




Jernbaneverket  
Utbygging

## GSM-R Transmission Planning Guidelines

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### ***ProArc REVISION HISTORY***

04U	Document cancelled in ProArc for transferral to \\oslfil002\gsm-r\0. Styringsystem\3A Styringsdokumenter	20.02.06	JPL	RB PD KL KB	JPL
03C	Updated with more Bx/Cx points	05.04.05	KB	RB	JPL
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## 1 General

This document gives guidelines for the transmission network planning in the GSM-R project of JBV Utbygging. The aim of these guidelines is to provide all transmission network planners of both the transmission transport network and the transmission access network with a common understanding of the network structure requirements, availability requirements, dimensioning criteria, interconnections, etc. in order to achieve a consistent transmission network complying with the GSM-R System requirements and JBV's future needs. However, general transmission planning aspects are omitted in these guidelines.

These guidelines assume the transmission transport network being realised with leased lines.

## 2 Transmission network planners responsibility

The transmission planning in the GSM-R project is performed by JBV Utbygging's project organisation. Detailed network planning and engineering will be performed by Siemens, the turn-key contractor of the GSM-R System delivery.

The GSM-R project shall produce the following transmission planning documents:

- Transmission plan
- NCP link report

Based on the transmission plan and the radio link report, Siemens shall engineer the transmission access network to be deployed. This includes planning of indoor and outdoor unit configuration, feeder length, DDF plan, mounting details etc.

Siemens has the overall responsibility of connecting all elements of the GSM-R System together as a complete network. Siemens must state all transmission circuit needs clearly and evidently in due time for the GSM-R project to provide any required leased lines. Siemens is to perform detailed planning and design of all transmission circuits to be delivered based on the transmission plan.

Leased lines will be provided by Bane Tele.

In the document the transmission planners are divided in two main roles:

- Overall transmission network planner:  
*Overall transmission network planning, includes the transmission transport network planning.*
- Transmission access network planner:  
*Detailed radio link and fibre optical transmission section planning.*

### 2.1 Transmission plan

The GSM-R project shall produce a transmission plan for each Section of the Line. The transmission plan will normally be included in the individual Work Order for the Section of the Line or latest by the first issuance of a Work Order for a transmission access network section. The transmission plan shall include the following information:

- Transmission network structure
- BTS rings (stating BTS-ID, related BSC, LL-ID, etc.)
- Transmission access network / transmission transport network interface points
- Optical cable overview including information of end-points, number of fibres, planned use of the individual fibres, etc.

The transmission plan shall be issued per section of the line and for centralised systems. Examples of the transmission plan per Section of the Line and for centralised systems are available in Proarc.

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The transmission plan shall be made in parallel with the NCP preparation. Normally, a NCP revision shall lead to a revision of the transmission plan if the NCP revision has an impact on the information in the transmission plan.

The transmission plan shall be made by the overall transmission network planner.

## 2.2 NCP link report

The GSM-R project shall produce a NCP link report for each Section of the Line. The NCP link report will be included in the individual Work Order for the Section of the Line. The NCP link report shall comprise the following information:

- Radio link:
  - site ID
  - site name
  - link ID
  - link capacity
  - antenna height
  - frequency band
  - link capacity (e.g. number of E1's or in Mbps)
  - radio link equipment type and configuration (stating equipment type and capacity, 1+0/1+1 configuration, Add/drop configuration, etc.).
  - antenna type forecast
  - planning details such as site data, allocated frequency channel, polarization scheme, hop length, link azimuth and tilt, antenna type and height.
  - link report, defining output power to be assigned, additional attenuation, etc
  - availability figures of the individual transmission access network sections
- Fibre optical transmission section:
  - site ID
  - site name
  - link ID
  - fibre transmission alternative
  - in the event of alternative 4 (ref. section 5.2) the NCP shall give information of the closest splice on the existing long-distance fibre optical cable of which the site shall be connected

In practice, the NCP link report will be included in the NCP (Nominal Cell Plan) of the SoL. (Examples of the NCP for individual sections of the line are available in Proarc)

The NCP shall be made by the transmission access network planner.

## 3 Overall transmission network planning

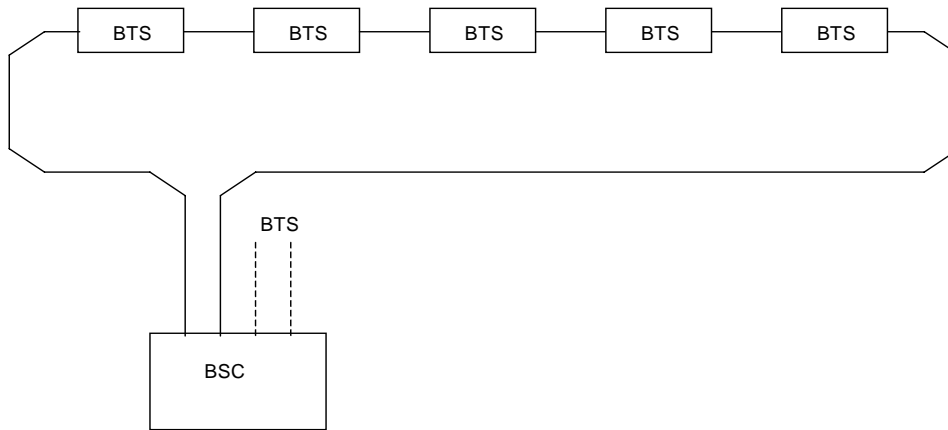
### 3.1 Basic capacity need

The BSS network of JBV's GSM-R network is normally dimensioned with BTSs equipped with 2 TRXs. A typical BTS with 2 TRXs supports 14 x 16 kb/s speech channels, and requires in addition up to 2 x 16 kb/s control channels. This leads to a requirement of 4 x 64 kb/s PCM timeslots for payload (normally speech) and one 64 kb/s timeslot for signalling, adding up to 5 x 64 kb/s timeslots per BTS. Hence, up to 6 BTS may use the same 2Mb/s signal, however, due to possible new BTSs or increased traffic need per BTS, a maximum of 5 *BTSs* are allowed to share a 2Mb/s signal.

In the event of the capacity of the BTS ring gradually appears to be a limitation, the BTS ring shall be split into 2 rings. Hence, each BTS may utilize more of the timeslots of the 2Mb/s signal.

### 3.2 BSS network structure

The BSS network of JBV's GSM-R network shall conform to the principle logical network structure given in the below Figure 1.



**Figure 1: Principle BSS logical network structure**

BTSs shall be linked to the BSC through a logical ring network structure. A logical BTS-ring will consist of up to 5 BTSs. The BTS-ring will be realized through 2Mb/s transmission circuits forming the ring. All interconnections forming the ring, being BTS-BTS or BTS-BSC, shall be realized in a separate geographical/physical route compared to all other interconnections within the specific BTS-ring.

The logical BTS ring shall support protection switching for all Abis channels between BTS and BSC. In the event of outage of an Abis channel between a BTS and the BSC, the BTS/BSC shall switch the Abis channel to its protected route within the ring structure.

Siemens will do time-slot allocation, and this will be documented by Siemens.

There will be 6 BSCs in the GSM-R network. The BTS-rings will be connected to BSCs. The transmission plan shall give information of which BSC the individual BTS-rings shall be connected. The location of 3 of the BSCs are decided, given in the below table. The remaining 3 BSCs locations will be decided based on technical room availability, evenly distribution of BTSs per BSC, optimal leased line cost, location of OAM-personnel, etc.

<b>BSC #</b>	<b>BSC location</b>	<b>Belonging BTSs</b>
BSC-01	Bodø (Bodø railway station)	BSC-01 controls BTSs of SoL A1, and partly A2 (Rognan – Majavatn).
BSC-02	Trondheim (Marienborg)	BSC-02 controls BTSs of parts of SoL A2 (Majavatn – Trondheim), parts of SoL B (Trondheim – Støren) and the complete SoL C and SoL E.
BSC-03	Trondheim (Marienborg)	BSC-03 controls BTSs of parts of SoL B (Støren – Hamar) and parts of SoL L (Hamar – Dombås).
BSC-04	Bergen (Bergen railway station)	BSC-04 controls BTSs of the sections Kristiansand – Stavanger and Geilo – Bergen, including Flåmsbanen.
BSC-05	Oslo (Oslo S)	BSC-05 controls BTSs of SoL F, G, H, I, J and parts of SoL L (Lillestrøm – Hamar).
BSC-06	Oslo (Oslo S)	BSC-06 controls BTSs of SoL N, P and parts of SoL K (Asker – Kristiansand) and SoL M (Hokksund – Geilo).

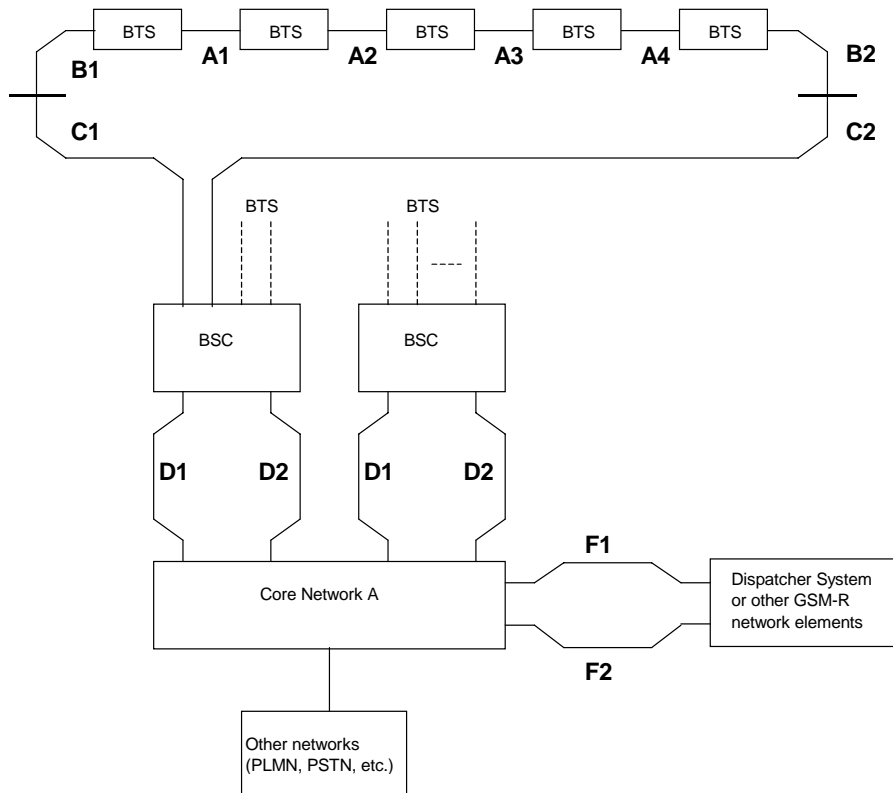
*The areas of which the BSC controls is given on a high level. Please refer to the individual transmission plans per SoL in order to get exact information of which BTS being controlled by which BSC.*

### 3.3 Transmission network structure

The GSM-R transmission network shall interconnect the individual elements of the GSM-R System. The GSM-R transmission network can be divided into two main parts:

- Transmission transport network
- Transmission access network

The transmission network structure will be as shown in the below figure:



**Figure 2: Transmission network overview.**

Referred to the above figure, Ax and Bx interconnections constitute the transmission access network and Cx and Dx interconnections constitute the transmission transport network.

Ax interconnects BTSs, and Bx is the access part of the BTS – BSC interconnection. The interface between Bx and Cx is aggregation points for transmission circuits between BTSs and BSC.

Ax, Bx and Cx interconnections will form a logical BTS-ring. The logical BTS-ring may consist of up to 5 BTSs. Physically the BTS-ring may be realised through several transmission access network sections:

- Ax interconnections will normally be one transmission access network section, but it may be necessary to realise the Ax interconnection with two or more transmission access network sections due to topology.
- Bx interconnections will normally be several transmission access network sections in order to transport the logical BTS – BSC interconnection to the Bx/Cx aggregation point (interface to the transmission transport network).
- Cx will be leased lines in the transmission transport network (Company provided item).

All interconnections forming the BTS-ring, being BTS-BTS or BTS-BSC, shall be realised in a separate geographical/physical route compared to all other interconnections within the specific BTS-ring.



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The transmission transport network, being Cx and Dx interconnections, will be realised as leased lines, i.e. being Company provided items. All transmission circuits constituting the MSC-BSC interconnection shall be realised as leased lines. The leased lines shall be split in two main routes forming fully diversity between the two main routes. All transmission circuits between MSC and BSC shall be divided equally between the two main routes.

Fx circuits connect the Train Control Centres to the GSM-R system. F1 and F2 shall always be routed in separate physical routes.

Interconnect to other networks will be realised as leased lines.

The GSM-R transmission network shall support the availability requirements of the GSM-R System.

### **3.4 DCN structure**

The DCN of the transmission access network was originally designed based on the radiolink equipment, but by the introduction of fibreoptical transmission solutions this will be a common DCN for the complete transmission access network.

The DCN will be realised through 2Mb/s transmission circuits between routers at the Bx/Cx interconnection points. The 2Mb/s transmission circuits will be realised within the transmission access network, i.e. the 2Mb/s transmission circuits for the DCN will be transported as a channel in the Transmission Access Network sections between the Bx/Cx interconnection points.

In the event of fibre optical transmission sections within a radio link chain, the in-band DCN of the radio link chain shall be connected through the fibre optical transmission section as an Ethernet connection.

In order to obtain a redundant path/route in the DCN, 2Mb/s leased lines shall be provided in a manner ensuring a meshed router network. The overall transmission network planner shall prepare and keep updated a total DCN network plan for the complete GSM-R system, including all sections of the line, in close cooperation with Siemens network planners. The DCN network plan shall be documented in Siemens OAM network design document.

### **3.5 Synchronisation structure**

Synchronisation of the GSM-R network will be based on synchronisation signals from Bane Tele. Bane Tele will provide 2 synchronisation signals at Marienborg via separate physical routes. Further described in documentation from Bane Tele.

Siemens will use these signals to synch the MSC, which will be the master of the GSM-R network. Further described in Siemens' high level network plan.

## **4 Transmission transport network planning**

Transmission transport network planning shall be performed by the overall transmission network planner.

### **4.1 Cx interconnections**

Ax, Bx and Cx interconnections will form a logical BTS-ring. The logical BTS-ring may consist of up to 5 BTSs.

Every single interconnection, being C1, C2, B1, B2, A1, A2, A3 and A4, shall be routed through a separate physical route compared to the all other interconnections forming the specific BTS-ring. A separate physical route means that the individual interconnections shall be separated by a minimum of 5 meters at any point. No single points of failure are acceptable.

The BTSs will include automatic protection switching functionality.

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Termination of Cx interconnections at Bx/Cx interface points may be done in the same transmission equipment node. Additionally, the fibrecable from the railway track to the equipment room forming the Bx/Cx interface point may be in the same duct, tray, etc.

Termination of Cx interconnections at the BSC shall be done in separate transmission equipment nodes. Each transmission equipment node shall be fed from separate fibrecables realised in separate physical routes. The transmission equipment may be placed in the same cabinet.

The required capacity of the transmission transport network will be dependent of the number of BTS-rings between Bx/Cx interconnection points. To be specified in the individual transmission plans of SoL.

## 4.2 Dx interconnections

Leased Lines D1 and D2 shall be routed in separate physical routes. A separate physical route means that the individual interconnections shall be separated by a minimum of 5 meters at any point. No single points of failure are acceptable.

Termination of Dx interconnections shall be done in separate transmission equipment nodes (applies to both termination points). Each transmission equipment node shall be fed from separate fibrecables realised in separate physical routes. The transmission equipment may be placed in the same cabinet.

The required capacity will normally be 2 x 2Mb/s realised in separate physical routes. Siemens is to be consulted for each BSC before leased lines is ordered from Bane Tele.

## 4.3 Fx interconnections

Leased Lines F1 and F2 (interconnection with Dispatcher system at train control centres) shall be routed in separate physical routes. A separate physical route means that the individual interconnections shall be separated by a minimum of 5 meters at any point. No single points of failure are acceptable.

Termination of Fx interconnections between Core network and GSM-R Dispatcher system shall be done in separate transmission equipment nodes (applies to both termination points). Each transmission equipment node shall be fed from separate fibrecables realised in separate physical routes. The transmission equipment may be placed in the same cabinet.

The required capacity will be 2 x 2Mb/s realised in separate physical routes.

## 4.4 Interconnection to other networks

Interconnection to other networks will be based on leased lines from Bane Tele. The leased lines are to be ordered with the required availability, but diversity is not required.

Interconnect to NetCom: Initially this will be 1 x 2Mb/s.

National roaming (Telenor): Initially this will be 2 x 2Mb/s.

International roaming (Banverket): Initially this will be 1 x 2Mb/s.

## 4.5 Purchase order issuance

Purchase orders shall be issued by transmission rollout responsible. The transmission planner of the transport network is responsible of initiating the purchase order issuance by stating the leased line need and the required routing of the leased line.

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## 5 Transmission access network planning

The transmission access network planning shall be performed by the transmission access network planner.

The transmission access network of the GSM-R network will be based on two different solutions:

- PDH radio relay systems
- SDH fibreoptical transmission

The transmission access network will terminate in the defined Bx/Cx interconnection points. As a guideline the Bx/Cx-points given in appendix 2 shall be used.

In order to optimise the transmission access network for future use of JBV, location of repeater sites shall if possible be located close to the track at JBVs telecom installation.

### 5.1 Radio link based transmission access network sections

The transmission access network will normally be based on PDH radio links. The radio link shall be the default solution of the transmission access network sections.

For SoL A-E the radio link equipment SRA-L has been used. For the remaining SoLs SRA-XD will be used.

The transmission access network shall normally be dimensioned with 8x2Mb/s PDH radiolink equipment with 1+0 configuration.

In the event of the Bx/Cx interconnection point being realised as a tail, the capacity of the link shall be twice the capacity of the normal links in order to terminate all transmission circuits from both directions, ie the capacity of such links will normally be 16x2Mb/s.

The SRA-L will be configured as terminal-muxes, while the SRA-XD normally will be realised in an add/drop configuration.

Radio links being tails in the transmission access network shall be realised with 1+1 Hot Standby configuration in order to protect the link in event of the equipment failure. The link shall be planned to meet the availability requirements as 1+0 configuration, and then be upgraded to HSBY configuration.

This does not apply for Bx/Cx interconnection points.

### 5.2 Fibre optical based transmission access network sections

If a fibre optical solution seems preferable from a environmental, economical or operational point of view, the transmission access network planner shall choose this as the transmission solution for the transmission access network sections in question.

There will be 4 typical alternatives of fibreoptical transmission:

1. Use of new fibre optical cable being established in tunnels as part of the GSM-R tunnel radio system
2. Use of existing fibre optical cable being a part of an existing tunnel radio system
3. Use of new fibre optical cable being established due to the fibre optical transmission need only.
4. Use of existing long distance fibre optical cable.

The fibre optical transmission solution will be SDH equipment; Surpass HiT 7050. Normally, the SDH-equipment shall be realised as add/drop configuration.

The SDH equipment shall be dimensioned with STM-1 line interface and tributary-interfaces with 21x2Mb/s and 4x100Mb Ethernet.

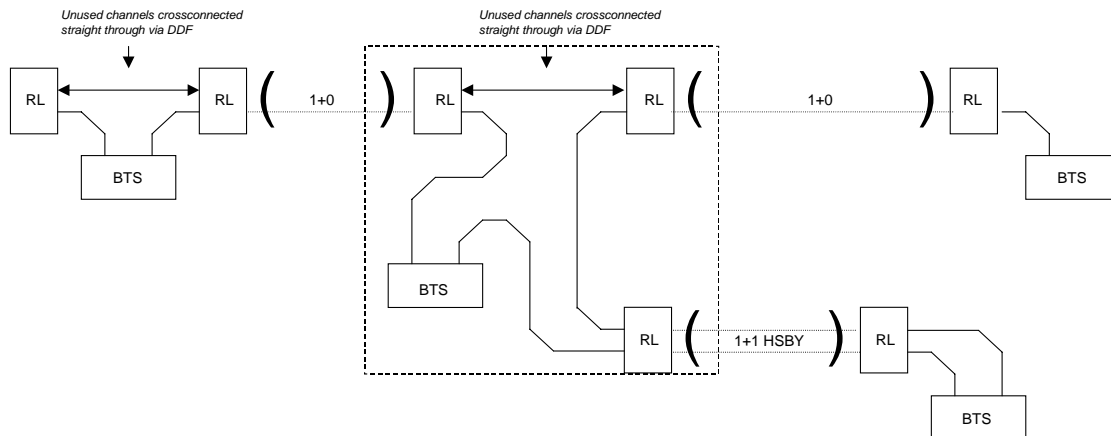
In the event of tail-site with fiber optical transmission the site shall be protected by SNC-protection over the tail. The SNCP shall be realised at VC-4 level. The VC-4s shall go through separate line-units in the HiT 7050 NE.

In the event of tail-site with fibre optical transmission, the NCP shall state “Tail-site (SNCP)” as a comment to the link. (See example in appendix 1)

### 5.3 Termination/routing of transmission circuits

*Termination/routing of transmission circuits at different site types at SoL A-E (apply to all sites):*

- All 2Mb/s transmission circuits shall be terminated at each site. The 2Mb/s transmission circuits not being used (for the moment), shall be crossconnected in the DDF (ie. patched straight through in the DDF).
- In the event of tails in the transmission access network structure, all 2Mb/s transmission circuit not to be terminated at the BTS at the end of the tail shall be connected through the shortest path possible.
- All transmission circuits (also unused circuits) shall be routed to the interconnection points of the transmission transport network. At the Bx/Cx interconnection points all 2Mb/s transmission circuits shall be terminated, i.e. 8x2Mb/s channels from each direction shall be terminated.
- The transmission circuits forming a BTS-ring shall pass each BTS only once. At sites with more than two radio links, ie. one or more tails connected to the site, the transmission circuits shall be connected in such a way that this principle is maintained. (Ref. the below figure)



**Figure 3: Transmission circuits at tail sites**

*Termination/routing of transmission circuits at different site types at remaining SoLs:*

- At all sites with radio link equipment only (SRA-XD):  
All tributaries shall be terminated/patched to the DDF. However, all unused circuits and all circuits not having their termination points at the site in question, shall be crossconnected in the radio link equipment (routed straight through in the crossconnection matrix of the equipment).
- At all sites with fiberoptical transmission equipment only:  
All tributaries shall be terminated/patched to the DDF. However, all unused circuits and all circuits not having their termination points at the site in question, shall be crossconnected in the fibre optical transmission equipment (routed straight through in the crossconnection matrix of the equipment).
- At all sites having both radio link equipment and fibre optical transmission equipment:  
All 2Mb/s transmission circuits shall be terminated at each site. The 2Mb/s transmission circuits not being used (for the moment), shall be crossconnected in the DDF (ie. patched straight through in the DDF).
- At all sites being an Bx/Cx interconnection point:  
All transmission circuits (also unused circuits) shall be routed to the interconnection points to the transmission transport network. At the Bx/Cx interconnection points all 2Mb/s transmission circuits shall be terminated at the DDF.
- At all tail sites:  
In the event of tails in the transmission access network structure, all 2Mb/s transmission circuit not to be terminated at the BTS at the end of the tail shall be connected through the shortest path possible. The transmission circuits forming a BTS-ring shall pass each BTS only once. At sites with more than

two radio links, ie. one or more tails connected to the site, the transmission circuits shall be connected in such a way that this principle is maintained. (Ref. the below figure)

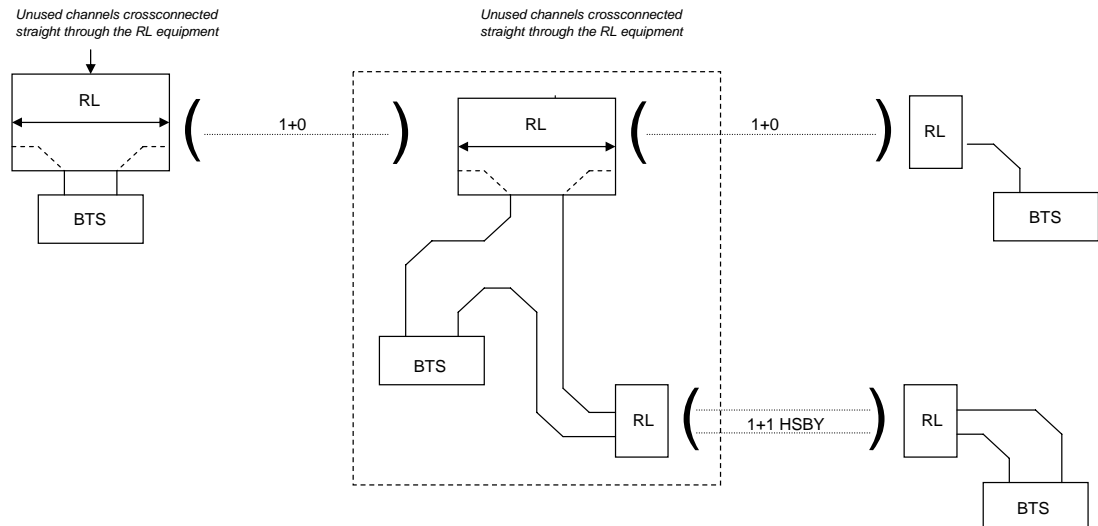


Figure 4: Transmission circuits at tail sites

## 6 Interconnection points between transmission transport network and transmission access network

Interconnection points to the transmission transport network shall be distributed evenly along the line. The distance between interconnection points to the transmission transport network is decided based on the following criteria:

- Availability calculations shall be made, and the overall system availability requirements shall be met. The availability calculation will be based on the availability figures from the radio link planning. The radio link planners have a guiding availability requirement of 99,985% per hop, however the availability calculations shall control that the overall availability requirements are obtained. The availability calculations shall be performed at least for one BTS ring between two Bx/Cx interconnections points. Please refer to availability calculations for the sections of the line given in *R:\gsmr\2.11.3 Transmission plans\Availability calculations*. The availability calculations shall be performed by the overall transmission network planner.
- The number of consecutive radio links shall normally not exceed 20, due to DCN dimensioning and availability requirements.

Interconnection points shall preferably be located in Bane Teles premises having a network nodes of their SDH network. If JBV owns a room in the building, JBV's room shall be preferred. All interconnection points shall be visited by the transmission access network planner prior to the NCP issuance.

## 7 Coding

BTS-ring coding:

Each BTS-ring shall be given a unique ID in the Transmission plan. The ID shall consist of a character indicating the Section of the line and a running number of the specific BTS ring (the running number shall increase by steps of 5 in the initial planning):

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Site coding: Refer to Radio planning guidelines.

Radio link coding: Refer to Radio link planning guidelines

## Appendix 1

Link ID	Length (km)	Site ID	Easting (zone 33)	Northing (zone33)	Easting (zone 32)	Northing (zone 32)	Antenna heighth - center (m)	Antenna type	Antenna direction (°)	Actual elevation (°)	Polarisation	Radio Equipment	Tx Power (dBm)	Operating Mode	Rx Level (dBm)	Centre Frequency (GHz)	Frequency Designation	Worst Month Availability (%)	Fibre transmission alternative	Connected to splice at km (alt 4)	Comments
M295	2.92	M2301B10A			501248	6730374	19.00	VHLP1-370 (38G 0.3m S)	248.48	5.40	Horizontal	SRAL XD 38 GHz 8x2 (1+0)	17.00	Single	-38.6811	37.45700	Low	99.9818734			
		M2301B13A			498534	6729304	7.00	VHLP1-370 (38G 0.3m S)	68.48	-5.40	Horizontal	SRAL XD 38 GHz 8x2 (1+0)	17.00	Single	-38.6811	38.71700	High	99.9827305			
M350	5.27	M2311B30A			434569	6710300	9.50	VHLP2-240 (26G 0.6m S)	304.73	0.24	Vertical	SRAL XD 26 GHz 8x2 (1+0)	18.00	Single	-36.4157	24.68200	Low	99.9869579			
		M2311B35C			430235	6713304	18.00	VHLP2-240 (26G 0.6m S)	124.73	-0.24	Vertical	SRAL XD 26 GHz 8x2 (1+0)	18.00	Single	-36.4157	25.69000	High	99.9880329			
M355 (Fibre transmission)		M2310B40A			447525	6707110													4	34.056	
		M2311B35C			430235	6713304													4	34.789	
M360 (Fibre transmission)		M2311B35C			430235	6713304													4	34.789	
		M2311B37A			427647	6713579													4	35.154	Tail-site (SNCP)
M365 (Fibre transmission)		M2311B37A			427647	6713579													1		
		M3211B43A			423820	6714002													1		
M370 (Fibre transmission)		M3211B43A			423820	6714002													2		
		M2311B45A			421896	6715649													2		
M375 (Fibre transmission)		M2311B45A			421896	6715649													3		
		M2311B50B			418796	6718763													3		
M380 (Fibre transmission)		M2311B50B			418796	6718763													4		
		M2311B60C			408558	6724936													4		

***Dette er ikke en reel NCP, kun et fiktivt eksempel for å vise hvordan fiberinformasjon skal angis.***

## Appendix 2

### Bx/Cx interconnection point overview

SoL A	SoL B	SoL C	SoL D	SoL E	SoL F	SoL G	SoL H	SoL I	SoL J	SoL K	SoL L	SoL M	SoL N	SoL O	SoL P
Bodø	Trondheim	Støren	NA	Stjørødal	Oslo	Ski	Oslo	Oslo	Oslo	Asker	Otta	Hokksund	Drammen	Myrdal	Roa
Rognan	Støren	Oppdal		Storlien	Ski	Askim	Lillestrøm	Roa	Sandvika	Drammen	Fron	Hønefoss	(Skoppum)	Flåm	Hønefoss
Bolna	Røros	Dombås			Moss	Mysen	Kongsvinger	Gjøvik	Asker	Hokksund	Tretten	Gulsvik	Tønsberg		
Mo i Rana	Tynset	Bjørli			Fredrikstad	Sarpsborg	Magnor		Spikkestad	Kongsberg	Lillehammer	Gol	Sandefjord		
Mosjøen	Alvdal	Åndalsnes			Sarpsborg					Nordagutu	Moelv	Ål	(Larvik)		
Majavatn	Koppang				Halden					Neslandsvatn	Hamar	Geilo	Porsgrunn		
Grong	Rena				Kornsjø					Nelaug	Mange pkt Hmr-Eidsv	Ustaoset	Skien		
Steinkjer	Elverum									Kristiansand	Eidsvoll	Myrdal	Nordagutu		
Stjørødal	Hamar									Snartemo	Gardermoen	Voss			
Trondheim										Sira	Lillestrøm	Dale			
										Egersund	(Mange pkt langs GMB)	Arna			
										Bryne		Bergen			
										Sandnes					
										Stavanger					

Note: Sites in brackets refer to uncertainty of redundancy