Reti Wireless & Internet of Things
Introduzione

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Programma del corso

- Elementi di trasmissione numerica
- Elementi di teoria dell'informazione
  - Codifica di canale e codici
- Trasmissione numerica sul canale wireless
- Trasmissione a banda stretta
- Trasmissione a banda larga
- Multiplazione – diversità
- Sistemi cellulari: da 1G a 6G
- Lo standard 802
  - WiFi
  - Bluetooth
  - Zigbee
- Reti di sensori
- Internet of Things

Libri di testo

- J.G. Proakis, M. Salehi, *Fundamentals of communication systems*, Prentice Hall International.
- G. L. Stüber, *Principles of Mobile Communication*, Springer, 2011.
- C. Smith, *Wireless networks*, Mcgraw-Hill.
- Martin Sauter, *3G, 4G and Beyond*: *Bringing Networks, Devices and the Web Together*, *2nd Edition*, John Wiley.
- J.G. Proakis, *Modern communication systems using MATLAB.* Cengage Learning 2013.

Materiale del corso

- Tutto il materiale del corso è accessibile sul sito moodle2.units.it. Chiave di accesso: RW2022
- Il corso è visibile su MS Teams: codice **l6p344w**.
- **Matlab**.

  Nel corso si farà ampio uso del programma Matlab.

  Per scaricarlo e installarlo sul proprio computer seguire le istruzioni riportate al link: https://dia.units.it/it/dipartimento/node/32619
- Orario lezioni

  Lunedì 14.15-15.45

  Martedì 14.15 – 15.45.

  Mercoledì 8.30 – 10.00.

  Giovedì 9.15 – 10.45.

Enti di normativa

- **International Telecommunication Union (ITU)**

- **3rd Generation Partnership Project** (**3GPP**)

  Accordo fra gli enti che gestiscono le telecomunicazioni nei vari stati, stipulato con l'obbiettivo di definire uno standard comune per il 3G a partire dal GSM, e in accordo con i requisiti e le specifiche *International Mobile Telecommunications 2000* dell'ITU.

  Oggi gestisce l'evoluzione degli standard cellulari.

- **Institute of Electrical and Electronic Engineers (IEEE)**
  - **IEEE 802 LAN/MAN** *Standards Committee* (LMSC)
    - **IEEE 802.11 Wireless LAN (WiFi)**
    - **IEEE 802.15 Wireless Personal Area Networks**
    - **IEEE 802.16 Broadband Wireless Access (WiMAX)**

3GPP Standard

Versione	Data	Informazioni
Phase 1	1992	GSM Features
Phase 2	1995	GSM Features, EFR Codec,
Release 96	1997 Q1	GSM Features, 14.4 kbit/s User Data Rate,
Release 97	1998 Q1	GSM Features, GPRS
Release 98	1999 Q1	GSM Features, AMR, EDGE, GPRS for PCS1900
Release 99	2000 Q1	Specified the first UMTS 3G networks, incorporating a CDMA air interface
Release 4	2001 Q2	Originally called the **Release 2000** - added features including an all-IP Core Network
Release 5	2002 Q1	Introduced IMS and HSDPA
Release 6	2004 Q4	Integrated operation with Wireless LAN networks and adds HSUPA.

3GPP Standard

Release 7	2007 Q4	Focuses on decreasing latency, improvements to QoS and real-time applications such as VoIP. This specification also focus on HSPS (High Speed Packet Access Evolution), EDGE Evolution.
Release 8	2008 Q4	First LTE release. All-IP Network (SAE). New OFDMA, and MIMO based radio interface, not backwards compatible with previous CDMA interfaces.
Release 9	2009 Q4	LTE/UMTS Interoperability.
Release 10	2011 Q1	LTE Advanced fulfilling IMT Advanced 4G requirements. Backwards compatible with release 8 (LTE). Multi-Cell HSDPA (4 carriers).

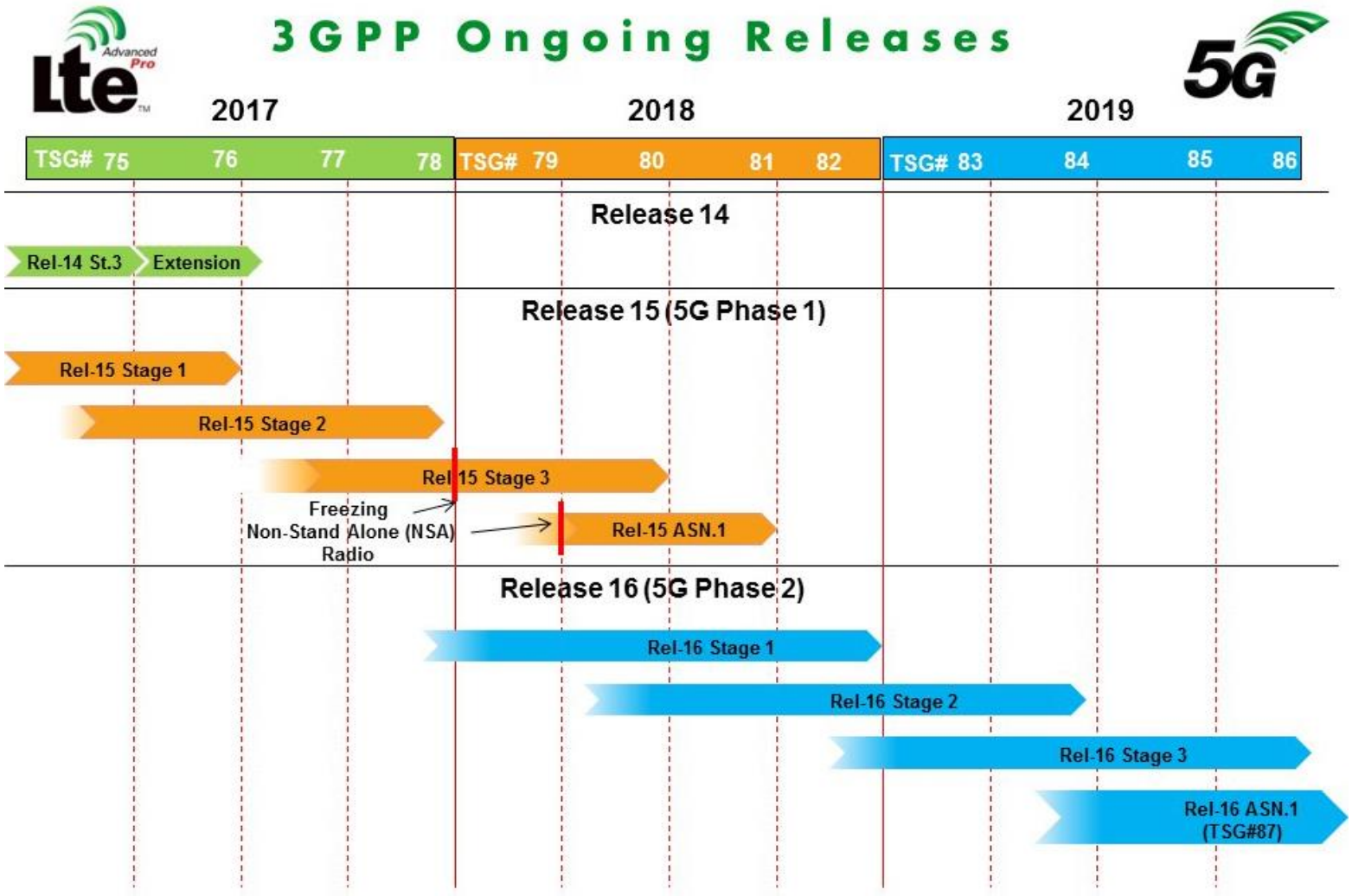
3GPP Standard

Release 11	2012 Q3	Advanced IP Interconnection of Services. Service layer interconnection between national operators/carriers as well as third party application providers. Heterogeneous networks (HetNet) improvements, Coordinated Multi-Point operation (CoMP). In-device Co-existence (IDC).
Release 12	2015 Q1	Enhanced Small Cells (higher order modulation, dual connectivity, cell discovery, self configuration), Carrier Aggregation (2 uplink carriers, 3 downlink carriers, FDD/TDD carrier aggregation), MIMO (3D channel modeling, elevation beamforming, massive MIMO), New and Enhanced Services (cost and range of MTC, D2D communication, eMBMS enhancements).
Release 13	March 2016	LTE in unlicensed, LTE enhancements for Machine-Type Communication. Elevation Beamforming / Full-Dimension MIMO, Indoor positioning.

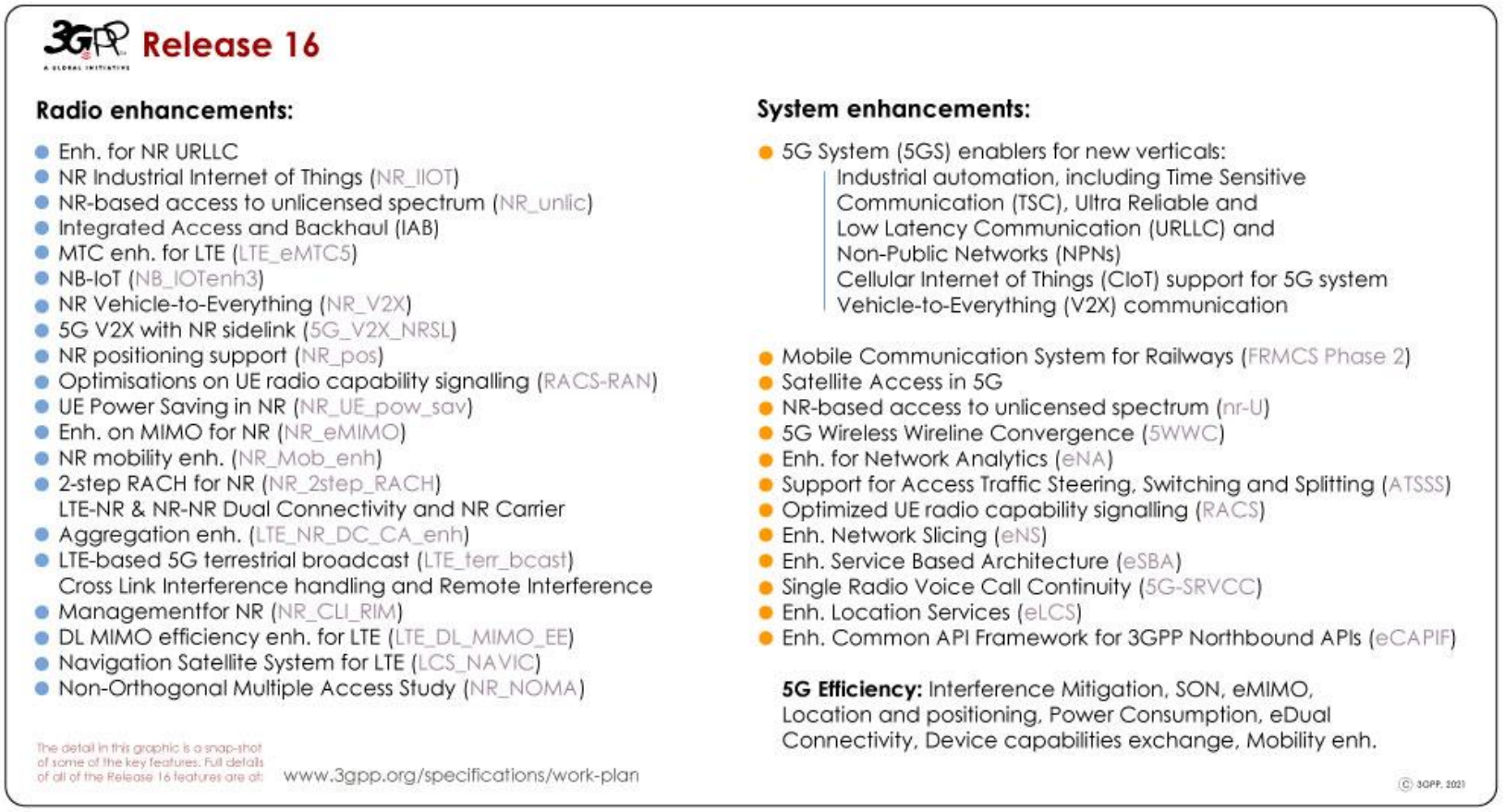
3GPP Standard

Release 14	Sept. 2017	5G requirements, Multimedia Broadcast Supplement for Public Warning System, Location services, Mission Critical Video over LTE, Enhancement for TV Video service, Latency reduction techniques for LTE, Channel model above 6 GHz, Robust Call Setup for VoLTE subscriber in LTE, Requirements for Next Generation Access Technologies, Multi-Carrier Enhancements for UMTS.
Release 15	Sept. 2018	5G: Phase 1. First set of 5G standards - including new work as well as the maturing of the LTE-Advanced Pro specifications.
Release 16		5G: Phase 2.

3GPP Standard



3GPP Standard



3GPP Release 16

Radio enhancements:

- Enh. for NR URLLC
- NR Industrial Internet of Things (NR_IIOT)
- NR-based access to unlicensed spectrum (NR_unlic)
- Integrated Access and Backhaul (IAB)
- MTC enh. for LTE (LTE_eMTC5)
- NB-IoT (NB_IOTenh3)
- NR Vehicle-to-Everything (NR_V2X)
- 5G V2X with NR sidelink (5G_V2X_NRSL)
- NR positioning support (NR_pos)
- Optimisations on UE radio capability signalling (RACS-RAN)
- UE Power Saving in NR (NR_UE_pow_sav)
- Enh. on MIMO for NR (NR_eMIMO)
- NR mobility enh. (NR_Mob_enh)
- 2-step RACH for NR (NR_2step_RACH)
  LTE-NR & NR-NR Dual Connectivity and NR Carrier
- Aggregation enh. (LTE_NR_DC_CA_enh)
- LTE-based 5G terrestrial broadcast (LTE_terr_bcast)
  Cross Link Interference handling and Remote Interference
- Managementfor NR (NR_CLI_RIM)
- DL MIMO efficiency enh. for LTE (LTE_DL_MIMO_EE)
- Navigation Satellite System for LTE (LCS_NAVIC)
- Non-Orthogonal Multiple Access Study (NR_NOMA)

System enhancements:

- 5G System (5GS) enablers for new verticals:
  Industrial automation, including Time Sensitive Communication (TSC), Ultra Reliable and Low Latency Communication (URLLC) and Non-Public Networks (NPNs)
  Cellular Internet of Things (CIoT) support for 5G system
  Vehicle-to-Everything (V2X) communication
- Mobile Communication System for Railways (FRMCS Phase 2)
- Satellite Access in 5G
- NR-based access to unlicensed spectrum (nr-U)
- 5G Wireless Wireline Convergence (5WWC)
- Enh. for Network Analytics (eNA)
- Support for Access Traffic Steering, Switching and Splitting (ATSSS)
- Optimized UE radio capability signalling (RACS)
- Enh. Network Slicing (eNS)
- Enh. Service Based Architecture (eSBA)
- Single Radio Voice Call Continuity (5G-SRVCC)
- Enh. Location Services (eLCS)
- Enh. Common API Framework for 3GPP Northbound APIs (eCAPIF)

5G Efficiency: Interference Mitigation, SON, eMIMO, Location and positioning, Power Consumption, eDual Connectivity, Device capabilities exchange, Mobility enh.

The detail in this graphic is a snap-shot of some of the key features. Full details of all of the Release 16 features are at: www.3gpp.org/specifications/work-plan

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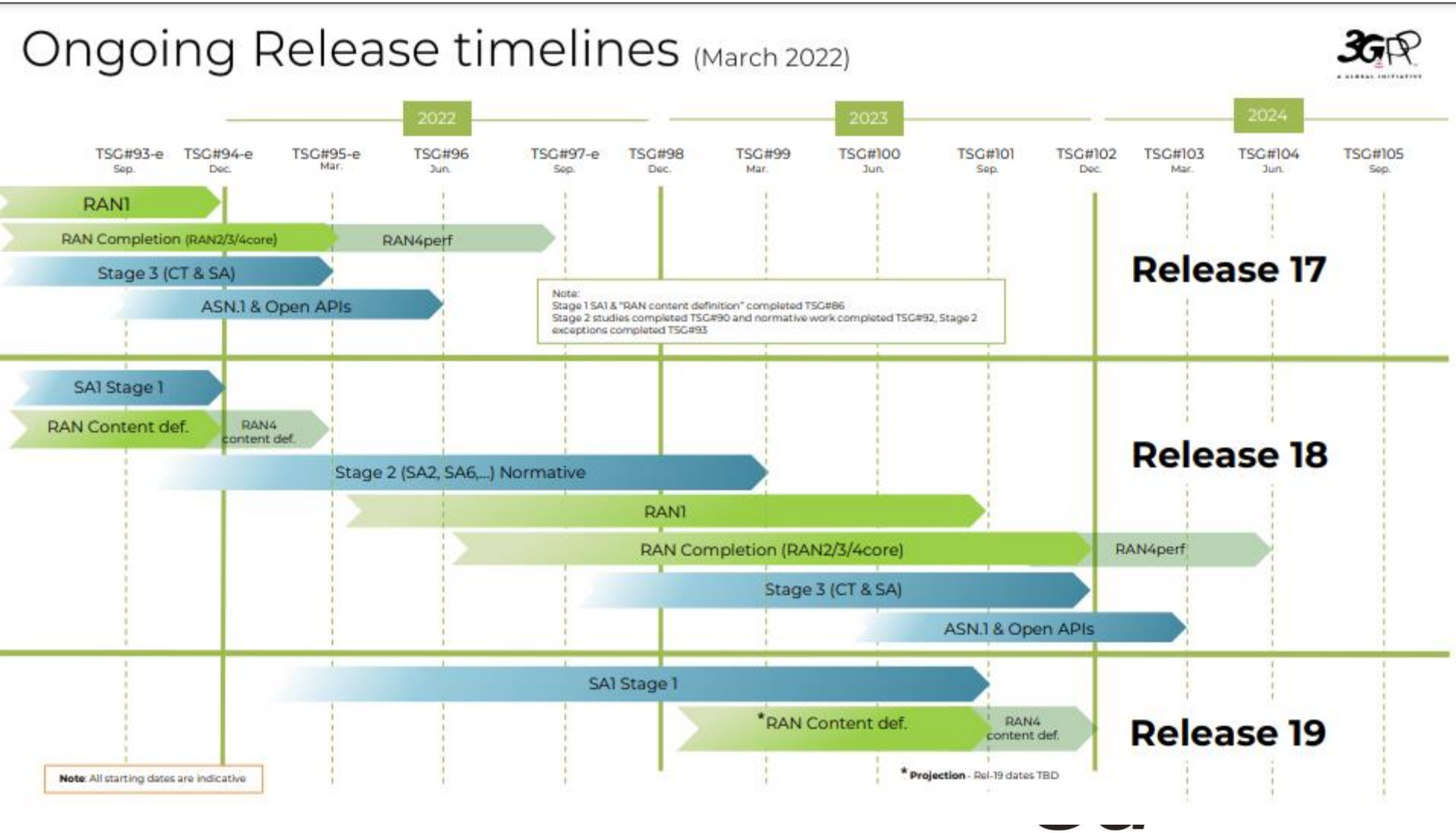
3GPP Standard

Release 17

- NR MIMO
- NR Sidelink enh.
- 52.6 - 71 GHz with existing waveform
- Dynamic Spectrum Sharing (DSS) enh.
- Industrial IoT / URLLC enh.
- IoT over Non Terrestrial Networks (NTN)
- NR over Non Terrestrial Networks (NTN)
- NR Positioning enh.
- Low complexity NR devices
- Power saving
- NR Coverage enh.
- NR eXtended Reality (XR)
- NB-IoT and LTE-MTC enh.
- 5G Multicast broadcast
- Multi-Radio DCCA enh.
- Multi SIM
- Integrated Access and Backhaul (IAB) enh.
- NR Sidelink relay
- RAN Slicing
- Enh. for small data
- SON / Minimization of drive tests (MDT) enh.
- NR Quality of Experience
- eNB architecture evolution, LTE C-plane / U-plane split
- Satellite components in the 5G architecture
- Non-Public Networks enh.
- Network Automation for 5G - phase 2
- Edge Computing in 5GC
- Proximity based Services in 5GS
- Network Slicing Phase 2
- Enh. V2x Services
- Advanced Interactive Services
- Access Traffic Steering, Switch and Splitting support in the 5G system architecture
- Unmanned Aerial Systems
- 5GC LoCation Services
- Multimedia Priority Service (MPS)
- 5G Wireless and Wireline Convergence
- 5G LAN-type services
- User Plane Function (UPF) enh. for control and 5G Service Based Architecture (SBA)

These are the Rel-17 headline features, prioritized during the December 2019 Plenaries (TSG#86)

3GPP Standard



3GPP Standard