Intermodal Terminal Alnabru

Results of the rail simulation for Building step 1

Vortrag im Rahmen der IT10 Rail am 21.01.2010 in Zürich

Auftraggeber:

Jernbaneverket Utbygging
Oslo
Norway

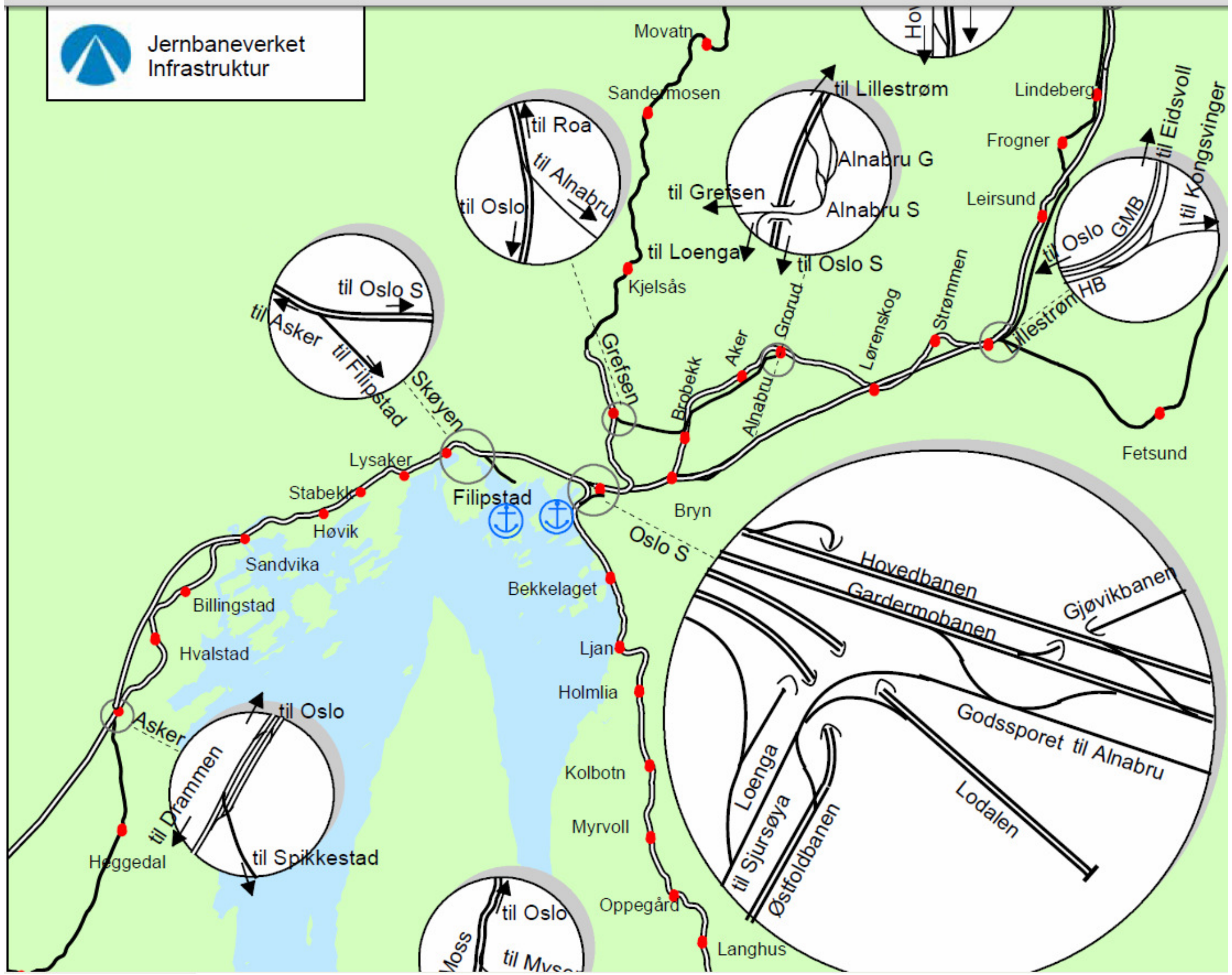
erarbeitet durch:

ETC Transport Consultants GmbH
Am Karlsbad 11
10785 Berlin
Germany

a member of the COWI group

Stand: 19.1.2010

Railway network of Greater Oslo Area



Heute:

Alnabru ist der größte Rangierbahnhof Norwegens.

Im Nordbereich erfolgt KV-Umschlag.

Alnabru liegt an der zweigleisigen Hovedbanen* (Lokaltog, halbstündlich mit Verstärkern)

Zukünftig:

KV-Drehscheibe Norwegens (Erhöhung des Schienenanteils)

Verdreifachung der Kapazität (1,5 Mio. TEU im Jahr)

Schrittweiser Umbau bis 2040 zum intermodalen Terminal mit bis zu 4 Kranmodulen im Final Layout

Parallele Ausweitung und Verdichtung des Regionalverkehrs

* Oslo S – Grorud - Lillestrøm – Eidsvoll: 68 km

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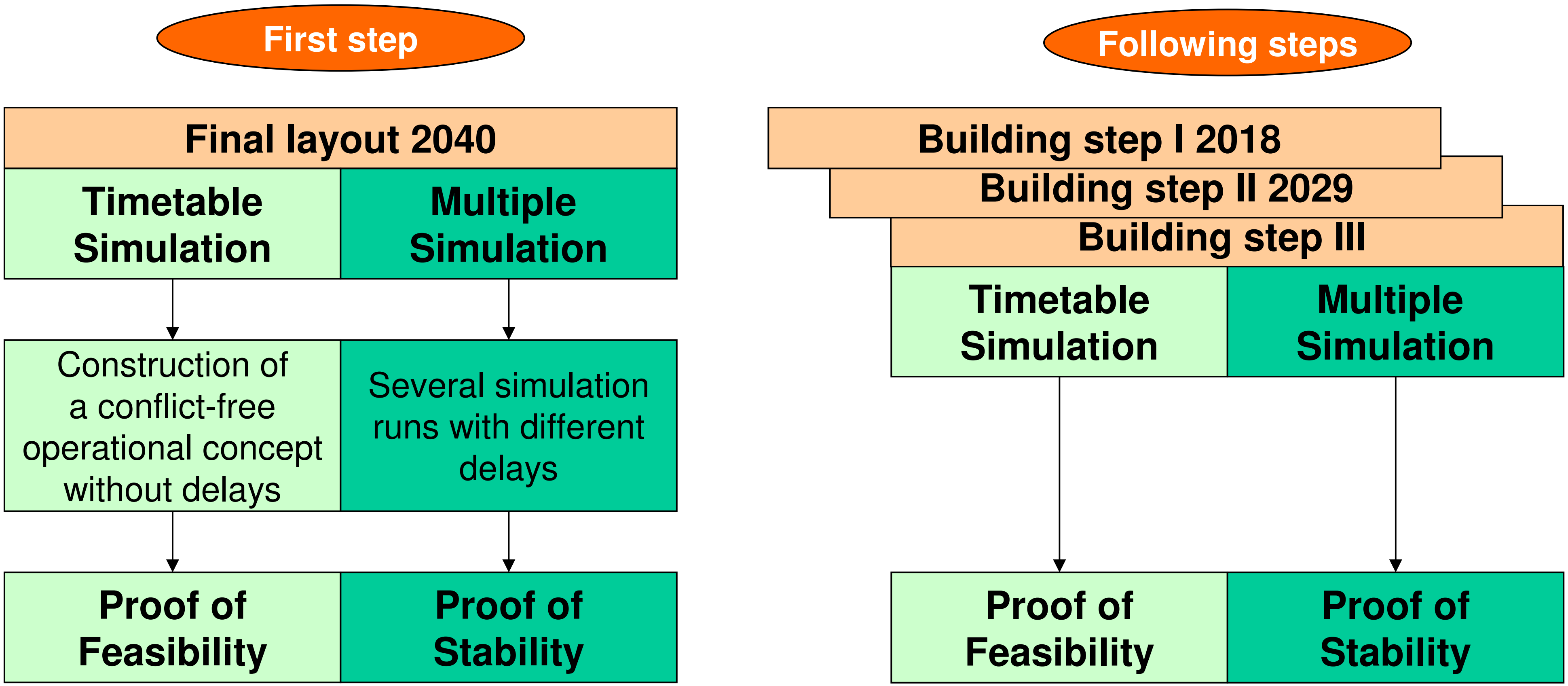
Simulation steps

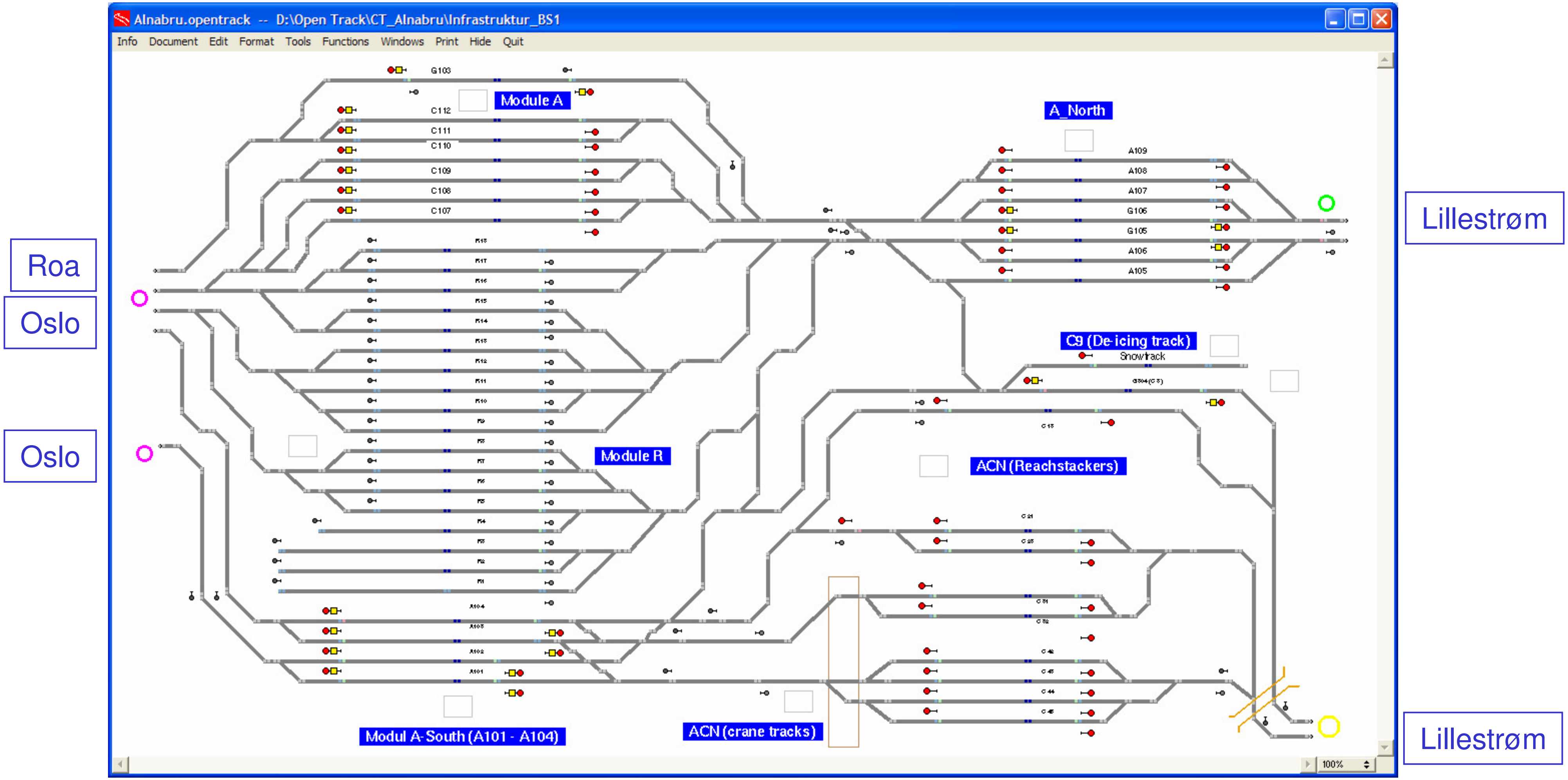


Introduction

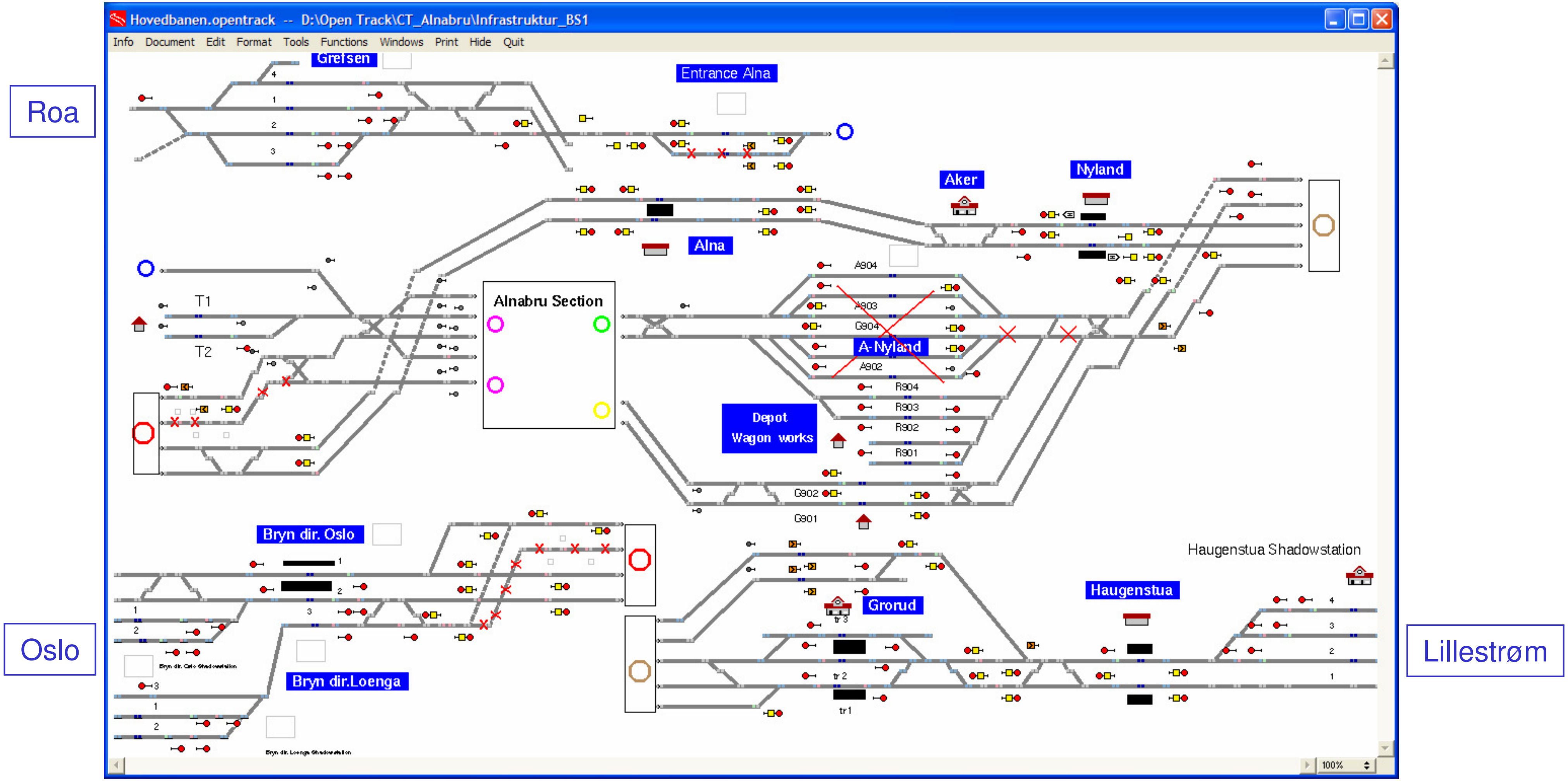
The main task of the railway simulation of Alnabru Building step 1 (BS1) is to answer the following questions:

1. Is the **chosen track layout capable** to cope with the expected cargo volume ?
2. Is the operational concept **robust** enough ?
3. Is the terminal – from the railway side – **dimensioned properly** or is it oversized ?

Track layout
Terminal area



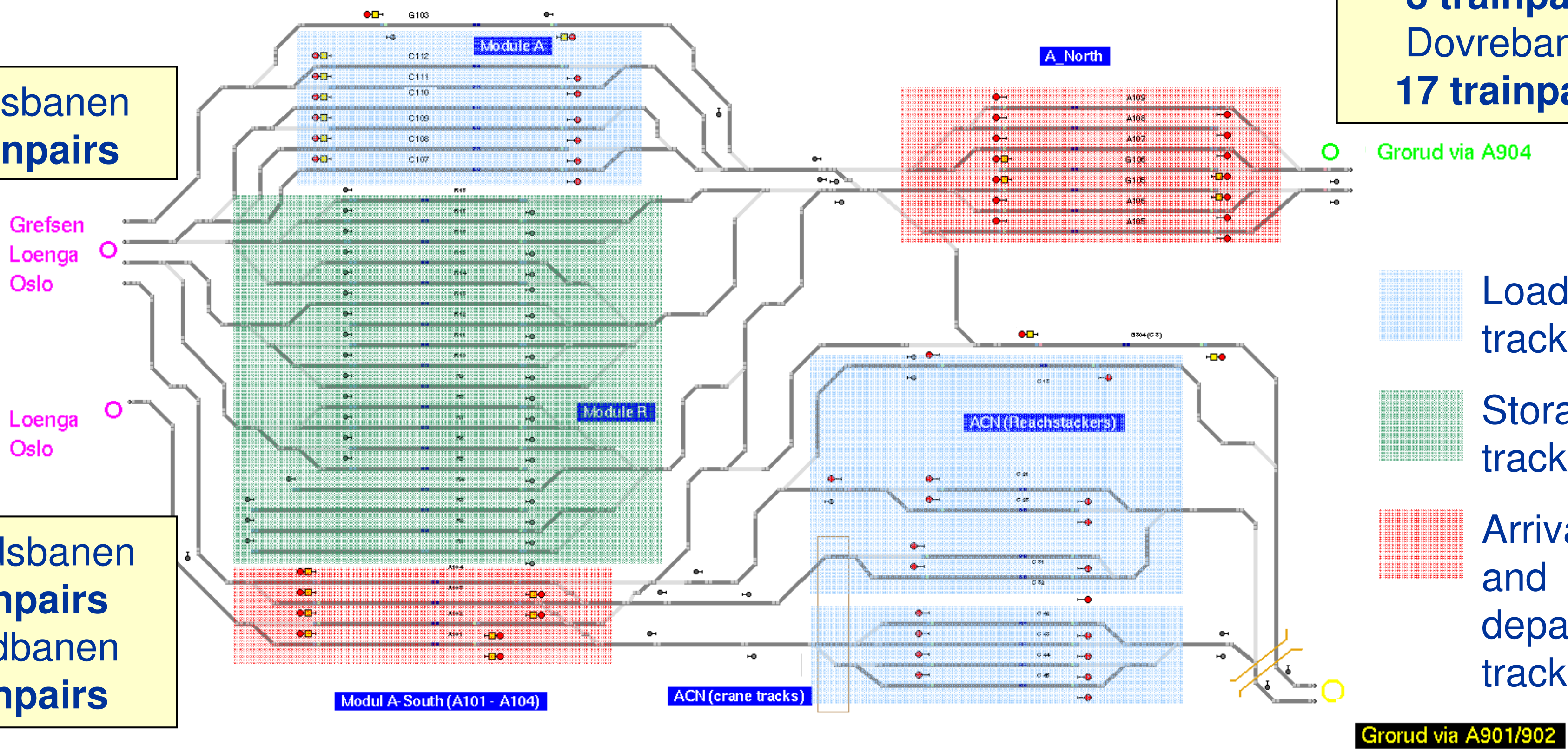
Track layout
Connections to the railway network



Track layout
Number of trains inbound and outbound

Kongsvingerbanen
8 trainpairs
Dovrebanen
17 trainpairs

Bergensbanen
10 trainpairs



Sørlandsbanen
7 trainpairs
Østfoldbanen
4 trainpairs

Loading tracks

Storage tracks

Arrival and departing tracks

Simulation strategy – step by step

1

The first train movements integrated in the simulation model is the group of **standard train routes** for inbound and outbound trains, including the shunting traffic between the inbound tracks and the loading tracks.

2

Regular movements of shunting locos and e-locos moving to and from the trains. These movements have been calculated analytically at first. Based on these figures, typical shunting movements have been integrated into the simulation.

3

Special movements to and from the wagon works. These events have a stochastic character and therefore can't be simulated in a timetable-based manner. Therefore they have been integrated on a random base.

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Occupation of loading tracks

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Module A

C107	C108	C109	C110	C111	C112
580	580	580	580	580	580
00:25			v Dovreb.	00:13	
	57029			00:17	n Dovreb.
			57033		01:25
	n Dovreb.			57031	
	02:25		02:13		
	02:35		02:17	n Dovreb.	
	v Dovreb.			03:25	
		03:35	57033		
	57001	v Dovreb.			
			n Dovreb.		
	05:13	57003	05:25		
	05:17		05:35		
		06:13	v Dovreb.		
	57001	06:17			
			57005		
	n Dovreb.	57003			07:35
	08:25		08:13		v Dovreb.
		n Dovreb.	08:17	08:35	
		09:25		v Dovreb.	57007
		09:35	57005		
		v Dovreb.		57009	10:13
			n Dovreb.		10:17
		57011	11:25	11:13	
			11:35	11:17	57007
		12:13	v Dovreb.		
	12:35	12:17		57009	n Dovreb.
	v Dovreb.		57013		13:25
		57011		n Dovreb.	13:35
	57015		14:13	14:25	v Dovreb.
		n Dovreb.	14:17	14:35	
	15:13	15:25		v Dovreb.	57017
	15:17	15:35	57013		
		v Dovreb.		57019	16:13
	57015		n Dovreb.		16:17
		57021	17:25	17:13	
	n Dovreb.		17:35	17:17	57017
	18:25	18:13	v Dovreb.		
18:35		18:17		57019	n Dovreb.
v Dovreb.			57023		19:25
		57021		n Dovreb.	19:35
57025			20:13	20:25	v Dovreb.
	20:35	n Dovreb.	20:17		
21:13	v Dovreb.	21:25			57027
21:17			57023	21:35	
	57029			v Dovreb.	22:13
57025			n Dovreb.		22:17
	23:13		23:25	57031	
n Dovreb.	23:17		23:35		57027

ACN Reachstacker

C13	C21	C23	C31	C32
>=580	>=580	>=580	>=580	>=580
v Bergen	00:05	23:58	419015	
55019			00:44	
		55017	00:48	01:07
01:32	01:55	n Bergen	419015	v Int. (KVB)
01:58	v Bergen	02:05	n Int. (KVB)	419101
	55001		02:55	02:35
55019				03:07
n Bergen	03:32	03:55		v Int. (KVB)
04:05		v Bergen		419003
		55003		04:44
			05:07	04:48
05:55		05:32	v Int. (KVB)	419003
v Bergen		05:58	419005	n Int. (KVB)
55005			06:44	06:55
		55003	06:48	
07:32		n Bergen	419005	
07:58		08:05	n Int. (KVB)	
			08:55	08:57
55005			09:07	
n Bergen		09:55	v Int. (KVB)	419102
10:05	09:58	v Bergen	419107	n Int. (KVB)
		55007	10:35	10:55
	55001		11:07	
11:55	n Bergen	11:32	v Int. (KVB)	
v Bergen	12:05	11:58	419009	
55009			12:44	
		55007	12:48	
13:32	13:55	n Bergen	419009	
	v Bergen	14:05	n Int. (KVB)	
	55011		14:55	
	15:32	15:55		
	15:58	v Bergen		
		55013		
	55011		16:57	
	n Bergen	17:32	419108	
	18:05	17:58	n Int. (KVB)	
			18:55	
		55013	19:07	18:57
	19:55	n Bergen	v Int. (KVB)	419114
19:58	v Bergen	20:05	419011	n Int. (KVB)
	55015		20:44	20:55
55009			20:48	21:07
n Bergen	21:32	21:55	419011	v Int. (KVB)
22:05	21:58	v Bergen	n Int. (KVB)	419113
		55017	22:55	22:35
	55015		23:07	
23:55	n Bergen	23:32	v Int. (KVB)	

ACN Crane

C42	C43	C44	C45
>=580	>=580	>=580	>=580
		v Stavanger	n Int. (ØVB)
	n Stavanger		00:35
	01:00	58015	01:25
	01:50		v Int. (ØVB)
	v Stavanger	02:10	
		02:10	419621
	58001		
		58015	03:36
	04:01		
		n Stavanger	
		05:00	05:25
05:50			v Int. (ØVB)
v Stavanger			
			419623
58005			
			07:36
07:27			
08:53			
58005		09:50	
		v Stavanger	10:25
n Stavanger	10:19		v Int. (ØVB)
11:00		58007	
11:50	58001		419525
v Stavanger		12:10	
	n Stavanger	12:10	12:45
58009	13:00		12:45
	13:50	58007	
13:18	v Stavanger		419525
		n Stavanger	
	58011	15:00	n Int. (ØVB)
			15:35
	16:10		
	16:10		
		17:25	
	58011	v Int. (ØVB)	
			17:54
	n Stavanger	419527	
19:02	19:00		419624
	19:50	19:45	
58010	v Stavanger	19:45	n Int. (ØVB)
n Stavanger			20:35
21:00	58013	419527	
	22:10	n Int. (ØVB)	21:54
	22:10	22:35	
			419622
	58013	23:50	

Track C107 is occupied only up to 25%, C32 up to 45% and C42 up to 60%. There are some more gaps in further tracks.

These tracks will serve as buffer inside the loading modules in case of delays.

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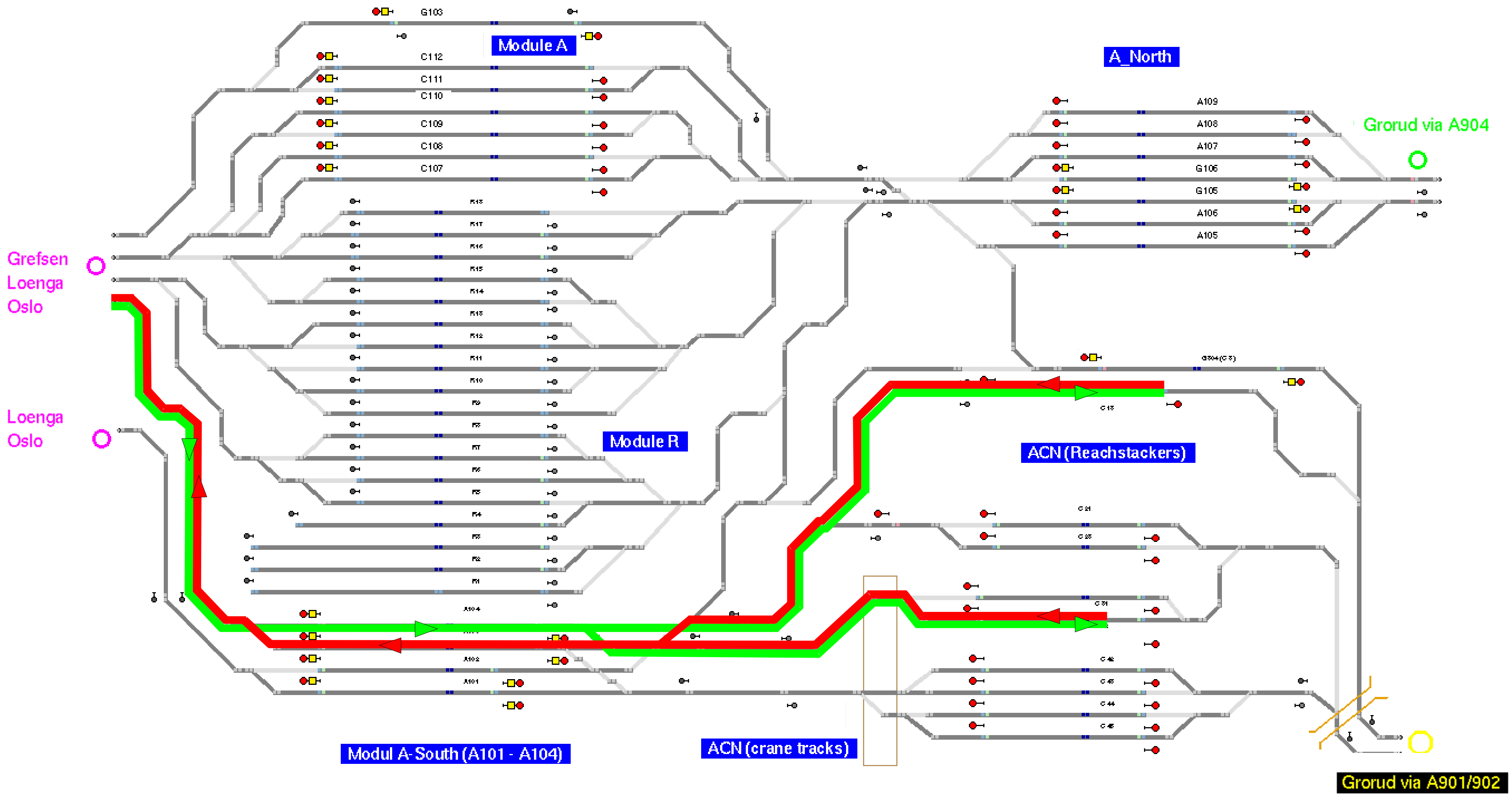
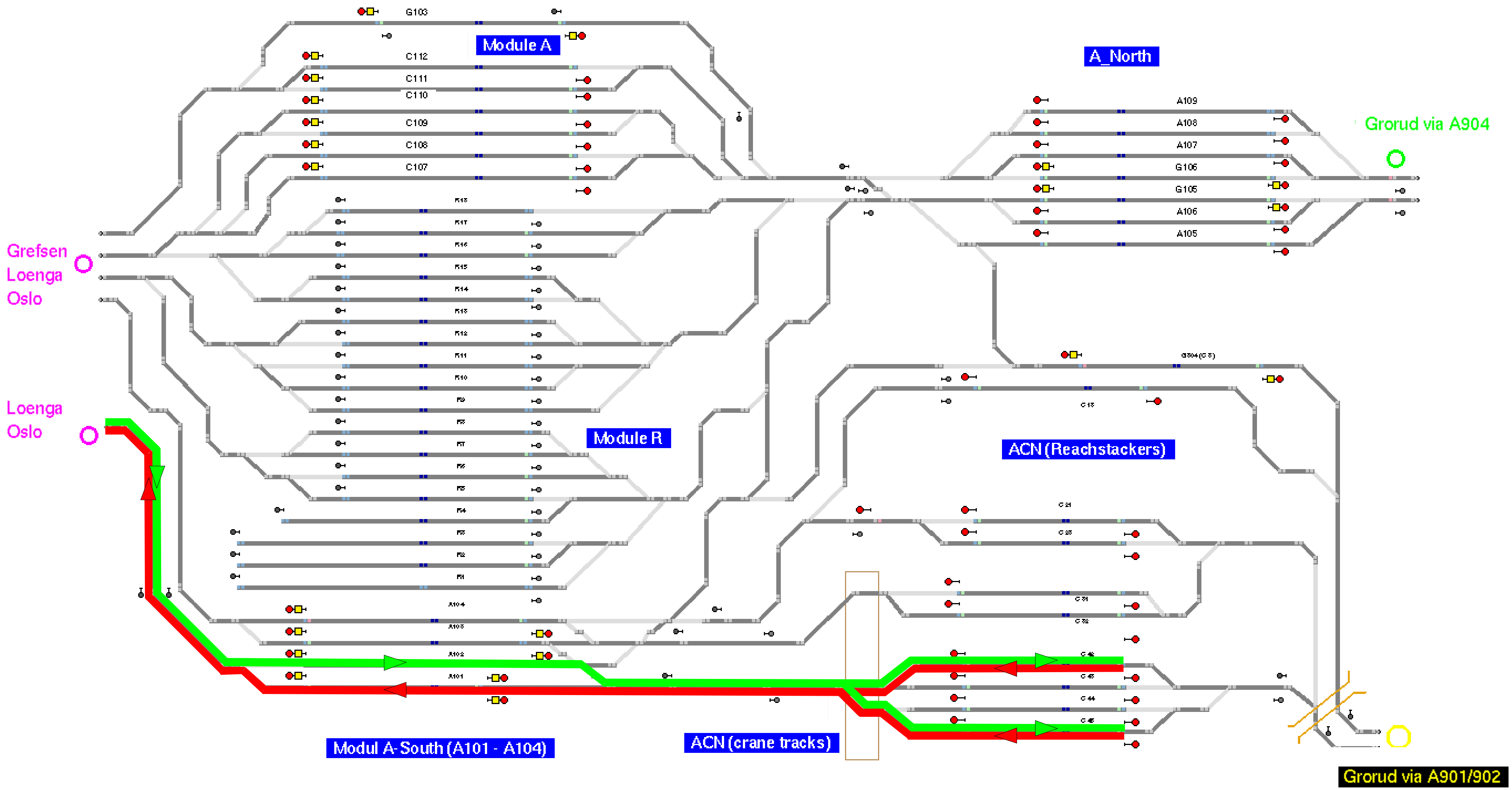
Standard routes into the terminal

Trains from and to Grefsen



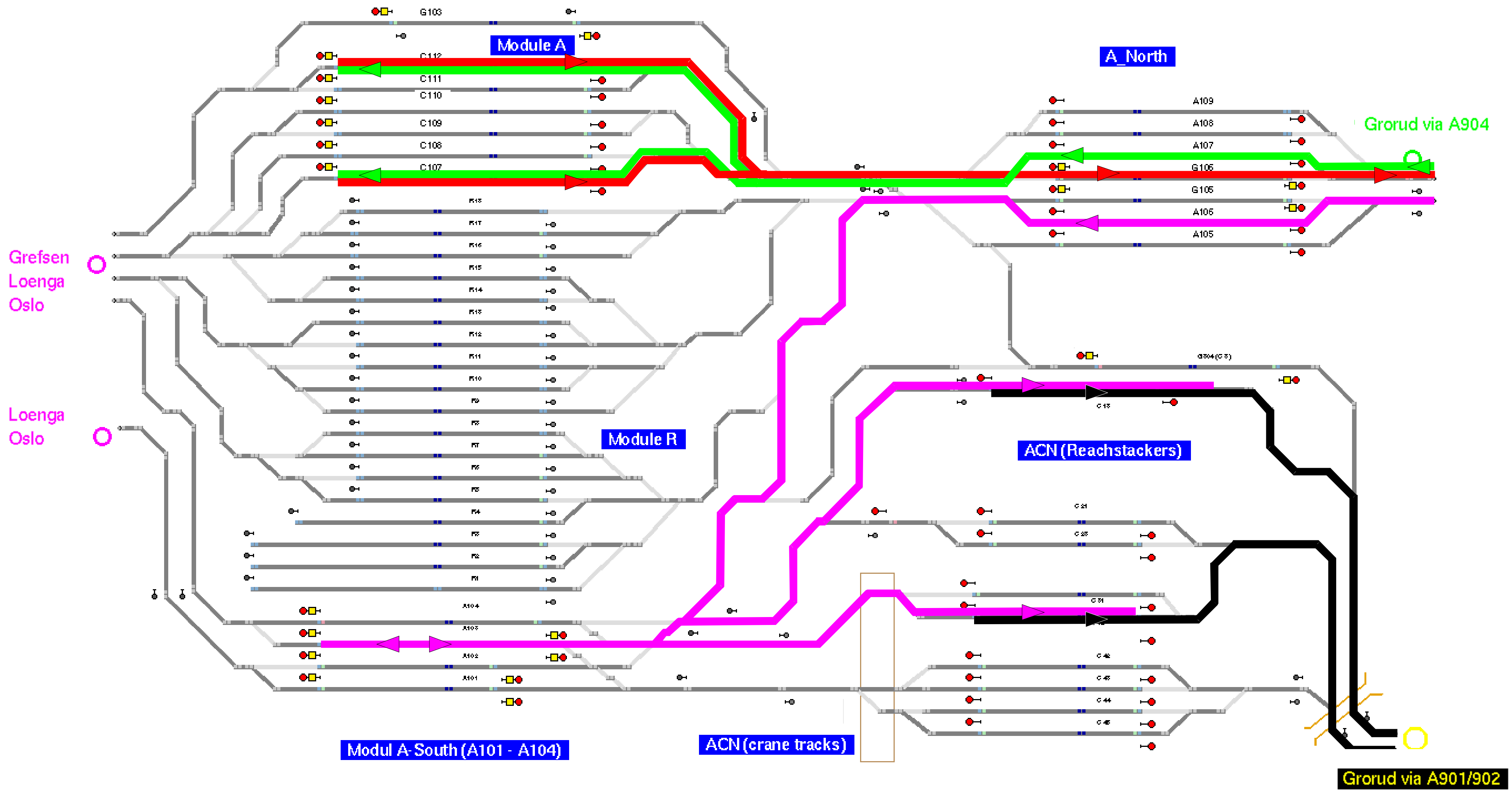
Standard routes into the terminal

Trains from and to Oslo / Loenga



Standard routes into the terminal

Trains from and to the North



Number of shunting movements

The simulation model comprises 16 different types of **regular shunting movements** in addition to the train movements. It includes

- shunting of e-locos and shunting locos to and from the trains
- shunting of trains to and from Module R
- shunting of trainsets with damaged wagons and
- movements from and to the loco depot.

The total number of **regular shunting** movements is **175.**

The total number of **special shunting** movements due to trainsets with damaged wagons is **44**.

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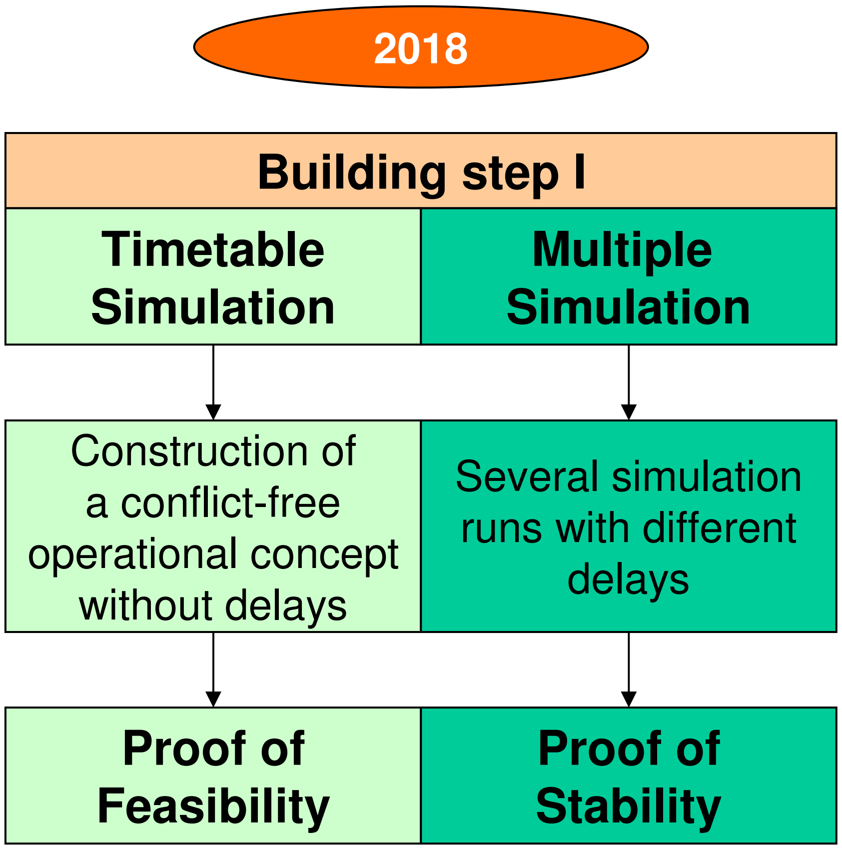
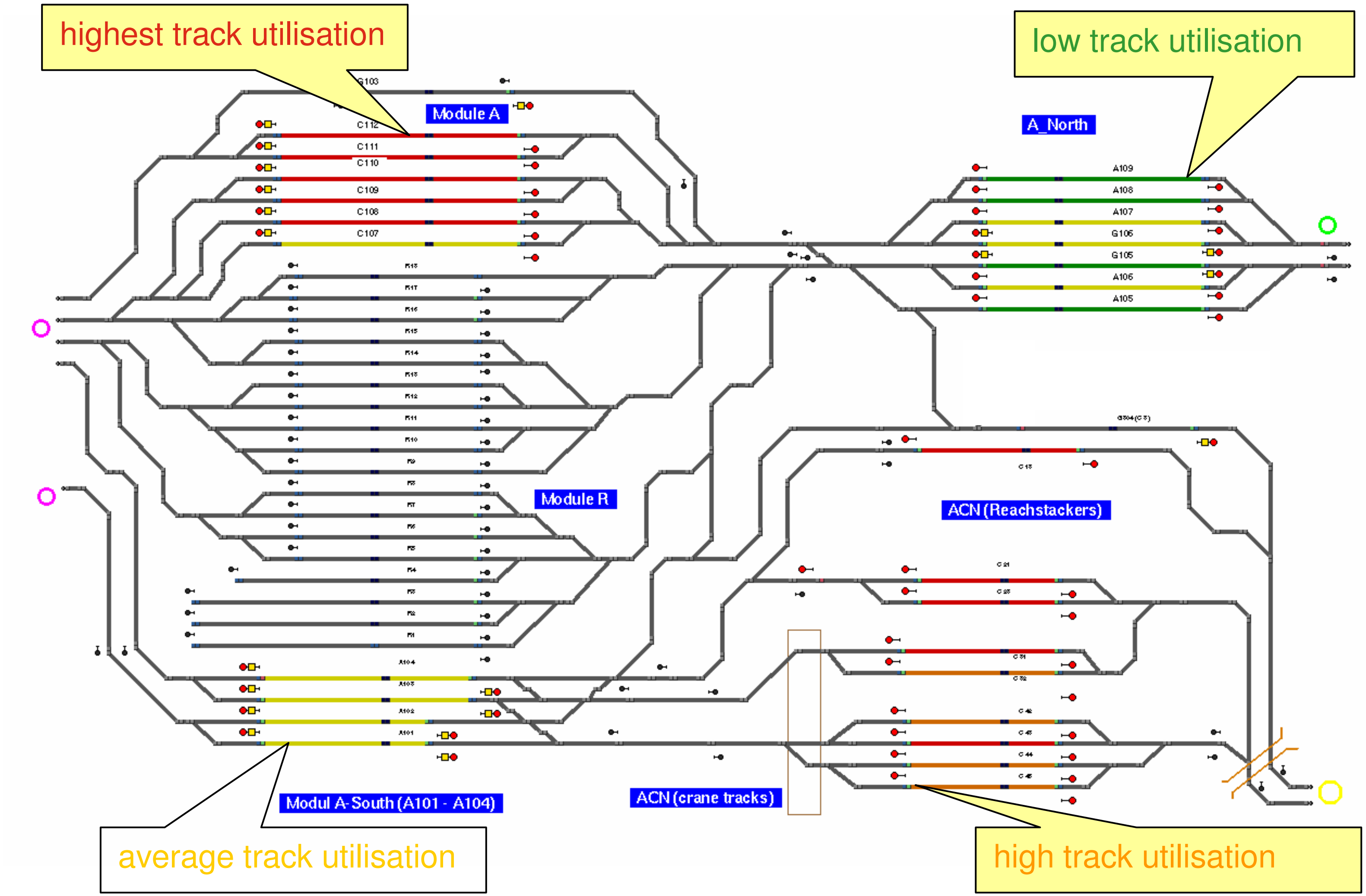
Simulation Building step I



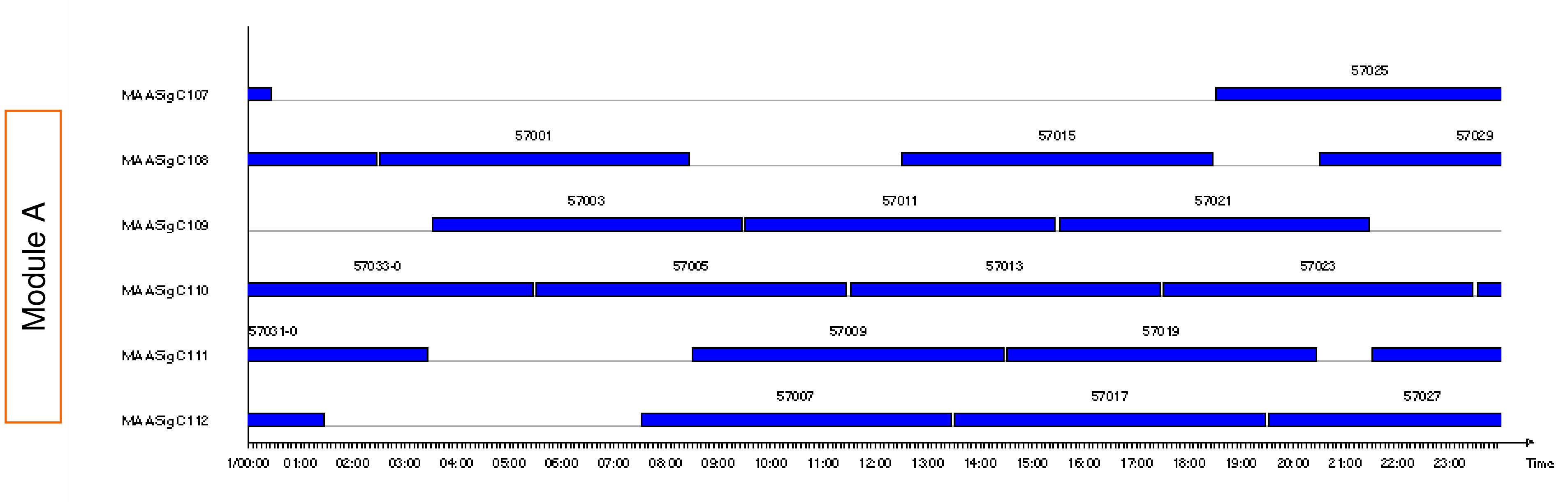
Results of the timetable simulation

Average track occupation time (train movements only)



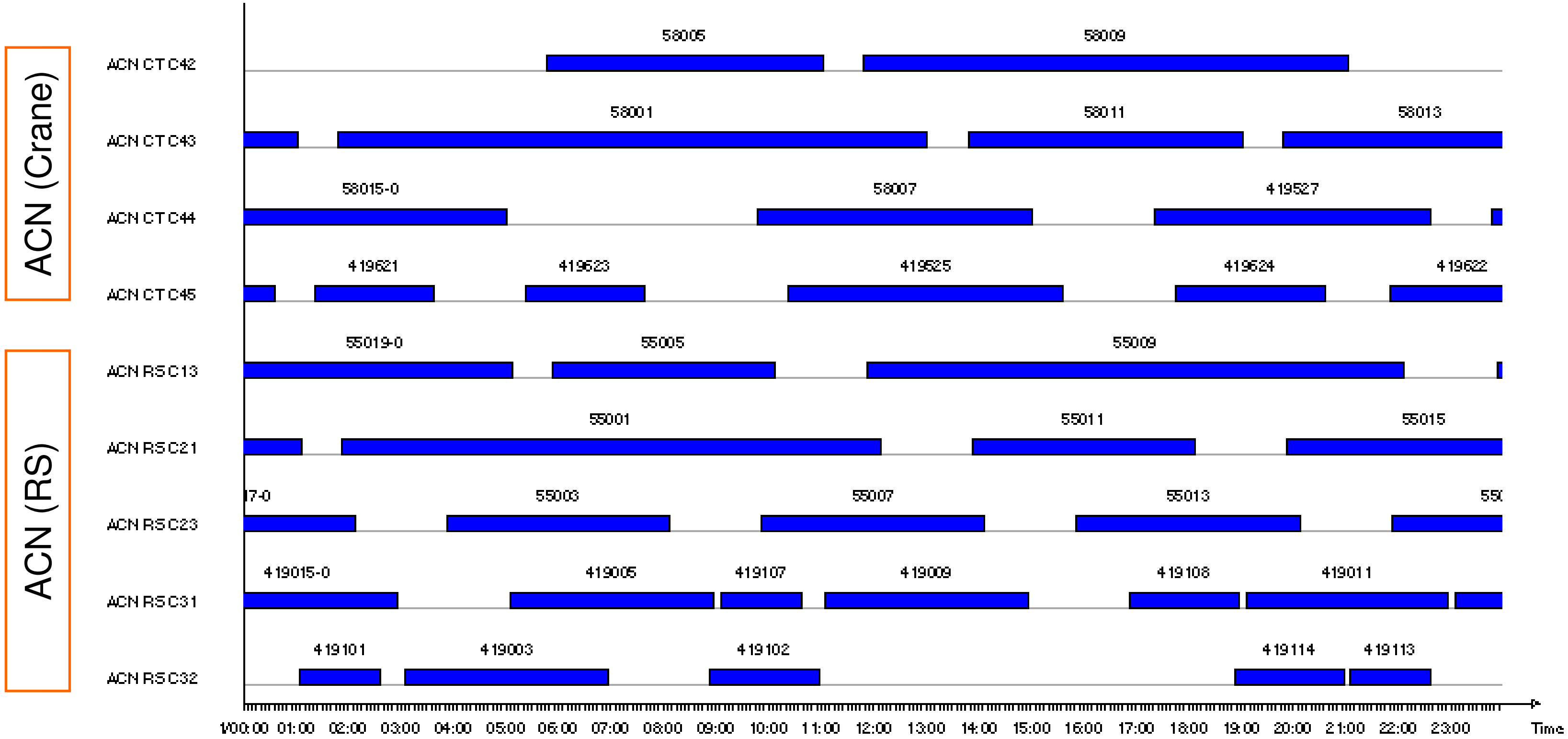
Results of the timetable simulation

track occupation time Module A



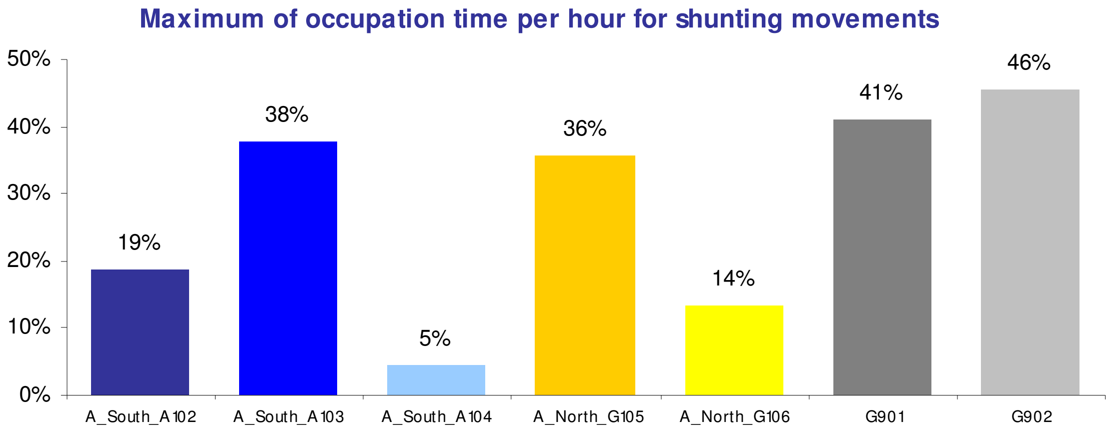
All tracks are in use in timetable simulation. Loading track C107 is occupied only up to 25 % and will serve as buffer in multiple simulation (with delays).

Results of the timetable simulation
track occupation time ACN



All loading tracks are in use in the timetable simulation. But there are reserve capacities, mainly in tracks C32 and C42, as buffer for the timetable simulation.

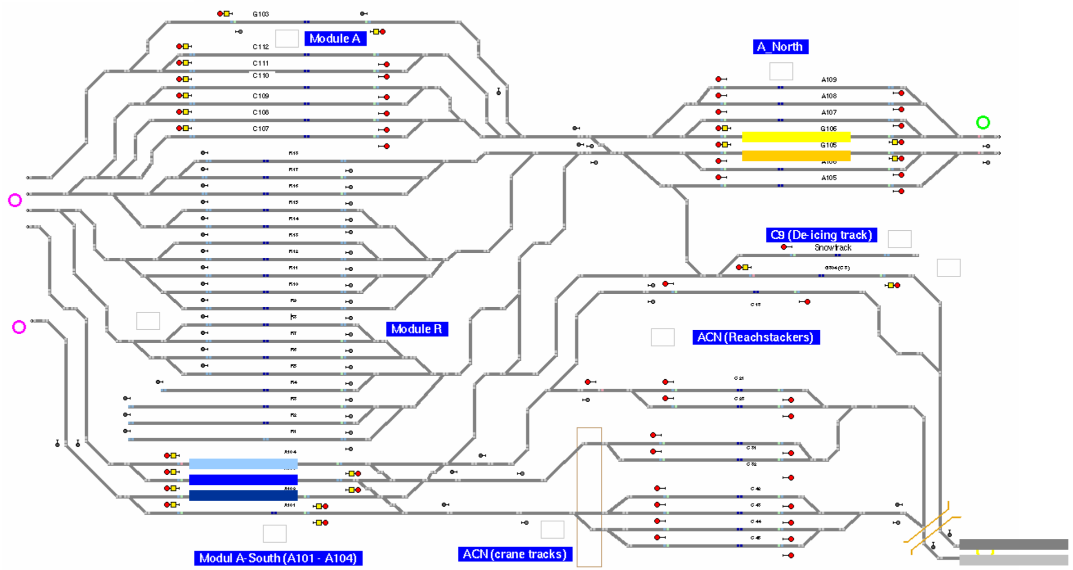
Results of the timetable simulation
Shunting movements



Shunting movements do **not increase** the track **occupation** of loading and arrival tracks during arrivals, since these tracks are **already occupied**, when a shunting loco enters.

Therefore shunting movements only **influence** the **track occupation of** A-tracks, when they are used for other purposes.

Concerning shunting movements tracks **G901 and G902** are the **most occupied tracks** in the whole terminal, followed by the departure tracks in A-South and A-North, which bear all necessary shunting movements to keep the arrival tracks clear for incoming trains.



Results of the timetable simulation

First Conclusions:

1. The **timetable simulation** shows that the construction of a **conflict-free operational concept is possible** with the chosen infrastructure layout.
2. **Some tracks** in the loading modules are not completely **occupied** in the timetable simulation without delays.
3. The **multiple simulation** has to **prove** if the capacity of the loading tracks is **sufficient**.

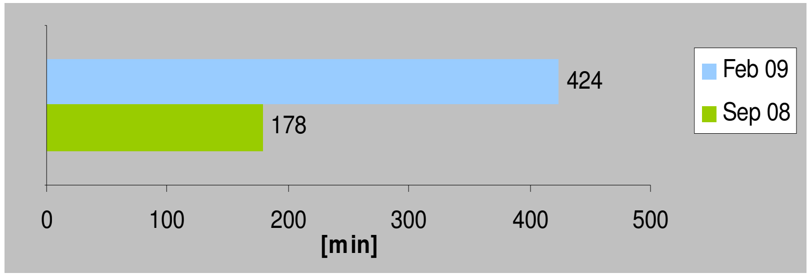
Multiple simulation
Introduction

The aim of the multiple simulation is to **prove the stability** of the operational program by implementing realistic delays.

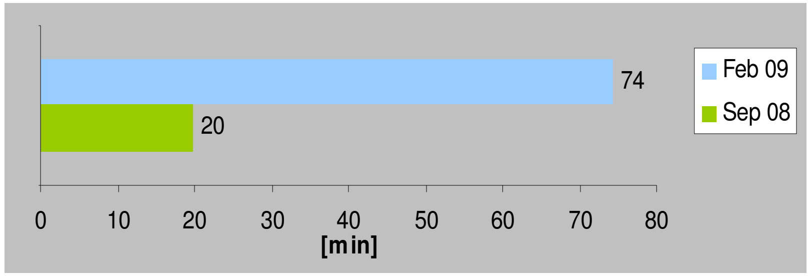
- Based on delay data of four week periods, delivered by JBV, two exponential **delay distributions** were built (s. following sheet).
- The relationship between delays of incoming (initial delay) and outgoing trains is defining the **operation stability**. A network is considered as stable, if the initial delays remain in approximately alike and not increase strongly.
- The multiple simulation comprises **20 runs**. In every simulation run **different trains** are delayed.
- The number of simulation runs **increases the statistical relevance** of the simulation.
- The 20 runs can be interpreted as **20 operating days** or almost three weeks of peak days.

Results of the multiple simulation
Parameters for distribution of delays

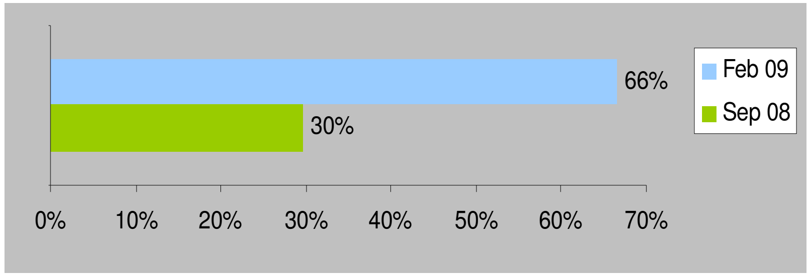
maximum of initial train delay (upper threshold)



mean initial delay (per delayed train)



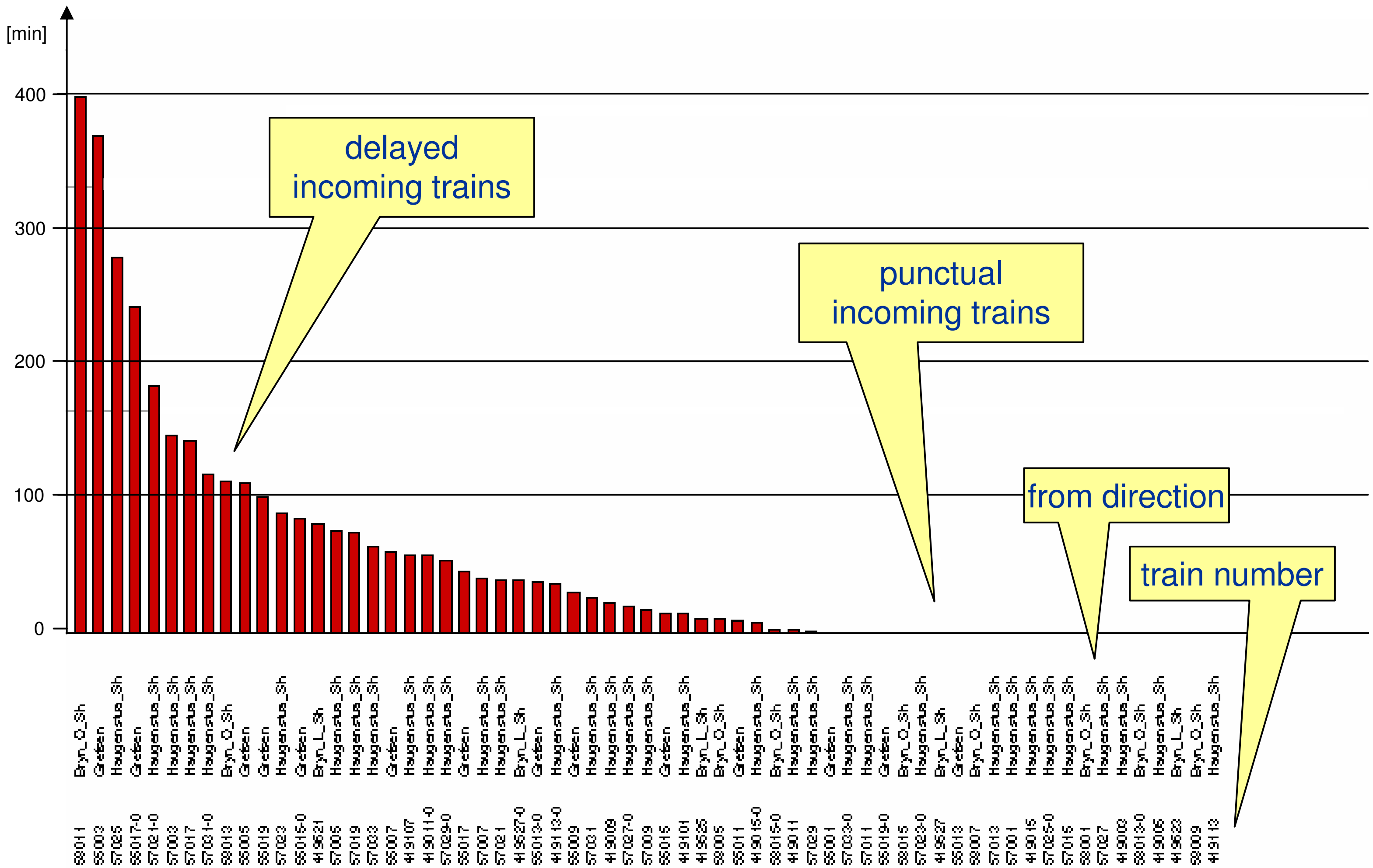
percentage of delayed trains



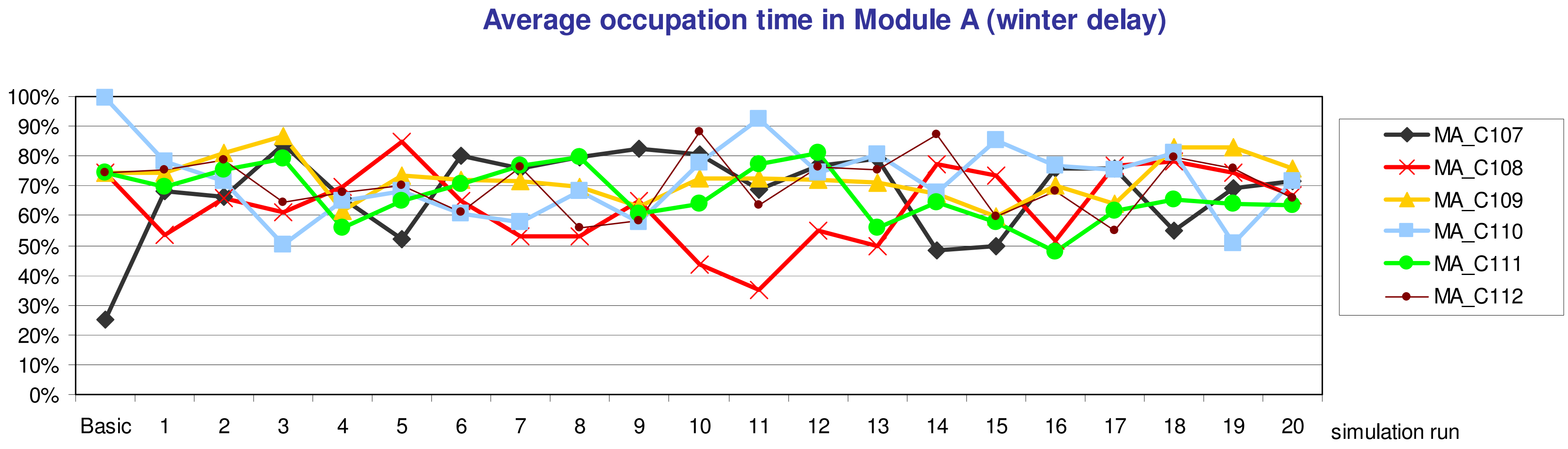
For the multiple simulation a typical negative exponential distribution was used. With help of a „random generator" an individual initial delay for each train was defined, which is based on the average delay.

The multiple simulation was executed with the winter delay distribution. Every positive simulation result is valid also for the summer delay distribution.

Results of the multiple simulation
Typical distribution of initial winter delay (1 out of 20)



Occupation times loading tracks Module A
Winter delay

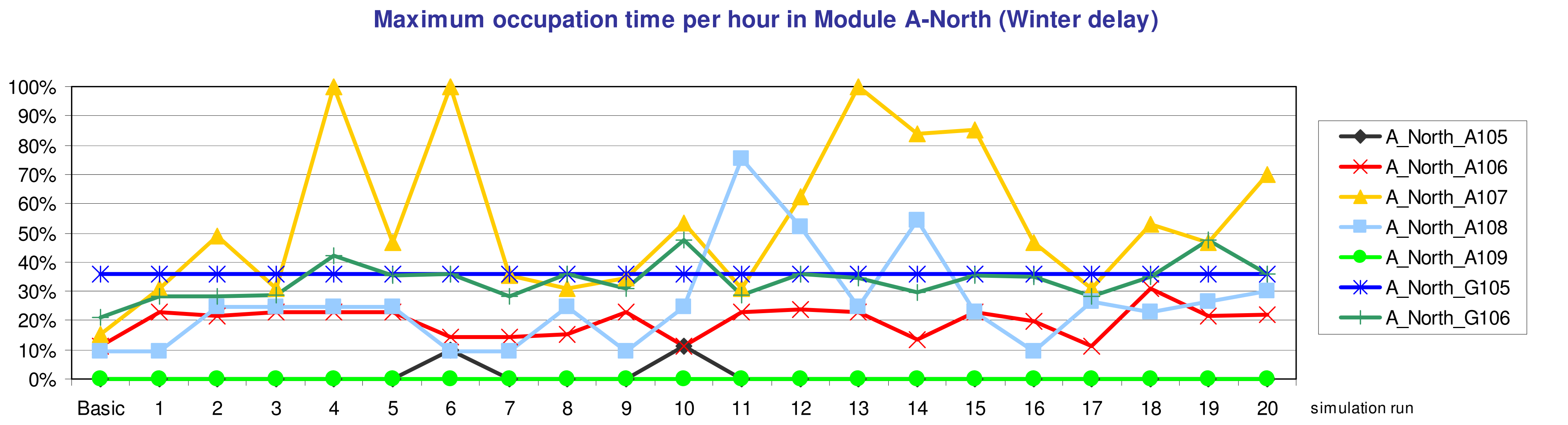


High and volatile occupation of all six loading tracks due to the fact that following trains are being directed to other loading tracks in case of lengthy winter delays.

In contrast to the timetable simulation (Basic, 97%) loading track **C110 (light blue) is now less occupied** in most simulation runs, because some of the trains were directed to other tracks and have used especially the **spare capacity of C107 (black).**

The total occupation of Module A is still not critical.

Occupation times tracks Module A-North
Winter delay



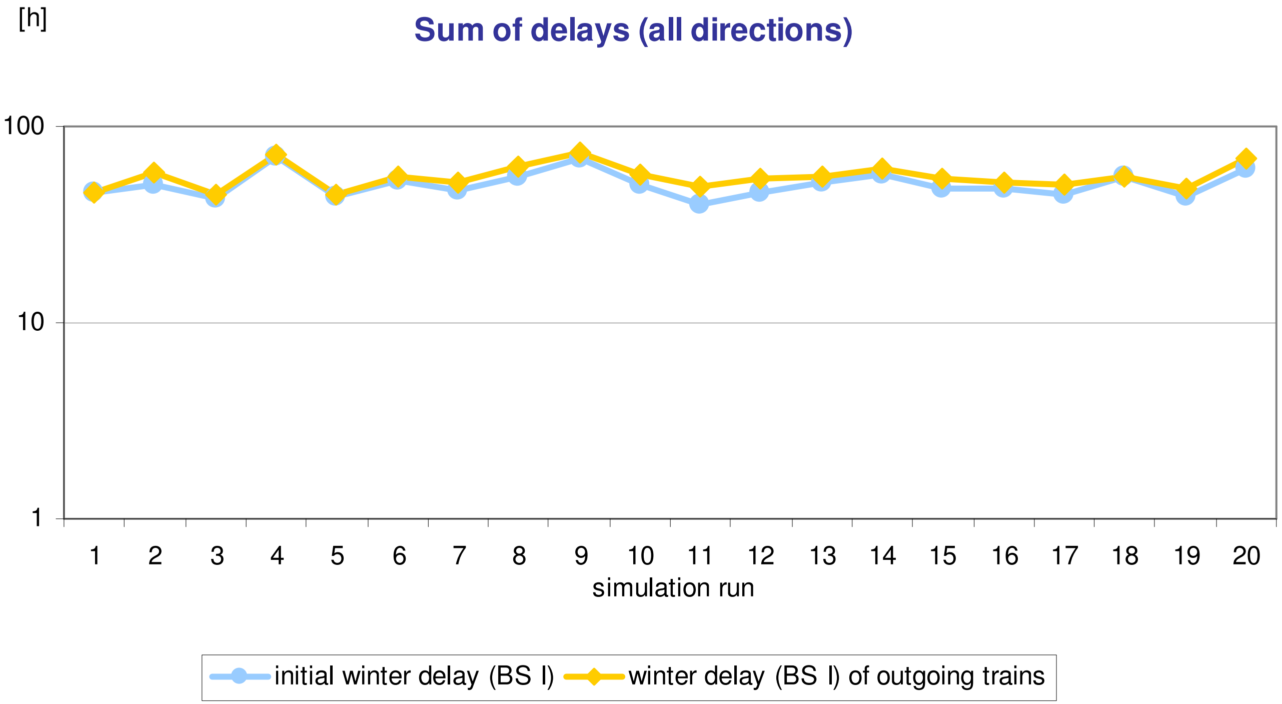
Of course module **A-North is slightly over-dimensioned in BS1**, because it has to serve fewer trains and only one instead of two six-track loading modules in the final layout.

But in BS1 it has to **serve as a buffer for the tight preliminary A-South** as mentioned above.

A-North is **also an alternative for incoming trains from the north to ACN**, because the Grorud tracks are already too occupied (see next sheet).

Therefore **a decrease in number of tracks for A-North is not recommended**.

Sum of incoming (initial) and outgoing winter delays

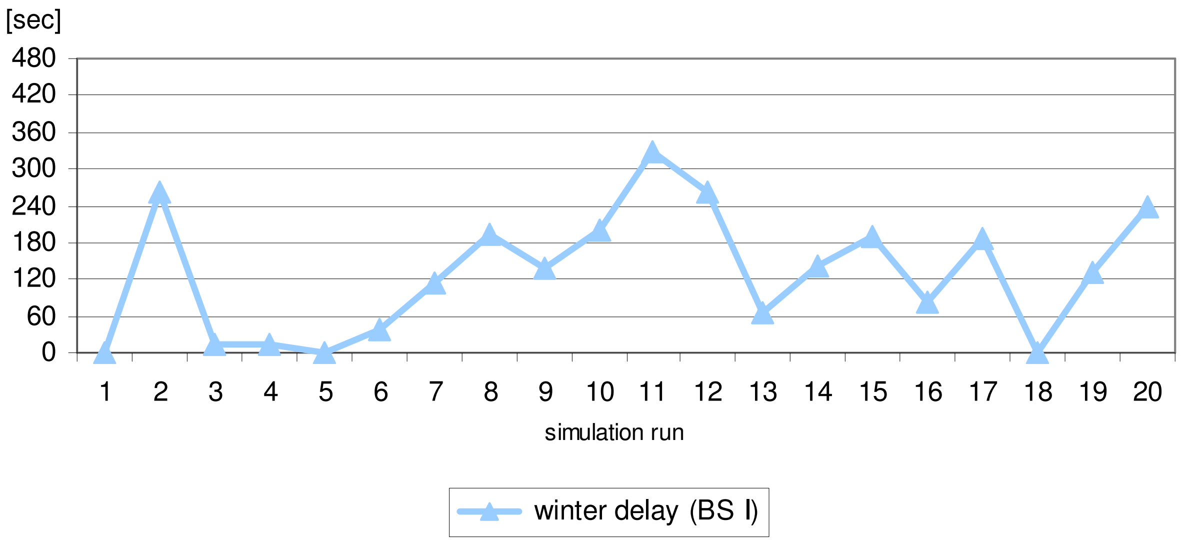


The diagram shows the sum of incoming (initial) and outgoing winter delays for the directions Haugenstua, Grefsen und Bryn, measured in hours.

The sum and the distribution of delays are different for each simulation run.

Increase of delay between incoming and outgoing trains

Average increase of delay per train



The stability of the operational concept can be described with the **average increase of delay per train**. There is **one peak with over five minutes** and some **other peaks with three to four minutes**. But most of the simulation runs with winter delay produce an average increase of **less than 180 seconds**. These figures show that **rail operations** in the terminal **can be kept running even with delayed incoming trains**.

In particular the **loading tracks have sufficient capacity**, so obstacles and **additional delays** occur **only in other parts** of the terminal.

Results of the multiple simulation

First Conclusions:

1. The **terminal is working**, **even with initial delays** of the incoming trains.
2. The **loading modules** have still **enough capacity**, although all loading tracks are occupied at some point.
3. **Module A-South** is occupied to a grade where the **operator has to react flexibly** to take in all arriving trains into the terminal immediately. **Reserve capacity** is available in the arrival tracks of **module A-North.**
4. The **double track solution** for the Grorud track is **necessary** for fluent operation, even with reduced regular train movement to save capacity for shunting movements.
5. **Module A-North** looks **over-dimensioned at first**. But it is necessary as a **capacity reserve for A-South** and the **Grorud tracks** in case of too much delays.

ETC Transport Consultants GmbH ☎ +49 30 - 25 46 5 - 326 e-mail: daniel.kerwien@etc-consult.de web: www.etc-consult.de

Conclusions and recommendations

The track layout is capable to cope with 1.5 Mio. TEU

1. The chosen track layout is **capable** of coping with the expected cargo volume.
2. The simulation with 46 trainpairs shows a **peak day**. If the terminal can handle this amount of cargo per day, it will have **enough capacity for the annual amount**.

The operational concept is robust

1. The simulation shows that **initial delays do not lead to significant increased delays** of outgoing trains and the rail operation inside the terminal is **stable**.

The terminal is dimensioned properly and not oversized

1. **All loading tracks are occupied at some point** during a peak day with winter delays. Therefore all of these loading tracks are **necessary**.
2. **The arrival tracks in Module A-South are occupied** to a grade where **queueing outside the terminal** is likely, if the operator does not **redirect trains** from the south to A-North last-minute. Some of the simulation runs show a **maximum occupation** of certain A-tracks **beyond the limit** of sufficient operational quality.
3. **Reserve capacity** is available in the southern arrival tracks of **Module A-North** and will be used to relieve the other A-tracks in case of big delays.