

## ***HSPA+ Design Details & System Engineering***

### **Course Duration:**

- 2 days

### **Course Description:**

- This course offers not only a detailed explanation of all vital Rel. 7 UTRA-features but also a condensed overview which makes this course a must for everybody who needs to setup, engineer, upgrade or operate HSPA+ equipment.
- In the beginning of the course we review HSDPA and HSUPA in order to lay the foundation of HSPA+ understanding. Then we soon introduce HSPA+ and its new optional features for both UE and UTRAN. We explain what optional features are behind CPC and Enhanced FACH.
- The following part reviews important HSDPA changes made in release 6 and in a bit more depth HSUPA. Note that these sections are not intending to replace detailed HSPA trainings in INACON's programs.
- Special focus is laid on the areas where HSPA+ improves existing HSPA networks, e.g. in terms of peak subscriber throughput, air-interface efficiency and UTRA-capacity as well latency reduction for RRC and user data transfer.
- The course continues with the elaboration of implementation of important key technologies like MIMO, higher order modulation schemes (4-PAM, 16-QAM, and 64-QAM), HS-SCCH-less operation, Enhanced FACH and Continuous Packet Connectivity (CPC).
- After this technology foundation the L1 signaling aspects are intensively covered followed by MAC and RRC HSPA+ specifics.
- In the next part we have a look into release 8 HSPA+ and work on features like 64-QAM together with MIMO and downlink interference cancellation in UE.
- The final chapter is dedicated to selected important scenarios of HSPA+ operation such as PDP context establishment, serving cell change, and the data flow

### **Prerequisites:**

- Participants should be already familiar with UMTS and HSPA. This should stem from previous exposure to design, troubleshooting or operations jobs in UMTS/HSPA telecommunication networks.
- HSPA+ deals to a great extend with amendments of HSPA Layer 1 but also enhances quite a bit RRC due to HS-DSCH reception in CELL\_FACH and XXX\_PCH so a fair knowledge of UMTS Protocol Stack architecture is advantageous.

## **Course Target:**

- The course enables the students to test, to plan, and to operate HSPA+ in their specific environment, in their specific networks.
- The student will be able to judge the various implementation variants of HSPA+ and to decide on a preferred implementation and deployment of HSPA+.

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

- How HSDPA has been enhanced in release 6 with F-DPCH and Pre- as well Postamble sending?
- What are the key principles of Scheduling and throughput generation in HSUPA, e.g. scaling of transport block with a certain power offset granted by NodeB?
- What are the differences in-between HSPA and HSPA+ in terms of peak data rates, efficiency and capacity?
- What is MIMO and what makes it that important for tomorrow's mobile radio standards?
- How MIMO is introduced in HSPA+ and what needs to be changed in terms of signaling and protocols?
- How MIMO competes with downlink Dual Cell HSDPA (dual carrier HSDPA)?
- What individual features hide behind the term Continuous Packet Connectivity and what needs to be done in order to efficiently implement them in HSPA+?
- How does the new generation of Layer 1 signaling look like in HSPA+ making use of HS-SCCH, e.g. how can uplink DTX and/or downlink DRX be switched on/off by NodeB?
- How do MAC and RRC protocols change for HSPA+ and in particular with the Enhanced FACH feature set? The so called eFACH enables higher throughput rates and reduced latency when FACH and PCH are replaced by HS-DSCH in CELL\_FACH and XXX\_PCH states!
- When and how MIMO can be combined with 64-QAM?
- How can downlink interference cancellation be implemented in the UE?
- How HSPA+ might evolve further beyond release 8?
- Will important scenarios like PDP context activation and serving cell change be different in HSPA+?
- How DL and UL data is transferred to and from TCP/IP services?

## **Who should attend this Course:**

- The course is mainly targeted at UE vendor, infrastructure vendor and network operator development/testing/operating staff who need to upgrade today's HSPA equipment/networks to HSPA+.

## Table of Content:

### Introduction to HSPA+

- **HSPA+ in the HSPA Roadmap**

UMTS R99 / R4, HSDPA R5, HSPA R6, LTE R8, HSPA+ R7, HSPA+ R8, HSPA+ R9, HSPA+ R10, HSPA+ R11

- **Main Features**

- ⇒ Release 7

Advanced Receivers, Higher Peak Rates, Continuous Packet Connectivity (CPC), Direct Tunneling – Flat Network Architecture

- ⇒ Release 8

Requirements for two branch Interference Cancellation (IC), CS Voice over HSPA (CSoHS), Performance Requirements for 15 HSDPA codes, MIMO + 64-QAM, Dual Cell Operation, Enhanced Discontinuous Reception (DRX), Improved L2 for UL, Enhanced UL for CELL\_FACH, Enhanced SRNS Relocation, PDCP and RLC Parameter

- **Optional and Mandatory Features in Rel. 7**

- ⇒ F-DPCH, MAC-e-hs and HS-SCCHless Support

- ⇒ Enhanced F-DPCH, CELL\_FACH and XXX\_PCH

Enhanced F-DPCH, HS-PDSCH in CELL\_FACH and XXX\_PCH

- ⇒ Enhanced Cell\_FACH, RLC Improvements

- ⇒ Iub Enhancements

HS-DSCH Data Frame Type1 - 3, RSEPS

- ⇒ Other Features

E-DPDCH Power Interpolation, E-DPCCH Power Boosting, New uplink DPCCH Slot Format #4, Uplink DPCCH Gating and Downlink DRX for HS-SCCH and E-XXCH

- ⇒ Practical Exercise: HSPA+ Features and their Benefit

- **Feature Review of HSDPA**

- ⇒ Release 5 HSDPA Feature Summary

- ⇒ Release 6 HSDPA Feature Summary

Improved HS-DSCH Reception for UE

- ⇒ HSDPA Timing

- ⇒ HARQ in HSPA

HARQ Techniques within HSPA/HSPA+, Type I Hybrid ARQ – Low UE Complexity, Type II Hybrid ARQ – High UE Complexity, Type III Hybrid ARQ – Medium UE Complexity, Parameters for signaling the HARQ scheme, Turbo Coding and HARQ, .1 IR and CC, .2 Full IR, .3 Partial IR, .4 Chase Combining

- ⇒ HSDPA Spreading and Modulation

- ⇒ The Code Tree

- ⇒ HSDPA Modulation

QPSK Modulation Mapper, 16-QAM Modulation Mapper, 64-QAM Modulation Mapper, WCDMA Physical Data Rates, QPSK, 16-QAM, 64-QAM

- ⇒ UE Categories

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HSDPA Categories Rel. 5 – Rel. 7, Code Rate and Soft Memory, HSUPA Categories Rel.6 and Rel. 7

- **Peak Throughput Increase in HSPA+**

- ⇒ Higher Order Modulation Schemes  
DL Modulation Schemes, UL Modulation Schemes
- ⇒ MIMO versus Downlink Dual Carrier  
Rel. 8 Dual Carrier HSDPA, MIMO

- **Channels in HSPA/HSPA+**

- ⇒ HSDPA Channels according to Releases  
Release 5 HSDPA Channel Properties, Single Sided RLC Re-establishment Procedure, Release 6 HSDPA Channel Properties, Channel Coding of PRE and POST (including HARQ-ACK), Release 7 HSDPA Channel Properties
- ⇒ HSUPA Detailed Channel View  
E-HICH, E-AGCH, E-RGCH, E-DPDCH and E-DPCCH, E-DCH, F-DPCH, E-DCH Serving RLS versus non-Serving RL, RG Combination Index, TPC Combination Index, Summary: HSDPA and HSUPA Channel Overview, Uplink DPCCH Slot Format – Rel.7 Slot Format #4

- **HSDPA Data Scheduling in the Downlink**

- ⇒ HSDPA Basic Operation and Scheduling  
MAC-(e)hs, New Channels, UE Scheduling
- ⇒ HS-DSCH Setup and Operation  
HS-DSCH Configuration – Radio Bearer Setup, HS-DSCH Operation

- **Scheduling in the Uplink**

- ⇒ SIR Considerations in a CDMA-system
- ⇒ Uplink Load Curve – Rise over Thermal  
Air Interface Load, Uplink Load, Load Estimation
- ⇒ Review of Rel. '99 Uplink TFC Selection
- ⇒ E-TFCI Selection  
Serving Grant Table 1 (Rel. 6), Serving Grant Update, Spreading Factor 4 Equivalents, Maximum Power Ratio
- ⇒ Serving Grant Table 2 (Rel. 7)
- ⇒ UE's Scheduling Requests  
Inband Scheduling Info on the E-DCH, Scheduled Transmission, Scheduled Transmission continued, Non-Scheduled Transmission, UE Power Head Room (UPH), Outband Happy Bit on the E-DPCCH, Scheduling Operation
- ⇒ Practical Exercise: Work out the differences between HSDPA and HSUPA!

- **HSPA+ Protocol Stack**

- ⇒ HSUPA Protocol Stack Details
- ⇒ HSDPA Protocol Stack Details  
MAC-ehs Protocol specifics – MAC-ehs header features

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## Release 6 HSDPA Enhancements

- **Purpose of F-DPCH (associated with HSDPA)**  
DPCH frame offset for F-DPCH  
⇒ F-DPCH Setup  
F-DPCH Slot Format, F-DPCH Quality Target Control, TPC Command Error Rate , UE Support , More Details on Fractional DPCH (F-DPCH)
  - **Preamble and Postamble in HSDPA Release 6**  
HSDPA Pre- and Postamble, UE Procedure for Receiving HS-DSCH
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## HSPA+ in Release 7

- **Higher Order Modulation Schemes**  
⇒ 64 QAM in DL  
Interference Sensitivity , QPSK, 16-QAM, 64-QAM, Consequences  
⇒ 64-QAM Setup  
Maximum flexible RLC-AM PDU Size supported in UMTS Rel. 7
- **MIMO for HSDPA**  
⇒ Single Stream and Dual Stream MIMO  
⇒ Precoding  
Motivation of Spatial Precoding, Plain MIMO, Multiple Rank Beamforming, Precoding and Spatial Diversity, Spatial Precoding, Codebook, PCI and CQI Loop, Codebook, PCI and CQI Loop  
⇒ MIMO Performance on Link Level  
SISO vs. SIMO, SIMO vs. MIMO, 2x2 MIMO vs. 4x2 MIMO, 16-QAM vs. 64-QAM
- **Continuous Packet Connectivity (CPC)**  
⇒ Introduction to CPC  
CPC Features, User Gain, System Gain  
⇒ HS-SCCHless Operation (Rel. 7 onwards)  
Pre-Conditions for HS-SCCHless Operation, TransmissionTiming, Details on HS-SCCHless Operation , 1st step, initial transmission of data packet, 2nd and 3rd step, retransmission of data packet  
⇒ Uplink DTX Cycles in CELL\_DCH  
Image Description continued, Uplink Discontinuous Transmission (DTX), Downlink Discontinuous Reception (DRX), Preconditions for DTX-DRX Enabling – Consistency Checks, Uplink DPCCH Gating  
⇒ RRC message ID's  
DTX and DRX Information  
⇒ CPC Timing  
Uplink CQI transmission  
⇒ Example for Uplink DPCCH Burst Pattern for 10 ms E-DCH TTI  
Uplink DRX, Downlink DRX  
⇒ Uplink DPCCH preamble and postamble  
Uplink DPCCH preamble and postamble for the DPCCH only transmission, Uplink DPCCH preamble and postamble for the E-DCH transmission, Uplink DPCCH preamble and postamble for the HS-DPCCH

transmission

⇒ Example of simultaneous Uplink DTX and Downlink DRX

⇒ HS-SCCH Order Timing

HS-SCCH Order for Activating/Deactivating uplink DTX, HS-SCCH Order for Activating/Deactivating downlink DRX

⇒ CPC and Enhanced F-DPCH

Timing Implications for CPC + Enhanced F-DPCH

## ● Upgraded L1 Signaling

⇒ HS-SCCH Review of Rel. 5 and 6

HS-SCCH Frame Structure, HS-SCCH Part 1 and 2 Forward Error Coding Chain, UE specific masking of Part 1 and Part 2, HS-PDSCH Code Allocation, Rel. 5/6 TBS Determination – TFCI Mapping, Octet aligned TBS Determination with MAC-e-hs, Turbo Coder Irregularities in HSDPA

⇒ HS-SCCH of Rel. 7

HS-SCCH Overview of Rel. 7, HS-SCCH type 1, No HS-SCCH, HS-SCCH type 2, HS-SCCH type 3, HS-SCCH Type 1, Legacy HS-SCCH Type 1, HS-SCCH orders, Usage like in R5, HS-SCCH Type 1 for 64-QAM Operation, QPSK, HS-SCCH Orders (Part 2 Meaning), Order type, DRX in HSPA+, DTX in HSPA+, 64-QAM Constellation Versions, HS-SCCH Type 2 (for HS-SCCH less operation), Use of the HS-SCCH-less operation, Procedure HS-SCCH-less operation, HS-SCCH Type 3, HS-SCCH Type 3 Overview, Channelization code set, Modulation scheme and TB number, PCI, TB block size, HARQ process number, RV and CV, Missing NDI field(s), CRC XOR H-RNTI, HS-SCCH orders, Modulation and Transport Block Number, HARQ Process Number, Redundancy Version and Constellation Version, Implicit Signaling of the NDI, HARQ for MIMO, RV for QPSK, RV + CV for 16-QAM

⇒ HS-DPCCH of Rel. 7

HS-DPCCH ACK/NACK, ACK-NACK of primary TB in R5, Preamble and postamble in R6, ACK-NACK of 2 TB's in R7, HS-DPCCH PCI and CQI Type A and B, CQI for Operation without MIMO, CQI for Operation with MIMO, Type A Reports, Type B Reports

⇒ E-AGCH and E-DPCCH

Changes in the E-TFCI Tables, Changes in the AG Tables, Changes in the SG Tables

## ● MAC-e-hs Entity versus MAC-hs

⇒ UTRAN side MAC-hs Details – CELL\_DCH only

Flow Control, Scheduling/Priority Handling, HARQ, TFRC selection

⇒ UE side MAC-hs Details – CELL\_DCH only

HARQ, Reordering Queue distribution, Reordering, Disassembly

⇒ UTRAN side MAC-e-hs Details

Some advantages of MAC-e-hs compared to MAC-hs, Flow Control, Scheduling/Priority Handling, HARQ, TFRC Selection (~ TFCI), LCH-ID Multiplexing, Segmentation

⇒ UE side MAC-e-hs Details

HARQ, Disassembly, Reordering Queue Distribution, Reordering, Reassembly, LCH-ID Demultiplexing

⇒ Differences in the MAC-e-hs and MAC-hs Header

MAC-hs Header Parameter Description, MAC-hs SDU, MAC-hs Header of MAC-hs PDU, MAC-e-hs Header Parameter Description, MAC-e-hs Header Parameter Details, MAC Headers for DTCH/DCCH, BCCH and PCCH, Practical Exercise: MAC-hs contra MAC-e-hs, MAC-hs / MAC-e-hs Stall Avoidance, Timer-Based Scheme, Window Based Scheme, MAC-(e)hs Reordering Functionality – Timer / Window based, MAC-e-hs / MAC-hs Reset

## ● Flexible RLC PDU Sizes

⇒ The RLC AMD PDU – Rel. 7 Enhancements

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The Poll (POLL) super-field (RLC-AM Control PDU), RLC AMD Header Fields, Release 7 Enhancement of the HE-Field and LI

- ⇒ Comparison of RLC-AM between Rel. 6 and Rel. 7  
RLC-AM Overhead

- **RRC State Operation Enhancements**

- ⇒ Transport Channel Type Switching with HSPA in R6  
Signaling Connection Release Indication – fast Dormancy, Transport Channel Combinations between UL and DL, Radio Bearer Multiplexing Options in Rel. 6
- ⇒ Operation of UTRA RRC States in Rel. 7 (UTRAN View)  
UE Idle mode, CELL\_DCH state
- ⇒ HS-DSCH Reception in CELL\_FACH and XXX\_PCH  
Overview, UE dedicated paging in CELL\_DCH, CELL\_FACH and CELL\_PCH, BCCH reception in CELL\_FACH, FACH Measurement Occasion Calculation, Measurement Reporting Procedure, (1) Operation in CELL\_FACH State, DCCH / DTCH reception in CELL\_FACH state, User data on HS-DSCH in Enhanced CELL\_FACH state, (2) Operation in CELL\_FACH State – Cell Update, (3) RRC Idle to Transient CELL\_FACH, Common H-RNTI selection in CELL\_FACH (FDD only), H-RNTI selection when entering Connected Mode (FDD only), Operation in URA\_PCH or CELL\_PCH State, Data Transfer in CELL\_PCH with dH-RNTI, State Transition from CELL\_PCH to CELL\_FACH to CELL\_DCH, CELL\_PCH and URA\_PCH Enhanced Paging Procedure

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## HSPA+ Enhancements in Release 8

- **Dual Cell HSDPA (DC HSDPA)**
- **MIMO and 64-QAM or Dual Cell Operation**

- ⇒ New UE Categories  
Data Rate of MIMO combined with 64-QAM, Soft IR Memory, The Alternative to MIMO: Dual Cell Operation.
- ⇒ L1 Signaling of MIMO and 64-QAM  
Modulation Schemes and TB Sizes, Signaling on the HS-SCCH type 3, Modulation Scheme and TB Number Field, Solution, CQI Signaling, CQI Tables used

- **Dual Branch Interference Cancellation**

- ⇒ Categorization of Advanced Receivers  
Introduction, Plain receivers, Receiver type 1, Receiver type 2, Receiver type 3, Receiver type 2i, Receiver type 3i

- **CS Voice Service over HSPA- (CSoHS)**

Why CsoHS?, What is new?., Jitter Management

- **E-DCH for Cell\_FACH**

- ⇒ Channel Mapping  
Legacy Implementation, Release 7-8 Implementation
- ⇒ Enhanced Cell\_FACH State
- ⇒ Fast Dormancy  
The Problem, 3GPP Solution
- ⇒ RLC and MAC UL Enhancements  
Flexible RLC in UL, MAC-i and MAC-is, MAC-i and MAC-is in Detail

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## Selected Scenarios

- **RRC and NAS Signaling for E-DCH Setup**
- **HS-DSCH and E-DCH Setup & Cell Change**
  - ⇒ RRC Connection Establishment (Radio Resource Control)
  - ⇒ Service Request and Ciphering (GPRS Mobility Management)
  - ⇒ PDP Context Activation Request (Session Management)
  - ⇒ ALCAP - AAL-2 Channel Setup for Control & User Plane  
MAC-d Flow Parameters
  - ⇒ HSPA Radio Bearer Setup – User Plane
  - ⇒ PDP Context Activation Accept
  - ⇒ HSPA Serving Cell Status  
E-DCH / HS-DSCH Serving Cell Change – E1D
  - ⇒ E-DCH SHO Preparation – Event 1A
  - ⇒ E-DCH SHO
  - ⇒ HSPA SHO Status
  - ⇒ HSPA Serving Cell Change – Event 1D
  - ⇒ HSPA Hard HO – Transport Channel Reconfiguration  
E-DCH SHO Status after High Speed Cell Change, Active Set Update with Radio Link Removal (Event 1 B)
  - ⇒ AAL-2 Resource Release in old Cell
  - ⇒ HSPA Cell Status after SHO – Single Cell in Active Set again
  - ⇒ PDP Context Deactivation – PS Call Release
  - ⇒ AAL-2 Resource Release of “HS-DSCH & E-DCH”
  - ⇒ RRC Connection Release – Idle Mode
- **Data Flow from TCP-IP packet in Uplink**
  - ⇒ Practical Exercise: Application Throughput Calculation

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## Solutions for Practical Exercises