Course ID **LTE-DIVE** Course Duration **4 days**	Course Title **LTE / LTE-A Deep Dive: RAN and Core**
Aimed At	This course is aimed at those charged with engineering networks, devices, software, or services. However, the course can be adapted to other audiences.
Prerequisites	Prior familiarity with LTE and the technologies leading up to it. (If the participants are lacking in some of the prerequisites, the course can be extended to cover them.)
Course in a Nutshell	This is a four-day in-depth, technology-centered course on the technical specifications of LTE and LTE-Advanced customized to client requirements. The course includes topics relevant to your needs from among the following major subject areas: Evolved Packet Core: LTE/LTE-A Network Architecture; LTE Layers and Functionality; LTE Network Entry, Access and Attachment; Other Relevant Features Such as MBMS, Voice, Roaming, etc.; New LTE Features; Unlicensed Operation in LTE; WiFi Aggregation and Interworking.
Customize It!	We can customize this course, usually at little to no additional cost, to your project requirements and participant backgrounds.

Course Outline

1. **Evolved Packet Core: LTE/LTE-A Network Architecture**

- **Introduction: 4G/LTE Requirement Roadmap and Standardization**
- **LTE/LTE-A EPC Network Architecture, Protocols, and Components**
    - LTE / LTE-A EPC Network Architecture
    - EPC Components
        - UE
        - eNB
        - MME
        - S-GW
        - P-GW
        - PCRF
    - LTE Interworking with 3GPP and non-3GPP Networks, including MNOs
        - AAA
- **EPC Protocols**
    - Non Access Stratum (NAS) Protocols
        - EPC Mobility Management (EMM)
        - EPC Session Management (ESM)
    - MME Protocols
        - Stream Control Transmission Protocol (SCTP)
        - S1-Application Part (S1-AP)
        - S11 Protocols
            - GTP-C / GTPv2-C

- - - IP
    - UDP
  - SGW Protocols
    - GTP-U / GTPv1-U
    - IP
    - UDP
  - PGW Protocols
  - LTE EPC Security Architecture
    - Authentication
    - Encryption
- **LTE Parameters**
  - Spectrum and Bands
  - UE Identities

2. **Layer 1, Physical Layer**

- **LTE Frame Structure, Channels and Signals**
  - OFDM / OFDMA / SC-FDMA Essentials
  - LTE Enumeration
  - Frame Structure
    - FDD Frame Structure
    - TDD Frame Structure
  - LTE Channels
    - Logical Channels
    - Transport Channels
    - Physical Channels
      - LTE Control Channels
      - LTE Data Channels
    - Channel Mapping in LTE
  - LTE Reference Signals
    - UL Reference Signals
    - DL Reference Signals
    - MIMO Reference Signals
    - LTE Synchronization Signals
  - LTE Modulation and Channel Coding
    - DL Modulation
    - UL Modulation
    - FEC Coding
    - LTE Frequency Hopping
- **LTE Transmission Procedures**
  - DL Transmission Procedure
    - DL-SCH Data Transfer
    - DL HARQ
  - UL Transmission Procedure
    - UL-SCH Data Transfer

- o UL HARQ
- **Multiple Antenna in LTE**
  - Multiple Antenna Basics
    - o MIMO Concepts
    - o Space Time Diversity Coding and Spatial Multiplexing
    - o Channel Ranks
    - o Beamforming
    - o Precoding
    - o Feedback
  - LTE Transmission Modes

3. **LTE Network Entry, Access and Attachment**

- System Acquisition/Scanning
- Synchronization
- LTE Attachment
- Random Access
- Authentication
- Default Bearer Establishment
- IP Address Allocation

4. **Layers 2 and 3, MAC/RRC/RLC Layer**

- **Layer 2 Structure and Operation**
  - Protocols and Packets
  - RLC / PDCP / MAC Sublayers
- **MAC Layer**
  - MAC PDU Formats
    - o MAC PDU (DL-SCH and UL-SCH)
    - o MAC Control Elements
    - o MAC Headers
    - o Transport Blocks
    - o Concatenation and Segmentation
  - MAC Procedures
    - o Random Access
    - o MAC Layer ARQ
    - o Discontinuous Reception (DRX)
- **Idle Mode and Paging Operation**
  - What Is Idle Mode and Why?
  - Active to Idle Mode Transition
  - Idle to Active mode Transition
  - Paging
  - Tracking Area Update
- **QoS Management**
  - EPS Bearers and SDF

- Default Bearers
- Dedicated Bearers
- Signaling Bearers
- EPC QoS Framework and PCC
  - PDN Connections
  - APN
  - QCIs, Different Class of Services and Their Priorities
  - TFTs
  - SPR
  - Policy Functions and Components (PCEF & PCRF)
- Scheduling in LTE
- **Handover in LTE**
  - Measurement and Report
  - X2-based Handoff
  - S1-based Handoff

5. **Other LTE Features**

- **Multicast Broadcast in LTE (MBMS and eMBMS)**
- **Voice Support in LTE**
  - CSFB
  - SVLTE
  - IMS Based SR-VCC (VoLTE)
- **Roaming in LTE**
- **Self-Organizing Networks (SON) Enhancements**
- **Enhanced Interference Management (eICIC)**
- **Network Planning in LTE (LTE Link Budget)**

6. **LTE-Advanced, Release 10 and Beyond**

- **Carrier Aggregation**
  - Concept
    - Definition & Benefit
    - LTE Band Combinations
    - Resource Allocation Options
  - Carrier Aggregation Types and Classes
  - Carrier Aggregation (CA) Operation
    - RRC Configuration
    - Component Carriers
    - Uplink Multiple Timing Advance for Carrier Aggregation Rel.11
  - Carrier Aggregation in Heterogeneous Networks
  - FDD-TDD Carrier Aggregation
  - LTE-WiFi Carrier Aggregation
- **Heterogeneous Networks (Hetnet) (High Level)**
  - Interference management for HetNet (eICIC)

- **Enhancements to LTE TDD for DL-UL Interference Management and Traffic Adaptation (eIMTA)**
- **LTE Device to Device Proximity Services**
- **Network-Assisted Interference Cancellation and Suppression (NAICS)**
- **RAN Sharing for LTE**
- **Dual Connectivity enhancements for LTE**
- **LTE Indoor Positioning**
- **Group Communication Systems**
- **Rel 14 Narrow Band LTE (NB-LTE) & Narrow Band Cellular Internet of Things (NB-CIOT)**

7. **Unlicensed Operation in LTE Release 12 and 13**

- **LTE-U Operation**
  - CSAT
  - Impact on Incumbent unlicensed Technologies (WiFi)
- **Licensed-Assisted Access using LTE**
  - Listen Before Talk (LBT)
  - Channel Access Frame work for LAA
  - RRM for LAA
  - Unlicensed Spectrum Aspects
  - Control Channels
  - Impact on Incumbent unlicensed Technologies (WiFi)
- **Further Enhancement in LTE Unlicensed Operation**
- **Spectrum Sharing**
- **Non-Standardized LTE Unlicensed operation**

8. **LTE + WLAN Aggregation (LWA) and Interworking**

- **LWA**
  - Control Plane Architecture and Functionality
  - Control Plane Architecture and Functionality
  - ANDSF
- **LTE-WiFi Interworking**

Wrap-up: Course recap, discussion, and Course evaluation

How You Will Learn

This is an intensive lecture-discussion course. You will learn from a wireless technologies expert with 25+ years of field expertise.