Automotive + Cellular = Connected Car

Duration: 2,5 days or 5 x ½ day

Table of Content:

Chapter 1: Review & Warming Up

- **Definition and Technologies 2G to 5G:** 2G, 3G, 4G, 5G

- **2G to 5G and their most important Characteristics:** Services, Technology, Network Architecture

- **Use Cases of Cellular in the Automotive Environment:** Remote Maintenance, Remote Surveillance, Remote Vehicle Control, V2X & eV2X, eCall

- **Network Architecture**: 2G circuit-switched and packet-switched, 3G, 4G and 5G, 5G option 3x (NSA) and option 2 (SA)

- **The Peer inside the Car**: TCU, CAN-bus, CAN-bus controller, eSIM, GNSS

- **Hardware Options for the TCU**: LTE-categories, 5G NR capabilities, NB-IoT, LTE-M, RedCap-devices and eRedCap-devices

- **Identification of the Mobile Station / User Equipment**: IMSI, IMEI, TMSI, GUTI

- **Identification of the Network**: PLMN / MCC/MNC, CGI, PCI

- **Other Involved Entities**: Fleet Management System (FMS), Connectivity Management Platform (CMP) and MNO (Mobile Network Operator)

Chapter 2: Basic Cellular Operation

- **Power On: PLMN Selection**: Initiation through SIM, PLMN-prioritization, RPLMN, VLPMN, HPLMN, equivalent HPLMN, interworking between upper layers and RR-layer in the UE / TCU.

- **Procedures in the Radio Link Layers:** Cell Selection, Cell Reselection, Handover, Measurement Reporting, Power Control

- **NAS-Procedures:** Attachment/Registration, (Mutual) Authentication in 2G, 3G, 4G and 5G, Secret parameter Ki, used algorithms, e.g. A3 and A8, how to obtain an IP-address (PDP-context activation, PDU-Session Establishment), presentation and introduction to important AT-commands to configure and trigger these procedures

- **Typical Problems**: (1) How to interpret TCU-logfiles to obtain status information (e.g. does the TCU possess an IP-address), (2) IP-address is private => NAT-issues

- **IMS-related Procedures**: The UE's Path to Packet-Switched Calls through the IMS, Registration, Session Setup and Control through the IMS: SIP & SDP,Codec Negotiation through SDP

- **Other Procedures worth knowing**: CSFB (Circuit-Switched FallBack), SRVCC (Single Radio Voice Call Continuity), types of SRVCC

Chapter 3: SIM-Evolution & eSIM-Handling

- **SIM & SIM-profile:** UICC and eUICC, (U)SIM-profile, profile identity, ISIM-profile

- **GSMA => Generic-eUICC-Test-Profile**: Content, structure, encoding and decoding with examples

- **SIM-Evolution:** traditional with FF1 – FF4, eSIM with MFF2, iSIM and soft SIM, mixed configuration SIM <=> eSIM

- **eSIM Handling:** Consumer Solution vs M2M (UI- and NW-constrained), Provisioning, handling of SIM-profiles on eSIM's

- **eSIM-Profile Handling for M2M (SGP.02):** Entities and their tasks and functions => CI, SM-DP, SM-SR, MNO, eUICC, how to trigger and execute an eSIM-profile switch

- **eSIM-Profile Handling for M2M (SGP.31/32):** Entities and their tasks and functions => eIM, SM-DS, eUICC, how to trigger and execute an eSIM-profile switch

Chapter 4: Automotive Use Cases & Introduction to MQTT

- **Operation Modes of the TCU:** fully active, half-sleep mode, deep-sleep mode, typical timers and triggers

- **Waking up the TCU:** Mobile Terminating SMS and how it may find the TCU, SMS-delivery options with and w/o IP-address, through NAS (EMM/5GMM)

- **OTA (Over The Air):** Operation option, tasks and functions, delivery options (binary SMS, USSD, IP)

- **Circuit-Switched eCall**: introduction to eCall, differentiation from emergency call and E911, Architecture with IVS, PSAP etc, Minimum Set of Data (MSD) and its content, insertion of MSD into speech, call-back option

- **NGeCall**: What is it?, preconditions for NGeCall to be used, execution, presentation and analysis of SIP: INVITE-message with MSD as metadata

- **MQTT in Vehicles and similar Devices**: Introduction to MQTT, protocol stack, event management, subscription and publication, MQTT-brokers with example presentation of Mosquitto

Only if time and interest:

- **Hands in the Mud => Analysis of internal logfiles**: Identification of important AT-commands in real-life logfiles, does the TCU possess an IP-address?, to which network did the TCU register?