

---

# Over-the-Air (OTA) Testing

---

— Journal Publications —

- [J1] Rajesh K. Sharma, Wim Kotterman, Markus H. Landmann, Christopher Schirmer, Christian Schneider, Frank Wollenschläger, Giovanni Del Galdo, Matthias A. Hein, and Reiner S. Thomä. Over-the-air testing of cognitive radio nodes in a virtual electromagnetic environment. *International Journal of Antennas and Propagation*, 2013(945283):1–16, 2013. doi:10.1155/2013/945283.
- [J2] Moray Rumney, Ryan Pirkel, Markus Landmann, and David A. Sanchez-Hernandez. MIMO over-the-air research, development, and testing. *International Journal of Antennas and Propagation, Special Issue on MIMO Over-The-Air Research, Development, and Testing*, 2012. doi:10.1155/2012/467695.

— Conference Publications —

- [C1] Matthias A. Hein, Christian Bornkessel, Wim Kotterman, Christian Schneider, Rajesh K. Sharma, Frank Wollenschläger, Reiner S. Thomä, Giovanni Del Galdo, and Markus Landmann. Emulation of virtual radio environments for realistic end-to-end testing for intelligent traffic systems. In *2015 IEEE MTT-S International Conference on Microwaves for Intelligent Mobility (ICMIM)*, Heidelberg, April 2015. doi:10.1109/ICMIM.2015.7117934.
- [C2] Rajesh K. Sharma, Christian Schneider, Wim Kotterman, Gerd Sommerkorn, Peter Grosse, Frank Wollenschläger, Giovanni Del Galdo, Matthias A. Hein, and Reiner S. Thomä. Virtual electromagnetic environment for over-the-air testing of car-to-car and car-to-infrastructure communication. In *XXXIth URSI General Assembly and Scientific Symposium (URSI GASS)*, Beijing, PR China, August 2014. doi:10.1109/URSIGASS.2014.6929561.
- [C3] Christopher Schirmer, Markus Landmann, Wim Kotterman, Gregor Siegert, Alexander Rügamer, Giovanni Del Galdo, and Albert Heuberger. Real world GNSS test environment under laboratory conditions. In *International Symposium on Certification of GNSS Systems & Services (CERGAL)*, Dresden, Germany, pages 25–31, July 2014.
- [C4] Christopher Schirmer, Wim Kotterman, Gregor Siegert, Alexander Rügamer, Giovanni Del Galdo, Albert Heuberger, and Markus Landmann. Accuracy of an OTA system emulating a realistic 3D environment for GNSS and multi-satellite receiver testing. In *IEEE 8th Sensor Array and Multichannel Signal Processing Workshop (SAM)*, pages 113–116, A Coruña, Spain, June 2014. doi:10.1109/SAM.2014.6882353.
- [C5] Wim Kotterman, Christopher Schirmer, Markus Landmann, and Giovanni Del Galdo. On arranging dual-polarised antennas in 3D wave field synthesis. In *8th European Conference on Antennas and Propagation (EuCAP)*, pages 3406–3410, The Hague, Netherlands, April 2014. doi:10.1109/EuCAP.2014.6902560.
- [C6] Christopher Schirmer, Markus Landmann, Wim Kotterman, Matthias Hein, Reiner S. Thomä, Giovanni Del Galdo, and Albert Heuberger. 3D wave-field synthesis for testing of radio devices. In *8th European Conference on Antennas and Propagation (EuCAP)*, pages 3394–3398, The Hague, Netherlands, April 2014. doi:10.1109/EuCAP.2014.6902557.
- [C7] Rajesh K. Sharma, Christian Schneider, Wim Kotterman, Gerd Sommerkorn, Peter Grosse, Frank Wollenschläger, Giovanni Del Galdo, Matthias A. Hein, and Reiner S. Thomä. Over-the-air testing

- of car-to-car and car-to-infrastructure communication in a virtual electromagnetic environment. In *IECON 2013 - 39th Annual Conference of the IEEE Industrial Electronics Society*, pages 6897–6902, Vienna, Austria, November 2013. doi:10.1109/IECON.2013.6700275.
- [C8] Gregor Siegert, Giovanni Del Galdo, Franziska Klier, Johannes Mahry, Günter Rohmer, Alexander Rügamer, and Markus Landmann. Multi-directional over the air testbed for robustness testing of GNSS receivers against jammers and spoofers. In *AIAA International Communications Satellite System Conference (ICSSC)*, Florence, Italy, October 2013. doi:10.2514/6.2013-5612.
- [C9] Alexander Rügamer, Giovanni Del Galdo, Johannes Mahr, Günter Rohmer, Gregor Siegert, and Markus Landmann. GNSS over-the-air testing using wave field synthesis. In *ION GNSS 2013*, Nashville, Tennessee, USA, September 2013.
- [C10] Markus Landmann, Marcus Grossmann, Naveen Phatak, Christian Schneider, Reiner Thomae, and Giovanni Del Galdo. Performance analysis of channel model simplifications for MIMO OTA LTE UE testing. In *7th European Conference on Antennas and Propagation (EuCAP)*, pages 1856–1860, Gothenburg, Sweden, April 2013. URL: <http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=6546610>.
- [C11] Wim Kotterman. Increasing the volume of test zones in anechoic chamber MIMO over-the-air test set-ups. In *International Symposium on Antennas and Propagation (ISAP)*, pages 786–789, Nagoya, Japan, October 2012. URL: <http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=6393972>.
- [C12] Michael Grimm, Alexander Krahe, Noman Murtaza, Rajesh Kumar Sharma, Markus Landmann, Reiner Thomä, Albert Heuberger, and Matthias Hein. Performance evaluation of directional spectrum sensing using an over-the-air testbed. In *CogART '11 Proceedings of the 4th International Conference on Cognitive Radio and Advanced Spectrum Management*, pages 1–5, Barcelona, Spain, October 2011. doi:10.1145/2093256.2093273.
- [C13] Alexander Krahe, Michael Grimm, Noman Murtaza, Wim Kotterman, Markus Landmann, Albert Heuberger, Reiner Thomä, and Matthias Hein. Over-the-air test strategy and testbed for cognitive radio nodes. In *URSI General Assembly Scientific Symposium*, Istanbul, Turkey, August 2011. doi:10.1109/URSIGASS.2011.6050532.
- [C14] Wim Kotterman, Markus Landmann, Albert Heuberger, and Reiner Thomä. New laboratory for over-the-air testing and wave field synthesis. In *URSI General Assembly Scientific Symposium*, Istanbul, Turkey, August 2011. doi:10.1109/URSIGASS.2011.6050580.
- [C15] Wim Kotterman, Albert Heuberger, and Reiner Thomä. On the accuracy of synthesised wave fields in MIMO-OTA setups. In *5th European Conference on Antennas and Propagation (EuCAP)*, pages 2560–2564, Rome, April 2011. URL: <http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=5782072>.
- [C16] Martin Käske, Christian Schneider, Wim Kotterman, and Reiner Thomä. Solving the problem of choosing the right MIMO measurement antenna: Embedding/de-embedding. In *5th European Conference on Antennas and Propagation (EuCAP)*, pages 2551–2555, Rome, 11-15 April 2011. URL: <http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=5782070>.

— Other Publications —

- [O1] Wim Kotterman, Markus Landmann, Horst Heringklee, Rainer Perthold, Matthias Hein, Reiner Thomä, and Giovanni Del Galdo. Realistic testing of operational radio communications from and to vehicles in virtual electromagnetic environments. In *6th ETSI Workshop on Intelligent Transport Systems*, Berlin, Germany, February 2014.
- [O2] Wim Kotterman and Giovanni Del Galdo. Influence of complex amplitude errors on the quality of synthesised wave fields. Technical Report COST IC1004 TD(13)07054, COST IC1004 action, Ilmenau, Germany, May 2013.
- [O3] Rajesh Kumar Sharma, Christian Schneider, Wim Kotterman, Frank Wollenschläger, Giovanni Del Galdo, Matthias A. Hein, and Reiner S. Thomä. Over-the-air testing: An overview of the ongoing activities in ilmenau. Technical Report IC1004 TD(13)07039, COST IC1004 action, Ilmenau, Germany, May 2013.
- [O4] Alexander Krahl, Michael Grimm, Noman Murtaza, Wim Kotterman, Rajesh Sharma, Markus Landmann, Albert Heuberger, Reiner Thomä, and Matthias Hein. Over-the-air test strategy and testbed for cognitive radio nodes. Technical report, COST IC0902 action, Castelldefels/Barcelona, Spain, October 2011. URL: [http://ic0902-workshop2011.cttc.es/images/WS\\_Abstracts/wg1-krahl.pdf](http://ic0902-workshop2011.cttc.es/images/WS_Abstracts/wg1-krahl.pdf), doi:10.1109/URSIGASS.2011.6050532.
- [O5] Wim Kotterman, Albert Heuberger, and Reiner Thomä. On the accuracy of synthesised wave fields in MIMO-OTA setups. Technical Report COST2100 TD(12)12070, COST 2100 action, Bologna, Italy, November 2010.
- [O6] Martin Käske, Christian Schneider, Wim Kotterman, and Reiner Thomä. Solving the problem of choosing the right MIMO measurement antenna: Embedding/de-embedding. Technical Report COST2100 TD(12)12081, COST 2100 action, Bologna, Italy, November 2010.
- [O7] Wim Kotterman, Alexander Krahl, Markus Landmann, Albert Heuberger, and Reiner Thomä. Over-the-air test vision for cognitive radio nodes. Technical Report TERRA-WG2(11)03, COST IC0905 TERRA action, Lisbon, Portugal, January 2011. URL: [http://www.univis.uni-erlangen.de/formbot/dsc\\_3Danew\\_2Fpub\\_view\\_26pubs\\_3D2010\\_3Atech\\_2FIE\\_2Fkomele\\_2Ftuilme\\_26dir\\_3Dtech\\_2FIE\\_2Fkomele\\_26ref\\_3Dpub\\_26years\\_3Dall](http://www.univis.uni-erlangen.de/formbot/dsc_3Danew_2Fpub_view_26pubs_3D2010_3Atech_2FIE_2Fkomele_2Ftuilme_26dir_3Dtech_2FIE_2Fkomele_26ref_3Dpub_26years_3Dall).
- [O8] Wim Kotterman, Alexander Krahl, Albert Heuberger, and Reiner Thomä. TU Ilmenau’s participation in the OTA HSDPA Round Robin. Technical Report COST2100 TD(11)11059, COST 2100 action, Aalborg, Denmark, June 2010. URL: [http://univis.uni-erlangen.de/formbot/dsc\\_3Danew\\_2Fpub\\_view\\_26pubs\\_3D2010\\_3Atech\\_2FIE\\_2Fkomele\\_2Ftuilme\\_26dir\\_3Dtech\\_2FIE\\_2Fkomele\\_26lang\\_3Den\\_26ref\\_3Dpub\\_26years\\_3Dall](http://univis.uni-erlangen.de/formbot/dsc_3Danew_2Fpub_view_26pubs_3D2010_3Atech_2FIE_2Fkomele_2Ftuilme_26dir_3Dtech_2FIE_2Fkomele_26lang_3Den_26ref_3Dpub_26years_3Dall).
- [O9] Alexander Krahl, Michael Grimm, Noman Murtaza, Markus Landmann, Albert Heuberger, and Reiner Thomä. OTA-test of a frequency- and space-selective cognitive radio node in receive mode. Technical Report COST2100 TD(10)12087, COST 2100 action, Bologna, Italy, November 2010. URL: [http://univis.uni-erlangen.de/formbot/dsc\\_3Danew\\_2Fpub\\_view\\_26pubs\\_3D2010\\_3Atech\\_2FIE\\_2Fkomele\\_2Fotates\\_26dir\\_3Dtech\\_2FIE\\_2Fkomele\\_26lang\\_3Den\\_26ref\\_3Dpub\\_26years\\_3Dall](http://univis.uni-erlangen.de/formbot/dsc_3Danew_2Fpub_view_26pubs_3D2010_3Atech_2FIE_2Fkomele_2Fotates_26dir_3Dtech_2FIE_2Fkomele_26lang_3Den_26ref_3Dpub_26years_3Dall).

— Master Theses —

- [M1] Ramona Brochloß-Gerner. Untersuchungen der Radiated Two Stage Methode in Hinsicht ihrer Genauigkeit und der Fähigkeit realistische Ausbreitungsbedingungen zu emulieren. Master thesis, Technische Universität Ilmenau, 2017. The work was carried out at Fraunhofer IIS.

- [M2] Robert Damm. Entwicklung und Implementierung eines MIMO-OTA-Kalibrationsverfahren. Master thesis, Fraunhofer Institut für Integrierte Schaltungen IIS, 2015. The work was carried out at Fraunhofer IIS.
- [M3] Henning Priebes. In-situ Calibration for Electromagnetic Wave Field Synthesis. Master thesis, Technische Universität Ilmenau, 2014.
- [M4] Usman Sherwani. Channel modeling and measurements for wireless sensor nodes in critical channel conditions. Master thesis, Technische Universität Ilmenau, 2014. The work was carried out at Fraunhofer IIS.
- [M5] Sher Ali Cheema. Performance Analysis of 3GPP LTE-A transmission modes with emulated MIMO channels in a multi-probe OTA testing Setup. Master thesis, Technische Universität Ilmenau, 2013. The work was carried out at Fraunhofer IIS.
- [M6] Naveen Phatak. Minimum emulation requirements for over the air LTE user equipment test. Master thesis, Technische Universität Ilmenau, 2012. The work was carried out at Fraunhofer IIS.

— Bachelor Theses —

- [B1] Christian Steinmetz. Entwurf einer GSM-R-Gruppenantenne zur Richtungsschätzung. Bachelor thesis, Technische Universität Ilmenau, 2014. The work was carried out at Fraunhofer IIS.
- [B2] Robert Damm. Bestimmung parasitärer Reflektionen in einem OTA Wellefeldsynthese Aufbau unter Anwendung von Parameterschätzalgorithmen. Bachelor thesis, Technische Universität Ilmenau, 2013.

## SatCom-on-the-Move (SOTM) Testing

— Conference Publications —

- [C1] Gregor Siegert, Wolfgang Felber, Florian Rasche, Mostafa Alazab, Dirk Ogermann, Andreas Knopp, and Markus Landmann. Advances of far field test range for satcom on-the-move terminals. In *7th Advanced Satellite Multimedia Systems Conference and the 13th Signal Processing for Space Communications Workshop (ASMS/SPSC)*, pages 428–435, Livorno, Italy, September 2014. doi:10.1109/ASMS-SPSC.2014.6934578.
- [C2] Gregor Siegert, Giovanni Del Galdo, Florian Raschke, Gerold Jäger-Waldau, and Markus Landmann. SOTM terminal testing under real-world conditions. In *AIAA International Communications Satellite System Conference (ICSSC)*, Florence, Italy, October 2013. doi:10.2514/6.2013-5690.
- [C3] Mostafa Alazab, Giovanni Del Galdo, Wolfgang Felber, Florian Raschke, Gregor Siegert, and Markus Landmann. Performance comparison of antenna de-pointing estimation methods for SOTM terminal testing. In *AIAA International Communications Satellite System Conference (ICSSC)*, Florence, Italy, October 2013. doi:10.2514/6.2013-5693.
- [C4] Gregor Siegert, Giovanni Del Galdo, Florian Raschke, Gerold Jäger-Waldau, and Markus Landmann. SOTM terminal testing under real-world conditions. In *ESA Antenna Workshop*, ESTEC, Noordwijk, The Netherlands, September 2013.
- [C5] Mostafa Alazab, Giovanni Del Galdo, Wolfgang Felber, Florian Raschke, Gregor Siegert, and Markus Landmann. Comparison of SOTM antenna pointing accuracy estimation methods. In *ESA Antenna Workshop*, ESTEC, Noordwijk, The Netherlands, September 2013.

- [C6] Mostafa Alazab, Marie Rieche, Markus Landmann, and Giovanni Del Galdo. Realistic emulation of the operational environment for satcom on-the-move (SOTM) terminals. In *IEEE-APS Topical Conference on Antennas and Propagation in Wireless Communications (APWC)*, Torino, Italy, September 2013.
- [C7] Mostafa Alazab, Giovanni Del Galdo, Wolfgang Felber, Albert Heuberger, Mario Lorenz, Florian Raschke, Gregor Siegert, and Markus Landmann. SOTM terminals evaluation under realistic conditions. In *IEEE 77th Vehicular Technology Conference (VTC2013-Spring)*, Dresden, Germany, June 2013.
- [C8] Mostafa Alazab, Wolfgang Felber, Giovanni Del Galdo, Albert Heuberger, Mario Lorenz, Markus Mehnert, Florian Raschke, Gregor Siegert, and Markus Landmann. Pointing accuracy evaluation of SOTM terminals under realistic conditions. In *34rd ESA Antenna Workshop on Challenges for Space Antenna Systems*, ESTEC, Noordwijk, The Netherlands, October 2012. ESA. URL: [http://univis.uni-erlangen.de/formbot/dsc\\_3Danew\\_2Fpub\\_view\\_26pubs\\_3D2012\\_3Atech\\_2FIE\\_2Fkomele\\_2Fpointi\\_26dir\\_3Dtech\\_2FIE\\_2Fkomele\\_26lang\\_3Den\\_26ref\\_3Dpub\\_26years\\_3Dall](http://univis.uni-erlangen.de/formbot/dsc_3Danew_2Fpub_view_26pubs_3D2012_3Atech_2FIE_2Fkomele_2Fpointi_26dir_3Dtech_2FIE_2Fkomele_26lang_3Den_26ref_3Dpub_26years_3Dall).
- [C9] Markus Landmann, Albert Heuberger, Markus Mehnert, Wolfgang Felber, Mario Lorenz, Florian Raschke, and Gregor Siegert. On earth realistic testing of satellite communication terminals on the move. In *33rd ESA Antenna Workshop on Challenges for Space Antenna Systems*, ESTEC, Noordwijk, The Netherlands, October 2011. ESA.
- [C10] Mario Lorenz, Markus Mehnert, and Albert Heuberger. Measurements of mechanical disturbances of vehicle mounted, mobile very small aperture terminals (VSAT). In *Proceedings of the 11th Workshop Digital Broadcasting*, pages 61–65, Erlangen, Germany, September 2010. URL: <http://publica.fraunhofer.de/documents/N-179359.html>.

— Other Publications —

- [O1] Florian Raschke. KASYMOSA - Ka-Band-Systeme für die mobile Satellitenkommunikation. In *GO-SATCOM 2015*, Neubiberg, Germany, October 2015. Abstract + Talk (no paper).
- [O2] Mostafa Alazab, Florian Raschke, Giovanni Del Galdo, and Markus Landmann. Conditions for satcom on-the-move (sotm) testing and type approving. In *GOSATCOM 2015*, Neubiberg, Germany, October 2015. Abstract + Talk (no paper).
- [O3] Mostafa Alazab, Florian Raschke, Giovanni Del Galdo, Colin Robinson, Martin Jarrold, David Hartsorn, Rolv Midthassel, and Markus Landmann. On standardizing conditions for SOTM testing and type approving. In *36th ESA Antenna Workshop on Antennas and RF Systems for Space Science*, ESTEC, Noordwijk, October 2015. Abstract + Poster (no paper).

— Master Theses —

- [M1] Niklas Beuster. Development of calibration procedures for a satellite communication test range. Master thesis, Technische Universität Ilmenau, 2015. The work was carried out at Fraunhofer IIS.
- [M2] Stefan Dornheim. Magnetic field emulation for mobile satellite communication terminals - concept, design and verification. Master thesis, Technische Universität Ilmenau, 2014. The work was carried out at Fraunhofer IIS.
- [M3] Johannes Mahr. Untersuchung der Abhängigkeiten zwischen Fahrzeugschütterungen und begleitenden Bildinformationen. Master thesis, Technische Universität Ilmenau, 2012. The work was carried out at Fraunhofer IIS.

- [M4] Mostafa Alazab. Measurement Setup for Antenna Depointing Estimation – Testing Satellite Communication On-The-Move (SOTM) Earth Terminals at the Fraunhofer Test Facility. Master thesis, Technische Universität Ilmenau, 2012. The work was carried out at Fraunhofer IIS.
- [M5] Gregor Siegert. Anforderungen an die Dynamik von mobiler Satellitenkommunikation. Diplom thesis, Technische Universität Ilmenau, 2010. The work was carried out at Fraunhofer IIS.
- [M6] Florian Raschke. Vergleichende Untersuchungen von Satellitenstrecken an einem experimentellen Aufbau im Ku- und Ka-Band. Diplom thesis, Technische Universität Ilmenau, 2010. The work was carried out at Fraunhofer IIS.

— **Bachelor Theses** —

- [B1] Volker Henze. Research on performance evaluation metrics for mobile satellite communication networks. Bachelor thesis, Technische Universität Ilmenau, 2015. The work was carried out at Fraunhofer IIS.
- [B2] Lukas Treybig. Konzeption und Verifikation einer Satellitenemulation für Ku- und Ka-Band-Satelliten. Bachelor thesis, Technische Universität Ilmenau, 2012. The work was carried out at Fraunhofer IIS.