

# Spectral Efficiency & Costs of Mobile Radio Systems

*A toolkit to compare spectral efficiency and costs of mobile radio systems*

## Course Duration:

- ▶ 1 day

## Course Description:

- ▶ At this time many different mobile radio systems are competing for the 4G market. On the one hand competition is beneficial, but on the other hand the figures and arguments for the different standards are often confusing and difficult to comprehend. This course addresses the needs of everybody who is involved in technical assessment and decision making related to the emerging 4G technologies.
- ▶ The course starts with an overview of the KPI's and gives the reasoning for a sound comparison of mobile radio standards.
- ▶ The processes to generate these KPI's are introduced: Simulation, Link Budgeting, Network Planning, and Network Engineering.
- ▶ This part ends with an overview of the 3G and 4G standards being addressed in this training: GERAN, UMTS/HSPA, LTE, WiFi and WiMAX.
- ▶ The following part presents the key dependencies of the cost related KPI's and their generation.
- ▶ Apart from the cost per user related KPI's to following KPI's are discussed in this training: Hard Blocking Capacity, Spectral Efficiency, Cell Density, and Cell Range.
- ▶ For the related standards publicly available figures for the KPI's are given.
- ▶ Apart from discussion the KPI's on their own also some background of how and why certain features of the standards influence these KPI's is given in order to enable the student to discuss and to challenge figures coming from 3<sup>rd</sup> parties.
- ▶ Finally the KPI's discussed in this training are combined in order to determine the cost position of the mobile radio system.

As in all our courses, we integrated several interactive exercises for a perfect learning experience.

## Pre-Requisites:

- ▶ The student needs to have previous exposure to communications and mobile radio as an engineer and needs to be interested in the effectiveness and cost effectiveness of mobile radio systems.
- ▶ Knowledge of mobile radio standards is very helpful to follow this training.

### **Course Target:**

- ▶ The student is enabled to understand relevant concepts of mobile radio KPI's and cost driving factors.
- ▶ The student is enabled to access the mobile radio standards KPI's with regard to performance and costs.
- ▶ The student is enabled to start working on related evaluations.
- ▶ The training is not enabling the student to create KPI's by means of simulations.

### **Some of your questions that will be answered:**

- ▶ Why and how mobile radio systems are compared with each other?
- ▶ What are the KPI's for cost and effectively comparison and what are the processes to generate them?
- ▶ Why the hard blocking capacity or peak throughput on its own is unreliable to compare mobile radio systems?
- ▶ How do standards, chosen algorithms and other factors influence the performance of a mobile radio system?
- ▶ To what extent and at what expense higher order modulation and MIMO improve the link level performance and spectrum efficiency?
- ▶ What approach is used for link budget calculation in order to determine the cell range and the cell density?
- ▶ How do high data rate, higher order modulation and MIMO impair the cell range?
- ▶ How do mobile radio systems turn from noise limited into interference limited systems and how this relates to frequency reuse?
- ▶ Why scheduling is a new dimension to improve the spectral efficiency?
- ▶ What are the publicly available KPI's of the different mobile radio systems?
- ▶ How costs can be derived from network engineering figures?
- ▶ What final trend can be seen for the different standards?

### **Who should attend this class?**

- ▶ Everybody who needs an understanding of the KPI's such as Spectrum Efficiency and Cost Position of mobile radio systems.
- ▶ People who are doing decisions about which mobile radio systems to follow and especially those who are involved in the technical evaluation of mobile radio systems.
- ▶ Operators and engineers who would like to look behind the confusing marketing figures of the different mobile radio standards.

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- **Comparing Mobile Radio Systems**
  - ⇒ The need to compare Mobile Radio Systems
  - ⇒ How to compare Mobile Radio Systems from the ARPU Perspective
  - ⇒ Other Influence Factors
- **Definition of Processes and KPI's**
  - ⇒ Overview
  - ⇒ Design of the Standard -> Hard Blocking Capacity
  - ⇒ Why Hard Blocking is not describing reliably the Spectral Efficiency?
  - ⇒ Link Level Simulations
  - ⇒ Link Budget -> Cell Range -> Cell Density
  - ⇒ Satisfied User Criterion (QoS)
  - ⇒ System Level Simulations -> Spectral Efficiency
  - ⇒ Network Planning
  - ⇒ Network Engineering -> Final Costs
- **Brief Introduction to Considered Mobile Radio Systems**
  - ⇒ GERAN
  - ⇒ UMTS/HSPA
  - ⇒ LTE
  - ⇒ WIFI
  - ⇒ WiMAX

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## Generating cost-related KPI's

- **Hard Blocking Capacity**
  - ⇒ Circuit Switched Hard Blocking
  - ⇒ Max. Packet Switched Throughput
  - ⇒ Max. Packet Switched Goodput
  - ⇒ Comparison of Different Standards  
GERAN, UMTS/HSPA, LTE, WiFi, WiMAX
- **Second Order KPI's by Link Level Simulations**
  - ⇒ How Performance is Measured
  - ⇒ How Standard and Algorithms limit the Performance
  - ⇒ Performance dependency on the Mobile Radio Channel
  - ⇒ Performance Improvement by Diversity and Beamforming
  - ⇒ Throughput Improvement by Higher Order Modulation
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  - ⇒ Performance Limitation by Signaling delays
  - ⇒ Combination of Benefits
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GERAN, UMTS/HSPA, LTE, WiFi, WiMAX
- **Rough Cell Density by Link Budget**
  - ⇒ Approach of Link Budget Calculation
  - ⇒ The Propagation Models
  - ⇒ Influence Factors and their Modeling
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GERAN, UMTS/HSPA, LTE, WiFi, WiMAX

- **Spectral Efficiency by System Level Simulations**

- ⇒ Approach of System Level Simulations
- ⇒ How interference works
- ⇒ Interference in Small Cells
- ⇒ Frequency reuse and Fractional Frequency Reuse
- ⇒ Improving the Interference Situation by Diversity and Beamforming
- ⇒ Why Higher Order Modulation and MIMO do not give max. Benefit in System Level Simulations
- ⇒ How AMR and DTX improve Spectral Efficiency
- ⇒ Good Scheduling – Key for high Spectral Efficiency
- ⇒ Signaling – Penalty for Spectral Efficiency
- ⇒ Comparison of Different Standards  
GERAN, UMTS/HSPA, LTE, WiFi, WiMAX

- **Detailed Cell Density & Physical Layer Configuration by Network Planning**

- ⇒ Approach of Network Planning
- ⇒ Network Planning and System Level Simulation

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## Derive final Costs by Network Engineering

- **Approach of Network Engineering**
- **Costs derived from Network Engineering**
  - ⇒ One-Time Investments
  - ⇒ Continuous Costs
- **A Simple Cost Model**
  - ⇒ Example scenarios

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## Conclusions and Results

- **Cost Trends for the different Standards**
  - ⇒ GERAN
  - ⇒ UMTS/HSPA
  - ⇒ LTE
  - ⇒ WiFi
  - ⇒ WiMAX
- **Summary of Approach of this Training**