



Joint 3GPP 3GPP2 Spatial Channel Model AHG Status Report

**3GPP TSG-RAN WG1#29 meeting
Shanghai, China, 5-8 November 2002**

Mailing list: 3GPP_3GPP2_SCM@list.etsi.fr

FTP: www.3gpp.org/ftp/tsg_ran/WG1_RL1/3GPP_3GPP2_SCM

and: [ftp.3gpp2.org/TSGC/Working/2002/3GPP_3GPP2_SCM](ftp://ftp.3gpp2.org/TSGC/Working/2002/3GPP_3GPP2_SCM) (Spatial Modeling)

SCM Adhoc Group Formation



- The Joint 3GPP-3GPP2 SCM AHG was formed through the collaboration of 3GPP and 3GPP2 by merging two adhoc groups:
 - 3GPP2 TSG-C WG3 Spatial Channel Model Adhoc Group
 - 3GPP TSG RAN WG1 MIMO Adhoc Group
- The Joint SCM work is in progress
 - Numerous companies representing both 3GPP and 3GPP2 actively participate
 - Approximately 170 participants follow the progress of the work
- Joint SCM has been assigned dedicated:
 - mailing list ([3GPP 3GPP2 SCM@list.etsi.fr](mailto:3GPP_3GPP2_SCM@list.etsi.fr))
 - Directory hosting of contributions in the 3GPP & 3GPP2 sites:
 - » [ftp.3gpp2.org/TSGC/Working/2002/3GPP_3GPP2_SCM_\(Spatial_Modeling\)](ftp://ftp.3gpp2.org/TSGC/Working/2002/3GPP_3GPP2_SCM_(Spatial_Modeling))
 - » www.3gpp.org/ftp/tsg_ran/WG1_RL1/3GPP_3GPP2_SCM

Joint SCM AHG Scope



- **Scope of the joint SCM AHG:**

To develop and specify parameters and methods associated with the spatial channel modeling that are common to the needs of the 3GPP and 3GPP2 organizations

- **Scope of the joint SCM is development of specifications for:**

- **System level evaluation.** Evaluation of proposals will be based on system level simulations. Four focus areas are identified. Current emphasis is on items a & b only.

- a. **Physical parameters (e.g. power delay profiles, angle spreads, dependencies between parameters)**

- b. **System evaluation methodology.**

- c. **Antenna arrangements, reference cases and definition of minimum requirements.**

- d. **Some framework (air interface) dependent parameters.**

- **Link level evaluation.**

- Defined for calibration only. These are static cases that represent a snapshot of the channel.

Timeframe - Meeting Schedule



- **Timeframe:**
 - Target date of August 2002 for completion of physical parameters specification (main body of work has been completed)
 - Deadline: March 2003 for completion of all items in the AHG's scope.
- **Past Meetings:**
 - Paris, France, April 10-11, 2002. Co-located with 3GPP RAN1 meeting
 - Seattle, USA, August 20-21, 2002. Co-located with 3GPP RAN1 meeting
 - Quebec City, CA, October 22-23, 2002. Co-located with 3GPP2 TSG-C WG3 meeting
- **Future Meetings:**
 - San Diego, USA, January 7-10 2003. Co-located with 3GPP RAN1 meeting
 - TBD after January 2003
 - Conference Calls scheduled every three weeks.

Current Progress



- **Deliverable Document**
 - **Output text (Latest version: SCM v.1.9). Currently contains all physical parameters agreed (link and system level).**
- **Link Level Assumptions have been (FINALIZED)**
- **System Level Assumptions (PHYSICAL PARAMETERS: 95% COMPLETE)**
 - **System Level assumptions form the basis for the evaluation of proposals**
 - **Parameters follow many COST 259 recommendations**
 - **No specific antenna topologies are enforced, only recommended**
 - **Assembled and studied numerous measurement data.**
 - **Modeling is developed as a general framework for all multiple antenna transmit or receive configurations**
 - **The wideband model can be translated to both 1.25MHz or 5MHz bandwidths**
 - **Evaluation methodology issues remain to be completed**

Link Level SCM Assumptions (1)



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Model		Case I		Case II		Case III		Case IV	
Corresponding 3GPP Designator*		Case B		Case C		Case D		Case A	
Corresponding 3GPP2 Designator*		Model A, D, E		Model C		Model B		Model F	
PDP		Modified Pedestrian A		Vehicular A		Pedestrian B		Single Path	
# of Paths		1) 4+1 (LOS on, K = 6dB) 2) 4 (LOS off)		6		6		1	
Relative Path Power (dB)	Delay (ns)	1) 0.0	0	0,0	0	0.0	0	0	0
		2) -Inf							
		1) -6.51	0	-1.0	310	-0.9	200		
		2) 0.0							
		1) -16.21	110	-9.0	710	-4.9	800		
		2) -9.7							
		1) -25.71	190	-10.0	1090	-8.0	1200		
		2) -19.2							
1) -29.31	410	-15.0	1730	-7.8	1730				
2) -22.8									
			-20.0	2510	-23.9	3700			
Speed (km/h)		1) 3 2) 30, 120		3, 30, 120		3, 30, 120		3	

Link Level SCM Assumptions (2)



UE/Mobile Station	Topology	Reference 0.5?	Reference 0.5?	Reference 0.5?	N/A
	PAS	1) LOS on: Fixed AoA for LOS component, remaining power has 360 degree uniform PAS. 2) LOS off: PAS with a Lapacian distribution, RMS angle spread of 35 degrees per path	RMS angle spread of 35 degrees per path with a Lapacian distribution Or 360 degree uniform PAS.	RMS angle spread of 35 degrees per path with a Lapacian distribution	N/A
	DoT (degrees)	0	22.5	-22.5	N/A
	AoA (degrees)	22.5 (LOS component) 67.5 (all other paths)	67.5 (all paths)	22.5 (odd numbered paths), -67.5 (even numbered paths)	N/A
Node B/ Base Station	Topology	Reference: ULA with 0.5?-spacing or 4?-spacing or 10?-spacing			N/A
	PAS	Lapacian distribution with RMS angle spread of 2 degrees or 5 degrees, per path depending on AoA/AoD			N/A
	AoD/AoA (degrees)	50° for 2° RMS angle spread per path 20° for 5° RMS angle spread per path			N/A

System Level SCM - Outline



An outline of the current system level modeling discussions is described below. Some methods and parameter values are still under evaluation.

Steps 1,2 - Channel Scenario, Drops, Geometry:

- Drop users in a multi-cell environment
- Assign BS-MS (NodeB-UE) distance, antenna patterns
- Assign MS (UE) orientation, speed vector
- Choose a Channel Scenario common to all drops. Each channel scenario defines a different set of physical parameters:
 - » Suburban Macro
 - » Urban Macro
 - » Urban Micro
 - » (Special cases: Far Scatterer Cluster, Urban Canyon, LOS)
- Each channel scenario defines a different set of physical parameters
 - » For generating lognormal BS/MS angle spread (AS)
 - » For generating lognormal delay spread (DS)

System Level SCM (2)



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Channel Scenarios spatial parameters

Channel Scenario	Suburban Macro	Urban Macro	Urban Micro
Mean composite AS at BS	$E(\sigma_{AS})=5^0$	$E(\sigma_{AS})=8^0, 15^0$	N/A
Measured overall composite AS at BS as a lognormal RV $\sigma_{AS}=10^{\epsilon_A x + \mu_A}$, $x \sim N(0, 1)$	$\mu_A = 0.69$ $\epsilon_A = 0.17$	$\mu_A = 0.87$ $\epsilon_A = 0.36$	N/A
Per path AS at BS (Fixed)	2 deg	2 deg	5 deg
Per path AoD Distribution st dev	$N(0, \sigma_{AS})$	$N(0, \sigma_{AS})$	$U(-30\text{deg}, 30\text{deg})$
Mean of RMS composite AS at UE	$E(\sigma_{AS, \text{comp}, UE})=72^0$	$E(\sigma_{AS, \text{comp}, UE})=72^0$	$E(\sigma_{AS, \text{comp}, UE})=72^0$
Per path AS at UE (fixed)	35^0	35^0	35^0
Per path AoA Distribution	$N(0, \sigma_{AoA}^2(P_r))$ Note 1	$N(0, \sigma_{AoA}^2(P_r))$ Note 1	$N(0, \sigma_{AoA}^2(P_r))$ Note 1
Mean total RMS Delay Spread	$E(\sigma_{DS})=0.17 \mu\text{s}$	$E(\sigma_{DS})=0.65 \mu\text{s}$	$U(0, 0.8) \mu\text{s}$
Measured overall narrowband composite delay spread as a lognormal RV $\sigma_{DS}=10^{\epsilon_D x + \mu_D}$, $x \sim N(0, 1)$	$\mu_D = -0.80$ $\epsilon_D = 0.288$	$\mu_D = -0.175$ $\epsilon_D = 0.17$	
Lognormal shadowing standard deviation	8dB	8dB	N/A

System Level SCM – Macro (3)



Step 3 - DS, AS, Shadowing and their correlations:

- Given a channel scenario perform random draws (log-normal) on Delay Spread (DS), Composite Angle Spread (AS) at NodeB/BS, and shadowing (LN) per drop.

$$s_{Dn} = 10^{(e_D a_n + m_D)} \quad m_D = E\{\log_{10}(s_{DS})\} \quad e_D = Std\{\log_{10}(s_{DS})\}$$

$$s_{An} = 10^{(e_A b_n + m_A)} \quad m_A = E\{\log_{10}(s_{AS})\} \quad e_A = Std\{\log_{10}(s_{AS})\}$$

$$s_{LN} = 10^{\left(\frac{s_{SF} g_n}{10}\right)}$$

- Where correlations between variables are established:

$$\begin{bmatrix} a_n \\ b_n \\ g_n \end{bmatrix} = \begin{bmatrix} r_{aa} & r_{ab} & r_{ag} \\ r_{ba} & r_{bb} & r_{bg} \\ r_{ga} & r_{gb} & r_{gg} \end{bmatrix}^{1/2} \begin{bmatrix} w_{n1} \\ w_{n2} \\ w_{n3} \end{bmatrix}$$

$$r_{ab} = \text{Correlation between DS \& AS} = + 0.5$$

$$r_{gb} = \text{Correlation between LN \& AS} = - 0.75$$

$$r_{ga} = \text{Correlation between LN \& DS} = - 0.75$$

System Level SCM – Macro (4)



Steps 4,5 - Power Delay Profile (PDP):

- PDP is not deterministic as in ITU models
- 6 distinct paths (3 paths for micro) are present at any time.
- Generate random delays for each path (exponentially distributed intervals from zero):

$$t_n = -r_{DS} \mathbf{s}_{DSk} \log z_n \quad z_n : U(0,1)$$

- Generate relative powers for each path (exponential profile with shadowing randomization).

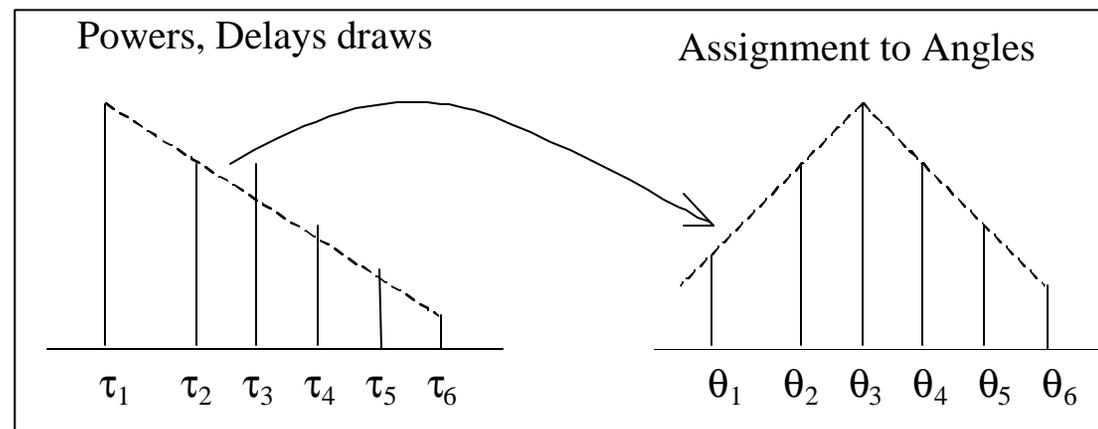
$$P_n = e^{\frac{(1-r_{DS}) \cdot t_n}{r_{DS} \cdot \mathbf{s}_{DSk}}} \cdot 10^{-x_n} \quad \text{where } x_n : N(0, \mathbf{s}_{RND}^2)$$

Step 6 – AOD Generation per path at BS (NodeB)

- Gaussian random AODs around the LOS direction:
- With $r = 1.07$ (suburban macro), $r = 1.3$ (urban macro) $N(0, r^2_{AOD,CS} \cdot \mathbf{s}_{ASK}^2)$.

Step 7 – PDP to AOD assignments:

- Order AODs in increased absolute value
- Assign path delays (in increasing order) to the ordered AODs.

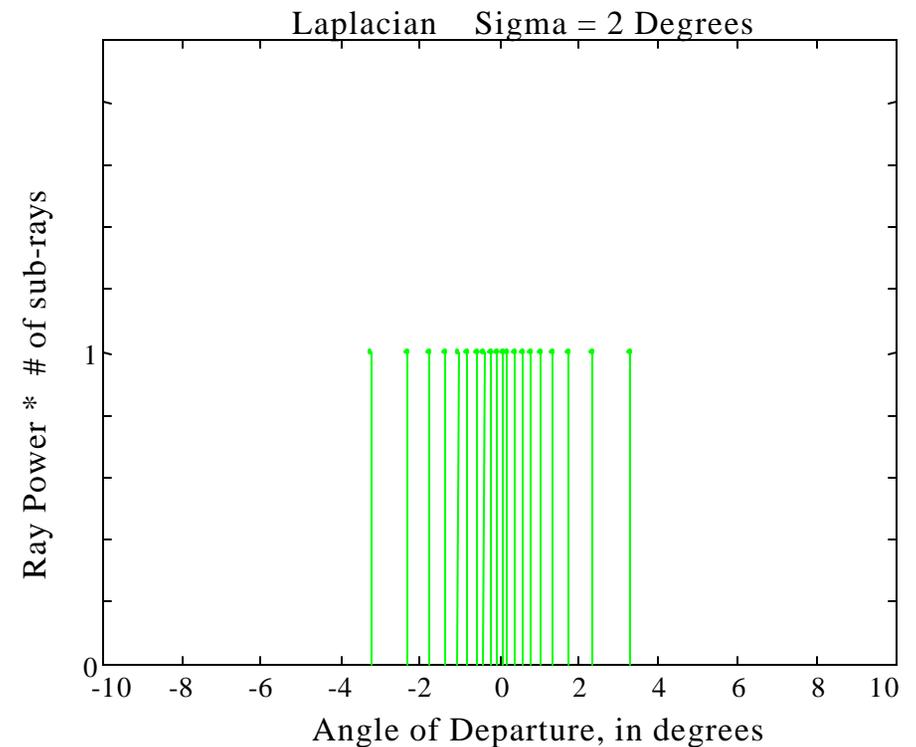
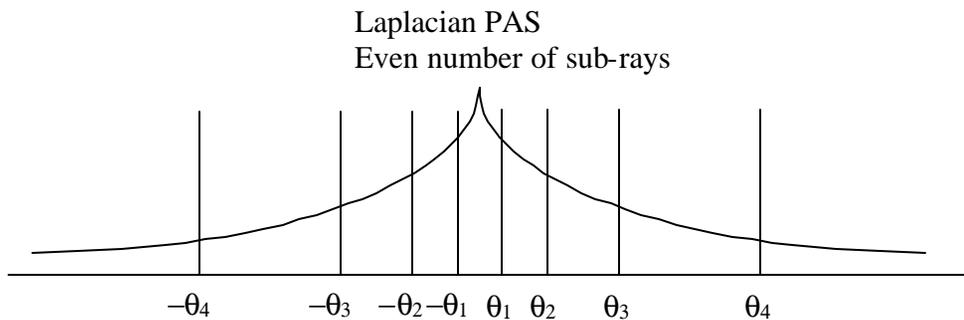


System Level SCM – Macro (5)



Step 8 – Per path channel generation at BS (NodeB)

- 20 sub-paths used for each path, all equal power.
- Laplacian power azimuth spectrum, random phases.

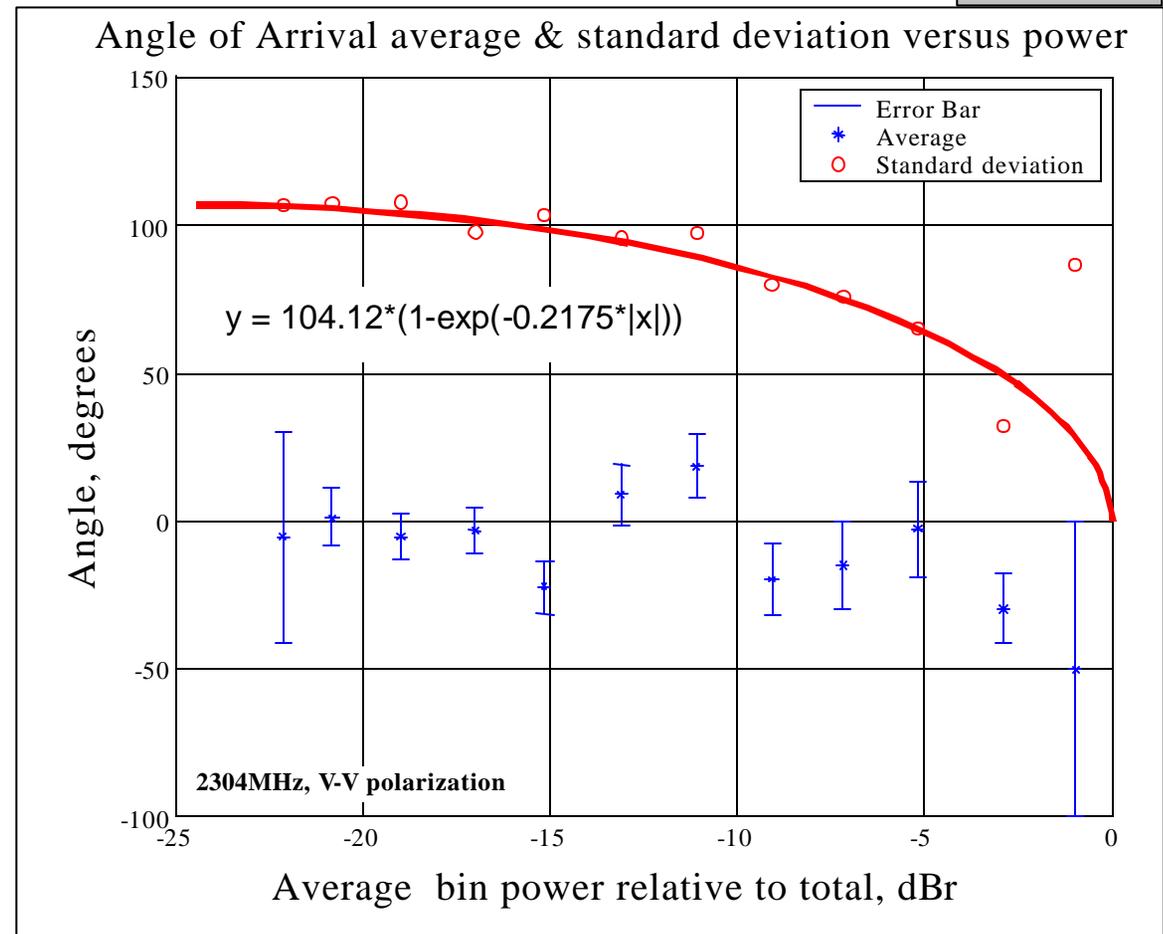


System Level SCM – Macro (6)

Step 9 – MS (UE) AOAs

- Per path AOA is a random draw. Variance is function of path relative power.
- $\sigma_{AoA} = 104.12(1-\exp(-0.2175 * |P_r|))$
- $N(0, \sigma_{AoA}^2)$.

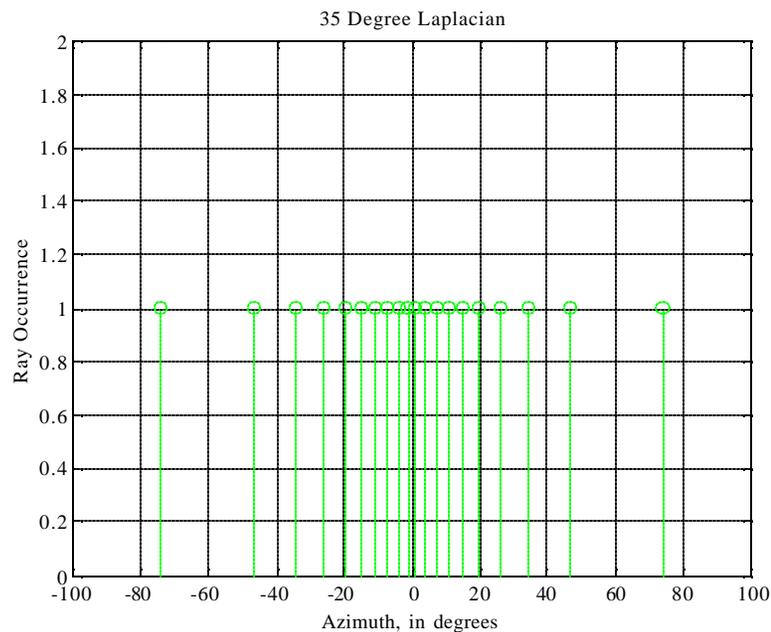
Measurements
provided
By Motorola



System Level SCM (7)

Step 10 – Per path channel generation at UE:

- 20 sub-paths used for each path, all equal power.
- Laplacian power azimuth spectrum, random phases.

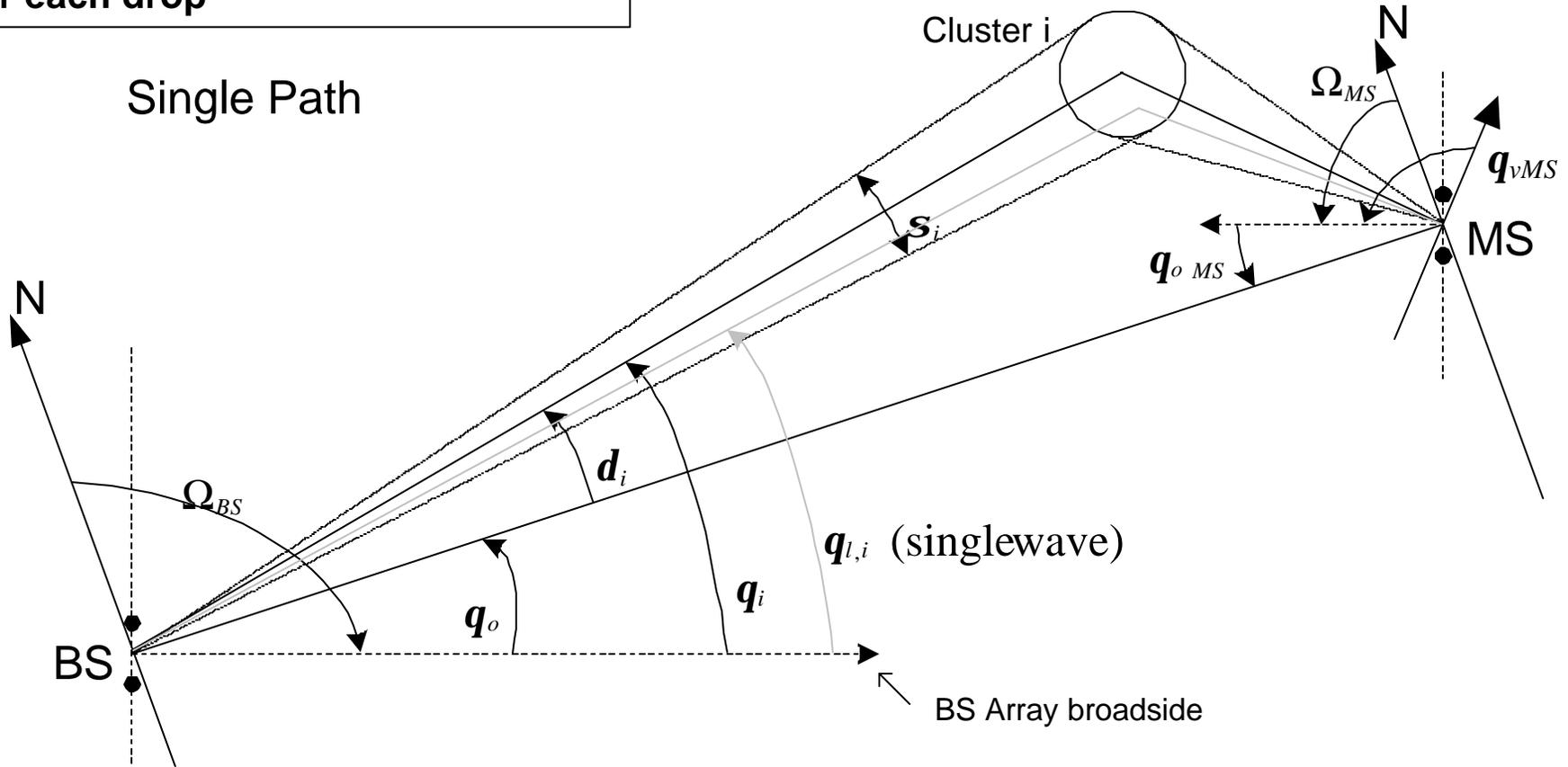


Steps 11,12 – Pairing of NodeB-UE sub-paths, antenna gains.

- Random pairing
- Assign antenna gains for NodeB and UE

System Level Spatial Parameters

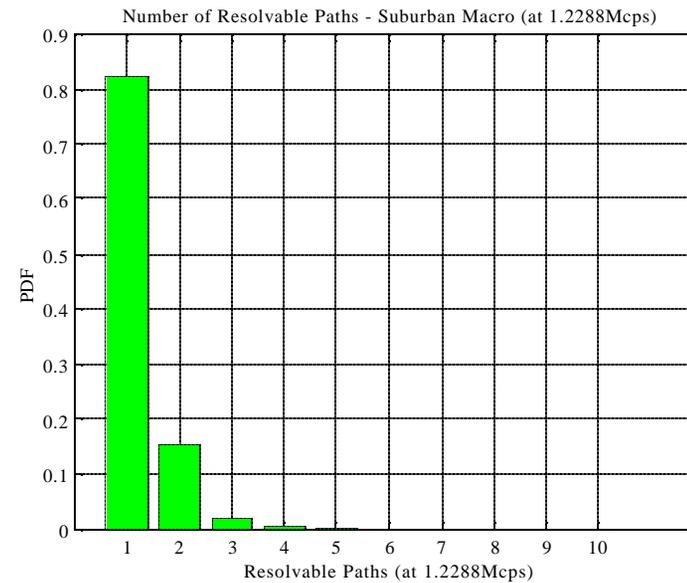
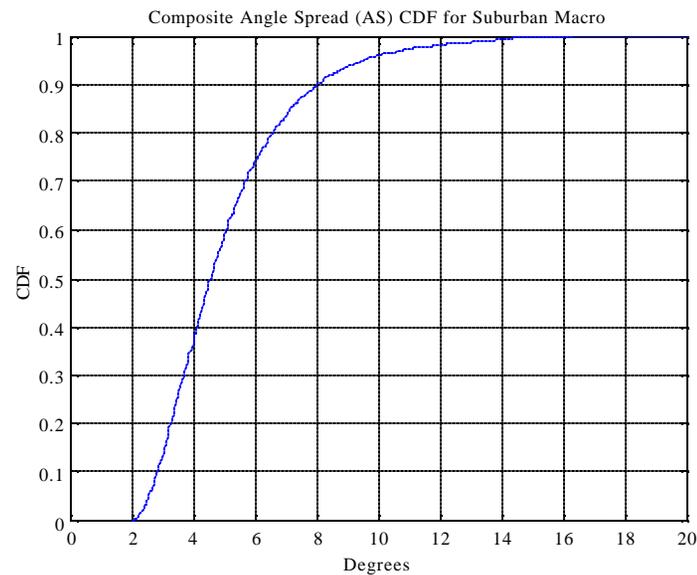
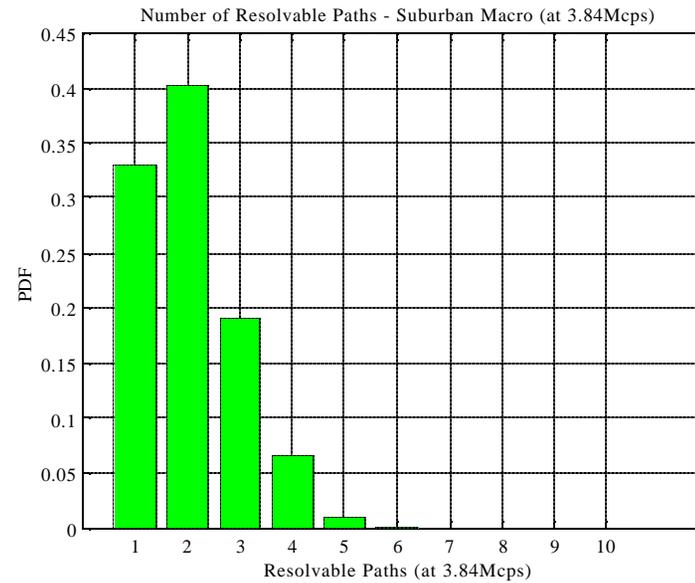
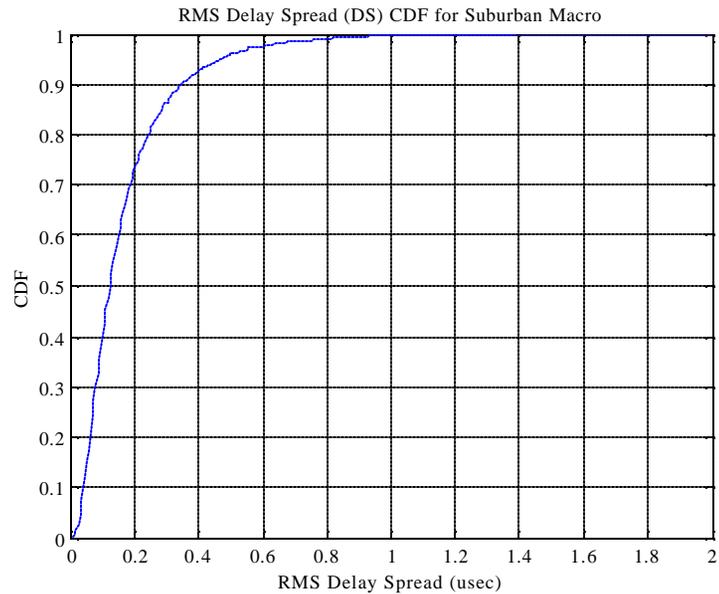
Spatial parameters calculated once for each drop



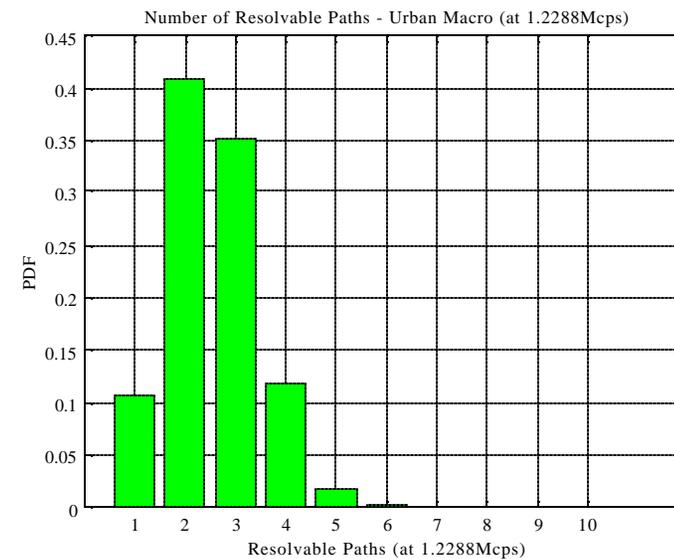
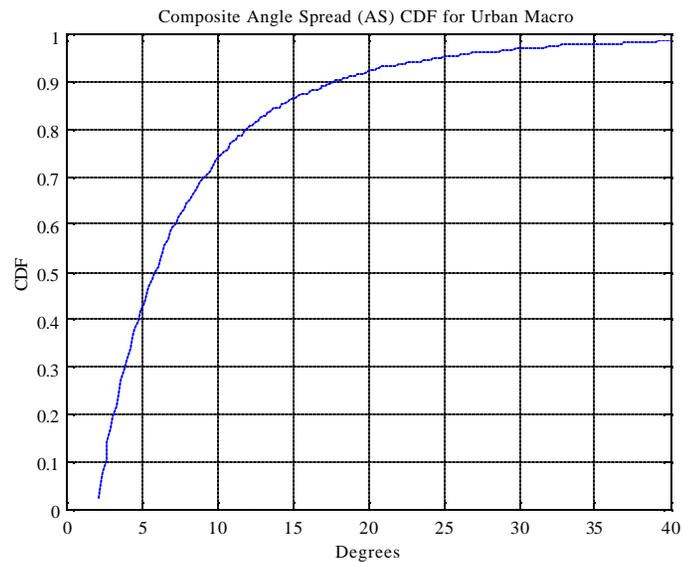
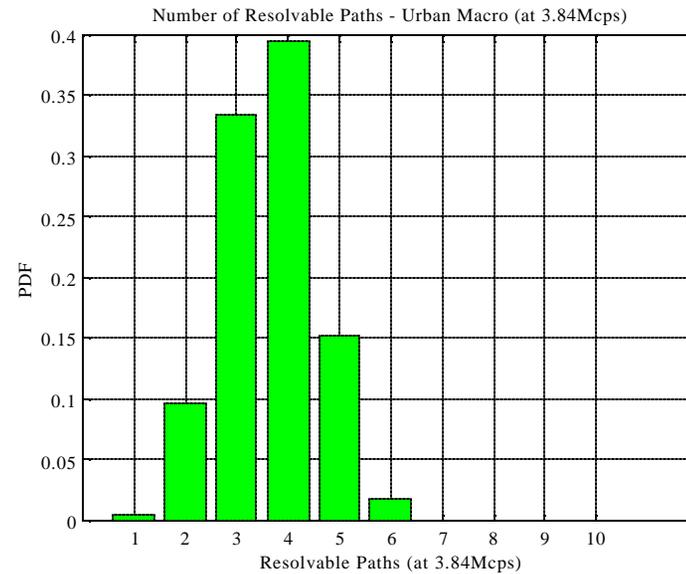
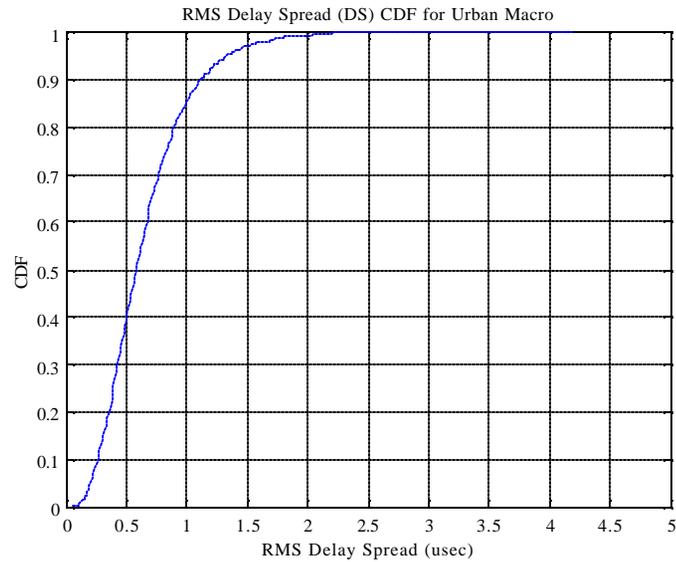
Example of Resulting statistics at BS (NodeB) – Suburban Macro



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Example of Resulting statistics at BS (NodeB) – Urban Macro



System Level SCM (8)



Additional special cases:

- **Far Scatterer Cluster model for urban macro.** It models a bad urban environment.
- **Cross Polarization modeling.** Cross polarization discrimination defined. Current model can cover all types of polarized antennas.
- **Urban Canyon Model.** Addresses the case where signals from all bases have highly correlated angles of arrival at the MS/UE.
- **Line of Sight model.** Rician factor is a function of the distance from the BS.
LOS component appears with linearly decreasing probability with respect to distance.
Cut-off distance at 300 meters from BS

Calibration

- **Provide reference cases for system level calibration.** Provide intermediate statistics.

Evaluation Methodology



loc Modeling:

- Currently under discussion.
- Explicit Spatial modeling of interfering sources.
- Possibly select only the strongest ones (active set). The rest modeled as AWGN sources.
- Objective is to reduce the excessive computational complexity. Determination will be made after examination of trade-offs between performance error and complexity

Channel Metric to FER mappings

- Proposal proponent should provide metric.
- Group currently works towards defining general purpose metrics (for SIMO/MISO/MIMO).
- It was agreed to use an MMSE space-time receiver as reference design.
- It was agreed that for SIMO/MISO (e.g. Tx Diversity or Rx Diversity) the current 1xEV-DV & 3GPP RAN1 methodology with the addition of the MMSE metric can cover most cases

Quasistatic modeling assumption

- Is being re-evaluated for MIMO cases.

Impact of SCM to Current System Level Simulations



Computational Complexity:

- Complexity increases linearly with number of Tx-Rx antenna pairs
- Some concerns on the complexity impact of ICI are under study.
- Fractional complexity increase due to higher number of resolvable paths modeled.
- Advanced receivers (e.g. MMSE) require more processing per user

Backwards compatibility to default ITU/1xEV-DV channel models

- Current ITU/1xEV-DV channel models are a subset of those in SCM
- The average behavior of SCM models is similar (in PDP) to the ITU/1xEV-DV ones
- SCM models do not collapse to exact ITU equivalent models

Evaluation Methodology

- SCM does not require modification of current Eval. Methodology assumptions (with small exceptions)
- SCM definitions can accompany current assumptions/definitions

Remarks



- The SCM group's output document is currently in a usable form for spatial channel based system level simulations
- Harmonized SCM AHG work will be communicated with WG4 of both 3GPP and 3GPP2 Forums
- SCM Work completion by March 2003 is feasible.