State of 5G and Considerations for **systems "beyond IMT-2020"**

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ABOUT ITU

UN specialized agency for ICTs

'Committed to Connecting the World'

193 **Member States**   **700+** **Private Sector**   **164 Academia**

Radiocommunication Sector

Allocation of radiofrequency spectrum and satellite orbits and **Develop** standards for radiocommunication

Development Sector

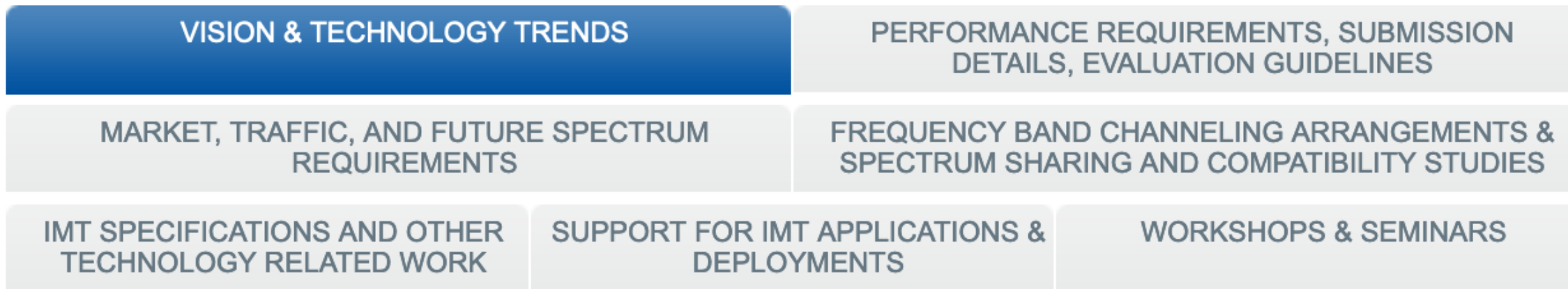**Bridging** the digital divide

Standardization Sector

Establishing international standards for telecommunications, information and communication technologies

Background: ITU-R WP5D

ITU-R Working Party 5D is responsible for the overall radio system aspects of **International Mobile Telecommunications** (IMT) systems, comprising the **IMT-2000**, **IMT-Advanced** and IMT for 2020 and beyond (incl. **IMT-2020**)

Working Party 5D is engaged in a wide range of activities for IMT. These activities include new information and deliverables to guide the continuing evolution of terrestrial IMT. At a high level the work is organized in these broad categories:

VISION & TECHNOLOGY TRENDS	PERFORMANCE REQUIREMENTS, SUBMISSION DETAILS, EVALUATION GUIDELINES
MARKET, TRAFFIC, AND FUTURE SPECTRUM REQUIREMENTS	FREQUENCY BAND CHANNELING ARRANGEMENTS & SPECTRUM SHARING AND COMPATIBILITY STUDIES
IMT SPECIFICATIONS AND OTHER TECHNOLOGY RELATED WORK · SUPPORT FOR IMT APPLICATIONS & DEPLOYMENTS	WORKSHOPS & SEMINARS

Background: Initial ITU-R documents

For each generation of terrestrial wireless technology*, ITU-R WP 5D has published

* So far: IMT-2000 / IMT-Advanced / IMT-2020

1) **A "Technology Trends Report"**
   - This report focuses on <u>future technology trends</u>
   - Attempts to project important technical advancements for the next generation of terrestrial wireless technology
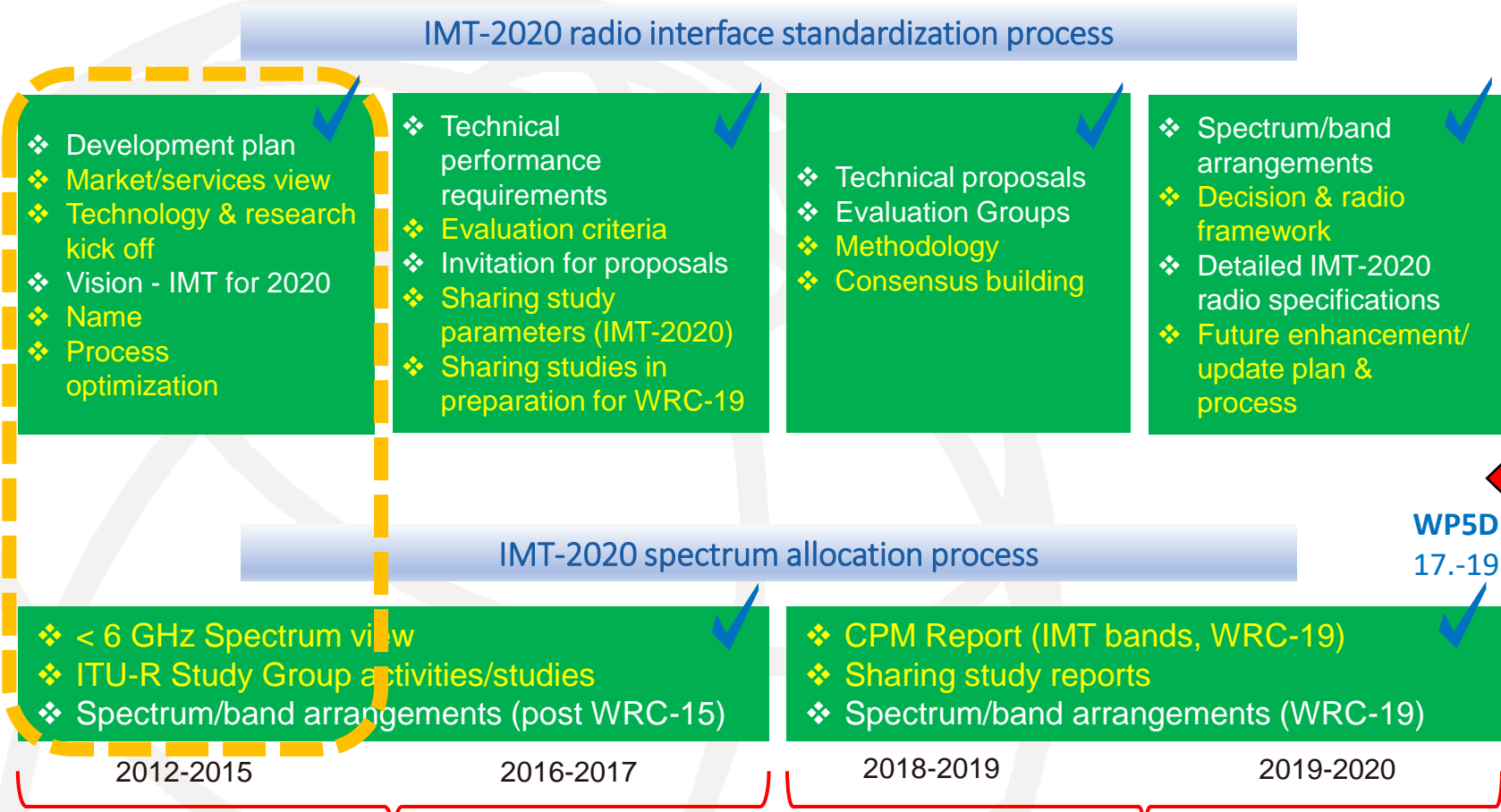
2) **A new "Vision"** document to become an ITU-R Recommendation
   - Will describe the overall objectives of the future development for systems "beyond IMT-2020"

Scope of the "old" Vision document of IMT-2020 (ITU-R M.2083-0):
"..defines the framework and overall objectives of the future development of International Mobile Telecommunications (IMT) for 2020 and beyond **in light of the roles that IMT could play to better serve the needs of the networked society**, for both developed and developing countries, in the future. In this Recommendation, the framework of the future development of IMT for 2020 and beyond, **including a broad variety of capabilities associated with envisaged usage scenarios**, is described in detail. Furthermore, this Recommendation addresses the objectives of the future development of IMT for 2020 and beyond, which includes further enhancement of existing IMT and the development of IMT-2020…"

IMT-2020 / 5G Process

IMT-2020 radio interface standardization process

- ❖ Development plan
- ❖ Market/services view
- ❖ Technology & research kick off
- ❖ Vision - IMT for 2020
- ❖ Name
- ❖ Process optimization

- ❖ Technical performance requirements
- ❖ Evaluation criteria
- ❖ Invitation for proposals
- ❖ Sharing study parameters (IMT-2020)
- ❖ Sharing studies in preparation for WRC-19

- ❖ Technical proposals
- ❖ Evaluation Groups
- ❖ Methodology
- ❖ Consensus building

- ❖ Spectrum/band arrangements
- ❖ Decision & radio framework
- ❖ Detailed IMT-2020 radio specifications
- ❖ Future enhancement/ update plan & process

New Report

ITU-R M.[**IMT.FUTURE TECHNOLOGY TRENDS TOWARDS 2030 AND BEYOND**]

- ❖ future technical aspects of terrestrial IMT systems considering the time frame up to 2030 and beyond.

WP5D #36bis
17.-19.11.20

WP5D #38
06/2021

WP5D #39
10/2021

IMT-2020 spectrum allocation process

- ❖ < 6 GHz Spectrum view
- ❖ ITU-R Study Group activities/studies
- ❖ Spectrum/band arrangements (post WRC-15)

- ❖ CPM Report (IMT bands, WRC-19)
- ❖ Sharing study reports
- ❖ Spectrum/band arrangements (WRC-19)

2012-2015   2016-2017   2018-2019   2019-2020

Input requested from External Organisations
(WP5D #36, 10/2020)

Setting the stage for the future:
vision, spectrum, and technology views

Defining the technology,
Allocate the spectrum

(ITU-R WP 5D)

Draft New Report - Overview

"Working document towards Preliminary Draft New Report ITU-R M.[IMT.FUTURE TECHNOLOGY TRENDS TOWARDS 2030 AND BEYOND]"

- The **Technology Trends report** focuses on the *Technical aspects* of future technologies, while the **Vision** document considers the *overall capabilities and possible usage scenarios*.

- Scope: The Technology Trends Report provides a broad view of future technical aspects of terrestrial IMT systems considering the time-frame up to 2030 and beyond. It includes information on technical and operational characteristics of terrestrial IMT systems, including the evolution of IMT through advances in technology and spectrally efficient techniques, and their deployment.

- The Technical report is closely tied in with the Vision (under development).

Draft New Report - Driving Factors

The contents of the **Technology Trends report** is still very much under discussion, but already we are seeing some very interesting contributions for future technologies

- Current **driving factors in the design of IMT Technology:**

  - Peak Data Rate, Guaranteed Data Rate,
  - Latency, Jitter,
  - Sensing resolution and accuracy,
  - Connection density, Energy efficiency,
  - Coverage, Mobility,
  - Spectrum utilization, controllable radio environment,
  - User-centric networking,
  - Native artificial intelligence (AI)

Current draft contents

- Technologies to **enhance the radio interface**
  - Advanced modulation, coding and multiple access schemes
  - E-MIMO (extreme-MIMO)
  - Co-frequency Co-time Full Duplex (CCFD) communications
  - Multiple physical dimension transmission incl. Reconfigurable Intelligent Surface (RIS)
  - Terahertz (THz) communications
  - Visible light communication
  - Ambient Backscatter Communication (AmBC)

- Technologies to **enhance radio network performance and precision**
  - New architecture to support new operation and business models
  - Technologies to support resilient and soft network and guaranteed QoS
  - Technologies to support Digital Twin Networking (DTN)
  - Technologies to support the convergence of communication and computing enabling intelligent network and services
  - Technologies to support the integration of terrestrial and non-terrestrial networks
  - Technologies to support native security

Current draft contents (cont.)

- Technologies for native **Artificial Intelligence (AI)** based communication
  - Network for AI
  - AI-assisted new air interface (AI-AI)
  - Ethics and its supervision for wireless AI

- Technologies to enhance service coverage

- Technologies to enhance privacy and security

- Technologies for integrated sensing and communication

- Technologies for integrated terrestrial and non-terrestrial communications

- Technologies for integrated access and super sidelink communications

- Technologies to enhance adaptability and sustainability

- Technologies for efficient spectrum utilization

- Terminal technologies

- [Technologies to support a wide range of new use cases and applications] Note: This section may be moved to the new "VISION" document

Timeline for the systems "beyond IMT-2020"
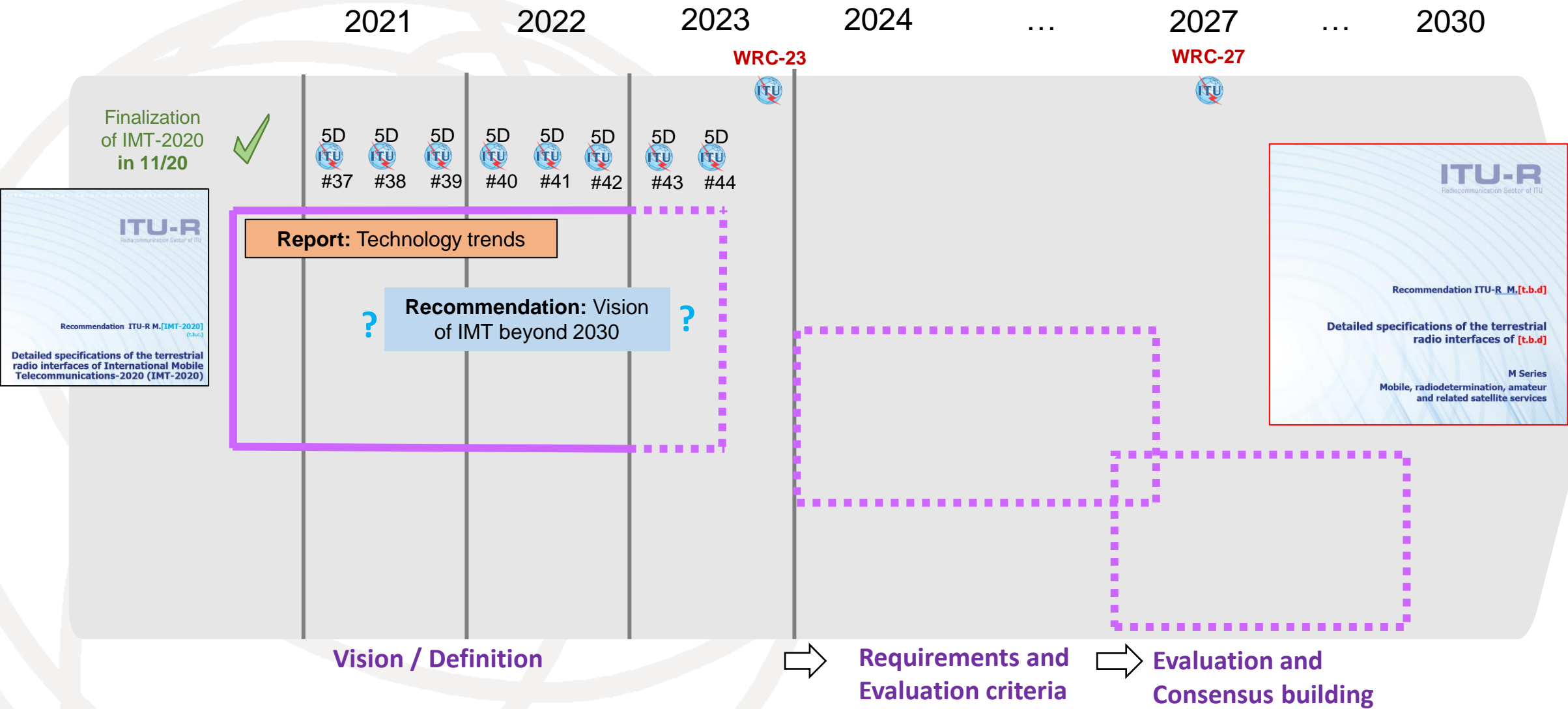
Finalization of IMT-2020 **in 11/20** ✓

| 2021 | 2022 | 2023 | 2024 | ... | 2027 | ... | 2030 |

WRC-23 **WRC-27**

5D ITU #37 5D ITU #38 5D ITU #39 5D ITU #40 5D ITU #41 5D ITU #42 5D ITU #43 5D ITU #44

Report: Technology trends

? **Recommendation:** Vision of IMT beyond 2030 ?

Recommendation ITU-R M.[IMT-2020] (t.b.c.)

Detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications-2020 (IMT-2020)

ITU-R
Radiocommunication Sector of ITU

Recommendation ITU-R M.[t.b.d]

Detailed specifications of the terrestrial radio interfaces of [t.b.d]

M Series
Mobile, radiodetermination, amateur and related satellite services

Vision / Definition ⇨ **Requirements and Evaluation criteria** ⇨ **Evaluation and Consensus building**

Non-Radio Standardisation work in ITU-T Beyond 5G SG5, SG11, SG13, SG15, SG17

ITU- SG5 is responsible for energy efficiency and electromagnetic fields (EMF)

ITU-T SG11 is responsible for protocols and test specifications

ITU-T SG13 is responsible for architecture and future networks

ITU-T SG15 is responsible for optical and transport networks
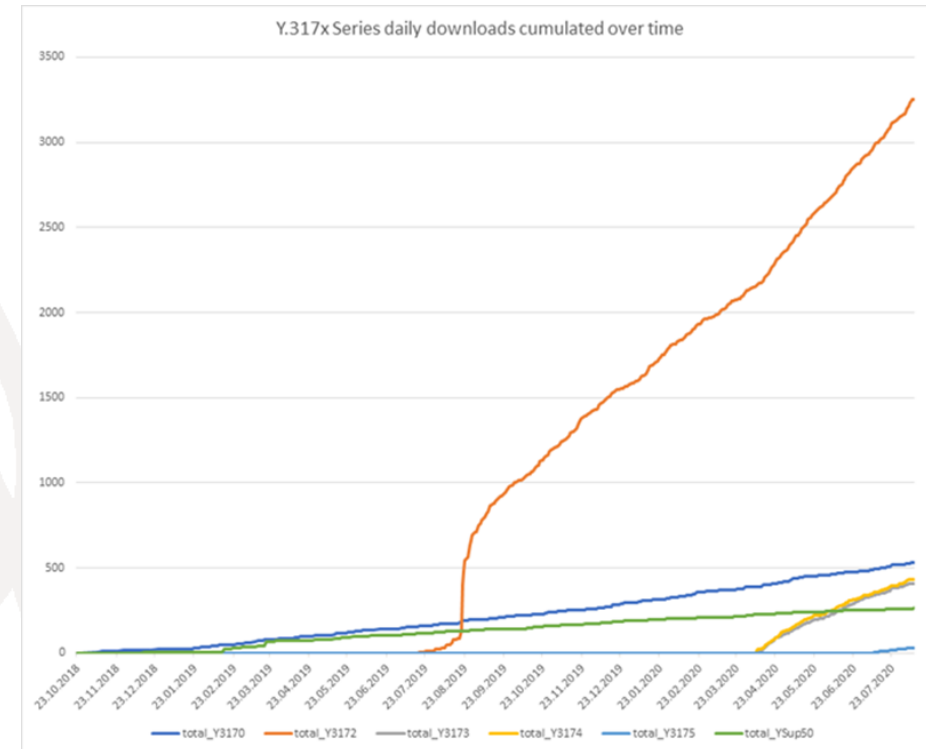
ITU-T SG17 is responsible for security

Machine Learning for 5G and Beyond

How to design
- network architectures,
- interfaces,
- protocols,
- algorithms,
- data format

to make best use of ML

How to synchronize Standards development with Open-Source Implementation

Y.317x Series daily downloads cumulated over time

ITU-T Y.317x Series Downloads (ITU-T SG13)

SG13 work on beyond IMT-2020

Fixed-Mobile Hybrid Networks

Mobile Networks

Fixed Networks

- **ICN: Information Centric Networking**

- **FMC: Fixed Mobile Convergence**

- **Network Softwarization**

- **Improved QoS**

- **Network 2030**

Autonomous Networks

Approaches to enable an autonomous network

three concepts of AN can be summarized as:
- Exploratory Evolution (making or creating new logic or solution)
- Online Experimentation (validating logic or solution) and
- Dynamic Adaptation (applying logic or solution)

Topics under consideration for pre-standardization efforts
- Requirements and architecture
- Use Case for autonomous behaviour
- Application of autonomous behaviour
- Trustworthiness including certainty and robustness while selecting and applying the autonomous decisions
- Proof of Concept (PoC)

Optical Networks to enable 5G and beyond

- Fronthaul, by PON, Radio over fiber

- CPRI over OTN for 5G fronthaul

- Optical transport network (OTN) beyond 100 Gbit/s

- Metro Transport Network (MTN)

- Wavelength division multiplex (WDM) technologies

- Frequency and time synchronization for 5G

- Management & Control of Transport Network supporting IMT-2020/5G

ITU-T SG15

Security to enable 5G and beyond

- Evolution
    - PKI, X.500 Series
    - Global SIM (901) for IoT/M2M
    - IoT Identification
    - SS7 Security

- Adoption/Consolidation
    - FIDO Alliance
    - OASIS STIX and TAXII
    - oneM2M

- New
    - Over the Air Software updates for Automotive
    - QKD, QRNG
    - DLT (Blockchain)
    - AI/ML
    - Privacy reserving multi-party computation
   - Cyber Defense Center for end-to-end security

ITU-T SG17

Quantum Key Distribution for 5G and beyond

- QKD uses the principles of quantum physics to secure the distribution of symmetric encryption keys.
  - "method for generating and distributing symmetrical cryptographic keys to be secure against any deciphering attacks with unbounded computational resources."
- Use cases exploring the potential of QKD for 5G are under study in ITU-T FG-QIT4N for:
  - 5G backhaul, fronthaul and mid-haul
  - Quantum-secure inter-domain 5G service orchestration
    - Applying QKD to SDN and NFV to secure interconnections of distributed VNFs

Testbed Federations for 5G and beyond

- The recent technological developments require more realistic tests and new use cases to be validated in real conditions. The consequence is that the testbeds are more important – the **testbed federations are needed**.

- Vertical industry needs to experiment and pilot their "5G enabled" business case before moving to commercial.

- There is a need to standardize a generic 5G and beyond application testing and validation framework which validates the vertical application in a systematic manner under different 5G technology choices.

- ITU-T SG11 and ETSI TC INT are developing Open APIs for interoperable testbed federations which will define reference model of testbed federations and related APIs to enable federation with other platforms and/or testbeds.
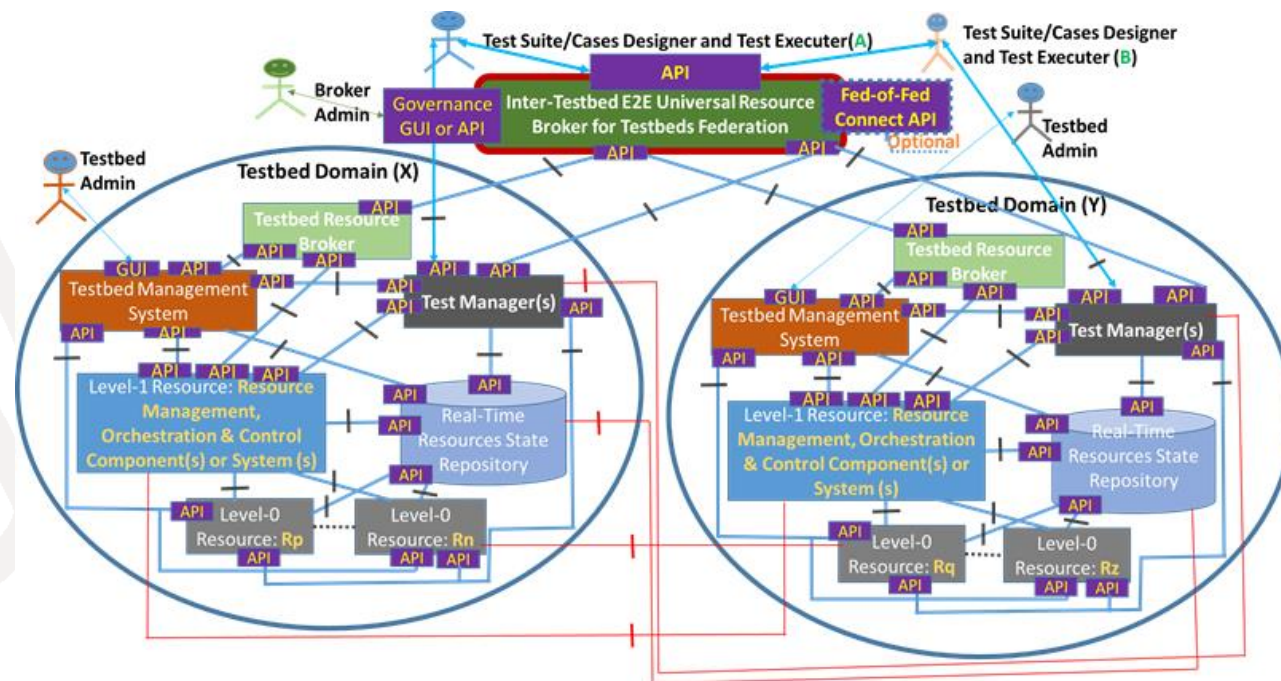
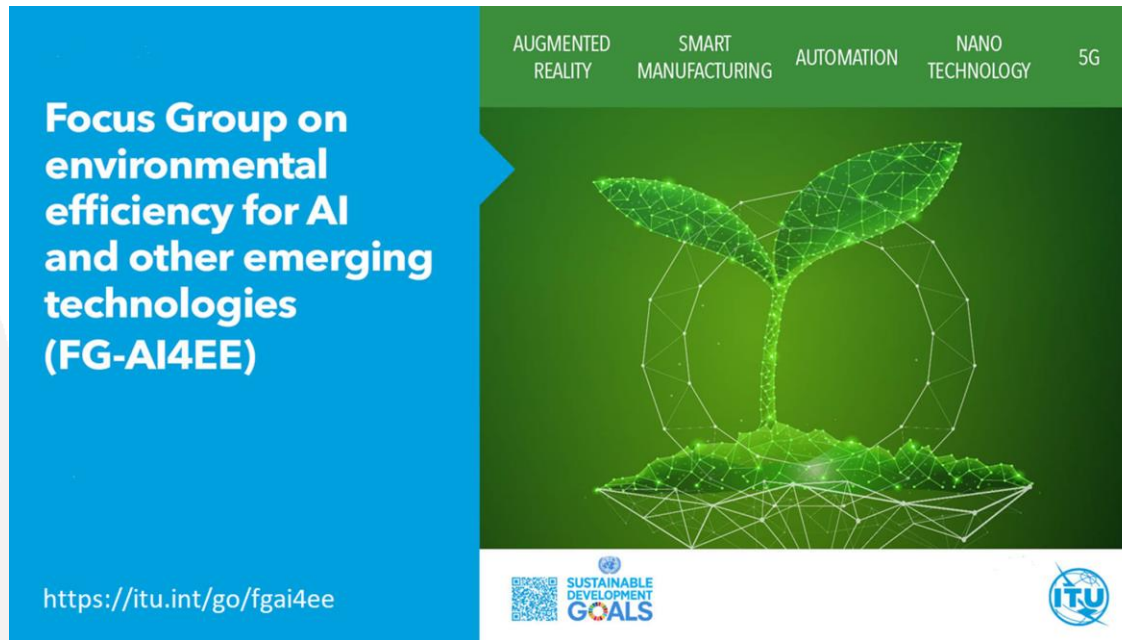Draft ITU-T Q.API4TB: Open APIs for interoperable testbed federations

ITU-ETSI-IEEE Joint SDOs Brainstorming Workshop on Testbeds Federations for 5G and Beyond: Interoperability, Standardization, Reference Model and APIs (virtual, 15-16 March 2021)
Key takeaways, Workshop Summary

Webinar
07 April 2020, 16:00-18:00 CEST (Geneva time)

Third Focus Group virtual meeting
08 April, 14:00-17:00 CEST (Geneva time)

More info/registration: https://itu.int/go/fgai4ee

13TH ITU ACADEMIC CONFERENCE

ITU KALEIDOSCOPE
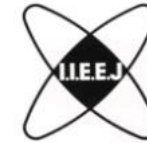### ONLINE 2021

Connecting physical and virtual worlds

6-10 December

IMPORTANT DEADLINES!
- Submission of full paper proposals: **27 June 2021**
- Notification of paper acceptance: 1 October 2021
- Submission of camera-ready accepted papers: 15 October 2021

PARTNERS

Kaleidoscope 2021 calls for original academic papers sharing insight into ongoing projects and research relevant to the development of persistent virtual realities and customized computer-generated environments. Particularly, this conference encourages submissions on technical standards for networks and services required to enable this transformation, including considerations on social and ethical implications.

6G Vision Workshop, Eindhoven, 31st March 2021

ITUJournal
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Special issue

Internet of Bio-Nano Things for health applications

Volume 2 (2021), Issue 1

www.itu.int/en/journal/j-fet/2021/001/Pages/default.aspx
Submission deadline 22 April 2021

ITUJournal
Future and evolving technologies

Special issue

Internet of Everything

Volume 2 (2021), Issue 2

www.itu.int/en/journal/j-fet/2021/002/Pages/default.aspx
Submission deadline 6 April 2021

Committed t

ITUJournal
Future and evolving technologies

Special issue

Terahertz communications
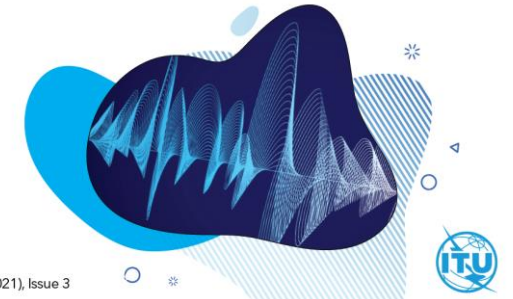
Volume 2 (2021), Issue 3

www.itu.int/en/journal/j-fet/2021/003/Pages/default.aspx
Submission deadline 12 April 2021

ITUJournal
Future and evolving technologies

Special issue

Wireless communication systems in beyond 5G era

Volume 2 (2021), Issue 4

www.itu.int/en/journal/j-fet/2021/004/Pages/default.aspx
Submission deadline 3 May 2021

6G Vision Workshop, Eindhoven, 31ˢᵗ March 2021

ITUJournal
Future and evolving technologies

Special issue

AI and machine learning solutions in 5G and future networks

www.itu.int/en/journal/j-fet/2021/005/Pages/default.aspx
Submission deadline 8 April 2021

CALL FOR SUBMISSIONS!

The ITU J-FET is currently accepting submissions to **5 special issues** to contribute to Volume 2 (2021)!

The publication also accepts paper submissions all year round, on **any topic within the Journal's scope:**
www.itu.int/en/journal/j-fet/Pages/about.aspx