

# Status report of MIMO OTA test development in CTIA

A new perspective on the challenge

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# Contents

- CTIA Overview
- ERP Working Group Overview
  - Sub-Groups
  - OTA Test Plan v3.1 release
  - OTA Test Plan v3.1 Roll-Out Schedule
- MIMO OTA Sub-Group (MOSG)
  - Mission Statement
  - Review of Technical Contributions
  - Future Meetings



# CTIA

## The Wireless Association™

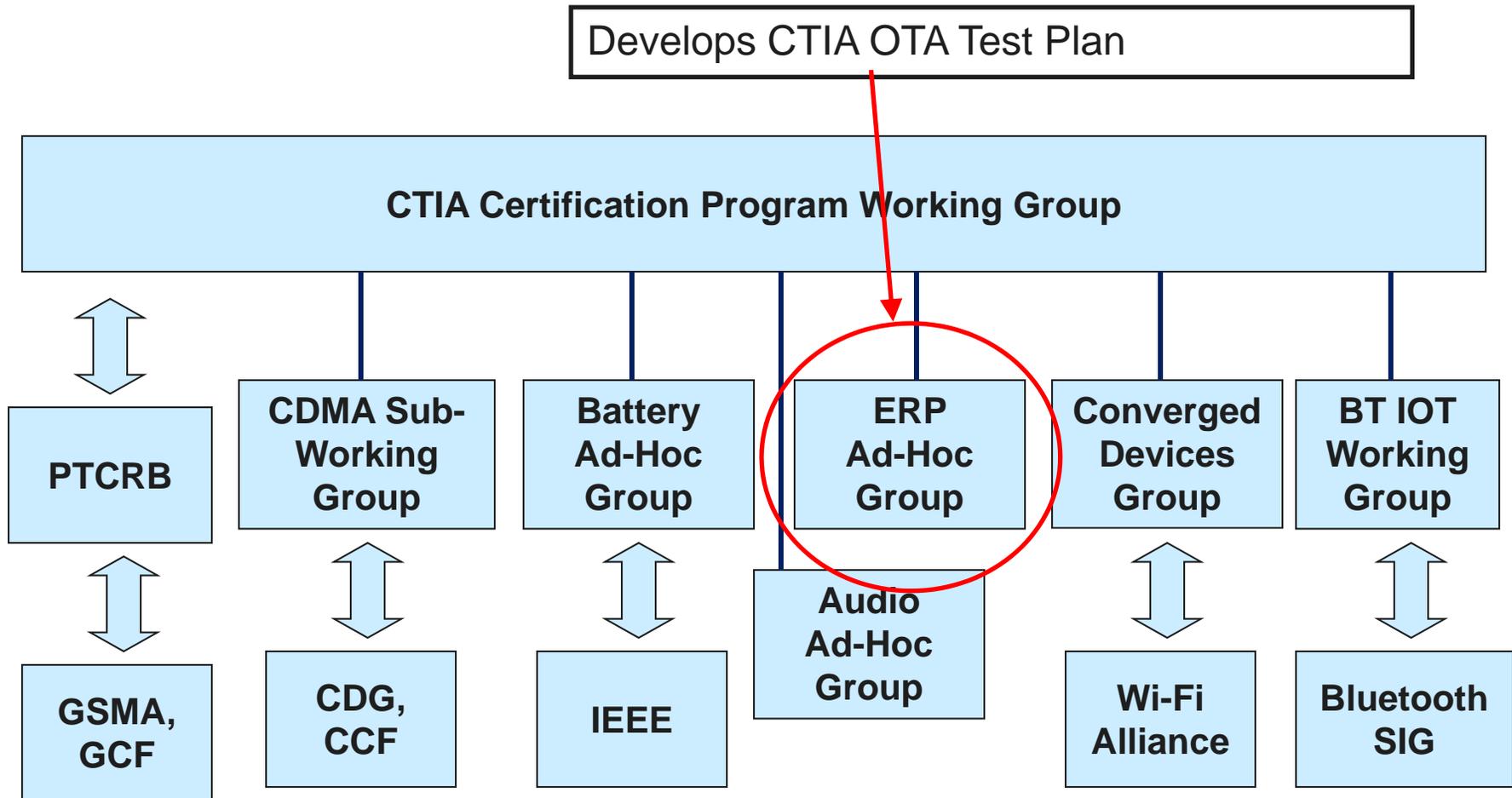


CTIA is the international association for the wireless telecommunications industry, dedicated to *expanding the wireless frontier.*

*“The Wireless Association, is an international organization representing all sectors of wireless communications – cellular, personal communication services and enhanced specialized mobile radio. As a nonprofit membership organization founded in 1984, we represent service providers, manufacturers, wireless data and Internet companies and other contributors to the wireless universe.”*



# CPWG Organization & Industry Relations

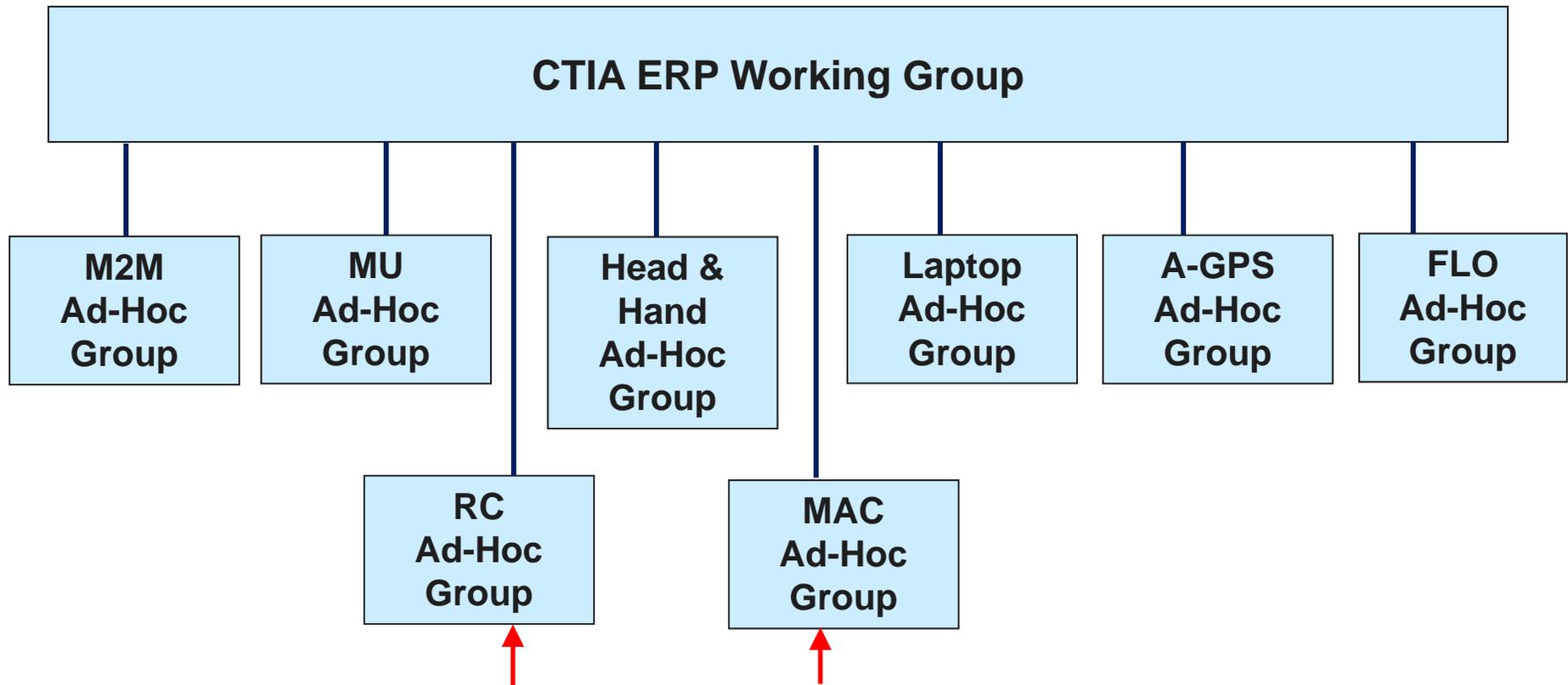


Sub-working group are created as needed and staffed and chaired by Subject Matter Experts from CTIA member companies



Courtesy CTIA

# ERP Working Group and Sub-Groups circa 2008 - 2010



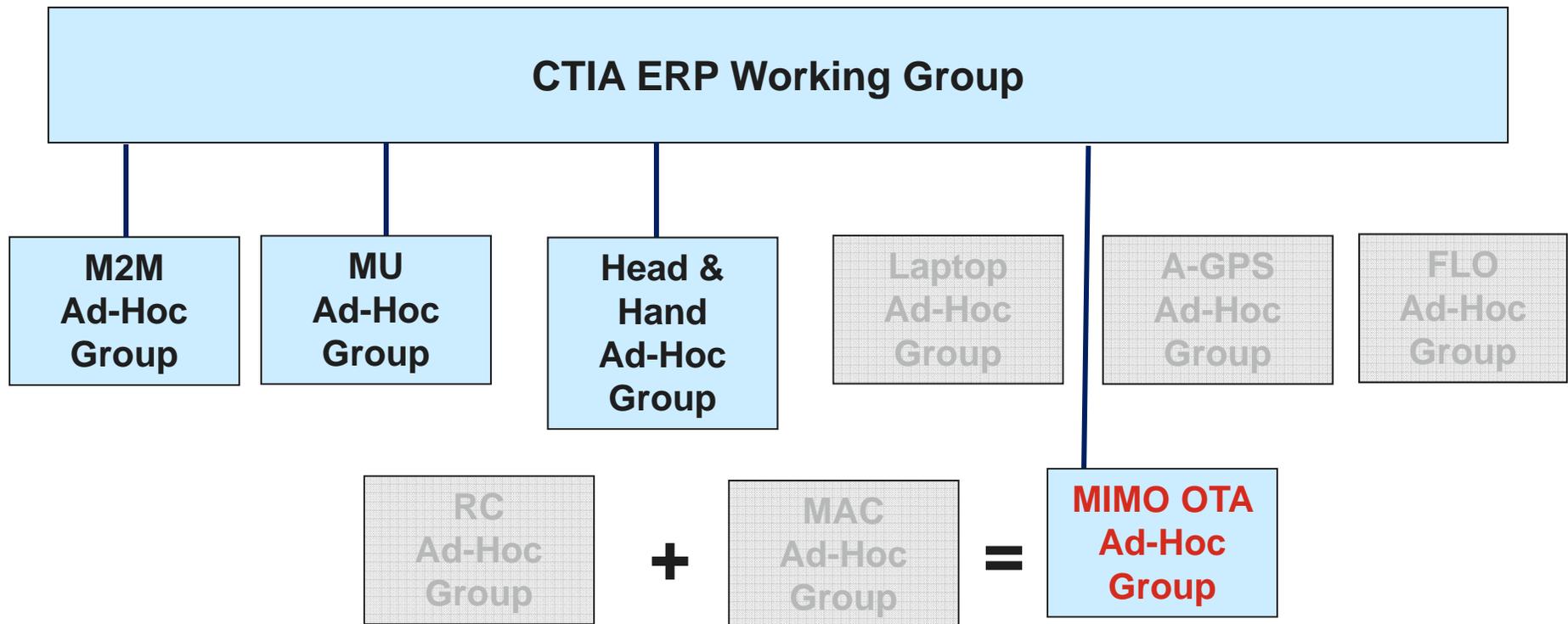
**These SGs worked on MIMO OTA**

Sub-working group are created as needed and staffed and chaired by Subject Matter Experts from CTIA member companies



# ERP Working Group and Sub-Groups

## March 2011



Sub-working group are created as needed and staffed and chaired by Subject Matter Experts from CTIA member companies

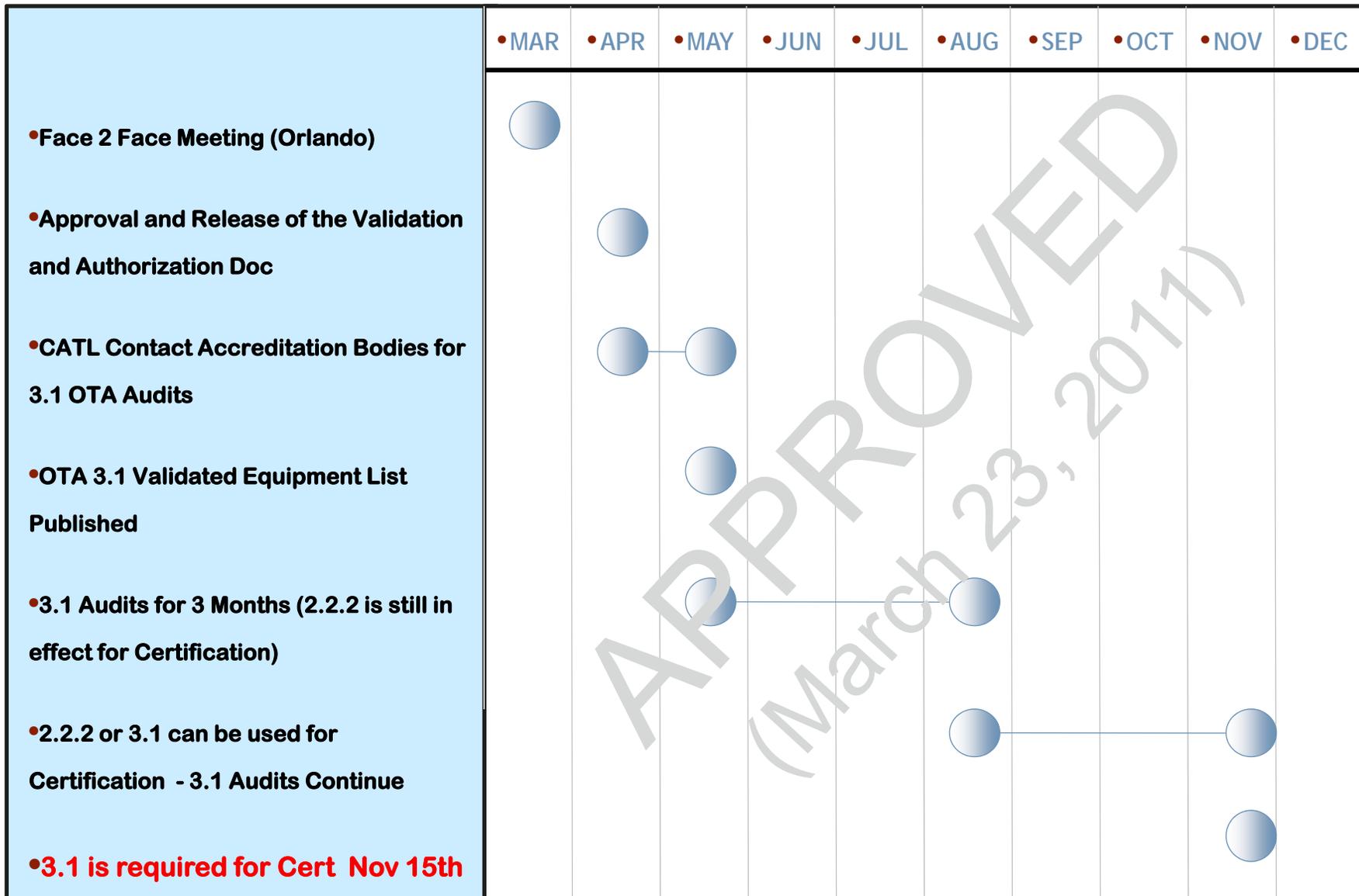


# The CTIA publishes their “Over The Air” (OTA) Test Plan

- **Release 3.0 April 2009**
  - Added hand phantom
  - Added laptop testing
  - Added A-GPS testing
- **Release 3.1 January 2011**
  - Modified hand phantom specifications



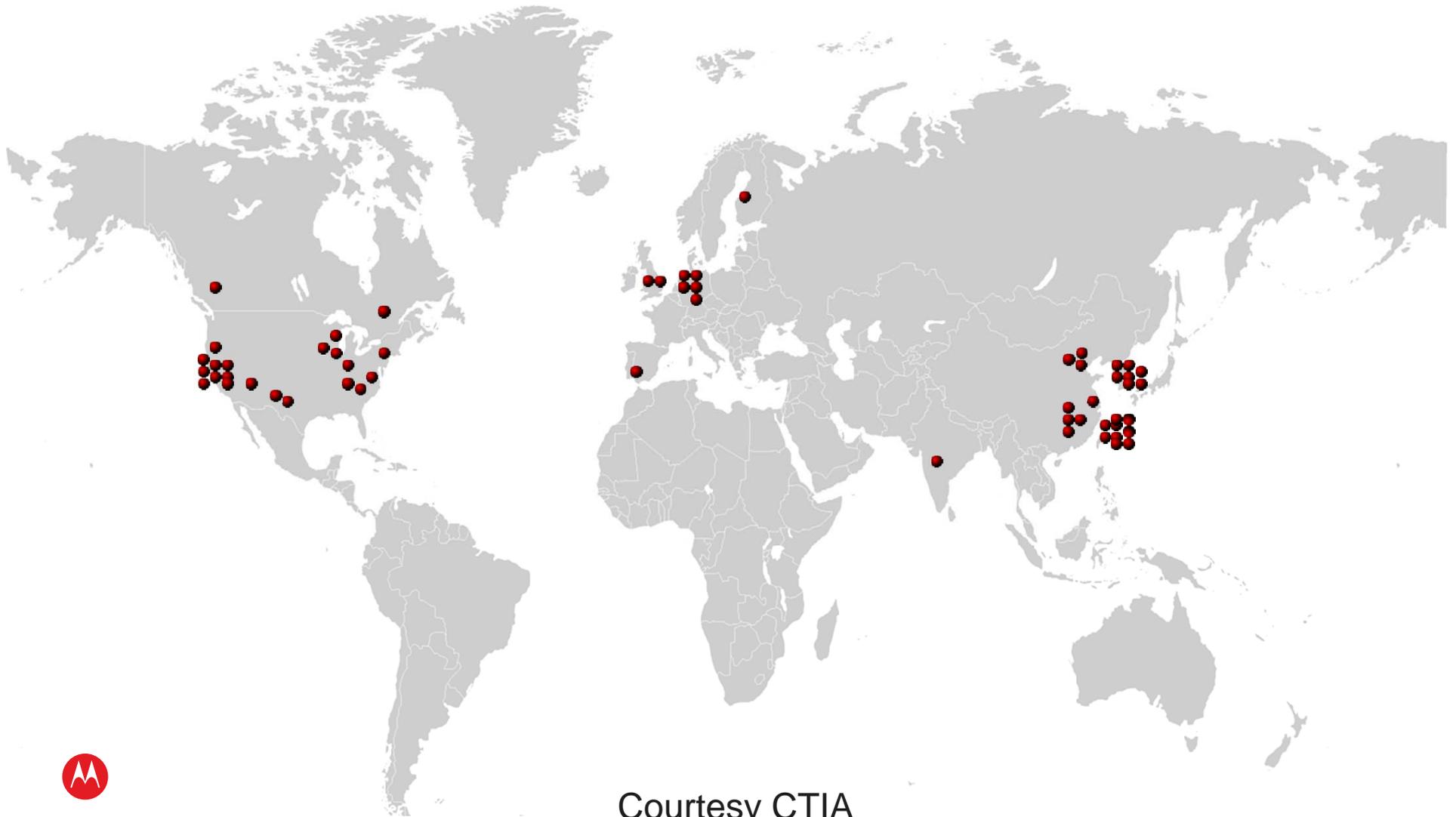
# ERP working group and v3.1 rollout schedule



APPROVED  
(March 23, 2011)



# Lab Distribution - 68 CATL's to date (March 2011)



Courtesy CTIA

# CTIA MIMO OTA Sub Group (MOSG)

## First F2F Meeting in Orlando FL, 22 March, 2011

- Co-chairs:
  - Scott Prather (AT&T) and Andy Youtz (Verizon Wireless)
- Secretary: Randy Leenerts (Nokia)
- First meeting: F2F 9am – 6pm in Orlando FL
- Future meetings:
  - Monthly conf calls
  - 2 x F2F / year (held at CTIA shows, coordinated with ERP meetings)
  - Next conf call: Monday, 16 May, 11 AM EST



# New ERP Sub-Group: MOSG (MIMO OTA SG)

## First Meeting March 22, 2011 Orlando FL

### MOSG Mission Statement:

#### **What carrier/industry needs does it support?**

US carriers are now or soon will be deploying commercial systems using the LTE radio interface with 2 x 2 downlink MIMO. The current CTIA OTA Test Plan v3.1 does not address OTA testing for devices other than SISO.

#### **How does it support the certification program?**

Downlink MIMO-capable devices will be subject to CTIA OTA certification as required by the US carriers.

#### **Will it be practical to implement in a lab environment?**

The final downlink 2 x 2 MIMO OTA test methodology shall be practical to implement in CTIA CATL labs for device certification purposes. Some labs may need to purchase new or additional equipment and software to meet the requirements of the described methodologies they choose to employ.

#### **What is the target timeframe?**

Agreement of 2 x 2 downlink MIMO OTA system performance requirements: June 30, 2011

Technical details of potential 2 x 2 downlink MIMO OTA methodologies: June 30, 2012

Draft of 2 x 2 downlink MIMO OTA Test Plan written: Oct 31, 2012

Initial release of 2 x 2 downlink MIMO OTA Test Plan: Jan 31, 2013

#### **What is the deliverable?**

The deliverable of the MIMO SG is a complete 2 x 2 downlink MIMO OTA Test Plan that is suitable for CTIA certification of LTE devices with a maximum physical dimension of 450mm, and operating in 3GPP bands 2, 4, 5, 12, 13, 14, and 17. This test plan may describe multiple 2x2 MIMO test methodologies.



# A Fresh Start in CTIA for 2x2 MIMO OTA with the MOSG

- Ground Rules:
  - All methodologies and metrics are on the table
  - First determine **what** needs to be measured,
  - Then determine **how** to measure it
- Measurement Uncertainty is a major issue
  - **IF** the OTA measurement system is not able to discern between good and bad devices, then another approach must be found
  - The carriers will have to agree on acceptable MU for the desired test parameter **before** any test method can be considered
- The OTA test methodology chosen should be directly correlated to core specifications
- The work in CTIA MOSG is separate from 3GPP and COST, but the final OTA test methodology will be applicable to LTE 2x2 MIMO in general.



# MOSG F2F Meeting, March 22, 2011 in Orlando FL

See MOSG document folder on CPWG website for full meeting notes. At: [CPWG Web Site](#)

- **LTE TRP/TIS Measurement**
  - Core specification review (conducted tests in 36.521-1)
    - Discussed only as a reference for LTE Receiver testing conditions
  - Applicability of core spec methodology to radiated testing
    - Generally agreed that 3GPP core specs are the reference to be used
  
  - **MOSG110303: *LTE TRP/TIS Test Procedure for LTE*, Nokia**
  - **MOSG110314: *LTE TRP/TIS*, Verizon**
  - **MOSG110315: *LTE Test Channels*, Verizon**
  
  - Validation of proposed TIS/TRP methodologies
    - MOSG will send proposed methodologies for final approval



# MOSG F2F Meeting, March 22, 2011 in Orlando FL

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## MOSG110303: *LTE TRP/TIS Test Procedure for LTE, Nokia*

- “3GPP has an ongoing LTE MIMO OTA measurement campaign. TRP and TRS are defined as one of the desired performance metrics for the measurement campaign. However, there is no standard way of measuring TRP and TRS of a LTE device, 3GPP TR 37.976 does not instruct how to evaluate these parameters.
- Intention of attached contribution is to define a LTE TRP/TRS test procedure that can be used for the purpose of the measurement campaign, following the guidelines of existing test methodologies, 3GPP TS 34.114 and TS 36.101. Assumption of the test is a cell edge scenario, where a LTE terminal operates in SIMO mode. MIMO performance of the terminals will to be evaluated by another test.
- The defined test is applicable to any 3GPP release 8-9 LTE device and it can be performed in existing TRP/TRS chambers, since single antenna downlink transmission mode is utilized.”



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## MOSG110314: *LTE TRP/TIS*, Verizon

- “Presently, the CTIA Test Plan for Mobile Station Over the Air Performance (v3.0) does not address the performance of LTE devices. This contribution defines test procedures for basic LTE device performance metrics (i.e. TRP, TIS, and gain balance). These metrics could be used as part of the Tier 1 testing proposed in RCSG091002. This contribution is a revised version of contribution MACSG100317-1”

Paul Moller summary: This contribution specifies the basic LTE conducted and SISO radiated FoM measurements, i.e. TRP, TIS, Gain Imbalance, complex radiation pattern in free space and phantom head.



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## MOSG110315: *LTE Test Channels, Verizon*

- “This contribution proposes test channels and RB allocations for LTE TRP and TIS testing.”
  - The embedded spreadsheet is a first pass at creating the test channel and RB allocation list for LTE. This list requires additional refinement. In particular, the ERP working group will need to discuss and address the following:
    - For TIS, are the 6 RB allocation cases necessary, i.e. is it reasonable to assume that the antenna will not have rolloff across a 5-10 MHz bandwidth so that only the full allocation cases are needed?
    - For TRP, are the 2 RB allocation cases necessary, i.e. is it reasonable to assume that the antenna will not have rolloff across a 5-10 MHz bandwidth so that only the 12 RB allocation cases are needed? (Note: The 2 RB allocation cases were added to insure PUCCH performance.)
    - Should the 10 MHz channel cases be included for Band 12? Operator option?
    - Should an intermediate channel test be required for LTE given the larger channel bandwidths?



# MOSG F2F Meeting, March 22, 2011 in Orlando FL

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- **Review of Metrics**

- R4-091995: *Figures of Merit for MIMO OTA Measurements*, 3GPP
  - This Tdoc from 3GPP was briefly reviewed
- **MOSG110311: *MIMO OTA Testing Proposal*, RCSG and MACSG Chairs**
- **MOSG110312: *MIMO OTA Industry Priorities*, Agilent**
- RCSG091002R1: *Tiered Approach to MIMO Radiated Performance Testing*, RCSG Chair
  - This contribution from the RCSG was briefly reviewed



## **MOSG F2F Meeting, March 22, 2011 in Orlando FL**

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### **MOSG110311: *MIMO OTA Testing Proposal*, RCSG and MACSG Chairs**

- For all intents and purposes, the top priority of all carriers is to determine whether or not a MIMO handset actually provides gain over a SISO device.
  - Carriers may have their own opinion as to which methodology should be employed to make this measurement
  - TRP measurement is a high priority overall
  - SISO TIS measurement is a high priority overall



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## **MOSG110312: *MIMO OTA Industry Priorities, Agilent***

After around two years of study of MIMO OTA in various industry groups this presentation summarizes industry priorities based on what we have learned so far. The scope is:

- High level criteria for MIMO OTA
- Efficacy
- Test system cost
- Test coverage
- Review of criteria affecting performance
- Measuring MIMO in median conditions
- Channel model, Doppler, spatial diversity, AMC, noise
- Review of major findings from COST2100 (HSDPA RX div)
- Thoughts on the major proposed test methods
- Anechoic
- Reverberation
- Antenna-based figure of merit and two-stage method

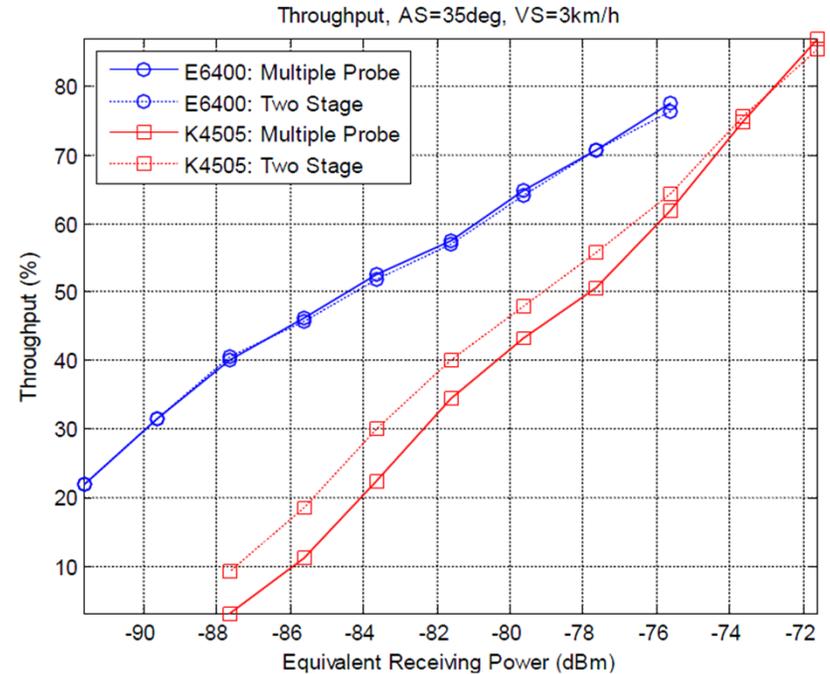
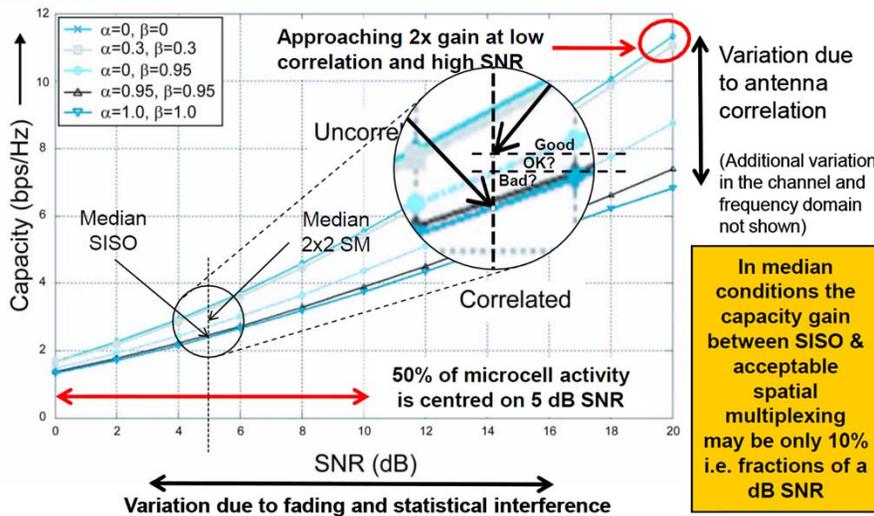


# MOSG F2F Meeting, March 22, 2011 in Orlando FL

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## MOSG110312: MIMO OTA Industry Priorities, Agilent

What should we expect from MIMO in median conditions?



# MOSG F2F Meeting, March 22, 2011 in Orlando FL

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- **RAN4 MIMO OTA Update**

- **MOSG110307: *Preliminary results of RAN4 LTE round robin test, Rohde & Schwarz***

- “This contribution presents results of the LTE round robin test shown during the recent RAN4 meeting in Taipei [1], and adds further results and analysis. In a test environment according to the two-channel method proposed by Rohde & Schwarz we evaluated the performance of the USB modems of the round robin test.”
- “The round robin measurements have shown already quite interesting results. The importance of checking the UE’s antennas under varying geometrical conditions, by including various combinations of polarizations as well as AoAs, has been shown. Also a comparison with external antennas is a good way to ensure that a proposed test method serves its purpose of distinguishing good and not so good antenna designs.”
- “Comparison of average throughput of all devices made in a 2D plane demonstrated the best MIMO antenna performance of the ZTE AL621 and the worst performance of the Samsung GT-B3740.”

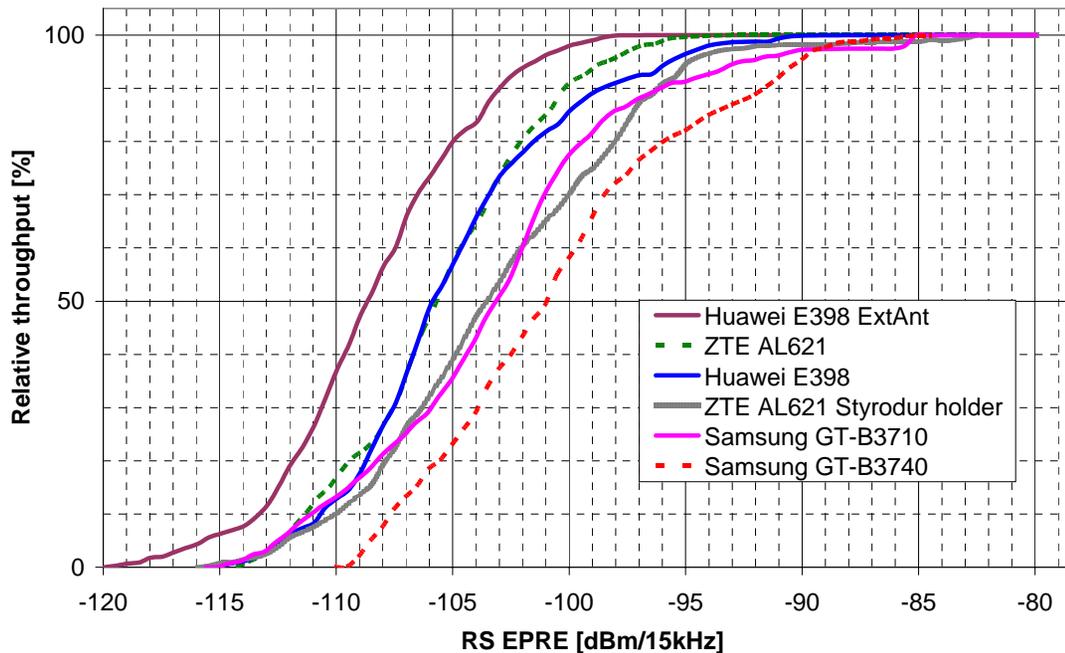


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- **RAN4 MIMO OTA Update**

- **MOSG110307: *Preliminary results of RAN4 LTE round robin test, Rohde & Schwarz***



1. Average throughput of the UEs calculated for measurement cases where the test antennas were placed in a 2D plane; all four polarization combinations



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- **Anechoic Chamber Measurement Methodologies**
  - **MOSG10306: *3D OTA Data for MIMO devices*, Rohde & Schwarz**
  - **MOSG110308: *Simplified SCME MIMO OTA test method*, Motorola Mobility**
  - **MOSG110309: *Validation of simplified SCMA MIMO OTA test method* Motorola Mobility**
  - **Michael (ETS) MOSG110319: Introduction to MIMO testing. Presenter: Michael Fogelle**



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### **MOSG10306: 3D OTA Data for MIMO devices, Rohde & Schwarz**

- “A first step towards a 3D evaluation is to change the orientation of the plane of the probe antennas with respect to the orientation of the UE. The easiest way to achieve this is a tilt angle of the UE on its turn device. When tilting the UE, the cut of the plane of the probe antennas through the unit sphere is covering different points on this sphere. Tilting the UE is easier than tilting the antenna ring by lowering the positions on one side, and raising them on the other side, with appropriate intermediate positions for the antennas in between.
- It is assumed that any single signal coming from an arbitrary spatial point will still need to be decomposed into two orthogonally polarized components. The orientation of these polarization planes, however, does not matter.
- The following series of figures indicates how this tilt angle is going to change the coordinate system of the UE with respect to the plane of the ring of probe antennas.
- Please note that we refer here to a “plane of the ring of probe antennas” even if a proposed test method might restrict this to a cluster of fewer, or even to two antennas. Therefore we define “plane of the probe antennas” as the virtual plane containing the UE and, at least, two probe antennas.”



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## **MOSG110308: *Simplified SCME MIMO OTA test method, Motorola Mobility***

- “It is theorized that a highly reduced number of subpaths per probe can be used and still retain sufficient accuracy to the original SCME model so as to be useful for OTA throughput measurements. This paper will describe the first steps taken to simplify the SCME model subpaths and then to evaluate the resultant uncertainty that is generated solely from this simplification.

### **Design of the experiment**

- This experiment was designed to evaluate the throughput error, comparing unchanged SCME channel model with a simplified version. In this experiment a set of passively measured [1] complex radiations pattern were used. The basic idea is to compare through simulations [2] the data throughput discrepancies adopting the same antenna complex radiation patterns applied to SCME and a sub-set of modified SCME channel model, which basically is represented by the SCME channel model with twenty sub-paths collapsed to the same AoA for each path. Initially for simplicity, the number of probes coincides with the number of SCM/SCME sub-paths, located on the average AoA of the respective clusters/paths, being uniformly distributed along the multi-cluster configuration, as described on figure 1.”



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## MOSG110308: *Simplified SCME MIMO OTA test method*, Motorola Mobility

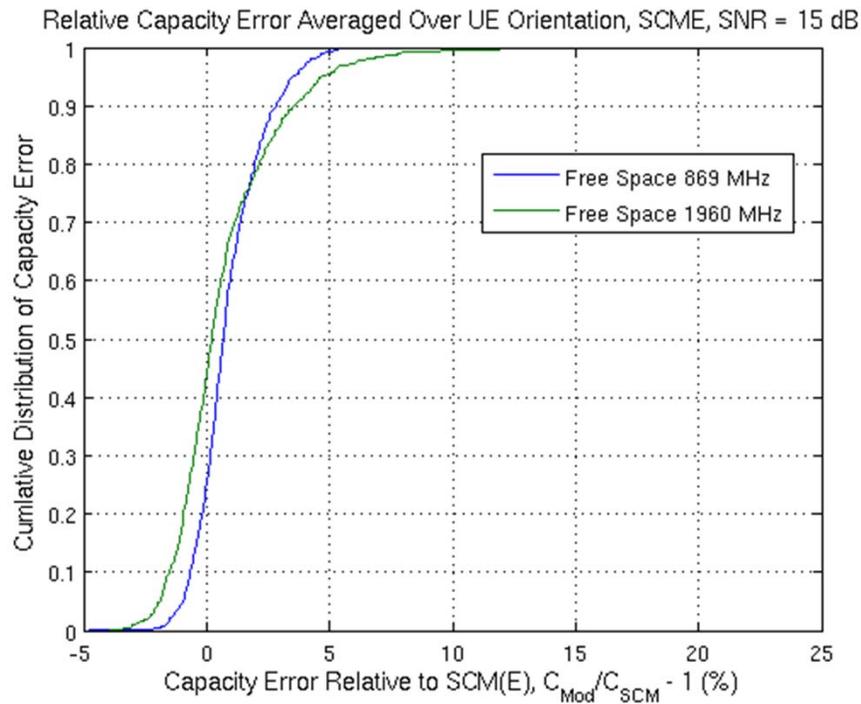


Figure 3. Relative Capacity Error Averaged over UE Orientation, SCME



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- **MOSG110309: *Validation of simplified SCMA MIMO OTA test method, Motorola Mobility***
  - “This document proposes a validation technique based on numeric emulation of predicted data throughput. The simplified SCME; or any channel model; is emulated numerically, and the predicted data throughput is calculated based on complex radiation pattern, generated through a non-intrusive method [1-4].
  - Gathering complex radiation pattern through CQI data stored in the DUT [8], enables the acquisition of magnitude and phase of antenna system, capturing the radiated and conducted DUT self-interference (desense), while avoiding measurement uncertainty probing antennas through coaxial cables [5]. The DUT complex radiation pattern is the used to predict the data throughput, adopting a post-processing algorithm [9], that follows the technical characteristics of the eNodeB agreed settings, therefore providing accurate predicted data throughput as well as antenna related FoM, such as radiated performance, magnitude of complex and envelope correlation coefficient and gain imbalance.”



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- **MOSG110319: Introduction to MIMO testing, ETS Lindgren**
  - Extensive efforts are underway to standardize on a next generation platform for wireless testing.
  - The ability to perform realistic RF environment simulation and evaluate end user metrics in real-world scenarios is an invaluable resource to wireless technology developers.
  - Detailed calibration and validation methods are required to ensure the validity of measured data.
  - While a throughput related metric is the logical choice, the industry must still choose the desired target metric (e.g. throughput sensitivity).



## **MOSG F2F Meeting, March 22, 2011 in Orlando FL**

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- **Reverberation Chamber Measurement Methodologies**
  - **MOSG110305: *LTE MIMO Throughput Measurements with Focus on Various Antenna Parameters*, Bluetest**
  - **MOSG110304: *Multipath Angle-of-Arrival in Reverberation Chambers*, NIST**
  - **MOSG110317: *A General Method for Assessing the Uncertainty in Reverberation Chamber TRP/TIS Measurements*, NIST**



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- **MOSG110305: *LTE MIMO Throughput Measurements with Focus on Various Antenna Parameters, Bluetest***
  - “This document presents results from LTE MIMO throughput measurements focused on detecting antenna performance differences. Measurements are performed in a Bluetest reverberation chamber. The measurements are performed on the dongles themselves and also when they are connected to external diversity antennas with high and low correlation.
  - LTE throughput measurements have been presented for several devices and antenna configurations. Measurements show the ability to differentiate between “good” and “bad” devices with good repeatability. It was also shown that individual antenna parameters, such as correlation and branch imbalance, can be analyzed with throughput measurements in reverberation chamber.”



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## MOSG110304: *Multipath Angle-of-Arrival in Reverberation Chambers*, NIST

- “The angle-of-arrival of multipath components impacts the performance of MIMO systems. This contribution presents experimental data to verify the assumption that the power received by a wireless device in a reverberation chamber is uniformly distributed over azimuth angle-of-arrival. The measurement procedure could also be used to evaluate techniques for manipulating the angle-of-arrival of multipath components so as to emulate spatial channel models for different environments.”
- Conclusions:
  - A moving antenna will stir the field.
  - Must quantify antenna scattering for synthetic aperture measurements.
  - Paddle stirring changes the *observed* angle-of-arrival of multipath.
  - New paddle position = new channel realization.
  - Incident power is uniformly distributed over azimuth.

Next steps:

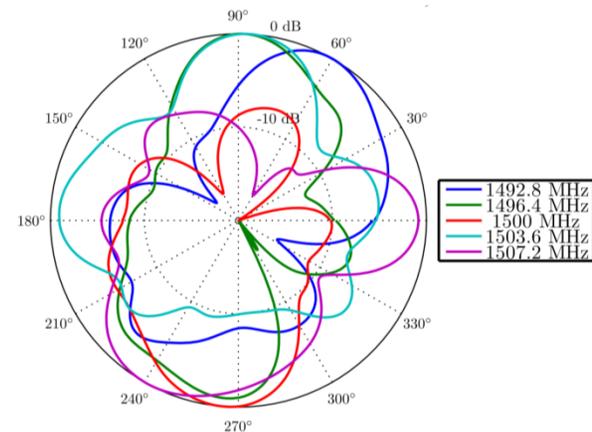
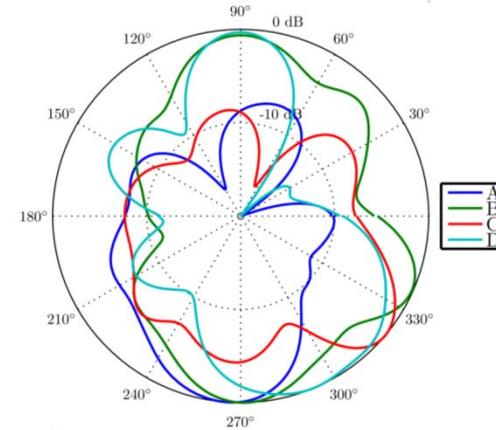
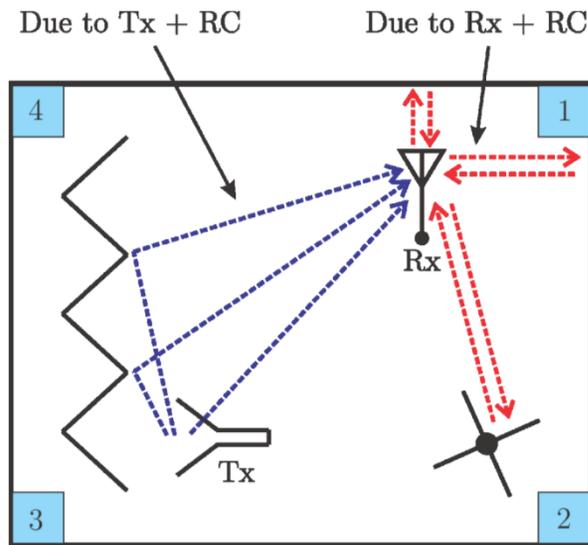
- Determine how to manipulate angle-of-arrival statistics to emulate urban micro, urban macro, etc.



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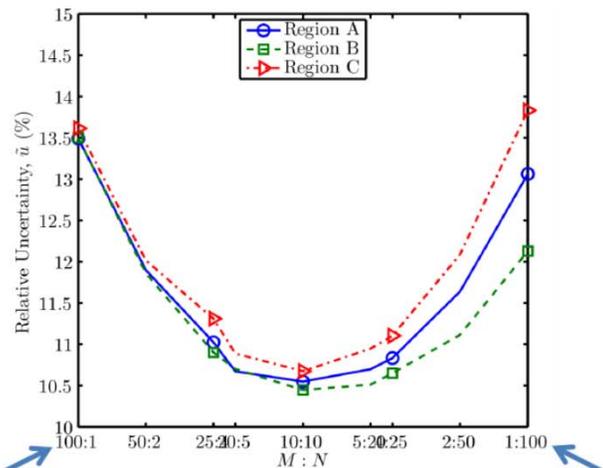


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## MOSG110317: A General Method for Assessing the Uncertainty in Reverberation Chamber TRP/TIS Measurements, NIST

“A range of factors can influence the uncertainty in reverberation chamber measurements. This contribution presents a general method for characterizing and minimizing measurement uncertainty and measurement time that is applicable to any reverberation chamber regardless of which mode-stirring techniques are used.”



$M=100$  antenna positions

$N=100$  paddle positions

$M$ Antenna Positions	1	2	4	5	10	20	25	50	100
$N$ Paddle positions	100	50	25	20	10	5	4	2	1

- A secondary question:
  - Are 100 samples created equally?
  - Which combination is best?
- Must characterize YOUR chamber.
  - Requires a comprehensive sweep of all combinations of measurement parameters.
  - Can be done once to decide on optimal combination, then use this combination for each calibration



# **MOSG OTA Test Plan Development**

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