Please check our wiki for help on navigating the form.

Horizon 2020

Call: H2020-MSCA-ITN-2019

(Marie Skłodowska-Curie Innovative Training Networks)

Topic: MSCA-ITN-2019

Type of action: MSCA-ITN-ETN

Proposal number: 861492

Proposal acronym: 5G4real

Deadline Id: H2020-MSCA-ITN-2019

Table of contents

How to fill in the forms

The administrative forms must be filled in for each proposal using the templates available in the submission system. Some data fields in the administrative forms are pre-filled based on the steps in the submission wizard.

1 - General information

Topic	MSCA-ITN-2019	Type of Action	MSCA-ITN-ETN
Call Identifier	H2020-MSCA-ITN-2019	Deadline Id	H2020-MSCA-ITN-2019

Acronym: 5G4real

Proposal title: 5G4real

Note that for technical reasons, the following characters are not accepted in the Proposal Title and will be removed: < > " &

Duration in months: *48*

Panel: ENG - Information Science and Engineering (ENG)

Descriptor1: Wireless communications, communication, high frequency, mob

Descriptor2: Networks (communication networks, sensor networks, network

Descriptor3: Software engineering, operating systems, computer languages

Free keywords: *Connectivity for all, virtualization, hardware disaggregation, distributed cloud, slicing, hybrid transport networks, multi-tenancy, blockchain security, network analytics, innovative business models*

Abstract

Recent years have witnessed a massive penetration of wireless communications in developing countries. However, while communication is crucial in human development, rural and suburban areas have generally been underserved or disregarded because classical network designs do not assure a quick (if any at all) return on investment. To date, it is clear that broadband connectivity solutions will only be widely accepted if technologies, deployment strategies and business models are designed under new paradigms. This also applies to the upcoming 5G systems: its tremendous potential performance and versatility require rethinking the conventional network concepts so that it can be adapted to specific rural scenarios and a new digital breach is avoided. In this sense, 5G4real seeks to coordinate international efforts with the goal of integrating novel technological solutions and emerging business models.
Through a networked program of research and training activities, 5G4real seeks to prepare a generation of researchers that will develop techniques for sustainable and economically viable wireless broadband connectivity. Results are expected to endow operators and communities with tools to make 5G a reality in low-return remote areas. From the technical point of view, 5G4real is committed to a drastic reduction of CAPEX through the development of viable solutions for decentralized network architectures, virtualization across domains, and mobile base stations under multi-tenancy exploitation regime; and a reduction of CAPEX/OPEX using heterogeneous transport networks, and virtual cores able to save on transport bandwidth and to provide off-line services. From a business perspective, new models will invoke a sharing-resources strategy among different stakeholders (operators, public administrations, community networks, etc.), and will be evaluated from techno-economic data

Remaining characters 109

Has this proposal (or a very similar one) been submitted to a previous ITN call in the last two years? ○ Yes ◉ No

Declarations

1) The coordinator declares to have the explicit consent of all applicants on their participation and on the content of this proposal.	☒
2) The information contained in this proposal is correct and complete.	☒
3) This proposal complies with ethical principles (including the highest standards of research integrity — as set out, for instance, in the European Code of Conduct for Research Integrity — and including, in particular, avoiding fabrication, falsification, plagiarism or other research misconduct).	☒

4) The coordinator confirms:

- to have carried out the self-check of the financial capacity of the organisation on http://ec.europa.eu/research/participants/portal/desktop/en/organisations/lfv.html or to be covered by a financial viability check in an EU project for the last closed financial year. Where the result was "weak" or "insufficient", the coordinator confirms being aware of the measures that may be imposed in accordance with the H2020 Grants Manual (Chapter on Financial capacity check); or	◉
- is exempt from the financial capacity check being a public body including international organisations, higher or secondary education establishment or a legal entity, whose viability is guaranteed by a Member State or associated country, as defined in the H2020 Grants Manual (Chapter on Financial capacity check); or	○
- as sole participant in the proposal is exempt from the financial capacity check.	○

5) The coordinator hereby declares that each applicant has confirmed:

- they are fully eligible in accordance with the criteria set out in the specific call for proposals; and	☒
- they have the financial and operational capacity to carry out the proposed action.	☒
The coordinator is only responsible for the correctness of the information relating to his/her own organisation. Each applicant remains responsible for the correctness of the information related to him and declared above. Where the proposal to be retained for EU funding, the coordinator and each beneficiary applicant will be required to present a formal declaration in this respect.	

According to Article 131 of the Financial Regulation of 25 October 2012 on the financial rules applicable to the general budget of the Union (Official Journal L 298 of 26.10.2012, p. 1) and Article 145 of its Rules of Application (Official Journal L 362, 31.12.2012, p.1) applicants found guilty of misrepresentation may be subject to administrative and financial penalties under certain conditions.

Personal data protection
The assessment of your grant application will involve the collection and processing of personal data (such as your name, address and CV), which will be performed pursuant to Regulation (EC) No 45/2001 on the protection of individuals with regard to the processing of personal data by the Community institutions and bodies and on the free movement of such data. Unless indicated otherwise, your replies to the questions in this form and any personal data requested are required to assess your grant application in accordance with the specifications of the call for proposals and will be processed solely for that purpose. Details concerning the purposes and means of the processing of your personal data as well as information on how to exercise your rights are available in the privacy statement. Applicants may lodge a complaint about the processing of their personal data with the European Data Protection Supervisor at any time.

Your personal data may be registered in the Early Detection and Exclusion system of the European Commission (EDES), the new system established by the Commission to reinforce the protection of the Union's financial interests and to ensure sound financial management, in accordance with the provisions of articles 105a and 108 of the revised EU Financial Regulation (FR) (Regulation (EU, EURATOM) 2015/1929 of the European Parliament and of the Council of 28 October 2015 amending Regulation (EU, EURATOM) No 966/2012) and articles 143 - 144 of the corresponding Rules of Application (RAP) (COMMISSION DELEGATED REGULATION (EU) 2015/2462 of 30 October 2015 amending Delegated Regulation (EU) No 1268/2012) for more information see the Privacy statement for the EDES Database.

2 - Participants & contacts

#	Participant Legal Name	Country	Action
1	UNIVERSITAT POLITECNICA DE CATALUNYA	ES	
2	CHALMERS TEKNISKA HOEGSKOLA AB	SE	
3	TELEFONICA INVESTIGACION Y DESARROLLO SA	ES	
4	THE CHANCELLOR MASTERS AND SCHOLARS OF THE UNIVERSITY OF CAMBRIDGE	UK	
5	FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V.	DE	
6	UNIVERSIDAD REY JUAN CARLOS	ES	
7	AMMBR RESEARCH LABS LIMITED	UK	
8	ERICSSON AB	Sweden	
9	INTERUNIVERSITAIR MICRO-ELECTRONICA CENTRUM	BE	

Information on partner organisations

Partner Organisation number	PIC Search PIC	Organisation legal name	Country	Academic Sector	Role of associated: Provide training	Role of associated: Host secondmends	
1	942650075	ACCELLERAN	Belgium	No	No	Yes	
2		Rheinisch-Westfälische Technische Ho	Germany	Yes	Yes	Yes	

2 - Administrative data of participating organisations

Coordinator

PIC	***Legal name***
999976202	*UNIVERSITAT POLITECNICA DE CATALUNYA*

Short name: UPC

Address of the organisation

Street CALLE JORDI GIRONA 31

Town BARCELONA

Postcode 08034

Country Spain

Webpage www.upc.edu

Specific Legal Statuses

Research and Innovation legal statuses

Public body .....yes

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....yes

Research organisation .....yes

Legal person .....yes

Academic Sector .....yes

Enterprise Data

SME self-declared status.....2013 - no

SME self-assessment .....2013 - no

SME validation sme..... unknown

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: Signal Processing and Communications Group ☐ not applicable

☒ Same as proposing organisation's address

Street: CALLE JORDI GIRONA 31

Town: BARCELONA

Postcode: 08034

Country: Spain

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

Title: Dr. Sex: (•) Male ( ) Female

First name: **Josep** Last name: **Vidal**

E-Mail: **josep.vidal@upc.edu**

Position in org.: Professor

Department: Signal Processing and Communications Group ☐ Same as organisation name

☒ Same as proposing organisation's address

Street: CALLE JORDI GIRONA 31

Town: BARCELONA Post code: 08034

Country: Spain

Website: www.upc.edu

Phone: +34934016457 Phone 2: *+xxx xxxxxxxxx* Fax: *+xxx xxxxxxxxx*

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Mercedes	TORRELLAS	cttinfo.europeus@upc.edu	*+34934017788*
Adrian	Agustin	adrian.agustin@upc.edu	*+34934017141*

Participant

PIC	***Legal name***
999980373	*CHALMERS TEKNISKA HOEGSKOLA AB*

Short name: CHALMERS TEKNISKA HOEGSKOLA AB

Address of the organisation

Street -

Town GOETEBORG

Postcode 41296

Country Sweden

Webpage www.chalmers.se

Specific Legal Statuses

Research and Innovation legal statuses

Public body .....no

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....yes

Research organisation .....yes

Legal person .....yes

Academic Sector .....yes

Enterprise Data

SME self-declared status.....2007 - no

SME self-assessment ..... unknown

SME validation sme.....2007 - no

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: Electrical Engineering ☐ not applicable

☒ Same as proposing organisation's address

Street: -

Town: GOETEBORG

Postcode: 41296

Country: Sweden

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

Title: Prof.

Sex: (•) Male ( ) Female

First name: **Tommy** Last name: **Svensson**

E-Mail: **tommy.svensson@chalmers.se**

Position in org.: Professor, Leader Wireless Systems Research Area

Department: Electrical Engineering ☐ Same as organisation name

☒ Same as proposing organisation's address

Street: -

Town: GOETEBORG Post code: 41296

Country: Sweden

Website: http://www.chalmers.se/en/staff/Pages/tommy-svensson.aspx

Phone: +46 31 772 18 23 Phone 2: *+xxx xxxxxxxxx* Fax: *+xxx xxxxxxxxx*

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Chalmers	Grants Office	grantsoffice@chalmers.se	*+xxx xxxxxxxxx*
Mareike	Lutz	mareike.lutz@chalmers.se	*+46 31 772 26 80*

Participant

PIC	***Legal name***
999910824	*TELEFONICA INVESTIGACION Y DESARROLLO SA*

Short name: TID

Address of the organisation

Street RONDA DE LA COMUNICACION S/N DISTRIT

Town MADRID

Postcode 28050

Country Spain

Webpage http://www.tid.es

Specific Legal Statuses

Research and Innovation legal statuses

Public body .....no

Non-profit .....no

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....no

Research organisation .....no

Legal person .....yes

Academic Sector .....no

Enterprise Data

SME self-declared status.....2015 - no

SME self-assessment .....2015 - no

SME validation sme..... unknown

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: Internet for all ☐ not applicable

☒ Same as proposing organisation's address

Street: RONDA DE LA COMUNICACION S/N DISTRITO C

Town: MADRID

Postcode: 28050

Country: Spain

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

Title: Dr. Sex: (•) Male ( ) Female

First name: **Yan** Last name: **Grunenberger**

E-Mail: **yan.grunenberger@telefonica.com**

Position in org.: Researcher

Department: Internet 4 all ☐ Same as organisation name

☒ Same as proposing organisation's address

Street: RONDA DE LA COMUNICACION S/N DISTRITO C EDIFICIO OESTE I

Town: MADRID Post code: 28050

Country: Spain

Website: www.tid.es

Phone: +34933653151 Phone 2: *+xxx xxxxxxxxx* Fax: *+xxx xxxxxxxxx*

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Javier	Garcia Rodrigo	javier.garciarodrigo@telefonica.com	*+34913129247*
Estanislao	Fernández	estanislao.fernandez@telefonica.com	*+34913129412*

Participant

PIC	***Legal name***
999977172	*THE CHANCELLOR MASTERS AND SCHOLARS OF THE UNIVERSITY OF CAMBRIDGE*

Short name: THE CHANCELLOR MASTERS AND SCHOLARS OF THE UNIVERSITY OF CAMBRIDGE

Street TRINITY LANE THE OLD SCHOOLS

Town CAMBRIDGE

Postcode CB2 1TN

Country United Kingdom

Webpage www.cam.ac.uk

Specific Legal Statuses

Research and Innovation legal statuses

Public body .....yes

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....yes

Research organisation .....yes

Legal person .....yes

Academic Sector .....yes

Enterprise Data

SME self-declared status..... unknown

SME self-assessment ..... unknown

SME validation sme..... unknown

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: Computer Science and Technology ☐ not applicable

☐ Same as proposing organisation's address

Street: 15 JJ Thomson Avenue

Town: Cambridge

Postcode: CB3 0FD

Country: United Kingdom

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

Title: Prof. Sex: (•) Male ( ) Female

First name: **Jon** Last name: **Crowcroft**

E-Mail: **jon.crowcroft@cl.cam.ac.uk**

Position in org.: Marconi Professor of Communication Systems

Department: Department of Computer Science and Technology ☐ Same as organisation name

☐ Same as proposing organisation's address

Street: 15 JJ Thomson Avenue

Town: Cambridge Post code: CB3 0FD

Country: United Kingdom

Website: https://www.cl.cam.ac.uk/~jac22/

Phone: +44 1223 763633 Phone 2: *+xxx xxxxxxxxx* Fax: *+xxx xxxxxxxxx*

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Carol	Nightingale	research-grants@cl.cam.ac.uk	*+xxx xxxxxxxxx*
Renata	Schaeffer	h2020@admin.cam.a.uk	*+xxx xxxxxxxxx*

Participant

PIC	***Legal name***
999984059	*FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V.*

Short name: Fraunhofer

Address of the organisation

Street HANSASTRASSE 27C

Town MUNCHEN

Postcode 80686

Country Germany

Webpage www.fraunhofer.de

Specific Legal Statuses

Research and Innovation legal statuses

Public body .....no

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....no

Research organisation .....yes

Legal person .....yes

Academic Sector .....yes

Enterprise Data

SME self-declared status.....2007 - no

SME self-assessment ..... unknown

SME validation sme.....2007 - no

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: Fraunhofer FIT ☐ not applicable

☐ Same as proposing organisation's address

Street: Schloss Birlinghoven

Town: Sankt Augustin

Postcode: 53757

Country: Germany

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

Title: Dr.

Sex: (•) Male ( ) Female

First name: **Mathias**

Last name: **Kretschmer**

E-Mail: **mathias.kretschmer@fit.fraunhofer.de**

Position in org.: Senior Researcher

Department: Fraunhofer FIT

[ ] Same as organisation name

[ ] Same as proposing organisation's address

Street: Schloss Birlinghoven

Town: Sankt Augustin

Post code: 53757

Country: Germany

Website: www.fraunhofer.de

Phone: 00492241143466

Phone 2: *+xxx xxxxxxxxx*

Fax: *+xxx xxxxxxxxx*

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Sabine	Mayer	sabine.mayer@zv.fraunhofer.de	*+498912053195*

Participant

PIC	***Legal name***
999886283	*UNIVERSIDAD REY JUAN CARLOS*

Short name: URJC

Address of the organisation

Street CALLE TULIPAN

Town MOSTOLES

Postcode 28933

Country Spain

Webpage http://www.urjc.es

Specific Legal Statuses

Research and Innovation legal statuses

Public body .....yes

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....yes

Research organisation .....yes

Legal person .....yes

Academic Sector .....yes

Enterprise Data

SME self-declared status.....2010 - no

SME self-assessment ..... unknown

SME validation sme..... unknown

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: Teoría de la Señal y Comunicaciones y Sist. Telemáticos y Comp. ☐ not applicable

☐ Same as proposing organisation's address

Street: Camino del Molino, s/n

Town: Fuenlabrada

Postcode: 28943

Country: Spain

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

Title: Dr. Sex: (•) Male ( ) Female

First name: **Javier** Last name: **Simó**

E-Mail: **javier.simo@urjc.es**

Position in org.: Associate Professor

Department: Teoría de la Señal y Comunicaciones y Sistemas Telemáticos y Computació ☐ Same as organisation name

☐ Same as proposing organisation's address

Street: Camino del Molino s/n

Town: Fuenlabrada Post code: 28943

Country: Spain

Website: https://gestion2.urjc.es/pdi/ver/javier.simo

Phone: +34670675414 Phone 2: +34914888167 Fax: +xxx xxxxxxxxx

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Maria	Rodriguez	maria.rodriguez.tato@urjc.es	+xxx xxxxxxxxx

Participant

PIC	***Legal name***
909374419	*AMMBR RESEARCH LABS LIMITED*

Short name: AMMBR RESEARCH LABS LIMITED

Address of the organisation

Street 77 Victoria Road

Town Cambridge

Postcode CB4 3BW

Country United Kingdom

Webpage www.ammbrtech.com

Specific Legal Statuses

Research and Innovation legal statuses

Public body .....no

Non-profit .....yes

International organisation .....yes

International organisation of European interest .....yes

Secondary or Higher education establishment .....no

Research organisation .....yes

Legal person .....yes

Academic Sector .....yes

Enterprise Data

SME self-declared status..... unknown

SME self-assessment ..... unknown

SME validation sme..... unknown

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

No department involved

Department name: *Name of the department/institute carrying out the work.* ☒ not applicable

☐ Same as proposing organisation's address

Street: *Please enter street name and number.*

Town: *Please enter the name of the town.*

Postcode: *Area code.*

Country: *Please select a country*

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

Title: Dr.

Sex: (•) Male ( ) Female

First name: **Arjuna**

Last name: **Sathiaseelan**

E-Mail: **arjuna@ammbrtech.com**

Position in org.: CEO

Department: AMMBR RESEARCH LABS LIMITED ☒ Same as organisation name

☐ Same as proposing organisation's address

Street: 77 Victoria Road

Town: Cambridge

Post code: CB4 3BW

Country: United Kingdom

Website: www.ammbrtech.com

Phone: +447971329880

Phone 2: *+xxx xxxxxxxxx*

Fax: *+xxx xxxxxxxxx*

Participant

PIC	***Legal name***
999910921	*ERICSSON AB*

Short name: EAB

Address of the organisation

Street TORSHAMNSGATAN 23

Town STOCKHOLM

Postcode 164 80

Country Sweden

Webpage

Specific Legal Statuses

Research and Innovation legal statuses

Public body .....no

Non-profit .....no

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....no

Research organisation .....no

Legal person .....yes

Academic Sector .....no

Enterprise Data

SME self-declared status.....2013 - no

SME self-assessment ..... unknown

SME validation sme..... unknown

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: Ericsson Research - Network Architecture and Protocols ☐ not applicable

☒ Same as proposing organisation's address

Street: TORSHAMNSGATAN 23

Town: STOCKHOLM

Postcode: 164 80

Country: Sweden

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

Title: Dr.

Sex: (•) Male ( ) Female

First name: **Gustav** Last name: **Wikstrom**

E-Mail: **gustav.wikstrom@ericsson.com**

Position in org.: Research Leader

Department: Ericsson Research - Network Architecture and Protocols ☐ Same as organisation name

☒ Same as proposing organisation's address

Street: TORSHAMNSGATAN 23

Town: STOCKHOLM Post code: 164 80

Country: Sweden

Website:

Phone: +xxx xxxxxxxxx Phone 2: +xxx xxxxxxxxx Fax: +xxx xxxxxxxxx

Participant

PIC	***Legal name***
999981149	*INTERUNIVERSITAIR MICRO-ELECTRONICA CENTRUM*

Short name: IMEC

Address of the organisation

Street KAPELDREEF 75

Town LEUVEN

Postcode 3001

Country Belgium

Webpage www.imec.be

Specific Legal Statuses

Research and Innovation legal statuses

Public body .....no

Non-profit .....yes

International organisation .....no

International organisation of European interest .....no

Secondary or Higher education establishment .....no

Research organisation .....yes

Legal person .....yes

Academic Sector .....yes

Enterprise Data

SME self-declared status.....2007 - no

SME self-assessment ..... unknown

SME validation sme.....2007 - no

Based on the above details of the Beneficiary Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.

Department(s) carrying out the proposed work

Department 1

Department name: IDLab Antwerp ☐ not applicable

☐ Same as proposing organisation's address

Street: The Beacon, Sint-Pietersvliet 7

Town: Antwerpen

Postcode: 2000

Country: Belgium

Department 2

Department name: IDLab Ghent ☐ not applicable

☐ Same as proposing organisation's address

Street: Technologiepark-Zwijnaarde 126

Town: Gent

Postcode: 9052

Country: Belgium

Dependencies with other proposal participants

Character of dependence	***Participant***	

Person in charge of the proposal

Title: Prof. Sex: (•) Male ( ) Female

First name: **Johann** Last name: **Marquez-Barja**

E-Mail: **johann.marquez-barja@imec.be**

Position in org.: Researcher

Department: IDLab Antwerp ☐ Same as organisation name

☐ Same as proposing organisation's address

Street: The Beacon, Sint-Pietersvliet 7

Town: Antwerpen Post code: 2000

Country: Belgium

Website: www.imec.be

Phone: +32 3 2658894 Phone 2: *+xxx xxxxxxxxx* Fax: *+xxx xxxxxxxxx*

Other contact persons

First Name	***Last Name***	***E-mail***	***Phone***
Lia	Vanherle	lia.vanherle@imec.be	*+32 16 283947*
Christine	Van Houtven	christine.vanhoutven@imec.be	*+32 16 281613*

3 - Budget

Researcher Number	Recruiting Participant (short name)	Planned start month	Duration (months)
1	UPC	8	36
2	UPC	8	36
3	THE CHANCELLOR MASTERS AND SCHOLARS OF THE UNIVERSITY OF	8	36
4	THE CHANCELLOR MASTERS AND SCHOLARS OF THE UNIVERSITY OF	8	36
5	URJC	8	36
6	URJC	8	36
7	AMMBR RESEARCH LABS LIMITED	8	36
8	Fraunhofer	8	36
9	TID	8	36
10	IMEC	8	36
11	IMEC	8	36
12	CHALMERS TEKNISKA HOEGSKOLA AB	8	36

Researcher Number	Recruiting Participant (short name)	Planned start month	Duration (months)
13	CHALMERS TEKNISKA HOEGSKOLA AB	8	36
14	EAB	8	36
Total			504

Participant Number	Organisation Short Name	Country	IOEI	No of researchers	Number of person.months	Researcher Unit Cost			Institutional Unit Cost		TOTAL
						Living allowance	Mobility Allowance	Family Allowance	Research, training and networking costs	Management and overheads	
1	UPC	Spain	no	2	72	224609,76	43200,00	18000,00	129600,00	86400,00	501809,76
2	CHALMERS TEKNISKA HOEGSKOLA AB	Sweden	no	2	72	286765,92	43200,00	18000,00	129600,00	86400,00	563965,92
3	TID	Spain	no	1	36	112304,88	21600,00	9000,00	64800,00	43200,00	250904,88
4	THE CHANCELLOR MASTERS AND SCHOLARS OF THE	United Kingd	no	2	72	329145,12	43200,00	18000,00	129600,00	86400,00	606345,12
5	Fraunhofer	Germany	no	1	36	114188,40	21600,00	9000,00	64800,00	43200,00	252788,40
6	URJC	Spain	no	2	72	224609,76	43200,00	18000,00	129600,00	86400,00	501809,76
7	AMMBR RESEARCH LABS LIMITED	United Kingd	yes	1	36	164572,56	21600,00	9000,00	64800,00	43200,00	303172,56
8	EAB	Sweden	no	1	36	143382,96	21600,00	9000,00	64800,00	43200,00	281982,96

Participant Number	Organisation Short Name	Country	IOEI	No of researchers	Number of person.months	Researcher Unit Cost			Institutional Unit Cost		TOTAL
						Living allowance	Mobility Allowance	Family Allowance	Research, training and networking costs	Management and overheads	
9	IMEC	Belgium	no	2	72	235440,00	43200,00	18000,00	129600,00	86400,00	512640,00
Total				14	504	1835019,36	302400,00	126000,00	907200,00	604800,00	3775419,36

4 - Ethics

1. HUMAN EMBRYOS/FOETUSES		Page
Does your research involve Human Embryonic Stem Cells (hESCs)?	○ Yes ◉ No	
Does your research involve the use of human embryos?	○ Yes ◉ No	
Does your research involve the use of human foetal tissues / cells?	○ Yes ◉ No	
2. HUMANS		**Page**
Does your research involve human participants?	○ Yes ◉ No	
Does your research involve physical interventions on the study participants?	○ Yes ◉ No	
3. HUMAN CELLS / TISSUES		**Page**
Does your research involve human cells or tissues (other than from Human Embryos/ Foetuses, i.e. section 1)?	○ Yes ◉ No	
4. PERSONAL DATA		**Page**
Does your research involve personal data collection and/or processing?	○ Yes ◉ No	
Does your research involve further processing of previously collected personal data (secondary use)?	○ Yes ◉ No	
5. ANIMALS		**Page**
Does your research involve animals?	○ Yes ◉ No	
6. THIRD COUNTRIES		**Page**
In case non-EU countries are involved, do the research related activities undertaken in these countries raise potential ethics issues?	○ Yes ◉ No	
Do you plan to use local resources (e.g. animal and/or human tissue samples, genetic material, live animals, human remains, materials of historical value, endangered fauna or flora samples, etc.)?	○ Yes ◉ No	
Do you plan to import any material - including personal data - from non-EU countries into the EU?	○ Yes ◉ No	
Do you plan to export any material - including personal data - from the EU to non-EU countries?	○ Yes ◉ No	
In case your research involves low and/or lower middle income countries, are any benefits-sharing actions planned?	○ Yes ◉ No	
Could the situation in the country put the individuals taking part in the research at risk?	○ Yes ◉ No	
7. ENVIRONMENT & HEALTH and SAFETY		**Page**

Does your research involve the use of elements that may cause harm to the environment, to animals or plants?	◯ Yes ◉ No	
Does your research deal with endangered fauna and/or flora and/or protected areas?	◯ Yes ◉ No	
Does your research involve the use of elements that may cause harm to humans, including research staff?	◯ Yes ◉ No	
8. DUAL USE		Page
Does your research involve dual-use items in the sense of Regulation 428/2009, or other items for which an authorisation is required?	◯ Yes ◉ No	
9. EXCLUSIVE FOCUS ON CIVIL APPLICATIONS		Page
Could your research raise concerns regarding the exclusive focus on civil applications?	◯ Yes ◉ No	
10. MISUSE		Page
Does your research have the potential for misuse of research results?	◯ Yes ◉ No	
11. OTHER ETHICS ISSUES		Page
Are there any other ethics issues that should be taken into consideration? Please specify	◯ Yes ◉ No	

I confirm that I have taken into account all ethics issues described above and that, if any ethics issues apply, I will complete the ethics self-assessment and attach the required documents. ☒

How to Complete your Ethics Self-Assessment

5 - Call-specific questions

Extended Open Research Data Pilot in Horizon 2020

If selected, applicants will by default participate in the Pilot on Open Research Data in Horizon 2020[1] , which aims to improve and maximise access to and re-use of research data generated by actions.

However, participation in the Pilot is flexible in the sense that it does not mean that all research data needs to be open. After the action has started, participants will formulate a Data Management Plan (DMP), which should address the relevant aspects of making data FAIR – findable, accessible, interoperable and re-usable, including what data the project will generate, whether and how it will be made accessible for verification and re-use, and how it will be curated and preserved. Through this DMP projects can define certain datasets to remain closed according to the principle "as open as possible, as closed as necessary". A Data Management Plan does not have to be submitted at the proposal stage.

Furthermore, applicants also have the possibility to opt out of this Pilot completely at any stage (before or after the grant signature). In this case, applicants must indicate a reason for this choice (see options below).

Please note that participation in this Pilot does not constitute part of the evaluation process. Proposals will not be penalised for opting out.

We wish to opt out of the Pilot on Open Research Data in Horizon 2020.	○ Yes	◉ No

Further guidance on open access and research data management is available on the participant portal: http://ec.europa.eu/research/participants/docs/h2020-funding-guide/cross-cutting-issues/open-access-dissemination_en.htm and in general annex L of the Work Programme.

[1] *According to article 43.2 of Regulation (EU) No 1290/2013 of the European Parliament and of the Council, of 11 December 2013, laying down the rules for participation and dissemination in "Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020)" and repealing Regulation (EC) No 1906/2006.*

START PAGE

MARIE SKŁODOWSKA-CURIE ACTIONS

Innovative Training Networks (ITN)
Call: H2020-MSCA-ITN-2019

PART B

"5G4real"

This proposal is to be evaluated as:

ETN

TABLE OF CONTENTS

LIST OF PARTICIPATING ORGANISATIONS

Consortium Member	Legal Entity Short Name	Academic	Non-academic	Awards Doctoral Degrees	Country	Dept./ Division / Laboratory	Scientist-in-Charge	Role of Partner Organisation
Beneficiaries								
Universitat Politècnica de Catalunya	UPC	√		√	Spain	Signal Theory and Communication Department	Dr. Josep Vidal	
Chalmers Tekniska Hoegskola AB	Chalmers	√		√	Sweden	Electrical Engineering	Dr. Tommy Svensson	
Telefonica Investiacion y Desarrollo SA	TID		√		Spain	CCDO/Global Innovation/Network Innovation/Internet for all	Dr.Yan Grunenberger	
The Chancellor Masters and Scholars of the University of Cambridge	UCAM	√		√	United Kingdom	Computer Science and Technology	Dr. Jon Crowcroft	
Fraunhofer Gesellschaft zur foerderung der angewandten Forschung E.V.	FIT		√		Germany	Fraunhofer FIT	Dr. Mathias Kretschmer	
Universidad Rey Juan Carlos	URJC	√		√	Spain	Teoria de la Señal y Comunicaciones y Sistemas Telematicos y Computadores	Dr, Javier Simo	
AMMBR Research Labs Limited	ARL		√		United Kingdom	AMMBR Research Labs limited	Dr. Arjuna Sathiaseelan	
IMEC	IMEC		√	√	Belgium	IDLab Antwerp	Dr. Johann Marquez-Barja	
Ericsson AB	EAB		√		Sweden	Ericsson Research	Dr. Gustav Wikström	
Partner Organisations								
Rheinisch-Westfälische Technische Hochschule Aachen	RWTH	√		√	Germany		Dr. Wolfgang Prinz	Grants PhD awards to FIT's ESRs
Accelleran	Accelleran		√		Belgium		Dr. Trevor Moore	Host secondments, participation in workshops and training

Data for non-academic beneficiaries:

Name	Location of research premises (city / country)	Type of R&D activities	No. of full-time employees / No. in R&D	Web site	Annual turnover (in Euro)	Enterprise status (Ys/No)	SME status (Yes/No)
TID	Madrid, Spain	Research	667/625	www.tid.es	111.78M	Yes	No
ARL	Cambridge, UK	Telecom, blockchin	4	www.ammbrtech.com	Part of the AmmbrTech group	No	Yes
IMEC	Leuven, Belgium	R&D on IoT and AI		https://www.imec-int.com/	€535M	No	No
EAB	Stockholm / Sweden	Telecom standardization, concept development, proof-of-concept implementation	23,600 (Total, 2017). 717 (Ericsson Research, 2018)	https://www.ericsson.com/en/tech-innovation/research	Net sales Q4 2018 5.2b Euro	Yes	No

START PAGE COUNT – MAX 30 PAGES

1. Excellence

1.1 Quality, innovative aspects and credibility of the research programme

1.1.1 Introduction, objectives and overview of the research programme

With the 5th Generation of cellular communications (5G) coming to market as quickly as 2020 for the first deployments, ambitious goals have been defined in terms of data rate, reliability and extreme low latency that will be enablers for a new wave of potentially disruptive usages and services.

When facing deployment, the telco industry has been deploying LTE technology under 3 submarkets: urban, suburban and rural. Economic studies[1] have modelled the cumulative revenues in each case and as a result urban deployments in big cities get the bulk of investments and rural areas remain underserved. In developed countries, lack of communication services often leads to little development or even depopulation of villages. In developing countries, it affects in a more crude way the UN Sustainable Development Goals (SDG)[2]. As of 2016, according to ITU, the adoption of broadband in developing countries was only 39%, and 35% of the 4 billion people deprived of Internet access live in areas without any mobile broadband coverage (3G or higher). Reversing this situation in the upcoming new generations of wireless systems require innovative technical and entrepreneurial solutions.

Some structural and conjectural **show-stoppers** for uniform and massive roll-out of new cellular technologies have been identified. While some of them are **traditional** (cost of deployment of new radio technology, new core network elements in the architecture, availability of transport infrastructure to support the new bandwidth, challenging access to energy, low traffic density,…), there are **new technical challenges** (misalignment of the telco workforce skill-set with the new challenges ahead, general decrease of the revenues in the telecommunication sector, lack of early-success and/or low adoption of virtualization and software-defined networks, increased software and hardware complexity with the introduction of white boxes hardware[3] and open source software[4],…), and **business barriers** (low expectation of revenues, lack of understanding of digital needs for rural areas, lack of control mechanisms over local operators, inadequate regulation ignoring the complexity of accessing remote areas,…). Overall, these difficulties force carriers to prioritize urban areas, which will likely get an abundance of connectivity options (fiber, 5G fixed wireless), while deployment in rural and suburban areas will be lagging. In 5G this phenomenon will likely be amplified, as early trials have shown the incompatibility of some 5G frequencies with the low density of population[5].

Meanwhile the appearance of humongous tech-sector players such as Apple, Google, Amazon and Facebook from US or Alibaba from China (as well as many other internet-based Over the top (OTT) players like Netflix, HBO, Uber, Airbnb, etc.) has been mainly relying on the abundance of fast and cheap connectivity through LTE and 3G. In order to foster the emergence of new players in Europe, 5G technology should be implemented in a global and consistent way, and to that end new approaches should be explored. As an inspiration, the deployment of fibre -which is the de facto support technology for carrying 5G data- in some countries has been mostly going from a competition between infrastructure (various players implementing their own networks in the streets, up to the building) toward a co-investment strategy due to the heavy investment required (i.e. civil work, and access to users' premises).

Some other initiatives have sprung in the direction of finding new approaches and generate open-acces knowledge, like Facebook's Telecom Infra Project[6], Google's Loon[7], Telefonica's Internet4All[8] or the UK project 5Gruralfirst[9]. All of them address interesting challenges on how to manage complex, heterogeneous technologies in a shared financial, regulatory and technological environment, while preserving the privacy and security of each final user and component owner. We advocate that, for 5G to be a global European and world-wide success including suburban and rural areas, such approaches

[1] http://www.umsinstitute.org/industries.asp?id=32
[2] https://www.un.org/sustainabledevelopment/sustainable-development-goals/
[3] https://www.opencompute.org/projects/telco
[4] https://www.linuxfoundation.org/projects/networking/
[5] https://www.lightreading.com/mobile/5g/nokia-bell-labs-and-verizon-stretch-fixed-5g-to-the-home/d/d-id/738134
[6] https://telecominfraproject.com/openran/
[7] https://loon.co/
[8] https://www.telefonica.com/ext/public-policy/conectividad/
[9] https://www.5gruralfirst.org/

should be fostered by enabling different parties to finance, build and operate a common network. In order to achieve consistent efforts, we need to train a *new generation of conscious, creative, entrepreneurial and innovative early-stage researchers* to solve those drastically different inter-domain challenges using modern tools around concepts such as automation, Artificial Intelligence (AI), data science, privacy and security. 5G4rel focuses its activities on the following objectives:

1. *How to use 5G network slicing[10], virtualization concepts and underlying technologies to enable a shared end-to-end infrastructure?*
2. *How to exploit the emergence of cloud technologies (public, private cloud, edge clouds, containers-based clusters, blockchain security,…) to serve the architecture need of a shared end to end infrastructure?*
3. *How to enable cloud actors to use and co-develop such shared infrastructure while coping with the need of trust and security?*
4. *How to generate new business models and devise new actors to thrive beyond the classical, hyper connected customer of dense urban area, and bridge the digital gap with the rural users in need of connectivity?*

The previous objectives demand to investigate through a cluster of multi-disciplinary challenges:

Challenge 1: 5G NR itself. By enabling **network slicing** in an end-to-end fashion over multiple network segments, it will indirectly enable *multiple players* to run concurrently multiple classes of customers' needs over the shared spectrum and/or infrastructure. Nevertheless, the provisioning of the overall shared resources to sustain slices running on top is still an open issue, and the necessary **trade-offs to run efficiently a shared end-to-end system in a dynamic fashion** needs to be identified, especially in terms of what should be shared at physical and logical level, under the 5G enhancements. Building a viable transport network supporting 5G in remote areas is part of the challenge.

Challenge 2: Disaggregation and edge computing as enablers. Initiatives such as Open Compute and Telecom Infra Project (TIP) are accelerating the disaggregation of hardware and software via opening specifications of hardware outside of the possibly slower standardization bodies. This intrinsically allows to *deploy cheaper* and more simple hardware, and *transfer the complexity to software* running elsewhere. As well, the emergence of edge computing is a necessary element for reaching the requirements defined for 5G networks in terms of latency for some use cases. Both disaggregation and emergence of new compute resources require the development of *unique competencies and talent* to **enable the control and operations of those resources in a harmonious way**. This could be inspired by the DevOps[11] movement and by the Site Reliability Engineer (SRE) role[12] in many **software-driven organizations**, still largely unknown to carriers' world.

Challenge 3: Virtualization and cloud computing. Network function virtualization (NFV) has been proposed since 2012 as the carriers-preferred approach to the virtualization. However, cloud actors such as Google or Netflix have introduced concepts and technologies -such as **containers or, more recently, Kubernetes**- that enable the optimization of resources to serve more users in scalable way. Amazon has demonstrated with their AWS offers that a lot of players are just interested into **getting compute, storage and network resource on demand with an extreme agility to manage it through software and automation.** Meanwhile carriers have unique requirements (Service Level Agreement, latency, bandwidth) that seem to be only implementable over NFV-based infrastructure; it is clear that the potential synergies between those worlds are worth to be explored. **Containers tech and cloud-level orchestration and management from the cloud world could bring benefits in a shared infrastructure** where players coming from the cloud world could play an important role[13] [14].

Challenge 4: Cloud players as connectivity supporters. A large part of the traffic of current mobile networks is today flowing towards a very limited number of actors. Those actors work at planetary scale and are openly sharing most of their technology through open-source. As an example, Google

[10] GSMA Whitepaper, https://www.gsma.com/futurenetworks/wp-content/uploads/2017/11/GSMA-An-Introduction-to-Network-Slicing.pdf
[11] https://devops.com/how-devops-can-create-smarter-more-agile-5g-telecom-networks/
[12] https://landing.google.com/sre/
[13] https://www.sdxcentral.com/articles/news/aws-offers-affirmed-networks-virtual-epc-as-a-hosted-service/2018/09/
[14] https://www.fiercetelecom.com/telecom/x-by-orange-takes-cloud-native-approach-for-serving-business-customers

(through Loon), Microsoft (with its TV white space program[15]) and Facebook (through TIP and its connectivity program with open source technologies such as Terragraph or Opencellular) are demonstrating interest in opening their services to a larger user base through the development of disruptive connectivity-based technologies. While their intention is clearly stirred to the increase of their monthly active users base, there is a large potential in taking advantage of their technology portfolio. We think that such co-investment in the infrastructure could be encouraged by adopting an **open approach to the infrastructure deployment**, framing the regulatory constraints into actual requirements and enabling actors to bring ideas to solve those requirements. As inspirational example, new fleet of Low Earth Orbits (LEO) satellites, new Free Space Optical Communication (FSOC) advances, High Altitude Platforms (HAP) could be technological helpers to solve the needs of carrying 5G connectivity overseas, mountains and less dense areas, but the **architecture of this shared network needs to be able to accommodate such heterogeneous environments, and maintain trust**: those actors are currently operating from their own infrastructure and datacenter, and to bring them to a shared one, some tough challenges such as solving trust in a multi-party environment should be covered [16].

Challenge 5: Innovative business models. End user services and applications providers are engines for new business models. Actors of various sizes are now leveraging cheap access from cloud actors to computational resources (under Amazon, Azure etc.) and rely on a very integrated platform model (Android/iOS/Web) pushed by Google and Apple to offer end-users access to a service (example: Uber, Deliveroo, etc.). Those services can be built using various forms (dedicated virtual machines, microservices), rely on various technologies (AI, voice processing etc.), and their business model is typically either built on micro-transaction, collection of data, or on a subscription model. Those actors are typically focusing on dense areas due to their problem of scaling their activities from 0 to a big level without too much investment. However**, extending their reach to less dense or even rural areas is more difficult, notably because of connectivity access, but mostly because those users are having different needs**. Very frequently, those users are ready to pay, but the actual infrastructure does not enable to reward the end-to-end providers in a homogeneous way, leading to an abnormal pricing scheme. Introducing **revenue sharing scheme, based on new metrics** (actual access to connectivity, local compute and storage resources etc.) could enable new business models to emerge for those users.

The 5G4real consortium is best placed to address these objectives because the existing synergies among partners (see Table 1.4b) ensure an ideal ecosystem to train researchers:

- Common *research experience* in community networks, artificial intelligence and security, infrastructure platforms, 5G access and heterogeneous backhaul
- Participation in previous *ITN-MSCA* (UPC, UCAM, TID, IMEC, Chalmers and EAB)
- Significant number of *collaborations* among partners *(see Table 1.4b)*
- Participation in many *industrial groups*: TIP, 5GBarcelona 3GPP, IETF, Small Cell Forum

1.1.2 Research methodology and approach

The ITN is structured in 6 WPs as presented in Table 1.1 and detailed in section 3.1, Table 3.1a.

WP1: 5G Network planning and business models (Research challenges: 1,5). Under the network slicing paradigm, telecom infrastructures can be shared to concurrently implement multiple services with different requirements. Network slicing techniques can also be adapted in a suitable way to allow multi-tenancy operation (by carriers, community networks, public administrations,…). This could dramatically benefit the sustainability of such infrastructures in rural areas. When using network slicing the concept of coverage is still tied to the propagation scenario, but depends as well on the type of service, the traffic load and the resources allocated and propagation in new frequency bands. The use of massive Multiple Input Multiple Output (MIMO) enhancements, mobile base stations, passive reflectors, organization of the network in terms of slices, multi-tenancy and joint Radio Access Network (RAN)-backhaul resource allocation translates the need for new simple planning tools into a

[15] https://blogs.microsoft.com/on-the-issues/2017/07/10/rural-broadband-strategy-connecting-rural-america-new-opportunities/
[16] https://azure.microsoft.com/en-us/blog/azure-confidential-computing/

real technical challenge where elasticity demands, switching on-off base stations, continuous runtime operation on the infrastructure, energy supply limitations and robust design should be considered (see ESR 2 in Table 3.1d). Dynamicity can be tackled using reinforcement learning techniques. In addition to the technology, the viability of such infrastructure in rural areas depends on the business opportunities (health, education, etc.) and collaborations of different actors (operators, communities, public institutions, service providers, regulators, etc.) with common socio-techno-economic-regulatory interests (see ESR 6 and part of ESR 7 in Table 3.1d).

WP2: 5G Network infrastructure. (Research challenges: 1, 2). 5G NR enhancements can be fully exploited to deliver enhanced radio coverage and reduce deployment. The network topology has to be exploited as well: low density of population and low costs call for the support of novel approaches involving mobile base stations (mounted on mobile high-altitude platforms, unmanned aerial vehicles (UAVs) or drones, balloons, etc.), both for access and transport nodes. Together with multi-hop solutions over backhaul, access, and user links a new flexible network topology is thereby created where information is switched over the suitable radio path. As a network solution, it could deliver mobile broadband services at lower infrastructure investments compared to fixed cellular networks and extend the reach of radio links beyond that of telecom towers (see ESR 13 in Table 3.1d). On the other hand, when moving base stations are part of hybrid backhaul (microwave, fibre, and satellite links) communications over the backhaul is challenging:

- The backhauling of moving base stations needs to be wireless and cope with fast varying radio channels, in 3 dimensions for mobile high-altitude platforms. Optimally designing such multi-hop meshed backhaul links and how to use them for terrestrial and high-altitude platforms that can be flexibly used in in-band Integrated Access and Backhaul (IAB) scenarios for 5G networks is challenging (see ESR 12 in Table 3.1d)
- Heterogeneous backhauling demands self-adaptive traffic engineering with QoS support in order to deal with the environmental changes and current traffic demand, finding the optimal path in order to reduce costs and deliver good rates (see ESR 1, 5 in Table 3.1d). Flexible protocols for control and user planes are needed. Mobility and temporary nodes introduce new needs from measurements and adaptation for predictability of links, as well as more information for good decisions and tools to route control and data in an efficient way (see ESR 14 in Table 3.1d).

Shared infrastructures could help reducing the costs per actor in the telecom networks, however aspects of trust, interfaces and signalling over the different players are challenging. Moreover, important questions arise, like how to implement and manage slices in such architecture? It turns out that conventional centralized schemes fail to guarantee per flow differentiated services, and distributed approaches have to be investigated. SLA provision, the heterogeneity of transport media and multi-tenancy exploitation call for virtualization and smart orchestration (see ESR 8, 11 in Table 3.1d). Likewise, another possibility to satisfy the different SLA required for the rural use case is with a *network slice bundle*, i.e. a family of network slice types required to serve a group of uses cases packaged into a single product, simplifying its management (see ESR 10 in Table 3.1d)

WP3: 5G Services, operations and architectural support (Research challenges: 2,3,4). Furthermore, with the objective of simplifying the network architecture and management, improve flexibility and efficiency and reduce costs, the micro-service model will be investigated (see ESR9 in Table 3.1d). The cloud industry led by Google, Facebook, Amazon or Microsoft has adopted micro-services-oriented architectures that can massively scale at the planetary level using standard hardware, with little consideration for legacy. We think that such a model (micro-services oriented, legacy-free) can be applied to efficiently implement virtualization to new greenfield deployment of 4G and 5G technology, in specific footprints (rural, IoT, fixed wireless) and can reuse many of the technologies open-source by the cloud world giant (i.e. containers, Kubernetes) as distributed infrastructure. However, the telco-oriented protocols (such as GTP, SCTP, Diameter) used by the telco software are creating specific challenges (multi-tenancy related security, multi-homing, bandwidth etc.) that should be addressed in a way that enable a cloud-ready experience in terms of automation (i.e. minimum effort to deploy and redeploy) and replicability (increase network footprint to new places) while

leveraging the new tools made available in the cloud industry (i.e. load balancers, orchestrator, monitoring, high performance network APIs,…)

On the other hand, blockchain is currently seen as an effective solution to provide a verifiable evidence of security. The ledger architecture makes it a natural fit for audit support for security and infrastructure management. In a multi-tenancy network operation regime, authentication of devices/operators and accountability issues are key applications. (See part ESR 7 in Table 3.1d).

Network analytics tools, supported by machine learning (ML), enable cognitive network slicing and achieve system-wide optimisation at different levels (physical, data link, network) and with various time scales. Such building blocks will infer the operational context and predict time evolution for context-aware and anticipatory optimisations. One of the applications is the placement of core and user applications. 5G networks are expected to generate a lot of control and data plane traffic, that will reduce the available resources and overload the transport network. Placing computation elements at the network edge (that allow moving user's applications and core functionalities) is especially beneficial for remote deployments. Network analytics tools have the potential to monitor the network and take decisions at this level while tackling scalability. (see ESR 3, 4 in Table 3.1d)

Table 1.1: Work Package (WP) List

WP No.	WP Title	Lead Benef. No	Start Month	End month	Activity Type	Lead Beneficiary Short Name	ESR involvement
1	5G Network planning and business models	6	8	44	Research	URJC	2, 6, 7*
2	5G Network infrastructure	9	8	44	Research	IMEC	1,5, 12,13,14, 10,11,8
3	5G Services, operation and architectural support	4	8	44	Research	UCAM	3,4,7*,9,
4	Training, networking and supervision	2	1	48	Management	Chalmers	ALL
5	Project management	1	1	48	Management	UPC	×
6	Communication, dissemination, data management, and innovation	8	1	48	Dissemination	EAB	ALL

1.1.3 Originality and innovative aspects of the research programme

The **credibility** of the proposal is sustained at different levels: i) by the quick development of 5G and the public expectations of wide deployment in the next few years; ii) the growing concern of the digital breach and the links between connectivity and economic development[17]; iii) the growing concern about the need of novel technical solutions and business models guaranteeing a positive return for 5G investments; iv) the major advances in and virtualisation tools, edge computing, blockchain security and data analytics, evidenced by the increasing number research publications in publications and symposia; v) the expertise of beneficiaries in the areas above.

Explored areas. Projects on wireless deployments for rural areas are not new: operators struggle to broaden the demands for 5G services and at the same time uniformly improve wideband coverage and get revenues from it. As an example, the UK National project 5Gruralfirst aims to exploit the 5G benefits for rural communities and industries. Also, the Telecom Infra Project led by Facebook seeks to create an open access, backhaul and core management by creating infrastructure technologies and methodologies to bring internet access to under deserved areas. Access is focused on removing some of the key blockers that make the connection to the end user difficult. In one of the trends to that goal, the telecommunication industry, despite a strong push since 2012, is still struggling towards the adoption of virtualization in production systems mainly because of back-compatibility issues.

Emerging and unexplored areas. The use of data analytics to optimize cellular communications systems at several layers has been widely explored in the past and applied under the name of self-

[17] http://www.itu.int/en/ITU-D/Technology/Pages/RuralCommunications.aspx

organising networks. However, its use for core network distribution and edge computing needs to be reconsidered in the context of 5G with state-of-the-art data analytics tools, where communication, computation and storage resources over several contexts can be jointly orchestrated. The application of such paradigms to the optimisation of wireless systems under a multi-tenancy exploitation model is still in its infancy. Regarding security, solutions exist to address scalability and energy efficiency of blockchain technologies. However, its use in commercial cellular networks has only been grasped.

1.2 Quality and innovative aspects of the training programme

1.2.1 Overview and content structure of the training programme

The training program of the 5G4real has been conceived to educate ESRs with the objective of providing experience, technical knowledge and a set of skills that allow them to tackle the major European research and societal challenges. The latest objective is very important, since there are many unfilled jobs due to the demanded skills, for example in US[18] there are 7 million. Among the most demanded soft skills in 2019 are: *time management, adaptability, collaboration, persuasion and creativity*, while *user experience design, people management, analytical reasoning, artificial intelligence, networks engineering and cloud computing* are demanded hard skills. 5G4real looks for:

a) To gain a thorough cross-sectoral knowledge/understanding of the fundamental technologies,
b) To carry out effective research and development in the area of 5G systems and networks,
c) To grasp the complete cycle of research and development from initial research to the final product,
d) To take advantage of an integrated and network-wide training programme aiming to enrich conventional academic training through research, complementary activities and transferable skills,

The number of recruited ESRs is 14 and they are distributed among partners as shown in Table 1.2a. All ESRs are expected to obtain a PhD degree at the end of the project (see section 1.3).

Table 1.2a Recruitment Deliverables per Beneficiary

ESR n.	Recruiting Participant	PhD awarding entities	Planned Start / (Duration)	Secondment host Institution	Project title
1	UPC	UPC	8/36	URJC, IMEC	Energy-aware joint resource management for access and heterogeneous backhaul networks
2	UPC	UPC	8/36	Chalmers, EAB	Network planning and monitoring for 5G in low density populated areas
3	UCAM	UCAM	8/36	ARL, Accelleran	Edge artificial intelligence: methods and functions for network management
4	UCAM	UCAM	8/36	TID	Network architectures in edge artificial intelligence
5	URJC	URJC	8/36	UCAM, FIT, TID	Real-time traffic engineering in self-organized adaptive mesh backhaul networks for rural 5G access networks
6	URJC	URJC	8/36	ARL, TID, Accelleran	Business and management cooperative models maximizing synergies between communities, carriers and public administrations
7	ARL	UCAM	8/36	UCAM, URJC	Trustworthy and accountable infrastructure sharing for 5G
8	FIT	RWTH	8/36	TID, URJC	End-to-end service level agreements with network slicing across a heterogeneous backhaul network
9	TID	URJC	8/36	UCAM, FIT	Micro-services oriented, legacy-free telco infrastructure for automated and replicable deployments in 4G/pre-5G networks
10	IMEC	Univ. Antwerp	8/36	Accelleran Chalmers	Assuring Service Performance through 5G slice bundles
11	IMEC	Gent Univ.	8/36	Accelleran, UPC	Distributed resource allocation in a shared 5G infrastructure
12	Chalmers	Chalmers	8/36	EAB, FIT	Flexible backhauling of mobile base stations
13	Chalmers	Chalmers	8/36	EAB, UPC	Efficient access and user association to mobile base stations
14	EAB	Chalmers	8/36	Chalmers, FIT	Mobile base stations and flexible network topology for high performance coverage

The *Training Committee* (described in section 3.2) monitors and supervises the network-wide training activities to ensure the envisioned objectives at three levels: local training, network-wide training and

[18] https://www.cnbc.com/2019/01/04/the-30-most-in-demand-skills-in-2019-according-to-linkedin-.html

secondment programme. The developed skills are grouped[19] into: a) *Knowledge and intellectual abilities to do research* (KIA), b) *Personal effectiveness* (PE), c) *Research governance and organisation* (RGO) and d) *Engagement, Influence and Impact* (EII).

The training programme items are detailed in the following:

1. *Training through structured postgraduate courses (skills: KIA).* The ESRs will benefit from the postgraduate courses offered by academic partners which are part of the EU academic space and officially accepted by EU institutions.
2. *Network-wide training (skills: KIA, PE, RGO, EII).* Table 1.2c presents the events organised to provide the network-wide training, in three categories: plenary meetings, network-wide workshops and open schools. Each plenary meeting will be organised and hosted by one beneficiary and will consist of: i) Advanced research courses, ii) Complementary courses and iii) Presentation of the results by ESRs. Table 1.2d provide a list of the tentative courses to be given and the involved partners in the preparation of each course and detailed in deliverable D4.1, see section 3.1. On the other hand, 5G4real plans to increase the visibility of results to both the scientific and industrial community: 5G4Real will organize 2 workshops at top-class IEEE conferences and one workshop for industrial, regulatory and government stakeholders.
3. *Training through participation in international conferences/workshops (skills: KIA, PE, EII).* One objective of the generated research results is to publish in flagship international journals and conferences/workshops. Furthermore, it will be strongly encouraged that ESRs participate as peer reviewers in conferences/journals and be session chairs during the meetings.

Table 1.2c Main Network-Wide Training Events. Complimentary courses, Scientific/Technical schools, Workshops (green, blue, orange)

	Main Training Events & Conferences	Knowledge and Intellectual abilities	Personal effectiveness	Research governance and organisation	Engagement, influence and impact	Lead Institution	Action Month (*estimated*) / Duration *(days)*
1	Complimentary Course 1			×	×	UPC	10 / 4d
2	School 1 and Project Meeting	×				Chalmers	12 / 4d
3	Complimentary Course 2				×	UCAM	15/ 4d
4	School 2 and Project Meeting	×				FIT	18/ 4d
5	Technical Workshop					Chalmers	18-24/ 1-2d
6	Complimentary Course 3	×				URJC	21/ 4d
7	School 3 and Project Meeting	×				IMEC	24/ 4d
8	Complimentary Course 4			×		EAB	27/ 4d
9	School 4 and Project Meeting	×				TID	30/ 4d
10	Industrial Dissemination Day: "Business models, ownership and shared broadband telecommunications infrastructures and services"					TID	
11	Complimentary Course 5		×	×	×	UPC	33/ 4d
12	School 5 and Project Meeting	×				UCAM	36 / 4d
13	Complimentary Course 6		×	×	×	FIT	39/ 4d
14	Technical Workshop					UPC, ESRs	39-45/ 1-2d
15	Remote and online talks available on-demand						M1-M48

4. *Training by role-playing (skills: PE, RGO).* The ESRs will be engaged in responsibilities of the project, such as co-supervision, co-management and co-organisation of events. This experience will help them to understand all the steps required for the organisation, provide a satisfactory planning and take into account the possible risks with the goal of improving their responsibility. To this end, the last project workshop is expected to be planned and organised by the ESRs Additionally, ESRs will take responsibilities in editing deliverables and newsletters.

[19] https://www.vitae.ac.uk/researchers-professional-development/about-the-vitae-researcher-development-framework

5. *Training through secondments (skills: KIA, PE, RGO, EII)*. The ESRs are expected to spend a cross-sectoral training period that will allow improving their research training (KIA), and most important improving their skills in terms of PE (self-confidence, responsiveness to change, work-life balance, continuing professional development), RGO (appropriate practice, project planning and delivery, risk management), and EII (enterprise, teaching, communication methods, equality and diversity, team working, cross-sectorial technical skills) (see section 1.4).
6. *Training through interaction with structured research teams (skills: PE, EII)*. The ESRs will have the opportunity to be involved with their contracting institutions by means of: a)The possibility of co-supervising bachelor/master thesis, b) The cooperation with other groups' members,c) Attending meetings of active national/international projects that will allow to understand the different type of project structures and operations and increase the networking agenda.

1.2.2 Role of non-academic sector in training program

Non-academic partners (TID, FIT, ARL, EAB) and partner organisations (Accelleran) actively participate in all aspects of the training programme: they provide to their recruited ESRs and hosted ESRs core research skills (see Table 1.2a) participate in network-wide training events by hosting events (Table 1.2c) and organising courses during plenary meetings (Table 1.2d).

Table 1.2d Main Network-Wide Training Courses and Schools

	Training	Objective	Knowledge and Intellectual abilities	Involved Partners	Event in Table 1.2c
1	Responsible Conduct in Research and Innovation	Overview of the rules and professional practices that are considered as responsible conduct of research and engineering, and the ones that are identified as misconduct	RGO	UPC	Course 1
2	Databases in Engineering	An introduction to all databases commonly used in engineering: Inspec, Compendex, IEEEXplore	EII	UPC, URJC,	Course 1
3	Open Science Research	Definition about what is open science, publications in open access, elaboration of data management plan	RGO, EII	UPC	Course 1
4	Introduction to Gender perspective and SDG challenges	Introduction of the 17 Sustainable Development Goals defined by UN[20]. Likewise, raise awareness about male chauvinism	RGO, EII	URJC, UPC, IMEC	Course 1
5	Mathematical tools for network research	A wide variety of mathematical tools and techniques help to understand and design key concepts: convex optimization, online convex optimization, stochastic modelling, control theory, multi-objective optimization, Estimation Theory, Factor Graphs, blockchain	KIA	UPC, Chalmers ARL	School 1
6	Writing scientific papers	To write scientific papers to conferences or journals	EII	Chalmers, URJC, UPC	Course 2
7	Presentation skills (scientific, non-scientific)	To learn how to plan a public presentation, depending on the expected audience: scientific experts, non-experts or non-scientific	EII	UCAM	Course 2
8	Teaching skills	Required skills to be an effective teacher: Patience, Creativity, Communication and collaboration, Likeable Personality and Self-discipline	EII	Chalmers, UCAM	Course 2
9	Management Models	Introduction to different strategies and tools facilitating collaboration among stakeholders when deploying and operating networks in rural settings	KIA	URJC, FIT, ARL	School 2
10	Performance evaluation – Simulations/5G testbeds and software tools	Introduction to methodology and modelling for link and system level evaluations including channel models, deployment and traffic as well as link-to-system measurements from testbeds and/or commercial 5G systems comparing simulations with real performance and discussions around modelling and assumptions vital for realistic evaluations	KIA	FIT, EAB, TID, Accelleran, IMEC	School 2
11	Linux Network, IP Namespaces, Open	A series of introductory mini-courses to acquire practical skills for understanding the building blocks of 5G4real	KIA	URJC	Course 3

[20] https://sustainabledevelopment.un.org/content/documents/2322UN%20Women%20Analysis%20on%20Women%20and%20SDGs.pdf

	vSwitch				
12	Programming network topologies (mininet, openflow, Faucet SDN)	Mininet allows creation of few pre-defined topologies such as single, linear, tree etc and it also allows to create a custom topology. The goal of the proposed course is to provide some insights on the creation of custom topology for a test-bed, thus researchers can test their ideas and protocols.	KIA	URJC	Course 3
13	Git (version-control system for tracking changes in computer files)	Learn a tool that allows to work on software collaboratively with other people	KIA	TID	Course 3
14	5G RRM and Slicing	Description of 5G system architecture, physical layer, waveforms, channel coding, numerology, frame structure, spectrum, latency and network energy efficiency. Network slicing in 5G, dividing the physical resources into logical network, network slice model. Network Function Virtualization (NFV) and software Defined Networking (SDN) in 5G.	KIA	Accelleran IMEC, Chalmers, EAB	School 3
15	Data Protection (Patent filing, licensing, exploitation of IPR)	Description of the different models to protect your research results. Learn how to write patents.	RGO	TID, EAB	Course 4
16	Standardisation (3GPP, ITU, IETF)	Overview of the different standardisation bodies and which type of contributions are expected	RGO	EAB, UCAM	Course 4
17	5G Session Management and Containers Networking in Telecom Infrastructure	Introduction to connection, registration and session management. Session and service continuity, splitting and reallocating the user plane. Network monitoring and Network Exposure Function. Introduction of the concepts, deploy an application with microservices and create and manage kubernetes deployment	KIA	TID, UCAM, EAB, FIT	School 4
18	Public funding schemes	Overview of the different European Public funding schemes	RGO	UPC	Course 5
19	Writing EC project proposals	How to write a successful EC project proposal	RGO	Chalmers	Course 5
20	Project management	Knowledge of Project management basics	RGO	FIT, ARL	Course 5
21	Conflict resolution and negotiation	Overview of the fundamental skills and tools for negotiation. Be aware about the cross-cultural issues. Lead a mediation process.	PE, RGO, EII	UPC	Course 5
22	Multi-access Edge Computing	Introduction to Multi-access edge computing. Review the benefits exploiting the computing resources at the edge of the network, and enabling the 5G capabilities and improving the Telecom Infrastructure	KIA	UCAM, Accelleran EAB, FIT, UPC	School 5
23	Entrepreneurship	Which is the profile of an entrepreneur. Introduction to basic concepts: entrepreneurship, entrepreneurial management, venture creation in society. Identification, assess of the opportunity, hypothesis testing and creating a prototype. Introduction to Start-up, scaling it and financing and profitability.		ARL, Accelleran	Course 6
24	Marketing and business development	Explain the purpose of business development, required skills and personality. Business development teams identify areas of opportunity (product, market, partnership,..)	PE, RGO,	TID	Course 6
25	Cooperative challenges	The objective is to train the ESRs in the context of team-building competitions towards multiple challenges promoting the critical thinking. For example in hackfest events (https://www.the-hackfest.com/)	EII	UPC	Course 6
26	Mindfulness	Introduction to basic concepts and practices to deal with the stress situations generated during the daily routine	PE, EII	UPC	Course 6
27	Objective Mother Tongue plus two	Although all the communication will be in English, each ESR should attend to language courses in the countries where the ESR stays for more than 5 months (if the ESR does not know the language)	KIA	ALL	Local
28	Workshop on successful job seeking	Knowing all the details of the salary, taxes. How to plan the job interview. Explore the different tools to search new jobs (Linkedin)		UPC	Local

1.3 Quality of the supervision

1.3.1 Structure

We have designed a supervision scheme that facilitates quality monitoring and cross-fertilization between academy and industry. Research/training supervisors will be assigned to all ESRs for helping/monitoring their activities for the entire project, not only in the technical respect but also in terms of ethics, responsibility and professional attitude. The SB will ensure, via regular meetings, that

all parties (ESRs/supervisors/institutions) are informed about the European Charter for Researchers and that its principles are observed & followed, overseeing quality and quantity of the supervision. 5G4real defines a two-tier supervision structure that will monitor and evaluate the progress of the ESRs' individual projects, both at *local* and *network-wide* levels.

At the *local level* each ESR would be supervised by academic and non-academic supervisors. The **main supervisor/s** comes from his respective beneficiary institution. In case of an academic institution this latter one will become the PhD programme supervisor, otherwise an additional supervisor will be needed. Furthermore, 5G4real defines an additional temporal supervision by one representative where the ESR is carrying out the secondment (see Table 1.3a).

At the *network-wide* level, 5G4real defines a management structure (more details in section 3.2) where the training committee supervises the training activities of all ESRs and a research committee that will review/monitor the scientific results identifying weaknesses or fostering possible collaboration.

Table 1.3a Supervisors per ESR. Academic, industrial and research institute (green,blue,white)

Researcher No.	Main Supervisor/s (home institution)	Secondment co-Supervisor	PhD programme supervisor
1	Dr. Antonio Pascual (UPC)	• Dr. Andrés Martínez (URJC) • Dr. Ingrid Moerman (IMEC)	Same as main Supervisor
2	Dr. Josep Vidal (UPC)	• Dr. Erik G. Ström (Chalmers) • Dr. Gustav Wikström (EAB)	Same as main Supervisor
3	Dr. Jon Crowcroft (UCAM)	• Dr. Arjuna Sathiaseelan (ARL) • Dr. Trevor Moore (Accelleran)	Same as main Supervisor
4	Dr. Richard Mortier (UCAM)	• Dr. Yan Grunenberger (TID)	Same as main Supervisor
5	Dr. Francisco Javier Simó (URJC)	• Dr. Jon Crowcroft (UCAM) • Dr. Mathias Kretschmer (FIT) • Dr. Yan Grunenberger (TID)	Same as main Supervisor
6	Dr. Andrés Martínez (URJC)	• Dr. Arjuna Sathiaseelan (ARL) • Dr. Yan Grunenberger (TID) • Dr. Trevor Moore (Accelleran)	Same as main Supervisor
7	Dr. Arjuna Sathiaseelan (ARL)	• Dr. Jon Crowcroft (UCAM) • Dr. Javier Simo (URJC)	Dr. Jon Crowcroft (UCAM)
8	Dr. Mathias Kretschmer (FIT)	• Dr. Andrés Martínez (URJC) • Dr. Yan Grunenberger (TID)	Dr. Wolfgang Prinz (FIT, RWTH)
9	Dr. Yan Grunenberger (TID)	• Dr. Jon Crowcroft (UCAM) • Dr. Mathias Kretschmer (FIT)	Dr. Javier Simo (URJC)
10	Dr. Johann Marquez-Barja (IMEC)	• Dr. Erik G. Ström (Chalmers) • Dr. Trevor Moore (Accelleran)	Same as main Supervisor (University of Antwerpen)
11	Dr. Ingrid Moerman (IMEC)	• Dr. Antonio Pascual (UPC) • Dr. Trevor Moore (Accelleran)	Same as main Supervisor (Universtity of Ghent)
12	Dr. Tommy Svensson (Chalmers)	• Dr. Gustav Wikström (EAB) • Dr. Mathias Kretschmer (FIT)	Same as main Supervisor
13	Dr. Tommy Svensson (Chalmers)	• Dr. Gustav Wikström (EAB) • Dr. Josep Vidal (UPC)	Same as main Supervisor
14	Dr. Gustav Wikström (EAB)	• Dr. Tommy Svensson (Chalmers) • Dr. Mathias Kretschmer (FIT)	Dr. Tommy Svensson (Chalmers)

1.3.2 Qualifications and supervision experience of supervisors

All supervisors and co-supervisors detailed in Table 1.3a have long experience in directly supervising or co-supervising PhD candidates, leading research projects and having collaborated with industry (see Table 1.3b).

Table 1.3b Supervisors' qualifications

Supervisor	Position	Master/PhD/ /Postdocs supervised	Publications /patents /citations	Experience (teaching, work in the industry)
Dr. Josep Vidal (UPC)	Full Professor	8 PhD and 45 Master Thesis	180 publ., 3 US patents, 25 contributions to standards,	Project Coordinator of 5 EC-funded collaborative projects, co-organizer of 4 intl. workshops, Associate Editor of Trans. on Signal Processing (2010-13) and member of the IEEE Comm. Signal Process. for Comm. and Electronics Technical

			h-index: 27	Committee. Full time professor at UPC.
Dr. Antonio Pascual (UPC)	Associate Professor	4 PhD and, 10 Master Thesis	100 publ., h-index is 18	Involved in multiple European and research network. UPC Best PhD Thesis Prize, and First National Prize of 2000/01 University Education by the Spanish Ministry of Education and Culture. Full time tenured professor at UPC.
Dr. Francisco Javier Simó Reigadas (URJC)	Associate Professor	1 PhD and 21 Master Thesis	56 publ., h-index: 13	Full-time Associate Professor at URJC with teaching experience in 17 degree or master courses. Participant in 30+ research projects, leading 8 of them. Currently, Dean of the School of Telecommunications Engineering at URJC.
Dr. Andrés Martínez Fernández (URJC)	Associate Professor	3 PhD and 15 Master Thesis	74 publ. h-index: 15	Full time tenured professor at URJC. He has directed numerous research and development projects funded by institutions such as the AECID, the European Union, the Inter-American Development Bank, the World Bank, etc.
Dr. Jon Crowcroft (UCAM)	Marconi Professor	50 PhD Thesis and 20 postdocs	320 publ., h-index: 88	Fellow of the Royal Society, the ACM, the British Computer Society, IET the Royal Academy of Eng. and IEEE. Chair of the Programme Committee at the Alan Turing Institute.
Dr. Richard Mortier (UCAM)	Reader	9 PhD Thesis	180 publ., h-index: 33	Consults, provides technical patent expertise, and engages in creation of an early stage delivery in startup companies. He manages a research budget of over £1M, and leading platform design and implementation of the Databox
Dr. Arjuna Sathiaseelan (ARL)	Chief Executive Officer	7 PhD Thesis	100 publ., h-index 18	He led Networking for Development Lab at University of Cambridge and chaired the IRTF GAIA research group until April 2018. Participation in standardization at IETF and ETSI
Dr. Mathias Kretschmer (FIT)	Head of Dept. and Senior Researcher	20 Master Thesis	50+ publ., 3 US Patents, h-index 12,	20+ years of experience in industry and R&D. Wiback.org. Participation in FP7 projects
Dr. Wolfgang Prinz (FIT, RWTH)	Division Manager at Fraunhofer FIT Ass. professor at RWTH	10 PhD and 50 Master Thesis	247 publ., h-index 31	Coordinator of national and international research projects. Editor of national and international journals and chair of international conferences.
Dr. Yan Grunenberger (TID)	Scientific leader of the *Internet para todos* program		45 publ., h-index 12	10+ years of experience in Telco industry (OEM, Carrier ISP) and R&D (university and private labs). Engaged with opensource communities. Participation in FP7 projects.
Dr. Johann Marquez-Barja (IMEC)	Researcher (IMEC) and Associate Professor at University of Antwerpen	9 PhD and 5 Master Thesis, 3 postdocs	92 publ., h-index 11	Guest Editor: MDPI Sensor, Elsevier PhyCom, International Journal of Distributed Sensor Networks. Associate Editor: SCA, JWCN, Journal of Communications Engineering and Networks, Software Networking Journal. Co-leader of the Citylab Smart City testbed
Dr. Ingrid Moerman (IMEC)	Staff member at IDLab (IMEC) and Professor at University of Ghent	32 PhD, 120 Master Thesis, 14 postdocs	766 publ., h-index 43	Longstanding experience in running and coordinating national and EU research funded projects. Leader of a research team of more than 30 members. associate and guest editor of EURASIP JWCN, Hindawi Wireless Communications and Mobile Computing, MDPI Sensors
Dr. Tommy Svensson (Chalmers)	Full Professor	11 PhD, 28 Master Thesis, 5 postdocs	249 publ., h-index 30	Leader Wireless Systems Research Area. Participation in FP7 and H2020 EU projects. Editor of IEEE Wireless Comm. Letters, chair of the IEEE Sweden Vehicular Technology, Communications, Information Theory Societies chapter
Dr. Erik G. Ström (Chalmers)	Full Professor	10 PhD, 30 Master Thesis, 5 postocs	150+ publ., h-index 31	Heads the Division for Communications and Antenna Systems, and leads the competence area Sensors and Communications at the traffic safety centre SAFER. Received the Chalmers Pedagogical Prize in 1998 and the Chalmers Ph.D. Supervisor of the Year award in 2009.
Dr. Gustav Wikström (EAB)	Researcher Leader (EAB)	2 Master Thesis	90+ peer-reviewed papers (7 in field), 100+ patents	He has been driving the evolution of network performance studies, and worked with WLAN and LTE capacity enhancements. Since 2015 he has been the driver of latency and reliability improvements (URLLC) in LTE and NR.
Dr. Trevor Moore (Accelleran)	Founder and CTO at Accelleran.			30+ years of experience in the communications industry. He was instrumental in defining the concept of the 3G Femtocell and the concepts behind the Iuh architecture during 2006 when working with ip.access. System architect for 3G femtocell, 3G UMTS infrastructure and WLAN SoC development. . CTO for 4G and 5G small cell solutions in Accelleran

1.3.3 ESR progress monitoring

A tentative training and research plan will be discussed and elaborated at the beginning of the project among ESR and all his supervisors. ESRs will meet weekly with his local supervisors/PhD programme supervisors, reviewing the progress on such a plan, and during the plenary meetings with other ESRs to present their obtained results (see section 3.2.4). ESR will meet their second supervisors and

plan/track the secondment activities. Before starting the secondment (of 3-6 months duration), a detailed research plan with identified milestones. The research plan will be discussed and agreed with the main and the third supervisors through teleconference meetings. During the secondment, the ESR will have at least weekly teleconferences with his/her main supervisor.

The core element in the supervision process is the **Project Career Development Plan** (PCDP) which is created by each ESR/supervisor in the first month of the appointment, and reviewed periodically. The PCDP is the reference document where the following aspects are detailed: the i) long-term career objectives, ii) training activities, iii) research workplan, iv) portfolio of competences, v) mobility plan, vi) publication and dissemination plan and vii) deliverables of the project where the ESR is involved.

The Project Coordinator, Research Committee and Training Committee (see section 3.2 for further description) will approve the PCDP and will subsequently monitor the activities and yearly assess the progress. They will also meet (at the plenary meetings or via teleconferencing) with the ESR and, together with the main supervisor, will evaluate the career prospects of the ESRs and will give them direct feedback and counseling in relation with the PCDP and long term goals.

1.4 Quality of the proposed interaction between the participating organisations

1.4.1 Contribution of all participating organisations to the research and training programme

The contribution of each partner to the research and training program is summarized in Table 1.4a, where the following information is provided per partner: which ESRs are recruited (see also Table 1.2a). With respect the partner organizations, RWTCH just participate for awarding the PhD while Accelleran actively participate in the secondment programme and training.

Table 1.4a Mapping of participating organisations to the research and training programme

Partner	Recruiting (ESRs)	Hosting Secondments	Courses from Table 1.2d	Schools from Table 1.2d	Awarding PhDs (ESRs)
UPC	1,2	11, 13	1, 2, 5, 6	1,5	1,2
UCAM	3,4	5, 7, 9	2, 4	4, 5	3,4, 7
URJC	5,6	1, 7, 8	1, 2, 3,	2	5,6, 9
ARL	7	3, 6	5, 6	1, 2	×
FIT	8	5, 9, 12, 14	5, 6	2, 4, 5	×
TID	9	4, 5, 6, 8	3, 4, 6	2, 4	×
IMEC	10, 11	1	1	2, 3,	10, 11
Chalmers	12,13	2, 10, 14	2, 5	1, 3	12, 13, 14
EAB	14	2, 12, 13	4	2, 3, 4, 5	×
RWTH (PO)	×				8
Accelleran (PO)	×	3, 6, 10, 11	6	2, 3, 5	10,11

Table 1.4b Synergies between participating organisations

Partner	Community Networks	AI and security	5G Network infrastructure	Infrastructure platforms	Previous collaborations	Industrial/ Standardisation Groups
UPC			×		TUCAN3G (FP7 project **UPC-URJC-TID**)	5GBarcelona, TIP, 5G IA, Networld2020
UCAM		×			Dr. J- Crowcroft was on **technical advisory board for TID** (2007-2010). Student internships UCAM-TID, METRICS (ITN-MSCA **TID-UCAM**)	
URJC	×			×	TUCAN3G (FP7 project **UPC-URJC-TID**), NAPO project (Development bank of Latin America, **URJC-TID**), Agreement **FIT-URJC** for evaluating FIT's Wiback solution in URJC labs	TIP
ARL	×	×			Collaboration ARL-UPC	
FIT	×		×	×	Agreement **FIT-URJC** for evaluating FIT's Wiback solution in URJC labs. METIS 5G (FP7 project **Chalmers-EAB-TID-FIT**)	TIP, Networld2020, 5GAA

TID				×	TUCAN3G (FP7 project **UPC-URJC-TID**), NAPO project (Development bank of Latin America, **URJC-TID**), J-Crowcroft was on **technical advisory board for TID** (2007-2010). Student internships UCAM-TID, METRICS (ITN-MSCA **TID-UCAM**), WINNER I/II 4G (FP6 project **Chalmers-EAB-TID**), METIS 5G (FP7 project **Chalmers-EAB-TID-FIT**)	5GBarcelona, TIP, Open CORD, O-RAN Alliance, 5GAA
IMEC			×			
Chalmers			×		5GCAR, mmMAGIC, Metis 2020 (**EAB-Chalmers**), WINNER I/II 4G (FP6 project **Chalmers-EAB-TID**), METIS 5G (FP7 project **Chalmers-EAB-TID-FIT**)	
EAB			×	×	5GCAR, mmMAGIC, Metis 2020 (**EAB-Chalmers**), WINNER I/II 4G (FP6 project **Chalmers-EAB-TID**), METIS 5G (FP7 project **Chalmers-EAB-TID-FIT**)	3GPP, 5GAA

1.4.2 Synergies between participating organisations

Table 1.4b evidences the common research areas in terms of community networks, AI and security, 5G network infrastructure and infrastructure platforms. Notice that more than one partner tackles each topic, fostering the collaboration and reinforcing previous collaborations, i.e. UPC-URJC-TID, UCAM-TID, URJC-TID, FIT-URJC, EAB-Chalmers, Chalmers-EAB-TID, Chalmers-EAB,TID-FIT.

1.4.3 Exposure of recruited researchers to different environments and complementarity thereof

The ESRs will be complement their research through secondments among the partners in the consortium. Table 1.4c depicts the projected secondments for each ESR that satisfies an intersectoral, interdisciplinary and international approach.

Table 1.4c Exposure of ESRs to different environments

Recruiter		Hosting Beneficiaries									Hosting P.O.
Parnter	ESR no	UPC	UCAM	URJC	ARL	FIT	TID	IMEC	Chalmers	EAB	Acccelleran
UPC	1			S (3M)				S (6M)			
UPC	2								S (3M)	S (4M)	
UCAM	3				S (6M)						S (3M)
UCAM	4						S (6M)				
URJC	5		S (3M)			S (4M)	S (3M)				
URJC	6				S (3M)		S (3M)				S (3M)
ARL	7		S (6M)	S (3M)							
FIT	8			S (4M)			S (4M)				
TID	9		S (6M)			S (3M)					
IMEC	10								S (3M)		S (7M)
IMEC	11	S (3M)									S (7M)
Chalmers	12					S (3M)				S (6M)	
Chalmers	13	S (4M)								S (6M)	
EAB	14					S (3M)			S (6M)		

2. Impact

2.1 Enhancing the career perspectives and employability of researchers and contribution to their skills development

It is widely recognised that 5G is a strategic opportunity for Europe[21]. The new generation of network technologies will allow providing wireless broadband service and supporting new types of applications based on Internet of Things, together with innovative business models across multiple sectors. But, in spite of the bright perspectives and promising results, and the potential high number of underserved rural subscribers, rural areas are still left behind in broadband connectivity[22] both at the European level and worldwide. The high cost of investment, the relatively low expected revenues and the low level of human development conform a vicious circle that results in the lack of viable business cases and hence little attention paid by standardisation groups, operators and industry. To reverse this situation and avoiding a new digital breach, a generation of specialists able to generate appropriate solutions is

[21] 5G for Europe: An Action Plan, 2016, https://ec.europa.eu/digital-single-market/en/news/communication-5g-europe-action-plan-and-accompanying-staff-working-document

[22] https://www.agriland.ie/farming-news/eu-broadband-behind-target-particularly-in-rural-areas/

required. 5G4real is conceived as a program that will train these high-quality researches with appropriate skills for leading positions specializing in the area of communications.

2.2 Contribution to structuring doctoral/early-stage research training at the European level and to strengthening European innovation capacity

2.2.1 Meaningful contribution of the non-academic sector to the doctoral /research training

According to the good practice elements in doctoral training[23] the non-academic sector collaborate with universities in the formation of the researchers in all aspects: i) *Research*: Supervise their recruited ESRs and those who carry out secondments in the industrial beneficiary, see section 1.2.3. ii) *Training*: With the objective of providing the adequate skills needed for the near future, see section 1.2.2, iii) *Networking*: Industrial partners are responsible for the industrial dissemination day, see Table 1.2c, where the work developed by ESRs will be introduced to telecom stakeholders. iv) *Technical supervision*: Non-academic partners are responsible of monitoring the technical progress of the ESRs' work, detecting business opportunities and supervising exploitation and innovation activities, see section 3.2.

The non-academic sector of 5G4real consists of TID (operator), Accelleran (5G manufacturer), FIT (wireless backhaul), EAB (Network Infrastructure) and ARL (wireless mesh networks) providing a necessary and complimentary ecosystem for research in 5G wireless networks.

2.2.2 Contribution to structuring doctoral/early-stage research training at the European level

The training programme satisfies the 7 principles for an Innovative Doctoral training[24]: a) *Research Excellence*: All ESRs will be enrolled in PhD programmes in different universities that ensures an adequate research environment. Furthermore, the research excellence of the supervisors (see Table 1.3b) will be fundamental to guide the ESRs in the proper research direction and train the research spirit. At the consortium level, workpackage leaders and technical coordinator (see section 3.2) will monitor the novelty of the research work. b) *Attractive Institutional Environment*: All beneficiaries of the ITN have experience in collaborative projects (ITN-MSCA, FP7, H2020), see section 5, and have excellent working conditions for the researchers. Likewise, UPC, UCAM, IMEC have adhered to the European Charter for Researchers and the Human Resources Strategy for Researchers (HRS4R)[25]. c) *Interdisciplinary Research Options*: 5G4real will promote the open science, identifying the adequate way of disseminating the research results (open source, licensing, …), ensuring replicability, and fostering the collaboration of ESRs with other researchers. d) *Exposure to industry and other relevant employment sectors*: The secondments ensure that ESRs will be in touch with academia, industry and research centres. e) *International networking*: The envisioned secondments are international, i.e. at a different country where the ESR is recruited. Likewise, the research work is planned to be presented in international conferences that allows the international networking. f) *Transferable skills training*: Section 1.2 describes all the transferable skills to be learned. g) *Quality Assurance*: Although each PhD programme defines a set of procedures to ensure the quality of the doctoral education (admission, supervision, awarding the doctorate degree, etc), 5G4real will also monitor the adequate progress of the researchers by the project development career plan (PDCP), see section 1.3.

5G4real is an ITN to train a new generation of researchers to exploit the 5G technical advances to deploy telecom infrastructures in suburban and rural areas with the objective of extending the connectivity everywhere and to everybody. In addition to train researchers, 5G4real is an opportunity to strengthen the previous collaborations among partners in this topic, see section 1.4.2, and thus continuing the research collaboration in projects at European and/or National level.

2.2.3 Strengthening European innovation capacity

5G4real is the first European initiative aiming at structuring a coherent and comprehensive training programme for a new generation of researchers that will be able to exploit 5G technical advances to extend connectivity everywhere and to everybody. 5G4real represents an opportunity to reinforce the

[23] https://www.leru.org/files/Good-Practice-Elements-in-Doctoral-Training-Full-paper.pdf
[24] https://euraxess.ec.europa.eu/sites/default/files/policy_library/principles_for_innovative_doctoral_training.pdf
[25] https://euraxess.ec.europa.eu/spain/services/human-resources-strategy-researchers-hrs4r

previous collaborations among partners in this topic (see section 1.4.2), and continuing the research collaboration in projects at European and/or National level.

In this context, the unique expected features of 5G4real leading to strengthening European innovation are: **1)** to ensure the presence of all the stakeholders profiles involved in bringing wireless broadband connectivity for everyone; **2)** the inclusion of SMEs that will generate not only the opportunity to bring new ideas into products, but also the knowledge for the incubation of new companies; **3)** to generate the opportunity of transferring fundamental research outcomes to standardization (TID and EAB are active contributors to 3GPP, and forums like TIP) and actual implementations (by manufacturers, operators and service creators), through a carefully designed research plan and supported by appropriate secondments; **4)** foster the interest of European and world-wide graduates and young researchers for new ICT technologies, and for bringing them to everyone; **5)** place the industrial beneficiaries in the position to deploy and commercialize European developed technologies in rural and suburban areas throughout the world, with the potential of new 1.5 billion subscribers

2.3 Quality of the proposed measures to exploit and disseminate the results

2.3.1 Dissemination of the research results

An adequate communication strategy is crucial for the success of the dissemination and eventual impact of results. In this regard, 5G4real has a dissemination and exploitation committee (see section 3.2) that is responsible for its design and implementation. The strategy focusses in 4 areas:

Publication in top conference and journals.
Submitting technical work to top conferences has a two-fold objective. In one hand the work goes through a though a review process that guarantees the novelty and importance of the work, and generates valuable feedback. Additionally, in case it is accepted, ESRs their presentation skills, and have the opportunity to interact with high-class researchers, again receiving valuable feedback and improving their networking. At least **1 conference publication per ESR is expected each year**. Examples of top conferences are: from *IEEE (Globecom, ICC, Vehicular Technology Conf., Netsoft, Infocom), ACM MobiCom, EUCNC*. Furthermore, the dissemination and exploitation committee will continuously monitor and encourage that papers accepted in conferences be extended, further elaborated and submitted to high-level journals. At least **2 journal publications per ESR are expected during the ITN lifetime**. It must be remarked that many/all PhD programmes define a minimum number of journal publications. Examples of top journals are: *IEEE (Trans. Communications, Trans. Wireless Comm., Journal on Selected Areas in Comm., Access), ACM Trans. on Multimedia Computing, Comm. and Applications, IET Comm., EURASIP Journal on Wireless Comm. and Networking.* Finally, the dissemination and exploitation committee will identify and encourage that ESRs working in similar areas (i.e. in the same workpackage) coordinate to generate joint technical publications. Some of them might be general enough to impact a wider audience and be published in top journals such as *IEEE (Communication Magazine),* It is expected that each ESR will generate **2 journal publications** during the duration of their contract (maybe 1 journal plus 1 patent for ESR contracted by industry).
Open-access engagement and reproducible research
Section 3.2 provides details on the data management plan (deliverable D5.5 in section 3.1), to ensure the adequate wide access to the results of the network. 5G4real plans the following strategies: **a)** Publication in open repositories (e.g. arxiv.org) when submitting a conference/journal, **b)** Working in an open-access version of the code to allow replicating the results of the accepted conference/journal publications, **c)** Open-access PhD dissertations, **d)** open-software in open-repositories (e.g. Github) and interaction with the users of that software, **e)** videos of the technical work presented at conferences.
Workshop/conference organization.
Three one day-workshops (M18, M32, M39 see Table 1.2c) will be organized with the objective of presenting a unified view of 5G4real achievements. The technical workshops will be collocated with important IEEE/ACM conferences and will consist on: i) panel, ii) technical work and c) invited talks, with a solid participation of industrials, being them beneficiaries or not
Standardisation
The dissemination and exploitation committee will meet quarterly with the relevant staff of the industrial partners to identify potential opportunities to contribute to standardisation bodies (3GPP, IETF), to industrial forums (Networld2020, 5G-IA, TIP) and to 5G development initiatives like 5GBarcelona (https://5gbarcelona.org), where UPC and TID are involved. These opportunities will be distributed to the ESR and their advisors who will decide on how to orient their work and generate contributions.

2.3.2 Exploitation of results and intellectual property

The obtained results will be reviewed by the Dissemination, Innovation and Exploitation Committee (see section 3.2) through the activity reports of ESR, in order to identify opportunities generate recommendations for exploitation in two respects: **i) Possible patent applications will be identified in the PCDP** (see section 1.3.3). All partners have Technology Transfer Offices to assists ESRs in selecting the best way to transfer the research results: license, patent, start-up, joint-venture, etc. ESRs will be trained in all these aspects (see training courses in section Table 1.2d). The Consortium

Agreement, (see section 3.2) will clearly specify the management of the pre-existing knowledge and the one generated during the ITN among all partners; **iv) Participation in interest groups**. An additional way of exploiting results in by participating in technical committees, special interests groups and standardisation (see section 2.3.1). The partners of 5G4real participate in groups such as, Networld2020 (UPC, FIT), TIP (UPC, URJC, FIT, TID, Accelleran), 3GPP (EAB, TID), IETF (UCAM). The feedback obtained in those meetings will be useful to adjust the research lines of ESRs and possibly set up collaborations with new partners. The suitable meetings to attend will be monitored and continuously updated in deliverable D6.1.

2.4 Quality of the proposed measures to communicate the activities to different target audiences

2.4.1 Communication and public engagement strategy

An essential aspect for a high-impact results dissemination is a tangible plan for targeting the non-specialist and young people. 5G4real has conceived multiple activities that will be detailed in D6.1:.

5G4real open days
All the beneficiaries will coordinate to organize during the same week an event open to local high-school students, advanced vocational education, bachelor and master students. Special care will be taken to attract the female audience (see section 3.2.7). It is expected a tour at the research laboratories, hands-on experiments, and interaction with ESRs. Furthermore, with the objective of showing the EU-level of the ITN, the visiting students will have the opportunity to interact (teleconference) with other visiting students present at premises of the other beneficiaries. The number of events and detailed schedule will be defined in D6.1
Social Media
A dedicated website will be maintained by UPC where the activities of all the ITN's will be uploaded periodically. However, with the objective of interacting with a larger community and improving the networking contacts, UPC will create a specific group in LinkedIn inviting networking contacts that could follow the results reported in the group. Furthermore, Twitter/Instagram will be used to interact with people. Finally, a YouTube channel will be created to store all the video material generated in the ITN such as conference presentations, lectures, experiments, open-days, public talks, etc. The social media groups will be managed by UPC. The media statistics (i.e. number of followers, subscribers, retweets, etc.) providing indicators of impact will be monitored and published by the PC
E-Newsletter
A summary of the ITN achievements will be published every 6 months (see WP6) where the content will be specifically designed to address a non-specialist audience. The E-newsletter will be available at the ITN webpage and distributed over the social media
Video-clips:
In addition to having 3-minutes video recordings of the technical research work, see section 2.3.1, it is expected generate **at least 1 video per ESR** where the target audience is non-specialist, and they will be available at ITNs' Youtube channel. Likewise, 5G4real will foster the participation of the ESRs in pitch contests (elevator pitches) to explain their research work to a wider audience, like the contests of thesis in 4 minutes at the UPC, (e.g. https://doctorat.upc.edu/en/thesis/contest-thesis-in-4-minutes).
Public talks
Each ESR will give a **public talk every year targeting to non-experts**. This talk will be recorded and made available through the social media. Examples of target events are: Night of Researchers, Science Week (UCAM), European Development Days, or science festivals (e.g. The International Science Festival in Gothenburg, http://vetenskapsfestivalen.se/in-english/).
Dissemination in press and general media
All partners have press and media offices (e.g. https://www.upc.edu/en/press-room) that will help to promote the results of the ITN to the local and national press, with the objective of raising the awareness about the benefits of the European ITN for the society. The target is to have up to **1 publication/interview per year**. Some tentative targets in the Spanish media are http://www.rtve.es/television/lab24/,
Regulators and industrial forums and panels:
The ITN activity will be disseminated in relevant industrial forums (Mobile World Congress, 5GBarcelona,…) where beneficiaries are actively participating. Likewise, 5G4real partners will organise meetings with local/regional/national policy makers and public bodies to show the benefits of the research in science at the long-term and the importance over the society. Finally, one meeting with NGOs (previously identified by the dissemination and exploitation committee), community networks, regulators will be organised to show network results and get feedback (workshop in M30, see Table 1.2c) and to discuss about opportunities and hurdles in rural areas.

3. Quality and Efficiency of the Implementation

3.1 Coherence and effectiveness of the work plan,

3.1.1. Work Packages description

Table 3.1 a Description of Work Packages

WP Number	**1**	**M8 –M44**
WP Title	5G Network planning and business models (Research)	
Lead Beneficiary	URJC (Dr. Javier Simó)	*Beneficiaries: ARL, UPC, URJC*

Objectives Planning tools for upper frequency bands and shared infrastructure deployments, 5G business models, smart contracts for shared infrastructures, definition of requirements for e-learning/e-health services.

Description of Work and Role of Specific Beneficiaries / Partner Organisations

Task 1.1. Network dimensioning (ESR2-UPC, M8-M24). Develop a deep understanding of the tradeoffs associated to the dimensioning of a RAN and backhaul network under the 5G NR paradigm and the slicing concept. Perform a technical analysis on how network planning tools can impact the deployment and operational cost of 5G in terms of required equipment, energy consumption, variable coverage, changes in maintenance activities and required backhauling bandwidth.

Task 1.2. Planning tool (ESR2-UPC, M18-M44) The number network elements (fixed and mobile base stations, edge servers/caches, backhaul routers, reflective passive elements, energy harvesting elements and core functionalities) are dimensioned and positioned appropriately taking into account the analysis performed in task 1.1.

Task 1.3. Smart contracts (ESR7-ARL, M8-M20) Defining the appropriate governance rules through a DAO and set of clearly defined smart contracts that are scalable and adaptable in a multi-stakeholder scenario.

Task 1. 4. 5G impact in rural areas (ESR6-URJC, M8-M26). Analysis of the potential impact that 5G technologies may have on the economy and basic services (education, health…) in rural areas as an incentive for public administration involvement.

Task 1.5. Business model (ESR6-URJC, M20-M44). Design of innovative business model to provide services in low-density areas which will be based on results from previous tasks and will promote a sharing-resources strategy among different stakeholders (operators, public administrations, community networks, etc.). Develop a methodology to derive techno-economic results.

Description of Deliverables

D1.1: Building blocks for 5G Network planning and business model (M20)

D1.2: Intermediate report on Network dimensioning and business models (M32)

D1.3: Planning tool, business models and techno-economic results (M44)

WP Number	**2**	**M8 –M44**
WP Title	5G Network infrastructure (Research)	
Lead Beneficiary	IMEC (Dr. Johann Marquez-Barja)	*Beneficiaries: UPC, URJC, IMEC, Chalmers, EAB, FIT*

Objectives: Open RAN for 5G, energy-aware integrated use 5G bands for access and heterogeneous backhaul, adaptive self-organized mesh backhaul, network slicing.

Description of Work and Role of Specific Beneficiaries / Partner Organisations

Task 2.1. Mobile base stations (ESR12-Chalmers, ESR13-Chalmers, ESR14-EAB- M8 – M44) Develop deep understanding of all drawbacks that mobile base statins impose in wireless communications, and design novel algorithms at PHY and MAC layers in order to have a viable solution that will provide coverage and connectivity in rural areas.

Task 2.2. Resource allocation and route selection in heterogeneous backhaul networks (ESR1-UPC, ESR5-URJC – M8-44) The goal is propose algorithms for network optimization and provide software for the monitorization and orchestration of a software-defined network.

Task 2.3. Slicing and edge devices (ESR8-FIT, ESR10-IMEC, ESR11-IMEC – M8-44) Provide slicing and edge computing support, management and optimization to the concepts developed in task 2.1 and task 2.2. Link to tasks in WP3.

Description of Deliverables

D2.1: State of the art on mobile base stations, network optimization in SDN-based networks and slicing (M20)

D2.2: Intermediate report on mobile base stations, heterogeneous backhaul and slicing (M32)

D2.3: Final report on report on mobile base stations, heterogeneous backhaul and slicing (M44)

WP Number	**3**	**M8 –M44**
WP Title	5G Services, operation and architectural support (Research)	
Lead Beneficiary	UCAM (Dr. Jon Crowcroft)	*Beneficiaries: UCAM, ARL, TID*

Objectives: Edge computing, artificial intelligence, network-wide security in a shared infrastructure, service level objectives with delivered connectivity/computing/storage resources, management of network slicing

Description of Work and Role of Specific Beneficiaries / Partner Organisations

Task 3.1. Cloud-based architectures (ESR9-TID, M8-M44), (ESR4-UCAM, M8-M44). Review cloud-system architectures including unikernels and containers, lambda services and micro-services. Design novel algorithms for network management across domains and creating cloud-ready API for automation, to support telco specific requirements of the new infrastructure. Replace swarm/Kubernetes with finer grain, large numbers (millions) of edge systems.

Task 3.2. Authentication in multi-tenancy networks (ESR7-ARL, M21-M44) Definition if the right blockchain architecture that can fulfil the needs identified in Task 1.3 (WP1) while efficiently addressing the challenges and scale in terms of energy, security and performance, considering permissioned versus permissionless blockchain.

Task 3.3 Network analytics (ESR3-UCAM, M8-M44). Use machine learning in 5G base stations and program on top of NFV to build up models of performance and faults that can be remotely queried and aggregated, reducing the required telemetry. Evaluation on real network data and system running on real network devices.

Description of Deliverables

D3.1: Survey of state of the art on cloud-based architectures and ML-based management (M20)

D3.2: Design and preliminary evaluation of scalable privacy preserving ML techniques (M32)

D3.3: In-depth benchmarking of cloud-based architectures and authentication techniques implementing network analytics (M44)

WP Number	**4**	**M1 –M48**
WP Title	Training	
Lead Beneficiary	Chalmers (Dr. Tommy Svensson)	*Beneficiaries: All*

Objectives: Supervision and coordination of all training events of the ITN. Preparation of the platforms to deliver the remote training.

Description of Work and Role of Specific Beneficiaries / Partner Organisations

Task 4.1 Remote training platform (UPC, All) M1-M48. Preparation of the platform for the remote training, repository of training materials and support to users.

Task 4.2 Network training event organisation (Chalmers, All). M1-M48. Local organisation and coordination of different training events described in section 1.2 and invited talks (Table 1.2c/d)		
Description of Deliverables D4.1 Report on training activities for the first (M12), second (M24), third (M36), and fourth (M48) year. Summary of the training activities carried out over the different periods. The document will be updated each year, releasing a new version. D4.2 Remote training platform user guide (M8). A users' guide to the available courses.		
WP Number	**5**	**M1–M48**
WP Title	ITN Coordination and Management	
Lead Beneficiary	UPC (Dr. Josep Vidal)	*Beneficiaries: All*
Objectives: Administrative management of the ITN with a close supervision of the envisioned deliverables and milestones. Identification of risks and solutions proposal to deal with them in the SB (supervisory board).		
Description of Work and Role of Specific Beneficiaries / Partner Organisations This WP monitors the adequate progress of the workplan according to the contract and the management structure defined in section 3.2.		
Description of Deliverables D5.1 Consortium agreement (M6). Internal managing rules (IPR, legal provisions to alter membership, management funds, etc), see sec. 3.2.2 D5.2 ITN Handbook (M4). Document with all organisational procedures agreed by all partners, see section 3.2.2 D5.3 Gender Issues Plan (M6). Generating recommendations to ensure gender equality, see section 3.2.7 D5.4 Risk Management Plan (M6). Identification of possible risks to be tackled during the ITN, see section 3.2.5. D5.5 Data Management Plan (M6). Management of the results generated in the ITN (publications, software, data, videos), see section 3.2.8. D5.6 Administrative Management and Quality reports (M12, M24, M36, M48). All management activities carried out each year. D5.7 Compilation of all individual Personal Career Development Plan (M3, M15, M27, M39). Progress monitoring and evaluation of individual projects and their objectives, see sec. 3.2.4.		
WP Number	**6**	**M1 –M48**
WP Title	Dissemination and outreach	
Lead Beneficiary	EAB (Dr. Gustav Wikström)	*Beneficiaries: All*
Objectives: Dissemination and promotion of the research results and ITN benefits towards experts, non-experts and creating public engagement. Identification of opportunities to exploit the results. Coordination of the open-data results fostering the collaboration with other stakeholders non-present at the ITN. Details on section 2.3.1, 2.3.2, 2.4.1		
Description of Work and Role of Specific Beneficiaries / Partner Organisations Task 6.1 Scientific dissemination (URJC, All) This task will promote among ESRs the opportunities for scientific dissemination (conferences, journals), see section 2.3.1. Task 6.2 Industrial dissemination (EAB, All) Promoting the research results in the industrial forums and standardization groups, see section 2.3.1 and 2.3.2 Task 6.2 Outreach and public engagement (FIT, All) The objective is to reach a larger audience, creating public awareness about the research developed in 5G4real. Specific actions have been defined in section 2.4.1		
Description of Deliverables *(brief description and month of delivery)* D6.1 Dissemination, Exploitation and Innovation Plan (M6). Overall plan for disseminating the obtained results. D6.2 Report on dissemination/outreach of the project (M12, M24, M36, M48). Description of all activities carried out per year.		
WP Number	**1**	**M8 –M44**
WP Title	5G Network planning and business models (Research)	
Lead Beneficiary	URJC (Dr. Javier Simó)	*Beneficiaries: ARL, UPC, URJC*
Objectives Planning tools for upper frequency bands and shared infrastructure deployments, 5G business models, smart contracts for shared infrastructures, requirements defined by e-learning/e-health services		
Description of Work and Role of Specific Beneficiaries / Partner Organisations Task 1.1. Network dimensioning (ESR2-UPC, M8-M24). Develop a deep understanding of the tradeoffs associated to the dimensioning of a RAN and backhaul network under the 5G NR paradigm. Perform a technical analysis on how network planning tools can impact the deployment and operational cost of 5G in terms of required equipment, energy consumption, increase or decrease in coverage, changes in maintenance activities, required backhauling bandwidth Task 1.2. Planning tool (ESR2-UPC, M18-M44) The number network elements (base stations, edge servers/caches, backhaul routers, reflective passive elements, energy harvesting elements and core functionalities) are dimensioned and positioned appropriately taking into account the analysis performed in task 1.1. Task 1.3. Smart Contracts (ESR7-ARL, M8-M20) Defining the appropriate governance rules through a DAO and set of clearly defined smart contracts that are scalable and adaptable in a multi-stakeholder scenario. Task 1. 4. 5G impact in rural areas (ESR6-URJC, M8-M26). Analysis of the potential impact that 5G technologies may have on the economy and basic services (education, health…) in rural areas as an incentive for public administration involvement. Task 1.5. Business Model (ESR6-URJC, M20-M44). Design of innovative business model to provide services in low-density areas which will be based on results from previous tasks and will promote a sharing-resources strategy among different stakeholders (operators, public administrations, community networks, etc.).		
Description of Deliverables D1.1: Building blocks for 5G Network planning and business model (M20) D1.2: Intermediate report on Network dimensioning and Business models (M32) D1.3: Planning tool and Business models (M44)		
WP Number	**2**	**M8 –M44**
WP Title	5G Network infrastructure (Research)	
Lead Beneficiary	IMEC (Dr. Johann Marquez-Barja)	*Beneficiaries: UPC, URJC, IMEC, Chalmers, EAB, FIT*

Objectives: open RAN for 5G, energy-aware integrated use 5G bands for access and heterogeneous backhaul, adaptive self-organized mesh backhaul, network slicing

Description of Work and Role of Specific Beneficiaries / Partner Organisations

Task 2.1. Mobile Base Stations (ESR12-Chalmers, ESR13-Chalmers, ESR14-EAB- M8 – M44) The goal is to have a good understanding of all the drawbacks that mobile base statins impose in the wireless communications, and to design novel algorithms at PHY and MAC layers in order to have a viable solution that will provide coverage and connectivity in rural areas.

Task 2.2. Resource allocation and route selection in heterogeneous backhaul networks (ESR1-UPC, ESR5-URJC – M8-44) The goal is propose algorithms for network optimization and providing software for the monitorization and orchestration of a software-defined network

Task 2.3. Slicing (ESR8-FIT, ESR10-IMEC, ESR11-IMEC – M8-44) Definition of the slices, management and optimization.

Description of Deliverables

D2.1: State of the art on mobile base stations, network optimization in SDN-based networks and slicing (M20)

D2.2: Intermediate report on mobile base stations, heterogeneous backhaul and slicing (M32)

D2.3: Final report on report on mobile base stations, heterogeneous backhaul and slicing (M44)

WP Number	**3**	**M8 –M44**
WP Title	5G Services, operation and architectural support (Research)	
Lead Beneficiary	UCAM (Dr. Jon Crowcroft), *Beneficiaries: UCAM, ARL, TID*	

Objectives: Edge computing, artificial intelligence, network-wide security in a shared infrastructure, service level objectives with delivered connectivity/computing/storage resources, management of network slicing, disaggregation of hardware,

Description of Work and Role of Specific Beneficiaries / Partner Organisations

Task 3.1. Cloud-based architectures (ESR9-TID, M8-M44), (ESR4-UCAM, M8-M44). Review cloud systems architectures including unikernels and containers, lambda services and micro-services. Design novel algorithms for system management and creating cloud-ready API for automation, to support telco specific requirements of the new infrastructure. Replace swarm/Kubernetes with finer grain, large numbers (millions) of edge systems.

Task 3.2. Authentication in multi-tenancy networks (ESR7-ARL, M21-M44) Definition if the right blockchain architecture that can fulfil the needs identified in Task 1.3 (WP1) while efficiently addressing the challenges and scale in terms of energy, security and performance, considering permissioned versus permissionless blockchain.

Task 3.3 Network Analytics (ESR3-UCAM, M8-M44). Use of machine learning at 5G base stations and programming on top of NFV to build up models of performance and faults that can be remotely queried and aggregated, reducing the required telemetry. Evaluation on real network data and system running on real network devices

Description of Deliverables

D3.1: Survey of state of the art on Cloud-based architectures and ML (M20)

D3.2: Design and preliminary evaluation of scalable decentralised privacy preserving ML (M32)

D3.3: In-depth benchmarking of Cloud-based architectures, authentication and network analytics (M44)

WP Number	**4**	**M1 –M48**
WP Title	Training	
Lead Beneficiary	Chalmers (Dr. Tommy Svensson), *Beneficiaries: All*	

Objectives: Supervision and coordination of all training events of the ITN. Preparation of the platforms to deliver the remote training.

Description of Work and Role of Specific Beneficiaries / Partner Organisations

Task 4.1 Remote training platform (UPC, All) M1-M48. Preparation of the platform for the remote training, uploading the training material and providing support to the users.

Task 4.2 Network training event organisation (Chalmers, All). M1-M48. Organisation and coordination with the local organisers the different training events described in section 1.2 and invited talks (Table 1.2c/d)

Description of Deliverables

D4.1 Report on training activities for the first (M12), second (M24), third (M36), and fourth (M48) year. Summary of the training activities carried out over the different periods. The document will be updated each year, releasing a new version.

D4.2 Remote training platform user guide (M8). A guide to show how the users can follow the different available courses.

WP Number	**5**	**M1–M48**
WP Title	ITN Coordination and Management	
Lead Beneficiary	UPC (Dr. Josep Vidal), *Beneficiaries: All*	

Objectives: Administrative management of the ITN with a close supervision of the envisioned deliverables and milestones. Identification of risks and propose solutions to deal with them in the SB (supervisory board).

Description of Work and Role of Specific Beneficiaries / Partner Organisations

This WP monitors the adequate progress of the workplan according to the contract and the management structure defined in section 3.2.

Description of Deliverables

D5.1 Consortium agreement (M6). Internal managing rules (IPR, legal provisions to alter membership, management funds, etc), see sec. 3.2.2

D5.2 ITN Handbook (M4). Document with all organisational procedures agreed by all partners, see section 3.2.2

D5.3 Gender Issues Plan (M6). Generating recommendations to ensure gender equality, see section 3.2.7

D5.4 Risk Management Plan (M6). Identification of possible risks to be tackled during the ITN, see section 3.2.5.

D5.5 Data Management Plan (M6). Management of the results generated in the ITN (publications, software, data, videos), see section 3.2.8.

D5.6 Administrative Management and Quality reports (M12, M24, M36, M48). All management activities carried out each year.

D5.7 Compilation of all individual Personal Career Development Plan (M3, M15, M27, M39). Progress monitoring and evaluation of individual projects and their objectives, see sec. 3.2.4.

WP Number	**6**	**M1 –M48**

WP Title	Dissemination and outreach
Lead Beneficiary	EAB (Dr. Gustav Wikström), *Beneficiaries: All*
Objectives: Dissemination and promotion of the research results and ITN benefits towards experts, non-experts and creating public engagement. Identification of opportunities to exploit the results. Coordination of the open-data results fostering the collaboration with other stakeholders non-present at the ITN. Details on section 2.3.1, 2.3.2, 2.4.1	
Description of Work and Role of Specific Beneficiaries / Partner Organisations Task 6.1 Scientific dissemination (URJC, All) This task will promote among ESRs the opportunities for scientific dissemination (conferences, journals), see section 2.3.1. Task 6.2 Industrial dissemination (EAB, All) Promoting the research results in the industrial forums and standardization groups, see section 2.3.1 and 2.3.2 Task 6.2 Outreach and public engagement (FIT, All) The objective is to reach a larger audience, creating public awareness about the research developed in 5G4real. Specific actions have been defined in section 2.4.1	
Description of Deliverables *(brief description and month of delivery)* D6.1 Dissemination, Exploitation and Innovation Plan (M6). Overall plan for disseminating the obtained results. D6.2 Report on dissemination/outreach of the project (M12, M24, M36, M48). Description of all activities carried out per year.	

3.1.2 List of major deliverables

The list of milestones for 5G4real are detailed in Table 3.1b.

Table 3.1 b Deliverables List

Scientific Deliverables						
No	**Deliverable Title**	**WP No.**	**Lead Beneficiary Short Name**	**Type**	**Diss. Level**	**Due Date**
D1.1	Building blocks for 5G Network planning and business model	1	URJC	R	PU	M20
D1.2	Intermediate report on Network dimensioning and business models	1	URJC	R	PU	M32
D1.3	Planning tool, business models and techno-economic results	1	UPC	R	PU	M44
D2.1	State of the art on mobile base stations, network optimization in SDN-based networks and slicing	2	IMEC	R	PU	M20
D2.2	Intermediate report on mobile base stations, heterogeneous backhaul and slicing	2	Chalmers	R	PU	M32
D2.3	Final report on report on mobile base stations, heterogeneous backhaul and slicing	2	FIT	R	PU	M44
D3.1	Survey of state of the art on cloud-based architectures and ML-based management	3	TID	R	PU	M20
D3.2	Design and preliminary evaluation of scalable privacy preserving ML techniques	3	UCAM	R	PU	M32
D3.3	In-depth benchmarking of cloud-based architectures and authentication techniques implementing network analytics	3	ARL	R	PU	M44
Management, Training, Recruitment and Dissemination Deliverables						
No	**Deliverable Title**	**WP No.**	**Lead Benef. Short Name**	**Type**	**Diss. Level**	**Due Date**
D4.1	Report on training activities	4	Chalmers	OTHER	PU	M12, M24, M36, M48
D4.2	Remote training platform user guide	4	UPC	OTHER	PU	M8
D5.1	Consortium agreement	5	UPC	OTHER	CO	M6
D5.2	ITN Handbook	5	UPC	OTHER	CO	M4
D5.3	Gender Issues Plan	5	UPC	OTHER	PU	M6
D5.4	Risk Management Plan	5	UPC	OTHER	CO	M6
D5.5	Data Management Plan	5	UPC	OTHER	CO	M6
D5.6	Administrative Management and Quality reports	5	UPC	ADM	CO	M12, M24, M36, M48
D5.7	Compilation of all individual Personal Career Development Plans	5	UPC	ADM	PU	M12, M24, M36, M48
D6.1	Dissemination, Exploitation and Innovation Plan	6	EAB	PDE	PU	M6
D6.2	Report on dissemination/outreach of the project	6	FIT	PDE	PU	M12, M24, M36, M48

3.1.3 List of major milestones

The list of milestones for 5G4real are detailed in Table 3.1c.

Table 3.1 c Milestones List

No	Title	WPs	Lead Beneficiary	Due Date	Means of Verification
MS1	Launch of the Project website and social media accounts (Twitter/Youtube, …) and D5.2	5	UPC	M4	Announcements of the ITN over the social media and distribution of the ITN handbook (D5.2) among partners
MS2	Advertising of ESR open positions.	5	UPC	M2	Description of the open positions will be available of the different platforms: Euraxess, linkedin, IEEE, webpage, social media
MS3	Consortium Agreement ready and signed	5	UPC	M6	Deliverable D5.1 submitted
MS4	Completion of Dissemination, Data Management, Quality, Knowledge, Gender Issues Plans	5	UPC	M6	Deliverables D5.2, D5.3, D5.4, D5.5, D6.1 submitted
MS5	Remote training platform activation	4	UPC	M7	Platform running and distribution of D4.2
MS6	ESR recruitment and PhD enrolment	5	UPC	M12	All ESRs recruited
MS7	Internal project review year 1	All	UPC	M12	Review of all activities of the project in the 1st year. Deliverables: D4.1, D5.6, D5.7, D6.2
MS8	Mid-Project review	All	UPC	M13-15	Meeting with EU project officer
MS9	Internal project review year 2	All	UPC	M24	Review of all activities of the project in the 2nd year. Update Documents: D4.1, D5.6, D5.7, D6.2
MS10	Internal project review year 3	All	UPC	M36	Review of all activities of the project in the 3rd year. Update Documents: D4.1, D5.6, D5.7, D6.2
MS11	Internal project review year 4	All	UPC	M48	Review of all activities of the project in the 4th year. Update Documents: D4.1, D5.6, D5.7, D6.2
MS12	Successful completion of PhD	1-3	UPC	M48	Announcement over the project website and social media about each successful PhD title

3.1.4 Fellow's individual projects

Table 3.1d Individual Research Projects

Fellow	Host institution	PhD enrolment	Start date	Duration (months)	Deliverables
ESR 1	**UPC**	**Y**	**M8**	**36**	D2.1, D2.2, D2.3
Project Title (WPs): Energy-aware joint resource management for access and heterogeneous backhaul networks (WP2)					
Objectives: a) To derive an analytical approach for the modelling of multiple services on heterogeneous backhaul and 5G RAN network under a multitenancy regime managed by a neutral operator. Energy-awareness constraints will be considered. b) To develop a framework for monitorization, orchestration and optimization of a software-defined network. The goal is to dynamically allocate/manage a wide range of resources (access – backhaul spectrum, RAN split, core services distribution) across tenants, , and to design optimal routes for flows associated to different network slices. c) To gain full understanding of system performance in terms of throughput and end-to-end delay for different network topologies, number of tenants, energy limitations and frequency bands used.					
Expected Results: a) A comprehensive understanding of the requirements and limitations for service provision in rural areas using a 5G NR network, b) To develop software tools for the monitorization, orchestration and optimization of a software-defined network that is capable of dynamically providing the best allocation of resources and routes for concurrent multiple services.					
Planned secondment(s): 1) IMEC, I. Moerman, M21, 6 months, Develop optimal techniques for concurrent 5G slicing across networks, **2)** URJC, A. Martinez, M30, 3 months, Identify the practical limitations, test and implement solutions over the URJC's testbed					
Enrolment in Doctoral degree(s): The ESR will be enrolled at Universitat Politècnica de Catalunya (UPC), https://doctorat.upc.edu/en					
Fellow	**Host institution**	**PhD enrolment**	**Start date**	**Duration (months)**	**Deliverables**
ESR 2	**UPC**	**Y**	**M8**	**36**	D1.1, D1.2,D1.3
Project Title (WPs): Network planning and monitoring for 5G in low density populated areas (WP1)					
Objectives: a) Develop a deep understanding of the tradeoffs associated to the joint dimensioning of a RAN and a backhaul network under the 5G NR paradigm. Design a planning tool where all network elements (base stations, edge servers/caches, backhaul routers, energy harvesting elements and core functionalities) are dimensioned and positioned appropriately in a multi-tenancy regime. b) Study the techno-economic benefits from deployment of reflective passive elements together with massive MIMO. c) Feed techno-economical models.					
Expected Results: a) Design a planning tool where all network elements (base stations, edge servers/caches, backhaul routers, energy harvesting elements and core functionalities) are dimensioned and positioned appropriately in a multi-tenancy regime., b) Generate recommendations for the deployment of economically viable 5G networks in rural and suburban deployments.					
Planned secondment(s): 1) Chalmers, M27, 3 months, Include the mixed fixed and mobile base stations deployment into the planning tool**., 2)** EAB, G. Wikström,M31,4 months, Integrate the concept of mobile base stations into the techno-economic model					
Enrolment in Doctoral degree(s): The ESR will be enrolled at Universitat Politècnica de Catalunya (UPC), https://doctorat.upc.edu/en					
Fellow	**Host institution**	**PhD enrolment**	**Start date**	**Duration (months)**	**Deliverables**

ESR 3	UCAM	Y	M8	36	D3.1, D3.2, D3.3
Project Title (WPs): Edge artificial intelligence: methods and functions for network management (WP3)					
Objectives: a) Use of machine learning at 5G base stations and programming on top of NFV to build up models of performance and faults that can be remotely queried and aggregated, reducing the required telemetry, b) Evaluation on real network data and system running on real network devices					
Expected Results: Code and prototype results and Publications					
Planned secondment(s): 1) ARL, A. Sathiaseelan, M20, 6 months, Integration of activities into the network simulator of ARL and evaluate performance, **2)** Accelleran, T. Moore, M27, 3 months, Understand the limitations of edge devices when implementing ML methods.					
Enrolment in Doctoral degree(s): The ESR will be enrolled at University of Cambridge (UCAM),					
Fellow	**Host institution**	**PhD enrolment**	**Start date**	**Duration (months)**	**Deliverables**
ESR 4	**UCAM**	**Y**	**M8**	**36**	D3.1, D3.2, D3.3
Project Title (WPs): Network architectures in edge artificial intelligence (WP3)					
Objective: Edge AI requires efficient sharing of model parameters during training, via a hierarchy of servers, via probabilistic sharing or via P2P or a mix of all of these techniques					
Expected Results: Code and prototype results and Publications					
Planned secondment(s): TID, Y.Grunenberger, M22, 6 months, Integrate the developed AI methods into an edge cloud network, and prove scalability in 5G TID testbed					
Enrolment in Doctoral degree(s): The ESR will be enrolled at University of Cambridge (UCAM),					
Fellow	**Host institution**	**PhD enrolment**	**Start date**	**Duration (months)**	**Deliverables**
ESR 5	**URJC**	**Y**	**M8**	**36**	D2.1, D2.2, D2.3
Project Title (WPs): Real-time traffic engineering in self-organized adaptive mesh backhaul networks for rural 5G access networks (WP2)					
Objectives: a) Build a flexible strategy for real-time self-adaptive mesh backhaul networks based on SDN/NFV techniques. b) Develop and validate a network optimization algorithm that consistently optimizes resource allocation in real-time operation while respecting QoS restrictions of all traffic classes and for all services admitted in the network.					
Expected Results: A complete technical solution achieving both expressed objectives will be proposed and experimentally proven					
Planned secondment(s): 1) FIT, M. Kretschmer, M10, 4 months, Learn on the experience of the WiBACK project and share technical approaches for mesh backhaul network adaptation, theoretically and experimentally**, 2)** UCAM, J. Crowcroft, M22, 3 months, Learn on advance networking techniques that can improve the performance of the backhaul network for specific services, such as ICN approaches that can be included, and others**, 3)** TID, Y. Grunenberger, M32, 3 months, Incorporate awareness on requirements that operators have both in the technical and managerial areas for a backhaul solution to be appropriate for rural 5G networks. Introduce the experimental results and combine with 5G testbeds in Telefonica					
Enrolment in Doctoral degree(s): The ESR will be enrolled at Universidad Rey Juan Carlos (URJC),					
Fellow	**Host institution**	**PhD enrolment**	**Start date**	**Duration (months)**	**Deliverables**
ESR 6	**URJC**	**Y**	**M8**	**36**	D1.1, D1.2,D1.3
Project Title (WPs): Business and management cooperative models that maximize synergy between communities, operators and public administrations for building, managing and maintaining shared telecommunications infrastructures for rural areas (WP1)					
Objectives: a) To characterize how the new technologies available will influence the business model of 5G networks. b) To evaluate the potential impact of 5G solutions on rural areas from different perspectives (economic benefits, basic services improvement through e-health or e-learning, acceptance of the communities, etc					
Expected Result: A business model designed to deploy 5G networks in rural areas taking advantage of new technologies available to share resources and based on a collaborative strategy between different stakeholders					
Planned secondment(s): 1) TID, C. Hernández, M10, 3 months, To understand big operators business model**, 2)** ARL, A. Sathiaseelan, M18, 3 months, To understand how blockchain technologies can be employed when sharing of network resources among different actors**, 3)** Accelleran, T. Moore, M26, 3 months, To understand the business model of base stations manufacturers and the technical solutions that are being implemented currently in base stations					
Enrolment in Doctoral degree(s): The ESR will be enrolled at Universidad Rey Juan Carlos (URJC),					
Fellow	**Host institution**	**PhD enrolment**	**Start date**	**Duration (months)**	**Deliverables**
ESR 7	**ARL**	**Y**	**M8**	**36**	D1.1, D3.2,D3.3
Project Title (WPs): Trustworthy and Accountable Infrastructure Sharing for 5G (WP1, WP3)					
Objectives: a) Defining the right blockchain architecture that can efficiently address the challenges and scale in terms of energy, security and performance. Evaluating permissioned vs permissionless blockchains will be an initial focus to define the architectural parameters of the proposed system model. b) Defining the appropriate governance rules through a DAO and set of clearly defined smart contracts that are scalable and adaptable. An interesting research angle would be to explore augmented smart contracts: agent driven smart contracts on the blockchain with semantics, advances in machine learning, and state of the art in multi agent systems research. These smart agents will be analyzed analytically and empirically using game theory and agent-based techniques. c) Development, integration of previous objectives into the Ammbr blockchain and carrying out a thorough evaluation					
Expected Results: a) Proposal of system, economic and governance model (WP1), b) Design and evaluation of the proposed models, and integration in the prototype with the Ammbr blockchain (WP3)					
Planned secondment(s): 1) UCAM, J. Crowcroft, M20, 6 months, Ellaborate on the implementability of blockchain architecture on an edge cloud simulator., **2)** URJC, J. Simó, M10, 3 months, Capture the constraints imposed in blockchain distributed architecture by the multi-tenancy, multi-domain access and backhaul architecture					
Enrolment in Doctoral degree(s): The ESR will be enrolled at University of Cambridge (UCAM), Prof. Jon Crowcroft					
Fellow	**Host institution**	**PhD enrolment**	**Start date**	**Duration (months)**	**Deliverables**
ESR 8	**FIT**	**Y**	**M8**	**36**	D2.1, D2.2, D2.3

Project Title (WPs): End-to-end service level agreements with network slicing across a heterogeneous backhaul network (WP3)					
Objectives: a) Assessment of current architecture to manage QoS/SLAs over links with variable capacity and/or availability. Design of primitives of configure and monitor E2E SLAs incl. Slicing Design of algorithms to optimally allocate network capacity to Slides and SLA within incl. Overbooking (for target WiBACK architecture) b) Validation and Evaluation via Emulation/Simulation/testbed					
Expected Results: a) Study on required enhancement to support E2E SLAs and Slicing, b) Algorithm for performance E2E SLA resource allocations incl. Slicing / Overbooking, c) Evaluation of proposed algorithm					
Planned secondment(s): 1) TID, Y. Grunenberger, M10, 4 months, Understanding of operator view and requirements towards E2E SLAs and network slicing. **2)** URJC, J. Simó, M14, 4 months, R&D Collaboration on slicing setup and maintenance algorithm design					
Enrolment in Doctoral degree(s): The ESR will be enrolled at RWTH Aachen					
Fellow	**Host institution**	**PhD enrolment**	**Start date**	**Duration (months)**	**Deliverables**
ESR 9	**TID**	**Y**	**M8**	**36**	D3.1, D3.2, D3.3
Project Title (WPs): Micro-services oriented, legacy-free telco infrastructure for automated and replicable deployments in 4G/pre-5G networks (WP3)					
Objectives: a) To develop new approaches to (i) adapt cellular telco software (and/or underlying libraries) to micro-services architectures, ii) create cloud-ready API for automation, management and monitoring of Lifecyle to deploy this software over private and public clouds based on containers and container-based orchestration engine. b) To overcome the challenges of operating telco-related protocols over cloud-centric infrastructure, we plan to develop innovative ways to restrict and adapt telco-specific workload to the new micro-service infrastructure by creating "protocol adapters" to reuse the existing cloud-based tools and techniques, and implement telco-aware elements (such as load balancers) to support telco specific requirements at the critical point of the new infrastructure					
Expected Results: 2 system or network-oriented venue conference publications, Open source software and demos					
Planned secondment(s): 1) FIT, M. Kretschmer, M16, 3 months, **2)** UCAM, J. Crowcroft, M30, 6 months					
Enrolment in Doctoral degree(s): The ESR will be enrolled at Universidad Rey Juan Carlos (URJC),					
Fellow	**Host institution**	**PhD enrolment**	**Start date**	**Duration (months)**	**Deliverables**
ESR 10	**IMEC**	**Y**	**M8**	**36**	D2.1, D2.2, D2.3
Project Title (WPs): Assuring Service Performance through 5G slice bundles (WP3)					
Objectives: a) Design and develop techniques to create diverse slices over radio resources (e.g. small cells) and how to group them (bundle), b) Develop techniques to dynamically orchestrate slice bundles depending on the fast-changing requirements of the use case with respect of the different slices, c) Use cases will dynamically manage SLAs (Use-cases will aim sub-urban and rural areas).					
Expected Results: a) A control framework (middleware) capable to create and manage slices and bundles., b) A set of different algorithms and mechanisms to orchestrate the slice and bundle components to met the dynamics of the use case., c) Demonstrations at high-impact public events and exhibitions					
Planned secondment(s): 1) Accelleran, T. Moore, M8, 7 months, To understand how the basic slicing and supporting framework is implemented in base-stations and enhance it to support slice bundles and validate it in an actual PoC based on Accelleran solutions**, 2)** Chalmers, T. Svensson / Erik G. Ström , M27, 3 months					
Enrolment in Doctoral degree(s): The ESR will be enrolled at University of Antwerp					
Fellow	**Host institution**	**PhD enrolment**	**Start date**	**Duration (months)**	**Deliverables**
ESR 11	**IMEC**	**Y**	**M8**	**36**	D2.1, D2.2, D2.3
Project Title (WPs): Distributed resource allocation in a shared 5G infrastructure (WP3)					
Objectives: a) Develop and validate radio virtualisation techniques that enable infrastructure sharing between multiple tenants guaranteeing full independence and isolation of tenants. The virtual infrastructure allocated to each tenant should have the same behaviour as a standalone physical infrastructure. B) Develop and validate techniques for distributed per flow resource allocation within a 5G slice, inspired by the approach applied by imec in the DARPA spectrum collaboration challenge (https://www.spectrumcollaborationchallenge.com)					
Expected Results: a) A SW/HW radio architecture and framework for 5G radio virtualization and PoC validation for at least 3 tenants, b) A distributed per flow resource allocation scheme validated (1) through simulations for gaining insights on true QoS performance, scalability, spectrum efficiency, etc. and (2) through experimentation focusing on distributed bootstrapping mechanisms and dynamic mapping of flows to available resources.					
Planned secondment(s): 1) Accelleran, T. Moore, M8, 7 months, To understand how the basic slicing and supporting framework is implemented in base-stations and enhance it to support distributed per flow resource allocations within the slice and enabling shared infrastructure and validate it in an actual PoC based on Accelleran solutions **2)** UPC, A. Pascual, M29, 3 months,					
Enrolment in Doctoral degree(s): The ESR will be enrolled at Gent University					
Fellow	**Host institution**	**PhD enrolment**	**Start date**	**Duration (months)**	**Deliverables**
ESR 12	**Chalmers**	**Y**	**M8**	**36**	D2.1, D2.2, D2.3
Project Title (WPs): Flexible backhauling of mobile base stations (WP2)					
Objectives: a) To find the optimal 3-D precoder design for (massive) MIMO moving backhaul links that are part of a flexible in-band integrated access and backhaul network, b) To develop multihop mesh techniques for backhauling moving base stations, c) To optimize the power allocation for energy-limited meshed moving backhaul links					
Expected Results: a) A comprehensive understanding of the potential and limitations of moving base stations in rural areas using multihop mesh techniques for backhauling of, potentially energy-limited, moving base stations, b) Efficient 3-D beamforming and power allocation techniques for moving backhaul links that are compatible with in-band integrated access and backhaul networks.					
Planned secondment(s): 1) EAB, G. Wikström,, M18, 6 months, with the purpose of identifying the practical limitations and implementability of the solutions proposed, and relate to the work of ESR14 focusing on mobile base stations and flexible network topology for coverage.**2)** FIT, M. Kretschmer, M25, 3 months, with the purpose of identifying the practical limitations and implement ability of the solutions.					
Enrolment in Doctoral degree(s): The ESR will be enrolled at Chalmers University of Technology					
Fellow	**Host institution**	**PhD enrolment**	**Start date**	**Duration (months)**	**Deliverables**

ESR 13	Chalmers	Y	M8	36	D2.1, D2.2, D2.3
Project Title (WPs): Efficient Access and User Association to Mobile Base Stations (WP2)					
Objectives: a) To develop efficient resource allocation and scheduling schemes for users served by cooperative hybrid fixed-moving base stations, b) To develop efficient multi-antenna beamforming techniques in the access links for cooperative hybrid fixed-moving base stations, c) To develop efficient user association techniques to moving base stations, taking their time-varying and potentially time-limited availability into account					
Expected Results: a) A comprehensive understanding of the potential and limitations for moving base stations in rural areas using dynamically employed hybrid cooperative access with fixed and moving base stations, b) Efficient resource allocation, scheduling, beamforming and user association techniques for moving base stations.					
Planned secondment(s): 1) EAB, G. Wikström, M25, 6 months, with the purpose of identifying the practical limitations and implementability of the solutions proposed, and relate to the work of ESR14 focusing on mobile base stations and flexible network topology for coverage. **2)**UPC, J. Vidal, M34, 4 months, with the purpose of understanding the potential of practical deployment and business models of moving base stations					
Enrolment in Doctoral degree(s): The ESR will be enrolled at Chalmers University of Technology					
Fellow	**Host institution**	**PhD enrolment**	**Start date**	**Duration (months)**	**Deliverables**
ESR 14	**EAB**	**Y**	**M8**	**36**	D2.1, D2.2, D2.3
Project Title (WPs): Mobile base stations and flexible network topology for high performance coverage (WP2)					
Objectives: a) To develop enablers for a flexible network topology supporting multi-hop access and backhaul links, as well as mobile and temporary nodes (base stations and other relays), b) To evaluate the network performance (coverage, throughput, energy consumption) for scenarios with mobile base stations and flexible network topology, c) To gain understanding of feasibility of deployment solutions with mobile base stations and flexible network topology for a rural scenario.					
Expected Results: a) A comprehensive understanding of the requirements and limitations for mobile base stations in rural areas using a 5G NR network with flexible topology. b)To develop architecture and protocol components for enabling mobile base stations and flexible network topology in 5G NR.					
Planned secondment(s): 1) Chalmers, T. Svensson, M13, 6 months, with the purpose of strengthening the fundamental aspects of the proposed solutions, and relate to the work of ESR12 and ESR13 focusing on PHY and MAC aspects of mobile base stations and flexible network topology for coverage. **2)** FIT, M.Kretschmer, M36, 3 months, with the purpose of proof-of-concept demonstration of mobile base stations and flexible topology					
Enrolment in Doctoral degree(s): The ESR will be enrolled at Chalmers University of Technology					

3.2 Appropriateness of the management structures and procedures

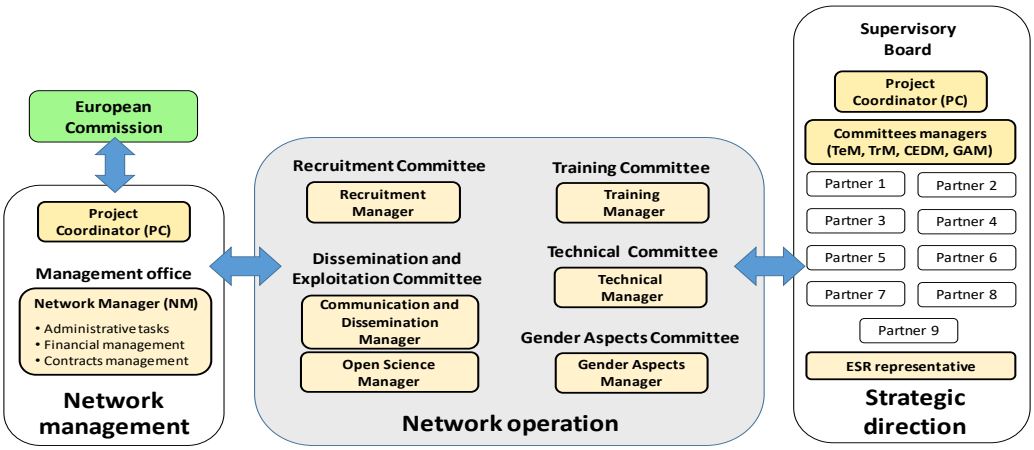

Figure 3.2a. Management structure

3.2.1 Network organisation and management structure

The overall network organisation and management structure, agreed by all the partners, is depicted in Figure 3.2a. Three bodies hold the executive and decision-making authority:

- ***Network management and EC communication*** are conducted by the Network Management Team led by the Project Coordinator (PC) who will supervise and give directions in all aspects of the ITN: network operation and strategic direction. The PC will be the single contact point to the EC. The PC will be reported by all the committees and the supervisory board. For administrative tasks, the PC will be assisted by Management Office that will be implemented by personnel of the European Project Office (EPO) at UPC (https://www.upc.edu/euresearch/en), who have a large experience in project and financial management and recruitment management that dates back to the Fifth Framework Programme (FP5). Under the current Horizon 2020 programme (2014-2020), UPC has been granted 122 projects, coordinating 33 (5 of them funded by the

European Research Council) plus 19 projects (coordinating 4) funded by other European programmes. All of these projects have an associated total EU financial contribution of EUR 47,5 million. Moreover, UPC has a significant experience with Marie Curie Actions, having managed 21 projects under H2020, 8 of them coordinated or monopartners.

- ***Network operation***: There will be 5 committees dealing with the daily operational activities of the ITN, whose participants and main responsibilities are presented in Table 3.2a (more details in the specific sections below):

Table 3.2a The committees for the network operation

Committee	Participants	Responsibilities
Recruitment Committee (RC)	• Project Coordinator • Recruitment manager • Gender aspects manager • 1 delegate per partner	• Define the recruitment strategy • Approve the proposals for the selection of ESRs at each institution • Monitor gender equity principles • Overview the overall recruitment process
Training Committee (TrC)	• Project Coordinator • Training manager • Open Science manager • Gender aspects manager • All ESR supervisors • ESR representative	• Progress monitoring of individual projects • Monitor the innovation of the training through: core research skills, advanced research skills and transferable skills • Monitor secondments and appropriateness of infrastructure of the participant organisations
Dissemination and Exploitation Committee (DEC)	• Communication, exploitation and dissemination manager • Technical WP leaders • Open Science manager • All ESR supervisors	• Review plans for public engagement and communication • Identify opportunities for contributing to high-impact conferences and journals • Identify research outputs candidate for exploitation and innovation • Monitor open science actions • Risks assessment and evaluation
Technical Committee (TeC)	• Project Coordinator • Technical Manager • Technical WP leaders • All ESR supervisors	• Assess the scientific novelty • Monitor scientific misconducts (e.g. plagiarisms) • Foster collaborations • Risks assessment and evaluation
Gender Aspects Committee (GAC)	• Gender aspects Manager • Training manager • Recruitment manager	• Generating recommendations for recruitment process • Monitoring gender dimension in recruitment and research • Designing and managing a half-day training programme

- ***Strategic direction***: The supervisory board (SB) is the maximum authority in the ITN and is responsible for the decisions regarding the overall strategy, and any changes in the workplan. It is chaired by the PC, will receive reports from the respective managers of committees and will monitor the evolution of the ITN, reviewing the achievements in terms of training, dissemination and technical results, and suggesting ways of facing adversities. There will be up to 2 meetings per year that can be held during the plenary events scheduled in the training network (see Table 1.2c in section 1.2) or via teleconference, and the participants are detailed in Table 3.2c (more details in the specific sections below).

Table 3.2c The supervisory board

Body	Participants	Responsibilities
Supervisory Board (SB)	• Project Coordinator • Training Manager • Technical Manager • Communication, Exploitation and Dissemination Manager • Gender aspects Manager • 1 delegate per beneficiary and/or Partner organisation • ESR representative	• Monitor the beneficiaries' arrangements for ESRs' supervision • Monitor the impact and excellence of the network activities, and carrying out corrective actions when needed • Approving the planned budget • Organising 2 meetings per year

We propose a list of personal management roles in Table 3.2b, with a brief description of their key functions. A complete listing of all responsibilities and tasks will be provided in the ITN Handbook (D5.2 due in M6).

Table 3.2b Personal roles in the network organisation

Key Role	Name/Groups/Function
Project Coordinator (PC)	**Dr Josep Vidal** (UPC), in RC, TrC, TeC, SB
Network Manager (NM)	**European Projects Office** (UPC) • Ensures that all project milestones and deliverables are produced in a timely manner with the maximum level of quality. • Monitors the Key-performance ITN indicators (D4.1, D5.6, D6.2) to measure the evolution of the network training. • Supervises the risk management plan (D5.4).
Financial Manager (FM)	**European Projects Office** (UPC), • Administers project resources and monitors project expenditure.
Recruitment Manager (RM)	**European Projects Office** (UPC), in RC • Supervises that the ESR recruitment procedure meets all the defined requirements.
Gender Aspects Manager (GAM)	**Sustainable Management and Equal Opportunities Office** (UPC), in RC, TrC, SB • Supervises that all consortium members establish and respect the defined gender policy.
Open Science Manager (OSM)	**Bibliotecnia** (UPC), in DEC, TrC • Supervises the incorporation of the Open Science guidelines (open data, open source, open methodology, open peer review, open access, open educational resources) at the ITN.
Training Manager (TrM)	**Dr. Javier Simo** (URJC), in TrC, GAC • Supervises the research-related and transferable competences: i) Knowledge and intellectual abilities, ii) Personal effectiveness, iii) Research governance and organisation and iv) Engagement, influence and impact. • Supervises the international, interdisciplinary and intersectoral mobility with an innovation-oriented mind-set.
Technical Manager (TeM)	**Dr. Yan Grunenberger** (TID), in SB, TeC • Ensures the smooth integration of the different research lines involved, promoting collaborations among ESRs and institutions. • Monitors the global research relevance of the project. • Working in close collaboration with the technical WP leaders.
Comm., Exploitation, and Dissemination Manager (CEDM)	**Dr. Gustav Wikström** (EAB), in SB, DEC • Supervises the dissemination activities of the individual partners and coordinates the dissemination plan Conducts proactive communicative actions (Conferences, Special Issues, public engagement). • Identifies business opportunities of the obtained results. • Supervises the exploitation and innovation activities of the partners and coordinates the elaboration and execution of exploitation and IPR plans.
ESR representative	**To be elected among the recruited ESR**, in SB • Represents the ESRs at the SB, providing some feedback about the views/opinions of the ESRs regarding the ITN. Elected annually. • Contact point for the ESR during the whole contract lifetime. ESR representative will report to the PC.
Technical WP Leaders (TWPL)	**Technical WP leaders** are in WP description in **section 3.1**, in TeC • Ensures that WP deliverables are produced on time and of high quality. • Ensures that the defined activities are performed timely and with the required quality, reporting to the TeM the ongoing progress.

3.2.3 Recruitment strategy

ESRs' recruitment will be under responsibility of the RC, chaired by the RM, and will strictly adhere to the European Charter for Researchers and to the Code of Conduct for the Recruitment of Researchers since UPC has been awarded with the Human Resources Excellence in research (https://euraxess.ec.europa.eu/jobs/hrs4r). Based on the ESRs individual projects description, the RC will define the list of ESRs to be recruited by M1. The SB will examine and approve it by M1.5. The recruitment procedure will be as follows:

Advertisement process (M2)
It will consist of advertising all available jobs through paper adverts in international scientific magazines and associations (e.g., IEEE Comm. Mag., IEEE Women in Engineering), electronic adverts in the EURAXESS Jobs Portal and mailing lists, partners' Master programs, international on-line recruitment sites (e.g., PhdJobs, Linkedin). It will include information about employment status, salary, benefits, duration of appointment, tasks to perform, documents to provide (CV, publication list, recommendation letters, university grades, etc), evaluation criteria, etc. It will remain published/open for at least 2 months.
Submission process (M2-M4)
An electronic procedure will be setup via the project website. Security requirements will be guaranteed. Each submission will be acknowledged by receiving a unique identifier.
Selection process (M4-M6)

The selection process will begin in M2 and will be initiated by each beneficiary. The recruitment team of each beneficiary will evaluate the CV of all candidates based on criteria decided by the SB adhering to the European Charter for Researchers & to the Code of Conduct for the Recruitment of Researchers (e.g., university grades, publications, industrial experience, mobility, awards, leadership, creativity, etc). Candidates will receive written feedback on strengths & weaknesses: a report for each candidate with an overall mark. Based on average marks, final candidates will be shortlisted for a two-day interview at the respective beneficiaries' premises. The RC will supervise the shortlist decisions taken in all cases. The first day, the candidates will be interviewed. The interview will consist of two parts: 30 minutes of self-presentation of the candidate and 60 minutes of discussion with the representatives of the beneficiary. Once the hearing of all candidates is terminated, the RC, the beneficiary and UPC's HRD delegates will meet to make a final decision. The SB will approve the final list of candidates. The RC will supervise that all partners adhere to existing regulations and ethical practices when dealing with users' data, in particular at the recruitment stage.
Conditions of appointment
The recruited ESRs will sign contracts no later than M8 in agreement with National legislations of home institutions and will have the same rights and duties as other members of staff. All partners are committed to physically host at their research premises recruited/seconded ESRs and to provide assistance to them in all administrative procedures (recruitment, secondment, visa, work permit, health insurance, accommodation, etc.).

3.2.4 Progress monitoring and evaluation of individual projects

As it has been mentioned in section 1.3, ESRs will be assigned up to 3 supervisors, with whom weekly face-to-face meetings and teleconferences will be held. With the objective of monitoring the different skills and competences acquired at the ITN, the following instruments are envisioned:

- Progress activity report will be sent every 4 weeks to the TeC, where the scientific novelty will be reviewed, in addition with the contributions to deliverables and milestones of the technical where the ESR is involved.
- During ITN meetings (Plenary, Schools,…) the ESRs will present their latest results and will receive feedback from other ESRs and/or TWPL.
- Team-building activities to address challenges in a cooperative way (hackfests, challenges created at the ITN, etc.), jointly organised by the TeM and the TrM.

3.2.5 Risk management

The PC together with the NM will monitor all the milestones and goals defined in the ITN, identifying possible delays of the tasks and proposing de adequate solutions. One of his duties is the elaboration of Risk Management plan (D5.4) envisioned in M6 and WP5. Some of the risks to be addressed are summarized in Table 3.2d.

Table 3.2d Implementation Risks

Risk No.	Risk	WP	Proposed mitigation measures
R1	Inadequate coordination	5	The NM from UPC has extensive experience in coordination of both RIA and ITN projects. The ITN Handbook with establish the rules to avoid this risk, and will define the steps have to be followed in case several beneficiaries decide to request a change of coordinator.
R2	Conflicts among beneficiaries	5	Well-defined procedures are defined in the ITN Handbook for conflict resolution. As a first step the PC will try to mediate among the partners in conflict trying to reach a solution. If this is not enough, the problem will be raised to the SB that will have to meet in an extraordinary to solve the problem in less than month since the conflict was first reported to the PC.
R3	Loss on focus on vision, objectives and milestones	All	The SB and SAB will monitor periodically how the ITN is attaining the objectives, and defining strategic decisions. This will be done using the deliverables and the periodic reports of the ESRs.
R4	Low interest of industry in project outcomes	6	The DEC, and the CEDM in particular, will promote the project results to the industrial partners. If it is identified that there is a low interest, the CEDM and DEC will ask the industrial partners to make an explicit proposal of how and what concrete actions should be carried out to solve this problem.
R5	Difficulties in recruiting ESRs	5	The RC will monitor since the very beginning of the ITN all the recruitment procedures to ensure that all the actions are carried out in a timely manner. If a low number of applications are received for a concrete position, the application period may be extended to guarantee the reception of high profile candidates. These extensions should always be such that the ESRs can be recruited in a timely manner.
R6	Withdrawal, unsatisfactory performance or misconduct of a recruited researcher	1-3	The situation has to be reported as early as possible to the PC and then to the SB. If the issue remains, ESR will be invited to quit its position and a new ESR will have to be recruited for the remaining. In that case, it should be checked if the completion of PhD is still possible.
R7	Individual project goals do not meet requirements to	1-3	Regular analysis with the different supervisors. If a problem is identified and cannot be solved at the supervisors' level, then it will be reported to the TeM and TWPL, that will

	obtain PhD		evaluate the scientific results and propose concrete corrective actions if the reasons are technical. In case that the reasons come from a misconduct of the ESR, the risk mitigation procedures of R6 will be applied.
R8	Supervisor leaves his position or an organization cannot fulfil its role	1	Alternative solutions are considered within the network partners through the SB. If there is not any solution, the goals of the work package are reassigned accordingly and communicated to the EC Project Officer for endorsement, if needed, of a transfer of the ESR to another institution in the ITN.
R9	Failure to get papers accepted in major international journals and conferences	6	The DEC, and the CEDM in particular, will promote the early identification of target journal and conferences and their deadlines since the beginning of the ITN. If the reasons why an ESR is not getting papers accepted due to low scientific quality of the work, the corrective actions identified in R7 will be applied.
R10	Unfitting budget spending profile	5	Yearly budget reports with expected spending profiles until the end of the project lifetime will have to be sent to the FM (TMO).

3.2.6 Intellectual Property Rights (IPR)

The management of the intellectual property is one of the main activities of the CEDM and is designed in two phases:

1. The internal management of IPR, by identifying the background, the foreground requiring protection and stating the conditions for transfer of ownership of knowledge such that interests of partners are preserved and objectives of the project are not compromised. All partners agree that they will work closely in order to define the best possible scenario for handling IPR issues.
2. Monitoring the diffusion of results, by stimulating and facilitating the process of patent filing and giving green light to publications related to potential IPR at the right time and with the proper notification to the EC[26].

In any case, partners will abide by the provisions of the Grant Agreement. In addition, CEDM will be in charge of managing all these activities detailed in the Dissemination, Exploitation and Innovation Plan, D6.1: **a)** Involving the right experts of each consortium partner in better define and then refine the objectives at very early stages of the project, **b)** Stress not only the classic definition of innovation, e.g., the commercial introduction of a new or significantly improved product or service, but also introducing more soft-skills oriented aspects and non-commercial approaches into the play, **c)** Help leveraging a good idea towards a real product in the market, overseeing all the steps in between, **d)** Support and drive the creation of a credible roadmap w.r.t. how to bring the new outcomes of the project into the markets**, e)** Organize workshops or seminars on the best known methods when dealing with exploratory works, as the ones involved in such collaborative research projects, **f)** Evangelize the best approaches for innovation, fostering using agile and lean methods, or methodologies focusing on taking the right decision in complex fast-pace changing environments, e.g., using the evolutions of the well-known AIDA model (Ref: http://www.eraofpriers.com/describe-aida-model/), **g**)Define indicators and/or measures to control and foster the innovation content of the progressing outcomes of the consortium partners, **h)** Stimulate, review and maintain partners' exploitation and IPR plans around the 5G4real results.

3.2.7 Gender aspects activities

The project encourages the participation of women in science and is committed to gender equality. Research content is gender neutral. A Gender Aspects Manager (GAM) see Table 3.2b will be designated. She will make sure that gender aspects are considered when selecting researchers and implementing the project. Concretely, tasks related to gender issues will be:

- Generating recommendations (in D5.3 Gender Issues Plan) for the selection of the candidates and the implementation of the project on the grounds of respect, equal opportunities and work-life balance. The GAM will also supervise how these recommendations are followed. The following aspects (among other) will be collected in D5.3: **1)** At the consortium level, care will be taken to have an adequate gender balance at the SB. The selection committees of each beneficiary will be required to have at least 40% of members of each gender, **2)** Female applications will be explicitly encouraged in the public advertisement of openings by showing female advisors

[26] In compliance with the lines of the Grant Agreement

involved in the project, mentioning the training program on gender (see below) and by clearly stating that the selection procedure will follows gender equity policies compliant with EC good practices, **3)** During the selection process, in case of candidates with equal or equivalent qualifications and competences, priority will be given to those candidates that assure a better gender balance of selected researchers**, 4)** The GAM will monitor the recruitment process, generate reports with indicators of the gender of applicants, selected ESR and selection committees for all beneficiaries. The GAM will report to the SB, **5)** Efforts will be made to invite external and outstanding female researchers to give talks at the ITN's plenary meetings. At least one talk on "Woman in Science" will be appointed, **6)** Introduce gender-awareness contents in the public awareness activities of the network, in particular those addressed to high school students, **7)** Life-work balance measures (e.g. flexible working hours, schedule meetings on family-friendly hours, use skype calls when needed will be encouraged), **8)** Supervision of the country-wise implications of parenthood during the network lifetime: maternity/paternity leaves, breastfeeding hours, contracts extension, **9)**Each institution will have to identify a contact point for gender issues. Furthermore, the ESR representative will be the person in charge of exposing any problem of the ESRs to the GEM and the SB.

- Monitoring gender dimension in research content: although research content is neutral, GAM will generate awareness of any future aspects that may have an impact on it.

3.2.8 Data Management Plan

The OSM, in collaboration with CEDM, will be responsible of the elaboration and monitoring of a living document D5.5 (first version on M6) for the FAIR (Findable, Accessible, Interoperable and Reusable) data management plan. UPC has an online tool (https://dmp.csuc.cat/) that meets the requirements suggested by Open Access and Open Data under H2020. UPC has expertise in the open-access (https://upcommons.upc.edu/) and is member of the Open Education Consortium (www.oeconsortium.org), some of the aspects to be considered in D5.5 are summarized in Table 3.2e

Table 3.2e Data management policies

Items	Description
Identification to whom the data/results might be useful	It will allow identifying which are the best channels to distribute the obtained results
Compilation of the policies about open-access from each institution	The strategy agreed in D5.5 must respect the policies of the institutions involved in the project
Data produced/used in the project	D5.5 will specify how this data will be obtained and under which conditions can be shared among partners and outside of the project (free, licensed or the required steps to be followed to ask permission to employ such data, i.e. Non-Disclosure Agreement). An adequate description of the stored data and its processing will be documented.
Software	The open-software produced in the project will be published in open-repositories (i.e. Github), so that the code could be re-used/reviewed by the scientific community. D5.5 will detail the duties of the owner (definition of a license, documentation, open to answer questions from community, possibility of integrate contributions from other people, …)
Publications	Preprints will be published in open repositories (i.e. arxiv.org), where it should be indicated if the work has been submitted/accepted in a Conference, open-access journal or closed-access journal. Indicators such as paper citations, full text views, and journal citation metrics (i.e. impact factor, article influence, …) will monitor to assess the impact of the result. Whenever possible, the code used to obtain the results will be published in open-access with the objective of having a reproducible and replicate result. Open-access PhD dissertations will be accessible through the www.dart-europe.eu (partnership of research libraries)
Video Presentations	Selection of the platform for publishing in open-access the webinars or videos of the work to be presented in conferences (i.e. UPCommons https://upcommons.upc.edu/?locale-attribute=en, YouTube, …).
Training Courses	Definition of which training courses (or training material) provided in the project can be made open, using open course ware platforms (i.e. http://ocw.upc.edu/)

3.3 Appropriateness of the infrastructure of the participating organisations

Table 3.3 Capacities of each participant

Participant	Description

UPC	Long experience in coordinating EC-funded projects and management of ITN-MSCA. The institution earned HR4SR. The European Project Office will lead the key-role of NM, FM and RM. UPC has an Intl. Relations Service to assist all the necessary steps for settling in Barcelona. Sustainable Management and Equal Opportunities Office will lead the key role of GM and Biblitecnia the OSM.
UCAM	The institution earned HR4SR. Departmental support for all graduate studies includes ample office space, lab and equipment and communications facilities. The two faculty directly involved in this ITN have track record collaborating with many of the partners in this proposal.
URJC	Long experience in coordinating research and training projects funded by EC and other international institutions. The URJC has several research premises: Wideband wireless laboratory, RF laboratory, and network laboratoy. The European Project Office will support the management activities. The institution also has an universitary residence, serveral libraries and sport facilities.
ARL	ARL CEO has led EU funded projects such as EC H2020 RIFE and UMOBILE recently. Several ongoing collaborations with UPC, Queen Mary University, University of Cape Town and University of Rwanda
FIT	Long experience in coordinating EC-funded as well as Industry-funded projects. Close collaboration and scientific exchange with RWTH Aachen.
TID	TID research centers in Spain with access to HW/SW resources for simulation and experiments. TID is one of the two funding members of the 5G platform 5TONIC (https://www.5tonic.org) and also owns a multi-site mobile testbed on SDN/NFV technologies. Each researcher at the lab also has access to workstations/laptops running Linux, Mac, or WindowsFinally, TID has a history of hosting students for internships that have resulted in a large number of published research papers.
IMEC	The institution earned HR4SR. Long experience in coordinating and participating in EU research projects, besides national and regional projects. We have a close collaboration with the local universities, including University of Ghent and University of Antwerp.
Chalmers	Long experience in EC-funded projects and experience of ITN-MSCA, strong support for guest researchers with help for relocation. Chalmers has internal processes for recruitments and employments in-line with the Charter & Code
EAB	EAB offers many support functions, such as an international mobility team at the HR department, administration and communication teams. Long experience in participating in EC-funded projects and other international collaborations.
Accelleran	Accelleran has a current portfolio of < 6GHz low-power outdoor integrated and virtualised 4G and 5G-Ready small cells, together with the RAN/vRAN Small Cell Software solutions, software development platforms environments and automated target testing test lab frameworks and laboratory equipment to be used by the ESRs during the secondments, particularly in the context of the validation of the research objectives via PoCs. Accelleran uses teleconferencing, sharing, communication, software management.. tools and an agile development process to enable an efficient distributed and on-site working environment. Accelleran participates currently in 4 H2020 projects: 5GCity, 5GUARDS, 5Genhance and Unicore.

3.4 Competences, experience and complementarity of the participating organisations and their commitment to the programme

3.4.1 Consortium composition and exploitation of participating organisations' complementarities

The objective of 5G4real is to train a new generation of researchers in order to produce innovative solutions to provide connectivity to rural and suburban areas, allowing a large number of benefits to this areas (health, e-learning, new business, ..). We believe that the consortium is the best one to develop such work because: A) The participating industries represent the different parts of a telecom network, B) Expertise over the different research areas (Table 1.4b), C) High qualified supervisors with a remarkable experience in their research areas, see Table 1.3b, D) Participation of different type of partners: *Academia* (UPC, UCAM, URJC, Chalmers), *Industry* (TID, EAB), *Research Institutes* (IMEC, FIT), *SME* (ARL, Accelleran).

3.4.2 Commitment of beneficiaries and partner organisations to the programme

All partners have been involved in all aspects of 5G4real, balancing the commitment of academic and non-academic partners. UPC (academia) is the coordinator while TID (industry) is the technical coordinator, see Table 3.2b for details about the different personal roles. The responsibilities in the organization of the main training events are equally distributed over **all partners** as it is shown in Table 1.2c, who coordinate among them and with TrC for defining the content of the courses and schools, see Table 1.2d. Furthermore, all ESRs are supervised by academic and non-academic partners, see Table 1.3a, with a two-fold objective: *i) earning the PhD degree at the end of the network and*, *ii) carrying out cross-sectoral and international secondments*. The commitment of each participant is summarized in Table 1.4a. Finally, it is important to remark the high number of synergies in the consortium as it is shown in Table 1.4b, in terms of *research areas, previous collaborations and common industrial groups* that will ensure the success of the programme.

4. EID specific requirements

N/A

5. Participating Organisations

Universitat Politècnica de Catalunya (UPC)	
General Description	UPC is a major technical university of Spain, specialized in the fields of engineering, architecture and science. As a leading member of international networks of excellence, UPC has a privileged relationship with global scientific and educational organizations. The university is organized in 42 Departments and 23 Schools concerning the main engineering fields. The Department of Signal Theory and Communications (TSC) is dedicated to research and education in ICT, being responsible for several undergraduate and postgraduate degrees, https://futur.upc.edu/TSC .
Role and Commitment of key persons (including supervisors)	**Dr. Josep Vidal**, (male), received the Telecommunication Engineering and the Ph. D. degrees from UPC, in 1989 and 1993, respectively. From 1989 to 1990 he joined the LTS at the Ecole Polytechnique de Lausanne as research assistant. In 1990 he joined the Signal Theory and Communications Dept. at UPC, where he is currently full professor. He has been visiting scholar at the Institut National Polytechnique de Grenoble (1992), Ecole Nationale Polytechnique de Toulouse (2006) and University of Hawaii (2007). He is also Honorary Professor at the Universidad Católica Andrés Bello in Caracas. He has published over 180 papers in peer-reviewed international conferences and journals, 5 book chapters and holds 3 US patents, in areas like Statistical Signal Processing, Information Theory and Machine Learning. He has supervised 8 PhD Thesis and 45 Master Thesis. Since 2000, he has led the participation of UPC in EC-funded collaborative projects of FP5, FP6 and FP7 and training networks (see below) As a result of these cooperations, 25 contributions to IEEE 802, 3GPP-LTE (RAN1-RAN2) and ETSI-BRAN bodies were issued. He co-organized 4 international workshops and served as Associate Editor of Transactions on Signal Processing from 2010 to 2013, and is member of the IEEE ComSoc Signal Processing for Communications and Electronics Technical Committee (SPCE TC). His h-index is 27+ and has 3000+ Google Scholar citations. **He will be in charge of the supervision of one ESRs and will dedicate 10% of his time to the project**. **Dr. Antonio Pascual Iserte**, (male), received the Electrical Engineering and the Ph.D. degrees from UPC, in 2000 and 2005, respectively. He was awarded the "First National Prize of 2000/01 University Education" by the Spanish Ministry of Education and Culture and with the “Best PhD Thesis Prize” by UPC. He worked as a Teaching Assistant at UPC till June 1999, and until December 2000 he was with Retevision R&D. In January 2001, he joined the Department of Signal Theory and Communications at the UPC, where he worked as a Research Assistant and Assistant Professor until April 2008, when he became Associate Professor. His research interests include: array processing, robust designs, OFDM, MIMO channels, multiuser access, energy efficiency and optimization theory. He has been involved in several national and European research projects and networks (see below). He has published around 100 papers in international and national conferences and journals in relation with the previously mentioned research topics. He has advised 4 doctoral thesis already finished (one of them awarded with the "Best PhD Thesis Prize" by UPC) and is currently advising two additional ones. He has supervised 10 Master thesis and 6 undergrad bachelor thesis. **He will be in charge of the supervision of one ESRs and will dedicate 10% of his time to the project.**
Key Research Facilities, Infrastructure and Equipment	The Signal Processing for Communications (SPCOM) group (https://futur.upc.edu/spcom) is an active research group of the Signal Theory and Communications department of UPC. It is composed of 16 academic staff, 2 associate researchers and 7 PhD students, associated to the Telecom Engineering School of UPC, which ranks 4th in Europe in the Shanghai Ranking's Global Ranking of Academic Subjects 2017. The expertise of SPCOM is quite broad in fundamental signal processing, wireless communications, satellite communications applied machine learning and communication networks, areas where active research is being conducted. The group has graduated some 20 PhD students in the last 10 years. SPCOM has state-of-the-art cluster of tens of computers/serves for advanced.
Status of Research Premises	UPC has independent premises and space for hosting all ESRs according to the project workplan. Libraries in Campus Nord provide online access to the most important journal and conference proceedings. The campus has dining halls, sport facilities and a health center.
Previous Involvement in Research and Training Programmes (RTP)	SPCOM members have participated in NoEs , Newcom, Newcom++, Newcom#, in FP5, FP6 and FP7 projects SATURN, ROMANTIK, FIREWORKS, ROCKET, FREEDOM, TROPIC, TUCAN3G.
Current Involvement in RTP	SPCOM is involved in the MSCA-ITN project 5GWireless at European level and in the 5G&B RUNNER-UPC project at National Level.
Relevant Publications and/or Research / Innovation Product	• J. Rubio, A. Pascual-Iserte, J. Vidal et al., “Network dimensioning and base station on/off switching strategies for sustainable deployment in remote areas”, EURASIP Journal on Wireless Comm. and Networking, vol. 2017, no. 215, Dec. 2017. • A. Agustin, J.Vidal, et al., “Efficient use of paired spectrum bands through TDD small cell deployments”, IEEE Comm. Magazine, vol. 55, no. 9, Sep. 2017. • A. Martínez Fernández, J.Vidal et al, “The TUCAN3G project: wireless technologies for isolated rural communities in developing countries based on 3G small-cell deployments”, IEEE Comm. Magazine, vol. 54, no. 7, July 2016. • O. Muñoz-Medina, A. Pascual-Iserte, J. Vidal, “Optimization of radio and computational resources for energy efficiency in latency-constrained application offloading”, IEEE Trans. on Vehicular Technology, vol. 64, no. 10, Oct. 2015. • S. Lagen, A. Pascual-Iserte, O. Muñoz, J. Vidal, “Energy Efficiency in Latency-Constrained Application Offloading from Mobile Clients to Multiple Virtual Machines”, IEEE Trans. on Signal Processing, vol. 66, No. 4, February 2018

Universidad Rey Juan Carlos (URJC)	
General Description	The URJC was created with the objective of offering high quality education and academic and scientific excellence. The Signal Processing for Communications and Networking Group was founded in 2005 and our research expertise includes signal processing, nonlinear optimisation, wireless communications, wireless systems, wireless ad-hoc networks, networking, business models and computer science and communication systems for developing countries. We have a broad experience in the development and coordination of competitive R&D projects, including both public (Spanish Ministry of Industry, Spanish Ministry of Science and Innovation, USA agencies, EU) and private funding. The group comprises more than 40 members including Faculty Members and Research Associates.
Role and Commitment of key persons (including supervisors)	**Dr Francisco Javier Simó Reigadas** (male) received his telecommunications engineering degree and Ph.D. from the Polytechnic University of Madrid in 1997 and 2007, respectively. Since 1999 he has worked in the field of ICT for development, initially as a practitioner in Africa, later as a researcher with the EHAS Foundation, and since 2005 as associate professor at the URJC. His main fields of research are broadband wireless rural networks. He has been the supervisor of 1 PhD thesis and 21 M.Sc theses, and professor in 8 degree courses and 9 master courses with high scores in evaluations by students. He has authored or co-authored 15 papers in JCR journals and has also been the director of two master studies. Presently he is the Dean of the School of Telecommunications Engineering at URJC**. He will supervise one ESRs and will dedicate 10% of his time to the project.** **Dr Andrés Martínez Fernández (**male) received his telecommunications engineering degree (1994) and Ph.D. (2003) from the Polytechnic University of Madrid. He is currently an associate professor in the Department of Signal Theory and Communications at the URJC, Madrid. His research interests include telemedicine and low-cost telecommunication systems for low resource settings. He has been the supervisor of 3 PhD thesis and 15 M.Sc theses and has been author or co-author of 26 papers in JCR journals. **He will supervise one ESRs and will dedicate 10% of his time to the project**. Dr Pedro de las Heras (male), Dr Eva María Castro (female), Dr Ignacio Prieto (male) and Dr Alejandro de la Fuente (male) will also support the ESRs to provide guidance on issues related with SDRs, optimization, business models or 5G access network.
Key Research Facilities, Infrastructure and Equipment	Wideband wireless laboratory with three mesh networks with different technologies, two WiMAX networks, more than 20 programmable WiFi routers, a channel emulator, 6 portable RF-shielded chambers, portable spectrum analysers, different types of high-gain outdoor antennas for the 2.4 and 5.8 GHz bands and all accessories. 4 USRP-based SDR systems and more than 20 computers. Outdoor telecommunications tower. RF laboratory with anechoic chamber, signal generators, vectorial signal analysers and oscilloscopes.
Status of Research Premises	URJC has independent premises and space for hosting the ESRs according to the project work plan.
Previous Involvement in Research and Training Programmes (RTP)	We have participated in TUCAN3G project in FP7, and in several projects funded by national calls: OPTICOM, WiREM, LOCMOTIC, GUIADE, OPEN-REACH, MASERATTI and Dr. SCRATCH.,
Current Involvement in RTPs	We are currently involved in the NAPO project Funded by the Development Bank of Latin America.
Relevant Publications and/or Research / Innovation Product	• Saldana, Jose, et al. "Alternative Networks: Toward Global Access to the Internet for All." IEEE Comm. Mag. 55.9 (2017): 187-193. • Martínez Fernández, Andrés, et al. "The TUCAN3G project: wireless technologies for isolated rural communities in developing countries based on 3G small-cell deployments." IEEE Comm. Mag. 54.7 (2016): 36-43. • Foche-Pérez, Ignacio, et al. "A dual IEEE 802.11 and IEEE 802.15–4 network architecture for energy-efficient communications with low-demanding applications." Ad Hoc Networks 37 (2016): 337-353. • Simo-Reigadas, Javier, et al. "Sharing low-cost wireless infrastructures with telecommunications operators to bring 3G services to rural communities." Computer Networks 93 (2015): 245-259. • Marques, Antonio G., et al. "Asymptotically optimal cross-layer schemes for relay networks with short-term and long-term constraints." IEEE Trans. Wireless Comm. 12.1 (2013): 333-345.

The Chancellor Masters and Scholars of the University of Cambridge (UCAM)	
General Description	The University of Cambridge as the host institution is an 800 year old, world leading university known for its excellence in research training, and for the complementary skills of the involved researchers.
Role and Commitment of key persons (including supervisors)	**Prof. Crowcroft** (male) is the Marconi Professor of Communications Systems in the Computer Laboratory of the University of Cambridge and the Chair of the Programme Committee at the Alan Turing Institute. He is a fellow of the Royal Society, the ACM, the British Computer Society, the IET the Royal Academy of Engineering and the IEEE. In 2009, Prof. Crowcroft received the SIGCOMM Award for lifetime contribution to the field of communication networks. Prof. Crowcroft is also the editor at large of IEEE Transactions on Networking, IEEE Network, IEEE Communications Surveys and Tutorials, etc.. Prof. Crowcroft has written, edited and co-authored a number of books and publications which have been adopted internationally in academic courses. He has published over 120 journal papers and 200 conference papers in the past four decades, with over 41,000 citations according to Google Scholar. Specifically, he has developed the theory and practice of routing data across interconnecting computers, which will lay the solid foundation for the MEC system construction and data offloading in this project. So far, he has supervised more than 50 PhD students and 20 postdocs, and currently supervises 6 PhD students and 2 postdocs. Researchers he previously supervised turned out to have very successful careers both in academy and industry. **He will be in charge of the supervision of one ESRs and will dedicate 10% of his time to the project** **Dr Richard Mortier** (male) is the Reader in Computing and Human-Data Interaction in the Systems Research Group of the Department of Computer Science & Technology at Cambridge University. He also consults, provides technical patent expertise, and engages in creation of an early stage delivery in startup companies, most recently Unikernel Systems (acquired by Docker Inc. in 2016) and Kvasir Limited (funded 2018). Prior to rejoining the Computer Laboratory, he was a Horizon Transitional Fellow with Horizon Digital Economy Research at the University of Nottingham (2009-2015), founder at Vipadia Limited (2008-2009), Researcher at Microsoft Research Cambridge (2002-2008), and post-doctoral research with Sprint ATL, CA (2001-2002). He, gained B.A. (Hons.) in Mathematics (1993-1996), a Diploma in Computer Science (1996-1997), and a Ph.D. in Computer Science (1997-2001). Past work has been inter-disciplinary, with publications in venues covering systems, networking, databases, HCI, sociology, and business studies. At Cambridge he now leads work in Human-Data Interaction (HDI), building user-centric systems to support all of us in having a stake as data collection, processing and computation become ubiquitous in our world. This currently involves managing a research budget of over £1M, and leading platform design and implementation of the Databox. He has supervised 9 Ph.D. students to completion. **He will be in charge of the supervision of one ESRs and will dedicate 10% of his time to the project**
Key Research Facilities, Infrastructure and Equipment	The students will be members of the Systems Research Group in the Computer Laboratory, consisting of 10 lecturers, 9 researchers, 5 visitors, and more than 20 students. Besides Prof. Crowcroft and Dr Mortier, and their systems expertise, the students will be surrounded by world-leading experts in communication system modelling, networking, and mathematics.Apart from the staff and students, a large number of researchers from EU and non-EU institutions visit the group every year, creating a unique place for exchange of ideas and collaboration.
Status of Research Premises	Regular seminars in the Computer Laboratory will help strengthen the students' research in the broad area of computing and communications systems. Students will also be provided with the appropriate space to conduct their work within the SRG group of the Computer Laboratory, and will enjoy all the benefits of the infrastructure, including library services, networks, social spaces and software tools.
Previous Involvement in Research and Training Programmes (RTP)	Past involvement in projects related with the computing systems includes UMOBILE and RIFE funded under EU Horizon 2020 He has also been recently involved in NaaS, and HAT, sponsored by EPSRC and Research Council's UK Digital Economy Program, respectively. The department has also made major contributions to a number of successful start-up projects, such as Raspberry Pi and Xen. Crowcroft was until recently the PI for the METRICS ITN which successfully graduated two PhD students in Cambridge.
Current Involvement in RTP	They have extensive experience in EU projects with respect to the Computer Laboratory, since they currently manage more than 15 active Horizon 2020 projects, including 3 Marie Sklodowska-Curie Action grants (including 1 Individual Fellowship).
Relevant Publications and/or Research / Innovation Product	• Connecting the Edges: A Universal, Mobile-Centric, and Opportunistic Communications Architecture CA Sarros, S Diamantopoulos, S Rene, I Psaras, A Lertsinsrubtavee, ... IEEE Communications Magazine 56 (2), 136-143 • Network Latency Control in Data Centres (Dagstuhl Seminar 16281) M Alizadeh Attar, J Crowcroft, L Eggert, K Wehrle Dagstuhl Reports 6 (7) • Emu: Rapid prototyping of networking services N Sultana, S Galea, D Greaves, M WÃ³jcik, J Shipton, R Clegg, L Mai, ... 2017 USENIX Annual Technical Conference (USENIX ATC 17), 459-471 • Guest Editorial Privacy Issues in Internet of Things R Mortier, J Crowcroft, C Perera, S Tarkoma, P Christen IEEE Internet of Things Journal 4 (4), 840-842 • Privacy-preserving Machine Learning Based Data Analytics on Edge Devices J Zhao, R Mortier, J Crowcroft, L Wang http://www.aies-conference.com/wp-content/papers/main/AIES_2018_paper_161.pdf

Ammbr Research Labs (ARL)	
General Description	ARL is the research branch of the AmmbrTech company. The aim is connecting the world's 4 billion poorly connected people blending wireless mesh networks, Blockchain, and Self-Sovereign Digital Identity. Our expertise includes high performance chip design, electronics and advanced cryptography.
Role and Commitment of key persons (including supervisors)	**Dr. Arjuna Sathiaseelan** (male) is Chief Executive Officer of ARL. Has 15+ years experience in academia with more than 100 publications as well as contribution to several standardisation activities at both the IETF and the ETSI. Has co-supervised 7 PhD and several Masters and UG students. He led Networking for Development Lab at University of Cambridge and chaired the IRTF GAIA research group until April 2018. **He will be in charge of the supervision of one ESRs and will dedicate 20% of his time to the project**. .
Key Research Facilities, Infrastructure and Equipment	ARL has several testbeds in different continents, mainly in Spain, South Africa, USA and the UK. The team includes 5 PhD researchers with ample experience in the topic of networking infrastructures, wireless and applications such as IoT.
Status of Research Premises	The beneficiary currently rents the research facilities. We have a large office space in Cambridge, UK that is capable of hosting both visiting researchers as well as PhD students.
Previous Involvement in Research and Training Programmes (RTP)	Arjuna was research lead as partner in the H2020 RIFE and U-Mobile. Leandro was coordinator of the EU FP7 FIRE CONFINE Integrated Project, and the Clommunity FP7 FIRE STREP project.
Current Involvement in RTP	.
Relevant Publications and/or Research / Innovation Product	• Towards Blockchain-enabled Wireless Mesh Networks, M. Selimi, A. Rao, A. Ali, L. Navarro, A. Sathiaseelan, ACM MobiSys Workshop on Cryptocurrencies and Blockchains for Distributed Systems (CRYBLOCK 2018), June 2018. (Best Paper Award) • Deep Diving into Africa's Inter-Country Latencies, A. Formoso, J. Chavula, A. Sathiaseelan, G. Tyson, IEEE INFOCOM, April 2018. • Towards Decentralised Resilient Community Cloud Infrastructures, A. Sathiaseelan, M. Selimi, A. Lertsinsrubtavee, C. Molina, L. Navarro, F. Freitag, F. Ramos, R. Baig, 2nd Workshop on Middleware for Edge Clouds Cloudlets (MECC), December 2017. • Will 5G See its Blind Side? Evolving 5G for Universal Internet Access, O. Onireti, J. Qadir, M. Imran, A. Sathiaseelan, ACM SIGCOMM GAIA, August 2016.

FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V. (FIT)	
General Description	Fraunhofer-Gesellschaft is the leading organization of institutes of applied research and development in Germany. Founded in 1949 as a non-profit registered association, the Fraunhofer-Gesellschaft is an autonomous organization with a decentralized organizational structure. With 66 institutes and independent research units and liaison offices in Europe, the USA and Asia, Fraunhofer-Gesellschaft has an established reputation for excellence at the front rank of applied research and development. 22,000 staff members work with an annual research budget of over 1.9 billion euros. Research on aspects regarding synergies between commercial telecom networks, community networks and public administrations for creating, maintaining and sharing infrastructures. While there are approaches such as OpenCellular in TIP to develop low-cost Access solutions, there is a lack of holistic solutions to address backhauling in low-income sparsely populated areas. Providing E2E SLAs combined with Network Slicing across a heterogeneous backhaul poses important and challenging questions to be addressed: **How to** manage QoS/SLAs over links with variable capacity and/or availability ? **How to** implement and enforce Slices in such an architecture ? **How to** allow each operator to manage its slice while not impacting and 'seeing' the other slices ? **How to** interface and signal to external networks (backbone an access) ? **How to** build / implement such a network based on low-cost / low-power equipment?
Role and Commitment of key persons (including supervisors)	**Prof. Wolfgang Prinz, PhD,** (male) Division Manager at Fraunhofer FIT, Associate Professor at RWTH Aachen, **Involvement 10%,** h-Index 31, Publications 247. PhDs/MSc supervised 10/50. He coordinated several national and international research projects such as a large European research project on collaborative work environments. He is editor of national and international journals and chair of international conferences. **Mathias Kretschmer, PhD**, (male) Head of Department and Senior Researcher with 20+ years of experience in industry and R&D. **Involvement 20%,** h-Index 12, 50+ Publications, 3 US Patents. MSc. Supervised 10.
Key Research Facilities, Infrastructure and Equipment	Fraunhofer FIT performs R&D on its wireless backhaul technology (WiBACK) and operates multiple outdoor testbeds in Germany which can be used to gather performance metrics and to evaluate and demo novel designs and algorithms in real world scenarios – a key requirement for R&D at Fraunhofer. Pilot deployments (via partners) are active in India, Uganda, Colombia, Mozambique, Italy (among others).
Status of Research Premises	Trainees / Fellows would be hosted at the Fraunhofer Campus in St. Augustin, Germany. This campus hosts three Fraunhofer Institutes with a total staff of about 600 peoples.
Previous Involvement in Research and Training Programmes (RTP)	Hosting ERCIM Fellow in 2015, LORIT4AE (FP7-PEOPLE-2012-IRSES) 2012-2014
Current Involvement in RTP	None
Relevant Publications and/or Research / Innovation Product	• Rademacher M., Jonas K., Kretschmer M., Quantifying the spectrum occupancy in an outdoor 5 GHz WiFi network with directional antennas, IEEE WCNC 2018. • C. Niephaus and O. G. Aliu and M. Kretschmer and S. Hadzic and G. Ghinea, Wireless Back-haul: a software defined network enabled wireless Back-haul network architecture for future 5G networks, IET Networks 2015 • WiBACK™ technology deployed in >10 pilot installations in world-wide (http://wiback.org)

Telefonica Investigacion y Desarrollo, SA (TID)	
General Description	Telefónica I+D -- the research and development company of the Telefónica Group -- was founded in 1988 and its mission is to contribute to the Group's competitiveness and modernity through technological innovation. With this aim, the company applies new ideas, concepts and practices in addition to developing products and advanced services. Telefónica I+D is one of the first private R&D centres in Spain as regards activity and resources and is the first company on the continent by number of European research projects in which it participates. The main asset of Telefónica I+D is its staff, which is 97% composed of university graduates from 18 nationalities. Currently collaborates with technological leaders and many organizations from 40 countries; among which figure more than 150 universities around the world. It also participates in the most important international forums on technological knowledge of the ICT sector, thus creating one of the largest European innovation ecosystems. In addition to the numerous technical awards it has won since its foundation, the company received the Príncipe Felipe Award for Business Excellence in 2002. Within Telefonica I+D, Internet Para Todos is the program to connect the unconnected of Telefonica, providing next business models, technologies and operating models to deploy connectivity in less dense, rural and isolated places.
Role and Commitment of key persons (including supervisors)	**Dr. Yan Grunenberger** (male) is the scientific leader of the Internet Para Todos program at Telefónica I+D. Dr Grunenberger has more than 10 years of experience in the wireless technologies from an academic (Grenoble University, CTTC) and industrial (Qualcomm, Telefónica) perspective. He has published over 15 papers in Conference venues such as IMC and CoNEXT and has been cited more than 500 times. He is participating to various events as panellist such as Telecom Infra Project (TIP) summit, and also engaged with some opensource communities related to cellular network (OAI). **He will be in charge of the supervision of one ESRs and will dedicate 10% of his time to the project**
Key Research Facilities, Infrastructure and Equipment	TID has been participating in numerous EU and Marie Curie projects on a regular basis ranging from network infrastructure to user behaviour profiling. TID has expertise on systems, networking, virtualization, machine learning, security, social network analysis. The TID lab has active RAN (eNB, UE), software defined radios, and SDN/NFV compatible servers in active use for a variety of complex analysis or simulation. Each researcher at the lab also has access to workstations/laptops running Linux, Mac, or Windows. In addition to the above, TID is also outfitted with enterprise level teleconference and live video streaming facilities. Finally, TID has a history of hosting students for internships that have resulted in a large number of published research papers.
Status of Research Premises	All research facilities and premises are fully owned by TID and independent from any other entity. At the same time, TID is 100% owned by Telefónica S.A.
Previous Involvement in Research and Training Programmes (RTP)	METRICS (ITN-607728): Measurement for Europe: Training and Research for Internet Communications Science. CARS (PIEF-GA-2010-273739): Context-Aware Recommender Systems FMIA (PIEF-GA-2009-255625): Future Mobile Information Access: Challenges and Opportunities
Current Involvement in RTP	ENCASE (RISE-691025): EnhaNcing seCurity And privacy in the Social wEb: a user centered approach for the protection of minors PROTASIS (RISE-690972): Restoring Trust in the cyber space: a Systems Security Proposal. INCOGNITO (RISE- 824015): IdeNtity verifiCatiOn with privacy-preservinG credeNtIals for anonymous access To Online services.
Relevant Publications and/or Research / Innovation Product	• Francesco Gringoli, Paul Patras, Carlos Donato, Pablo Serrano, Yan Grunenberger. Performance Assessment Open Software 5G Prototyping. IEEE Wireless Communications Magazine, 2018. (https://www.it.uc3m.es/pablo/papers/pdf/2018-gringoli-wcm-assessment.pdf) • Yan Grunenberger, Diag-logger, Opensource software for 4G modem tracing, 2018 https://github.com/ravens/diag-logger

INTERUNIVERSITAIR MICRO-ELECTRONICA CENTRUM (IMEC)	
General Description	At IMEC, we perform world-leading research in nano-electronics and create groundbreaking innovation in application domains such as healthcare, smart cities and mobility, logistics and manufacturing, and energy. The combination of our widely acclaimed leadership in microchip technology and profound software and ICT expertise is what makes imec unique. The IMEC IDLab research group (Internet & Data Lab, http://idlab.technology) performs fundamental and applied research on internet technologies and data science. IDLab is a joint research initiative between the University of Antwerp and Ghent University. It brings together over 300 researchers and targets challenges related to connecting everything and extracting high value from data. More specifically, the current research is structured in eight distinct research tracks: (1) distributing Intelligence in IoT, (2) Machine Learning & Data Mining, (3) Semantic Intelligence, (4) Multimedia Processing, (5) Electromagnetics & high-frequency circuit design, (6) Wireless Networking, (7) Fixed Networking and (8) Cloud and Big Data Infrastructures. IDLab has a unique research infrastructure used in numerous national and international collaborations.
Role and Commitment of key persons (including supervisors)	**Prof. Johann Marquez-Barja** (male) is an Associate Professor at University of Antwerpen, as well as an adjunct researcher in IMEC, Belgium. He was and is involved in several European research projects such as CREW, FORGE, WiSHFUL, Fed4FIRE/FAVORITE, Fed4FIRE+, eWINE, CONCORDA, 5G-CARMEN, FLEXNET, and FUTEBOL projects. Currently, he is also the Technical Coordinator of the FUTEBOL consortium, becoming Principal Investigator for imec within this project. He is a member of ACM, and a Senior member of the IEEE Communications Society and IEEE Education Society where he participates in the board of the Standards Committee. His main research interests are: 5G advanced heterogeneous dense cells architectures; elastic and flexible future wireless networks, and its integration and impact on optical networks; IoT clustering; softwarization and virtualization; provisioning and dynamic resource allocation towards dynamic converged networks. He is also interested in vehicular networks, mobility, and smart cities deployments. Prof. Marquez-Barja is co-leading the Citylab Smart City testbed, part of the City of Things programme, located in Antwerpen, Belgium. He has studied in USA, Bolivia, Cuba, and Spain. He holds a BSc+MSc Computer Science —graduated with Honours—, MSc. in Telematics, MSc on Computer Architectures, and a PhD in Architecture and Technology of Computer and Network Systems from the Universitat Politecnica de Valencia (Spain) -graduated with cum laude honours in 2012. **He will be in charge of the supervision of one ESRs and will dedicate 10% of his time to the project** **Prof**. **Ingrid Moerman** (female) received her degree in Electrical Engineering (1987) and the Ph.D. degree (1992) from the Ghent University, where she became a part-time professor in 2000. She is a staff member at IDLab, a core research group of imec with research activities embedded in Ghent University and University of Antwerp. She is coordinating the research activities on mobile and wireless networking, and she is leading a research team of more than 30 members at Ghent University. Her main research interests include: collaborative and cooperative networks, intelligent cognitive radio networks, real-time software defined radio, flexible hardware/software architectures for radio/network control and management, Internet of Things, Low Power Wide Area Networks (LPWAN), High-density wireless access networks, Next generation wireless networks, and experimentally-supported research. Ingrid Moerman has a longstanding experience in running and coordinating national and EU research funded projects. **She will be in charge of the supervision of one ESRs and will dedicate 10% of his time to the project**
Key Research Facilities, Infrastructure and Equipment	The IDLab group operates the City of Things CityLab testbed. City of Things is a collaborative initiative from imec, the City of Antwerp and the Flanders region to turn Antwerp into a living lab where businesses, researchers, citizens and city officials can experiment with smart technologies to make urban life more enjoyable and sustainable. This testbed is intended for wireless networking experimentation in the unlicensed spectrum. Moreover, within IDLab research infrastructure we count 8 different high-performance facilities ranging from cloud computing, wireless networks to smart cities and highways. Within this ITN, imec IDLab would leverage the City of Things Citylab testbed and w.ilab.t that offers several wireless technologies ranging from BT to LTE.
Status of Research Premises	IMEC (University of Antwerpen and University of Gent facilities) offers state of the art facilities for our researchers, offering them administrative support in their day to day research, as well as enabling opportunities to enhance both soft and technical skills. Our premises offer online access to major relevant information sources.
Previous Involvement in RTP	IMEC IDlab has been involved in several EU projects related to this ITN topic, ranging for IA, RIA, ITN, MSCA, actions/project. Regarding previous FP7 ITNs, IMEC has participated in SPAM, NAMSEN, MATCON, SEMISPINNET, HERODOT
Current Involvement in RTP	IMEC IDLab, with relation to this ITN topic, is currently involved in the FLEXNET (EU Celtic) project, H2020 5G-Carmen and CORCORDA projects, and the MSCA-ITN PHONSI, ELENA, TAPAS, HYCOAT FutureArctic
Relevant Publications and/or Research / Innovation Product	• C. Sexton, N. Kaminski, J. Marquez-Barja, N. Marchetti, and L. A DaSilva, "5G: Adaptable Networks Enabled by Versatile Radio Access Technologies", IEEE Comm. Surveys and Tutorials, Jan. 2017. • Self-organized energy-efficient cross-layer optimization for device to device communication in heterogeneous cellular networks, A Shahid, KS Kim, E De Poorter, I Moerman, IEEE Access 5, 2017 • Cooperation techniques between LTE in unlicensed spectrum and Wi-Fi towards fair spectral efficiency, Vasilis Maglogiannis, Dries Naudts, Adnan Shahid, Spilios Giannoulis, Eric Laermans and Ingrid Moerman, published in the special issue on 'Cognitive Radio Sensing and Sensor Networks' in the MDPI Sensors Journal, Volume 17, Issue 9, 31 August 2017 • An adaptive LTE listen-before-talk scheme towards a fair coexistence with Wi-Fi in unlicensed spectrum, Vasilis Maglogiannis, Dries Naudts, Adnan Shahid and Ingrid Moerman, Telecommunication Systems Journal, 10 January 2018

CHALMERS TEKNISKA HOEGSKOLA AB	
General Description	Chalmers University of Technology (Chalmers) was founded in 1829 and is an independent foundation university. Chalmers offers MS.c. Eng., M.Arch., B.Sc. Eng., Nautical, Licentiate and Ph.D. programs, as well as continued development programs for professionals. Chalmers has about 11,000 students and 2500 employees. Each year around 350 Ph.D. and Licentiate degrees are awarded as well as 1000 M.Sc. Eng. and M. Arch. degrees.
Role and Commitment of key persons (including supervisors)	**Dr. Tommy Svensson (male)** is (full) Professor in the Communication Systems group at Chalmers department of Electrical Engineering, where he is leading the Wireless Systems research on air interface and wireless backhaul networking technologies for future wireless systems. He received a Ph.D. in Information theory from Chalmers in 2003, and he has worked at Ericsson AB with core networks, radio access networks, and microwave transmission products. His main research interests are in design and analysis of physical layer algorithms, multiple access, resource allocation, cooperative systems, moving networks and satellite networks. He has co-authored 4 books, 75 journal papers, 120 conference papers and 51 public EU projects deliverables. **He will be in charge of the supervision of the two ESRs and will dedicate 20% of his time to the project.** **Dr. Erik G. Ström** (male) is a (full) Professor, heads the Division for Communications and Antenna Systems, and leads the competence area Sensors and Communications at the traffic safety centre SAFER. His research interests include signal processing and communication theory in general, and channel estimation, medium access, radio resource management, wireless positioning, and vehicular communications in particular. He has published 150+ scientific conference and journal papers with 4000+ citations. He was a co-guest editor for the Proceedings of the IEEE special issue on Vehicular Communications (2011). He received the Chalmers Pedagogical Prize in 1998 and the Chalmers Ph.D. Supervisor of the Year award in 2009. **He will be involved in the supervision of the two ESRs and will dedicate 5% of his time to the project.**
Key Research Facilities, Infrastructure and Equipment	Chalmers has modern laboratories with numerous workstations, C3SE simulation cluster (www.c3se.chalmers.se), simulation software (MATLAB, OPNET, NS-3, IT++ http://itpp.sourceforge.net, …), the MATE Massive MIMO testbed https://www.chalmers.se/en/projects/Pages/Massive-MIMO-test-bed.aspx, and the RF WebLab for online RF Measurements, http://dpdcompetition.com/rfweblab/.
Status of Research Premises	Chalmers owns its research premises, they are independent from other partners.
Prev.Involvement in RTP	Chalmers has been involved in numerous EU funded and national funded projects. E.g., in FP7, Chalmers was involved in 275 research projects and coordinated 22 multi-partner and 30 single-partner projects. The supervisor/Electrical Engineering department has been involved in FP6 WINNER I/II, Celtic WINNER+, FP7 ARTIST4G, METIS, H2020 mmMAGIC and HIGHTS, VINNOVA Excellence Centres CHASE, VINNOVA-MOST Sweden-China and numerous national VINNOVA/VR/SSF funded projects. • mmMAGIC (Millimetre-Wave Based Mobile Radio Access Network for Fifth Generation Integrated Communications), 2015-2017, https://5g-mmmagic.eu/. • HIGHTS (High precision positioning for cooperative ITS applications), 2015-2018, http://hights.eu/. • METIS 2020 (Mobile and wireless communications Enablers for the Twenty-twenty Information Society), 2012-2015, https://www.metis2020.com/. • ARTIST4G (Advanced Radio Interface Technologies for 4G Systems), 2010-2012, http://www.chalmers.se/en/projects/Pages/ARTIST4G.aspx. • WINNER I/II and Celtic WINNER+ (Wireless World Initiative New Radio), 2004-2010, http://projects.celtic-initiative.org/winner+/.
Curr. Involvement in RTP	In H2020, Chalmers is currently involved in 165 projects, of which 11 are ERC grants. Within MSCA Chalmers has 15 IF projects and is involved in 21 ITNs and 5 RISE projects. Chalmers also coordinates 18 collaboration projects, a.o. the Graphene Flagship with more than 150 partners. The supervisor/department is involved in H2020 5GCar, European Innovative Training Network SILIKA, VINNOVA Excellence Centres ChaseOn and GHz, and several national projects. • 5GCAR (Fifth Generation Communication Automotive Research and innovation), 2017-2019, https://5gcar.eu/.
Relevant Publications and/or Research / Innovation Product	• Y. Sui, A. Papadogiannis, J. Vihriälä, M. Sternad, W. Yang, T. Svensson, "Moving Cells: A promising solution to boost performance for vehicular users", Special Issue IEEE Communications Magazine, 51, (6), June 2013. • D. T. Phan-Huy, M. Sternad, T. Svensson, "Making 5G Adaptive Antennas Work for Very Fast Moving Vehicles", in IEEE Intelligent Transportation Systems Magazine, Volume 7, Issue 2, 2015. • M. Baianifar, S. Khavari, S.M. Razavizadeh, T. Svensson, "Impact of User Height on the Coverage of 3D Beamforming-Enabled Massive MIMO systems", 2017 IEEE 28th Annual International Symposium on Personal, Indoor, and Mobile Radio Communications (PIMRC), Montreal, QC, 2017, pp. 1-5. • B. Makki, T. Svensson, M. Brandt-Pearce, M.S. Alouini, "On the Performance of Millimeter Wave-based RF-FSO Multi-hop and Mesh Networks", IEEE Transactions on Wireless Communications, vol. 16, no. 12, pp. 7746-7759, Dec. 2017. • X. Tang, X. Xu, T. Svensson, X. Tao, "Coverage Performance of Joint Transmission for Moving Relay Enabled Cellular Networks in Dense Urban Scenarios", in IEEE Access, vol. 5, pp. 13001-13009, 2017.

Ericsson AB	
General Description	Ericsson is one of the world's leading manufacturers of telecom equipment and delivers a wide range of communication solutions. The company has been an active partner in developing all the major telecom standards NMT (1G), GSM (2G), WCDMA (3G), LTE (4G), and NR (5G). The research department at Ericsson employs more than 700 highly skilled researchers world-wide and is involved in more than a thousand patent applications every year. Ericsson is one of the main architects and contributors behind 5G.
Role and Commitment of key persons (including supervisors)	**Dr. Gustav Wikström**, (male), is a Research Leader at Ericsson Research in Stockholm, Sweden. He has a background in Experimental Particle Physics and received his Ph.D. from Stockholm University in 2009, following Master studies in Engineering Physics in Lund, Uppsala, and Rennes. After Post-doc studies in Geneva, he joined Ericsson Research in 2011. At Ericsson he has been driving the evolution of network performance studies, simulator development, and worked with WLAN enhancements. Through his work at Ericsson he has also been involved in more than 100 patent applications and authored 7 peer-reviewed papers. During 2015-2018 he was the driver of latency and reliability improvements (URLLC) in LTE and NR, working towards 3GPP 4G and 5G standardization and developing new concepts for critical communication. Since 2018 he is heading the research in Radio Network Architecture and Protocols.
Key Research Facilities, Infrastructure and Equipment	Ericsson Research has its main campus at the Ericsson headquarters located in Kista outside Stockholm. In the research area Network Architecture and Protocols (NAP) more than 150 researchers, out of which about half hold PhDs, work with concept development, innovation, and standardization for Radio Networks. Experts in all relevant areas of wired and wireless communication are available for close collaboration. The premises offer good opportunities for conferences and meetings. There are also lab areas and testing stations available on the Ericsson campus.
Status of Research Premises	The Tech House in Kista is the seat of Ericsson Research and all research areas are present there. It's a modern office building close to KTH Kista campus and the Ericsson main offices, with restaurants and other facilities close by. An ESR fellow will be seated together with a research team working on closely related topics and will be integrated in the ways of working and main relevant tasks at Ericsson.
Prev.Involvement in RTP	• METIS II (Mobile and wireless communications Enablers for the Twenty-twenty Information Society II), (Coordinator), 2015-2017, https://www.metis2020.com/ • METIS 2020 (Mobile and wireless communications Enablers for the Twenty-twenty Information Society), (Coordinator), 2012-2015, https://www.metis2020.com/ • mmMAGIC (Millimetre-Wave Based Mobile Radio Access Network for Fifth Generation Integrated Communications), 2015-2017, https://5g-mmmagic.eu/
Curr. Involvement in RTP	5GCar, https://5gcar.eu/, 5GCroCo, https://5gcroco.eu/
Relevant Publications and/or Research / Innovation Product	• J. Sachs, L. Andersson, J. Araújo, C. Curescu, J. Lundsjö, G. Rune, E. Steinbach, G. Wikström, *Adaptive 5G Low Latency Communication for Tactile Internet Services*, Proceedings of IEEE, 2018. • O. Al-Saadeh, G. Wikström, J. Sachs, I. Thibault, D. Lister, *End-to-End Latency and Reliability Performance of 5G in London*, Globecom 2018. • J. Sachs, G. Wikström, T. Dudda, R. Baldemair, K. Kittichokechai, *5G Radio Network Design for Ultra-Reliable Low-Latency Communication*, IEEE Network Volume 32 Issue 2, March 2018 • C. Hoymann, D. Astely, M. Stattin, G. Wikström, T. Cheng, H. Wiemann, N. Johansson A, M. Frenne, R. Blasco and J. Huschke, *LTE release 14 outlook*, IEEE Communications Magazine Volume 54 Issue 6, June 2016.

Partner Organisations

Rheinisch-Westfälische Technische Hochschule (RWTH) Aachen	
General description	Research on aspects regarding synergies between commercial telecom networks, community networks and public administrations for creating, maintaining and sharing infrastructures will be carried out in close collaboration with Fraunhofer FIT. The chair I5 at RWTH Aachen has an international reputation in the area of information systems, social media analysis and design, semantic web and e-learning.
Key Persons and Expertise	**Prof. Wolfgang Prinz, PhD,** (male) Division Manager at Fraunhofer FIT, Associate Professor at RWTH Aachen, h-Index 31, Publications 247. PhDs/MSc supervised 10/50. He coordinated several national and international research projects such as a large European research project on collaborative work environments. He is editor of national and international journals and chair of international conferences.
Key Research Facilities, Infrastructure and Equipment	The ESRs would be hosted at the Fraunhofer FIT campus.
Previous and Current Involvement in Research and Training Programmes	Fraunhofer FIT and the chair I5 at RWTH Aachen have a long standing record in the participation in EU research and training programmes. This include the coordination of successful EU projects such as CloudTeams, and Grantum as well as EIT funded projects on the development of a Blockcchain training course.
Relevant Publications and/or Research / Innovation Product	• *K*olvenbach S., Ruland R., Gräther W., Prinz W.: Blockchain 4 Education, 2018, Proceedings of 16th European Conference on Computer-Supported Cooperative Work-Panels, Posters and Demos • Fridgen G., Prinz W., Rose T., Urbach N.: Blockchain Lab–Design, Implementation and Evaluation of Innovative Business and Process Models, 2017, Journal on Blockchain engineering • Franken S., Kolvenbach S., Prinz W., Alvertis I., Koussouris S.: CloudTeams: Bridging the gap between developers and customers during software development processes, 2015, Elsevier Procedia Computer Science, pp 188-195

ACCELLERAN	
General description	Accelleran is a company dedicated to engineering best-in-class small cell solutions for the communications industry. Formed by a team with a track record in the small cell industry second to none, and working with leading vendors and operators in the industry, Accelleran is building the high capacity networks needed to serve the mobile internet of today and tomorrow. Accelleran delivers multi-platform multi-segment flexible carrier and mission critical grade LTE TDD and LTE FDD small cell solutions. The software architecture enables the delivery of residential, enterprise, urban and rural/remote small cell solutions based on a common small cell software engine which can map on different deployment architectures from a fully embedded Small Cell solution to distributed cloud RAN. Accelleran participates and is part of industry fora such as Small Cell Forum, O-RAN Alliance, M-CORD, TIP, Global TD-LTE Initiative, ETSI ISG MEC and CBRS Alliance. Accelleran is currently engaged in the development of next generation 5G networks
Key Persons and Expertise	**Dr. Trevor Moore** (male) is CTO and co-founder of Accelleran. Trevor has over 30 years of experience in the communications industry from early work in military communications, mobile data systems in the 80's at VHF and UHF and Fixed Wireless Access systems at 3.5GHz to more than a decade in cellular infrastructure systems development with Tier 1 equipment vendors and smaller start-up organisations. He was instrumental in defining the concept of the 3G Femtocell and the concepts behind the Iuh architecture during 2006 when working with ip.access in Cambridge and has since held leading roles in the emerging small cell industry with Technicolor and ip.access. A strong believer in the potential of small, cross-disciplinary teams working in a disciplined, light-weight methodology to out-perform conventional development structures, Trevor has now worked with the Accelleran team for more than six years to build a practice which we believe to be cutting edge not only in terms of return on investment but also the demonstrable quality of the resulting product. **Antonio Garcia** (male) is Director of Product Management and co-founder of Accelleran. Antonio Garcia obtained his M.Sc. degree in Computer Science in 1992 from the Universitat Politècnica de Catalunya (UPC), Barcelona, Spain. Since then, he has been working for the last 25 years in wireless and cellular technologies with leading edge companies across Europe. Antonio wireless professional career started in Silicon & Software Systems in the early days of DECT, where he developed residential, SOHO, relay and wireless local loop products based on DECT technology. He then moved into the world of cellular technologies in the very early days of UMTS where he was part of the Alcatel team developing a UMTS Radio Network Controller. He also worked in the definition of a GSM/GPRS/EDGE/UMTS mobile phone platform and later on in the Bluetooth silicon products of Alcatel Microelectronics (later ST Micro). He was also part of the Sony Ericsson Mobile Communications team developing the first UMTS phones of the Joint Venture and the development of the next generation UMTS Radio Network Controller of Nokia Siements Networks. As a result of these roles he gained important experience in all stages of software development lifecycle, both on the network side and mobile phone side. He then worked in ODM/OEM driven consumer electronics environments managing the connectivity and telecommunications technology strategy and innovation for Philips products, where he spent 7 years. Within that CTO-oriented innovation laboratory he followed and monitored important wireless and cellular industry trends and technologies, standardization bodies and industry forums. He was also in charge of specific innovation projects involving local wireless connectivity (WiFi, Bluetooth/Bluetooth Smart, NFC, ZigBee RF4CE/Pro, W-HDMI, DLNA,…) and cellular telecommunications (UMTS, LTE, Wimax,…) for Philips Consumer Lifestyle, Lighting and Medical products. He gained invaluable experience in the use of state-of-the-art technology for innovation-driven consumer-centric products. In the last few years he has been working and focusing on Small Cells. First in 3G in his assignment with ip.access and then after joining Accelleran in LTE and now 5G Small Cell products. Antonio strongly believes in the value that Small Cells can bring to operators, consumers and society as a whole. He considers Small Cells as an area that will exemplify the convergence of cellular and local wireless technologies and will blur the frontiers between traditional operator infrastructure and consumer products.
Key Research Facilities, Infrastructure and Equipment	Accelleran current portfolio of < 6GHz low-power outdoor integrated and virtualised 4G and 5G-Ready small cells, together with the RAN/vRAN Small Cell Software solutions, software development platforms and target testing test lab and equipment can be used during the secondments, particularly in the context of the ones focused in the validation of the research objectives via PoCs.
Previous and Current Involvement in Research and Training Programmes	Accelleran participates in Belgium national H2020 5GUARDS and European H2020 5GCity, 5Genhanced and Unicore projects
Relevant Publications and/or Research / Innovation Product	Accelleran is a SME and focusses on bringing Small Cell commercial products & services to market. The approach that Accelleran has taken in the software architecture enables architecture-agnostic carrier-grade low cost, flexible and multiplatform products for urban, suburban, rural and remote deployments. • Accelleran Carrier and mission-critical grade architecture-agnostic small cell RAN-vRAN software solutions have been selected as winner of the Small Cell Forum Award 2018 in the category "Outstanding innovation in small cell technology or architecture". See http://www.accelleran.com/accelleran-scf-award-winner/. • Accelleran was also selected by BT, in collaboration with TIP and Facebook, as one of the 2 winners in the TEAC (TIP Ecosystem Acceleration Centre) UK Wave 2 Final. See http://www.accelleran.com/accelleran-teac-uk-winner/ • In the context of Suburban and Rural solutions and innovative approaches to enable low cost rural deployments Accelleran has already integrated its Small Cell software solutions with TIP OpenCellular

6. Ethics Issues

N/A

7. Letters of Commitment

Lehrstuhl Informatik V
(Informationssysteme)
Prof. Dr. M. Jarke

Rheinisch-Westfälische Technische Hochschule Aachen

Informatik V • Ahornstr. 55 • D-52056 Aachen

Lehrstuhl Informatik V
RWTH Aachen - Ahornstr. 55
52056 Aachen - Germany
http://www-i5.informatik.rwth-aachen.de

Prof. Dr. M. Jarke
Tel: +49 241 8021501
Fax: +49 241 8888321
jarke@informatik.rwth-aachen.de

Letter of commitment

I undersigned **Wolfgang Prinz** in my quality of **Associate Professor,** hereby declare that my organization will participate as a **Partner Organization** of the ITN proposal **5G4REAL** submitted within the call **H2020-MSCA-ITN-2019** should the proposal be funded.

I am aware of and agree with the principle that the setting up of such provisions is a precondition for funding.

The doctoral students of the undersigned project will be enrolled in the Doctoral School and will be advised by **Wolfgang Prinz, Deputy Director Fraunhofer FIT**, who is beneficiary of the project. I commit to set up all necessary provisions to follow a doctoral degree programme including personalized supervision and collective training. The Marie-Skłodowska Curie researchers will be awarded a research doctoral degree when fulfilling, at the end of their research work, the requirements of our Doctoral School.

If needed, and as a Partner Organization this institution, **RWTH Aachen**, is authorized to sign agreements on joint international supervision of Doctoral Theses with ESR contracted by other partner organizations and contribute to the project by ensuring the highest quality training.

I hereby declare that I am entitled to commit into this process the Institution/Doctoral School I represent.

Yours sincerely,

St. Augustin, 10-Jan-2019, Prof. Wolfgang Prinz, PhD.

Accelleran N.V
Quellinstraat 49
2018 Antwerp
Belgium

14/01/2019

Letter of Commitment

Hereby I, Frédéric Van Durme, as CEO, express the intention of my organization to participate as **partner organization** for the 5G4real project. The proposal will be submitted within the framework of Marie Curie Innovative Training Networks (ITN), call H2020-MSCA-ITN.2019 as published on the website:

https://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/calls/h2020-msca-itn-2019.html

Accelleran N.V. is a startup/scaleup SME based in Belgium.
Accelleran is a company dedicated to engineering best-in-class small cell solutions for the communications industry. Formed by a team with a track record in the small cell industry second to none, and working with leading vendors and operators in the industry, Accelleran is building the high capacity networks needed to serve the mobile internet of today and tomorrow. Accelleran delivers multi-platform multi-segment flexible carrier and mission critical grade LTE TDD and LTE FDD small cell solutions. The software architecture enables the delivery of residential, enterprise, urban and rural/remote small cell solutions based on a common small cell software engine which can map on different deployment architectures from a fully embedded Small Cell solution to distributed cloud RAN. Accelleran participates and is part of industry fora such as Small Cell Forum, O-RAN Alliance, M-CORD, TIP, Global TD-LTE Initiative, ETSI ISG MEC and CBRS Alliance.

I confirm the intention of Accelleran to participate in the 5G4real in the following way:

- Host a number of 3-9 months secondments from the ESRs trained in the 5G4real project and enrich their knowledge and technical skills in applying 5G in suburban and rural areas
- Contribute our latest research findings to the training events for the benefit of the ESRs

The contact person in Accelleran for the duration of the project will be Dr. Trevor Moore (trevor.moore@accelleran.com).

Sincerely,

Frederic Van Durme

Frédéric Van Durme

Signature Certificate

Document Ref.: XDJMZ-Q44RE-2NTF8-VWNU9

Document signed by:

Frederic Van Durme

Verified E-mail:
frederic.vandurme@accelleran.com

IP: 89.248.140.15 Date: 14 Jan 2019 09:18:19 UTC

Frederic Van Durme

Document completed by all parties on:
14 Jan 2019 09:18:19 UTC

Page 1 of 1

Signed with PandaDoc.com

PandaDoc is the document platform that boosts your company's revenue by accelerating the way it transacts.

Universiteit Antwerpen

14 January 2019

Innovative Training Networks (ITN) Call: H2020-MSCA-ITN-2019
5G4REAL Training Network
Letter of Support

Prof. Dr. Herman Van Goethem, the undersigned, and legal representative of **Universiteit Antwerpen**, would like to express the intention of Universiteit Antwerpen to support and to co-operate in the H2020 MSCA-ITN "**5G4REAL**". The proposal is to be submitted to the European Commission by 15.1.2019 under the H2020-MSCA-ITN-2019 call.

The 5G4REAL consortium foresees this strengthening links to 5G communications work. We also believe the University of Antwerp could help by linking the training and research for maximising impact with relevant network players in Europe, considering the latest developments in end-to-end connectivity and network slicing. In addition this ITN training proposal is very relevant to the future goals of Universiteit Antwerpen in training of future world changers for 5G communications.

Prof. Johann Marquez-Barja from Universiteit Antwerpen, who is part of IDlab IMEC, will be the scientist-in-charge for the contributions of Universiteit Antwerpen and IMEC to 5G4REAL. Universiteit Antwerpen commits itself to actively participate and contribute to the project as described by their role in the final proposal such as:

- Offering technical support including membership of an Advisory Board should that be required. This may include a review of user requirements, proposed designs and architectures, test reports and business-related documents produced by the 5G4REAL project
- Academic supervision of the ESR allocated to IMEC, to be enrolled in the Antwerp Doctoral School
- Awarding a doctoral degree to ESR allocated to IMEC in case all PhD requirements of Universiteit Antwerpen are fulfilled
- Participating in progress meetings, offering key advice and insights to ESR allocated to IMEC
- Leverage of our innovation labs for the execution of the proposed projects of ESR allocated IMEC

University of Antwerp undertakes to treat commercially confidential any information concerning the 5G4REAL project proposal and to sign a mutually acceptable confidentiality agreement prior to joining the Advisory Board.

Yours sincerely,

Prof. dr. Herman Van Goethem
Rector Universiteit Antwerpen

Universiteit
Antwerpen

RESEARCH DEPARTMENT
RESEARCH CO-ORDINATION OFFICE

Nathalie Vandepitte
European Research Advisor

E Nathalie.Vandepitte@UGent.be
E EU-cel@ugent.be
T +32 9 264 3029

European Office
Campus UFO, rectoraat
Sint-Pietersnieuwstraat 25
9000 Gent
Belgium

www.ugent.be

Letter of Institutional Commitment

DATE 14 January 2019 | PAGE 1/2 | OUR REFERENCE

Innovative Training Networks (ITN) Call: H2020-MSCA-ITN-2019
5G4REAL Training Network
Letter of Support

Rik Van de Walle, the undersigned, and legal representative of **Ghent University**, would like to express the intention of Ghent University to support and to co-operate in the H2020 MSCA-ITN **"5G4REAL"**. The proposal is to be submitted to the European Commission by 15.1.2019 under the H2020-MSCA-ITN-2019 call.

The 5G4REAL consortium foresees this strengthening links to 5G communications work. We also believe the Ghent University could help by linking the training and research for maximising impact with relevant network players in Europe, considering the latest developments in resource allocation in shared 5G infrastructures. In addition, this ITN training proposal is very relevant to the future goals of Ghent University in training of future world changers for 5G communications.

Prof. Ingrid Moerman from Ghent University, who is part of IDlab IMEC, will be the scientist-in-charge for the contributions of Ghent University and IMEC to 5G4REAL.

Ghent University commits itself to actively participate and contribute to the project as described by their role in the final proposal such as:

- Offering technical support including membership of an Advisory Board should that be required. This may include a review of user requirements, proposed designs and architectures, test reports and business-related documents produced by the 5G4REAL project
- Academic supervision of the ESR allocated to IMEC, to be enrolled in the Ghent University Doctoral School

GHENT UNIVERSITY

RESEARCH DEPARTMENT
RESEARCH CO-ORDINATION OFFICE

- Awarding a doctoral degree to ESR allocated to IMEC in case all PhD requirements of Ghent University are fulfilled
- Participating in progress meetings, offering key advice and insights to ESR allocated to IMEC
- Leverage of our innovation labs for the execution of the proposed projects of ESR allocated IMEC

Ghent University undertakes to treat commercially confidential any information concerning the 5G4REAL project proposal and to sign a mutually acceptable confidentiality agreement prior to joining the Advisory Board.

Yours sincerely,
For the rector

Dr Dirk De Craemer
Head of the Research Co-ordination Office
Ghent University

Rik Van de Walle
Rector Ghent University

UNIVERSITEIT GENT

END PAGE

MARIE SKŁODOWSKA-CURIE ACTIONS

Innovative Training Networks (ITN)
Call: H2020-MSCA-ITN-2019

PART B

"5G4real"

This proposal is to be evaluated as:

ETN

Digitally sealed by the European Commission
Date: 2019.01.16 12:34:44 CET
Reason: Acknowledgement of Receipt

This electronic receipt is a digitally signed version of the document submitted by your organisation. Both the content of the document and a set of metadata have been digitally sealed.

This digital signature mechanism, using a public-private key pair mechanism, uniquely binds this eReceipt to the modules of the Participant Portal of the European Commission, to the transaction for which it was generated and ensures its full integrity. Therefore a complete digitally signed trail of the transaction is available both for your organisation and for the issuer of the eReceipt.

Any attempt to modify the content will lead to a break of the integrity of the electronic signature, which can be verified at any time by clicking on the eReceipt validation symbol.

More info about eReceipts can be found in the FAQ page of the Participant Portal. (http://ec.europa.eu/research/participants/portal/page/faq)