3GPP TSG RAN WG 1 ***TSGR1#20 R1-01-0519***
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Agenda Item: 7.1

Source: Siemens

Title: Further contribution on the Technical Report on TX diversity solutions for multiple antennas

Document for: Discussion and approval

This contribution contains further text input for the Technical Report on TX diversity solutions for multiple antennas. The document is divided into three sections:

First, as requested in the e-mail discussion of AH 26 one text proposal is made to consider also non-standardised adaptive antenna methods as a reference case in the TR.

Principles for soft handover using TX diversity techniques with more than two antenna elements are outlined in the second part of the document. A suitable concept is shown for the eigenbeamformer.

Finally it is proposed to include an unequal CPICH power setting in the simulation conditions. Simulations for the eigenbeamformer are presented for inclusion into the TR.

1 Comparison of the eigenbeamformer with non-standardised AA methods

The eigenbeamformer concept is applicable to a wide range of antenna deployments and propagation scenarios. The performance improvements have been presented already in Tdoc R1-01-0203 for the uncorrelated channel model, the micro cell scenario and the macro cell scenario. The results have been compared to the Rel 99 closed loop mode 1.

However, it was requested to compare the performance also with non-standardised adaptive antenna (AA) methods. Simulations have been presented by Siemens in the e-mail discussion paper R1-01-0442. Based on the comments received the simulations have been refined and results for the macro cell scenario have been added as well as simulations regarding a single antenna at the Node B.

In the following simulation results the simulation parameters as described in R1-00-1180 and R1-00-0867 have been used. A short description of the 4 different methods that are used in the comparison and their assumptions is given:

1. Single antenna case

   In this simulation one antenna at the Node B is assumed. Channel estimation at the UE is done using the CPICH which is sent with 10% of the total transmit power of Node B. No diversity techniques are applied.

2. Closed loop mode 1 with two antennas (Rel 99)

   Two antennas are assumed at the Node B. Channel estimation is done using the CPICH which is sent over both antennas with equal power (in total 10% of the total transmit power of Node B). An error rate of 4% was used for the feedback bits in the uplink. Further, ideal antenna verification was assumed. Between the two antennas a correlation equal to two adjacent antennas of the micro or macro cell scenarios has been used.

3. Non-standardised AA method (TXAA without feedback)

   An adaptive antenna concept with four antennas that determines the weights for each antenna from measurements on uplink channels is assumed. Since no feedback is done in uplink it would not need to be standardised. Channel estimation is done using the pilot bits of the DPCH.

   The simulations for the non-standardised AA method assume the following idealisations:

   - Calibration: the phase calibration due to different transmission paths in uplink and downlink is assumed to be perfect. The covariance matrix for the uplink and the downlink are assumed to be the same.

- Uplink measurements: The measurements on the uplink channel to obtain the covariance matrix are perfect. The covariance matrix is assumed to be perfectly known at the Node B.
- Frequency transformation: The transformation of the measurements in the uplink to antenna weights for the downlink to compensate the FDD frequency gap is assumed to be perfect.

4. Eigenbeamformer

   The same simulations as have been presented in Tdoc R1-01-0203 are used for the comparison. Here, the feedback error rate for short term bits for switching of the eigenbeams was 4%. The long term feedback to transmit the eigenvectors was assumed to be error free. The eigenvectors were quantized with 5 bits for phase and 3 bits for amplitude of each vector element. Ideal antenna verification was assumed at the UE.

1.1 Uncorrelated scenario

In an uncorrelated scenario non-standardised methods cannot track any direction towards the UE, since information about fading of each antenna is not available. The propagation paths are departing in all directions to reach the UE. No dominant direction can be observed. Therefore an omnidirectional characteristic would be the optimum for non-standardised methods, which consequently has the same performance as using a single antenna at the Node B.

To give a reference for a single antenna case two simulations have been done. In the first one the UE uses the CPICH for channel estimation and in the second one dedicated pilot bits of the DPCH are used . They are averaged over 4 slots using weighted multi slot averaging (WMSA) with weights (1 4 4 1).

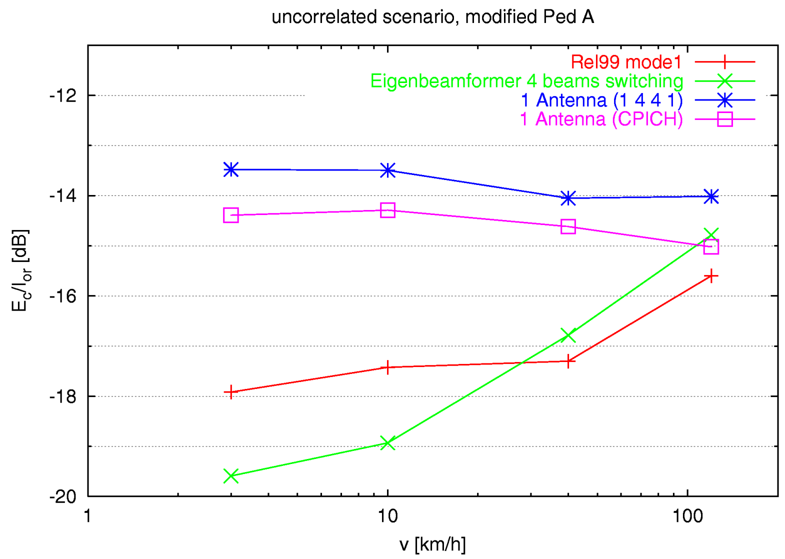

Figure 1: Simulation result for the uncorrelated antenna case

The simulation curves are shown in Fig. 1. The performance gain from one antenna to two antennas is about 3 dB. The eigenbeamformer with four antennas can achieve an additional gain of about 2.2 dB for a velocity of 3 km/h and 10 km/h

Channel estimation on dedicated pilots including a WMSA technique reduces performance of about 1 dB compared to channel estimation with CPICH.

It is not proposed to include these results as a reference in the TR since TXAA concepts without feedback cannot be used in an uncorrelated scenario.

1.2 Micro cell scenario

This simulation was already presented in Tdoc R1-01-0442. For the non-standardised AA method channel estimation is done using the pilot bits of the DPCH. Here, no averaging over slots is done. Further simulations results will be provided with WMSA.

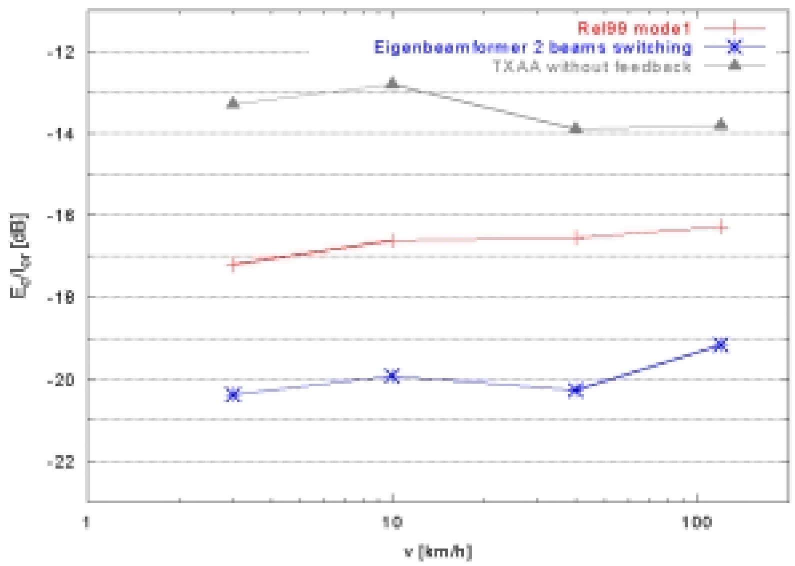

Figure 2: Simulation result for micro cell scenario

The performance of the non-standardised method with 4 antennas is lower than Rel99 closed loop mode 1. This due to the fact that fast fading cannot be mitigated and channel estimation is done using dedicated pilot bits and not the CPICH.

1.3 Macro cell scenario

In this comparison, for the non-standardised AA method (TXAA without feedback) channel estimation was done using pilot bits of the DPCH. They are averaged over 4 slots using WMSA (1 4 4 1).

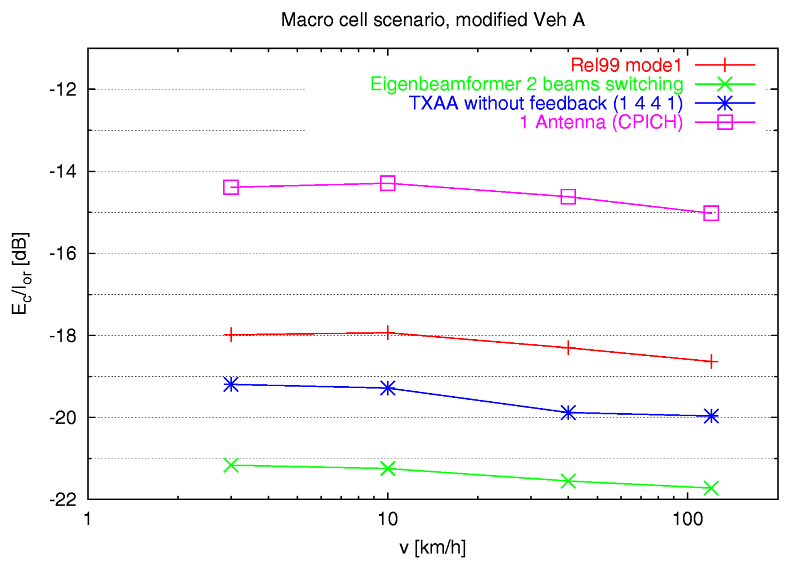

Figure 3: Macro; 1 antenna, Rel99 mode1, non-s-AA, EBF

The non-standardised AA method performs now better than Rel99 closed loop mode 1. However, the eigenbeamformer can still show additional performance gain of almost 2 dB.

1.4 Text proposal

It is proposed to include the curves of the Rel99 mode 1 and the non-standardised AA method for the micro cell scenario and the macro cell scenario in the Technical Report.

------ start text proposal (insertion of new section 6.2.3) ------

6.2.3 Reference to non-standardised AA methods

In order to justify the need of a further extension of closed loop TX diversity methods in the 3GPP standard a reference case for a non-standardised adaptive antenna method using 4 antennas at Node B is considered in this section.

When comparing the results, please note, that the non-standardised AA method would have some performance degradation which is not included in the simulation results. The following issues need to be addressed:

- phase calibration of to different transmission paths in uplink and downlink needs to be done
- measurements on the uplink channel to obtain the covariance matrix will not be perfect in practice
- transformation of the measurements in the uplink to antenna weights for the downlink to compensate the FDD frequency gap needs to be done

Figure 16 shows the performance of a non-standardised AA method (TXAA without feedback) in the micro cell scenario. For channel estimation dedicated pilot bits have been used. They are averaged over only one slot. Further simulation results will be provided using WMSA.

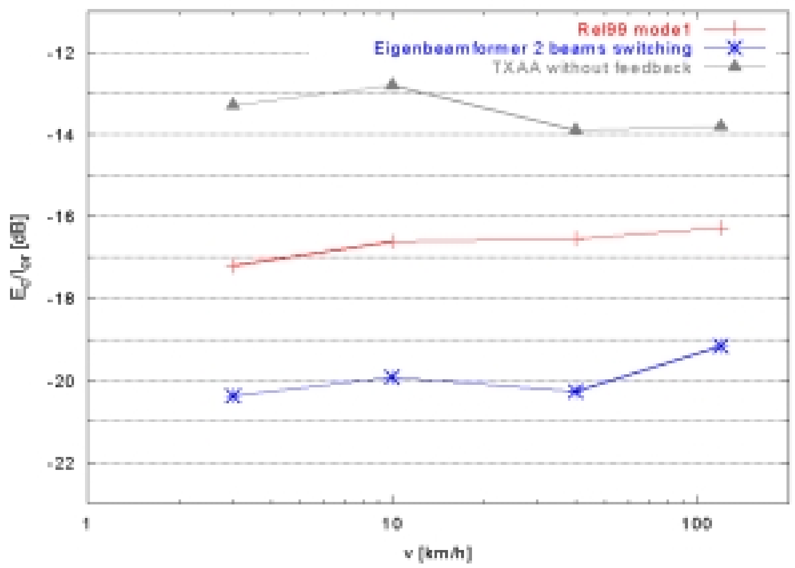

Figure 16: Simulation result for micro cell scenario

Figure 17 shows the performance of a non-standardised AA method in the macro cell scenario. For channel estimation dedicated pilot bits have been used. They are averaged over four slots using WMSA (1 4 4 1).

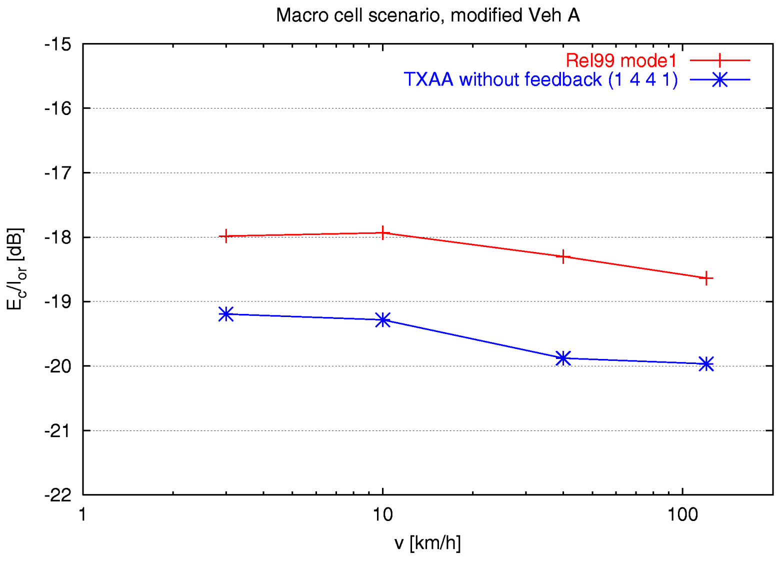

Figure 17: Simulation result for macro cell scenario

Simulation results for uncorrelated antennas are not shown, since TXAA methods without feedback are not applicable in this case.

------ end text proposal ------

2 Soft handover

Soft handover needs also to be considered when specifying TX diversity schemes with more than 2 antennas. Going to a larger number of antennas leads to smaller antenna lobes. Therefore a simply sum that optimizes all antenna weights for all Node Bs in the active set by solving one formula is not possible (see equation (2) in section 7.1 of TS 25.214). So for each Node B individual feedback of antenna weights is more appropriate.

With respect to the eigenbeamformer a concept for soft handover could be the following:

The UE sends only long term feedback to the Node Bs which are in the active set. The feedback must directly or indirectly contain the identifier of the corresponding Node B. Each Node B transmits with the antenna weights based on the received feedback. Short term feedback is not used. The feedback format for this soft handover concept must therefore be changed in a way that each feedback bit represents long term information. For one eigenbeam 27 bit + 3 bit indicator = 30 bits are needed. Thus, each eigenbeam will be transmitted within two frames (20 ms).

The performance loss when using no short term bits will be compensated by the fact that at least two cells are in the active set and diversity is achieved by different sites.

------ start text proposal ------

8.2 Eigenbeamformer concept

The procedures for initialization and compressed mode singularities will be defined for the eigenbeamformer concept in a straightforward way.

For soft handover the following procedure could be applied: During soft handover between cells that are using eigenbeamforming the UE sends only long term feedback to the Node Bs which are in the active set. The feedback must directly or indirectly contain the identifier of the corresponding Node B. Each Node B transmits with the antenna weights based on the received feedback. Short term feedback is not used. The feedback format for this soft handover case must therefore be changed in a way that each feedback bit represents long term information. For one eigenbeam 27 bit + 3 bit indicator = 30 bits are needed. Thus, each eigenbeam will be transmitted within two frames (20 ms).

The performance loss when using no short term bits will be compensated by the fact that at least two cells are in the active set and diversity is achieved by different sites.

------ end text proposal ------

3 Unequal CPICH power

Some discussion already took place related to CPICH power for four antennas. For channel estimation and calculation of the antenna weights additional CPICH power for antenna 3 and 4 is needed. In a cell with mostly Rel99/R4 UEs for backward compatibility the power of the CPICH of antenna 1 and 2 must be the same as for a Rel99/R4 cell which is about 10% of the total transmit power. This value is taken from the assumptions used for the test cases in WG 4. What remains open, and what can be optimised is the amount of additional pilot power on antenna 3 and 4.

In this section we propose to add an unequal CPICH power assignment to the 4 antennas in the simulation conditions in section 6.1.1 of the TR. The total power of all 4 antennas is still 10% of the total transmit power, but the power distribution is unequal with ratio

power of antenna 1&2 : power of antenna 3&4 = 80 :20

The proposed changes to the Technical Report can be found below. According to these simulation conditions new simulation results have been included for the eigenbeamformer.

------ start text proposal part 1 ------

6.1.1 Regular simulation assumptions

Table 4 1 lists the simulation parameters that should be used in the Tx diversity simulations.

Table 4. Recommended simulation parameters for multiantenna Tx diversity simulations.

Bit Rate	12.2 kbps
Chip Rate	3.84 Mcps
Convolutional code rate	1/3
Carrier frequency	2 GHz
Power control rate	1500 Hz
PC error rate	4 %
PC Step Size	1 dB per antenna
Channel model(s) and UE velocities	1-path Rayleigh: 3, 10, 40, 120 km/h Modified ITU Ped A: 3, 10, 40 km/h Modified ITU Veh. A: 10, 40, 120 km/h
CL feedback bit error rate	4 %
CL feedback delay	1 slot
TTI	20 ms
Downlink DPCH slot format	#10 or #11
Min. # of RAKE fingers for modified Vehicular A channel	5
Target FER/BlkER	1 %
Geometry (G)	-3, 0 and 6 dB
Common Pilot **- equal CPICH** **- unequal CPICH**	-10 dB total antenna 1&2 : antenna 3&4 = 50:50 antenna 1&2 : antenna 3&4 = 80:20
Correlation between antennas	0
Performance measure	$T_x E_b/I_{or}$
CL feedback rate	1500 Hz

The following notes should be taken:

1. Definition of Tx E_b/I_{or}

E_b = The average energy per information bit as measured at the base station. Defined after CRC attachment but before channel encoding.

I_{or} = The total power density of the base stations in soft handoff with the mobile, measured at the base station

2. Definition of Geometry (G)

Geometry, G, is defined as:

$$G = \frac{average(R_x\ I_{or})}{I_{oc} + N_o} \qquad (10)$$

where,

$R_x\ I_{or}$ = The total power density of the base stations in soft handoff with the mobile, measured at the mobile station

I_{oc} = The interference power density at a mobile due to all the base stations not in soft handoff with the mobile

N_o = The thermal noise power spectral density

3. Power control step size

The power control step size is 1 dB per antenna. This means that when up/down command is received the tranmitter increases/decreases the Tx power per antenna by 1 dB which also results in 1 dB increase/decrease of the total Tx power.

4. Modeling of downlink channels

The only common channel modeled in downlink is the CPICH. The detailed implementation of the CPICH can vary but the total power allocated to it is 10 % of the total Tx power of the BS. The power ration between antennas 1&2 and 3&4 can be either 50:50 (equal CPICH) or 80:20 (unequal CPICH). This ~~10 %~~ power allocation needs to be valid only in the beginning of the simulation, i.e. the CPICH total power is kept fixed during the simulation. Thus, the change of the user signal power due to power control does not affect the total CPICH Tx power.

------ end text proposal part 1 ------

------ start text proposal part 2 (section 6.2.1 with new figures) -----

6.2.1.1 Uncorrelated case

In Figure 12 the performance of the eigenbeamformer with switching between Nbeam = 4 eigenvectors compared to the Release-99 mode 1 with two antennas is shown. The eigenbeamformer performs about 2~~.2~~ dB better than Release-99 mode 1 for the UE velocity of 3 km/h and 10 km/h, depending in the CPICH power on antennas 3 and 4. Using four eigenbeams in an uncorrelated scenario has the result that each antenna element is addressed by one eigenbeam and effectively switching between antenna elements is done. The degradation when using unequal CPICH power with less power on antennas 3 and 4 is about 0.4 dB.

For higher velocities the Release-99 mode 1 with only two antennas will have the same or better performance. This can be explained with the increased number of feedback bits for 4 antenna elements which cannot be transmitted fast enough.

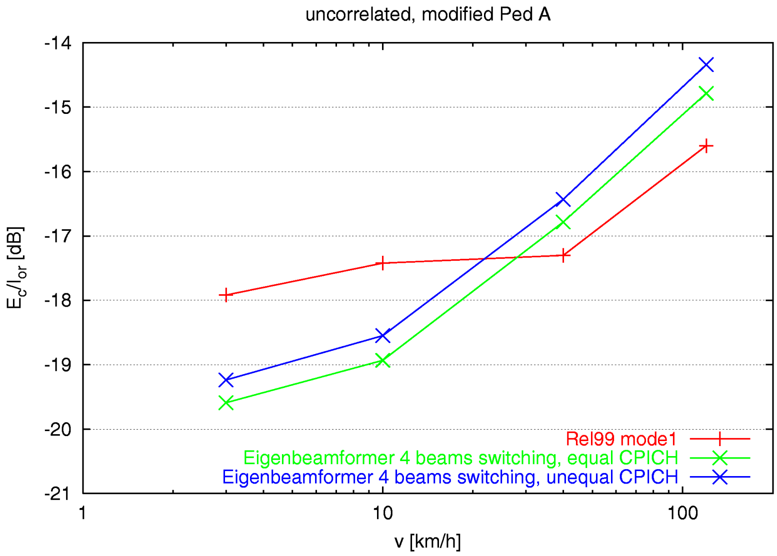

Figure 12. Simulation results for 0 dB geometry and uncorrelated antenna paths

Note that the velocity of 120 km/h is shown here for explanation of the behaviour and is quite unrealistic for the assumed Pedestrian A channel model.

6.2.1.2 Micro cell scenario

For the micro cell scenario switching between Nbeam = 2 eigenbeams was done. For all simulated velocities the eigenbeamformer performs with an advantage of about 3 dB compared to Release-99 mode 1. Using less CPICH power on antennas 3 and 4 leads to only a marginal performance loss.

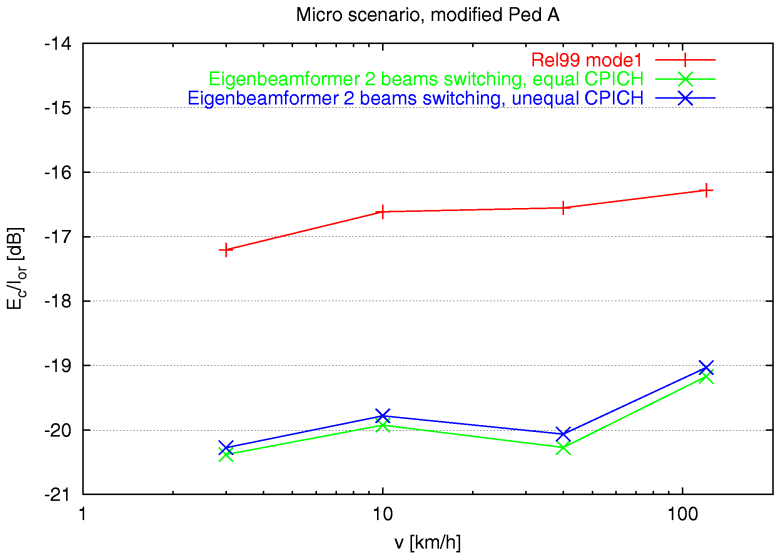

Figure 13. Simulation results for 0 dB geometry and micro cell scenario

Note that the velocity of 120 km/h is shown here for explanation of the behaviour and is quite unrealistic for the assumed Pedestrian A channel model.

6.2.1.3 Macro cell scenario

For the macro cell scenario also switching between Nbeam = 2 eigenbeams was done. For all simulated velocities the eigenbeamformer performs with an advantage of about 3 dB compared to Release-99 mode 1. The degradation when using unequal CPICH power with less power on antennas 3 and 4 is about 0.2 dB..

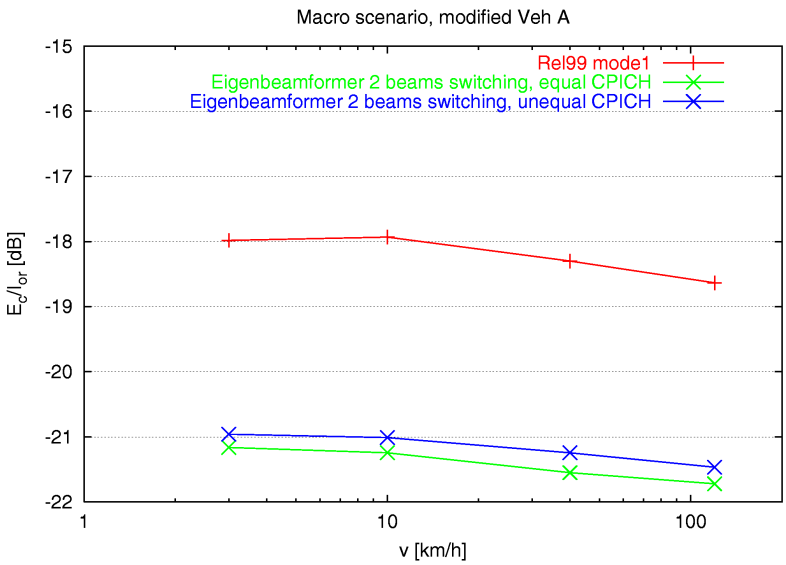

Figure 14. Simulation results for 0 dB geometry and macro cell scenario

------ end text proposal part 2 ------

4 Summary

With this document we propose to add a reference to non-standardised AA methods in the TR. Also one suitable concept for soft handover between cells using eigenbeamforming is proposed to include in the TR. Finally simulation conditions for unequal CPICH power are proposed. The simulation results for the eigenbeamformer are updated according to the new CPICH power settings.