GSM-R Radio Planning Guidelines

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Revision	Changes	Pages affected	Date	Signature
00			Des02	KL og PR
01	Adjusted from BaneTele a.s. to JBV organization	All	11.06 2003	KL
02	• chapter on slow fading simplified • 2W CAB column in link budget removed because is N/A • how to prioritise between candidates • modification of chapter on interworking with SA, radio link planning and vendor • cell plan templates and release routine • revised coverage requirements due to new input from JBV/HK • Attachment 1 showing the subsection IDs is included • Attachment 2 showing the train control areas is included • requirement on antenna separation is revised • tunnel redundancy requirement changed from 500 m to 1000 m to be in accordance with revised requirements from JBV/HK • cell plan templates included as appendices • Candidate status related to cell plan document release • Information on feeder type revised • Information on content in FCP; incl. frequency planning strategy • chapter on working in the planning tool is moved to other document • included explanation on cell-ID • included explanation on BSIC	12 Attachment 6 22 24 Appendices + page 25 10 Attachment 1 Attachment 2 15 24 Appendices 3-5	Sep03	KL

		27 Chapter 5.3		
03	• included information on how to set antenna height based on info about antenna section height and RL-antenna height • site selection process updated based on most recent input • interworking process updated • included column on BTS type and configuration in NCP site list template	Section 5.2.3 Section 6.3 Section 9.1	Nov03	KL KL KL
04	• quality audit cell plans • default antenna • new chapter on tracking of sites added • updated site priority rules • mast lengths • sector numbering • initial optimisation • Attachment list updated • interworking process updated • signalling channels modified • antenna tilt simplified • should strive to use site owner's name	9.2.2 5.3.1 9.3 6.2 and 6.3 5.3.3 5.3.3 12 9.1 3.1.2 5.3.5 10.1	May04	KL
05	• chapter on interworking process updated	9.1	July 5, 2004	KL

	• new Attachment 14 Checklist of NCP, FCP and TSSR			
06	• added description on how to analyse drive test files • coverage requirements updated for high traffic density areas • routine for opimization added • • 5.6: BS240 is default BTS type. • 9.2.1: FCP is now per SoL, not site. • 9.2.2: Action request-procedure added. • 3.3 Coverage req: moved train controller area and shunting area requirements here. coverage req outside main tracks added. • 5.13: frequency planning: new group allocation strategy. • 5.3.7.1: antenna mounting cleareances added. • Att 2: train controller areas updated (fagernut changed to myrdal) (sak 03/2548-36) • Att. 6: Link Budget: lnf-fading increased to 9 db, interfence margin reduced to 1 dB, measurement requirements updated: -88dBm 2W MS unbalanced, -83dBm 2W MS balanced, -95dBm CAB. • Att. 4+5+8+9, Nominal Cell Plan (NCP) is now separate document GSM-00-M-00014. • Att 10: antenna list updated with RFS substitutes. • Att 11: optimization report: new measurement reqs. changed result tables. • Att 12: CellIDs: administrative sites shall have 65aab, siteID shall start with X9999 • Att 15+16+17 FCP SoL template added. • Att 14: checklist removed into separate document. GSM-00-M-00013 • Att 20: Endringsmelding fra nettplanlegger added.	Ch 12 Ch 3.3 Ch12	Aug, 2004 Sep. 2004 29.10.04	KL ML JB

	Misc. changes in attachements and chapter 10.2 of main document. Attachements changed: Attachment 06 - Link Budget.xls Attachment 10 - Antenna list.xls Attachment 12 - CellIDs - 050429.xls Attachment 15 - FCP SoL template.dot Attachment 20 - Endringsmelding fra nettplanlegger.doc Attachment 21 - Action Request.doc	Ch. 10.2		JPL
	Cellids – no leading zeros	Att. 12		JB
	Modified sections on coverage and quality – more precise definition of probability.	Ch 3.2 & 3.3		EBj
	C/I explained.	Ch. 4.5		EBj
	RFS/Celwave preferred antennas	Ch. 5.3.1		EBj
	Inserted Asset level requirements for cross-border coordination	Ch. 5.13		EBj
	Updated site ID convention	Ch. 10.1		EBj

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1 Introduction

These guidelines describe how the GSM-R radio planning in the JBV Utbygging GSM-R project shall be done. The document does not deal with radio planning during the operational phase – only during the rollout phase from start of radio planning up until the initial optimisation is finished.

These guidelines shall be read and used by all radio planners in the project but may also be of use for other participants in the project.

Radio planning requirements are described, and the practical implications of the requirements are gone through. This embraces network dimensioning, base station location, base station configuration as well as network initial optimisation.

Descriptions of equipment are included where relevant for radio planning. The radio planner's part in the rollout process is also described.

The radio planning handbook is not meant to be all-embracing. It describes only the radio planning aspects that are specific in this particular project. General radio planning guidelines and GSM radio planning technology subjects should rather be found in literature.

2 Radio planner's responsibility, main tasks and part in project

The radio planner's main responsibility is to locate base stations in such a way that the requirements on capacity, quality and coverage are satisfied and at the same time follow other guidelines for radio planning given in this document.

The radio planner's main tasks in the rollout project are:

- Dimensioning
- Choosing the best base station locations, satisfying a set of requirements
- Configure and set radio planning parameters for the base stations chosen, also satisfying requirements
- Initial optimisation: take actions so that base stations are tested, analyse results and issue, if necessary, change orders so that the base stations satisfy the radio requirements and are ready for delivery to operator organization
- Documentation: Issue preliminary, nominal and final cell plans, keep database in Asset updated

A radio planner will also hold responsibilities in an operator's organization, but these responsibilities are not described in this document.

A radio planner should work in close cooperation with the persons responsible for radio link planning and site acquisition (SA). He/she will play a part and have interfaces as described in separate chapter on the rollout process, chapter 9.

3 Network requirements and prerequisites

Network requirements are described in both Ref. #2 and #3. Where these requirements are not complete or no longer valid, we've suggested additional requirements. If requirements in this document is different from requirements in references, the requirements in this document shall prevail.

3.1 Capacity

3.1.1 Traffic channels

In Ref. #4 250 Erlang is estimated as the traffic need for the rail track areas in Greater Oslo. This need is repeated in Ref. #1. This includes for instance:

- Voice- and data communication for train conveying
- Voice- and data communication for administrative personnel
- Voice- and data communication for operation- and maintenance personnel
- Data communication for information to passengers
- Data communication for transmission of train data
- Data communication for service applications (ticket vending machines etc.) on board the trains
- ERTS/ETCMS (for train signalling)

The capacity need at the point of launch will be much less because there is no need for train signalling capacity yet, and as we see in Ref. #4 the major capacity demand is from train signalling.

Blocking is set to 1%.

If we subtract the capacity allocated for train signalling we see that we need approximately 50 Erlang for the area of Greater Oslo.

If so, the capacity need and distribution is:

Area	Traffic share	Erlang
Oslo S	55 %	28
Alnabru	20 %	10
Lodalen	10 %	5
Skøyen-Bestum	5 %	3
Resten av området	10 %	5

Table 1 Capacity distribution

Base stations covering these areas must be equipped to provide adequate capacity according to this table. See 5.1 for table showing the CU (Carrier Unit) to Erlang mapping.

No capacity estimates are done for the rest of the country. We are awaiting traffic estimates input from both JBV/HK and NSB for the rest of the country; this includes area along track, in train stations, in bus stations, in workshop, in shunting areas, in administrative areas as well as in other areas that may require special attention with regards to capacity.

Due to redundancy requirements there shall be a minimum of 2 CUs on all cells. Our estimate/guess is that along track there is need for only 1 CU if traffic requirements alone were to determine the number of CUs.

3.1.2 Signalling channels

In GSM there are 8 timeslots per CU at full rate.

The first timeslot on the first CU is always reserved for signalling. If the signalling capacity need is high, 2 timeslots can be allocated for signalling on the single CU. If there are more CUs than one, the signalling capacity can be allocated from the first timeslot on all CUs or all signalling can be taken from timeslots only on the first CU. Signalling capacity is needed for call set-up and termination as well as for handovers. For location update and SMSs a special type of logical signalling channel called SDCCH is used.

In particular one must look at how much more signalling capacity is needed in a GSM-R network compared to a public network. In a public network handovers will be take place in a much more distributed manner than in a GSM-R network where handover will take place in "lumps" as a train full of users pass a handover zone. We assume that more signalling capacity will be needed in a GSM-R network than in a public network.

Also the use of SMS must be estimated as this influences much on the number of SDCCHs needed. .

3.2 Quality

The cell edge coverage probability for 2W handheld outdoor along the track shall be 95%.
The cell edge coverage probability for 8W cab radio shall also be 95%.

Designed GSM-R network RxQual value shall be 3 or lower for at least 95% of the samples in a 100 meter long sliding window along the railway track. (TEMS gives 4 samples every 0.48 sek. For the test train, which according to the test specification is driving with 75 km/h, this corresponds to 40 samples per 100 meter. To satisfy the 95% requirements, 38 of these samples then needs to have RxQual 3 or better).

We suggest to use the value 3 as the GSM decoder can handle frames with RxQual value 3 and less and correct necessary errors. RxQual values 5 and more will cause GSM frames to be deleted because of severe errors. RxQual values 4 and higher for at least 4 seconds during GSM-R network initial tuning/optimisation should be noted and necessary actions to be taken to correct them.

GSM-R network initial optimisation is described in Attachment 12..

Other Radio Network quality measures:
Dropped call rate shall not exceed 1%.
Radio Network congestion shall not exceed 1%.
Handover success rate shall be at least 99%.
Traffic channel blocking shall not exceed 1%.

3.3 Coverage

The coverage shall satisfy 95% cell edge coverage probability for 2W handheld outdoor. Thus, during network initial optimisation 95% of the RxLev measurement samples in a 100 meter sliding window should be better than the defined signal level for coverage, according to the same principles as described in section **Feil! Fant ikke referansekilden.**.

For an unbalanced network this refers to –82dBm design level in planning tool. For a balanced network this corresponds to –77 dBm design level in planning tool. See link budget in Attachment 6. The requirement is thus signal level better than –77 dBm. An additional requirement is valid for CAB radio.

The coverage requirements set are the same regardless of train intensity. However, capacity requirement is a function of train intensity and thus the frequency planning restrictions will lead to a higher concentration of base stations in high traffic demand areas. The consequence of this is that the coverage requirements will be over fulfilled in areas with high train intensity.

It's up to JBV/HK and NSB to set requirements for indoor coverage in administrative areas and also to specify in which areas there shall be indoor coverage. Until these requirements are available the radio planner shall strive to achieve indoor coverage in all major train station and bus station areas as well as in workshops and in shunting areas. This can best be achieved by locating a BTS at the spot.

For tunnels the same coverage probability requirements as for surface coverage apply. Tunnel design shall however be performed by system vendor Siemens; not by project. The project radio planner's responsibility is to ensure that the signal level is higher than –77dBm at the entire track, including area just outside tunnel portal.

3.3.1 Coverage gap requirement

If a site is out of operation, a coverage gap will occur. CAB radio and handhelds will experience different coverage gaps. For CAB radio, the accumulated coverage gap must not exceed a given requirement X; i.e. the signal level shall not be below –95 dBm for a length of totally X km if a site fails. The coverage gap requirement X is different for different SoLs, and summarized below:

In GSM-R rollout phase 1 there are no requirement for coverage gap for SoL A, B and C. For SoL E the requirement is 10 km.

In GSM-R roll-out phase 2 there are three different requirements for coverage gap according to traffic density:

- Maximum 5km coverage gap:
  - Kongsberg - Oslo - Lillehammer
  - Oslo - Halden - Kornsjø
  - Skien - Tønsberg - Drammen (Vestfold)
  - Bergen - Arna - Voss
  - Melhus - Trondheim - Steinkjer
  - Stavanger - Sandnes - Egersund

- 0 km coverage gap (dobbeltdekning)
    - Oslo Sentralbanestasjon
    - Trondheim stasjon
    - Alnabru skiftestasjon
    - Lillestrøm stasjon
    - Hamar stasjon
    - Drammen stasjon
    - Kristiansand stasjon
    - Stavanger stasjon
    - Bergen stasjon
    - Asker – Gardermoen (Gardermobanen)

- For all other SoL the requirements is 10 km.

3.3.2 Train controller area (toglederområde)

Due to the need for routing of calls from train to the train controller area responsible for the area in which the train is located, some means of location information is needed. This will as a backup solution be solved by use of cell-ID.

For all controller area borders the handover area shall at the earliest start 1,5 km from the "innkjørsignal" in each end of the station representing the controller area border. The cell shall not go as far as the next "blokkpost" or station.

The entire station area out to "innkjørsignal" on each side + 1,5 km should be covered by one cell only if possible. If coverage cannot be provided by one cell only it may be accepted to design with two cells.

The abovementioned signals should all be surveyed and GPS positions taken, so that the planner is aware of their exact location. Preliminary positions may be found in the BaneData utility, but to get the most up-to-date information, the "signalavdeling" in JBV Drift responsible for the station shall be contacted for info. They shall also be hired to perform the actual survey.

The defined controller area borders are found in Attachment 2. See also ref. 10.

3.3.3 Shunting areas

A cell must not cover two shunting areas.

3.3.4 Coverage of areas outside main lines.

Some side tracks, administrative buildings, etc. may also be covered. A report is scheduled late first half 2005 listing all these areas, but up till then, planner should ask "premissgiver" in each case.

3.4 Frequency resources

For GSM-R in Europe a paired 4 MHz band is reserved for GSM-R. Uplink is in the area 876-880 MHz, and downlink is in the area 921-925 MHz.

JBV is awarded a licence from PT allowing for use of the full spectrum. The licence is nationwide.

3.5 Civil works (CW) requirements

There may be CW restrictions such as for instance maximum available mast height. SA agent is responsible for fulfilling these requirements and shall inform radio planner about this if applicable and relevant for any of the candidates chosen.

3.6 Transmission access network requirements

All BTS sites shall have a transmission solution based upon radio link. The GSM radio planner's candidates shall be chosen in cooperation with the radio link planner in order to minimize use of radio link repeater sites; i.e. radio planner should strive to achieve line-of-sight between candidates.

3.7 Safety and redundancy

There shall be a minimum of 2 CUs on each base station.

For all base stations the power backup time requirement is 8 hours. There are no requirements to type of backup source; i.e. whether it's batteries or UPS. This topic is for radio planner's information only.

All tunnels longer than 1000 m shall be built with feeding of every other repeater from separate base stations. This means that if a tunnel is longer than 1000 m the radio planner should try to design a network such that there is pickup signal from 2 base stations.

For safety reasons, and economical reasons as well, the radio planner should try to avoid locating sites in the "slyngfelt" on tracks where this is applicable.

3.8 Rollout plan

3.8.1 Train traffic areas

Rail tracks that are to be covered:

- Trondheim - Fauske - Bodø (starting in Bodø)
- Hamar - Støren - Trondheim
- Støren - Dombås - Åndalsnes
- Stavne - Leangen
- Hell - Storlien
- Oslo - Moss - Kornsjø
- Ski - Mysen - Sarpsborg
- Oslo - Roa - Gjøvik
- Oslo - Lillestrøm - Kongsvinger - Riksgrensen (incl. Romeriksporten)
- Oslo - Asker - Spikkestad
- Asker - Kristiansand - Stavanger
- Lillestrøm - Dombås (incl. Gardermobanen)
- Hokksund - Hønefoss - Bergen
- Drammen - Skien - Nordagutu
- Myrdal – Flåm
- Roa - Hønefoss

This plan comprises all major rail tracks in Norway with the exception of Ofotbanen. These tracks are to be covered for 2W outdoor handheld and CAB radio.

JBV/HK and NSB is to give input on which train stations, administrative areas, workshops etc. that need indoor coverage. JBV/HK is also to give input on other areas that need particular attentions such as for instance shunting areas.

4 Link budget and propagation model

4.1 The dimensioning process

Before the detailed radio planning starts, network dimensioning must be carried out in order to get a rough estimate of the network. Dimensioning involves setting up link budgets, tuning propagation models and setting up standard site configurations. This work has already been carried out in this project, and the content of this chapter is for radio planner's information.

The link budget is found in Attachment 6.

4.2 Recommended link budget

In the recommended link budget we've set equipment related parameter values based on Siemens equipment. For parameters other than equipment related we've set values equal to those often used in GSM public networks.

The columns for 2W and 8W are applicable for coverage along the rail tracks. If coverage is to be obtained onboard trains a repeater must be mounted on the train.

It's then recommended to plan with:

- Minimum design signal level accepted is –95 dBm for cab radio, 8W.
- Minimum design signal level accepted is –77 dBm for handheld outdoor, 2W.

The toughest requirement shall apply; i.e. –77 dBm.

4.3 Explanation to link budget parameters

This is not a complete explanation to all link budget parameters but an explanation to selected parameters of particular interest for this GSM-R link budget.

4.3.1 Fading margins

There are two types of fading: Fast fading which is also called Rayleigh fading and slow fading which is also called log-normal fading.

4.3.1.1 Fast fading

MSs travelling at high speed will experience less Rayleigh fading than MSs travelling at low speed. At high speed signal samples are measured at longer distance from each other than at low speeds. At 90 km/h a new signal sample is measured every 12th meter. This implies that the samples are more independent of each other and it's not likely that the MS experiences low signal strength because of a Rayleigh fading dip. The highest speeds are attained in rural areas where there are no signal reflections from buildings and thus Rayleigh fading is also not very dominant in these areas.

4.3.1.2 Slow fading

The signal strength value calculated by the radio planning tool can be considered as a mean value of the signal strength in a small area with a size determined by the resolution and the accuracy of the propagation model. Assumed that the fast fading is removed, the local mean value of the signal strength fluctuates in a way not considered in the prediction algorithm. This deviation of the local mean in dB compared to the predicted mean has nearly a normal distribution. Therefore this variation is called log-normal fading.

The received signal strength is a random process, and it's only possible to estimate the probability that the received signal strength exceeds a certain threshold value. In the results from a prediction in the radio planning tool, 50% of the locations can be considered to have a signal strength that exceeds the predicted value. In order to plan for a probability higher than 50% that a signal strenght is above the threshold, a log-normal fading margin is added to the threshold during the design process.

A common way to calculate log-normal fading margin is to use Jakes curves.
The log-normal fading margin is dependent of type of fading environments (urban, suburban, rural, etc.) and area coverage.

4.3.2 Diversity gain

There are two different types of antenna diversity applicable to GSM-R; space diversity and polarisation diversity. In case of space diversity two RX antennas are positioned at a certain minimum distance from each other. Typically space diversity improves the uplink by 3-5 dB.

Polarization diversity offers possibilities to replace two space diversity antennas separated by several meters with one dual polarized antenna.

The advantage of polarization diversity is that a dual polarized antenna offers very low correlation between two received signals - especially in critical environments such as indoor and in-train. The drawback of polarization diversity is that due to different propagation characteristics, the propagation loss for the horizontally polarized component is higher than for the vertically polarized component. In order to compensate for the downlink slant loss, an extra 2 dB margin is added to the downlink propagation loss.

In our project we've set the uplink diversity gain to 1 dB due to the fact that we plan coverage mostly in rural areas where the diversity gain will not be very high.

4.3.3 Antenna height gain

The link budgets for handheld outdoor is calculated for MS to be 1,5 m above ground. This is considered default height, and no gain is added.

The CAB will be at a height approximately 4,5 m above ground. In the CAB link budget we have included an extra gain of 4 dB to account for this.

4.4 Propagation models

A propagation model is a model calculating the loss between the mobile terminal and the base station. It's necessary to use such a model in a planning tool because there is no mathematical solution to the loss calculation. Loss must be found empirically; i.e. measurements must be carried out in order to obtain loss data for different types of environment. There are mathematical wave trace models. However, these are not practical for use in large areas.

The propagation model to be used as default is named "model_1" and can be found in radio planning tool. This model is based on measurements done on NetCom sites in Hallingdal; thus the model is well tuned to clutters forest and agricultural land. Another model that should not be used is named "model_2". This model has a lower diffraction loss. A report describes the making of this model; see ref. 9.

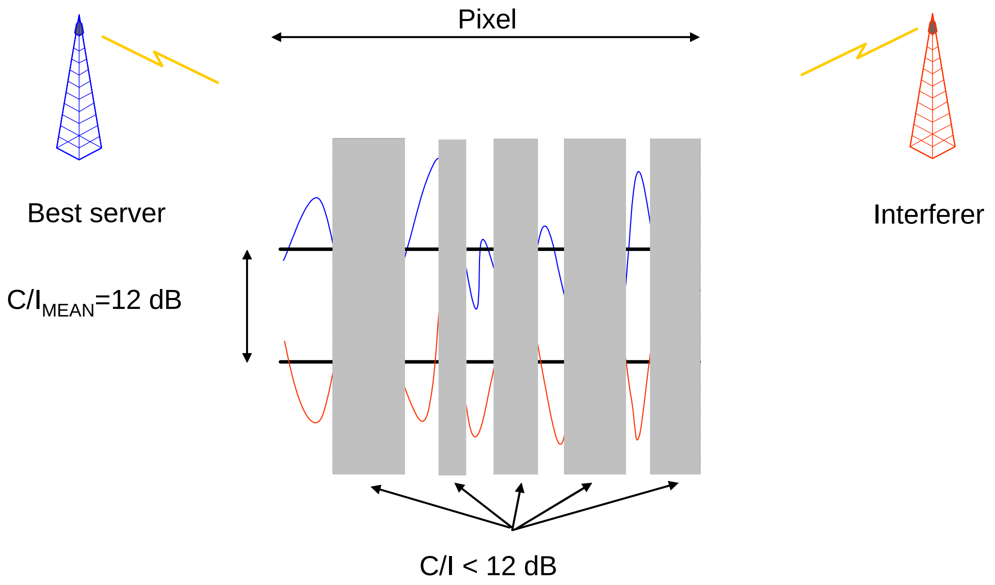
4.5 Interference

In general the following requirements apply for interference:

Cochannel interference: $C/I_C > 12$ dB

Adjacent channel interference: $C/I_A > -6$ dB

The figures are based on GSM recommendations, with an additional degradation margin of 3 dB added. When predicting interference in Asset we must take into consideration that Asset predicts the median signal level in a cell. Consider a worst-case scenario where the interferer and the best server slow fading are uncorrelated. The probability that the C/I in a certain pixel will be lower than the level predicted by Asset will then be the 50%. This is illustrated in the figure below.



Figur 1: C/I with 50% confidence

We want to have 95% cell edge probability in our predictions. To achieve this we must add a slow fading margin. The average standard deviation for the slow fading in the GSM-R network is 5.0 dB. If the best server fading (σ_B) and the interferer fading (σ_I) are uncorrelated, the total standard deviation σ_{TOT} for the C/I can be calculated as:

$$\sigma_{TOT} = \sqrt{(\sigma_B^2+\sigma_I^2)} = \sqrt{(5^2+5^2)} = 7.1 \text{ dB}$$

According to the lognormal distribution we must then add a fading margin of 11.7 dB. Thus, the required values for the Asset predictions will be:

Cochannel interference: $C/I_C > 12+11.7$ dB ≈ 25 dB

Adjacent channel interference: $C/I_A > -6$ dB + 11.7 dB ≈ 7 dB

When calculating and plotting interference in Asset, we use the *Co- and adjacent channel interference* function under *Options/Array settings.* The *Adjacent channel offset* shall be set to -18 dB. Thus the co –and adjacent channel interference can be presented in one plot.

The C/I value can be translated to RxQual as follows:

C/I_{TOT}	Asset colour	Speech quality	BER	RxQual
> 24 dB	Blue	Very good	<3 %	4
21-24 dB	Green	Good	3-5.5 %	4-5
18-21 dB	Yellow	Medium	5.5-9 %	5-6
15-18 dB	Orange	Bad	9-15 %	6-7
12-15 dB	Red	Very bad	15-22 %	7

According to the specifications for the GSM-R project, the minimum RxQual shall be 4. Thus the required C/I as predicted by Asset is 24 dB.

5 Network configuration

See ref. 14 for Siemens BSS network design.

5.1 Number of CUs and allocation of signalling capacity

On all cells along track there shall be a minimum of 2 CUs. For cells covering other areas the need may be higher. This must be considered on a site by site basis until further traffic requirements are received from JBV/HK and NSB.

In cooperation with system vendor Siemens it has been decided that default configuration in the case of 1 cell/2CUs is that TS0 on CU1 is a MAINBCCH; i.e. normal broadcast control channel while TS1 on CU1 is a SDCCH/8 in order to reserve sufficient amount of signalling.

5.2 Cells and sectors

A cell is defined to be an area covered by a CU. A sector is defined to be an antenna direction. A cell can be distributed onto several sectors. If we have one cell per sector we have dedicated CUs per antenna direction.

For all stations along the rail track in rural areas and for other stations where the capacity demand is low, i.e. maximum 2 CU, there shall be one cell only. We should always try to configure with only one cell per station where this is possible from a frequency and capacity planning point of view. Also, at high speeds handover between cells on same site (intra-BTS handover) should be avoided, and this is another reason for not splitting cells in rural high-speed areas. The handover between BTSs is easier to perform since the signal strength of the serving and neighbouring cells are more or less equal during a longer period of time.

For stations where the capacity demand requires 3 CU a total evaluation must be done on whether to perform a cell-split; i.e. to configure with more than one cell.

For stations with 4 CU or more, cell-split shall be done. Special care must be taken to plan for intra-BTS handover, especially if this is in a high-speed area.

5.3 Antennas

5.3.1 Antenna type

The radio planner should choose an antenna to make sure that requirements on coverage and quality are fulfilled.

High gain directional antennas should be used extensively in order to achieve coverage along the rail tracks. Also in urban areas these antennas should be used but here the purpose is rather to achieve cell border control.

All antennas used shall be x-polar; i.e. there is only one antenna per sector. Omni and indoor antennas are excepted from this.

In valleys and in areas where a “wider” coverage is needed, antennas with a higher vertical diagram and thus lower gain can be used. This must be considered on a sector-by-sector basis.

The antenna has a major impact on the cell characteristics such as coverage, interference contribution etc. It’s important that the radio planner has a wide range of antennas to choose from so that coverage can be tailored. However, from a logistics point of view the number of antenna types should be kept to a minimum. As a compromise the radio planner can choose antennas from the table in Attachment 10.

The default 65° antenna to be used is RFS APX906515-7T0. This is due to cost reasons as is RFS APX906516-7T0 is twice as expensive as APX906515-7T0. These are RFS/Celwave antennas.

Wa may substitute the RFS antennas with Kathrein antennas. The substitute for RFS APX906515-7T0 is Kathrein 739623. The substitute for APX906516-7T0 is Kathrein 739630. The latter is twice as expensive.

Kathrein also has a 35° antenna, 741785, that shall only be used in cases where it’s absolutely needed as it’s very expensive.

All antennas can be found in antenna database in planning tool.

5.3.2 Antenna direction

There should normally be a minimum of 2 sectors on all base stations along the rail track – one sector in each direction along the track. The radio planner should always consider a third sector in order to get "extra" coverage from the base station. A third sector can be added at very low cost. Be aware though that the loss in the cell splitter then increases by 2 dB.

The direction (or azimuth) is to be given in degrees in a 360° system counting clockwise. Example: An antenna direction of 90° means that the antenna is pointing directly eastwards.

5.3.3 Sector numbering and number of antennas per sector

Sector numbering is to start at 0º and go clockwise.

Example 1:

- 130º, sector 1
- 210º, sector 2
- 330º, sector 3

Example 2:

- 0º, sector 1
- 110º, sector 2
- 200º, sector 3

As a general rule we use only one antenna per sector. This allows for easy mounting and low environmental impact. We achieve polarization diversity by using cross-polar antennas.

Be aware that if new sectors are added at a later stage, the sector numbering shall be renamed.

Example 3:
A site has two sectors; sector 1 at 210° and sector 2 at 350°. Later a new sector is added at 90°. The new sector is then sector 1. The former sector 1, 210°, must be renamed to sector 2 and the former sector 2, 350°, must be renamed to sector 3.

5.3.4 Antenna height

In existing masts in rural areas we should try to mount the antennas as high as possible. If a new mast is required the radio planner shall make predictions in order to estimate necessary height to achieve the required level of coverage. Radio planner shall also when on survey estimate height of vegetation and other local obstructions and based upon that set antenna height such that height is higher than obstructions. See Attachment 7.

Antenna height is to be stated by the height <u>at the bottom</u> of the antenna.

Standard masts delivered are 12m, 18m, 24m, 30m, 36m, 42m and 48m; i.e. standard masts are made up by 6m sections. The 6m sections can be split into 3m sections if necessary. However, a 18+3m mast has the same cost as a 24m mast, and thus 3m sections shall only be used if height is critical due to acceptance by ground owner, community authorities etc.

Guyed masts are delivered in heights 50m, 60m and 70m.

Example: If the radio planner estimates a need for an antenna height of approximately 22m and the antenna to be used is an antenna of 2,6 m length, the antenna height should be set to 21,4 m - thus ensuring that the top of the antenna is at the exact top of the 24 m mast.

The radio planner shall of course take notice of the antenna height requested by the radio link planner in order to make sure that the antenna heights set are coordinated.

5.3.5 Antenna tilt

When tilting is necessary, electrically tilted antennas should be used in suburban and urban areas because it allows for a much better control of the antenna lobe. In rural areas mechanical tilt should be applied.

Maximum allowed tilting is half of the vertical 3dB diagram for the antenna. The reason for this is to try to keep control of the antenna lobe at mast fluctuations.

Mechanical tilting is only a change in the vertical angle for the installed antenna. Tilting is done by physically changing the antenna direction downwards. Electrical tilt however is an in-built tilt in the design of the antenna. Electrical tilt is usually better than the mechanical tilt since it will down tilt the pattern in all directions, while the mechanical tilt will mainly change the direction in the main lobe direction and the side lobes will not be much effected. However, for a railway design, the side lobe interference is not of much concern, resulting in sufficient tilting effects with a mechanically tilted antenna. Combining the two are also possible.

When applying tilt in the GSM-R project the following guidelines should be followed:

- Keep the tilting to a minimum. It is better to save the tilting option for later in order to fix specific local problems. If tilting is already applied in an area it is difficult for the radio planner to use the tilting option as a tool to fix specific problems as interference etc.
- Be aware that tilting may have to be applied in order to obtain a “clean” handover area

Tilt is to be given in degrees in a 360° system. Antenna down tilt is to be denoted by a positive sign and up tilt with a negative sign.

5.3.6 Antenna separation

The distance between our own GSM-R antennas and other antennas shall as a general rule be minimum 1 m horizontally and minimum 0,5 m vertically. This applies to antennas in other frequency areas; i.e. antennas for other systems than GSM. This generally applies if antenna directions aren’t pointing towards each other. In the case that antenna directions are pointing towards each other, special considerations must be done.

Our own GSM-antennas can be mounted back-to-back.

5.3.7 Mounting of antennas

5.3.7.1 Mounting tolerances

Antennas shall be mounted at the height, azimuth and tilt as given in the TSSR, within these limits:
azimuth: +/- 5,0 degrees

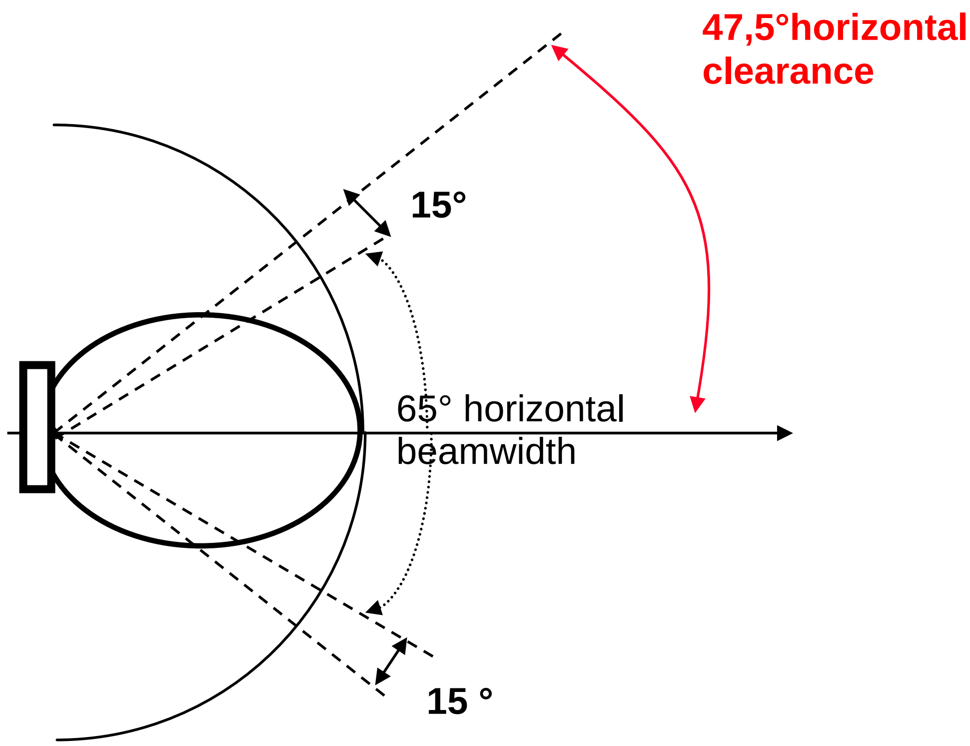
tilt: +/- 0,5 degrees
heigth: +/- 0,5 meters

5.3.7.2 Horizontal clearing

When deciding on antenna placement there are certain rules to follow to avoid the distortion of the antenna beam due to obstacles in the near-field of the antenna.

The following apply:
For horizontal clearance you add a margin of 15° to the beam width.

Example: If you have an antenna with 65° horizontal beam width, this means that in an area of [(65°/2) + 15°=47,5°] out on the side of the antenna there should be no obstacles.



Antenna direction

Figure 1 Horizontal clearance

Antennas can be mounted back-to-back if the difference between the azimuths are high. If the difference between the azimuths for instance is smaller than 90° in the case of antennas with 65° beam width, it's uncertain which effect occurs with joint antenna diagrams in the area between them.

5.3.7.3 RX blocking

The lower frequencies within the GSM-R downlink band can be received by GSM900 BTS which is co-located. The distance between the lower GSM-R transmit band and the upper GSM900 receive band is only 6 MHz.

GSM 05.05 recommendations specifies blocking characteristics for in-band and out-of-band for GSM900 as follows:

In-band (870 – 925 MHz)	Blocking req./dBm
600 kHz < If-foI < 800 kHz	-26
800 kHz < If-foI < 1.6 MHz	-16
1.6 MHz < If-foI < 3 MHz	-16
3 MHz < If-foI	-13
Out-of-band (> 925 MHz)	+8

Table 2 Blocking characteristics

Values in table correspond to the antenna reference point (ARP).

Due to the fact that the GSM-R TX-band is 6 MHz apart from the GSM900 RX-band, which is still an in-band scenario, the blocking requirement of –13 dBm is adequate.

In case of blocking level of –13 dBm at the BTS cabinet reference point, the isolation estimation is independent of individual filter behaviour of different BTSs. An assumed output power at the GSM-R side of 40 dBm means that a total attenuation of 53 dB is required. With reasonable margin this means about 60 dB isolation between GSM-R and GSM900 systems. The actual blocking resistance is dependent of the duplex filters, band pass filters, amplifiers etc. used in the particular GSM900 BTS.

Vertical separation will give the highest isolation. The coupling loss in the air can reach 50 dB or more in case of 2-3m vertical separation (antenna near field). The coupling losses are dependent of antenna types and mounting environment.

If base station antennas are facing each other the total antenna gain must be taken into account when calculating isolation. To achieve about 60 dB isolation the antennas with 15 dBi gain must be more than 800 m from each other.

5.3.7.4 TX noise

The requirement of noise suppression is stated in the specification for GSM-R. Noise should be below –98 dBm in the critical GSM900 RX band. The short guard band between lower GSM-R and upper GSM900 puts high requirements on the TX filters in the GSM-R BTS. This means that the normal GSM900 filters cannot be used in the GSM-R BTS.

5.3.7.5 TX intermodulation

With separate antenna systems for GSM-R and GSM900 the intermodulation (IM) products are attenuated to a harmless level. The GSM-R frequencies themselves are too close in frequency (4 MHz) to cause IM3 interference. IM5 should be suppressed enough to be harmless after 40 to 60 dB attenuation.

5.3.7.6 RX intermodulation

This is the kind of interference that normally puts the highest requirements on co-located systems. The IM products may be high but the actual interference is only present when strong transmitters, for example very strong MSs, are using frequencies that in combination with the used GSM-R TX frequencies produce IM products that exactly hit the used GSM900 RX frequencies.

The minimum RX IM rejection level in the GSM specification is set to –43 dBm. This means that the IM products of two signals of –43 dBm should not degrade the sensitivity. Higher levels may however cause interference. The 6 MHz guard band to GSM-R means that the TX signal is attenuated before it reaches the RX. It is important to estimate RX band pass attenuation of combiner/divider unit (CDU) of BTS in order to estimate total isolation. On the other hand blocking is always present while RX IM is a matter of unfortunate MS position, output power and frequency.

5.4 Feeder cable type

We accept a maximum total loss in feeders and connectors of 4 dB. We assume 2 dB loss in connectors and thus 2 dB is the total loss allowed in the feeder cable.

The type of feeder cable is decided on TSS by the participants there. Radio planner cannot decide the feeder type in cell plan because the exact length of feeder cable is measured for the first time at TSS.

The following guidelines apply at TSS:

- For feeder length below 30 m we use ½” cable but of course a thicker cable, for instance 7/8”, can be used if that’s more convenient from a logistics point of view
- For feeder length below 50m we use 7/8” cable
- For feeder length between 50m and 75m we use 1 ¼”

- For feeder length between 75m and 100m we use 1 $^{5}/_{8}$"

These guidelines are based upon loss calculated for the actual feeders to be used.

Upon reception of TSSR the radio planner enters the correct cable length in the planning tool.

5.5 Combiners and splitters

In the transmit direction the CUs must be combined when configuring with one cell only. Further the signal must be split into the planned number of sectors.

Default combiner is included in base station cabinet, DUAMCO 2:2 and doesn't have to be specified in cell plan by radio planner.

Default splitter is also delivered. Splitter is installed in top of mast – close to antennas- if nothing else is specified. The default configuration is then 2 feeders up in the mast and splitters in the top. In the case of 2 sectors there are 2 2:1 splitters. In the case of 3 sectors there are 2 3:1 splitters.

5.6 BTS type

Two types of BTSs are used in this project; BS40 and BS240. BS40 has a maximum capacity of 4 CUs in a 2/2 configuration. BS240 has a maximum capacity of 6 CUs in a 2/2/2 configuration. See ref. 12 for full descriptions of Siemens BSS.

Default BTS type is BS240. For SoL ABCDEFO, the default BTS type was BS40.

5.7 Output power

Output power is as default set to 45 dBm for all configurations. This is the maximum output possible with Siemens BTSs at the top of the cabinet after combining with a 2:2 DUAMCO combiner. Output power may be decreased in the optimisation process if necessary.

5.8 Diversity

Polarization diversity will be used by configuring with cross-polar antennas.

5.9 BSC allocation

It's up to the transmission network planner in cooperation with system vendor Siemens to decide on controller areas. The radio planner should however make sure that parameters are set so that each base station is assigned to the correct BSC. Also, the radio planner should make sure that the handover zone is sufficiently long for handover between stations connected to different BSCs as the inter-BSC handover involves extra signalling and will take longer than an intra-BSC handover.

5.10 Location area

Location area borders shall not be planned for in high traffic density areas because location update calls for extra signalling capacity. Location area borders shall also be avoided on or nearby train controller area borders.

LAC border should be set equal to the BSC-area. In many cases we run out of NCC-numbers, and in that case there can be several location areas within a single BSC.

5.11 Group Areas

All cells must be mapped to VGCS group areas. Among other things, these are used for defining who recieves an emergency call.

The Central Systems Department is in charge of this mapping, but will coordinate closely with the radio planner to define mapping based on cell coverage, signalling area and train controller area. Public Emergency Call (110,112,113) routing will also be such a joint task.

5.12 Neighbour lists and handover algorithms

5.12.1 Handover algorithm

We are to implement a standard handover algorithm to be set for all cells because tailoring of handovers is too elaborate. The handover algorithm to apply as is a standard power budget algorithm.

See ref. 14.

Tailoring must be carried out if drive test results show handover failures, for instance in areas where signal drops rapidly This could for instance be applicable at tunnel portal areas or in cuttings

5.12.2 Handover zone

We assume than time allowed for handover is 5s. We add 5s to this in order to allow for several handover attempts. A train travelling at 210 km/t (airport express) will cover 583 m in 10s. A train travelling at 160 km/t (regular trains) will cover 444 m in 10s. The overlapping zone; i.e. area in which two cells both exceed –77 dBm shall be minimum 600 m for the airport express track and minimum 450 m for all other tracks.

In most areas this will be achieved automatically, and no particular attention will have to be paid during planning. The radio planner should however be aware of handover areas such as for instance in curves where signal level drops rapidly.

5.12.3 Where to avoid handovers

The radio planner should try to avoid handovers in the following areas:

- In train stations
- At tunnel portals
- Between cells on same site on high-speed tracks if site is close to track; i.e. along high-speed tracks there should be only one-cell configurations to avoid this

5.12.4 Handover list

A neighbour list for a cell along the track should as a default minimum include two neighbours in each direction; i.e. 4 neighbours. Extra neighbours should be added if necessary. Be aware that all neighbours to which a handover is theoretically possible should be in the handover list.

Take special care to include in neighbour list all cells that may become relevant if the closest neighbour cell is out of operation.

All neighbours shall be mutual.

5.13 Frequency planning

We have been assigned frequencies in a 4 MHz band. This corresponds to 19 frequencies of 200 KHz and a guard channel.

The frequency reuse of the BCCH channels in a GSM network is normally between 12 and 15. For a GSM-R network a much smaller reuse is possible. An over all reuse between 6 or 8 should not imply any problems. Even as low as 4 could be possible along the railway track. Our strategy is to apply a reuse of 8 as. See table below. This allows for 2 CUx per cell and leaves three frequencies in spare.

Frequencies shall be allocated from the following frequency groups:

	A1	A2	A3	A4	A5	A6	A7	A8
BCCH	956	965	958	967	960	969	962	972
TCH1	964	957	966	959	968	961	970	963

Table 3 Frequency groups

Spare frequencies: 955, 971, 973. Note that spare frequencies are the first frequency in the spectrum (955) + the last frequency (973) + one interleaved (971). This is done in order to make it possible to allocate the spare frequencies on the same site.

When allocating frequencies to sites along the track we should do it in the following order:
A1, A3, A5, A7, A2, A4, A6, A8, A3, A1, A5 etc.

This order can also be followed when we have the odd 2-cell or 3-cell site along the track:
1-cell site: A1
2-cell site: A3, A5
1-cell site: A7
3-cell site: A2, A4, A6
1-cell site: A8
1-cell site: A3 (Note reversal of A1 and A3 to avoid neighbour channel interference)
1-cell site: A1
1-cell site: A5

etc.

The spare frequencies should be used in cells where it's necessary to add frequencies outside the frequency groups in order to avoid interference. This could for instance be applicable on "umbrella" cells.

For urban areas where we have several multiple-cell sites in the same area special care must be taken.

For the first couple of years there will most likely be no cells with more than 2 CUs - whether it's a one-cell site or a multiple-cell site. When capacity increases we may see cells with more than 2 CUs, and then a new frequency plan must be made and implemented.

At the Swedish border there are restrictions on which frequencies can be used. See Ref. 15: "Agreement between National Post and Telecom Agencies in Norway and Sweden concerning the use of the frequency bands 876-880 MHz and 921-925 MHz for GSM-R in the border areas".

For the channels dedicated to the Norwegian network, the requirement is that the measured signal on the Swedish side shall not exceed 19 dBuV/m 15 km from the border. (Measured with antenna 3 meter above ground, 50% location probability). This corresponds to a predicted level in Asset of -121.3 dBm.

5.14 BSIC

Radio planner is to set BSIC per cell, and the BSIC consists of:
- NCC (network colour code)
- BCC (base station colour code)

The NCC has been assigned by PT and is a one digit number given to each of the operators within a country. For us the number is 3. The BCC is decided by the radio planner and is a one digit number (0-7).

The combination of BCCH and BSIC shall be unique within a single location area.

5.15 Interference control and capacity enhancing features

In low speed areas a GSM-R network is equal to a standard GSM network, and all interference control features applied in standard GSM networks can be applied.

In high speed areas the situation is different. Features like DTX, BTS power control, hierarchical cell structures, frequency hopping and cell load sharing are not recommended to be used in the high speed areas of the GSM-R network.

We see no need for specific interference control features to be used. Interference should be controlled by classical frequency planning.

6 Base station location

6.1 Radio planning matters influencing the location

Good site locations are essential in order to obtain required coverage, but also to satisfy other requirements the radio planner should obey to.

Radio planning location issues in unprioritized order:
- There must be good line-of-sight in the main directions and no near obstructions. Distant obstructions can be used to control the cell border.
    - By near obstructions we mean structures closer than 50-100 m
    - A near obstruction can for instance be a block of flats or a mountain
    - Near obstruction can also be for instance forest which is higher than the antennas

- In areas where reflections easily occur this must be taken into consideration and calculations must be done in order to avoid signal dispersion
- Antennas should be higher than average rooftop/forest level
- In urban areas the antennas must be placed so that coverage is obtained but at the same time interference into other cells is avoided. Antennas must not be placed so high that it leads to unclear cell borders; this will lead to interference, uncontrolled handovers and interleaved coverage. Such "umbrella" sites should also be avoided in rural areas because also there they are difficult to control and may lead to a poor network.
- In urban areas the sites should not be placed in hills if this can be avoided. If it cannot be avoided the antenna directions should be uphill.
- In areas where indoor coverage is required the antennas should be as close as possible to the building which is to be covered. This means that for instance train station buildings will be a good location for obtaining indoor coverage at the station. If we have more than one base station to use they should be placed at different sides of the building in order to ensure signal penetration from different angles.
- In his outdoor design the radio planner should make sure that the signal level requirement is satisfied also at the tunnel portals
- The radio planner must be particularly aware that coverage is obtained in terrain cuttings/culverts, alternatively he must make sure that the signal level is high enough that repeaters can be used. This is often difficult to discover in planning tool as the digital maps aren't accurate enough. Survey is essential here.
- The radio planner should not plan handovers in areas where we know that the signal may drop fast like for instance at tunnel portals. The radio planner should locate base stations in order to ensure that handover areas have a controllable signal level.

However, the radio planner should be very careful to balance these radio planning requirements to requirements from civil works and other considerations.

If radio planner is in doubt about which location is the best, measurements can be carried out. A test transmitter is then placed at the site location candidate and measurements can then be done in the area of interest. These measurements are very time- and cost consuming and should thus be avoided and only be used in cases where for instance a base station can possibly be saved.

Also note that placing antennas is usually a trade-off between coverage requirements, esthetical considerations, mounting feasibility and radiation concerns.

6.2 Matters influencing the location other than radio planning matters

The radio planner's main task is to locate base stations such that the radio planning requirements are fulfilled. SA agents, CW personnel etc. that the radio planner is cooperating with often have other requirements to take notice of and those requirements will often be in conflict with the radio planner's requirements. It's the SA agent's responsibility to attend to these location matters other than radio planning matters. Further it should be stressed that also the radio planner has a responsibility to make sure that time- and cost estimates are fulfilled.

6.3 Candidate search; which locations matters to prioritise

See ref. 11 for full description on how to prioritise site candidates.

6.4 Repeaters

Repeaters for tunnel coverage will be handled by system vendor Siemens. Repeaters for surface coverage will be handled by us. However, the radio planner should not deliberately plan with repeaters. Coverage shall be obtained by BTSs. If during testing/initial optimisation it turns out that there are areas with coverage gaps, repeaters may be used.

7 Site survey

7.1 Introduction

During the radio planning of a GSM network, the site survey is a crucial activity. Therefore, great care is taken to make sure that conducting site surveys will meet the desired goal of the network as it was intended and designed in the plan. Radio planner surveys sites together with radio link planner and SA agent.

It's of high importance that radio planner fills out the radio planning survey report, Attachment 7, on site.

7.2 Site survey equipment

Actual site surveys may not require a lot of supporting tools. However, here's a list of tools that may be of use:

- Digital Camera (bring extra batteries)
- GPS
- Paper maps
- Compass
- Binoculars
- Safety equipment - Mast climbing equipment.
- Planning tool coverage plots

7.3 Positioning

7.3.1 Map datum

Geographical map-datum is a mathematical description of the geographical position compared to the distance to the centre of the earth. Different datum are used for different positions around the globe in order to assign as accurate coordinates as possible. Since the earth is not completely circular different methods are used. In extreme cases, by applying two different datum, the positions can differ up to as much as 600 meters. It is therefore important that the planners verify that the datum UTM(WGS84=EU89=EUREF89) is applied to the GPS when recording the coordinates during the survey.

7.3.2 GPS

In order to derive accurate coordinates of a location (usually termed as *position fix* or *waypoint*), the GPS must be placed in unobstructed location to sight as many satellites as possible. At least four satellites must be obtained to get accurate readings assuming correct map datum is properly defined in the GPS.

8 Radio planning in tunnels

Planning shall be done by system vendor Siemens that has an end-to-end responsibility. The radio planner is however responsible for supplying an adequate donor signal level at tunnel portal in cases where repeaters are to be used.

For tunnels shorter than 1000 m there shall be donor signal level available for at least one of the tunnel portals. This donor signal shall be at a level equal to or better than –77 dBm; i.e. corresponding to the signal level requirement that applies in all other areas.

For tunnels longer than 1000 m there shall be donor signal level available at both of the tunnel portals and from separate base stations. The signal level requirement is the same.

Radio planner should be aware that due to low resolution of maps in radio planning tool, extra caution should be taken when analysing coverage predictions at tunnel portals. It’s preferable that radio planner surveys tunnel portals in order to be sure that coverage predictions are reliable.

9 The rollout process and radio planner’s cooperation with radio link planner and SA

9.1 The interworking process

This chapter describes on a high level the process of interworking between radio planning, radio link planning and SA with focus on radio planner’s role. The radio planner shall relate to this process and follow the different stages. This chapter also contains references to document templates to be used by radio planner.

Please also see ref. 1 and 13.

Before any planning starts it’s important that all existing sites that we have documentation for (NetCom, Telenor Nett, Telenor Mobil, Norkring, JBV) are included in tool database.

1. Radio planner does preliminary planning; map studies, predictions, evaluations of existing sites in tool etc
2. Radio planner issues the Preliminary Nominal Cell Plan (PNCP) which is a project internal document to be used as a basis for survey and equipment budgetary planning. The PNCP includes only theoretical sites. No survey need take place before release of PCNP. The PNCP site list template to be used is found in Attachment 3.
3. Radio planner, radio link planner and SA perform joint site survey where they verify candidates. In cases where radio planner for some reason cannot participate, radio planner asks radio link planner to fill out survey report, but as a general rule this survey is a joint survey. On survey SA is responsible for registering coordinates and evaluating the candidate from a civil works perspective as well as taking notes of access and site owner’s data. Radio planner is responsible for giving site IDs and site names. Radio planner shall also make sure that pictures are taken. All survey reports shall be completed on site. Survey report template can be found in Attachment 7. Number of candidates shall as a minimum be two (2) for greenfield sites on private property. For all other sites it’s sufficient to pick out one (1) candidate. All existing sites found proper shall be surveyed.
4. Radio link planner performs more extensive LOS-check survey on her/his own.

5. After survey the radio planner does predictions and further evaluations. The SA agent is responsible for updating site database as well as making all pictures taken on survey available on the network for all candidates surveyed.
6. Radio planner issues the document Nominal Cell Plan (NCP). This document lists all the first priority candidates and is the formal input to SA ordering acquisition to start. NCP is issued only after thorough discussions with SA and radio link planner in order to come up with a joint list of the first priority candidates. NCP also acts as an equipment forecast document to procurement group. NCP consists of non-theoretical candidates; i.e. all candidates shall be surveyed and verified before the NCP is issued. Also all LOS-checks must be done. A template for NCP document as well as NCP site list is found in Attachment 4 and 5.
7. While acquisition is ongoing the communication between SA agent, radio link planner and radio planner shall be very close. In cases where there are two candidates the SA shall take place in parallel for those candidates but naturally with emphasis on the first priority candidate. Radio planner issues an "Action request" at once. Also radio planner must update the NCP when necessary in order for NCP to contain first priority candidates. ONLY RADIO PLANNER HAS THE AUTHORITY TO CHANGE PRIORITY OF SITES. SA and radio link planner give their input to radio planner who then verifies suggested change of priority. Radio planner verifies the responses to "innplasseringssøknad" in the case when site is owned by Telenor, NetCom etc.
8. Work order per site for civil works can be issued when SA is ready; i.e. when contract with site owner is signed and SAR is complete.
9. When SA is finished the site is ready for Technical Site Survey (TSS).
10. Radio planner normally participates on the TSS.
11. Radio planner verifies the Technical Site Survey Report (TSSR).
12. The building permit application is issued after TSS. In the odd case where building permit application is rejected there will be a new candidate, and radio planner shall then issue an Action Request + a revised NCP.
13. If planner sees the need for a change to a site, an "Action request" is issued. This is regardless of TSSR is approved or not.
14. Radio Planner issues Final Cell Plan (FCP) SoL before commisioning of the sites.
15. When site is ready for drive test the vendor performs the drive test and delivers drive test log files to radio planner.
16. Radio planner analyses drive test log files and issues change order if necessary. (Change of frequency, add neighbour in list, change antenna direction etc.)
17. Vendor implements change order and verifies by doing a new drive test.

As a general rule a radio planner shouldn't have to visit a candidate more than twice – first time is the joint survey with SA, second time is the TSS. However, due to re-planning, an extra visit may be required in some areas.

See ref. 13 for flowchart of this process.

9.2 Cell plan release routine

9.2.1 PNCP, NCP and FCP

Before survey the radio planner releases the PNCP site list; i.e. the list of theoretical candidates. There is no approval of the PNCP site list.

After survey and further predictions + thorough interworking with radio link planner and SA the radio planner releases the NCP for all the verified first priority candidates.

FCP shall be released for a SoL befor commisioning of the sites.

Cell plans shall be stored at 5.\Site data\SoL\Radioplaner for hele strekningen\…
NCPs and FCPs shall also be stored in ProArc.

See ref. 1 about flag setting corresponding to the different cell plans.

9.2.2 Action Request

Each time a change is performed to a site before it is built, radio planner or radio link planner shall issue an "Action request" quickly.
After a while, a revised NCP should also be issued, to avoid inconsistencies in the site list, link list and maps.

9.2.3 Quality check of cell plan content

The quality check process for cell plans is as follows:

- Radio planner and radio link planner finishes the cell plan (PNCP, NCP or FCP)
- Radio planner is responsible for sending the cell plan document to radio planner and radio link planner for quality check. The radio planner and radio link planner doing the quality check are others than the ones responsible for the planning of the SoL in question.
- Radio and radio link planner do the quality check:
    - Radio planner checks all radio data for coherency and logic. Radio planner is also responsible for checking the NCP main document for coherency and logic. In particular the radio planner shall check the counting in the table in the summary chapter.
    - Radio link planner checks all radio link data for coherency and logic
    - Radio and radio link planner shall check the planning as such only on a very high level; radio planner may for instance check for coverage gaps and radio link planner may for instance check for LOS
- Radio planner is responsible for sending the document to network planning manager for approval
- Network planning manager:
    - invites to presentation meeting if it's a first revision of NCP
    - approves and sends the paper version of cell plan to document centre for registration in ProArc and tells radio planner to send the file per e-mail
- Document centre distributes the cell plan to relevant parts according to name lists

See Attachment 14 for detailed description of quality check.

9.2.4 Cell plan templates

Cell plan templates are attachments to this document. Please see end of document for list of attachments.

Certain plots are to be attached to the NCP. These are listed in the NCP template.

9.3 Site tracking

Site Tracking is performed by other departments.

10 Site coding convention

10.1 Site ID

Site name for sites and repeaters shall consist of a site ID and a local name

Site ID:

ABBBBYXX

A - SoL-ID; defined ID for Section of the Line

BBBB - BaneID; geographical area of SoL where site is located, see Attachment 1

Y - Type of site:
- B = Base station
- R = Repeater
- L = Pure radio link station

(in phase 1 all these letters were used; from phase 2 on only “B” will be used for all sites)

XX - Running number; running number is within BaneID, not site type, this means that a base station and repeater cannot have the same running number within one BaneID

Z - Candidate letter; Running character from A to S, for each candidate site in a nominal search area. The character T is reserved for the theoretical (nominal) candidate identified during initial planning. Candidate letter indicates the order in which candidates were surveyed, and *not* priority.

Local name:

The local name will have two parts. The first part describes the area in which the site is located, and should be unique withing the network. The second part describes the specific candidate. If existing site is used as candidate the same name as used by the owner should be given.

Example:

M1680B09A Nesbyen/Veltebakken_GF (SiteID is M1680B03, while site name is Nesbyen/Veltebakken where Nesbyen is the area and Veltebakken is the candidate.
This is base station (B) nr 9 on BaneID 1680 on Section of the Line
M: Hokksund – Hønefoss – Bergen.) It is a greenfield site

M1680B09B Nesbyen/Åsabakken TM This is candidate B within the same area, and it’s a Telenor Mobil candidate.
The candidate name shall have the following extensions when relevant:

NC – NetCom
TM – Telenor Mobil
TN – Telenor Nett
NK – Norkring
GF – Greenfield
RT – Rooftop
The running number starts from the end of the subsection of the line closest to Oslo
- Running numbers is to be every other initially, ie. 1, 3, 5... , making it easier to fill in sites later
- The running number is within the defined 4-digit subsection

10.2 Cell ID (CI)

Cell ID (CI) is a unique ID for a cell in the GSM network. According to the GSM specifications the CI shall consist of maximum 5 digits. A requirement in the project is that it should be possible to deduce the site ID of a site to which a cell belongs when knowing the CI of the cell.

We have the following system for assignment of CI:
Digit 1: This is a number corresponding to SoL.
Digit 2: This is a number corresponding to subsection.
Digits 3 and 4: This is a running number; the same as in the site ID.
Digit 5: This is the number of the cell on the site.

With reference to the mapping table in attachement 12, here's an example:

Example 1: A1321B09Da = 15091. 1 corresponds to SoL A, 5 corresponds to subsection 1321, B09D corresponds to 09 (the candidate letter can be omitted here) and 'a' corresponds to 1.

See Attachment 12 for overview of CIs.

11 Working in the radio planning tool Enterprise Asset

There is a separate document describing the use of planning tool Asset. See ref. 1.

12 Initial optimisation

Siemens performs drive tests, and the project performs analysis of drive test files delivered. Based on drive test #1, actions request (AR) and change requests (CR) are released as formal documents. After all action requests have been carried out, a validating drive test #2 is performed. After analysing this drive test, an optimization report shall be released as a formal document. See ref. 1.

Drive test files for both directions shall be analysed.

Planner shall identify all areas where signal level is below required level, as given by the Link Budget [attachment 6]. If the area is longer than 100 m, action shall be planned for. This action may for instance be adjustment of antenna (height, tilt, direction, type). If problem can be solved only by very expensive means such as for instance new site, the problem shall be discussed with network planning manager. In some cases it might then be better to apply for exemption from requirements.

Planner shall identify all areas where RxQual ix higher than requirements. If the area is longer than 100 m, action shall be planned for. This may for instance be change of frequency.

Planner shall identify all handovers and plan for actions in cases where there are extensive ping-pong handovers or any other types of unwanted handovers. Actions may for instance be adjustment of antenna.

12.1 Optimization at different rollout stages

There will be different documents to release depending on the rollout stage of the regarded sites.

a) Before tuning and drivetest #1: Changes to database parameters shall be communicated by issuing a new revision of the FCP SoL document. Changes to physical configuration shall be communicated by issuing an “Action Request”[attachment 20] document.

b) After drive test #1 has been performed, tuning requests are formally released as Change Request and/or Action Request documents.
   a. Action Request (AR) are released as one document per site. It must be specified that the AR is part of the “tuning” activity.
   b. Change Requests (CR) are released as o per-SoL document. You might issue one or more CR documents based on the nature of the changes. (hint: gather all neighbour changes in one CR, all handover changes in another).
   c. Siemens Tunnel Planners might also issue AR or CR. The same templates shall be used, but the documents shall be sent to JBV for approval.

c) After SAT SoL is approved, the Operations Centre is responsible for the sites. Tuning activities can be initiated either by them or by the GSM-R project – in either case the activity must be coordinated. The radio planner issues AR and/or CR formally to Siemens and orders a validating drive test.

ARs and CRs shall be put in the folder ‘Optimalisering’ under ‘5. site Data (fellesmappe)/<SoL>

All ARs and CRs shall be tracked in the excel sheet at ‘2.2.7/Optimization/Oversikt over alle AR og CR.xls’

Latest: In 2005 CR and AR where merged in a common AR to cover all types of work requests to Siemens.

See Attachment 11 for optimisation report template.
See Attachment 21 for Action Request template.

13 REFERENCES

1) 3A-GSM-039 Using Aircom Enterprise in the GSM-R project,

2) NORNE, kravspesifikasjon nett, Jernbaneverket, June 12 2001

3) Konseptrapport GSM-R, Jernbaneverket, November 2001

4) "Prediksjon av dekning og frekvensbehov for GSM-R i Oslo-området". Report made by consultancy house Teleplan, May 8 2001.

5) GSM 05.05 (Phase 2+), "Radio Transmission and Reception", ETSI, version 6.2.0, 1998

6) GSM 03.30 (Phase 2+), "Radio Network Planning Aspects", ETSI, version 6.0.1, 1998

7) W. C. Jakes, Jr., "Microwave Mobile Communications", John Wiley & sons, New York, 1974

8) n/a

9) "Modelloptimalisering Jernbaneverket". Report made by consultancy house Teleplan, April 23 2003.

10) Konsekvensvurdering av alternativ anropsruting i GSM-R. Report made by BanePartner December 2003.

11) Prioritering av siter i rollout fase 2 GSM-R; 3A-GSM-041

12) TED-BSS and TED-BS24x, Siemens technical descriptions

13) Flytskjema for nettplanlegging (\\Oslfil002\gsm-r\7. QA\7.8 Prosesskart TOA\GSM-R_05_TB_Organisasjon_rev. 06c.pdf)

14) GSM-00-A-20004 BSS network design, Siemens prosjekteringsdokumentasjon;

15) Agreement between National Post and Telecom Agencies in Norway and Sweden concerning the use of the frequency bands 876-880 MHz and 921-925 MHz for GSM-R in the border areas

16) Nominal Cell Plan (NCP) Template (2. Network Planning & System Design\2.02. Radio Planning\2.2.2. Documents\Nominal Cell Plan (NCP) Template)

14 ATTACHMENTS

All the attachements are stored on the server in the following directory:

\\Oslfil002\gsm-r\2. Network Planning & System Design\2.02. Radio Planning\2.2.2. Documents\Radioplanning guidelines\Vedlegg

1	BanestrekningsID
2	Train Controller Areas
3	<not used>
4	<not used>
5	<not used>
6	Link Budget and measurement requirements
7	Radio Planning Survey Report
8	<not used>
9	<not used>
10	Antenna List
11	Optimization Report Template
12	Cell IDs
13	<not used>
14	<not used>
15	<not used>
16	<not used>
17	<not used>
18	<not used>
19	Link Planning Survey Report
20	<not used>
21	Action Request template
22	<not used>