

# LTE over Satellite System Study

System Demonstration: November 14-15, 2016





## Welcome Note

Dear valued Guests,

welcome to the Chair of Signal Processing and the Institute of Information Technology located at the Universität der Bundeswehr München. We are delighted being able to present you the results of our system study on Long Term Evolution (LTE-4G) networks for military tactical and long-haul communications.

With the advent of cyber-attacks, information warfare and terrorist threat situations, the Bundeswehr is facing yet unknown challenges with respect to the necessary evolution of their C4ISR portfolio and equipment. For a seamless transition of information, be it sensor data, voice, video, or even effector commands, a reliable and secure communication network is the key prerequisite. This core communication network is the physical link between various devices acting in different communication channels in terms of bandwidth, data rate and type of content. Moreover, since effective cyber security must start on the physical layer, this core network is among the most security-critical resource worthy of protection. At the same time, users want to access the network with various devices from literally different centuries in terms of their design age, at any time and from any place in the world. Bringing all these aspects together is among the most complex and challenging missions ever to be accomplished by the Bundeswehr's procurement agency.

In this context, we as a research institution of the Bundeswehr want to contribute to the technical knowledge and the assessment capabilities of the BAAINBw's project team. We are proud of having been awarded the design study "LTE over Satellite" to explore the benefits and drawbacks of a 4G-based core network in MILCOM situations. In this study it has been our ultimate goal to develop and compile an LTE based network that does not only focus on a tactical scenario in the battlefield but also incorporates a long-haul satellite link. Although the LTE standard has always been a prominent candidate for next-generation tactical communications due to its flexibility, scalability and mature technology, the standard finds its origin in cellular mobile networks rather than in military scenarios. Consequently, it has been our objective to raise and, possibly, answer the most important questions arising when a commercial LTE network is connected to other communication means like SATCOM on the Move terminals, fixed satellite links or even legacy equipment. In order to evaluate the network, together with our sponsors in the BAAINBw we have configured a bunch of exemplary scenarios that we believe might be meaningful to the daily business in the military. Throughout the study we have gained a lot of experience and insight not only into the "bits and pieces" of such a system but especially into the problems and issues that are yet unsolved in military off-the shelf products.

Today we are glad to present our results to the audience of military and commercial practitioners, having followed our invitation. This success would not have been possible without the excellence and effort contributed by our partners from research and industry. All of them have been carefully selected; they are in the peer groups of their respective fields of expertise. Our partners have contributed with their knowledge, experience, as well as their latest technologies, making this study a success despite of challenging timeline and budget constraints. On behalf of our institute as well as our project partners we want to thank you for your interest in our study, and we appreciate your feedback. Looking forward to some exciting hours and many fruitful discussions, we invite you to approach us with whatever question you might have!

Welcome again!

Prof. Dr.-Ing. Andreas Knopp  
Chair Holder

Robert Schwarz  
Study Coordinator



## Agenda

Monday, 14<sup>th</sup> November

- 14:00 h: Opening remarks
- 14:15 h: Results Presentation of "LTE over Satellite".
- 14:45 h: Briefing into the Demonstration.
- 15:00 h: Institute / Showcases Guided Tour
- 15:30 h: *Coffee break*
- 16:00 h: Start of the Demonstration Campaign
- 18:00 h: End of Day One.
- 18:30 h: *Dinner* at the University-Casino.

Tuesday, 15<sup>th</sup> November

- 08:30 h: Demonstration Campaign (cont'd)
- 12:00 h: *Lunch break*
- 13:00 h: Concluding Remarks on the "LTE over Satellite" Demo
- 13:15 h: Add-on Showcase: Operation of MPM Modems  
„L-3 Com Linkabit in SOTM Environment “.
- 15:00 h: Conclusion of the Event



## LTE over Satellite Study in a Nutshell

**The missions which the Bundeswehr undertakes around the globe require the development of highly mobile and tactical communication networks with very short preparation times in many cases. These networks can seamlessly be integrated in to long-haul communication links by using Bundeswehr-owned satellites. The “LTE over Satellite” system study, led by the Bundeswehr University, Munich, addresses possible solution approaches.**

A core requirement underlying the modern-day operational principles of the Bundeswehr is the provisioning of broadband voice and data communication between the operations support coordination center and forces on out-of-area deployment. Air-dropped and mobile forces operate on foot or in vehicles, and they need flexible and dynamically reconfigurable communication solutions that also incorporate long-haul satellite links with SATCOM on-the-Move (SOTM) terminals.

The mobile command vehicle would incorporate a complete Long Term Evolution (LTE) network and an SOTM terminal for the long-haul connection to the mission network. In such a scenario the terrestrial communication network should remain independently operational even if the satellite link is disrupted. A further requirement of the Bundeswehr is to centrally integrate the security related LTE core network components, such as the Home Subscriber Server (HSS) in the secure operations support coordination center. In the event of the command vehicle being compromised, important information or even control of the LTE network might otherwise fall completely into enemy hands.

Therefore, the distributed LTE core network components have to cope with the typically long delays of geostationary satellite links and much lower data rates in comparison with the terrestrial links. The possibilities and constraints regarding the implementation of an end-to-end quality-of-service (QoS) concept also presents a major challenge. Hence, there is a need to harmonize the QoS models of the satellite, LTE and terrestrial network. With this in mind, the Institute for Information Technology of the Bundeswehr University, Munich (UniBwM), is conducting the “LTE over Satellite” system study on behalf of the Federal Office of Bundeswehr's equipment, information technology and in-service support. The UniBwM heads a consortium that includes the Fraunhofer institute of integrated circuits IIS, the blackned GmbH and the INRADIOS GmbH. The project team is also supported by the Bundeswehr Communication and Information Systems School in Feldafing.

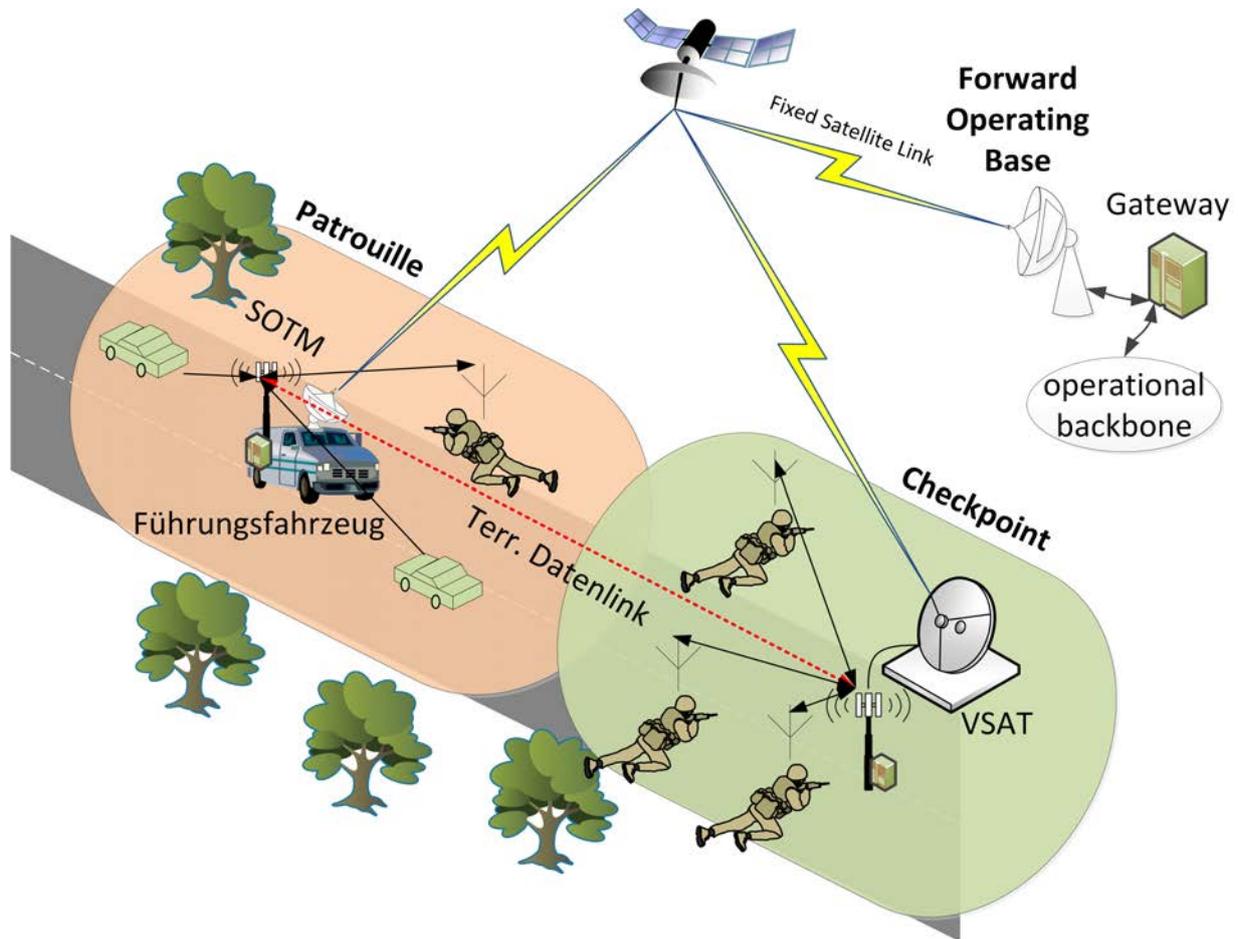
It is for the first time in a R&D that a holistic approach is being taken in the design of hybrid satellite and terrestrial networks, based on the results of the SOTM system performance analysis.

Once the system design phase has been completed, a practical demonstration on the feasibility of the developed solution approaches will follow in the second half of 2016 at the UniBwM. A communication scenario will be demonstrated in which a mobile and a stationary LTE network are interconnected via satellite link, enabling the IP-based data traffic between the command vehicles, a drone and the dismounted soldiers carrying LTE equipment.

First laboratory trials involving the Bundeswehr's Wideband Broadcast Access (WBA) SATCOM network have yielded promising results. Altogether, the “LTE over Satellite” system study will demonstrate essential aspects of a comprehensive mobile tactical communication solution approach and thus provide decision-makers in the Bundeswehr with information that is useful for the current procurement initiatives.



## LTE over Satellite: The Reference Use-Case



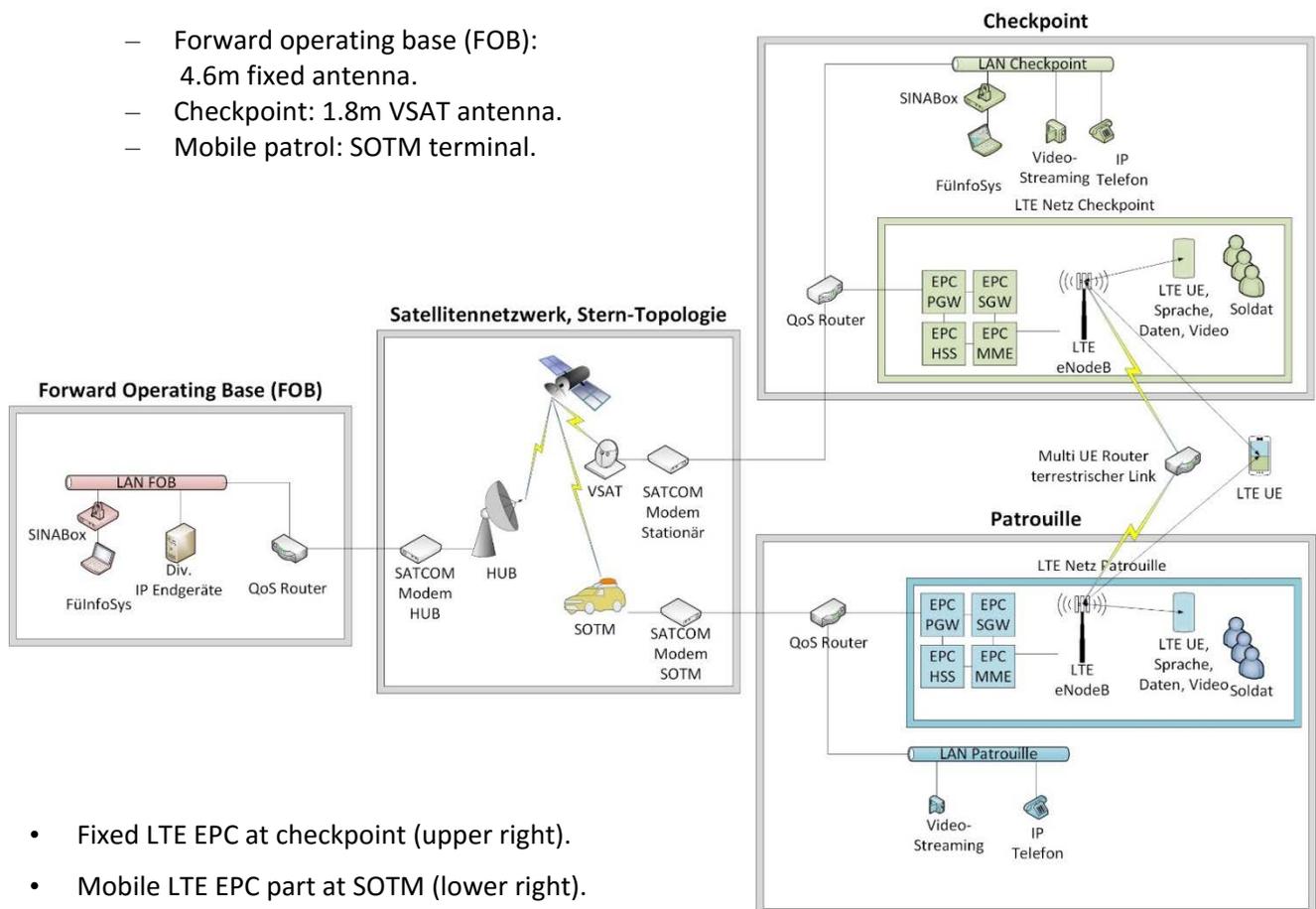
- Highly mobile and tactical communication network via LTE cells.
- Independent LTE cells with reliable security mechanism.
- SOTM terminal for the long-haul connection to the mission network.
- Long-haul communication links by using Bundeswehr-owned satellites.
- Independently operational even if the satellite link is disrupted.



## The LTE over Satellite Demo Scenario

### Simplified block diagram of the setup during the demo

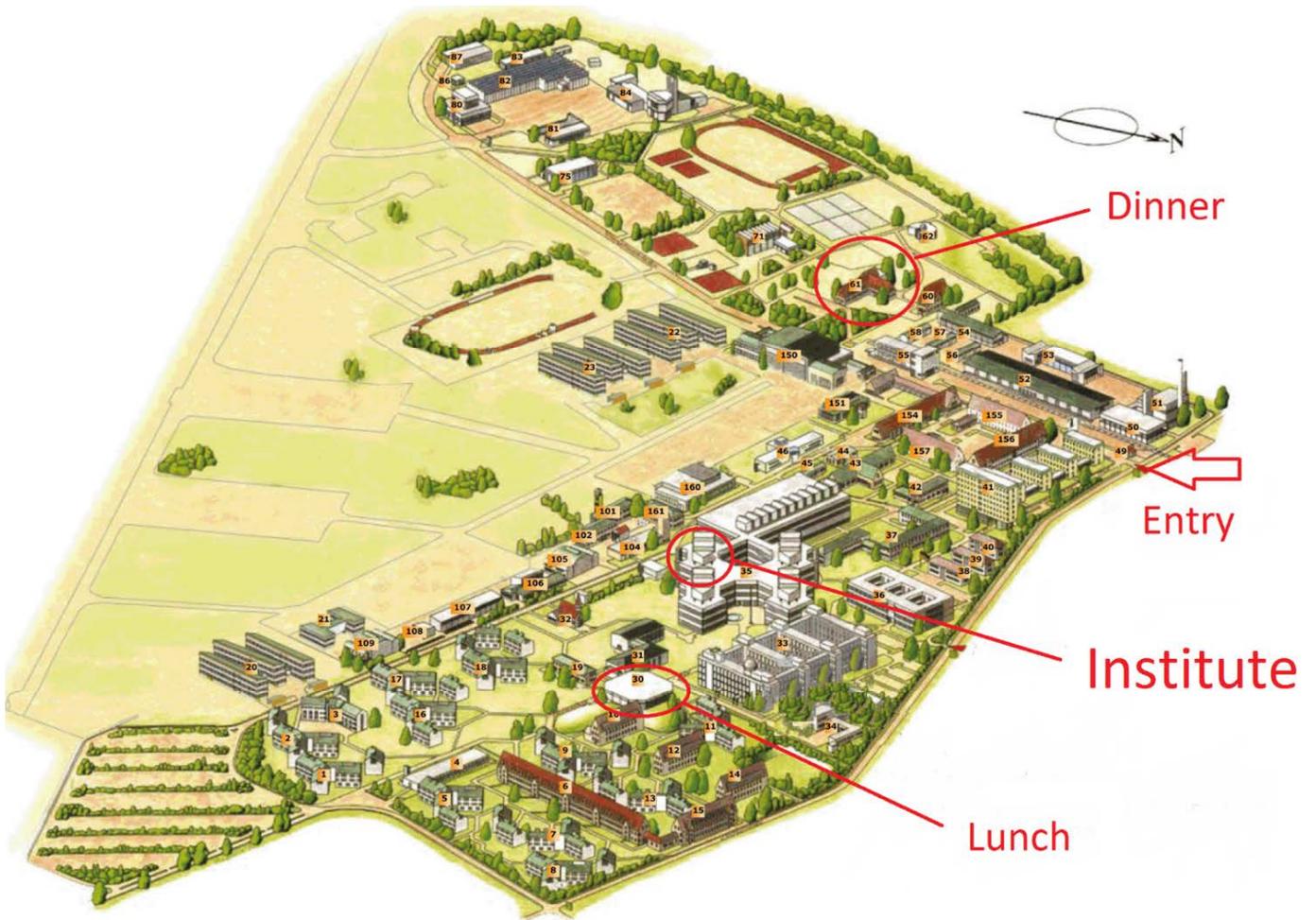
- 3 SATCOM earth stations:
  - Forward operating base (FOB): 4.6m fixed antenna.
  - Checkpoint: 1.8m VSAT antenna.
  - Mobile patrol: SOTM terminal.



- Fixed LTE EPC at checkpoint (upper right).
- Mobile LTE EPC part at SOTM (lower right).
- Fixed LTE EPC components at FOB (left).



# Campus Map





## Venue and Contact Information



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