# Deliverable 6.3
# Standardisation activities

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***Abstract***

This deliverable includes the work conducted within Task 6.2 “Standardisation”. The main objective of this task is to promote project results in standardisation bodies. In this task, ARIADNE will proceed in a 3-step approach for the coordination and planning of the contribution strategy. Firstly, Standardisation Bodies (SB) relevant to the project, will be identified. Consequently, SB will be monitored so as to ensure the alignment of the project technical work with standards evolution and the achievement of high level interactions, based on the progress and maturity of the work to be done. Finally, the project partners will proceed to actual contributions, where and to the extent possible. Such activities aim at identifying the gap between the technical research and the standardisation bodies work items, fostering potential ARIADNE’s outcome.

Disclaimer



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Impressum

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# Executive summary

The ARIADNE project aims to investigate innovative technologies, techniques and procedures to enable efficient high-bandwidth wireless communications in the D-band. ARIADNE will contribute to the study and development in an integrated and innovative way of new technologies for Beyond 5G (B5G) networks.

The ARIADNE project defines three main pillars that will be the basis for the work to be carried out and will allow to achieve the main objective. The three main pillars are the following:

- To develop new radio technologies for communications using the above 100GHz D-Band frequency bands (Pillar 1),
- To exploit the opportunities emerging for advanced connectivity based on metasurfaces where objects in the environment can become tunable reflectors for shaping the propagation environment in D-band (Pillar 2),
- To employ Machine Learning and Artificial Intelligence techniques to management functions necessary for the high-frequency communications, dynamic assignment and reconfiguration of the metasurfaces to provide continuous reliable high bandwidth connections in Beyond 5G scenarios (Pillar 3).

Task 6.2 is defined at the beginning of the project as following:

“Promoting the project’s results in standardisation bodies is of primary importance for the ARIADNE’s consortium. In this task, ARIADNE will proceed in a 3-step approach for the coordination and planning of the contribution strategy. Firstly, Standardisation Bodies (SB) relevant to the project will be identified. Consequently, SB will be monitored so as to ensure the alignment of the project technical work with standards’ evolution and the achievement of high level interactions, based on the progress and maturity of the work to be done. Finally, the Project partners will proceed to actual contributions, where and to the extent possible. Such activities aim at identifying the gap between the technical research and the standardisation bodies work items, fostering potential ARIADNE’s outcomes. ARIADNE’s effort on standardisation activities will be driven by participation of the project partners to related standardisation bodies Partners’ roles: NOKIA will act as Task Leader. All the partners will also contribute to standardisation activities.”

Deliverable 6.3 is an outcome of the standardisation activities after 12 months from the project start. It will give a snap-shot of standardisation bodies or interest groups proposed to be followed. Optionally information on which partner is following activities and works of those groups is also provided. Secondly there will be an updated plan of contribution to standardisation activities from each partner. Actual List of Standardisation activities are not planned to be included in this M12 deliverable, but potential topics are mentioned in the section on partner’s plan of contribution.

Deliverable 6.4 will be created at the end of the project (M36). It will summarize all activities, contributions and achievements towards standardisation made under ARIADNE project.

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# List of figures

# Abbreviations

| Abbrev. | Expansion |
|---|---|
| 3GPP | 3rd Generation Partnership Project |
| 5G | Fifth Generation (mobile cellular networks) |
| 5G PPP | 5G Public Private Partnership |
| AI | Artificial Intelligence |
| AP | Access Point |
| B5G | Beyond 5G |
| BBU | Baseband Unit |
| BEP | Bit Error Probability |
| BTS | Base Transceiver Station |
| E2E | End-to-end |
| eCPRI | Enhanced Common Public Radio Interface |
| EM | Electromagnetic |
| eMBB | Enhanced Mobile Broadband |
| ETSI | European Telecommunications Standards Institute |
| FDMA | Frequency Division Multiple Access |
| ISG | Industry Specification Group |
| ITU | International Telecommunication Union |
| KPI | Key Performance Indicator |
| LOS | Line of Sight |
| LTE | Long Term Evolution |
| ML | Machine Learning |
| mMTC | Massive Machine Type Communications |
| mmWave | Millimeter Wave |
| MW | Microwave |
| mWT | Millimeter Wave Transmission |
| NLOS | Non Line Of Sight |
| NR | New Radio is a new radio access technology (RAT) developed by 3GPP for 5G |
| P2MP | Point-to-Multipoint |
| P2P | Point-to-Point |
| RF | Radio Frequency |
| RIS | Reconfigurable Intelligent Surface |
| RRH | Remote Radio Head |
| RX | Receiver |
| TX | Transmitter |
| uRLLC | Ultra Reliable Low Latency Communications |
| UE | User Equipment |
| V2V | Vehicle-to-Vehicle |
| V2X | Vehicle-to-Everything |
| WP | Work Package |

# 1 Introduction to the project

## 1.1 Background

The ARIADNE project is targeting to enable efficient high-bandwidth wireless communications by developing three complementary but key new technologies for beyond 5G networks in an integrated and innovative way:

- ARIADNE will develop new radio technologies for communications using the above 100GHz D-band frequency ranges. (Pillar 1)
- ARIADNE will exploit the opportunities emerging for advanced connectivity based on metasurfaces where objects in the environment can become tunable reflectors for shaping the propagation environment in D-band. (Pillar 2)
- ARIADNE will employ Machine Learning and Artificial Intelligence based management techniques necessary for the high-frequency communications and dynamic assignment and reconfiguration of the metasurfaces, in order to provide continuous reliable High Bandwidth connections in the Beyond 5G scenario. (Pillar 3)

To realize this novel system concept, ARIADNE will propose a novel hybrid wireless system architecture taking benefits from the bandwidth-rich D-band and Artificial Intelligence. Also ARIADNE targets to take advantage from a number of envisioned research innovations and advanced technology enablers:

- A novel Communication Theory framework beyond the Shannon paradigm
- Intelligent surfaces (metasurfaces) used to enable tunable or switchable reflections and overcome limitations resulting from obstructed links and NLOS scenarios
- Propagation characterisation in the D-band for indoor/outdoor, LOS and NLOS
- Highly integrated D-band transceiver RF-frontend architectures and spectral efficient baseband processing, energy-efficient carrier aggregation, and D-band MIMO antenna design
- Waveform design, wireless access, tracking and resource allocation based on the pencil beamforming principle, and
- ML-based approaches for ultra-reliable connectivity, optimal and adaptive RRM and E2E network optimisation (resource allocation, routing, etc).

### 1.1.1 System concept

ARIADNE's system concept has been defined in the ARIADNE deliverable D1.1 on "Use case definition and system requirements". The concept revolves around three main use cases with distinct scenarios for each of them.

- Use case 1: Outdoor backhaul/fronthaul networks of fixed topology
- Use case 2: Advanced NLOS connectivity based on metasurfaces
- Use case 3: Adhoc connectivity in moving network topology

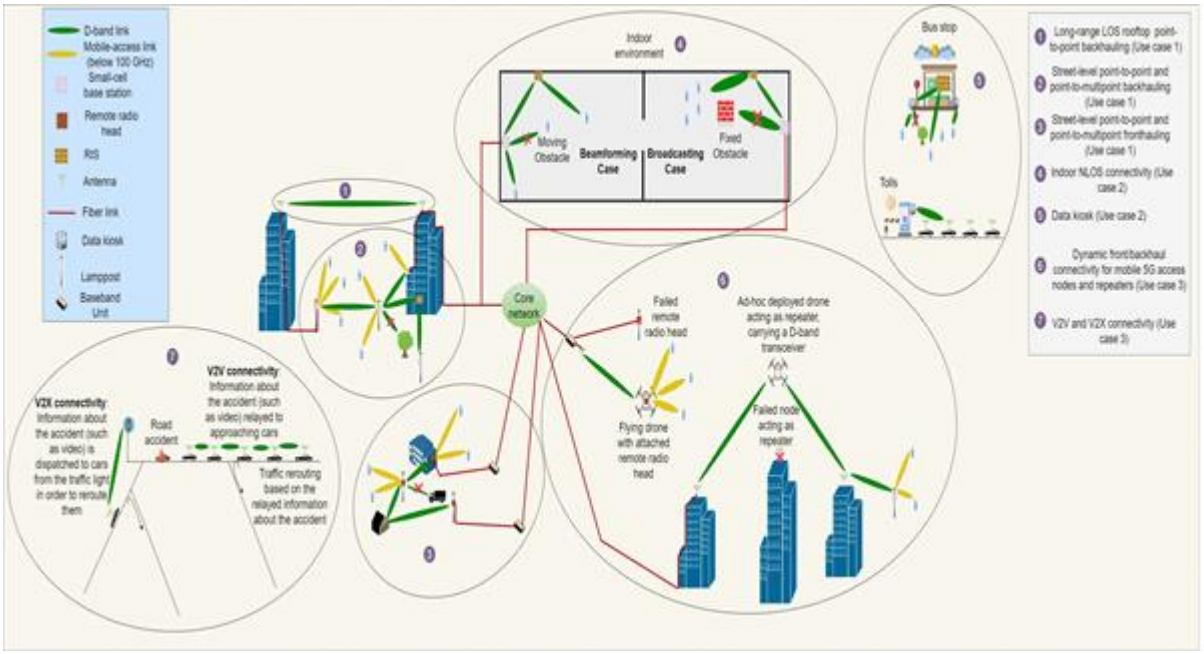


**Figure 1. System concept of ARIADNE [1]**

### 1.1.2 Objectives and vision

In the project Description of Work, ARIADNE vision has been defined as follows.

“ARIADNE will carry out a substantial number of well-planned and coordinated research and development tasks all directed towards realizing the three visionary pillars and achieving the corresponding objectives. As illustrated in Figure 3, the tasks involve engaging in analytical and fundamental studies, algorithm and signal processing, resource management strategy and network modules interface design as well as network architecture and model-based and data driven optimization. For each of the above three objectives, the key technology breakthroughs (innovations, theoretical findings, techniques) will be demonstrated, validated and evaluated by means of

- Definition of a proof-of-concept software simulation and hardware demonstration platform
- Implementation of the ARIADNE demonstration platform, and
- Evaluation of the ARIADNE system performance.”

ARIADNE goal is to considerable increase the capabilities of the current wireless 5G systems in terms of achievable data rates and reliability. This could be achieved by employing a number of technological inventions, such as exploitation of the D-band, design and development of highly energy-efficient RF frontend, employment of metasurfaces together with ML approaches to reconfigure the wireless environment, and utilization of AI aided medium access, resource and network management protocols. To realise this goal a multifaceted methodology plan is presented below.

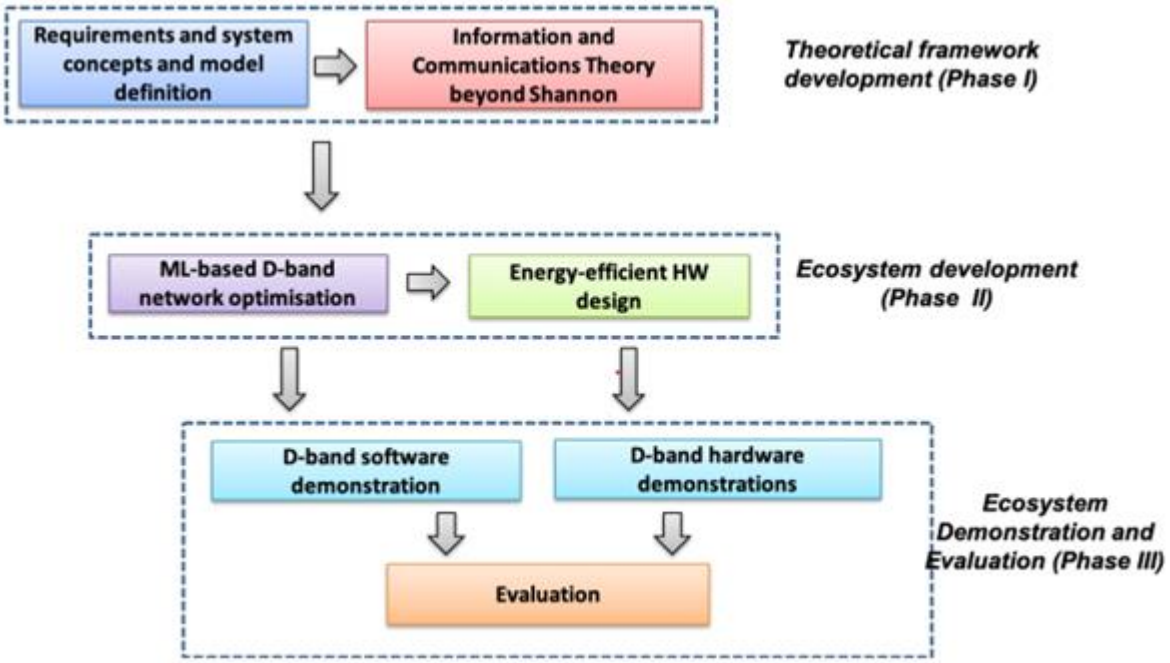


**Figure 2. ARIADNE methodology**

In addition to performing the three main building blocks (pillars), the ARIADNE project should successfully address the following seven major Key Performance Indicators (KPIs):

- Aggregate throughput of wireless access for any traffic load/pattern (100 Gbit/s).
- End-to-end (E2E) throughput in all relevant usage scenarios, backhaul/fronthaul, adhoc backhaul, NLOS / obstructed (100 Gbit/s).
- E2E latency minimisation ('zero' latency).
- Coverage of the D-band link (100m outdoors).
- Connectivity reliability for massive number of nodes ('always' available).
- Energy efficiency (energy consumption reduction by 10x compared to 5G).
- Complexity reduction (10x compared to 5G).

Figure 3 shows an overview of the relation between the three main pillars and the objectives and vision of ARIADNE project.

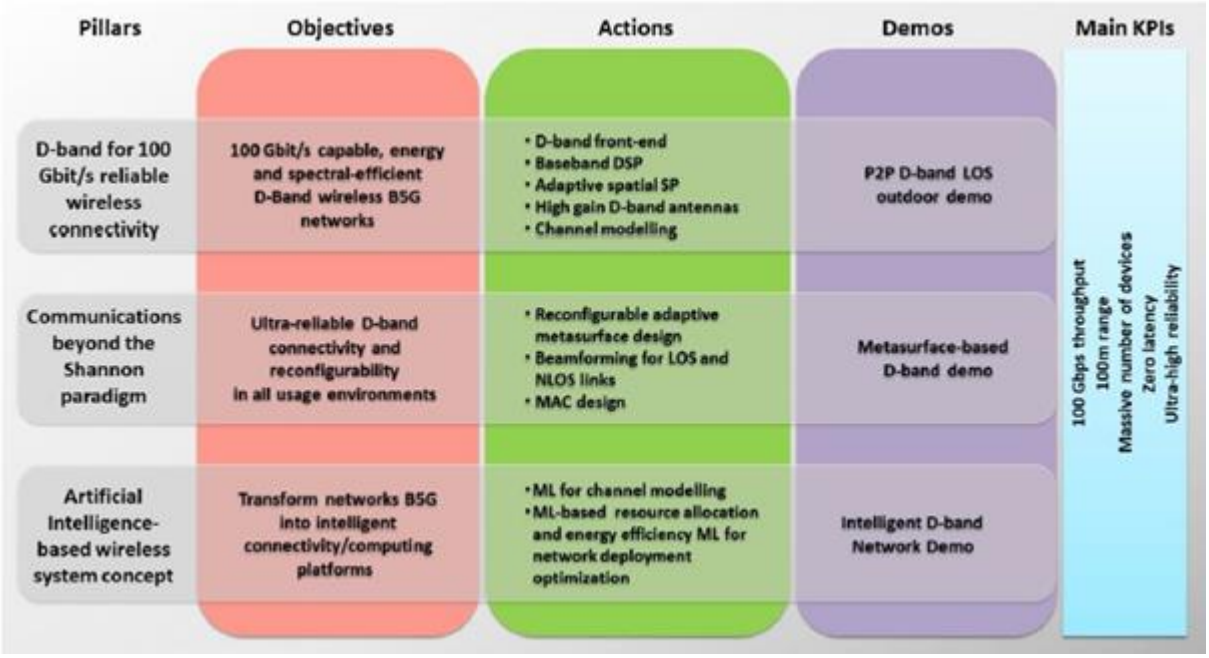


**Figure 3. Summary of the ARIADNE objectives and vision**

## 1.2 Introduction to task standardisation

ARIADNE will be forerunner in technology development for bandwidth rich D-band spectrum by investigating, theoretically analyzing, designing, developing and showcasing in a proof of concept demonstrator an innovative wireless communications concept addressing networks beyond 5G.

The highly innovative nature of the project has the great potential to generate inputs for standardisation. Active follow-up, participation and contributions to relevant interest groups and standardisation bodies based on the work addressed in the project are envisaged.

It is anticipated that some of the ARIADNE work can be integrated into relevant standards in the 5G-PPP and maybe in other bodies as well.

Presenting the results of the project to standardisation bodies is of highest priority for the ARIADNE consortium. Therefore a 3-step approach has been planned for the coordination and planning of the contribution strategy.

- Firstly, Standardisation Bodies (SB) or Interest Groups (IG) relevant to the project, will be identified.
- SB's or IG's identified to be relevant will be monitored so as to ensure the alignment of the project technical work with standards evolution and the achievement of high level interactions, based on the progress and maturity of the work to be done.
- Project partners will proceed to actual contributions, where and to the extent possible. Such activities aim at identifying the gap between the technical research and the standardisation bodies work items, fostering potential ARIADNE's outcomes.

ARIADNE's effort on standardisation activities will be driven by the participation of the project partners in related standardisation bodies and interest groups.

The project has a task dedicated to standardisation activities running for the whole duration of the project, T6.2, which is organized in WP6 - Dissemination, Standardisation and Exploitation. T6.2 is Lead by NOKIA and works in collaboration with the technical WP teams. Several consortium partners actively contribute to key standards bodies and the technical WPs will provide information on relevant standardisation activities or agendas alignement from targeted groups in an early stage to this task.

There are two deliverables related to the standardisation to be produced in T6.2:

- D6.3 (M12) (NOK) - Standardisation activities: Regularly updated list of standardisation activities of the project
- D6.4 (M36) (NOK) - Standardisation activities: Regularly updated list of standardisation activities of the project

Deliverable 6.3 is an outcome of standardisation activities after 12 months from the project start. It will give a snap-shot of standardisation bodies or interest groups proposed to be followed. Optionally information on which of the partners are following activities and work of those groups is also provided. Secondly there will be an updated plan for contribution to standardisation activities from each partner. The actual list of Standardisation activities is not planned to be included in this M12 deliverable, but potential subjects are mentioned in the section on partner's plan of contribution.

Deliverable 6.4 will be created at the end of project (M36). It will summarize all activities, contributions and achievements towards standardization within ARIADNE project.

# 2 Standardisation bodies or interest groups to be followed

## 2.1 Information on relevant standardisation bodies or interest groups

### 2.1.1 3GPP

Website: https://www.3gpp.org/

3GPP is an umbrella term for a number of organisations concentrated on developing mobile communication protocols. It consists of seven national or regional standards organisations as primary members ("organisational partners") and a variety of other organisations ("market representation partners"). Organisational partners define the scope, content and resourcing of standardisation work and act as the primary decision-making body. Market representation partners primarily offer advice and insight into the market requirements to support the standardisation work.

3GPP standards are divided into releases. The releases consist mainly of Technical Specification and Technical Report documents, each of which may undergo many revisions over several releases.

Specification work is done in specification groups. There are three top level Technical Specification Groups (TSGs) and several Working Groups (WGs) under each TSG. WGs prepare and discuss change requests against current 3GPP specifications. Change requests that are agreed by WGs move to approval by the corresponding TSG.

The working group most relevant for ARIADNE is RAN1 WG, which is working on the radio layer 1. Meetings are held every three months and the next one, 104-e, is arranged as an online meeting on 2021-01-25 – 2021-02-05.

Release 17 is currently being worked on with freeze date target at the end of 2021. Due to the ongoing difficulties in organising physical meetings the schedule will likely be delayed. Release 17 does not include any items directly related to ARIADNE and is not likely to do so in the future due to the release content having already been frozen. The work area most interesting from ARIADNE point of view is extension of NR support to frequencies from 52.6 GHz to 71 GHz. This work is being planned in RAN1 WG.

Release 18 would be the best place to direct any inputs from ARIADNE. The planning will start after release 17 is finished, which is most likely sometime in 2022. Items are brought to the working group agenda as liaison statements and change requests. These are created by the 3GPP member organisations.

### 2.1.2 US mmWave Coalition

Website: https://mmwavecoalition.org/

mmWave Coalition is a US based group of companies that focuses on advocating opening up regulations that govern the use of frequencies between 95 GHz and 450 GHz. Specific aims (from the coalition website):

- Create large contiguous blocks of spectrum by proposing service rules, including Part 101 and Part 30, that span existing Fixed Service (FS), Mobile Service (MS) bands, and

present passive (US 246) bands, *e.g.* 102-130 GHz facilitating speeds comparable with fiber optics technology.

- Update present US Allocation Table US246 to enable controlled sharing of passive above 90 GHz spectrum under strict conditions that protect the passive uses of them — which is much easier at these frequencies than at lower bands.
- Extend quantitative RF safety limits above present 100 GHz to decrease regulatory uncertainty.

The last update on the website was done in August 9th2019. Latest submission visible in the FCC archives i May 2020 but other than this there are no records of activities since August 2019.

Main interest towards this group from ARIADNE's point of view would be dissemination of any findings from the project that could affect or be affected by the regulatory framework.

### 2.1.3 ITU-R

The origins of the International Telecommunication Union (ITU) (http://www.itu.int) date back in 1865, when the International Telegraph Union was founded in Paris. The ITU is a specialized agency of United Nations with its base in Geneva, Switzerland. Currently the ITU is formed by 193 Member states and more than 700 organisations from the private sector and academia. Since 1992 the ITU has been structured into three sectors:

- **Telecommunication Standardization Sector** (**ITU-T**). The ITU-T assembles experts from around the world to develop international standards known as ITU-T Recommendations which act as defining elements in the global infrastructure of information and communication technologies (ICTs).
- **Telecommunication Development Sector** (**ITU-D**). The ITU-D fosters international cooperation and solidarity in the delivery of technical assistance and in the creation, development and improvement of telecommunication and ICT equipment and networks in developing countries.
- **Radiocommunication Sector** (**ITU-R**): The mission of the ITU-R is, inter alia, to ensure rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including those using satellite orbits, and to carry out studies and adopt recommendations on radiocommunication matters, by:
    - holding World and Regional Radiocommunication Conferences and Seminars to expand and adopt Radio Regulations and Regional Agreements covering the use of the radio-frequency spectrum;
    - approving ITU-R Recommendations, developed by ITU-R Study Groups (SG) in the framework set by Radiocommunication Assemblies, on the technical characteristics and operational procedures for radiocommunication services and systems;
    - coordinating activities to eliminate harmful interference between radio stations of different countries;
    - maintaining the Master International Frequency Register (MIFR); and

- offering tools, information and seminars to assist national radio-frequency spectrum management;
- carrying out studies and adopting recommendations on radiocommunication matters.

The ITU-R is the most relevant Sector for Wireless Technologies. Organized by the ITU-R, the most important events regarding the regulation of the use of the spectrum are the **World Radiocommunication Conference**s (WRC) that are held every three to four years and that are presented in Section 2.1.4.

The **Radiocommunication Assemblies** (**RA**) are responsible for the structure, programme and approval of radiocommunication studies. They are normally convened every three or four years and may be associated in time and place with WRCs. The last one took place in Egypt in 2019 associated to the WRC-19. The RA:

- assign conference preparatory work and other questions to the Study Groups;
- respond to other requests from ITU conferences;
- suggest suitable topics for the agenda of future WRCs;
- approve and issue ITU-R Recommendations and ITU-R Questions developed by the Study Groups;
- set the programme for Study Groups, and disband or establish Study Groups according to need.

The ITU-R Study Groups develop the technical bases for decisions taken at World Radiocommunication Conferences and develop global standards (Recommendations), Reports and Handbooks on radiocommunication matters. More than 5000 specialists, from administrations, the telecommunications industry as a whole and academic organizations throughout the world, participate in the work of the Study Groups on topics such as efficient management and use of the spectrum/orbit resource, radio systems characteristics and performance, spectrum monitoring and emergency radiocommunications for public protection and disaster relief.

There are six Study Groups (SGs) specializing in the following areas:

- SG 1 Spectrum management (www.itu.int/ITU-R/go/rsg1)
- SG 3 Radiowave propagation (www.itu.int/go/ITU-R/rsg3)
- SG 4 Satellite services (www.itu.int/ITU-R/go/rsg4)
- SG 5 Terrestrial services (www.itu.int/go/ITU-R/rsg5)
- SG 6 Broadcasting service (www.itu.int/ITU-R/go/rsg6)
- SG 7 Science services (www.itu.int/ITU-R/go/rsg7)

Subgroups, known as Working Parties (WPs) and Task Groups (TGs) are established to study the questions assigned to the different Study Groups.

#### **2.1.3.1** ITU-R SG 3 – Radiowave propagation

Study Group 3 deals with the propagation of radio waves in ionized and non-ionized media and the characteristics of radio noise, for the purpose of improving radiocommunication systems. The technical work is carried out in the following four Working Parties:

- WP 3J – Propagation fundamentals. WP 3J provides information and develops models describing the fundamental principles and mechanisms of radiowave propagation in non-ionized media. Such material is used as the basis of propagation prediction methods developed by the other Working Parties.
- WP 3K – Point-to-area propagation. WP 3K is responsible for developing prediction methods for terrestrial point-to-area propagation paths. In the main, these are associated with terrestrial broadcasting and mobile services, short-range indoor and outdoor communication systems (e.g. radio local area networks, RLAN), and with point-to-multipoint wireless access systems.
- WP 3L - Ionospheric propagation and radio noise. WP 3L studies all aspects of radiowave propagation in and through the ionosphere.
- WP 3M - Point-to-point and Earth-space propagation. WP 3M addresses radiowave propagation over point-to-point terrestrial paths and Earth-space paths, both for wanted and unwanted signals.

Meetings of the four WPs of SG3 are jointly organized once per year, usually in Spring. The last one was carried out remotely in August 2020, because of the Covid-19 pandemic. The WP meetings have a technical orientation and produce proposals of changes of ITU-R Recommendations or additions of new ones as well as other technical documents (Handbooks, Reports, Fascicles). They are followed in some years by a general SG3 meeting, where the ITU-R Recommendations are approved.

**Interest for ARIADNE**

The topic of radiowave propagation is related to the activity of ARIADNE WP1. The proposals studied at the WP 3J, 3K and 3M meetings can be of interest, and the documents released can be of application for the ARIADNE activity. However, at the moment the number of documents discussed related to the D-band is limited.

In the last meeting, several proposals to modify current Recommendations on gas attenuation, rain specific attenuation, attenuation by vegetation, and others were discussed. They can affect the D-Band.

Technical work is in same cases originated by Liasion Statements (LS) coming from other SG of ITU or from other entities. Currently there is a LS on Propagation Issues in the range 116-260 GHz issued by CEPT WG on Spectrum Engineering and related to the protection of radioastronomy services. Because of the frequency range, some results could be of application to ARIADNE.

Results of our work in WP1 could be contributed to ITU-R SG3 future meetings.

### 2.1.3.2 ITU-R SG 5 –Terrestrial Service

This Study Group focuses on systems and networks for fixed, mobile, radiodetermination, amateur and amateur satellite services.

Four Working Parties (WPs) carry out the studies on questions assigned to Study Group (SG) 5 and one Task Group (TG) which conducts studies on WRC-19 Agenda item 1.13.

- WP 5A: Land mobile service above 30MHz (excluding IMT), wireless access in the fixed service, amateur and amateur-satellite services
- WP 5B: Maritime mobile service including the Global Maritime Distress and Safety System (GMDSS), the aeronautical mobile service and the radiodetermination service
- WP 5C: Fixed wireless systems, HF and other systems below 30 MHz in the fixed and land mobile services
- WP 5D: IMT systems

WP 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. For the last 30 years, ITU has been coordinating efforts of governments and the industry in the development of a global broadband multimedia international mobile telecommunications system, known as IMT. Since the year 2000, the world has seen the introduction of the first family of standards derived from the IMT concept: IMT-2000. There are currently several billions IMT subscribers in the world and these systems are continuing to expand and evolve. IMT provides a global platform on which to build the next generations of mobile services – fast data access, unified messaging and broadband multimedia – in the form of exciting new interactive services.

Study Group 5 and its Working Parties maintains a number of Recommendations (www.itu.int/pub/R-REC) and Reports (www.itu.int/pub/R-REP) relating to the fixed, mobile, radiodetermination, amateur and amateur-satellite services. Study Group 5 is also responsible for development of IMT, as illustrated in the following figure.

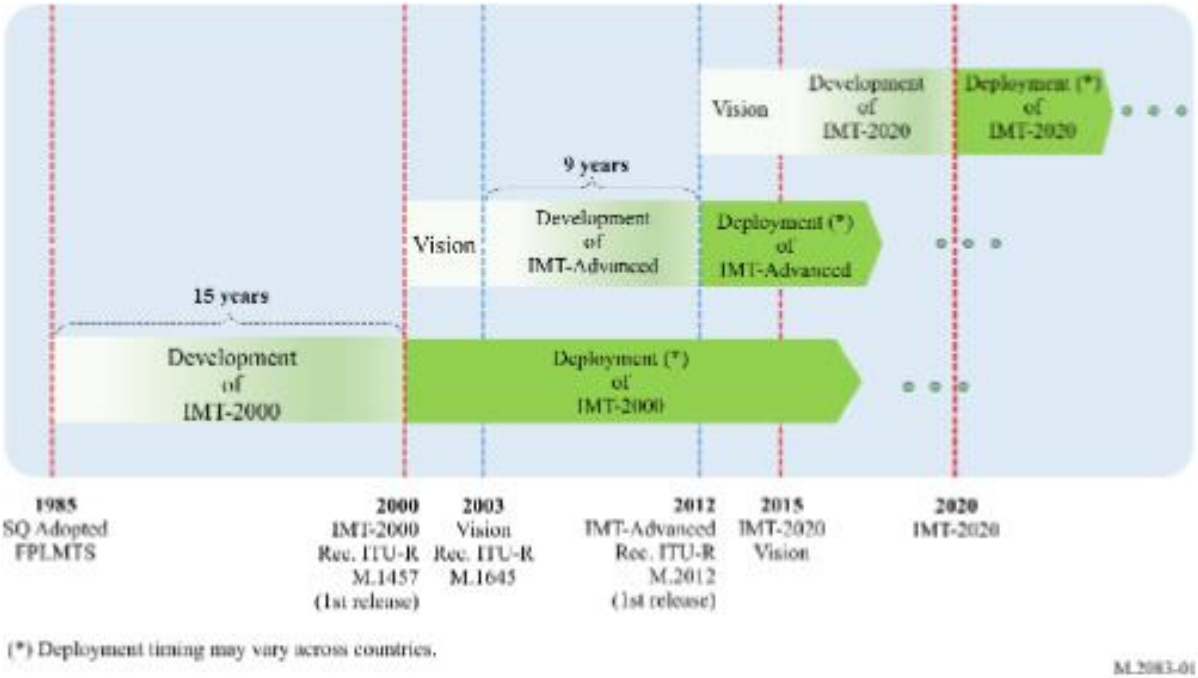


**Figure 4. Development of IMT**

**IMT-2020 Evaluation Process**

ITU-R has commenced the process of developing ITU-R Recommendations for the terrestrial components of the IMT-2020 radio interface(s). This work is guided by Resolution ITU-R 65. Resolution ITU-R 65 on the "Principles for the process of future development of IMT for 2020 and beyond" outlines the essential criteria and principles, which will be used in the process of developing the Recommendations and Reports for IMT-2020, including Recommendation(s) for the radio interface specification.

Report ITU-R M.2410 describes key requirements related to the minimum technical performance of IMT-2020 candidate radio interface technologies. It also provides the necessary background information about the individual requirements and the justification for the items and values chosen. Provision of such background information is needed for a broader understanding of the requirements. This Report is based on the ongoing development activities of external research and technology organizations.

Report ITU-R M.2411 deals with the requirements, evaluation criteria and submission templates for the development of Recommendations and Reports on IMT-2020, such as the detailed specifications of IMT 2020. It provides the service, spectrum and technical performance requirements for candidate Radio Interface Technologies (RITs)/Set of Radio Interface Technologies (SRITs) for IMT 2020.

Report ITU-R M.2412 provides guidelines for the procedure, the methodology and the criteria (technical, spectrum and service) to be used in evaluating the candidate IMT-2020 radio interface technologies (RITs) or Set of RITs (SRITs) for a number of test environments. These test environments are chosen to simulate closely the more stringent radio operating environments. The evaluation procedure is designed in such a way that the overall performance of the candidate RITs/SRITs may be fairly and equally assessed on a technical basis. It ensures that the overall IMT 2020 objectives are met.

The first invitation for submission of proposals for candidate radio interface technologies (RITs) or a set of RITs (SRITs) for the terrestrial components of IMT-2020 was issued by WP5D in March 2016. This Circular Letter invitation also initiated an ongoing process to evaluate the candidate RITs or SRITs for the terrestrial components of IMT-2020 and invited the formation of independent evaluation groups (IEGs) and the subsequent submission of evaluation reports on these candidate RITs or SRITs.

In February 2017, WP5D announced the availability of Report ITU R M.2410 – Minimum requirements related to technical performance for IMT 2020 radio interface(s).

In July 2017, WP5D announced the availability of two new Reports ITU R M.2411 – Requirements, evaluation criteria and submission templates for the development of IMT 2020 and ITU-R M.2412 – Guidelines for evaluation of radio interface technologies for IMT 2020.

In December 2019, the successful closure for all IMT-2020 candidate technology submissions was announced (Step 3).

In March 2020, WP5D provided information on the completion of IMT 2020 evaluation process (Step 4) and announced the availability of the final evaluation reports from registered Independent Evaluation Groups (IEGs) as well as a consolidated summary.

ITU-R has determined that the IMT-2020 candidate technology submission proposals listed below have successfully completed Step 7 and all preceding Steps of the evaluation process, and thus are accepted for inclusion as IMT-2020 technologies in the standardisation phase for IMT-2020 (Step 8). Candidate technology submissions accepted for first release of Recommendation ITU-R M.[IMT-2020.SPECS] are:

- Candidate SRIT submission from 3GPP proponent
- Candidate RIT submission from 3GPP proponent
- Candidate RIT submission from China (People's Republic of)
- Candidate RIT submission from Korea (Republic of)
- Candidate RIT submission from TSDSI

ITU-R has decided (October 2020) that the IMT-2020 candidate technology submission proposals listed below will require additional evaluation to conclude their respective final assessments. They will, therefore, on an exceptional basis continue in the process, rewinding to the evaluation phase by IEGs (Step 4), in order to consider additional supplied material. The successful evaluation of any of these two proposals would result in their inclusion in the revision to the published first release of Recommendation ITU-R M.[IMT-2020.SPECS]. Candidate technology submissions granted an extension in the IMT-2020 Evaluation Process are:

- Candidate SRIT submission from ETSI (TC DECT) and DECT Forum
- Candidate RIT submission from Nufront

This extension phase in the evaluation process should be completed by October 2021.

Further information on the IMT 2020 Evaluation Process is available on https://www.itu.int/en/ITU-R/study-groups/rsg5/rwp5d/imt-2020/Pages/submission-eval.aspx

### 2.1.4 ITU WRC-23

Organised by the ITU-R, the most important events regarding the regulation of the use of the spectrum are the **World Radiocommunication Conference**s (WRC) that are held every three to four years. It is the job of WRC to review, and, if necessary, to revise the **Radio Regulations** (RR), the international treaty governing the use of the radio-frequency spectrum and the geostationary-satellite and non-geostationary-satellite orbits. The last Conference (WRC-19) took place in Sharm el-Sheikh, Egypt in October-November 2019. The following one (WRC-23) will be organised in 2023. The works to prepare the next WRC start immediately after the closure of the precedent one, within the ITU and other regulatory bodies such as CEPT in Europe.

The use of the spectrum is defined in the Article 5 of the Radio Regulations by the **Allocations** of the frequency bands. An allocation is officially defined as an "Entry in the Table of Frequency Allocations of a given frequency band for the purpose of its use by one or more radiocommunication services or the radio astronomy service under specified conditions." The allocations are defined for the three ITU-R regions and complemented by notes that allow the incorporation of particular situations affecting some countries. Region 1 comprises Europe, Africa and part of Asia, Region 2 includes America and Region 3 the rest of the world.

**Interest for ARIADNE**

The future implementation and deployment of wireless systems in the D band will make use of the frequency bands allocated for the services of interest. It is relevant to know the current situation of the allocations (already taken into account in the work of WP3) and their likely evolution in the future.

The Final Acts of WRC-19 do not change substantially the allocations in the range 100-200 GHz. Only the following changes are made to Art. 5 of the RR and published in the subsequent version of 2020.

- In the frequency bands 105-109.5 GHz, 111.8-114.25 GHz and 217-226 GHz, the use of this allocation is limited to space-based radio astronomy only.
- The frequency band 155.5-158.5 GHz is allocated to the following services: FIXED, MOBILE and RADIOASTRONOMY for the three ITU Regions.

Additionally, Resolution 731 of WRC-19 invites the ITU-R to conduct studies the conditions for frequency sharing between active and passive services in several frequency bands above 71 GHz, some of them within the range of interest of ARIADNE.

Resolution 811 of WRC-19 defines a proposal of agenda for the next Conference WRC-23, including several urgent items. None of them is explicitly defined for the frequency bands of interest of ARIADNE.

Resolution 812 defines a preliminary agenda for the following Conference WRC-27, to be held in 2027. Again, none of the items make explicit reference to the frequency bands of interest for ARIADNE.

The conclusion that can be drawn is that a need to modify the current frequency allocations in the 100-200 GHz range has not been identified. The current allocations published in the 2020 edition of the Radio Regulations are not expected to change within the next decade.

See references [2] and [3].

### 2.1.5 ITU-T SG13

One of the three sectors under ITU is ITU-T, which coordinates and facilitates the establishment of ICT recommended standards for the telecommunications. These may impact the management, interoperability and reliable delivery of services in an efficient manner.
In order to come up with recommendations, various study groups (composed of expert members from private, public or related bodies) operate under ITU-T. There are three areas for which standards have been devised by the ITU-T, namely for cybersecurity, machine learning (ML) and video compression.
For ARIADNE, the Study Group 13 (SG 13) of the ITU-T, which deals with the application of machine learning in telecommunication networks, is particularly relevant, and interesting not only to follow but eventually to contribute as well.

As part of SG13, a focus group on machine learning for future networks including 5G (shortly FG-ML5G) was established in November 2017 [4]. In nearly 3 years of its activity, the FG-ML5G recommended 10 technical specifications. These serve as recommendations to address machine learning in future networks regarding interfaces, network architectures, protocols, algorithms and data formats. Some of the specifications published by this group

are well aligned with the work in ARIADNE especially the specification on ‘‘Architectural framework for machine learning in future networks including IMT-2020" (codenamed as ITU-T Y.3172 and completed rather recently on January 2020). Some key aspects on the relevance of the Y.3172 specification to ARIADNE are presented below.

**Interest for ARIADNE**

The specification Y.3172 (Architectural framework for machine learning in future networks including IMT-2020" (ITU-T Y.3172) is arguably one of the most impactful of FG-ML5G specifications. Hence, it is of interest for ARIADNE. It proposes a reference architecture, which highlights far reaching measures that need to be planned and put in place before machine learning models are trained and operationalized. The specification addresses the potential and challenges of decentralization to train the models at the core and edge of the networks. This is undoubtedly an under-addressed area - not just in telecommunication but other industries and businesses, as recent market surveys and studies found that deployment of ML models in production remains low [5]. This is partly due to the lack of guidelines and standards.

The Y.3172 specification further addresses the use of containers for managing large-scale orchestration of ML models and functions. At the heart of the proposed reference architecture is the concept of ML pipelines, which serve as a discrete unit of work that may encapsulate a specific functionality like fetching heterogeneous data from diverse sources, pre-processing data, training a model, triggering retraining or model updates, making predictions on incoming data, triggering an action in regards to a run time event, and scaling up the resources to maintain QoS performance levels. With ML pipeline as a loose-coupling artefact, various network layers can be integrated together. This enables the development of contextually-aware, advanced AI and ML functions, which on one hand, harness cross modular information for making improved automated decisions in real time and on the other hand, can be realized in a common approach. However, it cannot be ignored that these design recommendations are yet to be broadly adopted and tested so ML related guidelines ought to be applied rather pragmatically.

**Relating with Y.3172 recommendations**

Work going on and planned for the future in ARIADNE can be shaped along standardisation concepts proposed in Y.3172. ARIADNE does not aim at a unifying software technology stack because the focus is on solving hard problems in multiple tiers of beyond 5G wireless architecture. Nevertheless, the recommendations in Y.3172 are of interest as there are several areas, especially concerning the application of Machine Learning, where they may be beneficial to future-proof our work. One possible means of compliance is to abide by and adopt the pipeline-based design of Y.3172 standard. Towards this, we sketch out the following highlights:

- One of the foundational concepts in Y.3172 is to develop data processing and machine learning functionality as a pipeline. A typical pipeline consists of nodes that perform ETL (Extract Transform Load) operations. Pipelines can extract data from diverse sources, perform transformations on data and store the updated data in the required sinks). Training ML models, updating them, measuring their performance

and applying them to get predictions on new unseen data in real time, should also be developed as pipelines. The basic reasoning behind pipeline design is re-usability of a modular unit of work and its unifying capability to integrate disparate sub-systems, which are prevalent in telecommunication networks

- The RapidMiner approach to build ETL and ML functionality is also pipeline based, with the ease to create pipelines visually. This approach can be of interest to be leveraged for ARIADNE. Moreover, RapidMiner pipelines are not limited to any particular implementation language or execution environment and can integrate many native environments and disparate sources by exposure as web-service endpoints.
- The Y.3172 specification argues for an ecosystem or management tooling around the pipelines to manage large-scale deployment and orchestration of ML and AI functions across different layers of the network (both at core and edges with restrained resources). These recommended capabilities exist in RapidMiner platform, which can be used to benefit ARIADNE.

**Other industrial standards in ML and their current standing in the market**

- PMML [6]
  - The Predictive Model Markup Language (PMML) is an XML-based model interchange format, that can be used to describe a predictive model (e.g. a machine learning model) using the XML schema provided by the standard. The PMML models may be reconstructed at different systems and hence allow for inter-operable exchange. It has been developed by the Data Mining Group [7], which is an independent vendor-led consortium that develops data mining standards.
- PFA [8]
  - The Portable Format for Analytics is a JSON-based interchange format, that can also be used (much like PMML) to describe a predictive model. The PFA has also been developed by the Data Mining Group.
- De-facto standards
  - Although the DMG standards are gradually becoming more popular in AI/ML tools, the scientific and industrial landscape regarding the AI/ML methods and technologies is changing very actively. This has resulted in niche and agile players to surface as market leaders when it comes to developing AI/ML products. This is because these products have demonstrated technical depth and rapid innovation expected by different verticals and market segments - earning them a strong position in the AI/ML industry. For instance, the Gartner magic quadrant reports for Data Science and Machine Learning platforms [9] for the last 6 years, place RapidMiner and of course some other vendors of AI/ML software as industrial leaders. This has led to the recognition of some vendor-specific approaches as de-facto standards in their own rights. Therefore, such state-of-the-art approaches and products are arguably leading the industrial adoption of AI/ML by making these complex methods easier to use, which delivers their customers a competitive edge through value-added enterprise ready services.

The group SG13 is planning to create a new focus group to continue the work of the previous FG-ML5G on applying machine learning to 5G communications and the automation of the

networks. The new group will be very well aligned with ARIADNE both in terms of work and regarding its timeline. The new Focus Group under Study Group 13 will be about Autonomous Network and ARIADNE will target this group for potential contributions with the work that is already part of the project objectives.

### 2.1.6 ETSI ISG mWT

The ETSI Industry Specification Group (ISG) on Millimeter Wave Transmission (MWT) is focused on the frequency spectrum 6-42 GHz and 50-300 GHz for backhaul and fronthaul applications [ETSI-0], [ETSI-1]. Tracking the activities and upcoming meetings can be best achieved through their main web site [ETSI-0], while [ETSI-1] provides a more descriptive summary of the work.

Huawei Technologies in the UK chairs the group currently. The ARIADNE partner Nokia participates actively in this group through their colleagues in Italy. As the name of the group indicates, it is a mostly industry driven organisation. Members comprise major 5G / mobile network stakeholders, including operators world-wide and suppliers, e.g. Vodafone, Deutsche Telekom, BT, Huawei, NEC etc. However, it is possible for non-member organizations to participate by technical contributions and attend meetings without having voting rights.

The group releases white papers and Group Reports that consider contributions from industry participation in research projects and direct funded industrial research and development work. The most significant recent publication for ARIADNE is [ETSI-2], which analyses and proposes on the use of current D-band spectrum, based on the ITU-R Radio Regulation from 2016. As of today, this is probably still the most comprehensive summary of the industrial state of the art and latest transmission experiments. Also, of high interest for ARIADNE is the Group report on the 5G Wireless Backhaul / X-Haul [ETSI-3].

**Interest for ARIADNE**

Since ETSI ISG mWT started to focus on the evolution of 5G and Fixed Wireless Access beyond 2020 in recent years, considering also more and more the spectrum above 100 GHz, ARIADNE can perfectly contribute with its work to those activities through the industrial partners. Both Group Reports on the D-band spectrum show that ETSI ISG mWT may be a very relevant platform to interact with and present the results of ARIADNE. The next meetings are scheduled for February and May 2021 [ETSI-0]. Although, so far, the focus of the released reports was mostly on radio technologies and propagation / transmission aspects [ETSI-4], which are rather topic to WP1 and WP3, it is expected that all technical work packages WP1, WP2, WP3, WP4 and WP5 may contribute in the future. E.g. one can easily anticipate that the considerations on SDN related to microwave and millimeter wave transmission can be extended by new AI-based and RIS-based ideas arising from the work of WP2 and WP4.

See References [10] - [14].

### 2.1.7 ETSI TM4

The Technical Committee (TC) ATTM addresses Access, Terminals, Transmission and Multiplexing including all aspects within the ETSI scope - cabling, installations, signal transmission, multiplexing and other forms of signal processing up to digitalization in private

and public domain; excluding those aspects that relate to Hybrid Fibre-Coaxial cable networks which are covered by TC Cable.

TC ATTM closely collaborates with the Technical Bodies responsible for communications, networking and services and the exact boundary between the activities is be adapted to the members' needs.

TC ATTM covers the following issues:

- Transmission issues of interfaces
- Frequency management on the non-radio communication infrastructures
- Analogue and digital presented communication interfaces of balanced wired (twisted pair), coaxial cable and optical fibre infrastructures
- Interfaces based on new technologies, as far as they are relevant for communication infrastructures
- Point-to-point and point-to-multipoint radio systems and infrastructures used for the fixed service (core and access networks), covering all equipment aspects including antenna parameters
- Transmission related aspects of network architecture(s) (including protection issues)
- Specification of the transmission functions and performance of the network elements such as transmission paths, path elements, sections, systems, functional entities, antenna, cable and optical fibre.

The interfaces referred to above could be public or private, switched or non-switched, seen from either the network or the terminal side.

TM4 is one of the 4 Working Groups of ATTM and refers to Fixed Radio Systems.

**ETSI TM4: Fixed Radio Systems** has the following objectives:

- Specifications for point-to-point and multipoint radio systems, in the fixed service used in core and access networks, covering all equipment aspects including antenna parameters. Radio-frequency matters that may affect CEPT/ECC radio-frequency allocation and policy are excluded.
- Functional requirements for radio-frequency equipment interface, including allocation of overhead.
- Co-operation and technical support towards ECC/PT SE19 for channel arrangements and improved spectrum usage in the frequency bands allocated to fixed service (in co-ordination with ETSI WG ERM/RM).

The last complete standard seems to be ETSI EN 302 217 v3.2.2 (02-2020) "Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 1: Overview, common characteristics and system-independent requirements" and "Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 2: Digital systems operating in frequency bands from 1 GHz to 86 GHz; Harmonised Standard for access to radio spectrum".

The WG organises a meeting once a year. The last meeting, ATTMTM4#64, was organised on 26 Oct – 30 Oct 2020.

As it is mentioned in ETSI portal, during 2020 the TM4 would work on "TR on Fixed Radio Systems; New technologies and solutions of 5G microwave backhaul".

**Interest for ARIADNE**

From the available information, it is evident that ETSI TM4 has not included D-band in their agenda yet, as the latest standard covers the bands up to 86 GHz. However, it is of our interest to follow the work of the working group and promote D-band as a frequency range of great importance for future systems.

In terms of technical issues, WP3 is quite relevant targeting equipment aspects and antenna parameters in point-to-point and point-to-multipoint scenarios.

### 2.1.8 ECC SE19

The Electronic Communications Committee (ECC) is one of three business committees of the European Conference of Postal and Telecommunications Administrations (CEPT).

The Electronic Communications Committee (ECC) brings together 48 countries to develop common policies and regulations in electronic communications and related applications for Europe, and to provide the focal point for information on spectrum use. Its primary objective is to harmonise the efficient use of the radio spectrum, satellite orbits and numbering resources across Europe. It takes an active role at the international level, preparing common European proposals to represent European interests in the ITU and other international organisations. ECC works with all stakeholders, the European Commission and ETSI to facilitate the delivery of technologies and services for the benefit of society.

Two of the ECC's main outputs are "Decisions" and "Recommendations" on major harmonization issues. ECC Reports and CEPT Reports are studies which respectively inform ECC Decisions and Decisions of the European Commission; the latter are binding on EU Member States.

WG SE (Spectrum Engineering) is one of the Working Groups supporting ECC and specifically SE19 is dedicated to Fixed Services (FS).

The main objectives of ECC SE19 are to:

- Prepare harmonised frequency plans and guidelines for introducing novel broadband applications in the FS;
- Study developments in new FS technology;
- Study compatibility/sharing issues involving traditional FS (such as radio relay links) as well as broadband FS applications;
- Co-ordinate the relevant activities in ITU-R;
- Liaise/contribute to ETSI ATTM/TM4 in accordance with the CEPT/ETSI MoU.

Meeting #85 (web meeting) was organised 1 – 3 September 2020 with the following Work Items:

- To consider the doubling of maximum channel width for some selected FS bands in the range from 11 to 38 GHz (11 GHz, 18 GHz, 23 GHz, 28 GHz, 32 GHz, 38 GHz)
- Guidelines on how to plan Bands and Channels (Carriers) Aggregation (BCA) Fixed Service Links
- Considerations of FS use within CEPT administrations towards introduction of 5G in the 26 GHz band
- To derive a methodology for protection criteria for FS except long term

- New microwave Point-to-MultiPoint technologies based on active antennas for 5G backhaul above 26 GHz
- Consideration of ECC Recommendations due to discrepancy with ERC Rec 70- 03 (Fixed Service allocated in the bands 57-64 GHz and 64-66 GHz)
- Revision of ECC Report 173 “Fixed Service in Europe-current use and future trends post 2016”.

Th next meeting #86 will be organised on 1 – 3 December 2020 and will be also web meeting. No agenda is available.

Two of the latest deliverables of the group are:

- ECC/REC/(18)01 - Radio frequency channel/block arrangements for Fixed Service systems operating in the bands 130 - 134 GHz, 141-148.5 GHz, 151.5-164 GHz and 167 - 174.8 GHz (April 2018)
- ECC Report 282 - Point-to-Point Radio Links in the Frequency Ranges 92-114.25 GHz and 130-174.8 GHz (September 2018).

Both documents are related to D-band and are publicly available.

**Interest for ARIADNE**

The group has already published work on D-band which is important. Moreover, the group accepts contributions from new participants after following a certain procedure. Under these conditions, there might be ground for ARIADNE to interact with ECC SE19. It is also noted that ECC SE19 cooperates with ETSI TM4.

In terms of technical items, ARIADNE could contribute to channel arrangements and efficient use of frequency bands through WPs 1, 2 and 3.

### 2.1.9 WWRF

**Wireless World Research Forum**

The Wireless World Research Forum, (http://www.wwrf.ch/) is an influential forum and a place to promote new ideas for advanced technologies and novel system concept that define wireless evolution. WWRF organises two meetings a year, following the format of technical workshops where research contributions are invited by members and non-members and proceeding are made available to the meeting attendees and to WWRF members. The forum organises workshops and special sessions at international conferences and regular seminars and webinars on cutting-edge wireless research and innovation topics. Furthermore, it produces “Outlooks” (white papers) and various edited books and magazine publication series, as means for disseminating innovative visions and discuss technology evolution trends.

The work within WWRF is organised in a number of working groups illustrated in the following figure. Additionally to the plenary WWRF meetings, the working groups hold separate meetings focusing on specific research and technology topics.

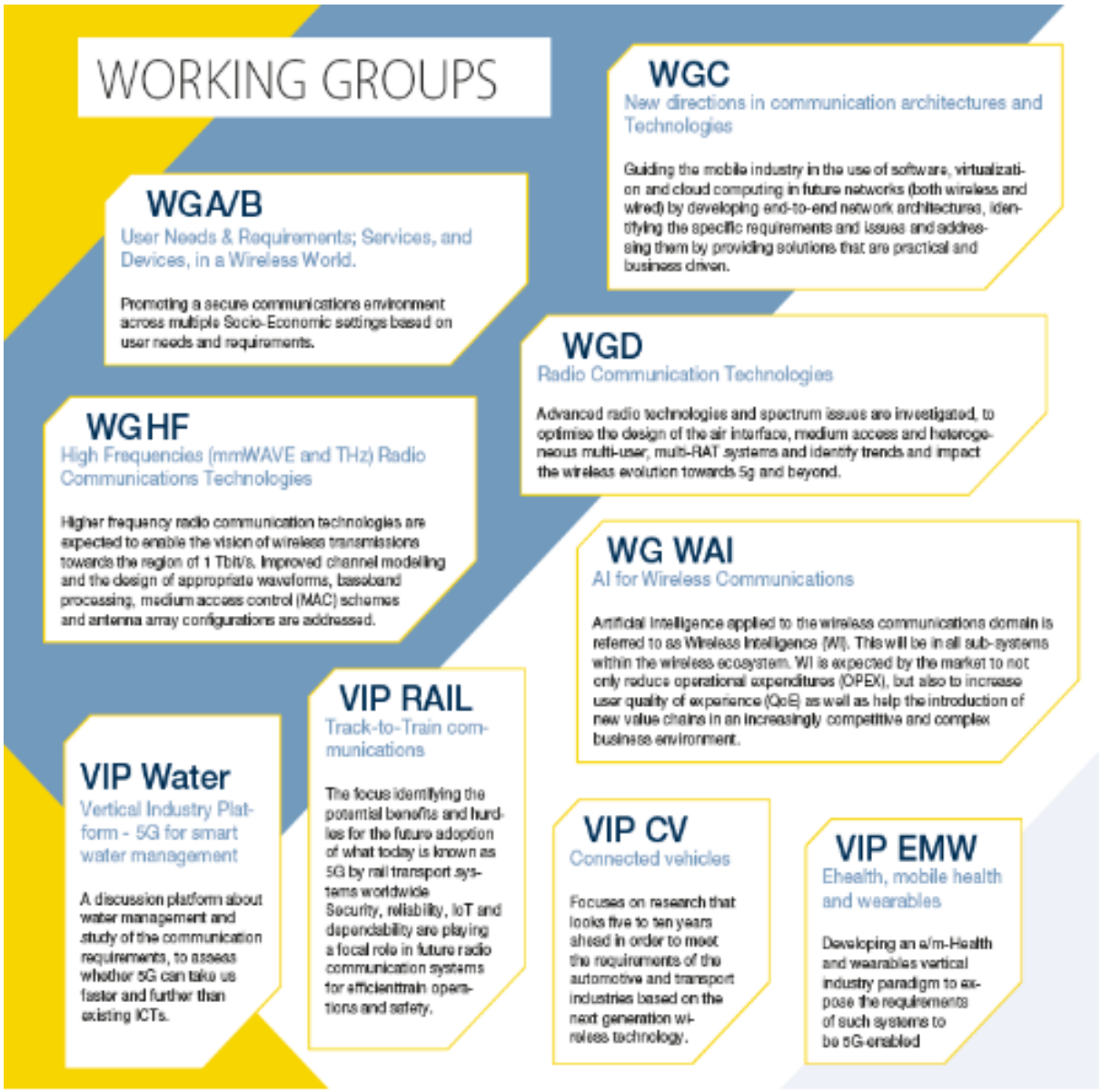


**Figure 5. The structure of WWRF in working groups**

The UPRC group in ARIADNE project has been an active member of the WWRF, assuming several leadership roles over the last 20 years, with main focus on the WWRF Working Group D on Radio Communication Technologies and on the Working Group on High Frequencies Radio Communications. The latter has been established in 2016 and aims at studying and building consensus around enabling technologies for the mmWave and THz bands.

Working Group D (WGD) on Radio Communication Technologies addresses research aspects focusing on the air interface for wide-area and local-area wireless communication systems, spectrum issues and other distributed resource sharing for future wireless systems. In particular, WGD covers topics such as multi-carrier air interfaces, smart antenna and MIMO technologies, cooperative communications, interference management, cross-layer design, overhead signalling and complexity issues. Physical-layer security of wireless systems is also covered in this working group.

As wireless networks evolve beyond IMT-2020, challenging requirements resulting from the ever-decreasing cell size along with the explosive increase in the number of cells and the

number of users and devices to be connected, breaking the interference barrier and maintaining the per user/node capacity will need powerful PHY/MAC cross-layer design and emphasis on the optimization of performance versus complexity/overhead trade-off. New technology enablers (e.g. massive MIMO, Reconfigurable Intelligent Surfaces etc.) and new extreme resources opportunities (e.g. THz communications) are attracting a great amount of interest in this WG. These activities have - from time to time and when it was considered appropriate - resulted in the creation of more focused WWRF working groups, such as the Working Group on High Frequencies.

The vision of the WG on High Frequencies is to provide a discussion platform/thinktank, by engaging a critical mass of experts from industry, regulators and academia, in order to investigate the trends, requirements, enablers and challenges in the specification, design, optimization and adoption of high frequencies radio technologies in future wireless networks. The main objectives of this WG are to

- Study the requirements and research and technology challenges for high frequencies radio communications.
- Report of the advances on channel modeling, physical layer and wireless access issues.
- Facilitate collaborations and consensus building among various experts and actors.
- Organise workshops to encourage dissemination and interactions.
- Follow/participate/contribute to research/technology/regulatory/standardisation fora (e.g. NGMN, 5G-PPP, ITU-R, IEEE, etc).

Over the last ten years, WWRF has championed several cross-working group activities focused on the wireless evolution to and beyond 5G, including workshops and special sessions, presentations, white papers and journal special issues. The ongoing effort to roll out 5G technologies, and the ongoing debate on how to meet the requirements of the various vertical industries that will make use of 5G are being studied within WWRF and publications such as Outlook series are a good guide to them. But the mission of WWRF is to look beyond current technology and businesses to identify the key research trends that will impact wireless world in the next 5-10 years.

As an example, the Vertical Industry Platform (VIP) programme of working groups focuses on vertical industry requirements, including connected vehicles, e-health, rail networks and the water industry, while new technical working groups have been set up to address key technology questions, such as the impact of AI technologies on communication networks.

ARIADNE project results could be disseminated within the Working Groups on High Frequencies and AI for Wireless Communications. ARIADNE vision, system concept and architecture could provide input to the beyond 5G discussions within WWRF.

**WWRF and IMT-2020 evaluation process**

WWRF has been very supportive of the ITU's evaluation process for IMT-2020 and participated as an independent evaluation group (IEG). A group of interested members was formed in 2018 to investigate how WWRF could implement the evaluation procedure. Available resources dictated that WWRF was not able to provide a complete evaluation in all

use cases but has concentrated on those of most importance to our members, in particular those working on developing IMT-2020 in emerging and developing markets.

Based on the individual studies of the IEG members and the discussions and consensus reached, the WWRF IEG decided to focus their evaluation on the proposals submitted to ITU-R by Nufront [1] and TSDSI respectively [2] and a small project team was formed to progress this work.

A WWRF working group ('ITU EVAL') and dedicated sessions within the WWRF conferences were organized. The WWRF IEG has studied the various features and technologies proposed and provided an assessment by inspection, analysis and based on simulation results, where it was deemed necessary. The assessment was submitted to the ITU WP5D in time for the February 2020 Meeting #34 in the form of a document entitled: "FINAL EVALUATION REPORT FOR RIT SUBMISSIONS FROM TSDSI (IMT-2020/19) AND NUFRONT (IMT-2020/18)" (Document noted by ITU WP5D as 5D/120). The team participated in the face-to-face Meeting #34 held in Geneva, during 19-26th February 2020, where it supported the evaluation outcomes.

The official IMT-2020 evaluation process was planned to be completed in June 2020. However, as the evaluation of two of the proposals was not conclusive, an extension has been granted targeting the complete evaluation of the two pending proposals, namely Nufront and ETSI DECT proposals. The WWRF IEG is currently involved in the further evaluation of these proposals, which is expected to be completed by October 2021 (WP5D meeting #39).

### 2.1.10 THz Interest Group within IEEE (IEEE 802.15.3d)

The IEEE standards are mostly familiar to public from the various 802.11 based wireless local area network (WLAN) standards. The IEEE also has close proximity (short range communications) standards, such as 802.15 wireless personal area network (WPAN) standards. Among the .15 family of standards we can find one of the first standards for +100 GHz bands. The 802.15.3d standard [15] is developed for the lower THz band from 252 to 325 GHz. This is part of the high rate WPAN standards (.15.3) and formally supports data rates of +100 Gbps.

The 802.15.3d has been developed by IEEE 802.15 WPAN Terahertz Interest Group (IGthz) led by Thomas Kürner. The 802.15.3d supports two different physical layer (PHY) techniques; **THz on-off keying** mode PHY (THz-OOK PHY), and **THz single carrier** mode PHY (THz-SC PHY). The former is meant to be simplified version of the standard for simple devices whereas the single carrier mode offers the full data rate via carrier based modulations (pi/2 BPSK, pi/2 QPSK, pi/2 8-PSK, pi/2 8-APSK, 16-QAM, and 64-QAM).

Both PHY techniques rely on the same channeling formed of various possible bandwidths (2.16, 4.32, 8.64, 12.96, 17.28, 25.92, 51.84, and 69.12 GHz). The number of sub-bands for the whole 252 – 325 GHz band depends on the chosen bandwidth. The total throughputs vary greatly depending on the bandwidth, coding and modulation, and pilot words. The THz-OOK PHY has a throughput range from 1.29 Gbps to 59.14 Gbps. The THz-SC PHY has a throughput range from 1.13 Gbps to 315.39 Gbps. It should be noticed that the maximum data rates herein require very high receiver sensitivities up to -32 dBm.

Given the specifications above and in the standard itself, similar channeling and data rates would be possible to utilize at the D band (110 – 170 GHz). The D band is more fragmented due to reserved bands. But in principle the 802.15.3d could be partially realized on the D band as well. The IEEE 802.15.3d can be better benchmarked against the ARIADNE channel models when those are ready to find out how the .15.3d would work in the D band.

See References [15].

## 2.2 Working list

ARIADNE innovations and technologies are expected to contribute and influence the developments within various regulatory bodies, including ITU-R, ITU-T, ETSI, 3GPP and the THz Interest Group within IEEE (IEEE 802.15.3d), thus helping to pave the way to future D-band ultra-high rate capable wireless networks. It has been important to follow ongoing standardisation activities at different standardisation bodies, interest – or working groups.

The main target has been to identify bodies or groups most relevant to ARIADNE work and start to follow them up on subjects which are relevant to ARIADNE. When ARIADNE outputs are available, the project aims to share those outputs with targeted bodies or groups to synchronise with related standardisation activities.

Of particular interest is the ETSI mWT ISG (millimetre wave transmission industry specification group), a global pre-standardisation initiative, which offers an industry-wide platform to create the conditions for large-scale usage in current and future transmission networks of mmWave and beyond. This group has recently placed emphasis on the D-band (modelling, techniques, experimentation and demos).

ITU-T SG13 is also a relevant group for ARIADNE and there is already an identified interested in follwoing the group recommendations on “Architectural framework for machine learning in future networks including IMT-2020” and participating in new Focus Group that are planned to follow up the work achieved in the FG 5GML.

In the field of Data Mining and Machine Learning, the speed of innovation is very high and as a results there are only a very few formal standards. Instead many open-source software libraries, solutions, software stacks have witnessed extreme popularity and are often treated as de-facto standards.

Of particular interest and potentially greater impact are the works on channel modelling, baseband signal processing, RFIC, D-band antennas, beamforming (LOS, NLOS), intelligent RRM and networking optimisation based on Machine Learning and theoretical and practical assessment of the performance and impairments at such high frequency regime and with such high bandwidths.ARIADNE will monitor closely the standardisation activities and participate and contribute where relevant. To observe relevant standardization bodies, a list of bodies of potential interest to the project has been created. In this working document, information on who shall be following, and later also who will be contributing, to specific standardisation bodies is included. This document has been saved to ARIADNE working directory at Onlyoffice.

Link: https://onlyoffice.eurescom.eu/Products/Files/#7974

# 3 Plan for contributions

## 3.1 UPRC

UPRC will drive and coordinate the contributions to WWRF and the contributions towards research workshops and calls for research input initiated by ITU-R and ITU-T. UPRC is chairing the WWRF WG on High Frequencies and is also heavily involved in the IMT 2020 evaluation process as leader of the WWRF IEG.

## 3.2 UPM

The propagation group of UPM participates on a regular basis in the Working Parties WP 3J and 3M of Study Group 3 (Propagation) of ITU-R (International Telecommunications Union-Radiocommunications Sector). The results obtained on the propagation modelling of atmospheric effects can be contributed in future meetings, either as informative documents or as proposals of new Recommendations or Reports.

## 3.3 UOULU

Channel models developed in the project are candidates for submitting to standardisation organisations and/or benchmarking the existing standards with ARIADNE channel models to properly assess a need for new D band specific standards. UOULU also considers participation in the IEEE 802.15 meetings and specifically in the Terahertz Interest Group (802.15.3d) meetings to see the possibilities of utilizing ARIADNE project outcomes on future development of high frequency standards.

## 3.4 Fraunhofer IAF

The Fraunhofer IAF will support the industrial partner's standardisation efforts by providing experimental setups and verification measurements with their specialized infrastructure. Fraunhofer IAF also considers attending the ETSI ISG mWT and present the work on the ARIADNE radio technologies.

## 3.5 NCSRD

NCSRD is planning to contribute to standardisation activities regarding channel modelling, system level analysis/concepts, antenna specifications/parameters and complex event recognition tools to assist AI-based decision making.

## 3.6 TID

TID is participating in the ONF (within OTCC) in several projects like 5G-xHaul, focused on wireless transport. TID has actively participated in TR-532 model and its definition and has also participated, organised and hosted several PoCs with participation of several other operators, the majority of the microwave vendors, including those most relevant in the industry.

Also, TID is participating in the Telecom Infra Project for the definition and engineering of an Open Microwave equipment following the approach of defining open systems available for implementation in the industry, thus fostering and universalising the development of products around such specifications.

## 3.7 Nokia

Nokia plays an active role in various standard groups like 3GPP, ETSI etc. impacting new 5G standard releases to support upcoming 5G and beyond vertical business needs.

## 3.8 RapidMiner

RapidMiner will evaluate and where possible shape its contributions in alignment with key aspects of the ITU-T specification Y.3172. RapidMiner plans to watch the follow-up group of ITU-T FG-ML5G (which is being planned) and provide input to their related consultation initiatives. RapidMiner will also offer tutoring activities to enable project partners on its own de-facto industry-leading approaches to create AI/ML solutions.

## 3.9 Aalto

Evidence of propagation channel characteristics from our 140 GHz spatio-temporal measurements can be inputted to standardisation bodies for channel modelling activities. As an academic partner, Aalto does not attend meetings in standardisation bodies regularly. Possible materials from Aalto therefore can be embedded into those of other partners in ARIADNE, who make regular contributions to the standardisation bodies.

## 3.10 ICOM

ICOM is participating in the ETSI mWT ISG Plugtests that aim to trial interoperability of SDN solutions for Microwave and Millimetre-wave transport applications. Two Plugtests have been performed up to now and ICOM plans to continue its participation in future events.

## 3.11 Eurescom

Eurescom as project coordinator will support the project activities in standardisation, and provide information at project and inter-workpackage level in order to facilitate the contributions to specific standardisation bodies.

Eurescom will support the project and participate in standardisation bodies meetings or present the project at standardisation events per request and as required.

Eurescom will act as the project representative deputy at the 5G-PPP Pre-standards group.

# 4 Vision of standardisation topics

The following visions are based on the assessment or current understanding at the time of writing this document (M12).

## 4.1 WP1

The +100 GHz channel models determine the corresponding channels maximum capabilities, that is, the possible modulation orders and techniques, required coding rates, receiver sensitivities, and total achievable throughputs given bandwidths and transmit powers, etc. Thus, the channel modelling works in ARIADNE is directly applicable to future D band systems standards development.

## 4.2 WP2

Beamforming techniques and algorithm development for general beamforming, user tracking, etc. could provide valuable inputs to future standards. One of the main differentiators of the ARIADNE project vision are the reconfigurable intelligent surfaces (RISs). The RISs, on the other hand, are still an open research topic. Today, it seems that those would bring great benefits in certain usage scenarios where line-of-sight cannot be guaranteed. Therefore, upon finding channel models with RISs, ARIADNE can contribute significantly to possible future systems standards involving radio propagation environment shaping by RISs.

## 4.3 WP3

Reconfigurable, energy and spectrally efficient radio technologies will play a significant role for the success of D-band communications. Equally important will be new or extended open radio management interfaces for the introduction of AI-based network optimisation. ARIADNE envisions contributing to both areas by monitoring the standardisation bodies and participating in white papers and workshops. The implementation of RIS and reflect array antennas that address frequencies above 100 GHz will lead to a performance roadmap, that is backed up by experiments. This will help to reveal limitations due to fabrication tolerances, which may restrict possible use cases. The standardisation will benefit from this practical experience. ARIADNE envisions contributing to the technology roadmaps of RIS and reflect array antennas by white papers and presentations addressing standarisation groups.

## 4.4 WP4

This work package deals with various resource allocation, planning and optimization challenges that need to be addressed in order to manage the network in an effective and efficient manner. Ongoing and planned future work explores and applies state of the art techniques for automated decision making, such as the use of constraint solving optimizations, Machine Learning, and further AI approaches (both conventional and cutting edge), which may be used in liaison with each other to attack the problem at hand in the most befitting manner.

Many of these tasks also require data generation schemes, which must be configurable and reusable to generate data for reproducible research. These schemes as well as the optimization solutions including Machine Learning methods can be shaped as a library of pipelines wherever possible. The feasibility and impact of this endeavor are yet to be fully

evaluated, however, part of our ongoing work is already being shaped as partially Y.3172-compliant. Moreover, beyond Y.3172, the experience of applying AI and ML in ARIADNE can be used to influence the future standardisation works of FG-ML5G's successor focus group on Autonomous Networks.

Additionally, complex event recognition/forecasting approaches that combine machine learning with event detection methods shall also be examined and/or applied within these specialized domains. The goal of such tools is to timely detect/forecast potentially hazardous events/situations that may be acted upon by taking reactive/proactive measures.

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