



**TECHCOM<sup>®</sup>**  
*Consulting*

COMPETENCE FOR TELECOMMUNICATIONS

# TRAINING PROGRAM TECHCOM<sup>®</sup> CONSULTING

Training Product Line 2018

## TECHCOM<sup>®</sup> Consulting GmbH

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TECHCOM<sup>®</sup> Consulting trainings product portfolio:

- Technical theoretical trainings
- Software based technical trainings
- Web Sessions / E-Learning from concept to implementation
- Tailored technical trainings developed by customer demand

Training selector bar

TECHCOM<sup>®</sup> Consulting trainings will give the opportunity to keep pace with the swift development in the fields of telecommunication and information technology. In specific trainings where you attain the knowledge and strategic skills in order to position your corporation on the hard-fought market.

Product training

explains how to improve work load using TECHtrace<sup>®</sup> software for network performance and optimization.

Introductory level

explains mechanisms and principles of telecommunication networks and technologies.

Intermediate level

provides knowledge of procedures, protocols, interfaces and functionalities of telecommunication networks and technologies.

Expert level

provides more detailed and specified explanation of the functionalities and proposals to improve coverage, capacity and quality of 2G, 3G, 4G, 5G mobile telecommunication networks with examples from real networks.

## General Information on Knowledge Services

All learning documentation are provided in English language and electronically format per Email or Web-downloader.

All trainings can be offered as Classroom training or Web Session.

All training fees are in Euro per participant and exclusive Value Added Tax or any other taxes.

Training location taking place outside of our training center in Oberhaching/ Munich has to be agreed in advance.

All prices will be mutually agreed.

In general, TECHCOM<sup>®</sup> Consulting General Terms and Conditions shall remain valid and enforceable.

TECHCOM<sup>®</sup> Consulting is committed to helping you get more value from the knowledge you already own and reating new experience that will help you to rival in a social and mobile world.

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\*This offer refers to all products described in the training program taking place in the TECHCOM<sup>®</sup> Consulting Training Center in Munich. Please note that for the requested Open Seminar & Web Sessions should be enrolled no less than 4 participants per one delivery.

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## TECHCOM® Consulting GmbH

TECHCOM® Consulting is an internationally operating training and consulting company in the fields of telecommunications and IT.

As a company specializing on training, TECHCOM® Consulting offers innovative concepts and realizations individually adapted to the clients needs. TECHCOM® Consulting provides specialists in fixed network, data communication and mobile networks who have long term experience in training, methodical teaching and in development of modular course documentation.

In the training area TECHCOM® Consulting works for nearly all relevant international system suppliers, measurement equipment manufacturers in hardware/software and/or technology training. Additionally TECHCOM® Consulting offers technology training, network planning and optimization workshops as well as tracking and tracing courses to network operators all over the world.

TECHCOM® Consulting offers in addition to conventional training virtual classroom training, operates content management systems and develops customized elearning products.

In the consulting area TECHCOM® Consulting supports human resource departments in structuring the education plans for their employees and supports its customers in different projects which are e.g. network planning and optimization, network evaluation, quality of service management etc. TECHCOM® Consulting combines its experiences in the consulting and training area to guarantee a high quality level according to the customer needs.

What TECHCOM® Consulting offers in the field of Telecommunication and IT is:

- Theoretical as well as hardware/ software trainings
- Individualized training, designed from your concepts
- ELearning design from first the concept to the final solution
- Support in personnel development concepts

## General Information on Knowledge Services

Techcom® trainings put you in the position to keep pace with the swift development in the fields of telecommunication and information technology. In specific workshops you attain the knowledge and strategic skills in order to position your corporation on the hardfought market better. Technical, microeconomic and marketing aspects will also be dealt with.

- All training documents are provided in English language.
- Course fees are in Euro and exclusive Value Added Tax.
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Please take a look at our newsletter. That way you will be informed about our seminar program, updates and changes, and interesting technology developments. You can download the actual Newsletter at our homepage [www.techcom.de](http://www.techcom.de).

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## Data Networks & Transmission

INTERMEDIATE LEVEL

### Fibre Optics

**Ordering number** TA-TC 2010

**Duration** 3 days / web session 3x4 hours

**Objectives** The course describes the physical principles of optical transmission, laser types and the implementation of the fibre optics technology. It explains the physical transmission, characteristics and performance of fibre optics and the basics of interference phenomena as well as the link budgets at optical networks. Finally, examples of implementation and network design are discussed.

**Target audience** Technical personnel who require information regarding Fiber Optics.

**Prerequisites** Basic knowledge of telecommunications, optics and laser technology.

**Contents**

1. Fibre Optics - Introduction
2. Physical Transmission
3. Optical Fibre & Characteristics
4. Fibre Performance
5. Link Budget at optical networks
6. Measurements & test procedures
7. Fibre Optics cables/terminations
8. Optical Fibre Routing Planning

## Data Networks & Transmission

INTERMEDIATE LEVEL

### ATM Technology

**Ordering number** TA-TC 3200

**Duration** 2 days / web session 3x3 hours

**Objectives** The course gives a detailed overview about ATM as a protocol for layers 2/3 (OSI model). Topics are the cell-structure, routing and the Quality-of-Service-Categories. The ATM-reference model is discussed and an overview about signaling protocols is given.

**Target audience** Technical personal and network management.

**Prerequisites** Basic knowledge of telecommunication networks and data transmission.

- Contents**
1. Why ATM?
    - STM (Synchronous Transfer Mode)
    - PTM (Packet Transfer Mode)
    - ATM (Asynchronous Transfer Mode)
  2. ATM Cells & Cell Transport
    - The ATM-Cell; Cell Transport
    - ATM Reference Model
  3. Layer Tasks
    - Connections in the Reference Model
    - Structure of Traffic Management
  4. Objectives
    - Traffic Descriptors, Service Categories
    - Structure of Traffic Management
    - Operation, Administration & Maintenance
  5. Operation, Administration & Maintenance
    - Principles, Layers & Flow, Functions
  6. ATM Networks
    - Structure, Services & Classification
  7. Signaling
    - SVCs & SPVCs and UNI Signaling



## Data Networks & Transmission

INTERMEDIATE LEVEL

### TCP/ IP Technology

**Ordering number** TA-TC 3300

**Duration** 2 days / web session 2x4 hours

**Objectives** The participant learns the concepts of TCP/IP as most important protocol suite for data networks. The Internet is described in its past and future developments. The role of IP in networks, addressing and routing mechanisms are explained for the most popular version 4 and for IPv6 of IP, TCP, UDP and the most important applications of TCP/IP are discussed.

**Target audience** Personnel from the technology, marketing and management field.

**Prerequisites** Basic knowledge of data communication.

- Contents**
1. Fundamentals of data transmission
    - The Internet; Communication layers
  2. The data link layer
    - Ethernet, bridging and switching
  3. The Internet Protocol IP
    - Tasks of network layer protocol
    - Internet Protocol Version 4
    - Addressing and Subnetting
    - Address Translation and Resolution
    - IP Version 6
  4. Routing
    - Fundamentals of Routing; Routing Information Protocol; Open Shortest Path First
  5. Transport Layer Protocols TCP and UDP
    - Tasks of Transmission Control Protocol; TCP Datagram; TCP protocol flow; UDP
  6. TCP/IP Applications
    - Auto configuration, DHCP
    - Remote command execution, Telnet, Rlogin and File transfer, FTP, TFTP, NFS
    - Mail transfer, SMTP, POP, IMAP and Hypermedia Transfer, WWW

## Data Networks & Transmission

INTERMEDIATE LEVEL

### IPv6

**Ordering number** TA-TC 3320

**Duration** 1 day / web session 1x4 hours

**Objectives** In global networks IPv4 does not work sufficiently any more. These aspects that range from the address exhaustion problem to the support of real time data, are presented in the course. The concepts to overcome these shortcomings in IPv6 are explained. This covers addressing, auto-configuration, real time support and finally the transition and introduction scenarios for IPv6 are presented.

**Target audience** Personnel who need information about the new possibilities, the practical realization and introduction of the new Internet standard.

**Prerequisites** Basic knowledge about IPv4.

- Contents**
1. Introduction: Why not IPv4
    - Address Exhaustion; New applications and their requirements; IPv6 packet structure
  2. IPv6 addressing and routing
    - IPv6 addressing
    - Address classes
    - Routing in IPv6 networks
    - Extension Headers for Routing
  3. Auto Configuration
    - Stateless and stateful auto configuration
    - Name servers
    - IPv6 and the data link layer and Mobility in IPv6
  4. Routing difference aspects
  5. Real time applications
    - QoS realization in IPv6
    - Packets and flows
    - Capacity reservation
  6. Security aspects
    - Security mechanisms, Ciphering and authentication
    - Extension Headers for security
    - Key Infrastructure
  7. Transition from IPv4 to IPv6
    - Double stack, Tunneling; Interworking; The 6 Bone; Availability of IPv6

## Data Networks & Transmission

INTERMEDIATE LEVEL

### Voice over IP (VoIP)

**Ordering number** TA-TC 3330

**Duration** 2 days / web session 2x4 hours

**Objectives** Participants will learn about Voice over IP and where it is used. This includes a detailed look at several protocols which are defined for Voice over IP transmission.

**Target audience** Technical technicians and engineers.

**Prerequisites** An understanding of IP is recommended.

**Contents**

1. Introduction
2. OSI and TCP/IP
3. Transmission Methods
4. H.323
5. SIP
6. SDP
7. RTP/ RTCP
8. H.248
9. VoIP in Mobile Networks
10. Examples of VoIP applications

## Data Networks & Transmission

INTERMEDIATE LEVEL

### TCP/ IP in 3G

**Ordering number** TA-TC 3400

**Duration** 2 days / web session 2x4 hours

**Objectives** This seminar addresses the needs of network operators who need to enable packet data applications on top of GPRS and UMTS. The participants will learn about the details of TCP/ IP transmission and its protocols and see how they are used in relation to UMTS. Particular emphasis is given to services in 3G Systems that make use of TCP/ IP including Voice over IP. The seminar concludes with a look into the future TCP/ IP based 3G system that will emerge in the upcoming years (with IP Multimedia Subsystem).

**Target audience** Technicians and engineers who want to understand TCP/ IP (UDP/ IP) transmission and how it relates to mobile networks.

**Prerequisites** Understanding of TCP/ IP, GPRS, and UMTS data transmission characteristics is expected.

- Contents**
1. Introduction
    - Computer Networks - definition/ history; Mobile Networks - definition/ history
    - Merging Ideas/ Mobile IP (leading to IMS, etc.)
  2. TCP/ IP Protocol Stack
    - OSI Model; / Ethernet protocol / TCP/ IP Model
  3. Main Protocols used with TCP/ IP
    - IP; TCP; UDP; SCTP
  4. 3G System
    - Network Architecture
    - GRPS & UMTS Protocols
    - PDP Contexts and Packet-switched traffic
  5. Application Protocols
    - HTTP/ Java; WML/ WAP; FTP; SMTP; POP; RTP/ RTCP; DNS
  6. Security and protection
    - IPsec; Proxy Servers; Firewalls; Authentication; Encryption
    - Redandancy aspects protocols & BFD protocol
  7. Synchronization
    - TOP / SyncEth
  8. Services
    - Service Classifications
    - Mobile Systems Service Models (GSM/ UMTS) and Value-added services
  9. Voice over IP
    - Voice over IP; SIP/ SDP
  10. IMS

## Data Networks & Transmission

INTERMEDIATE LEVEL

### IP fundamentals for LTE transmission planners

**Ordering number** TA-TC 3500

**Duration** 3 days / Web session 3x4 hours

**Objectives** The training should inform the participants according to the LTE transmission networks: main principles of IP technologies, protocols in IP and LTE transport networks, QoS basics, interfaces in the RAN and Core.

**Target audience** Engineers, who works with LTE transmission networks.

**Prerequisites** Basic knowledge of the LTE standard and network architecture.

**Contents**

1. OSI and TCP/IP models, overview of LAN technologies
2. LAN technologies, Ethernet standard overview, Layer 2 (data link).
3. Internet Protocol (IP) v4: principles, header, addressing, subnetting. Layer 3 (network)
4. IP4 routing principles and protocols; IP v6 overview; MPLS Overview
5. Protocols of transport layer: TCP, UDP, SCTP. NAT & NAPT. QoS, IPSec
6. IP in the LTE networks: interfaces, protocols, signaling, protection, synchronization, QoS

## Data Networks & Transmission

INTERMEDIATE LEVEL

### LTE Transmission Planning

**Ordering number** TA-TC 3520

**Duration** 2 days / web session 2x4 hours

**Objectives** LTE Network architecture and protocols - Describe the architecture of the LTE Radio Access Network - Network Elements, Interfaces and Protocols General transmission features - Describe the most important used transport features IP Planning IPsec - Describe the various options for implementation of IPsec QoS, scheduling and shaping - Explain QoS handling Dimensioning of eNB Interfaces (if Traffic Model available) - Perform link dimensioning Introduction to Transport Monitoring - examples of transport related counters and PIs.

**Target audience** Engineers working in E-UTRAN transmission (S1, X2 interfaces).

**Prerequisites** IP/ Ethernet Transmission knowledge.

**Contents**

1. Introduction to LTE Transport Features
2. Feature Description – Parameters
3. IP Planning
4. IPsec
5. QoS Planning
6. Dimensioning

## Data Networks & Transmission

INTERMEDIATE LEVEL

### GSM and UMTS Transmission Network

<b>Ordering number</b>	TA-TC 3800
<b>Duration</b>	5 days / web session 5x4
<b>Objectives</b>	The training should inform the participants according to the GSM and UMTS transmission network: - Main principles of ATM technologies - Main principles of IP technologies - Protocols in ATM and IP - QoS in ATM and IP - Interfaces in the RAN and Core.
<b>Target audience</b>	Engineers/ technicians, everyone who needs knowledge according to the Transmission Network.
<b>Prerequisites</b>	Basic knowledge of the GSM/GPRS/EDGE and UMTS/ HSPA standard and network architecture.
<b>Contents</b>	<ol style="list-style-type: none"> <li>1. OSI, ATM and TCP/IP models, overview of LAN technologies, SDH/ PDH/ microwaves. Layer 1 (physical).</li> <li>2. ATM &amp; LAN technologies, Ethernet standard overview, Layer 2 (data link).</li> <li>3. Internet Protocol (IP) v4: principles, header, addressing, subnetting. Layer 3 (network).</li> <li>4. IP4 routing principles and protocols; IP v6 overview; MPLS Overview.           <ul style="list-style-type: none"> <li>• Protocols of transport layer:               <ul style="list-style-type: none"> <li>• TCP, UDP, SCTP</li> <li>• NAT &amp; NAPT</li> <li>• QoS</li> <li>• IPSec</li> </ul> </li> </ul> </li> <li>5. IP &amp; ATM in the 2G/ 3G RAN and Core           <ul style="list-style-type: none"> <li>• Interfaces</li> <li>• Protocols</li> <li>• Signaling</li> <li>• Protection</li> <li>• Synchronization</li> <li>• QoS</li> </ul> </li> </ol>

## Mobile Networks Technologies

### INTRODUCTION LEVEL

## GSM System

**Ordering number** TA-TC 1000

**Duration** 3 days / web session 3x4 hours

**Objectives** The course provides an overview about GSM, the most successful standard of 2nd generation. It highlights the potentials of GSM networks, sketches the evolutionary path and the limits of this standard. Special emphasis is given to the radio transmission technology. The course can be booked together GPRS/ EDGE.

**Target audience** Personnel requiring a broad technical overview about GSM networks.

**Prerequisites** Basic knowledge of telecommunications.

- Contents**
1. Introduction
    - History of mobile communication, Single-cell, 1st and 2nd generation systems
  2. Global Systems of Mobile Communications (GSM)
    - The GSM Standard: Phase1, Phase2, Phase 2+
    - GSM900, GSM1800, GSM1900
  3. Cellular Networks: basic concepts
    - Mobility: roaming, location update, handover
    - Radio: duplex transmission (FDD/ TDD), multiple access (FDMA/ TDMA/ CDMA)
  4. GSM Services
    - Tele Services: voice, fax, SMS
    - Bearer Services: wireless data 9.6kbps
    - Supplementary Services
  5. GSM Network Architecture
    - Subsystems: NSS, BSS, OSS, MS
    - Interfaces
  6. GSM Transmission
    - Transmission over fixed lines: PCM30
    - Transcoding and Rate Adaptation (TRAU)
    - Transmission over the air interface
  7. GSM Security
    - Encryption, Authentication, IMEI Check, Subscriber confidentiality
  8. GSM Protocols
    - Logical channels, Physical channels, SS7 in GSM networks



## Mobile Networks Technologies

INTERMEDIATE LEVEL

### GPRS and EDGE System

**Ordering number** TA-TC 1010

**Duration** 2 days / web session 2x4 hours

**Objectives** The course presents the network capability and network architecture of GPRS. GPRS protocols and the GPRS radio interface solution are introduced. The enhancements of EDGE (EGPRS) are discussed. The participant learns about mechanisms, which enable an efficient usage of Internet services and applications with GPRS/ EDGE. The course can be booked together with GSM System.

**Target audience** Everybody from the technology, management and sales sector, with demand for general knowledge concerning GPRS/ EDGE capabilities, network architecture and protocols.

**Prerequisites** Good GSM knowledge.

- Contents**
1. Introduction
  2. (E)GPRS Architecture
    - Data Transmission in GSM - the Drawbacks
    - (E)GPRS Network Architecture
    - High Level Functions Required for (E)GPRS Network Elements
    - Radio Interface Concepts
  3. (E)GPRS Services
    - Subscriber Profile
    - Security Features
  4. Protocol Layers within (E)GPRS
    - TCP/ IP Basics
    - Transmission Plane
    - Signaling Planes
  5. Transmission
    - GPRS Identities
    - Mobility Management (MM) States
    - Packet Data Protocol (PDP) States
    - Examples of GPRS MM and Session Management Procedures
    - Interworking of GPRS with Public IP networks
  6. (E)GPRS Radio Interface
    - Packet Data Logical Channels
    - Layered Perspective of the Radio Interface
    - Some Tasks of the physical and MAC/RLC layer
  7. (E)GPRS Enhancements
    - e.g. dual carrier EGPRS, higher modulation

## Mobile Networks Technologies

INTERMEDIATE LEVEL

### Cellular Networks: from GSM to LTE

**Ordering number** TA-TC 1070

**Duration** 3 days / web session 3x4 hours

**Objectives** The course introduces into the most important aspects of 2G and 3G mobile communication networks and the path towards 4G. The standards and their evolution, services, network architecture and the principles of the radio transmission technology of GSM, GPRS/ EDGE as well as UMTS/HSPA and LTE will be explained and the system capabilities discussed.

**Target audience** Personnel from the technology and management sector requiring a general overview about mobile communications.

**Prerequisites** Basic knowledge of telecommunications.

- Contents**
1. The Path from 1G to 4G
  2. 2G: GSM (Phase 1 & 2)
    - GSM Services
    - GSM Network
    - Basic GSM Procedures
    - GSM Air Interface
  3. 2.5G: GSM Evolution
    - GSM Phase 2+ Overview
    - Service Evolution
    - GPRS, EDGE/ E-GPRS
  4. 3G: UMTS Rel. 99
    - The UMTS Network and WCDMA Air Interface
  5. 3.5G: UMTS Evolution
    - UMTS Evolution - Overview
    - UMTS Core Network
    - HSPA and HSPA+
  6. 4G: LTE/ LTE-Advanced (Overview)

## Mobile Networks Technologies

INTERMEDIATE LEVEL

### UMTS System

**Ordering number** TA-TC 1100

**Duration** 3 days / web session 3x4 hours

**Objectives** The course introduces into the standardization and further evolution of UMTS. It offers an overview about the UMTS service concept, the network elements and interfaces. A main item is the explanation of the WCDMA radio interface solution UTRAN.

**Target audience** Personnel from the technology, management and sales sector, with demand for general knowledge concerning the UMTS standard, network and WCDMA radio interface solution UTRA and the related Radio Access Network UTRAN.

**Prerequisites** GSM & GPRS knowledge.

**Contents**

1. Introduction - the Path from 1G to 4G
2. 3G/ UMTS Standardization
3. GSM & UMTS Evolution
  - Network Evolution
  - Data Rate Evolution
  - Service Evolution
4. UMTS Network Architecture
5. UMTS Services, Identities & Security
6. WCDMA Transmission
7. Radio Resource Management
8. UMTS FDP Channels
9. 3.5G: UMTS beyond Rel. 99
  - HSPA, HSPA+
  - MIMO
  - LTE

## Mobile Networks Technologies

INTERMEDIATE LEVEL

### HSDPA, HSUPA & HSPA+

**Ordering number** TA-TC 1120

**Duration** 3 days / web session 3x4 hours

**Objectives** The participant will be informed about principles, network & protocol modifications and physical channels. The evolution beyond Rel. 6 (HSPA+) will be discussed. Several 3GPP Release 7 - 11 features, pushing the HSPA+ peak data rates step by step towards 4G requirements, improving the spectrum efficiency, enabling RT over IP services and leading towards a flat UMTS network architecture are explained.

**Target audience** Radio Network Planners, UTRAN System Specialists, UTRAN Network Engineers & Designers and UTRAN Field Engineers.

**Prerequisites** UMTS air interface and UMTS protocol architecture knowledge.

**Contents**

1. Introduction: 3GPP Air Interface Evolution; Reasons for HSPA
2. HSDPA Principles
  - HSDPA Objectives & Standardization
  - Adaptive Modulation & Coding AMC
  - Multi-Code Operation & Data Rates
  - HSDPA Network & UE Categories
3. HSDPA: Protocols & Resource Allocation
  - MAC-hs tasks; Fast Link Adaptation, H-ARQ & Packet Scheduling
4. HSDPA Physical Channels
5. HSDPA Handover
6. HSUPA Principles
  - E-DCH, Adaptive Coding & Data Rates
  - HSUPA Network & UE Categories
7. HSUPA: Protocols & Resource Allocation
  - MAC-e & MAC-es
8. HSUPA Physical Channels
9. HSUPA Handover & Power Control
10. HSPA+: Rel. 7 HSDPA & HSUPA Enhancements
  - Higher Order Modulation; MIMO; Network & UE Receiver Evolution
  - Network Evolution & UE Receiver Types
11. HSPA+ Rel. 8 - 11 Enhancements
  - Higher Order Modulation & MIMO / Dual-Cell DC-HSDPA; Multi-Carrier MC-HSPA

## Mobile Networks Technologies

INTERMEDIATE LEVEL

### UMTS Release 4 - 11 Radio Innovations

**Ordering number** TA-TC 1140

**Duration** 2 days / web session 2x4 hours

**Objectives** The participant learns about the central enhancements of the UMS radio interface in UMTS Rel. 4 - 11 and the ongoing discussion about 4G (Advanced-IMT). Special emphasis is given to the new UMTS frequency ranges and UMTS boosters HSDPA, HSUPA, MIMO & HSPA+pushing UMTS to 3.5G and beyond. Finally, the UMTS Long Term Evolution LTE, paving the path towards 4G, is introduced.

**Target audience** Personnel from the technology and management sector needing to understand the new UMTS Release 4 - 11 features and their influence onto the capabilities/ services of UMTS.

**Prerequisites** Good knowledge of UMTS Release 99.

**Contents**

1. Why UMTS Release 4 - 11?
2. New UMTS Frequency Ranges
3. HSDPA (Rel. 5)
4. HSUPA (Rel. 6)
5. MIMO (Rel. 7)
6. HSPA+ (Rel. 7 & beyond)
7. WLAN Integration (Rel. 6)
8. LTE (Rel. 8) & LTE-Advanced (Rel. 10)
9. Summary & Conclusions

## Mobile Networks Technologies

INTERMEDIATE LEVEL

### IP Multimedia Subsystem IMS

**Ordering number** TA-TC 1160

**Duration** 1 day / web session 1x4 hours

**Objectives** The participant will learn about UMTS Release 4 and UMTS Release 5/ 6 with an emphasis on the IP Multimedia Subsystem (IMS) as defined in UMTS Release 5 and 6. Related topics such as SIP/ SDP and service options are also included.

**Target audience** UMTS Network Engineers, UMTS System Specialists and UMTS Field Engineers.

**Prerequisites** Knowledge of TCP/ IP and IP as well as basic knowledge of UMTS Release 99.

- Contents**
1. UMTS and All IP
    - Mobile Communications and the Internet
    - UMTS Release '99 Objectives
    - The Emergence of IMS
  2. Separation of Concerns in Release 4
    - Multi-Service Switching Network Architecture
    - Bearer Independent Circuit Switched Core Network
    - Bearer Independent Packet Switched Core Network (Optional Feature)
  3. SIP/ SDP
  4. UMTS Release 5 Core Network Issues
    - HSS (home Subscriber Server)
    - IMS
  5. IMS improvements (Release 6 to 10)
  6. Options and Services
    - Virtual Home Environment (VHE)
    - Open Service Access (OSA)
    - Intra-Domain Connection of RAN Nodes to Multiple CN Nodes

## Mobile Networks Technologies

INTERMEDIATE LEVEL

### Fundamentals of LTE

**Ordering number** TA-TC 1220

**Duration** 2 days / web session 2x4 hours

**Objectives** The course describes the standardization & principles of the UMTS Long Term Evolution LTE and the Enhanced Packet System EPS. It introduces into the principles of the new LTE/EPS network architecture and interfaces. Special emphasis is given to the LTE radio interface E-UTRA, the OFDMA & SC-FDMA transmission principles, the E-UTRA capabilities and limits. LTE-Advanced, pushing LTE towards  $\approx 1/2$  real  $\approx 1/2$  4G will be introduced, too. Finally, LTE and LTE-Advanced are compared to HSPA+ according to the air interface capabilities, spectrum efficiency and market aspects.

**Target audience** Personnel from the technical area and management requiring information according to LTE.

**Prerequisites** Knowledge of UMTS, HSPA

**Contents**

1. LTE & EPS objectives, standardization & milestones
2. LTE & EPS Network, Architecture & Interfaces
3. E-UTRA Layer 1 Overview & OFDM(A) Principles
4. E-UTRA Transmission: OFDMA & SC-FDMA
5. LTE & MIMO
6. LTE Frequencies
7. LTE-Advanced
8. Comparison: LTE & LTE-Advanced vs. HSPA+

## Mobile Networks Technologies

**EXPERT LEVEL**

### LTE (Long Term Evolution) for Experts

**Ordering number** TA-TC 1230

**Duration** 5 days / web session 5x4 hours

**Objectives** The course guides the participants from LTE & EPS specification & network basics via LTE air interface protocols & radio transmission principles towards details of the LTE Physical Layer. It describes the network & protocol architecture with emphasis to the radio interface E-UTRA & the radio access network E-UTRAN. It discusses in detail the LTE radio transmission, logical, transport & physical channels, data rate boosters & used frequency ranges. A description of central LTE-Advanced features, pushing LTE towards real 4G capabilities and data rates beyond 1.1 Gbps is given. Finally, LTE is compared with other 3G & 4G standards according to capabilities, efficiency & market chances.

**Target audience** Technical personnel who require detailed information regarding LTE.

**Prerequisites** Knowledge of UMTS, HSPA

- Contents**
1. LTE & EPS (Evolved Packet System) objectives, standardization & milestones
  2. LTE & EPS Network, Architecture & Interfaces
    - E-UTRAN & EPS architecture
    - The LTE UE, Interfaces, The Home eNodeB concept (Femto-Cells)
  3. E-UTRA(N) Radio Protocols & Resource Allocation
    - E-UTRA & E-UTRAN Protocol Overview
    - MAC: LTE Resource Allocation
    - Logical, Transport & Physical Channels
  4. E-UTRAN Interfaces S1 & X2 - Protocol & Procedures (optional)
  5. E-UTRA Layer 1 Overview & OFDM(A) Principles
  6. E-UTRA Downlink Transmission: OFDMA
  7. E-UTRA Uplink Transmission: SC-FDMA
  8. LTE & MIMO
    - LTE Transmission Modes
    - LTE & MIMO - data rates
  9. LTE Transport Channel Processing
  10. LTE Physical Layer - Channels & Procedures
    - FDD & TDD Timing
    - Physical Channels
    - Cell Search & Initial Access
  11. LTE Frequencies & related Coverage
  12. LTE-Advanced (Rel. 10/11) features
  13. Comparing: LTE & LTE-Advanced vs. HSPA+



## Mobile Networks Technologies

INTERMEDIATE LEVEL

### Next Generation Networks (NGN)

**Ordering number** TA-TC 1250

**Duration** 3 days / web session 3x4 hours

**Objectives** This course provides detailed information about Next Generation Networks (NGN) with a focus on the IP Multimedia Subsystem (IMS) as an implementation of NGN. The network architecture and elements are examined followed by an in-depth look at signaling and protocols. Different types of access technologies are considered.

**Target audience** The course focuses on people who want to understand Next Generation Networks (NGN) including IMS, and the protocols and access technologies involved.

**Prerequisites** Knowledge of 2G/3G service platform and IP transport

- Contents**
1. Introduction
    - Network Types and Role of IMS
    - Evolution of Mobile Networks
    - IMS Service Concepts
  2. NGN Architecture
  3. NGN Elements
    - NGN Elements
    - IMS Implementation
  4. NGN Services
  5. NGN Signaling
    - SIP/SDP
    - RTP/RTCP
    - H.323
    - H.248/MEGACO
  6. NGN Access Technologies
  7. Summary & Conclusions

## Mobile Networks Technologies

INTERMEDIATE LEVEL

### TETRA System

**Ordering number** TA-TC 1340

**Duration** 3 days / web session 3x4 hours

**Objectives** The participant will be informed about the TETRA system. This includes a description of the TETRA standard, system architecture, components and interfaces as well as services and the radio transmission.

**Target audience** Personnel requiring a broad technical overview about the TETRA system, transmission, properties & capabilities in comparison to GSM.

**Prerequisites** Knowledge about GSM.

- Contents**
1. Introduction
  2. The TETRA standard
  3. TETRA Network architecture
    - Core Network
    - Radio Access Network
    - Mobile
    - Interfaces
  4. TETRA Services
  5. TETRA Transmission
    - Fixed line transmission
    - Air Interface Transmission
  6. Traffic Management
    - Mobility Management
    - Call Control
    - Security Management
  7. TETRA Release 2
    - Trunked Mode Operation (TMO) Range Extension
    - Adaptive Multiple Rate (AMR) Voice Codec
    - Mixed Excitation Liner Predictive, enhanced (MELPe) Voice Codec
    - TETRA Enhanced Data Service (TEDS)
  8. TETRA Enhanced Data Service
    - Physical layer and lower MAC layer enhancements
    - Higher protocol layer enhancements & Services and applications
    - Services and applications

## Mobile Networks Technologies

EXPERT LEVEL

### Enhancements of WCDMA and LTE towards 5G

**Ordering number** TA-TC 1400

**Duration** 3 days (web session 3x4 hours)

**Objectives** This course gives substantial information about the path of enhancement from nowadays WCDMA and LTE to 5th generation mobile networks on the basis of 3GPP. Extensions of the physical layer and the radio resource management still under study as well as specified already from 3GPP R12 onwards are presented in detail. Changes to be expected for the architecture both of the radio access and core network are discussed as well. New types of services and their impact on network requirements are presented.

**Target audience** Personnel from technical departments (especially planning and rollout)

**Prerequisites** Good knowledge about WCDMA and LTE (especially air interface and RRM up to 3GPP R11)

- Contents**
1. Evolution of 5G Mobile Communication
    - Traffic increase, Services and use cases
    - Network requirements, 5G Time line
  2. Antenna Technology
    - High frequency bands
    - High order DL MIMO
    - Beam forming, Active antenna systems
  3. UE Performance
    - UE categories
    - Network assisted interference cancellation and suppression
    - UL MIMO, Battery power saving
  4. Multi Cell Operation
    - Multi carrier aggregation
    - Coordinated multi point operation
    - Dual connectivity
  5. Heterogeneous Network
    - RRM for small cells, Mobility enhancements
    - Interference reduction, Interworking with Wi Fi
  6. Services
    - Voice, Multimedia broadcast services, Proximity services
    - Machine type communication
  7. Miscellaneous RRM Enhancements
    - Physical channels, State transitions
    - Application specific congestion control, Licensed assisted access

## Mobile Networks Technologies

INTERMEDIATE LEVEL

### Benchmarking HSPA+ and LTE

**Ordering number** TA-TC 4100

**Duration** 2 days

**Objectives** The seminar offers a benchmark of LTE and HSPA+ on their way towards 4G. The standards will be compared according to their network architecture and transmission principles. The technical capabilities, strengths, weaknesses, limits, cost aspects and market penetration will be analyzed. The current situation of these standards will be discussed as well as future chances & development trends. The question according to the “Tomorrow” of mobile communications – competition, complementarity, or fight for survival will be worked out with the participants.

**Target audience** Technical management

**Prerequisites** Basic UMTS knowledge

- Contents**
- 4G (HSPA+, LTE) Standardization, Market & User View
    - 4G Requirements, Standardisation, Candidates
    - Worldwide Mobile Market & Forecasts
  - Network Architecture trends (CAPEX/ OPEX, performance)
    - UMTS/ HSPA vs. LTE/ EPS Network
    - Trends in Network Management (SON)
  - HSPA+ Air Interface: Principles, Capabilities & Limits
    - WCDMA Principle: Fit for the future?
    - HSDPA & HSUPA Principles, Data Rates & Capabilities
    - HSPA+ Rel. 7 - 11: Boosting HSPA towards 4G
    - UMTS/HSPA: Capabilities, Chances, Problems & Limits
  - LTE Air Interface Principles
    - OFDMA & SC-FDMA for LTE, WiMAX & WLAN
    - LTE Air Interface Principles, Key Parameters & Limits
    - Benchmarking LTE FDD & TDD Mode
    - LTE Transmission: MIMO, Beamforming & other options
    - The
  - Benchmarking: HSPA+ vs. LTE (FDD & TDD)
    - Network Solutions
    - Benchmarking the Air Interface Solutions
    - Frequency Ranges/ Band & Coverage
    - Coverage Aspects & Hierarchical Cellular Structures
    - Capacity, Throughput, Spectrum Efficiency & Peak Rates
  - Final Discussion: Complement or Competition, Coexistence or Replacement
  - Final Discussion: how will the Mobile Market change with in the next decade

## Signaling and Protocols

INTERMEDIATE LEVEL

### SS7 Signaling and Applications in Mobile Networks

**Ordering number** TA-TC 1510

**Duration** 4 days / web session 4x4 hours

**Objectives** The course informs about the structure of the Signaling System No. 7 including an overview of their usage in PSTN, IN and mobile networks. The course focuses on the fundamental SS7 protocols, MTP / ISUP, their functions, messages and signaling flows used in various situations. In course is included also the use of IP in SS7, routing and CAMEL overview.

**Target audience** engineers requiring knowledge in functionality/structure of the SS7 protocols or applications software.

**Prerequisites** Good knowledge of 2G or 3G Systems.

- Contents**
1. Protocol Models
    - Layered Software Architecture; The Four Level Model, OSI Reference Model Basic Signaling
    - Signaling Methods; Introduction to CAS and CCS
  2. Introduction to SS7
    - SS7 Network Architecture, Protocols in 2G & 3G
  3. MTP - Message Transfer Part
    - MTP Levels 1-3
  4. MTP over ATM
    - ATM protocol
  5. ISUP - ISDN User Part
    - Call Routing in ISDN networks; ISUP Procedures
  6. ISUP Call Set-up
  7. SCCP - Signalling Connection Control Part
    - Addressing & Routing; Formatting Rules
  8. TCAP - Transaction Capabilities Application Part
    - Applications of TCAP; Formatting Rules of TCAP; Message Coding
  9. MAP - Mobile Application Part
    - PLMN-MAP Interfaces; MAP Coding
  10. MAP Traffic Case
    - Location Registration and various MAP-related Scenarios
  11. SS7 over IP
    - Stream Control Transmission Protocol (SCTP); Format and Function of SCTP-messages; SCTP Features
  12. Redundancy and routing principles inside the SS7 system
  13. M3UA-Protocol, SUA-Protocol: INAP Protocol Family; Introduction to IN, IN service overview and IN conceptual mode
  14. CAMEL Application Part (CAP): CAMEL basics; Camel Service Environment / CAP protocol overview

## Signaling and Protocols

INTERMEDIATE LEVEL

### GSM Signaling

**Ordering number** TA-TC 1600

**Duration** 3 days / web session 3x4 hours

**Objectives** The course provides participants an understanding of the architecture and the functions of the protocols used in the different interfaces in a GSM network. Trainees will be capable of understanding relevant information in the GSM specifications and similar documents regarding GSM protocol functions and signaling procedures.

**Target audience** Engineers requiring knowledge in GSM and the access part of the network. Reference is provided for MS-BSS-MSC/VLR.

**Prerequisites** Basic understanding of telecommunications.

- Contents**
1. GSM Overview
    - Architecture
  2. GSM Signaling
    - OSI Reference Model, GSM Signaling Protocols, ISUP
  3. Um Air Interface
    - Layer 1-3 (Um) on Air
  4. Abis Interface
    - Layer 1-3 on Abis
  5. A-Interface
    - Signaling System CCS7
    - Formatting Rules
  6. Other Interfaces
    - MAP, TCAP, ASN.1
  7. Complete GSM Procedures
    - General Remarks, Location Update, MOC, MTC
  8. SMS Transfer point to point
    - Network Elements and Protocols
    - SMS on Air Interface and in Core Network
    - SMTP, SMRP, SMCP Protocols and Formatting Rules
  9. Handover
    - Overview to handover signalling intra/ inter BSC
    - Handover for TCH and SDCCH
    - Example flows for Inter-/ Intra-Cell Handovers in BSC
    - GSM – UMTS and UMTS – GSM HO

## Signaling and Protocols

INTERMEDIATE LEVEL

### (E)GPRS Core Network Signaling Protocols

**Ordering number** TA-TC 1610

**Duration** 3 days / web session 3x4 hours

**Objectives** The course provides a detailed picture of GPRS protocols specific to the core network. Therefore the basic GMM and SM procedures are discussed in detail together with explanation of the principles of data packet tunneling used in GPRS. The protocols LLC and SNDCP that provide the transfer services between MS and SGSN will be explained too.

**Target audience** Engineers dealing with maintenance, development, mobile service solution consulting and GPRS project managers.

**Prerequisites** Knowledge of GPRS and basic knowledge about IP is required. The participant should be familiar with SMS in GSM Phase 2.

- Contents**
1. Introduction
    - GPRS network architecture and GPRS protocols
    - GPRS data tunneling mechanism
  2. MS (Mobile Station) - CN (Core Network) signaling
    - Logical Link Control protocol (LLC)
    - GPRS Mobility Management protocol (GMM)
    - Session Management protocol (SM)
  3. MS - CN user plane
    - Sub-network Dependent Convergence Protocol (SNDCP)
  4. Gb Interface
    - Frame Relay transport
    - Network Service and virtual channel concept
    - Base Station Subsystem GPRS Protocol (BSSGP)
  5. Gn Interface
    - IP / UDP transport
    - GTP version 2 and GTP tunnels
    - GTP-C procedures
    - GTP-U procedures and data transfer
  6. Inter-working of GPRS backbone with ISP networks
    - Dynamic address allocation (with and without DHCP)
    - RADIUS authentication and accounting - overview
    - DNS for mobile subscribers – overview

## Signaling and Protocols

INTERMEDIATE LEVEL

### (E)GPRS Air Interface Signaling Protocols

**Ordering number** TA-TC 1620

**Duration** 3 days / web session 3x4 hours

**Objectives** The course provides a detailed description of protocols used on the Um interface for EGPRS and GPRS as seen from the perspective of a mobile station. The enhancements of EGPRS compared with GPRS are discussed. Procedures between mobile station and access network respectively core network will be explained.

**Target audience** People dealing with maintenance, development, mobile service solution consulting and GPRS project managers.

**Prerequisites** Good knowledge of GSM and GPRS in general.

- Contents**
1. Introduction
    - (E)GPRS Network Architecture and GPRS Protocol Overview
    - MM and SM States
  2. (E)GPRS Radio Interface Organisation
    - GMSK and 8PSK Modulation and Coding
    - Frame Organisation
    - Channel Organisation
  3. Radio Link Control / Medium Access Control (RLC/MAC)
    - RLC/MAC Tasks
    - (E)GPRS RLC/MAC Messages
    - (E)GPRS RLC/MAC Block Structure
  4. Logical Link Control (LLC)
    - LLC Tasks
    - LLC States, Frames, and Procedures
  5. GPRS Mobility Management / Session Management (GMM/SM)
    - GMM/SM Tasks and States
    - GMM Signaling Procedures
    - SM Signaling Procedures
    - GMM/SM Frame Format
  6. Sub-Network Dependent Convergence
    - SNDCP Tasks
    - SNDCP Frames



## Signaling and Protocols

INTERMEDIATE LEVEL

### WCDMA Protocols and Procedures

**Ordering number** TA-TC 1700

**Duration** 3 days / web session 3x4 hours

**Objectives** The course offers an overview about the WCDMA protocol architecture (core network, UTRAN and radio interface) for R99 and HSPA(+). Central aspects are the 4 WCDMA specific interfaces Iu, Iub, Iur and Uu. Examples of important procedures within the WCDMA network are discussed as well as the WCDMA security mechanisms and the WCDMA service concept.

**Target audience** Personnel from the technology sector requiring an overview about protocol structures, procedures and security mechanisms in WCDMA.

**Prerequisites** Knowledge about GSM, GPRS and WCDMA.

- Contents**
1. Introduction
    - WCDMA network and identities
  2. Core Network Protocol Architecture
    - Circuit Switched Domain
    - Packet Switched Domain
  3. UTRAN Protocol Architecture (Iu, Iub & Iur Interface)
    - Transport Network Layer
    - Control Plane
    - User Plane
  4. Radio Protocol Architecture (Uu Interface)
    - Physical layer
  5. Procedure Examples
    - RRC establishment and release
    - Routing Area Update
    - Mobile originating and terminating call
    - Inter RNC soft handover and S-RNS relocation
    - Intra- and Inter-system hard handover
  6. WCDMA Security
    - IMEI check
    - (P-)TMSI Allocation
    - Authentication
    - Ciphering & Integrity Check
  7. WCDMA Service Concept
  8. VHE, CAMEL and OSA

## Signaling and Protocols

INTERMEDIATE LEVEL

### WCDMA Radio and Application Protocols

**Ordering number** TA-TC 1710

**Duration** 4 days / web session 4x4 hours

**Objectives** The course introduces the participants to the radio, application and user plane protocols and their architecture in WCDMA. Procedures and concepts of all radio protocols from layer 1 to layer 3 (access stratum) and the WCDMA specific application and user plane protocols on Iub, Iur and Iu will be discussed in detail.

**Target audience** This course has been developed for people dealing with UTRAN for planning, diagnosis, optimization and maintenance.

**Prerequisites** The participants need general knowledge about signaling protocols and should have experience with GSM signaling. They should know basics about the WCDMA system.

- Contents**
1. WCDMA Architecture and Protocol Stack
  2. Radio Protocol Architecture and WCDMA Channels
  3. Signaling Protocols UE – Radio Access Network
    - Physical layer procedures (layer 1)
    - Medium access control, radio link control and packet data convergence protocol (layer 2)
    - Radio resource control (layer 3)
  4. Application Protocols
    - Node B application part (Iub)
    - Radio network subsystem application part (Iur)
    - Radio access network application part (Iu)
  5. User Plane Protocols
    - Frame protocols (Iub, Iur)
    - Iu user plane protocol (Iu-CS)
    - GPRS tunneling protocol (Iu-PS)

## Signaling and Protocols

INTERMEDIATE LEVEL

### WCDMA Transport Protocols

**Ordering number** TA-TC 1720

**Duration** 2 days / web session 2x4 hours

**Objectives** The course introduces the participants to the transport protocols and their architecture in WCDMA. Procedures and concepts of the transport protocols required both for ATM and IP based transport on Iub, Iur and Iu will be discussed in detail.

**Target audience** This course has been developed for people dealing with UTRAN for planning, diagnosis, optimization and maintenance.

**Prerequisites** The participants need general knowledge about signaling protocols and should have experience with GSM signaling. They should know basics about the WCDMA.

**Contents**

1. WCDMA Architecture and Protocol Stack
2. IP based Transport Layer
  - Internet protocol
  - User datagram protocol
3. SS7 over IP
  - Stream control transmission protocol
  - MTP level 3 user adaptation

## Signaling and Protocols

EXPERT LEVEL

### WCDMA Signaling for Smartphones

**Ordering number** TA-TC 1730

**Duration** 3 days / web session 3x4 hours

**Objectives** Smartphones introduce several challenges to the networks in which they operate. They have to be always on while the battery consumption has to be kept to a minimum. Often they are used for services like Instant Messaging, Skype, Facebook and so on, which are characterized by frequent signaling transfer, but low effective user data. On the other hand WCDMA signaling has been originally developed for applications like web browsing with low signaling and high user data transfer. This course gives information, how such challenges can be solved and which solutions have been proposed by 3GPP.

**Target audience** This course has been developed for people dealing with UTRAN for planning, diagnosis, optimization and maintenance.

**Prerequisites** Knowledge about WCDMA protocols and procedures.

- Contents**
1. Smartphones within WCDMA Networks
    - 3GPP evolution of related features
    - UMTS and LTE, WLAN, EGPRS
    - What are smart phones
  2. Signaling between UE and Radio Access Network
    - Radio protocol architecture and WCDMA channels
    - Layer 2 signaling (MAC, RLC and PDCP)
    - Layer 3 signaling (RRC)
  3. Smartphone Related Signaling
    - Signaling challenges
    - Signaling congestion scenarios
    - Continuous packet connectivity
    - Enhanced Cell\_FACH state
    - Fast dormancy
  4. Procedure Examples
    - PS RAB setup
    - PDP context activation
    - Instant messaging with smart phone
    - State transition with smart phone
  5. Usage of Smartphones within Femto Cells
    - CSG cells
  6. Network elements configuration planning aspects for smartphone dominates areas (up on request)

## Signaling and Protocols

INTERMEDIATE LEVEL

### WCDMA FDD Physical Layer and Procedures

**Ordering number** TA-TC 1740

**Duration** 3 days / web session 3x4 hours

**Objectives** The course describes the physical layer of the WCDMA FDD mode including the latest HSPA+ features. The radio transmission (modulation, scrambling and spreading) with all relevant physical channels as well as the physical layer procedures (cell search, random access, dedicated channel synchronization, adaptive modulation and coding, fast re-transmission, power control, handover etc.) are explained in detail.

**Target audience** WCDMA FDD planners, radio optimization engineers, personal concerned with performance measurements.

**Prerequisites** Good knowledge of the WCDMA network architecture and basic knowledge of the WCDMA protocols and procedure.

- Contents**
1. WCDMA Network Architecture and Protocols
  2. Spreading & Modulation
    - Channelisation & Scrambling Codes
    - Code & Time Multiplexing of Control & User Data
    - WCDMA Modulation methods
  3. WCDMA FDD Mode Channels
    - Logical, Transport & Physical Channels
    - Rel. 99 Physical Channels
    - HSPA physical channels
  4. Physical Layer Procedures
    - R99 procedures (cell search, random access, paging)
    - HSPA procedures (adaptive modulation and coding, fast re-transmission, continuous packet connectivity)
  5. Multiplexing & Channel Coding
    - CRC detection
    - Coding & Interleaving (UMTS & HSDPA)
    - Frame & Slot Segmentation
  6. Power Control
    - Open loop
    - R99 and HSUPA inner and outer loop
    - HSDPA power handling of user and control data
  7. Mobility
    - Intra-frequency (soft handover, serving cell change)
    - Inter-frequency and inter-system handover

## Signaling and Protocols

INTERMEDIATE LEVEL

### Camel Phase 4 Signaling Protocols for CS Services

**Ordering number** TA-TC 1750

**Duration** 2 Days / web session 2x4 hours

**Objectives** The Participants get to know in detail the intelligent network procedures for circuit switched services. IN functionalities for PS services, SMS and Any Time Operations are not part of this course.

**Target audience** People with strong technical background responsible for trouble shooting, development and solution consulting and tracing.

**Prerequisites** Participants should know the CAMEL network elements from core network point of view and understand the relevant procedures and parameters in the CAP (CAMEL Application Part) protocol as well as in the MAP (Mobile Application Part protocol). Any participant is required to have a detailed knowledge about standard GSM/ GPRS/ UMTS procedures concerning the core network.

- Contents**
1. CAMEL Phase 4 - CS Network Architecture
    - CAMEL principles and CAMEL network architecture
    - Relevant protocols
  2. TCAP/CAP Protocol Stack
    - SS7 options (narrowband, broadband, SS7 over IP)
    - SCCP connection-less service (global title translation)
    - SCCP subsystem management
    - TCAP transaction handling
    - TCAP dialogues and CAP version negotiation
  3. Version 4 General Architecture
    - Basic Call State Models BCSM of all CAMEL versions
    - Detection Points
    - Transaction Handling
  4. CAP Version 4 Operations
    - CAP operations and parameters
    - Examples

## Signaling and Protocols

INTERMEDIATE LEVEL

### UMTS Core Network Protocols

**Ordering number** TA-TC 1760

**Duration** 4 days / 4x4 hours

**Objectives** The course explains the core network relevant protocols on the Iu interface and within the core network itself. This covers the protocols SCCP, RANAP, GTP-U and Iu UP protocol on Iu. The MM, GMM, SM and CC protocol between UE and CN are treated, too. The protocols GTP-C, BSSAP+, TCAP/MAP within the CN will be explained together with the UE- CN protocols.

**Target audience** Personnel with technical background in mobile communication networks, like maintenance personal, technical sales, project integration management and developers.

**Prerequisites** Knowledge of functionalities, network elements, procedures in UMTS.

- Contents**
1. UMTS network and protocols
    - Network architecture and interfaces
    - UMTS protocol stacks
  2. Iu interface – control plane
    - general aspects, tasks and protocols
    - Radio Access Bearer, SCCP, RANAP
  3. Iu interface - user plane
    - Iu-PS : GTP-U
    - Iu-CS : Iu User Plane protocol
  4. UE-CN protocols
    - General on UE-CN protocols
    - CS protocols: MM, CC/ PS protocols: GMM, SM
    - Coordinated mobility management: BSSAP+
    - Formatting of UE-CN messages
  5. CN signaling protocols
    - Bearer independent call control (BICC)
    - Gateway Control Protocol (H.248)
    - Media Gateway Control Protocol (MEGACO)
    - IP bearer control protocol (IPBCP)
    - Complete sequence
  6. Service platform protocols / IMS
    - SIP/SDP and IMS network architecture
    - DIAMETER protocol
    - Quality of Service Policy protocol (COPS)
    - IMS signaling procedure

## Signaling and Protocols

INTERMEDIATE LEVEL

### LTE Protocols and Procedures

**Ordering number** TA-TC 1800

**Duration** 2 days / web session 2x4 hours

**Objectives** The Course describes the UMTS Long Term Evolution LTE and Evolved Packet System EPS network, interfaces and protocol architecture. It introduces into the central protocols of the E-UTRA, X2 and S1 interface, giving procedure examples. Finally the central signalling flows, such as Attach, Service Request and Handover are discussed.

**Target audience** Personnel from the technology sector requiring an overview about the LTE & EPS network protocols & procedures.

**Prerequisites** Knowledge of the UMTS network & protocols and LTE.

- Contents**
1. Introduction
  2. LTE & SAE Network Architecture
  3. LTE Radio Interface Protocols - Overview
  4. Non-Access Stratum NAS
  5. Radio Resource Control RRC
  6. Data Link Layer L2: PDCP, RLC & MAC
  7. S1 Interface
  8. X2 Interface
  9. other Interfaces
  10. Important Procedures
    - Attach
    - Tracking Area Update
    - Service Request
    - S1 Release
    - X2-based Handover
    - Detach



## Signaling and Protocols

INTERMEDIATE LEVEL

### SIP - Session Initiation Protocol

**Ordering number** TA-TC 1810

**Duration** 1 day / web session 3x3 hours

**Objectives** This course provides detailed information about SIP (Session Initiation Protocol) from IETF and the various protocols that are used with it. Aspects such as security and interworking with legacy networks are considered. Finally, an example of a network where SIP would be used in real life - 3GPP's IMS and the difference between SIP and H.323 protocols will be shown.

**Target audience** Network engineers requiring an understanding of SIP and related protocols.

**Prerequisites** Knowledge of protocol structures and protocols including IP, TCP, UDP and RTP is required. Previous knowledge of Voice over IP is useful.

- Contents**
1. Introduction
    - IP-based Multimedia Communication
    - Voice over IP
    - Introduction to SIP
  2. SIP Structure and Syntax
    - SIP Structure
    - SIP Syntax
    - Protocols Used with SIP
  3. SDP - Session Description Protocol
    - IMS Network Architecture and Elements
    - Interfaces and Protocol Stacks
    - Charging in IMS
  4. SIP Security
    - SIP Security Mechanisms
    - Transport and Network Layer Security
  5. Advanced SIP Functions
    - Advanced SIP Functions
    - Interworking with Legacy Networks
  6. SIP and Mobility - IMS
    - IMS as Next Generation Networking
    - Elements and interfaces of IMS based on SIP
    - SIP Signaling Examples in IMS
  7. SIP versus H.323
  8. Examples of SIP applications

## Signaling and Protocols

EXPERT LEVEL

### LTE Radio Interface - Physical Layer

**Ordering number** TA-TC 1820

**Duration** 4 days / web session 5x3 hours

**Objectives** The course describes the physical layer of the LTE Air Interface E-UTRA (3GPP Rel. 11) with focus on the FDD mode. The LTE radio transmission (modulation, coding, antenna mapping) with all relevant physical channels and the physical layer procedures (cell search, random access, synchronization etc.) are explained. Flexibility and capabilities of the LTE Air Interface solution will be discussed.

**Target audience** LTE FDD planner, radio engineers, radio optimization engineers, personal concerned with performance measurement.

**Prerequisites** Knowledge of UMTS/HSPA and LTE.

- Contents**
1. Introduction
  2. LTE Network Architecture & Interfaces
  3. LTE Air Interface Protocols
    - E-UTRA & E-UTRAN Protocol Overview (PHY, RLC, MAC, PDCP, RRC, RRC & NAS + States)
    - MAC: LTE Resource Allocation
    - Logical, Transport & Physical Channels
  4. E-UTRA Layer 1 Overview & OFDM(A) Principles
  5. E-UTRA Downlink Transmission: OFDMA
  6. E-UTRA Uplink Transmission: SC-FDMA
  7. LTE & MIMO
    - LTE Transmission Modes
    - Antenna mapping & precoding
    - LTE & MIMO - data rates
  8. LTE Transport Channel Processing
  9. LTE Physical Layer - Channels & Procedures
    - L1 Channel Mapping
    - Physical Resource
    - FDD & TDD Timing
    - Physical Channels
    - Cell Search & Initial Access
  10. LTE Frequencies
  11. LTE-Advanced (Rel. 11)

## Radio Network Planning & Optimization

INTERMEDIATE LEVEL

### GSM Radio Network Planning

**Ordering number** TA-TC 6020

**Duration** 4 days / web session 4x4 hours

**Objectives** After a presentation of the fundamental GSM and BSS concepts the principles of GSM network coverage, capacity and frequency planning are explained in detail, as well as the most important features to enhance coverage and capacity.

**Target audience** Radio network planners and optimization engineers, BSS system specialists and field engineers.

**Prerequisites** Knowledge about the GSM network architecture.

- Contents**
1. Introduction
    - GSM and BSS fundamental aspects
    - Planning objectives and principle steps
    - Antennas and Antenna near products
  2. Coverage Planning
    - Propagation models / Link budget
    - Impact of hardware and Cell range calculation
  3. Capacity Planning
    - Traffic theory (Erlang B and C)
    - Traffic distribution, forecasting and measurements
    - Dimensioning of control and traffic channels and of TRXs
    - Dimensioning of Abis interface (static and dynamic Abis)
  4. Frequency Planning
    - Spectrum masks and Frequency allocation (concept of re-use, BCCH and TCH layer)
    - Interference reducing features (frequency hopping, power control, handover, DTx)
    - Interference analysis
  5. Increase of Network Coverage
    - Repeater, antenna tilt, feeder less site and extended cell
  6. Increase of Network Capacity
    - Enhanced voice codecs (half rate, adaptive multi rate)
    - Orthogonal sub-channel
    - Mobility features (cell reselection, power budget and traffic reason handover)
    - Layered network

## Radio Network Planning & Optimization

EXPERT LEVEL

### GSM and (E)GPRS Optimization of Radio Networks

**Ordering number** TA-TC 6040

**Duration** 3 days / web session 3x4 hours

**Objectives** The participants will learn how to monitor their network with various types of counters and KPIs to detect faults and to analyze the causes of these problems. Based on real life network examples, the troubleshooting of bad cells, BTSs and sites by call phase and root cause drill down will be shown. Finally it will be demonstrated, how to perform a network audit by checking the configuration data bases and analyzing the problems dominating on cluster, BSC or even PLMN level.

**Target audience** Personnel from performance monitoring and optimization department as well as BSS system specialists and field engineers.

**Prerequisites** Detailed knowledge about the GSM and (E)GPRS air interface as well as about GSM and (E)GPRS radio parameters and features.

**Contents**

1. Introduction to optimization
  - Process & Targets
  - Work flow
  - Troubleshooting
  - Audit
2. KPIs and counters (generic description)
  - Counter - performance indicator - KPI
  - Types of counters
  - Monitoring
3. Troubleshooting
  - Top level KPIs (end user experience, network view)
  - GSM root cause analysis and solutions (paging, random access, access grant, SDCCH signaling, traffic channel, handover, interference and coverage)
  - (E)GPRS root cause analysis and solutions (EGPRS problems, CCCH capacity, TCH capacity, mobility, radio timeslot and TBF throughput)
4. Audit
  - Configuration management (consistency check, feature check, parameter check, frequency plan check)
  - Performance management (traffic, radio performance, dominating problems)

## Radio Network Planning & Optimization

EXPERT LEVEL

### GSM and (E)GPRS Radio Resource Management, Features and Parameters

**Ordering number** TA-TC 6050

**Duration** 5 days / web session 5x4 hours

**Objectives** On the basis of the specification, the participant learns in detail about the GSM and (E)GPRS radio resource management features and parameters to configure and control them. This includes the configuration and allocation of radio resources, mobility management by cell re-selection and handover and the optimization of the air interface by power control and capacity enhancement on the basis of multi layer operation. A qualitative discussion of different features implementations realized in practice by different vendors is given, too.

**Target audience** Personnel from planning and optimization departments.

**Prerequisites** Detailed knowledge about the GSM and (E)GPRS radio network.

- Contents**
1. Introduction to parameter planning
  2. Radio resource configuration
    - GSM timeslot configuration/ (E)GPRS timeslot configuration
  3. Radio resource allocation
    - GSM resource allocation/(E)GPRS resource allocation
  4. Activity states
    - GSM states / (E)GPRS states
  5. Measurement report
    - Standard report / Enhanced report / Timing of MS measurements / Averaging
  6. Power control
    - GSM closed loop power control
    - (E)GPRS open loop power control
  7. Handover control
    - Handover types / Synchronised handover / Adjacent cell evaluation / Timers / Radio reason handover / Urgent handover / Traffic reason handover
  8. Multilayer operation
    - Macro and micro cells / Dual band network / Normal and tight frequency reuse layer / High and low power TRx layer
  9. GSM voice coding
    - Classical FR and HR / AMR
  10. Mobility to UMTS
    - Cell selection / Handover

## Radio Network Planning & Optimization

EXPERT LEVEL

### GSM and (E)GPRS Troubleshooting of Radio Netw. with Life Netw. Analysis

**Ordering number** TA-TC 6060

**Duration** 2 days / web session 2x4 hours

**Objectives** Based on OSS performance data of the customer's own network, troubleshooting of the worst cells, BTSs and sites by call phase and root cause drill down will be done. Additionally a network audit will be given analyzing the problems dominating within the BSC area selected by the customer. This workshop is considered as additional module to the course "GSM and (E)GPRS Optimization of Radio Networks".

Optimization examples will be discussed on the basis of OSS data of the customer's network, which are summarized as report. TECHCOM will analyze one BSC area on the basis of the vendor specific OSS statistic. Air interface performance (RxLev, RxQual, frame erasure rate, C/I, MCSs, RLC BLER and LLC frame erasure rate) and traffic distribution (SDCCH and TCH Erlang, number of TBFs, throughput) will be analyzed with a geographical accuracy better than cell level.

**Target audience** Personnel from performance monitoring and optimization department as well as BSS system specialists and field engineers.

**Prerequisites** Detailed knowledge about the GSM and (E)GPRS air interface as well as about GSM and (E)GPRS radio parameters and features.

- Contents**
1. Report summary about most critical problems detected within customer's network
  2. Call flow and root cause analysis for worst cells
    - Paging, random access and access grant
    - SDCCH and TCH setup and drop
    - TBF setup and drop
    - HO
    - NACC and NCCR
  3. Audit
    - Traffic distribution for SDCCH and TCH Erlang
    - Traffic distribution for number of TBFs and (E)GPRS throughput
    - Performance distribution for timing advance, RxLev, RxQual and frame erasure rate
    - Performance distribution for C/I, MCSs, RLC block error ratio and LLC frame erasure rate
    - Dominating failure causes during call setup, call release, HO and NACC/NCRR on BSC level

## Radio Network Planning & Optimization

INTERMEDIATE LEVEL

### GPRS and EDGE Radio Network Planning

**Ordering number** TA-TC 6120

**Duration** 4 days / web session 4x4 hours

**Objectives** After a presentation of the fundamental GPRS/ EDGE concepts the principles of GPRS/ EDGE network coverage, capacity and frequency planning are explained in detail, as well as the most important features to enhance coverage and capacity. The impact of different types of applications on the planning process is taken into account also.

**Target audience** Radio network planners and optimization engineers, BSS system specialists and field engineers.

**Prerequisites** Knowledge about the GSM and GPRS/EDGE network architecture.

- Contents**
1. Introduction to GPRS/EDGE
    - Network architecture
    - Protocols and procedures (network access, state transitions, temporary block flow)
    - Logical and physical channels
    - Air interface (C/I, modulation and coding schemes)
  2. Coverage Planning
    - Impact of hardware (transmitter and receiver characteristic)
    - Propagation models
    - Link budget (role of modulation and coding scheme, incremental redundancy)
  3. Frequency Planning
    - Spectrum masks
    - Reference interference performance
    - Frequency allocation (re-use and C/I, BCCH / non-BCCH layer, (E)GPRS / non-(E)GPRS layer)
    - Interference reducing features (frequency hopping, open loop power control, cell re-selection)
  4. Capacity Planning
    - Traffic theory (CS and PS traffic characteristics and models)
    - Dimensioning of control and traffic channels and of TRXs (GPRS territory, role of C/I for capacity per timeslot)
      - Dimensioning of Abis interface (dynamic Abis)
  5. Optimization
    - Physical optimization (antenna tilt, feeder, MHA)
    - Feature and parameter optimization (channel configuration, enhancements for link adaptation, multi-carrier operation)
  6. Services in GPRS Planning
    - Telecommunication services / Traffic classes / IP services

## Radio Network Planning & Optimization

INTERMEDIATE LEVEL

### WCDMA Radio Network Planning

**Ordering number** TA-TC 6220

**Duration** 5 days / web session 5x4 hours

**Objectives** After a presentation of the fundamental Rel'99 and HSPA concepts the principles of Rel'99 and HSPA network coverage, capacity and code planning are explained in detail, as well as the most important features to enhance coverage and capacity. The participant will learn also in detail about the impact of HSPA and HSPA+ on coverage, average and peak throughput.

**Target audience** Radio network planners, UTRAN system specialists and field engineers.

**Prerequisites** Knowledge about the WCDMA network architecture.

- Contents**
1. WCDMA radio interface evolution
  2. Rel'99 and HSPA Fundamentals concerning RNP
    - R99/ HSDPA/ HSUPA
  3. HSPA+
    - Higher Order Modulation (Rel. 7)
    - MIMO (Rel. 7)
    - Network & Terminal Evolution (Rel. 6 & 7)
    - Rel. 8 & Rel. 9 Enhancements
  4. Rel'99 and HSPA Radio Resource Management & RNP
    - R99/ HSDPA/ HSUPA
  5. Link budget and coverage calculation
    - Planning process & Propagation models
    - R99/ HSDPA/ HSUPA link budget
    - Comparison R99 – HSDPA - HSUPA
    - Coverage improvement
  6. Load and capacity calculation
    - R99 load calculation & HSDPA/ HSUPA capacity
  7. Improving Coverage & Capacity
    - Coverage Limitation & Improvements/ Capacity Improvement
  8. UMTS and GSM co-planning
    - UMTS and GSM/ Multi-Operator-Interference
  9. Deployment
    - HSDPA Deployment Process
    - HSDPA Coverage & Layering Options



## Radio Network Planning & Optimization

EXPERT LEVEL

### WCDMA Optimization of Radio Networks\*)

**Ordering number** TA-TC 6240

**Duration** 3 days / web session 3x4 hours

**Objectives** The participants will learn how to monitor their network with various types of counters and KPIs to detect faults and to analyze the causes of these problems. Based on real life network examples, the troubleshooting of bad cells and node Bs by call phase and root cause drill down will be shown. Finally it will be demonstrated, how to perform a network audit by checking the configuration data bases and analyzing the problems dominating on cluster, RNC or even PLMN level.

**Target audience** Personnel from performance monitoring and optimization department.

**Prerequisites** Detailed knowledge about the WCDMA air interface and the WCDMA radio parameters and features.

- Contents**
1. Introduction to Optimization
    - Targets and process
    - Troubleshooting
    - Audit
  2. KPI and Counters
    - Counter - performance Indicator - KPI
    - Types by trigger (event - ratios, gauge - histograms)
    - Types by content (traffic, signaling, usage, integrity, air interface)
    - Monitoring process (time and geographical aggregation)
  3. Troubleshooting
    - Troubleshooting Process
    - 3GPP Parameters
    - End user experience (top KPIs)
    - Signaling (network level KPIs, call phases, call setup, call drop)

## Radio Network Planning & Optimization

EXPERT LEVEL

### WCDMA Radio Resource Management, Features and Parameters

**Ordering number** TA-TC 6250

**Duration** 5 days / web session 5x4 hours

**Objectives** The course gives a deep understanding of the WCDMA radio resource management features including HSPA(+) and the related radio parameters on the basis of 3GPP. RRM features like R99 power control, admission control, packet scheduling and handover control and their HSPA(+) counter parts are discussed in detail. A qualitative discussion of different features implementations realized in practice by different vendors is given, too.

**Target audience** Personnel from planning, optimization and network management department.

**Prerequisites** Good knowledge about the WCDMA air interface and WCDMA radio planning concepts.

**Contents**

1. Introduction to radio resource management
2. Radio channel configuration
3. Power control
4. Load control
5. Admission control
6. Packet scheduling
7. Code tree management
8. PLMN and cell selection
9. Handover procedures
10. HSDPA protocol features
11. HSDPA power resource management
12. HSDPA code resource management
13. HSDPA mobility
14. HSDPA+
15. HSUPA protocol features
16. HSUPA power resource management
17. HSUPA mobility

## Radio Network Planning & Optimization

EXPERT LEVEL

### WCDMA Troubleshooting of Radio Networks with Life Network Analysis

**Ordering number** TA-TC 6260

**Duration** 2 days / web session 2x4 hours

**Objectives** Based on OSS performance data of the customer's own network, troubleshooting of the worst cells and node Bs by call phase and root cause drill down will be done. Additionally a network audit will be given analyzing the problems dominating within the RNC area selected by the customer. This workshop is considered as additional module to the course "WCDMA Optimization of Radio Networks".

Troubleshooting and optimization will be discussed on the basis of OSS data of the customer's network, summarized as report. TECHCOM will analyze one RNC area selectable by the customer, which can be equipped with any vendor. Air interface performance (RSCP, Ec/Io, CQI, SHO overhead, block error ratio) and traffic distribution (number of RRC connection requests, throughput, number of HSPA(+) users) will be analyzed with a geographical accuracy better than cell level.

**Target audience** Personnel from performance monitoring and optimization department.

**Prerequisites** Detailed knowledge about the WCDMA air interface and the WCDMA radio parameters and features.

- Contents**
1. Report summary about most critical problems detected within customer's network
  2. Call flow and root cause analysis for worst cells
    - RRC and RAB setup and access
    - RRC and RAB drop
    - SHO, inter-frequency and inter-system HO
  3. Audit
    - Traffic distribution for RRC connection requests, throughput and number of HSPA(+) users
    - Performance distribution for Ec/Io, RSCP, CQI, SHO overhead and block error ratio
    - Dominating failure causes during call setup, call release and HO on RNC level

## Radio Network Planning & Optimization

EXPERT LEVEL

### WCDMA Counters and Key Performance Indicators

**Ordering number** TA-TC 6270

**Duration** 4 days / web session 4x4 hours

**Objectives** This course provides guidance on how to monitor the performance of the WCDMA network, especially the UTRAN. Important KPIs are introduced to evaluate accessibility, retainability and mobility procedures as well as the performance of the air interface and the quality of service experienced by the user. Practical sections present the evaluation of 3GPP failure causes and of the air interface performance based on call trace and OSS data.

**Target audience** Personnel from performance monitoring and optimization / troubleshooting department.

**Prerequisites** Good knowledge about the WCDMA air interface and the radio planning concepts.

- Contents**
1. WCDMA Network Overview
    - Quality requirements in WCDMA networks
    - WCDMA architecture and protocols
    - Performance data and key performance indicators
  2. Call and Connection Analysis
    - Service concept
    - Call setup and release
    - PS traffic in UTRAN
    - Practical protocol trace examples
    - Optional appendix: NAS procedures
  3. Mobility
    - Handover types; Measurements
    - Soft handover; Hard handover / SRNC relocation
    - HO parameter verification with TECHtrace®
  4. Quality
    - Resources in UTRAN and ATM and IP/Ethernet measurements
    - Throughput measurements and Radio measurements
    - Codes and Quality and load related KPIs
    - Air Interface quality and load verification with TECHtrace®
  5. HSPA / HSPA +
    - General aspects
    - HSDPA (setup and release, serving cell change, throughput, number of users, power and codes, CQI)
      - HSUPA (setup and release, soft handover, throughput, number of users, power)
      - HSPA+ (higher modulation, MIMO, dual carrier HSPA, F-PDCH, high speed Cell\_FACH, Voice over HSPA, continuous packet connectivity)
        - Practical protocol trace examples

## Radio Network Planning & Optimization

INTERMEDIATE LEVEL

### LTE Radio Network Planning

**Ordering number** TA-TC 6420

**Duration** 5 days / web session 5x4 hours

**Objectives** The participant will learn all fundamental aspects of the LTE air interface needed for LTE radio network planning. LTE coverage and capacity calculation will be explained in detail. Exercises will be done by the participants on basis of an LTE planning EXCEL sheet developed by TECHCOM.

**Target audience** Radio network planners, E-UTRAN system specialists and field engineers.

**Prerequisites** Basic knowledge about the LTE network architecture and air interface.

- Contents**
1. Network architecture and interfaces
    - LTE objectives and standardization / Architecture overview / EUTRAN and EPC architecture / LTE UE / Interfaces
  2. LTE radio interface protocols
    - E-UTRA and E-UTRAN protocols overview / MAC resource allocation / Logical, transport and physical channels
  3. E-UTRA layer 1 key aspects and OFDM(A) principles
  4. E-UTRA transmission ODFMA and SC-FDMA
  5. LTE and MIMO
    - Multi antenna transmission principles in LTE / Spatial multiplexing MIMO principles / Spatial multiplexing MIMO in LTE
  6. LTE physical channels and procedures
    - Physical layer design / Cell search and random access procedures / DL and UL physical channels
  7. Physical layer overhead
    - Dimensioning flow / Generic overhead characteristics / DL and UL signaling overhead
  8. LTE frequencies
    - LTE frequencies / Inter cell interference coordination / Frequency hopping / Frequency selective scheduling
  9. LTE link budget
    - Principles of coverage calculation / DL and UL link budget / Examples
  10. LTE capacity
    - Capacity dimensioning process / LTE capacity / throughput versus SINR / Parameters affecting the LTE capacity
  11. VoLTE
    - VoLTE as GBR service / VoLTE codecs / Protocol header overhead / Coverage / Capacity
  12. Outlook to LTE advanced
    - The real 4G / LTE R10 technology components / Network architecture enhancements / LTE R11 and beyond forecast
  13. PCI, PRACH and paging
    - PCI and PRACH planning / Page capacity

## Radio Network Planning & Optimization

EXPERT LEVEL

### LTE Planning and Optimization for Roll Out

**Ordering number** TA-TC 6430

**Duration** 5 days / web session 5x4 hours

**Objectives** The workshop will support the participants to shorten the LTE roll out phase. They will get a deep understanding of the initial planning and the related parameter settings, as well as of the performance monitoring of the air interface and user experience required during roll out within a multi-vendor environment. Additionally the reuse of existing 2G/3G sites will be discussed, and how one can predict the LTE performance on basis of the 2G/3G performance at such reused sites. Optionally OSS life data of the customer's network will be discussed, which are summarized as report. TECHCOM will analyze a cluster of 100 eNodeBs on the basis of the vendor specific OSS statistic. In dependence on the availability of timing advance counters, air interface performance (RSRP, RSRQ, CQI) and user experience (throughput, BLER) will be analyzed with a geographical accuracy better than cell level. Optionally OSS life data of 2G/3G sites to be reused for LTE will be analyzed as well, and the expected LTE performance will be discussed. This analysis will cover 1 BSC/RNC area.

**Target audience** Engineers working in E-UTRAN planning, performance monitoring and optimization department as well as experts for technology swaps and upgrades.

**Prerequisites** Good knowledge about the LTE air interface.

- Contents**
1. Coverage Planning
    - Link budget
    - Coverage calculation
  2. Cell Capacity Estimate
    - Physical channel dimensioning and overhead
    - Throughput
    - Role of inter-cell interference coordination
  3. Reuse of Existing 2G/3G Sites
    - Problems
    - Prediction of LTE performance
  4. Fundamental Parameter Settings
    - Codes (PCI, PRACH root sequence index)
    - Power (cell power, open loop power control)
    - Idle Mode Mobility
    - Connected Mode Mobility
  5. Network diagnostics
    - Air interface performance on DL (RSRP, RSRQ, CQI, cell matrix)
    - Air interface performance on UL (RSSI, SINR, UE power headroom)
    - User experience (throughput, BLER, drop)
  6. X2 and S1 dimensioning
    - Introduction to Transport Dimensioning
    - Based on Air Interface Throughput
    - Based on Traffic Demand
    - C- and M-Plane Dimensioning

## Radio Network Planning & Optimization

EXPERT LEVEL

### LTE Optimization of Radio Networks

**Ordering number** TA-TC 6440

**Duration** 3 days / web session 3x4 hours

**Objectives** The participants will learn how to monitor their network with various types of counters and KPIs to detect faults and to analyze the causes of these problems. Based on numerous real life network examples, the troubleshooting of bad cells and eNodeBs by call phase and root cause drill down will be shown. Finally it will be demonstrated, how to perform a network audit by checking the configuration data bases and analyzing the problems dominating on cluster or even PLMN level.

**Target audience** Personnel from performance monitoring and optimization department.

**Prerequisites** Detailed knowledge about the LTE air interface and the LTE radio parameters and features.

- Contents**
1. Introduction to Optimization
    - Optimization targets and process
    - Troubleshooting
    - Audit
    - LTE specific features
  2. Counters and KPIs
    - Hierarchy of measurements (counter – PI – KPI, aggregation)
    - Classification of performance measurements
    - Air interface related measurements (CQI, RSRP/RSRQ, UL RSSI/SINR, power headroom)
    - Signaling related measurements (accessibility, retainability, mobility)
    - Integrity measurements (user throughput, block error ratio, packet loss and delay)
    - Traffic measurements (resource block utilization, number of users, cell throughput)
  3. Optimization and Troubleshooting
    - RF optimization (antenna tilt and azimuth, interference, crossed feeders)
    - Setup and access failure causes (PRACH procedure, RRC and ERAB establishment)
    - Drop causes (network and user view, ERAB and UE context drop)
    - User experienced data rate (impacts from high layers, air interface related causes)
    - HO failure causes (preparation and execution, event optimization)
    - Parameter tuning (UL power control, physical channel configuration)
  4. Audit
    - Configuration management (consistency, feature and parameter check)
    - Performance management (traffic and radio performance)

## Radio Network Planning & Optimization

EXPERT LEVEL

### LTE Radio Resource Management, Features and Parameters

**Ordering number** TA-TC 6450

**Duration** 5 days / web session 5x4 hours

**Objectives** The course gives a deep understanding of the LTE radio resource management features and the related radio parameters on the basis of 3GPP. RRM features like physical CH configuration, DRx in idle / connected mode, admission / load control, link adaptation / MIMO, packet scheduling, power control and ICIC, idle / connected mode mobility and SON are discussed in detail. A qualitative discussion of different features implementations realized in practice by different vendors is given, too.

**Target audience** Personnel from planning, optimization and network management department.

**Prerequisites** Good knowledge about the LTE air interface and LTE radio planning concepts.

- Contents**
1. LTE Parameter Database, System Info and Signaling Timer
  2. Physical Channel Configuration
    - Channel Overview / LTE Access / DL and UL Physical Channels
  3. LTE Bearer Handling
    - Radio Protocols / Bearer Model / Paging / DRx in Connection Mode / QoS Configuration
  4. LTE Admission and Congestion Control
    - Admission Control / Preemption / Load Control
  5. LTE Link Adaptation, MIMO and CoMP
    - Link Adaptation... / ...on PDSCH and PUSCH / for VoLTE / ...on PDCCH / MIMO / Coordinated Multi-Point Operation
  6. LTE Packet Scheduling
    - Administration / Time Domain Scheduling / Frequency Domain Scheduling / VoIP / Carrier Aggregation
  7. LTE Power and Interference Control
    - UL Power Control and DL Power Settings / ICIC Frequency and Time Division / ICIC State Transitions / Dynamic ICIC and Interference Shaping
  8. LTE Idle Mode Mobility
    - Cell (Re)Selection Process / Measurements in Idle Mode / S and R Criterion / Load Balancing in RRC Connection Release
    - Speed of UE / Access Restrictions / Closed Subscriber Groups
  9. Connected Mode Mobility
    - Handover Architecture and Process / Measurements in Connected Mode / HO Events
    - Redirection / SRVCC and CSFB / Load Balancing / Closed Subscriber Groups
  10. LTE SON Features and Applications
    - SON Architecture / Self Deployment / Automatic PCI Configuration
    - Automatic Neighbor Planning and Optimization / Minimization of Drive Test



## Radio Network Planning & Optimization

EXPERT LEVEL

### LTE Troubleshooting of Radio Networks with Live Network Analysis

**Ordering number** TA-TC 6460

**Duration** 2 days / web session 2x4 hours

**Objectives** Based on OSS performance data of the customer's own network, troubleshooting of the worst cells and eNodeBs by call phase and root cause drill down will be done. Additionally a network audit will be given analyzing the problems dominating within a cluster selected by the customer. This workshop is considered as additional module to the course "LTE Optimization of Radio Networks". Troubleshooting and optimization will be discussed on the basis of OSS data of the customer's network, summarized as report. TECHCOM will analyze one cluster selectable by the customer, which can be equipped with any vendor. Air interface performance (RSRP, RSRQ, CQI, block error ratio) and traffic distribution (number of RRC connection requests, throughput, number of users) will be analyzed with a geographical accuracy better than cell level.

**Target audience** Personnel from performance monitoring and optimization department.

**Prerequisites** Detailed knowledge about the LTE air interface and the LTE radio parameters and features.

- Contents**
1. Report summary about most critical problems detected within customer's network
  2. Call flow and root cause analysis for worst cells
    - RRC, ERAB and UE context setup and access
    - RRC, ERAB and UE context drop
    - Intra eNodeB, inter eNodeB and inter-system HO
  3. Audit
    - Traffic distribution for RRC connection requests, throughput and number of users
    - Performance distribution for RSRP, RSRQ, CQI and block error ratio
    - Dominating failure causes during call setup, call release and HO on cluster level

## Radio Network Planning & Optimization

EXPERT LEVEL

### LTE Counters and Key Performance Indicators

**Ordering number** TA-TC 6470

**Duration** 4 days / web session 4x4 hours

**Objectives** This course provides guidance on how to monitor the performance of the LTE radio access network. Important KPIs based on 3GPP are introduced to evaluate accessibility, retainability and mobility procedures as well as the traffic and the performance of the air interface and the quality of service experienced by the user. Specific services and enhanced features like VoLTE, carrier aggregation and SON are included. Use cases present the evaluation of 3GPP failure causes and of the air interface performance based on OSS data.

**Target audience** Engineers working in E-UTRAN performance and QoS monitoring and field engineering.

**Prerequisites** Good knowledge about LTE air interface and RRM parameters and features.

- Contents**
1. Measurement categories
    - Signaling procedures / Traffic / User experienced quality / Coverage
  2. Accessibility
    - Bearers in EPS / RRC connection, UE context and E-RAB
  3. Retainability (RRC connection, E-RAB and UE context release)
  4. Mobility
    - HO options in connected mode / Signaling UE - eNodeB / Intra- and inter-eNodeB HO / Inter-system PS HO, voice mobility and redirection / KPIs for mobility optimization by SON
  5. Re-establishment
    - Signaling flow / Causes / UE context retrieval
  6. Utilization and traffic
    - Air interface and HW utilization / User traffic / Throughput and data volume
  7. Integrity and quality
    - Uu interface data link layer / MAC and RLC layer / PDCP packet loss and delay / Instantaneous and experienced speed / QoS for VoLTE
  8. Availability and coverage
    - Cell availability KPIs
    - DL and UL related measurements
    - Timing advance

## Radio Network Planning & Optimization

INTERMEDIATE LEVEL

### GSM and UMTS Network

**Ordering number** TA-TC 6510

**Duration** 5 days / web session 5x4 hours

**Objectives** The training will inform the participants about the GSM / (E)GPRS and UMTS / HSPA network architecture. Network elements, interfaces and protocol architecture will be discussed as well as air interface related functions and the physical channels.

**Target audience** Engineers and technical experts.

**Prerequisites** Basic knowledge about the GSM / (E)GPRS and UMTS / HSPA standard network elements and air interface.

- Contents**
1. GSM network
    - Architecture
    - Protocols
    - Procedures
    - Logical and physical channels
  2. GPRS / EDGE network
    - Extensions of GSM architecture towards GPRS / EDGE
    - Protocols
    - Procedures
    - Logical and physical channels
  3. UMTS network
    - Architecture
    - Protocols
    - Logical, transport and physical channels
    - Radio resource management
  4. HSPA network
    - HSDPA protocol extensions
    - HSDPA channels
    - HSDPA mobility
    - HSUPA protocol extensions
    - HSUPA channels
    - HSUPA mobility
    - HSPA+

## Radio Network Planning & Optimization

EXPERT LEVEL

### GSM/ WCDMA/ LTE System Interworking

**Ordering number** TA-TC 6540

**Duration** 4 days / web session 4x4 hours

**Objectives** The course will present the parameter data base concepts as well as the cell re-selection and handover procedures related to mobility between 2G, 3G and 4G networks. The signaling flow coming up during inter-RAT mobility will be discussed, together with the performance measurements needed to monitor the individual phases of these procedures.

**Target audience** Engineers from planning, performance monitoring and optimization departments who need detailed knowledge about inter-RAT mobility between 2G, 3G and 4G networks.

**Prerequisites** Good knowledge about 2G, 3G and 4G air interface, basic knowledge about 2G, 3G and 4G parameter planning and performance monitoring.

- Contents**
1. Interworking GSM to WCDMA
    - Features and Parameters (BSS parameter objects for mobility to 3G, cell re-selection, ISNCCR, ISHO)
    - Performance Measurements and KPIs (signaling flow and monitoring for ISHO and ISNCCR)
  2. Interworking WCDMA to GSM
    - Features and Parameters (RAN parameter objects for mobility to 2G, cell re-selection, ISHO)
    - Performance Measurements and KPIs (signaling flow and monitoring for ISHO and RNC-BSC-relocation)
  3. Interworking LTE to GSM and WCDMA
    - LTE HO architecture according 3GPP (HO measurements and trigger)
    - Features and Parameters (LTE parameter objects for outward mobility, cell re-selection, NACC, HO, redirection, CSFB)
    - Performance Measurements and KPIs (signaling flow and monitoring for HO, redirection and CSFB)
  4. Interworking GSM + WCDMA to LTE
    - Interworking of WCDMA with LTE (RNC parameter objects for mobility to 4G, cell re-selection, HO, monitoring)
    - Interworking of GSM with LTE (BSS parameter objects for mobility to 4G, cell re-selection, ISNCCR, monitoring)

## Radio Network Planning & Optimization

EXPERT LEVEL

### Multi-technology coverage planning for in-building installations

**Ordering number** TA-TC 6630

**Duration** 3 days / web session 3x4 hours

**Objectives** The participants will learn how to model RF propagation within buildings. Different types of environment like office buildings, shopping malls and tunnels will be taken into account. Next the link budget for radio access networks from 2nd to 4th generation will be discussed, including cell size estimates for typical in-building installations. Finally it will be shown, how the link budget is modified by repeaters. Limitations arising from processing and propagation delay will be presented as well.

**Target audience** Radio network planners and field engineers working especially with in-building installations.

**Prerequisites** Good knowledge of the GSM, WCDMA and LTE air interface.

- Contents**
1. In-building propagation models
    - Types of propagation models
    - Tunnels
    - In-house environment
  2. Multi-technology link budgets and in-building cell size estimates
    - GSM
    - LTE
  3. Repeater
    - GSM Modification of link budget
    - Limitations due to delays

## Radio Network Planning & Optimization

INTERMEDIATE LEVEL

### Core Network and Transmission Planning

**Ordering number** TA-TC 6720

**Duration** 4 days / web session 4x4 hours

**Objectives** This training addresses to the planning and design principles of the Circuit Switched CS and Packet Switched PS domain of the GSM/ (E)GPRS and WCDMA Core Network of 3GPP R4 and the related transmission network. It describes network assessment and dimensioning. Measurements of quality to end are discussed as well as mobility management (security, location management etc.) and interoperability.

**Target audience** Operator and supplier staff related to core network.

**Prerequisites** Knowledge about the GSM / (E)GPRS and WCDMA standard, network elements and interfaces.

- Contents**
1. Introduction to network planning
    - Network planning process / Backbone
  2. CS and PS domain architecture
    - Network evolution
    - CS and PS network elements
    - Identities and registration areas of the CN network
    - Further evolution (IMS, Flexible A, Gb, Iu interfaces)
  3. Network assessment
    - General rules / CS and PS core network assessment / Results of network assessment
  4. Network dimensioning
    - General rules / Dimensioning of CS domain / Dimensioning of PS domain
  5. Signaling planning / routing
    - Evolution of the SS7 system
    - Redundancy and routing principles within the SS7 system
  6. CS Core network planning
    - Introduction
    - Iu-CS, Nb, Mc and Nc interface
  7. PS core network planning
    - Introduction
    - Limitations
    - Overhead and QoS
    - Iu-PS, Gn/Gp and Gi interface
  8. Optimizing the network
    - Quality of service
    - Optimization

## Radio Network Planning & Optimization

EXPERT LEVEL

### Rel. 4 Core Network Procedures and Parameter

**Ordering number** TA-TC 6750

**Duration** 4 days / web session 4x4 hours

**Objectives** The course discusses the 3GPP R99 and R4 CS and PS core network architecture, interfaces and protocols. It delivers central signaling procedures and related parameters of the CS and PS domain, as well as call flow related procedures.

**Target audience** Operator and supplier staff related to core network.

**Prerequisites** Knowledge about the GSM / (E)GPRS and WCDMA standard, network elements and interfaces.

- Contents**
1. UMTS Rel. 99 & Rel. 4 CN Architecture & Protocols
    - UMTS Rel. 99 & Rel. 4 CN Architecture
      - UMTS network architecture
      - SS7 Signalling Introduction
      - GSM and UMTS numbering
    - UMTS Rel. 99 & Rel. 4 CN Protocols MTP, ATM in 3G, SCCP, ISUP, TCAP, MAP, SS7 over IP, GTP, H.248 protocol, Nb interface, BICC protocol, SIP
  2. CS Domain Signalling Procedures
  3. PS Domain Signaling Procedures
    - Mobility management
    - Authentication procedure
    - Paging
    - GPRS / UMTS roaming
    - Session management
    - Data transfer process
  4. Main Rel. 4 specific CN Procedures
    - MO and MT sequence
    - Call clearing sequence
  5. CAMEL Basics:
    - CAP protocol overview
    - CAP Operations flow examples

## Radio Network Planning & Optimization

INTRODUCTION LEVEL

### LTE (Long Term Evolution) Training Bootcamp - Crash Course

<b>Ordering number</b>	Tailored
<b>Duration</b>	10 days
<b>Objectives</b>	The course explains generally the LTE system, but focuses on E-UTRA, starting with the protocols and procedures on the different E-UTRA interfaces. A detailed description is given especially for the air interface, radio planning and the most important parameters. The course introduces the participants also to performance monitoring by counters and KPIs and in to the transport network. All aspects discussed during the training are based on 3GPP.
<b>Target audience</b>	Radio planning and optimization as well as performance and configuration engineers.
<b>Prerequisites</b>	Good knowledge about both 2G and 3G.
<b>Contents</b>	<ol style="list-style-type: none"><li>1. LTE and EPS objectives, standardization and milestones</li><li>2. LTE and EPS network, architecture and interfaces</li><li>3. E-UTRAN radio</li><li>4. LTE radio planning</li><li>5. LTE 3GPP parameters</li><li>6. LTE 3GPP network monitoring</li><li>7. Introduction to LTE transport</li></ol> <ul style="list-style-type: none"><li>• <a href="http://www.techcom.de/en/download/TA-TC_LTE_Crash_Course_description_SM_MO.pdf">http://www.techcom.de/en/download/TA-TC_LTE_Crash_Course_description_SM_MO.pdf</a> PDF Download for more details</li></ul>



## Presentation, Administration, Radio Networks Performance Analyses & Optimization

EXPERT LEVEL

### Network Performance Analysis with TECHtrace® OSS/ PRO

<b>Ordering number</b>	TA-TC 7410
<b>Duration</b>	4 days / web session 4x4 hours
<b>Objectives</b>	The participants will learn to load OSS data to the TECHtrace® OSS/PRO software to obtain presentations of various KPIs in forms of reports, diagrams and geographical distributions. The detection of bad cells by automatic analysis techniques will be discussed. The participant will get an understanding of the interpretation of standard OSS KPIs and new ones generated by the TECHtrace® OSS/PRO software on the basis of real life measurements.
<b>Target audience</b>	Personnel from performance monitoring and optimization departments who will analyze the performance of their network on the basis of OSS data.
<b>Prerequisites</b>	Good knowledge about the UMTS and HSPA air interface and the related parameters and features. Good knowledge about signaling and OSS counter/ KPI within the UTRAN.
<b>Contents</b>	<ol style="list-style-type: none"> <li>1. Introduction to TECHtrace®           <ul style="list-style-type: none"> <li>• Software architecture</li> <li>• Import of OSS data</li> <li>• GUI overview</li> </ul> </li> <li>2. Working with the software           <ul style="list-style-type: none"> <li>• Representation of KPIs by reports and diagrams</li> <li>• Geographical KPI distribution</li> <li>• Automatic detection of bad cells</li> </ul> </li> <li>3. Air Interface Analysis           <ul style="list-style-type: none"> <li>• User distribution (propagation delay)</li> <li>• Cell quality and coverage (<math>E_c/I_o</math>, RSCP)</li> <li>• HSDPA quality (CQI)</li> <li>• Cell overlap (adjacent to own cell interference ratio, SHO overhead)</li> <li>• DL load (TCP and HSDPA power)</li> <li>• UL load (RTWP and own cell load)</li> </ul> </li> <li>4. Traffic Analysis           <ul style="list-style-type: none"> <li>• RRC traffic (RT and NRT services, signaling procedures)</li> <li>• Throughput (RT and NRT services, signaling procedures, R99 and HSPA)</li> <li>• Number of users and throughput per user</li> <li>• Channel card utilization</li> </ul> </li> </ol>

## Presentation, Administration, Radio Networks Performance Analyses & Optimization

PRODUCT TRAINING

### Introduction to TECHtrace® V. 2.0

**Ordering number** TA-TC 7500

**Duration** 2 days / web session 2x4 hours

**Objectives** The participants will learn to use the functionalities offered by the TECHtrace®. They will learn about the structure of TECHtrace® and how to work with software.

**Target audience** Performance and optimization engineers.

**Prerequisites** Good knowledge about the air interface and the performance monitoring of mobile networks. The participants should know the technology depending on software package.

- Contents**
1. Introduction to TECHtrace®
    - Software architecture
    - Data flow between OSS and TECHtrace®
  2. TECHtrace® Explorer
    - Common structure and functions
    - Report template editor
    - Geo template editor
    - Calculate reports/maps
  3. TECHtrace® Map
    - Structure and main functions
    - Layers and objects
    - Settings
  4. TECHtrace® Reporter
    - Common structure and functions
    - Layouts
    - Tables and diagrams
    - Edit template
    - Settings

## Presentation, Administration, Radio Networks Performance Analyses & Optimization

PRODUCT TRAINING

### Administration of TECHtrace® OSS/ PRO

**Ordering number** TA-TC 7600

**Duration** 3 Days / web session 3x4 hours

**Objectives** The participants will learn to handle the script language and the script engine of the TECHTrace® OSS/PRO software. They will learn to define own performance indicators, reports and geo maps, and how they can monitor this way their network in a vendor independent way.

**Target audience** Performance and optimization engineers.

**Prerequisites** Good knowledge according to Introduction to TECHtrace® OSS/PRO and good knowledge about script languages or C(++).

- Contents**
1. Introduction
    - Software architecture and administration work flow
    - TTWHClient
    - TTCommander
    - TTScripManager
  2. Definition of performance indicators
    - PI editor
    - Types of PIs and types of data aggregation
    - Configuration of tabular representation of PIs
  3. Programming of import scripts
    - Creation of scripts
    - Objects used by script engine
    - Script example
  4. Programming of reports scripts
    - Script editor
    - Definition of source performance indicators
    - Types and definition of diagrams
    - Configuration of overall representation
  5. Programming of geo map scripts
    - Script editor
    - Script parameters