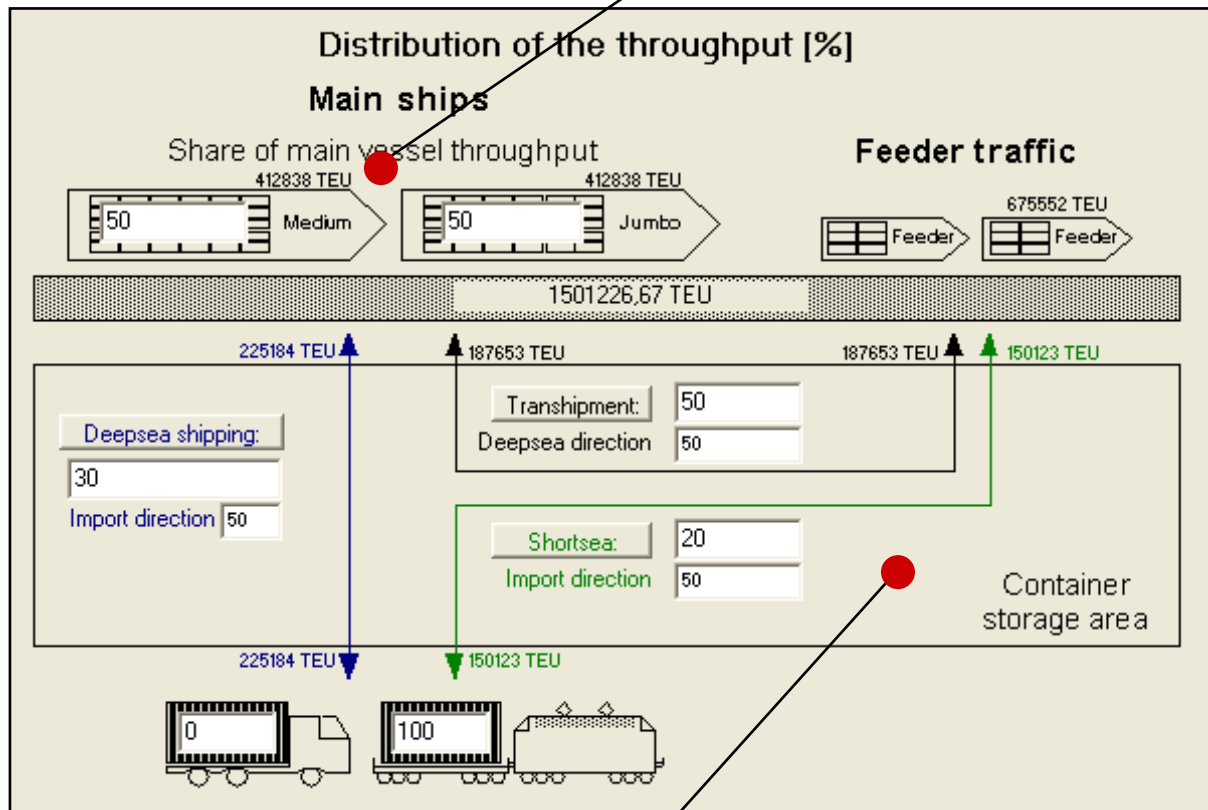
Crane list:
 QC 1
 QC 2
 QC 3
 QC 4
 QC 5
 QC 6
 QC 7
 QC 8
 QC 9
 QC 10
 QC 11

Quay segments
 Quay A
 Quay B

Dock arrival: 60
Departure: 60
Security distance [m]: 30

Throughput distribution

distribution of main vessel throughput



throughput flow

Container mix

Container mix [%]

Name	Probability	Size 1	Size 2	Size 3
Standard	80,00%	1,00 (50,0%)	2,00 (50,0%)	2,25 (0,0%)
Empty	15,00%	1,00 (50,0%)	2,00 (50,0%)	2,25 (0,0%)
Reefer	4,00%	1,00 (50,0%)	2,00 (50,0%)	2,25 (0,0%)
Dangerous	1,00%	1,00 (50,0%)	2,00 (50,0%)	2,25 (0,0%)

Add type Delete type Clear all

Color

Name	Probability	TEU	Probability
Standard	80,00	Size 1 1,00	50,00
		Size 2 2,00	50,00
		Size 3 2,25	0,00

container type definition

share of container sizes

Storage area definition

max. utilization of the storage area

area definition

Stacking area	Capacity	Utilization	Cntr types
■ Standard	24700 TEU	70,0%	1
■ Empty	12900 TEU	90,0%	1
■ Reefer	530 slots	70,0%	1
■ Dangerous	270 TEU	70,0%	1

Name:

Total capacity: TEU

max. utilization: %

Container types:

- Standard
- Empty
- Reefer
- Dangerous

available container slots per container type

Container dwell times

definition of dwell times

Container type	Trans. av	Gate av	Rail av
Standard	5,0 / 5,0	5,0 / 5,0	5,0 / 5,0
Empty	20,0 / 20,0	20,0 / 20,0	20,0 / 20,0
Reefer	2,0 / 2,0	2,0 / 2,0	2,0 / 2,0
Dangerous	5,0 / 5,0	5,0 / 5,0	5,0 / 5,0

Transshipment		min.	exp.	max.
Import		1,00	5,00	9,00
Export		1,00	5,00	9,00
Gate				
Import		1,00	5,00	9,00
Export		1,00	5,00	9,00
Rail				
Import		1,00	5,00	9,00
Export		1,00	5,00	9,00

∅ container dwell time per container type

Generation of a vessel schedule

annual throughput

definition of an average weekly vessel schedule

Yearly Throughput TEU

Weekday distribution of vessel arrivals

	Mon	Tue	Wed	Thu	Fri	Sat	Sun	av./day	per week	per year
Feeder	20,00	24,00	12,00	12,00	12,00	16,00	4,00	3,51	24,65	1282
Medium	0,00	30,00	20,00	0,00	40,00	5,00	5,00	0,57	3,97	206
Jumbo	0,00	0,00	20,00	20,00	0,00	20,00	40,00	0,26	1,86	97

∅ vessel arrivals per vessel type

normalize

Set fixed day time Fixed day time

Time :

No. of belated %

Max. delay hours Equal Distributed

daily vessel distribution

Ok Cancel

Simulation data

throughput distribution for simulation

TEU	Deepsea/Shortsea 29,9% / 20,1%			Transhipment 50,0%			Totals			Vessels
	imp	exp	total	imp	exp	total	imp	exp	total	
Jumbo	113275	113231	226505	94363	94347	188709	207637	207578	415215	99
Medium	117999	117856	235855	98294	98249	196543	216293	216105	432397	207
Feeder	155098	155196	310294	193986	193854	387841	349085	349050	698135	1287
Total	386372	386282	772654	386642	386450	773092	773014	772732	1545746	1593

Name	Day	Type	Prio...	TEU	Cycle	Generic Properties	Arrival Time	Custom subtype properties
Feeder ID: 352	1	Feeder (A*)	3	660	once	Single arrival	Arrival every 7 days	
Feeder ID: 351	1	Feeder (A*)	3	577	once			
Feeder ID: 355	2	Feeder (A*)	3	474	once			
Feeder ID: 1265	2	Feeder (B*)	3	173	once			
Feeder ID: 353	2	Feeder (A*)	3	488	once			
Feeder ID: 354	2	Feeder (A*)	3	426	once			
Feeder ID: 356	2	Feeder (A*)	3	524	once			
Feeder ID: 1266	2	Feeder (B*)	3	201	once			
Medium ID: 114	2	Medium (A*)	2	1373	once			
Feeder ID: 358	3	Feeder (A*)	3	361	once			
Medium ID: 115	3	Medium (A*)	2	1820	once			
Jumbo ID: 6	3	Jumbo (A*)	1	2814	once			
Feeder ID: 357	3	Feeder (A*)	3	627	once			
Feeder ID: 360	4	Feeder (A*)	3	545	once			
Feeder ID: 373	4	Feeder (A*)	3	420	once			

Single arrival Arrival every 7 days
 Whole Year

First Week: 1
 Day: Monday
 Time: 13 : 31
 Mo 01 Jan 13:31

No. of belated: 0,0 %
 Max. delay: 0,0 hours Equal Distributed

data sheet of vessel arrivals

arrival data of the vessel selected from the list

A vertical decorative bar on the left side of the slide, consisting of a grid of black and grey squares, with a small orange image of a container stack at the top.

Simulation

- **simulation time:** 1 year

- **preliminary time:** 2 weeks
(for pre-occupancy of quay and stacks)

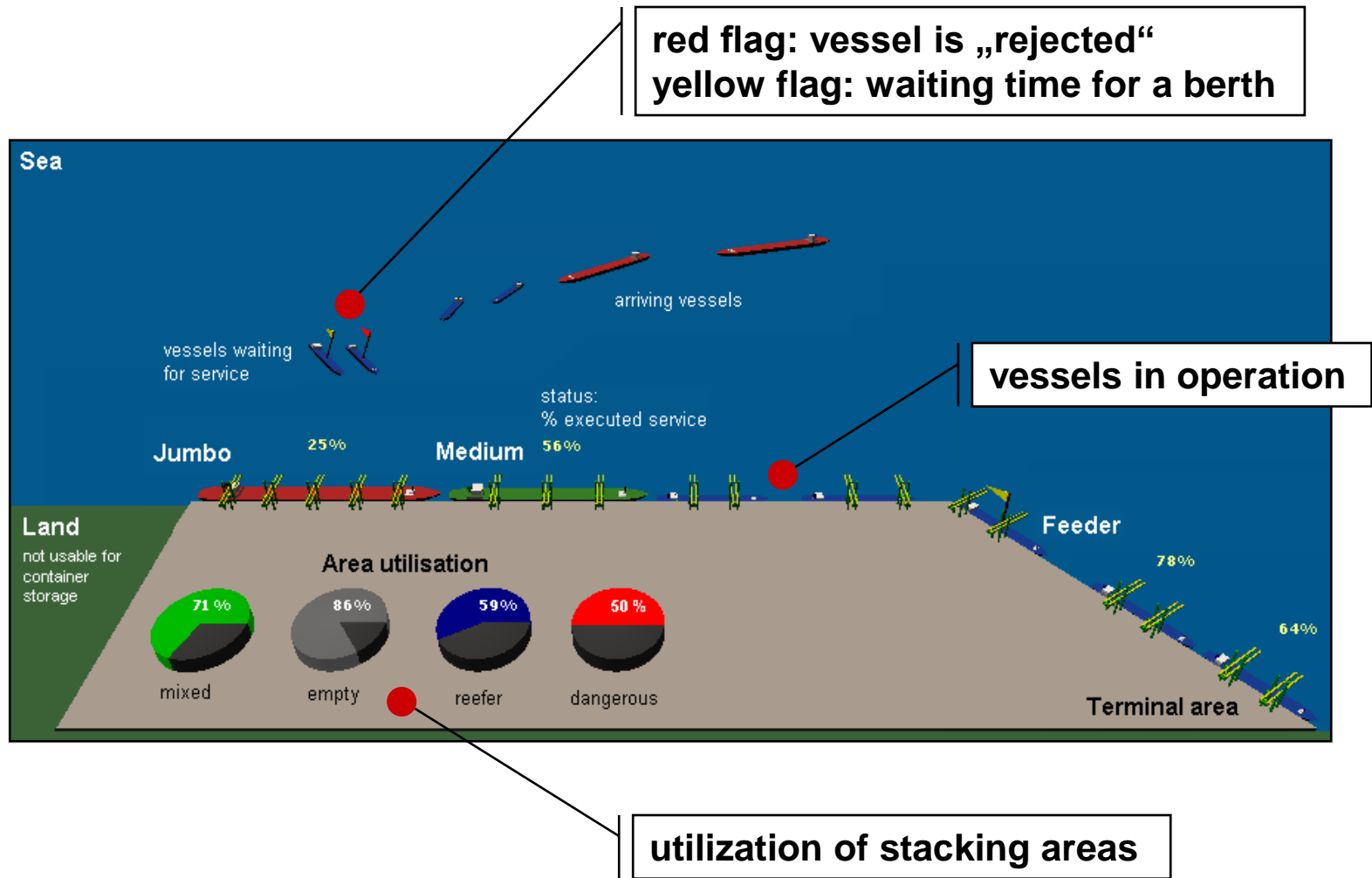
- **Simulation**
 - single runs for configuration check
 - several runs for evaluation

- **saving of simulation results**
 - average data over all simulation runs
 - if necessary data of each single run

Animation

- **3D animation of the quay**
- **animation of the area utilization**
- **online animation during simulation**
- **supplementary animation for fault analysis**
 - The last simulation run is recorded as a “film” which can be turned back and forward.
- **adaptation of the animation speed according to the requirements**
- **zoom and sight onto the terminal from various perspectives**

Animation



red flag: vessel is „rejected“
yellow flag: waiting time for a berth

vessels in operation

utilization of stacking areas

Simulation result evaluation

- **quay evaluation**
 - quay utilization – maximum and average
 - crane requirement – maximum and average

- **vessel evaluation**
 - berthing times - maximum and average for any vessel type
 - waiting times - maximum and average for any vessel type
 - „rejected“ vessels – waiting time over maximum
 - crane performance - minimum, maximum and average

- **stacking area evaluation**
 - evaluation of the area utilization regarding to capacity overrun as well as maximum utilisation overrun

Total evaluation

simulated container volume

Total volume: 1450221.00 TEU Total volume [including rejected ships]: 1505876.00 TEU

Feeder

Number			Berthing time		Operation time		Waiting time			TEU		Container		Ship to shore cranes	
total	waiting*	rejected	av.	max.	av.	max.	av. (total)	av. (waiting)	max.	total avg	total max	av.	max.	no.	moves/hr
1287.00	125.00	35.00	08:30:33	29:01:12	08:23:23	24:02:34	00:20:28	03:25:00	07:55:20	522.77	1266.00	348.50	846	2.06	20.69
	9.71%	2.72%	Berthing without waiting time: 90.29%												

Medium

Number			Berthing time		Operation time		Waiting time			TEU		Container		Ship to shore cranes	
total	waiting*	rejected	av.	max.	av.	max.	av. (total)	av. (waiting)	max.	total avg	total max	av.	max.	no.	moves/hr
207.00	5.00	6.00	15:12:12	29:39:54	15:12:12	29:39:54	00:01:57	01:18:15	02:24:32	2012.22	3372.00	1341.50	2249	3.58	24.98
	2.42%	2.90%	Berthing without waiting time: 97.58%												

Jumbo

Number			Berthing time		Operation time		Waiting time			TEU		Container		Ship to shore cranes	
total	waiting*	rejected	av.	max.	av.	max.	av. (total)	av. (waiting)	max.	total avg	total max	av.	max.	no.	moves/hr
99.00	4.00	5.00	18:36:34	34:14:33	18:36:34	34:14:33	00:02:30	00:58:43	02:10:55	4162.29	6659.00	2774.77	4440	4.93	30.33
	4.04%	5.05%	Berthing without waiting time: 95.96%												

Total 8.41% 2.89%

*excludes rejected ships

share of waiting and „rejected“ vessels

vessel type evaluation:

- operation time
- waiting time
- container volume
- quay crane performance

Total evaluation

Statistic				
Quay length	Quay util.		no. of used StSC	
	av.	max.	av.	max.
1501m	24.18%	62.76%	4.65	10

Yard utilisation					
Stack name	maximum	average	over capacity	over	
Standard	114.00%	69.63%	4.12%	46.24%	53.76%
Empty	103.00%	79.01%	1.05%	23.31%	76.69%
Reefer	174.00%	72.38%	13.45%	47.09%	52.91%
Dangerous	120.00%	69.20%	4.16%	46.36%	53.64%

Ship distribution								Quay segment occupation		area evaluation			
avg	Mon	Tue	Wed	Thu	Fri	Sat	Sun	%	Quay A	%	20'	40'	45'
Feeder	5.00	5.90	2.92	3.04	2.96	3.94	0.88	Feeder	100.0	Feeder	50.0	50.0	0.0
Medium	0.00	1.13	0.85	0.00	1.63	0.19	0.17	Medium	100.0	Medium	0.0	0.0	0.0
Jumbo	0.00	0.00	0.38	0.35	0.00	0.38	0.79	Jumbo	100.0	Jumbo	50.0	50.0	0.0

Throughput distribution												
%	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Feeder	81.59	140.92	117.44	78.70	82.59	100.91	81.05	89.26	102.00	118.86	120.61	90.11
Medium	89.89	107.83	129.89	67.28	90.02	95.60	70.05	107.02	113.11	119.02	125.21	85.89
Jumbo	81.77	66.58	134.12	80.44	82.11	96.52	80.04	90.40	169.41	88.97	83.19	144.18
Total	83.96	111.52	125.44	75.99	84.53	98.23	77.70	94.53	123.39	110.80	111.74	103.60

quay evaluation

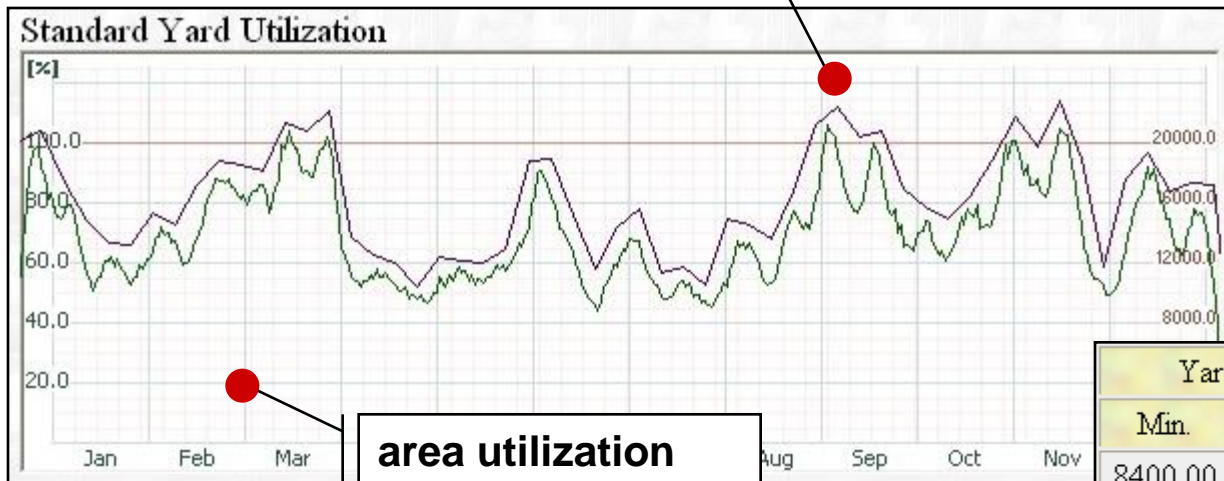
area evaluation

vessel schedule

throughput distribution

Area evaluation

slot capacity overrun

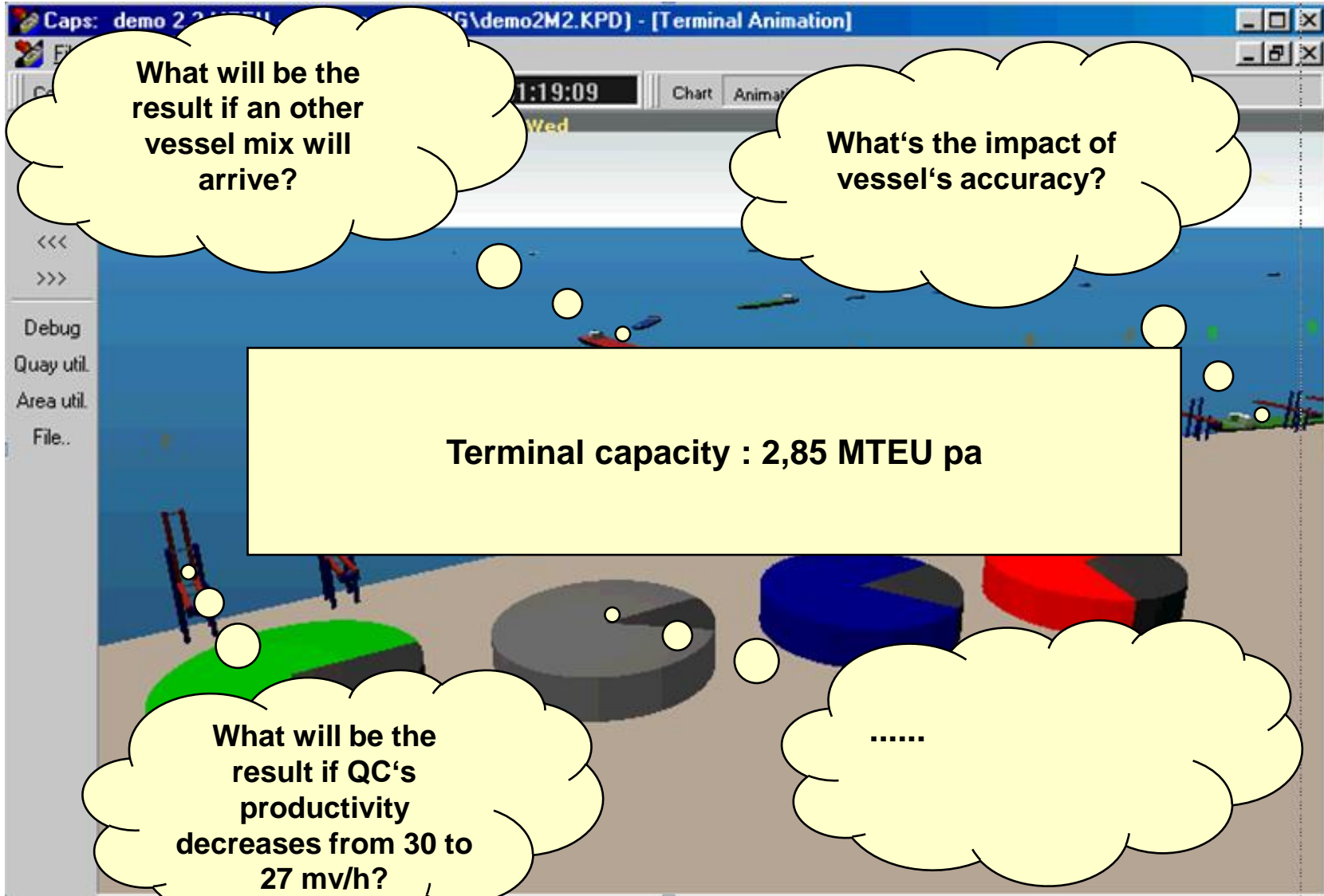


area utilization during simulation

Yard occupation [TEU]		
Min.	Av.	Max.
8400.00	13926.28	22800.00
Given operational capacity: 70.00%		

area occupancy and slot requirement

Capacity planning



The screenshot shows a simulation window titled "Caps: demo 2 2... (G\demo2M2.KPD) - [Terminal Animation]". The interface includes a clock showing "1:19:09", a "Wed" day indicator, and a sidebar with "Debug", "Quay util.", "Area util.", and "File..". The main area displays a 3D terminal scene with ships and cranes. A central yellow box contains the text "Terminal capacity : 2,85 MTEU pa". Four thought bubbles pose questions: "What will be the result if an other vessel mix will arrive?", "What's the impact of vessel's accuracy?", "What will be the result if QC's productivity decreases from 30 to 27 mv/h?", and ".....".

What will be the result if an other vessel mix will arrive?

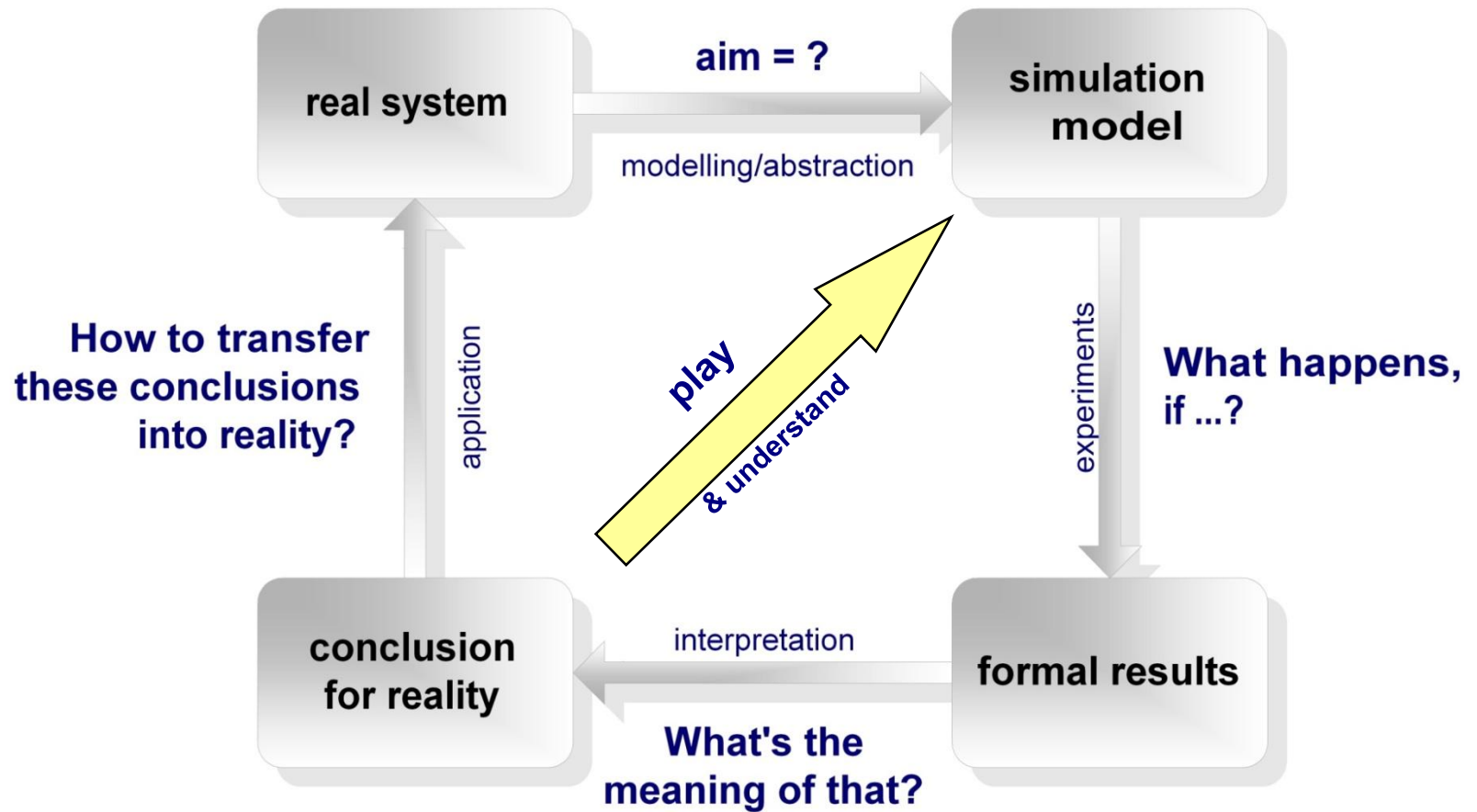
What's the impact of vessel's accuracy?

Terminal capacity : 2,85 MTEU pa

What will be the result if QC's productivity decreases from 30 to 27 mv/h?

.....

Simulation cycle



Reuse existing simulation models for sensitivity analysis and for getting a better understanding of the real terminal

ISL Applications' product strategy

Marketing Software Products

- training, customising first model → getting started
→ priority 1
- supporting the start-up of new projects
(e.g. Eurogate group and Sandwell)
→ priority 2
- complete studies or black box models
(including analyzing, optimizing, ...)
→ priority 3



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