5G is the next enhancement in mobile communications. This course introduces 5G technology in terms of the current 3GPP roadmap and network deployment by 2019. In so doing, an end to end view of the 5G system is examined, including the new architecture requirements for 5G. In addition, key aspects of the new 5G air interface are also introduced, before looking into the details of Non-Standalone operation. The course then takes a “day in the life” approach to the 5G handset, detailing typical activities such as Registration, Security, PDU Session Establishment, Mobility and Interworking.

This course has no prerequisites.
This course will contain the following sections:

1. 5G Concepts and Drivers

**Topic areas covered include:**

- **Driving Factors for 5G:**
  - 3GPP Smarter, ITU-R requirements.
  - eMBB, URLLC, MloT.
  - Performance requirements.
- **5G Standardization:**
  - IMT-2020.
  - 5G Technology Roadmap.
- **5G Use Cases:**
  - 5G Small Cells.
  - 5G Based Backhaul.
- **Key Trends Associated with 5G.**

2. 5G System Architecture

**Topic areas covered include:**

- **High Level Architecture:**
  - 5G RAN Architecture (detailed functionality of RAN functions and reference points):
    - UE, ng-eNB, gNB.
    - Xn, N2, N3.
  - 5G Tracking Areas.
  - 5G RAN Deployment Options.
- **5G Core Architecture (detailed functionality of 5GC functions and reference points):**
  - AMD, SMF, UPF, UDM, AUSF, PCF, AF, Data Network.
  - N1, N4, N5, N6, N7, N8, N9, N10, N11, N12, N13, N14, N15, N35, N36, N37.

3. 5G New Radio and NG-RAN

**Topic areas covered include:**

- **New Radio Air Interface:**
  - New Radio Multiple Access – CP-OFDM:
    - Frame Structure.
    - Variable Subcarrier Spacing.
  - Higher Order Modulation:
    - 256QAM, 64QAM, 16QAM, QPSK.
  - Frequency Bands and Bandwidths:
    - ITU WRC.
    - 5G Spectrum Goals, mmwave.
  - Spectrum Sharing:
    - Coordination Options.

---

**5G System Architecture (cont.)**

- **5G Service Based Architecture:**
  - Network Functions Virtualization.
  - SBA Model.
  - Core Network API usage.
  - Positioning SBA APIs:
  - Complimentary Network Functions for SBA:
    - UDSF, CHF, NRF, NEF.
- **Network Slicing:**
  - Network Slicing Architectural Considerations:
    - Functionality, Performance, User Groups.
    - S-NSSAI Composition.
    - NSSF, NWDAF.
  - Network Slicing Overview of Operation.
- **Multi-Access Edge Computing.**

---

**12 CPD Learning Credits**

**ITP accredited course**

**LiveOnsite, LiveOnline, OnlineAnytime**
5G New Radio and NG-RAN (cont.)

- Massive MIMO:
  - Use Cases and Deployment Considerations.

- 5G RAN Deployment Options:
  - Options 1, 2, 3, 4, 5, 7.

- Dual-Connectivity:
  - Multi RAT Dual Connectivity:
    - NR-DC, EN-DC, NGEN-DC, NE-DC.
    - RRC Considerations.
  - MCG Split SRB.
  - User Plane Splitting:
    - MCG Bearer, MCG Split Bearer, SCG Bearer, SCG Split Bearer.
  - Mobility and Dual Connectivity.

- C-RAN:
  - C-RAN Protocol Stack Split:
    - gNB-CU, gNB-DU, gNB-CU-CP, gNB-CU-UP, E1, eCPRI.
  - Focus on F1:
    - F1AP, User Data Transfer.

Non Standalone Operation (cont.)

- EN-DC Change of Secondary Node.
- EN-DC Release of Secondary Node.
- Inter MeNB Handover with EN-DC.

5. 5G Initial Procedures

Topic areas covered include:

- Identities Used in 5G:
  - Subscriber Related Identities:
    - SUPI, SUCI, 5G-GUTI Composition, PEI, IP Addressing.
  - Network Related Identities:
    - NGCI, gNB ID, TAI, GUAMI, FQDN, DNN.

- Registration and Connection Management:
  - Registration Management:
    - RM Deregistered, RM Registered.
  - Connection Management:
    - CM Connected, CM Idle.
  - RRC States:
    - RRC Idle, RRC Connected, RRC Inactive.

- Network Access:
  - PLMN and Access Network Selection.
  - Cell Selection / Reselection.
  - RRC Connection Establishment:
    - RACH procedure.

- 5G Registration.
- Network Function Selection.
- Deregistration:
  - UE Initiated Deregistration.
  - Network Initiated Deregistration.

6. 5G Security

Topic areas covered include:

- 5G Security Overview.
- 5G Security Algorithms.
- Authentication and Key Agreement:
  - AV Generation:
    - KAUSF, XRES*, AUTN, RAND.

4. Non Standalone Operation

Topic areas covered include:

- Non Standalone Access Architecture:
  - EN-DC Model.
  - MN Terminated SCG Bearer, SN Terminated MCG Bearer.
  - Options 3a and 3x.
  - EN-DC Split Bearer Protocol Stack.

- Initial Procedures:
  - Initial Attach Considerations.
  - Preparing for EN-DC in the RAN:
    - X2 Management.

- EN-DC Secondary Node Addition:
  - SgNB Addition Request and Request Acknowledge:
    - User Plane Splitting Configuration.
  - RRC Connection Reconfiguration.
  - Updating the User Plane Path.
  - Secondary Node Modification.
5G Security (cont.)

- 5G AKA:
  - Key Derivation at the AMF.
  - Device Authentication.
  - 5G HE AV, 5G SE AV, HXRES*, HRES*, KSEAF.

- Security Procedures:
  - Key Distribution in 5G:
    - Key Hierarchy.
  - NAS Signalling Security.
  - RRC Signalling Security.

- Securing AN to CN Communication:
  - IPSec Basic Operation:
    - IPSec ESP.
  - Establishment of gNB Security Associations:

7. Exchanging Data in 5G

Topic areas covered include:

- PDU Sessions:
  - PDU Session Connectivity:
    - Anchor and Intermediate UPFs.
  - PDU Session Types:
    - IP, Ethernet, Unstructured Data.

- QoS Model for 5G:
  - QoS Flow Parameters:
    - QFI, QoS Rule Composition, PDR.
  - 5QI - 5G QoS Identifier:
    - Resource Type, Priority, PDB, PER, Averaging Window, Maximum Data Burst Volume.
    - Allocation and Retention Priority.
  - Controlling Bit Rate:
    - UE AMBR, Session AMBR, MFBR, GFBR.
    - Reflective QoS.

- Establishing a PDU Session:
  - Establishing a QoS Flow (PDU Session Modification).

- Utilizing PDU Sessions:
  - Service Request.
  - Paging.
  - RRC Inactive State and Paging.
  - Releasing the Access Network Resources.
  - Session and Service Continuity.

8. 5G Mobility

Topic areas covered include:

- CM Idle Mobility Procedures:
  - Discontinuous Reception.
  - Cell Reselection.
  - Registration Area Update.

- CM Connected Mobility – Handovers:
  - Xn Based Handover Procedure.
  - Xn Handover with UPF Relocation.

- CM Connected Mobility – N2 Handover.

- Dual Connectivity – Secondary Node Change.

- Roaming in 5G:
  - Home Routing, Local Breakout:
    - SEPP.
  - IP Packet Exchange.
  - IPX Connectivity Options.

9. Interworking with LTE and Wi-Fi

Topic areas covered include:

- Interworking with LTE:
  - Single and Dual Registration Mode.
  - Basic Mobility Scenarios (with N26).
  - Basic Mobility Scenarios (without N26).

- Connected Mode Mobility Procedures (with N26):
  - 5GS to EPS Handover.
  - EPS to 5GS Handover.

- Interworking with Non-3GPP Networks:
  - Architecture for Non-3GPP Accesses:
    - Non-3GPP Access Registration.
    - Establishing PDU Sessions.
    - Modifying a PDU Session.
    - Utilizing PDU Sessions.

Watch a Sample Video Online
Managed Learning Services

As part of our managed learning service we can offer you and your organisation a full range of services including:

- Bespoke content and courseware development
- Product specific training packages, including product updates
- Dedicated trainers to understand your products and training requirements
- Managed training delivery services – administrative aspects including scheduling and liaison
- Customizable learning management system
- Traditional classroom, virtual classroom or video based online learning options

For more information, visit [mpirical.com/about-us/managed-learning-services](http://mpirical.com/about-us/managed-learning-services)

---

The Mpirical Network Visualisation Solution: **NetX Bringing Telecoms to Life!**

Imagine the benefits of having an entire mobile network available from your desktop.

- Where you can view a complete network map.
- Watch call flows across the network.
- Investigate network procedures.

NetX does this... and even more with our NetX customization options! NetX is not just a learning aid, it is a valuable resource in the day to day activities of any telecoms professional and has been spotlighted as such by the 3GPP.

Explore NetX further at [www.mpirical.com/netx](http://www.mpirical.com/netx)