

A1-1

Trainset Configuration Concept

Version log

Version	Date of release	Author	Approval	Changes in sections/req ID

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1. General

As part of Nt renewal program will the long-distance coaches and locomotives be replaced. The new trainset will operate under similar conditions as existing services and can be either locomotive-hauled trainset or Multiple Unit trainset. As Multiple Unit trainset has only been in limited use for the long-distance operation has Nt investigated the feasibility to perform the complete operations with electric motor units (EMU) and Bimodal motor units (BMU), together referred to as MU's or Multiple Units in this document. The study is by no means complete to cover every aspect, but it indicates that operations with MU's could be an alternative to Locomotive hauled operation.

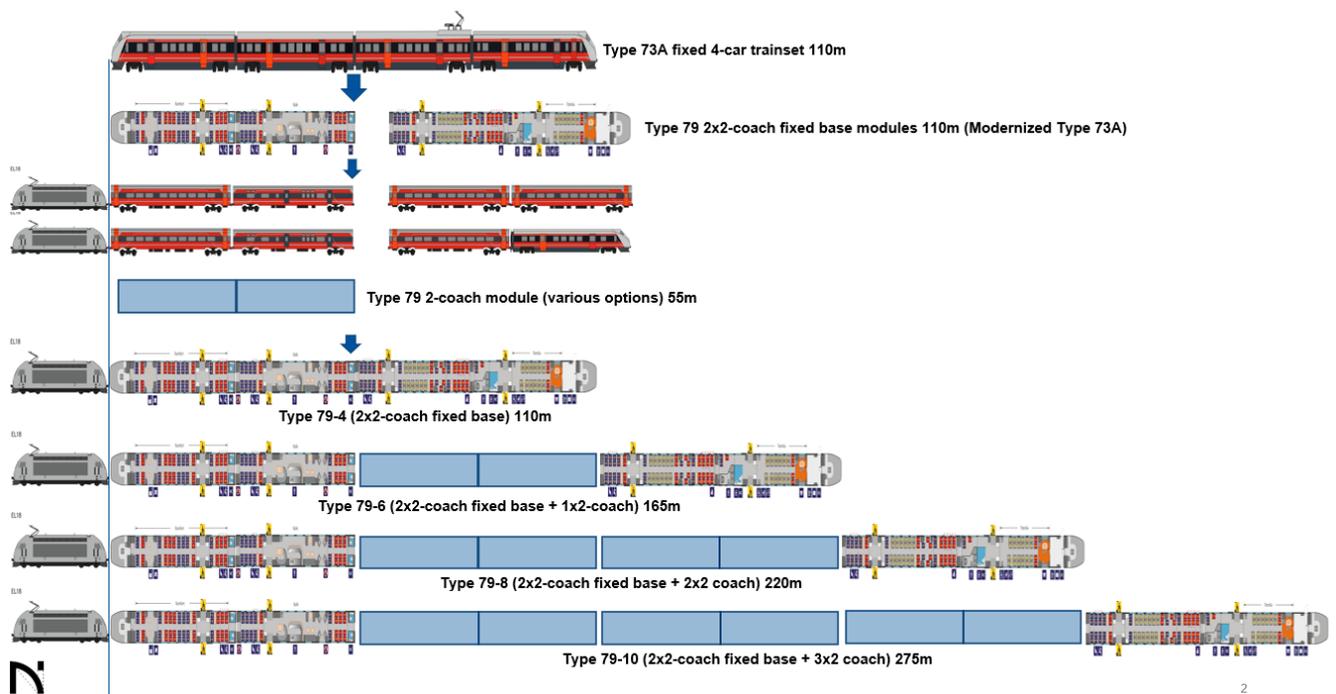
A trainset is built up by Configurable Units, CU's, where a CU can be one or more cars coupled together. The length of the car and CU is subject to supplier's solutions if all requirements are fulfilled. This can be applied to locomotive hauled trainset and MU trainset. Given the max length that can be handled in workshop, 110 meters, the Nt MU analysis is based on two CUs building up a 110-meter MU trainset.

This document primarily focuses on one of many possible configurations and shall only be seen as an information to the suppliers, whereas the supplier may introduce any other configuration that would meet the Requirements. Nt have also reviewed push-pull, dual locomotive and other consists and these consists could be configured to fulfill the Requirements Specifications. The detailed Requirements document is intentionally written to be applicable to both MU service and Locomotive hauled coach service.

1.1 Concepts reviewed

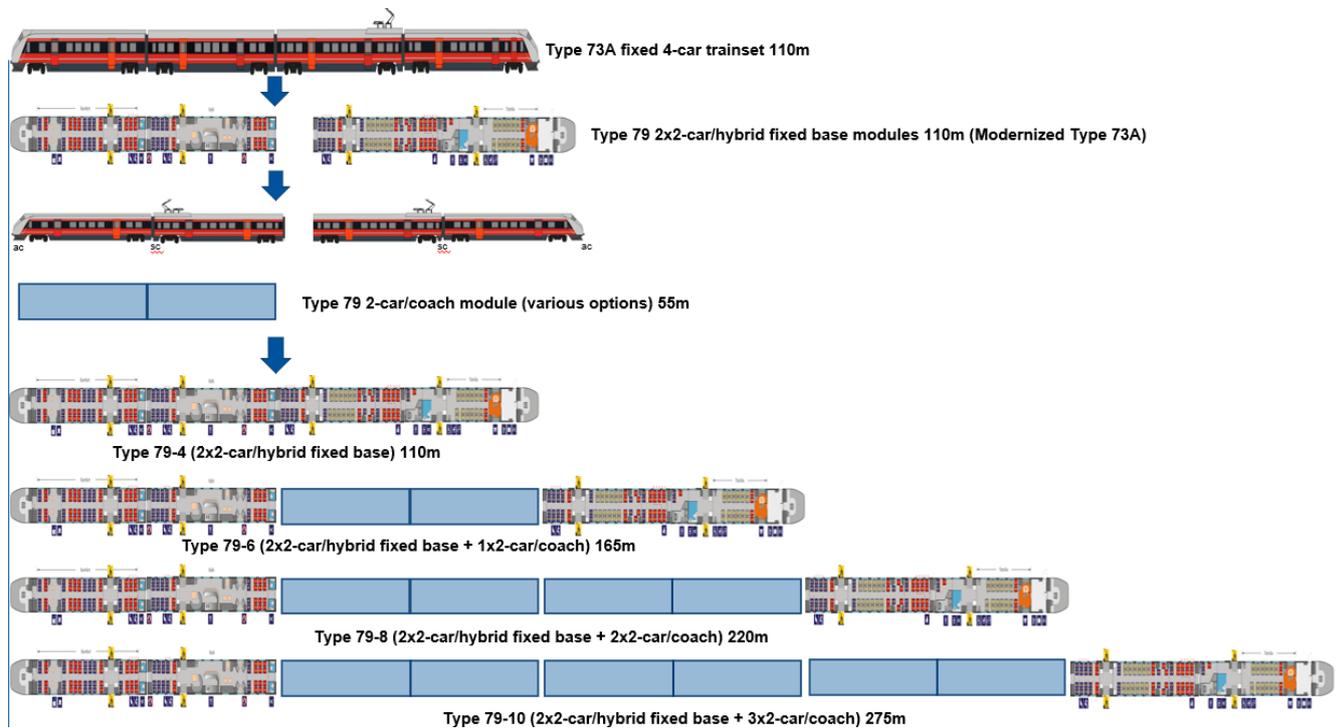
As discussed Nt analysis covered various solutions for traction system and passenger comfort. The existing type 73 EMUs and locomotive hauled trainset formed the base for the analysis with the intention to find as many commonalities as possible and thereby reduce the amount of variants. The following figures indicate the thinktank process.

Type79 Locomotive & coaches (Standard & Push-pull) – 2-coach module concept



Type79 Flexible EMU – 2-car module concept

Type79 EMU Locomotive & coaches (Push-Pull hybrid) – 2-car hybrid/coach module concept



2. Delivery

The number of trainset and spare units are primarily based on the overall requirements from Jernbanedirektoratet and the present service on the defined lines.

The new fleet should have a total capacity of 5750 day-seats and 900 beds/sleeping positions, including spares, and each trainset for the four lines shall have the minimum day and night capacity and be able to operate the four lines with required number of trainsets per day and per night, as defined in Requirements. It should be noted that these requirements not necessarily are fully aligned and then the most restricted requirement shall be fulfilled.

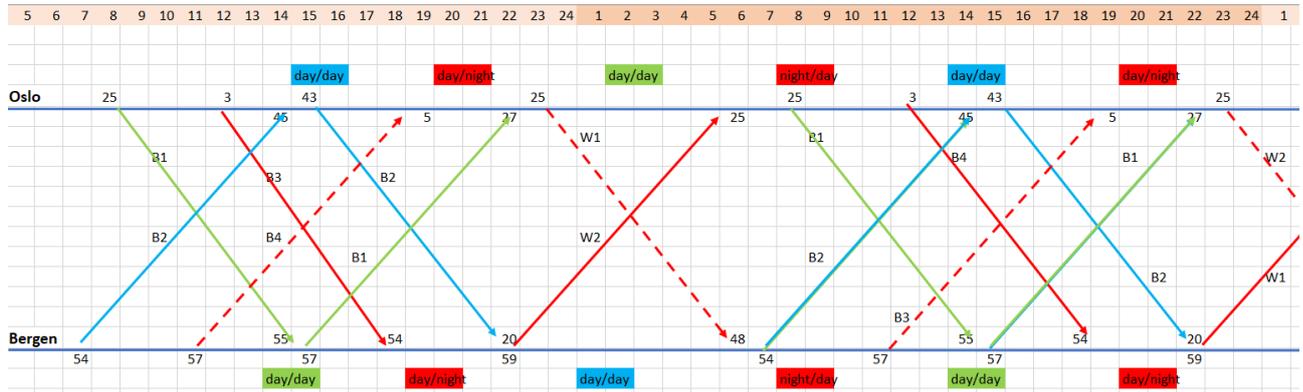
This would lead to the proposed number of complete trainset and the offered spare Units/cars of selected types.

The current operators of the new trainset have different requirements for their service which could result in several variants and options for some trainset or CUs.

3. Operation

As part of the analysis, various ways to increase the utilization of the Rolling Stock was studied. By enhancing the turn arounds at end stations, it would be possible to increase the utilization and ensure most trainset operate at least one full return trip per 24 hours.

Example of timetable analysis



If possible, from operations perspective, the present timetable for the lines allows for turnaround times of down to 40-45 minutes for day-to-day service and 2,5 hours for day to night or night to day service. The operator’s ability to clean and prepare trainset will determine if these turnaround times are achievable in normal service.

The timetable analysis indicates that it would be possible to increase the utilization of the trainset so that the trainset normally performs one full return service, day/day, day/night or night/day for 24 hours. This mean the average utilization would be 360 000 km/year based on average 14 hours operation/day and 365 days/year.

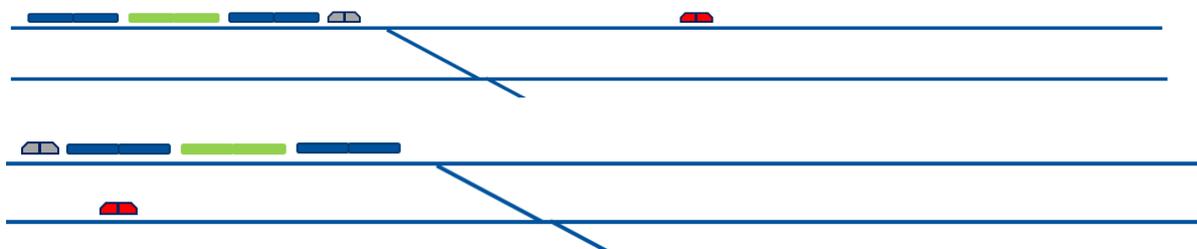
3.1 Turnaround at end stations

The MU concept and the locomotive hauled concept have strengths and weaknesses for turnaround at end stations.

- A fixed MU concept will require cleaning and preparing the trainset for the next trip. Shunting can be reduced as there will always be a cab in direction of travel.
- The locomotive concept will require the locomotive to change place into direction of travel position, unless two locomotives or push-pull cab units are used.

The Oslo and Bodö depots have parallel tracks and switches in both ends for easy change of direction for locomotive hauled trainset. Bergen, Trondheim and Stavanger depots are “fork” shaped and hence need shunting assistance to change direction for single locomotive hauled trainset.

Locomotive hauled shunting start/end position at “fork” shaped depot



It is considered as an advantage if a trainset can be reconfigured and change direction without support of a separate shunting power unit.

Bergen station and depot is considered as one single operating area, where the main track for long distance and local trains crosses the depot area required for shunting. The area will be first on the list of depots where ERTMS operation will be introduced.

4. MU concept

TSI LOC&PAS accepts MU's in fixed or predefined formations, and the studied concept would be defined as predefined formations. It will be the supplier's responsibility to analyze the homologation requirements and optimize the homologation process.

The Trainset length is primarily restricted by the max length of 110 meter for a section that can be taken into a workshop for maintenance. This implies all trainset longer than 110 meter will be split into max 110 meter length to enter workshop.

Bergen depot can only stable trainset up to 220 meters. This implies, trainset longer than 220 meter will be split during stabling. Stabled trainsets or parts are subject to all Norwegian environmental conditions

Based on depot and workshop restrictions, the passenger experience requirements and the traction power requirements, the analyzed configuration is based on CUs of 55 meter that could be combined into lengths in multiples of 55 meters and with shortest unit for operation is 110 meters.

The cars within a CU are fixed connected, while the connection between CUs may be performed with automatic couplers and quick release inter-car connections/gangways.

To eliminate configuration change between day and night service, the reviewed concept is based on dual functionality for some CUs. Sleeping compartments for night service are also used as small seating compartments for day service. Also, the Comfort class compartment is equipped with recliner seats, that would be used both for day and night service.

Two base configurations are analyzed, one short 165 meter consisting of three CUs and one long 220 meters consisting of four CUs. The short trainset could be shortened to 110 meters, and the longer trainset could be extended to 275 meter or even longer if requested for specific operations.

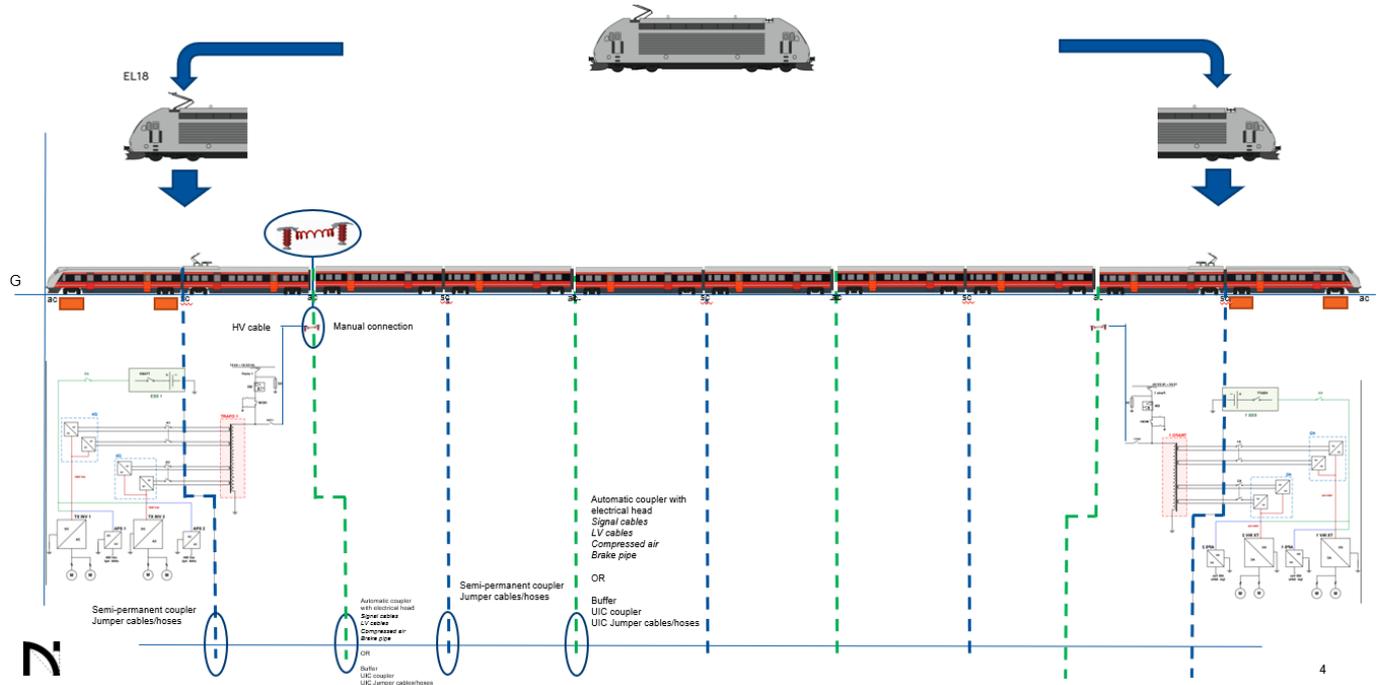
The main driver for the two base configurations is to match the requested capacity for day and night service on the different lines and at the same time have a more centrally placed bistro for the longer trainset.

Long and Short MU base configuration

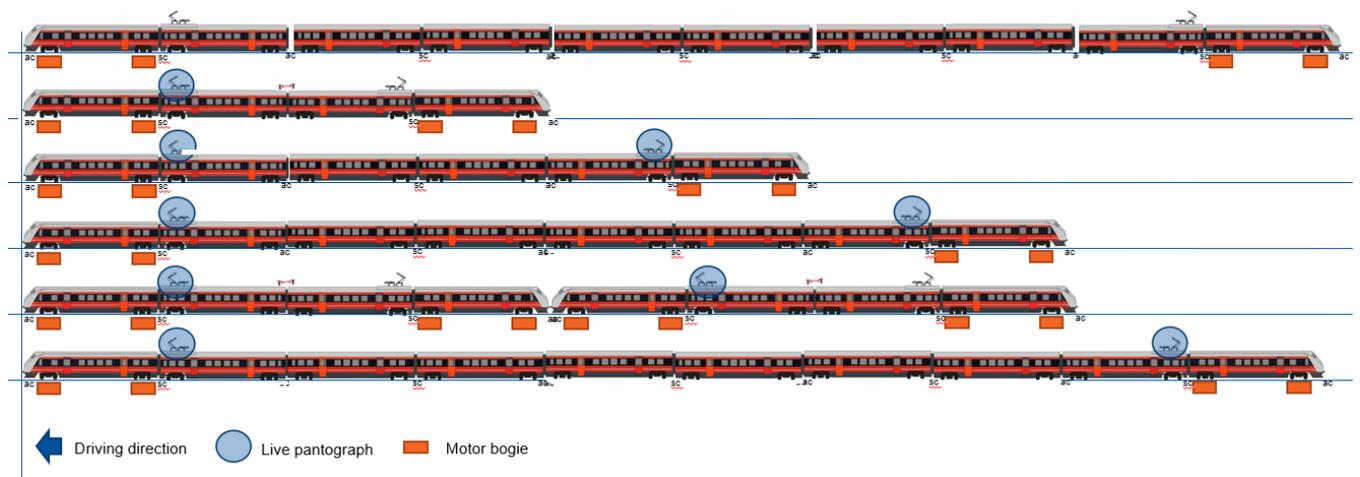


The motorization concept has been considered when the MUs are defined as it impacts the configuration. In the Nt analysis the 110-meter MU, includes two CUs where each CU contain one motorized car plus one car containing the high voltage and main transformer equipment. For longer MU's, non-powered CUs are inserted. The intention is to minimize the configurations on each line and currently there is one common day /night configuration per line.

Type 79 EMU-Locomotive & coach (Push-Pull hybrid)



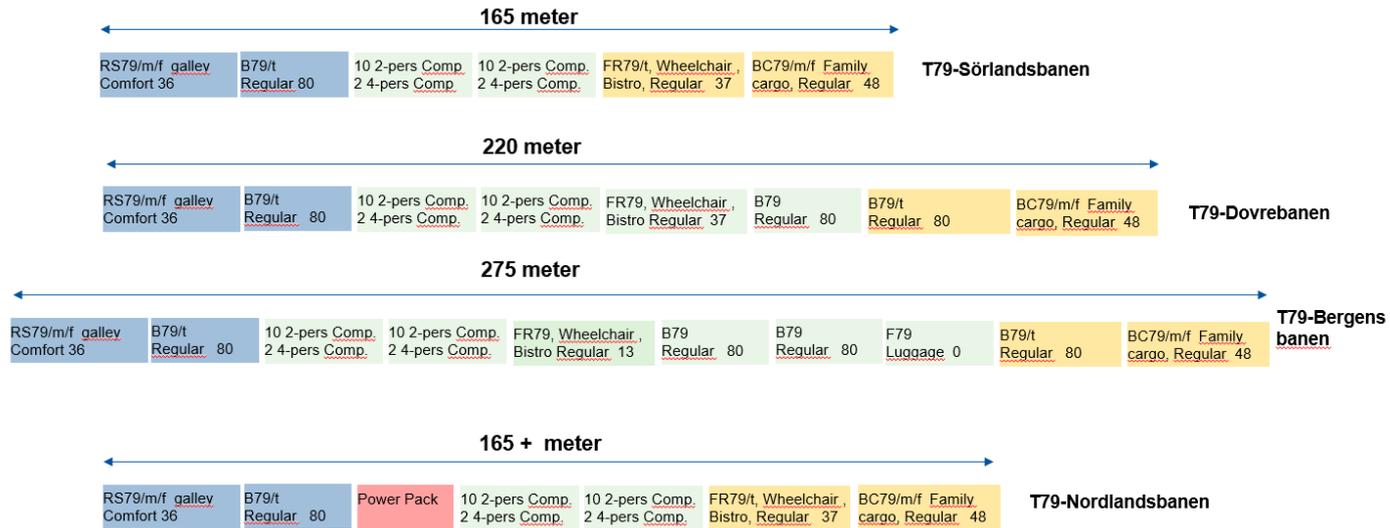
The motorization concept could be implemented in various configurations as shown in following figure.



The shortest trainset used in Nt configuration is currently 165 meters, but it could be considered advantageous if a 110-meter trainset can be used still meeting the performance/capacity requirements. This would be the natural replacement for the present Type 73B fleet that is due for replacement during the next 4-6 years.

While the 165-meter trainset will operate with two active pantographs, should a 110-meter trainset operate with one active pantograph and roof mounted high voltage connection between main transformers. This to fulfill requirement for multiple operation of 110-meter trainset.

Trainset formations for the lines.



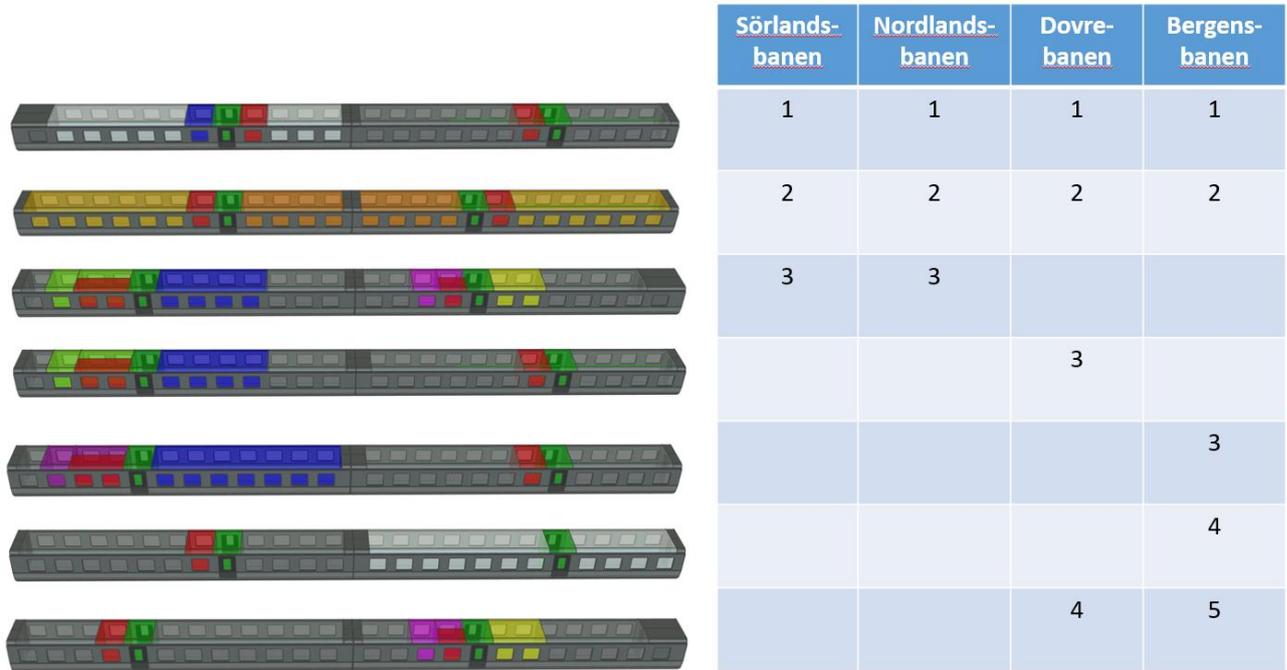
It should be noted that Bergensbanen requires a larger Bistro as covered under Exhibit A1-2.

4.1 Layouts

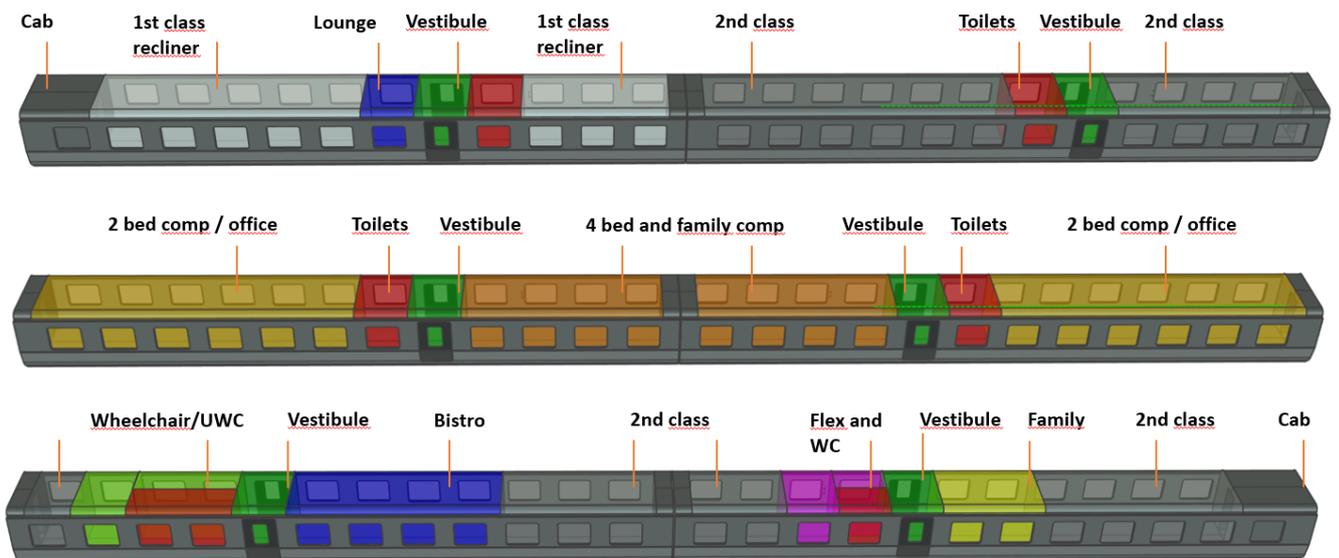
The following figures show the layouts for the CUs the Nt analysis is based on.

CU re-use matrix

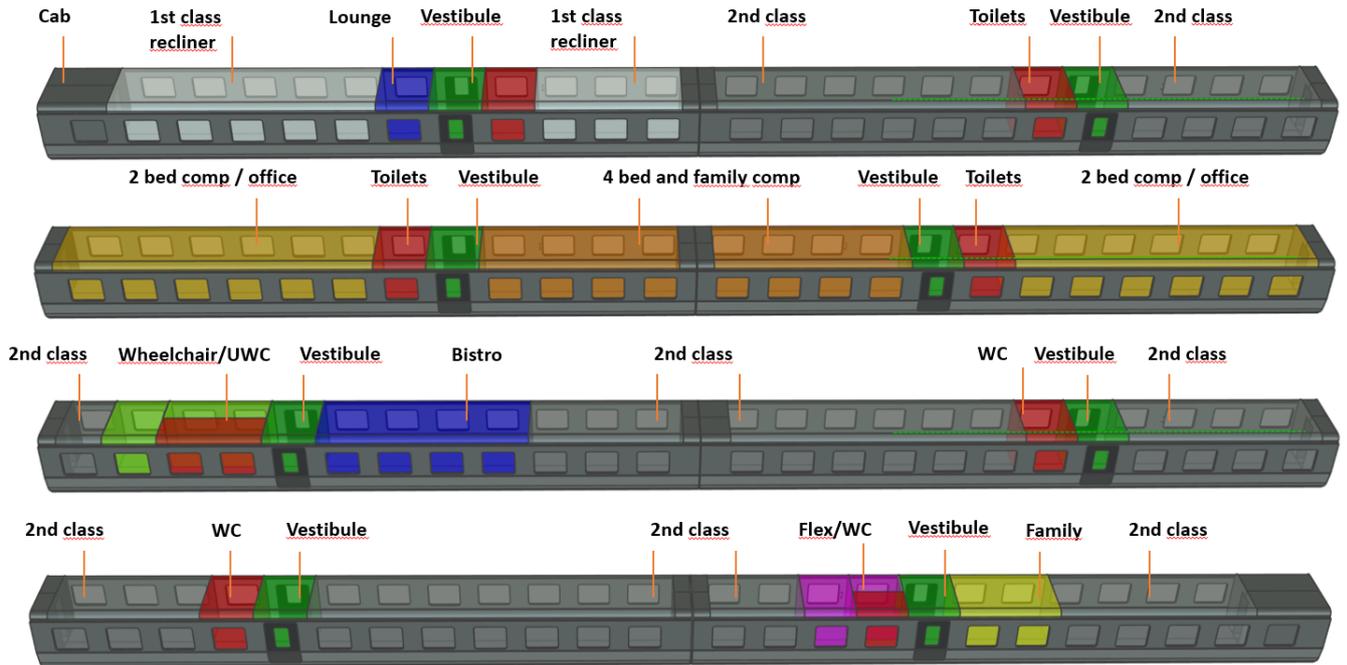
Seven CUs are foreseen to cover the total need for all lines



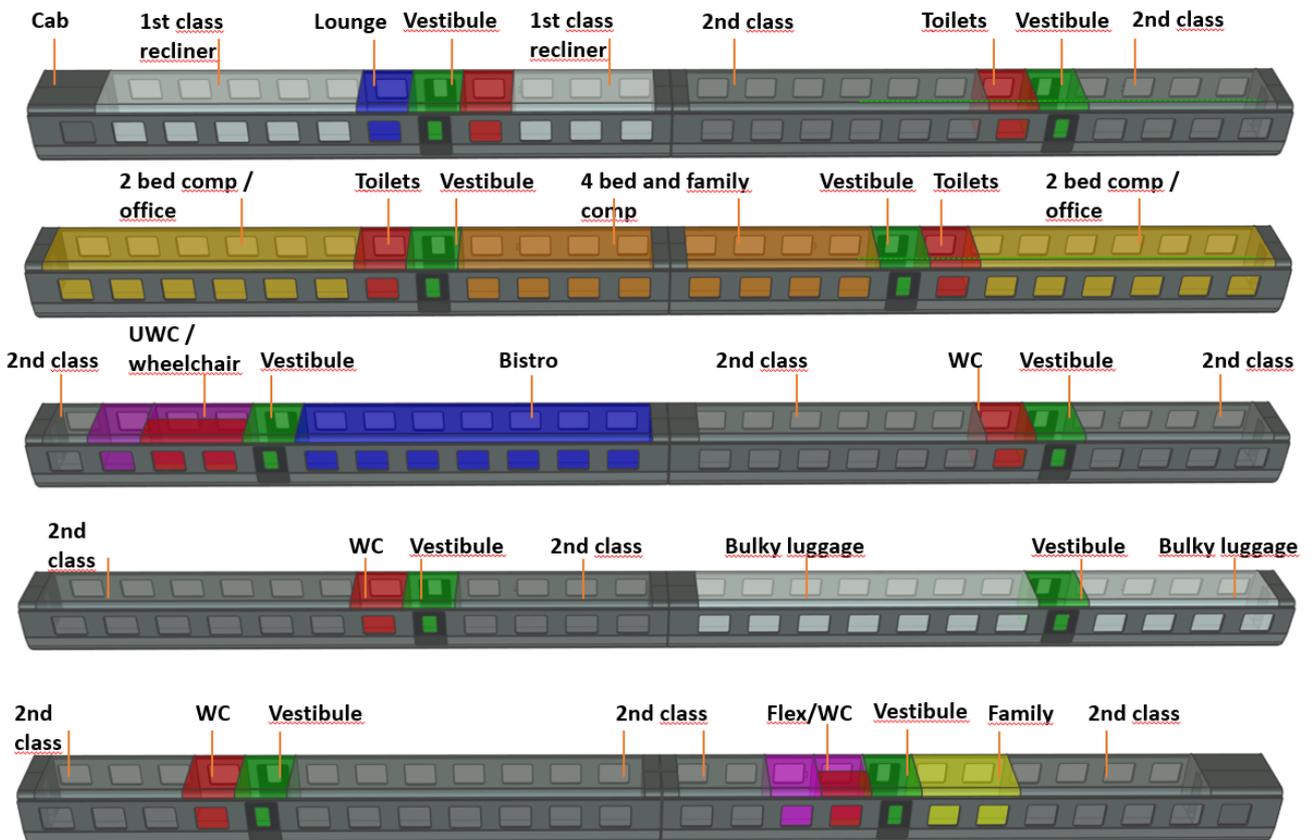
Configuration for Sörlandsbanen and Nordlandsbanen excluding PowerPack



Configuration for DovreBanen

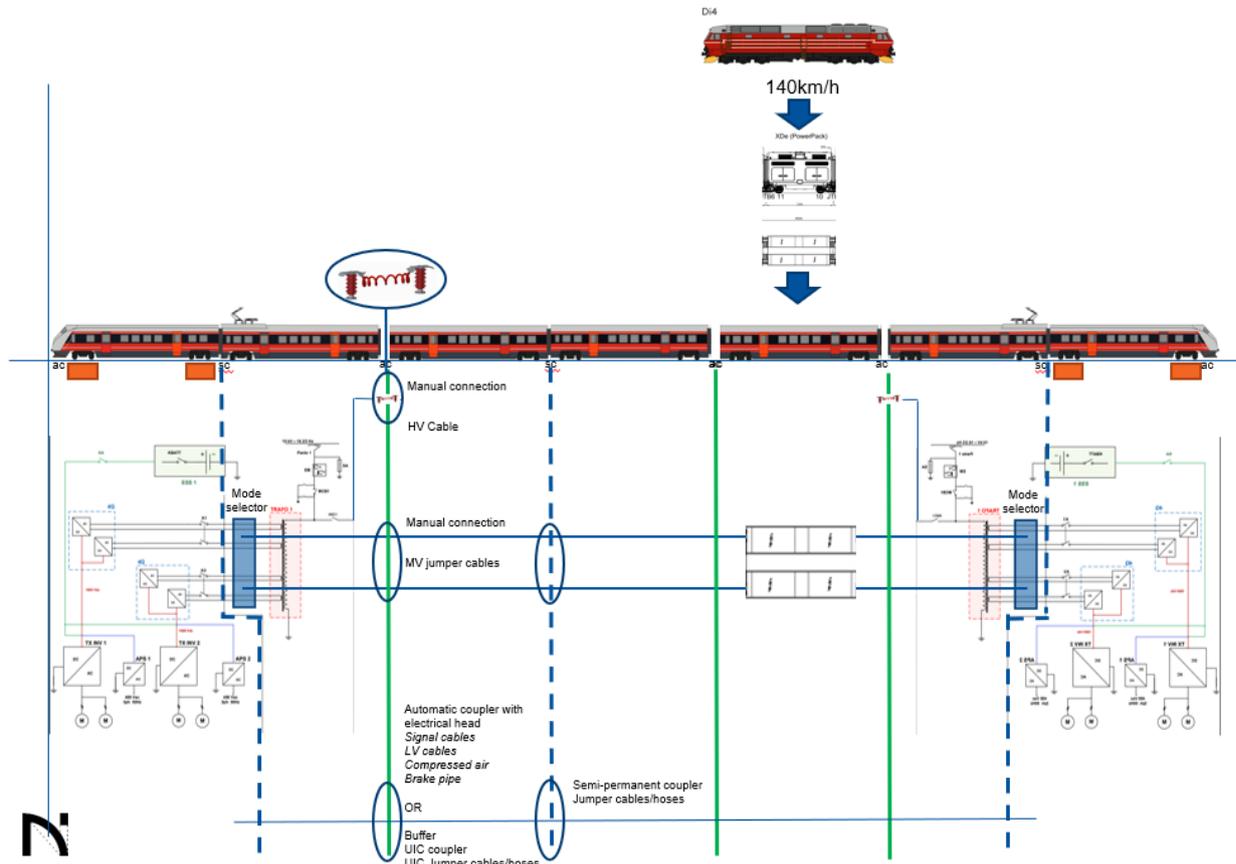


Configuration for Bergensbanen



5. Bi-Modal operation

Nordlandsbanen is not electrified, and present operation is performed with diesel locomotives. The supplier is free to propose other alternatives of compliant propulsion. The Nt studied alternative for MU operation is to introduce a Power Pack that powers the MU's normal traction system. Given the size and weight it must be further investigated if the Power Pack solution can be integrated in normal cars or if, as is foreseen in our analysis, a separate car for the power pack is required.



A consequence of a Power Pack is the required feed and control from Power Pack to end CUs. The supplier should elaborate and evaluate if the intermediate CUs for Nordlandsbanen shall be identical to the other lines intermediate CUs and all CUs can be spares for each other, or if it is more beneficial that Nordlandsbanen holds its own spare CUs.

A long-term study to partly electrify Nordlandsbanen is done, and the intention is to electrify portions of the line and then operate with battery over the none electrified sections. This solution could possibly be of interest to introduce at a midlife upgrade.

6. Capacity

The capacity requirement for the contract - 5750 day-seats and 900 beds/sleeping positions - is the guiding requirement for the Primary Delivery. This gives a total capacity of 6650 passengers for day and night operation.

For the analysis the following assumptions were used and can be seen as an attempt to ensure the various aspects have been covered.

Consolidated assumptions for capacity calculations

The Trainset(s) shall meet the following capacities:	Sörlandsbanen day	Sörlandsbanen night	Nordlandsbanen day	Nordlandsbanen night	Dovrebanen day	Dovrebanen night	Bergensbanen day	Bergensbanen night	Note:
Seating places, any type excluding folding seats	220	168	252	168	356	204	488	238	Minimum values
-of which Comfort or Recliner seating Places	10-20%	10-20%	10-20%	10-20%	10-15%	10-15%	10-15%	10-15%	Lower value is minimum
Sleeping places, beds or Recliner Seating Places	60	60	60	60	90	90	90	90	Target value, minimum value is 90% of target value
-of which are beds	50-80%	50-80%	50-80%	50-80%	50-80%	50-80%	50-80%	50-80%	Target value is 66%
Bistro	Medium	Medium	Medium	Medium	Medium	Medium	Large	Large	
Toilets	Se ref	Se ref	Se ref	Se ref	Se ref	Se ref	Se ref	Se ref	A1:3.6.11.1
Cargo	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	One (1)	One (1)	Specification to be added, estimated length is approximately 20-25 meters including cargo door area
Exterior door	Se ref	Se ref	Se ref	Se ref	Se ref	Se ref	Se ref	Se ref	A1:3.5.4.d
Comfort lounge	One (1)	One (1)	One (1)	One (1)	One (1)	One (1)	One (1)	One (1)	
Flex area	One (1)	One (1)	One (1)	One (1)	One (1)	One (1)	One (1)	One (1)	
Family play area	One (1)	One (1)	One (1)	One (1)	One (1)	One (1)	One (1)	One (1)	Specification to be added, estimated length is 3 to 4 meters

With the described MU configuration and service per the technical requirements, the fleet size required to perform this service would be as shown in table below.

The spare CUs are mainly used to adjust the total seated/sleeping capacity.

Trainset and CU qty to meet capacity

		Sörlandsbanen		Bergensbanen		Dovrebanen		Nordlandsbanen		Cars	Passenger	
		qty	Delta	qty	Delta	qty	Delta	qty	Delta	Sum in TS	cars	
Base TS and adjustments to adapt to trainsize	Base TS short	3				2		3		6	6	36
	Base TS long			4						6	8	48
	B79				4					4	1	4
	Luggage car F79 Powerpack				4				3	4	1	4
Spare parts distributed on the lines	Base TS short	1				1		1		2	6	12
	Base TS long			1						2	8	16
	B79				4		3			7	1	7
	Sleeper								2	2	1	2
	Luggage car F79 Powerpack				1				1	1	1	1
										Total	130	
										incl spares	36	

The distributed trainset with adjustments plus one complete spare trainset per line should be sufficient for the intended service. As seen in the table below, the total number of seats are 5868 and 1528 sleeping positions i.e surpassing the requirements.

It should be noted that this capacity is ambitious and based on calculations from an empty train tube.

Please also note that to simplify calculations, capacity is added up from car level instead of from CU level.

Total seats/beds from the total no of trainset and CUs

Number of cars and seats/beds including spares								
	Short	Long	Delta		Cars	Seat/ car	Seats	Beds
			Short	Long				
Base TS	6	6						
Spare TS	2	2						
RS79/m/f	1	RS79/m/f	1		16	36	576	576
B79/t	1	B79/t	1		16	80	1280	
Sleeper	1	Sleeper	1	1	17	18	306	476
Sleeper	1	Sleeper	1	1	17	18	306	476
		FR79 bistro	1	0	8	37	176	
		B79	1	0	11	80	880	
		B79	0	0	8	80	640	
		F79	0	0	5	0	0	
		B79/t	1		8	80	640	
FR79/t bistr	1				8	37	296	
BC79/m/f	1	BC79/m/f	1		16	48	768	
					130		5868	1528

The table below shows the calculated capacity for one Trainset for the different lines. The counted cars are only passenger cars; luggage cars and Power packs are omitted in the table below.

Capacity per trainset for the different lines

Short formation	Long formation	Sörlandsbanen				Bergensbanen				Dovrebanen				Nordlandsbanen			
		Cars		Seats		Cars		Seats		Cars		Seats		Cars		Seats	
		Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day
RS79/m/f	RS79/m/f	1	1	36	36	1	1	36	36	1	1	36	36	1	1	36	36
B79/t	B79/t	1	1	80	80	1	1	80	80	1	1	80	80	1	1	80	80
Sleeper	Sleeper	1	1	28	18	1	1	28	18	1	1	28	18	1	1	28	18
Sleeper	Sleeper	1	1	28	18	1	1	28	18	1	1	28	18	1	1	28	18
	FR79 bistro	0	0	0	0	1	1	13	13	1	1	37	37	0	0	0	0
	B79	0	0	0	0	1	1	80	80	1	1	80	80	0	0	0	0
	B79	0	0	0	0	1	1	80	80	0	0	0	0	0	0	0	0
	F79	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
	B79/t	0	0	0	0	1	1	80	80	1	1	80	80	0	0	0	0
FR79/t bistro		1	1	37	37	0	0	0	0	0	0	0	0	1	1	37	37
BC79/m/f	BC79/m/f	1	1	48	48	1	1	48	48	1	1	48	48	1	1	48	48
		6	6	257	237	10	10	473	453	8	8	417	397	6	6	257	237

7. Alternative configuration

In addition to the described configurations, a variant with interchangeable day/night CUs has been analyzed.

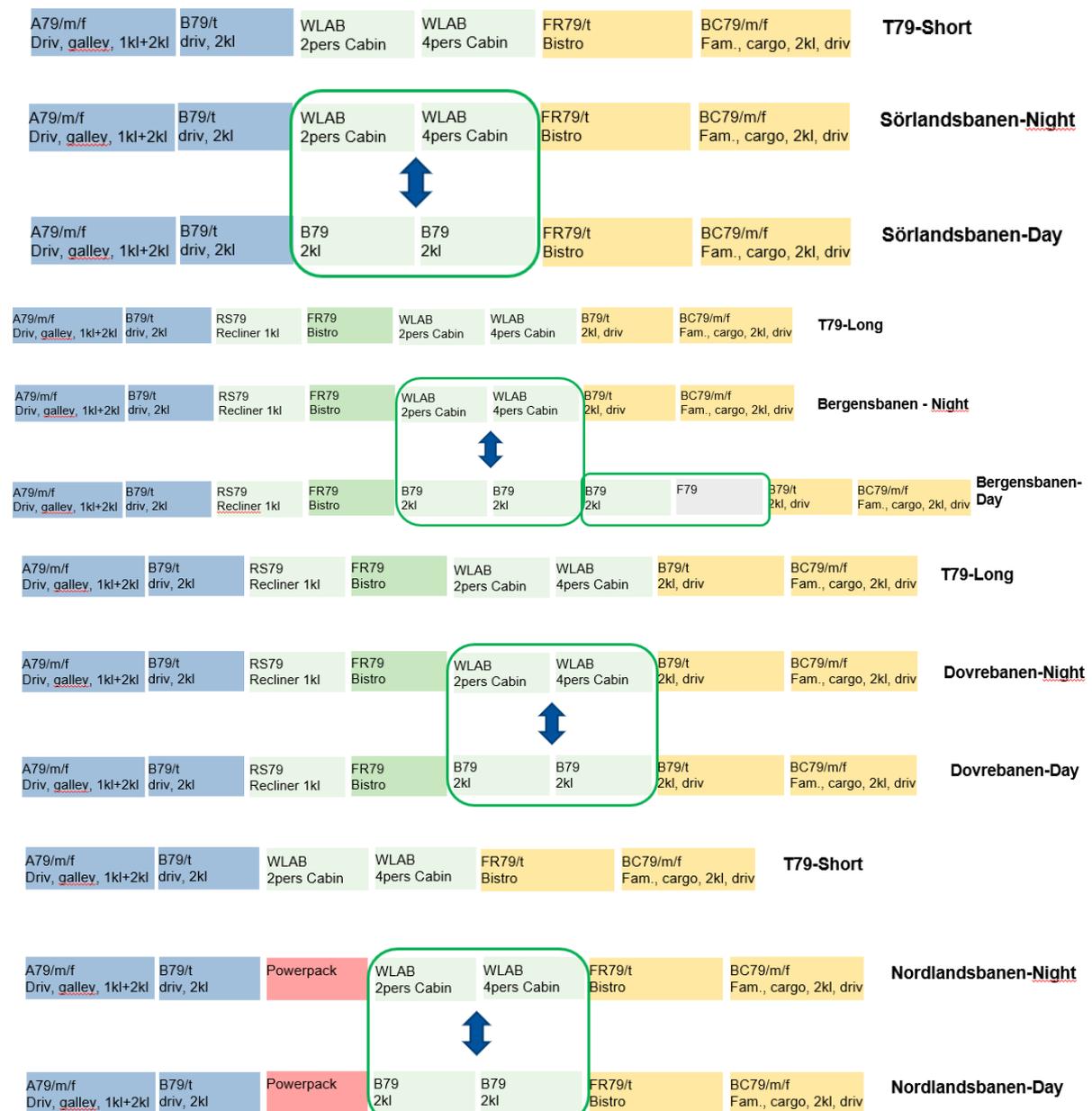
Both concepts would fulfill the overall capacity requirements though in different ways. Also the number of Trainset to fulfill the time table requirements are the same, as long as the shunting operations between day/night and night/day configurations can be accommodated in around 2,5 hours.

The difference between day and night configurations are replacing a Regular class CU with a Sleeper CU in operation each day.

Base configurations



Configurations for the different lines.



The current time tables supports theoretically above variants of train configurations. Very short turn arounds, less than one hour, are only required for Day->Day service, whereas the Day->Night and Night->Day service will have more than two hours for shortest turn around. Simulations indicate this is possible with the available depot layouts.

7.1 Shunting requirements

The replacement of Sleepers with normal Regular class CUs will increase day service seating capacity, but the shunting between day and night service will require another setup than for Trainset with the preferred common day/night configuration.

The shunting time depends on depot constraints and depot operational concept, and Nt's brief analysis of all required shunting movements indicate the actual shunting time would be around 40-50 minutes in worst case.

EMU shunting start/end position

