# 5G Radio Access Network Design

## A Brief Overview on the 5G-PPP Project METIS-II

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***Abstract*—The METIS-II project will be an EU-funded project within the 5G Infrastructure Public Private Partnership (5G-PPP) that is dedicated towards an overall 5G radio access network (RAN) design. It will build strongly upon the METIS project, which has laid the foundation for 5G by identifying key scenarios and requirements and determining the most promising technology components and key system design characteristics. However, METIS-II will go significantly further than previous projects by developing a comprehensive and detailed 5G RAN design according to "technology readiness level 2". This is seen as an especially important step to ensure a timely and efficient standardization of 5G, likely to start in 2016. To achieve this, in addition to the technical work on designing the comprehensive control and user plane of an overall 5G RAN, the METIS-II project has the ambition to actively foster the collaboration within 5G-PPP, for instance by conducting workshops in particular with other projects within the wireless strand, and obtain an early pre-standardization consensus on fundamental design aspects related to the 5G RAN. In this paper, a brief overview on the project is provided, covering the objectives, the consortium composition, project structure and key innovations, as well as the timing and expected impact of the project.**

***Keywords*—5G RAN design, 5G-PPP, METIS-II, H2020**

### I. INTRODUCTION

The 5th generation of cellular communications (5G) will address the communication needs for humans and devices far beyond 2020 and enable the all-communicating world. Different from earlier generation changes, 5G will not only considerably improve the telecommunication services currently offered to end users, but it will enable the support of evolved services tailored for other industries and humankind as such, for instance vehicular safety and transport system efficiency, industrial control, eHealth applications, the Internet of Things etc. [1], [2]. Roughly, the overall set of services expected to be relevant in the 5G era can be grouped into three categories as shown in Figure 1: Extreme mobile broadband (xMBB) services, where user data rates are required that are 10-100x higher than in LTE-A Rel. 11; ultra-reliable machine-type communications (uMTC), where latency has to be on the order of milliseconds, and massive MTC (mMTC), where 10-100x more devices need to be served than today, with stringent cost and power constraints [3], [4]. These diverse requirements necessitate fundamental paradigm changes in the design of cellular communications, as well as a highly versatile, scalable and efficient overall system design.

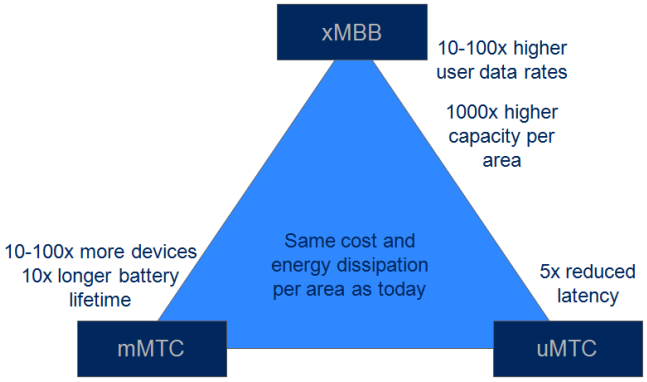


**Figure 1. Key services and corresponding requirements of the 5G system [4].**

The recently concluded METIS (Mobile and wireless communications Enablers for the Twenty-twenty Information Society) project [3] has laid the fundament for 5G by determining key 5G scenarios, test cases and KPIs, which are now globally referred to [5], and by identifying and structuring the key technology components that are necessary to fulfill the 5G vision of the all-connected world. However, there is still a long way to go towards the successful deployment of an economically feasible and energy-efficient 5G system that addresses the diverse 5G requirements. While previous research has yielded a manifold of radio access technology elements tailored to different 5G use cases, it is now essential to design the framework for an efficient integration of all these concepts with each other and with legacy radio access technology into one holistic 5G system that can efficiently scale to meet all 5G use cases. Further, the proposed technology components have to be complemented by all further functional elements that are needed for a comprehensive and detailed radio access network (RAN) specification according to "technology readiness level 2". Finally, it has to be proven that this overall RAN design is techno-economically feasible and energy-efficient, and the standardization and development process has to be started in a well-organized way.

The METIS-II project, described in this paper, will take exactly these steps, and hence enable a timely and efficient 5G standardization. The remainder of this paper is structured as follows: In Section II, the project objectives are introduced, followed by a description of the consortium and project structure in Section III. Section IV describes the key

innovation pillars in METIS-II, and the timing and expected impact of the project is addressed in Section V.

## II. Project Objectives

The METIS-II project will pursue the following objectives:

**1) Develop the overall 5G RAN design**, focusing particularly on designing the technology for an efficient integration of legacy and novel radio access network concepts into one holistic 5G system. Note that the term "5G" here refers to the overall future wireless communications system including evolved legacy (e.g. LTE-A and Wi-Fi) and novel radio access technologies introduced in the 5G timeframe. As a pre-requisite to an overall RAN design, the project aims to obtain an early consensus within the consortium and the broader 5G-PPP ecosystem on key design aspects in 5G, such as e.g.

- which novel air interfaces will be needed in addition to an evolution of legacy standards to span the overall 5G requirements space,
- above which protocol stack layer should novel air interfaces provide common functionality, and on which layer should they be integrated and aggregated among each other and with legacy standards such as LTE-A, and
- on what time scale should specific 5G RAN functionalities (e.g. radio resource management, radio resource control, mobility etc.) operate, and consequently, how should the necessary functionalities be best abstracted, grouped and tackled in standardization and implementation?

Ultimately, the consortium will formulate a comprehensive control and user plane design of an overall 5G RAN according to "technology readiness level 2", comprosing both legacy and novel air interfaces. It will be described which functionality is performed on which time scale by which (logical or physical) entities, and the signalling on the radio interface and between network entities will be described in terms of the kind and time scale of information exchange.

**2) Provide the 5G collaboration framework within 5G-PPP for a common evaluation of 5G RAN concepts** from both a performance and techno-economical perspective. More specifically, METIS-II will further refine 5G scenarios, requirements and key performance indicators (KPIs), building upon the work done in METIS and taking into consideration input from bodies such as ITU-R [6] and NGMN [7]. Further, METIS-II will develop a performance and techno-economical evaluation framework, and perform a consolidation with other 5G-PPP projects on spectrum and overall 5G RAN design aspects. To foster the global collaboration and consensus-building on these topics, METIS-II envisions to make many documents available at an early point to other 5G-PPP projects and beyond, and conduct various workshops in collaboration with other projects within and outside 5G-PPP. Finally, METIS-II will develop an open-source 5G evaluation and visualisation tool for illustrating the key use cases of a 5G system as such, and the benefit of the key 5G RAN design elements developed within the project.

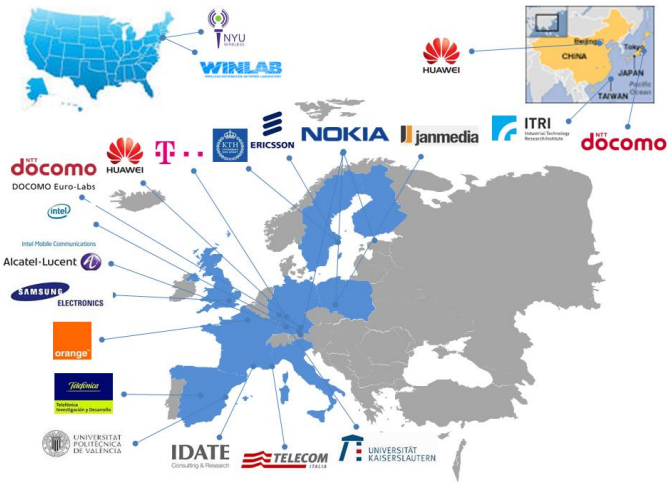


**Figure 2. The METIS-II project consortium.**

**3) Prepare concerted action towards regulatory and standardisation bodies** for an efficient standardisation, development and economically attractive roll-out of 5G.

The METIS-II project plans to utilize its strong composition and global scope, i.e. containing the leading mobile network operators and leading network vendors including non-European partners, to strongly support regulatory and standardisation bodies. In particular, it is envisioned that METIS-II provides input to the 5G requirements work of ITU-R WP5D, contributes to the preparation of WRC-19, and helps to shape models and assessment methodologies as well as timing and content of 5G study and work items in 3GPP.

## III. Project Consortium and Structure

The METIS-II consortium has been composed to enable a most efficient and meaningful technology design, and to facilitate global consensus building and exert global influence on 5G RAN design. More specifically, the consortium, depicted in Figure 2, comprises of

- key global vendors (Alcatel-Lucent, Ericsson, Huawei, Intel, Nokia Networks and Samsung),
- leading mobile network operators (DOCOMO, Deutsche Telekom, Orange, Telefonica and Telecom Italia),
- key research groups from universities and research institutes (ITRI, University of Kaiserslautern, WinLAB, Universitat Politecnica de Valencia, Polytechnic Institute of New York University and Royal Institute of Technology),
- and two small enterprises (Janmedia Interactive and iDATE), aiding the consortium in providing an appropriate proof-of-concept, and strengthening the ability of the consortium to evaluate 5G concepts and architectural solutions from a techno-economical point of view.

The project is coordinated by Ericsson, and the technical management is provided by Nokia Networks.

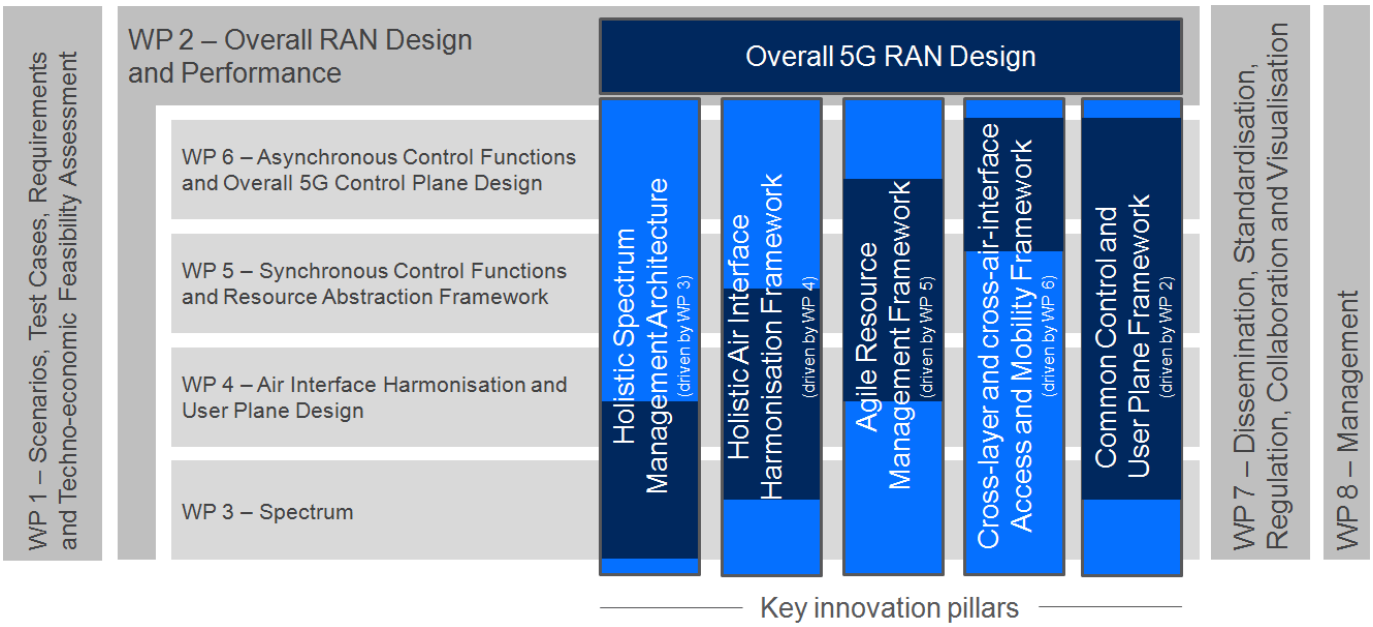


**Figure 3. The METIS-II project structure.**

The project structure of METIS-II, as depicted in Figure 3, consists of technical work packages (WPs) and key innovation pillars which span multiple WPs each.

WP 1 will refine the key 5G scenarios and requirements that have been established in METIS, and consolidate the existing 5G test cases into a small set of very specific test cases that are most suitable for being adopted in the 5G standardization process. WP 1 will further analyse the scenarios, test cases and technical solutions developed in the project from a qualitative and quantitative techno-economic feasibility point of view.

WP 2 will provide the overall RAN design and form an umbrella over technical WPs 3-6, which focus on different parts of the RAN design. WP 2 will also provide a framework for the quantitative performance assessment of developed 5G concepts, along the lines of the consolidated test cases from WP 1. The aim here is to review the methodology and models used in 3GPP, and potentially enhance these through more sophisticated models of environment, traffic or user mobility, in order to better capture the wider range of communication use cases and corresponding KPIs in 5G, while still being tractable in complexity and hence likely to be adopted in the 5G standardization process. METIS-II will share the proposed models and conduct workshops with other projects to obtain a wide consensus on these.

Among the technical WPs, WP 3 will be concerned with spectrum, looking both into regulatory and technical aspects, WP 4 will focus on user plane design, and WPs 5 and 6 will focus on control plane design, splitting the work such that synchronous control functions (e.g. radio resource management) are covered in WP 5 and asynchronous functions (e.g. radio resource control) in WP 6. It has to be noted that part of the METIS-II work is to determine the most suitable function split in 5G, and hence the stated initial considerations on which functions should be synchronous or asynchronous will be revisited during the project.

WP 7 will take care of the dissemination of the project concepts, and prepare a concerted approach towards standardization and regulation bodies. It will furthermore initiate and conduct joint technical workshops within 5G-PPP and beyond, in order to foster a wide consensus on key 5G RAN design aspects and accelerate the 5G system design. A key output of WP 7 will further be the development of an open-source evaluation and visualization platform for 5G concepts, which is expected to be essential for the illustration of 5G use cases as well as the comprehensive 5G RAN concepts developed in the project.

## IV. Key Innovation Pillars in METIS-II

As stated before, a key objective of the METIS-II project is to provide an overall 5G RAN design, in particular looking into an efficient integration of evolved legacy and novel radio access technologies. More precisely, the overall METIS-II RAN design will be built upon the following key innovation pillars, indicated in Figure 3 and detailed in Figure 4:

**Holistic spectrum management architecture**. METIS-II will define, in collaboration with other projects and related forums, a framework and architecture for flexible spectrum management and multi-operator collaboration in 5G. The key difference to previous METIS activities is a significantly stronger focus on the integration of spectrum above 6 GHz, the consideration of new 5G user groups and vertical industries, as well as the increased flexibility required to make best use of different kinds of spectrum access mechanisms. METIS-II will also focus on providing technical justification and rationale why more spectrum above 6 GHz is needed for

5G. This is done by describing spectrum related impacts of innovative 5G concepts to create a common spectrum rationale and justification, focused on technical topics. This will facilitate preparations towards WRC-19. In contrast to the past, not only the overall quantity of the available spectrum, but in particular the different qualities of spectrum (bandwidth, propagation conditions etc.) will define its potential usage and drive the work in METIS-II. The initial acceptance of spectrum sharing concepts like Licensed Shared Access (LSA, such as in CEPT FM 52 and 53 [8]) opens the door for a broader adoption of spectrum sharing concepts, in particular dynamic spectrum sharing, for other bands as well.

**Holistic air interface harmonisation framework**. METIS-II will develop a framework to harmonize similar protocol functionalities in the different protocol layers of the most promising air interface variants to be used in 5G, including both legacy and new air interfaces, with the aim to keep device and infrastructure complexity tractable. By harmonization it is meant that multiple 5G air interfaces either use the same user plane properties or functionalities, or that generic user plane properties or functionalities are developed to suit multiple air interfaces via parametrization. It is of course essential that harmonisation is only applied to an extent that does not sacrifice the performance of individual air interfaces too much. While there has already been previous work on, e.g., developing novel air interfaces scalable to some extent of 5G scenarios, there has yet been no work on a holistic air interface harmonisation framework suitable to respond to the overall 5G requirement space. METIS-II will carry out a detailed analysis of various air interfaces in terms of their flexibility in supporting multiple bandwidths, receiver complexity, multiple access efficiency, sampling rate etc. and then select a set of 5G air interface candidates, including legacy standards, which seem most promising to jointly address the needs in 5G.

**Agile Resource Management (RM) framework**. The METIS-II project will define a new complex multi-link, multi-layer network ecosystem. There, new flavours of control and user plane integration and protocol adaptation will be present, which will provide opportunities to re-design several functions (e.g. interference management, power control, RAN moderation etc.) so as to meet the 5G requirements. Several solutions for RM functions (e.g., [9]) have been proposed which improve the overall performance. However, the ultra-dense environment of 5G networks will ask for out-of-the-box thinking to provide edgeless end-user experience. For this, METIS-II will further enhance recent solutions (e.g., [10],[11]), looking into RM strategies from an algorithmic point of view, while also developing the enablers to integrate these in the overall 5G control plane. To achieve this, further abstractions to the established concept of radio resource management (RRM) will be provided, and a holistic multi-air-interface framework for assigning services to the most suitable resource not only in terms of time, frequency and space, but also in terms of air interface variant and network processing resources (i.e. real and virtual network elements), will be designed. A key aspect of this framework is to enable an easy integration of existing and novel air interface variants, and facilitate the introduction of further air interface variants in the future. In this context, METIS-II will investigate different design options, such as a split of RM functionality into an air-interface-dependent and air-interface-agnostic part.

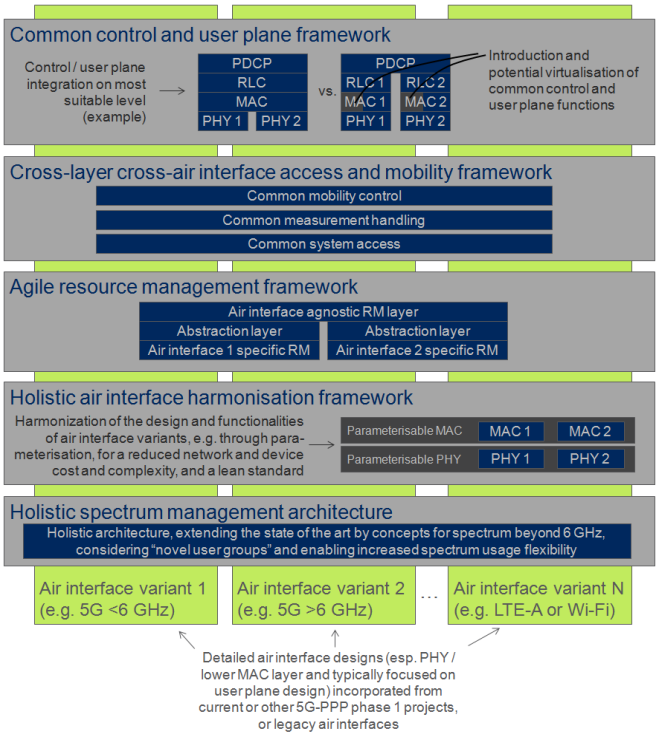


**Figure 4. The key innovation pillars in METIS-II for the integration of evolved legacy and novel radio technology.**

**Cross-layer and cross-air-interface access and mobility framework**. The METIS-II project will extend the cross-layer optimization concept to another dimension, enabling a higher interaction of functionalities from the multiple air interfaces (LTE-A evolution and new air interface(s)) in order to improve the overall resource usage. New procedures will be designed in such a way that functionalities of one air interface (e.g. LTE-A) could be used in a flexible way by another air interface, where this coordination is enabled by a control plane framework which is common for these air interfaces (which could be realized, e.g., by common RRC functionalities). To give an example, one of the concepts that will be studied is a Unified System Access, where unified system information for all air interfaces can be made available to the mobile terminals. One of the goals is to design solutions that are energy efficient e.g. by reducing the amount of broadcast signals [12]. Related to 5G mobility, METIS-II will design a flexible beamforming-based mobility framework to support multiple frequency ranges (up to mmWave bands), covering both ideal and non-ideal backhaul technologies. This will take into account the beamforming concepts developed by other EU projects focused on the physical layer design. Herein, cross-air-interface optimizations will also be explored, in order to e.g. leverage the benefits of beamforming.

**Common control and user plane framework.** METIS-II will design a common control / user plane framework for multiple 5G air interface variants, including the evolution of legacy standards such as LTE-A. This will allow the further development of multi-connectivity features such as fast link switching, control / user plane diversity, throughput aggregation, etc. in order to fulfil the different 5G requirements. To achieve this goal, integration alternatives over the multiple protocol layers (RRC / PDCP / RLC / MAC / PHY) will be investigated and a recommendation will be issued in terms of which layers should be common / aggregated to the different air interfaces based on different criteria such as the required synchronicity between the different layers, end-to-end delays, potential benefits from coordination, etc. Control / user plane functions will be evaluated in particular with respect to their suitability for virtualization.

## V. Project Timing w.r.t. Standardization and Regulation Timelines and Expected Impact

The METIS-II consortium is composed of a large number of key actors involved in the standardization of cellular communications systems, which provides an optimal platform for the partners to discuss and align on ideas and concepts before and during the early standardisation process of 5G. The set of partners in the consortium ensures that a significant part of the participants in standardisation will already have aligned on key 5G RAN design aspects, and should thus carry enough weight to ensure that the technologies developed in METIS-II and put forward for standardisation will also be included in the final standard. The large presence of operators and vendors in the project ensures that the technologies developed are highly relevant for future systems and can be rolled out in an economically attractive way and with a reasonable timeline.

As mentioned earlier, METIS-II puts a strong emphasis on the collaboration between 5G-PPP projects, and hence plans to disseminate many project documents already at a very early point in time within 5G-PPP, conduct workshops with other projects, and then publish public deliverables which have already been discussed and found consensus within 5G-PPP.

To maximize impact, the METIS-II timeline is closely aligned with the currently expected timelines of standardization and regulation initiatives such as 3GPP, NGMN and ITU, as illustrated in Figure 5. Among many deliverables, in particular the following deliverables (abbreviated through D) are expected to provide timely and highly relevant input to the stated bodies:

- In month 7 (January 2016), D 1.1 will contain the refined 5G scenarios, requirements and test cases, and D 2.1 will define the performance evaluation framework for the 5G RAN, in both cases already having been discussed and consolidated within 5G-PPP
- In month 11 (May 2016), D 3.1 will be published on the spectrum scenarios, requirements, rational for bands beyond 6 GHz and KPIs, again after consensus in 5G-PPP
- In month 12 (June 2016), D 2.2 will state the key 5G RAN design aspects that the partners have concluded on, which should have a strong impact on 3GPP Rel. 14 and beyond
- Finally, in month 24 (June 2017), D 2.4 will state the overall 5G RAN design, well in time to influence 3GPP Rel. 14 work items and Rel. 15 study items

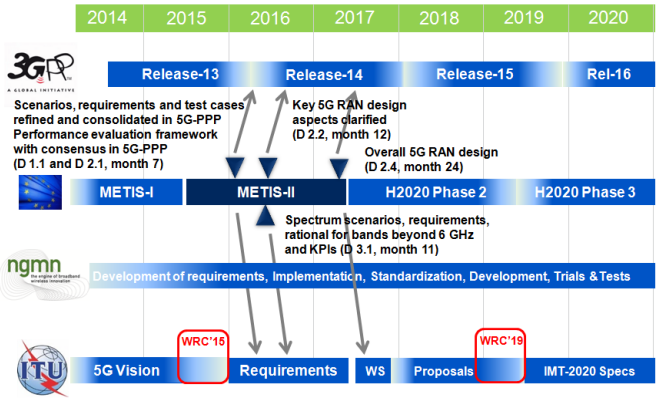


**Figure 5. Timing of METIS-II w.r.t. standardization and regulation timelines and expected impact.**


## Acknowledgment

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