

A stylized illustration of a smart city in shades of blue and white. It features various elements like houses, buildings, cars, and people, all interconnected by a network of lines and nodes. Labels such as 'CONNECTED CITY', 'CONNECTED HEALTH', 'CONNECTED HOUSE', and 'CONNECTED TRANSPORTATION' are scattered throughout the scene. The overall theme is digital connectivity and infrastructure.

The 5G Infrastructure Public-Private Partnership

H2020 5G related calls & collaboration enhanced with US stakeholders

Werner Mohr

Chair of the board of 5G Infrastructure Association

<http://5g-ppp.eu/>

Outline

- Horizon 2020 Work Program references
- Objective ICT-07-2017: 5G PPP Research and validation of critical technologies and systems
- Objective ICT-08-2017: 5G PPP Convergent technologies
- Program approach and international cooperation
- Horizon 2020 Call 2 funding budget and time plan
- Discussion

Horizon 2020 Work Program 2016/17

- Work Program 2016/17 published at EU ICT Conference in October 2016 in Lisbon, Portugal
 - http://ec.europa.eu/research/participants/portal/desktop/en/funding/reference_docs.html#-
- 5. Leadership in enabling and industrial technologies = Introduction
 - http://ec.europa.eu/research/participants/data/ref/h2020/wp/2016_2017/main/h2020-wp1617-leit_en.pdf
- 5.i. Information and Communication Technologies
 - http://ec.europa.eu/research/participants/data/ref/h2020/wp/2016_2017/main/h2020-wp1617-leit-ict_en.pdf
- Focus on objectives for direct US cooperation
- However, Horizon 2020 is open for international cooperation

Horizon 2020 5G PPP Call 2 objectives

154 million € Funding including joint calls

- ICT-07-2017: 5G PPP Research and Validation of critical technologies and systems
- ICT-08-2017: 5G PPP Convergent Technologies
- (EUJ-01-2016: Joint Call EU-Japan, different timing)
- (EUK-01-2016: Joint Call EU-Korea, different timing)
- Call 2: Opening May 10, 2016, Closing November 8, 2016

Wireless access and radio network architecture/ technologies

- Novel air interface technologies, heterogeneous set of requirements (low rate sensors including mission critical M2M to very high rate HD/3D TV and immersive services, supporting local and wide area systems), enabling usage of frequency bands above 6 GHz
- Hardware architectures technologies and building blocks
- (Radio) Network functional architectures and interfaces leading to vision / reference architecture for 5G
- Co-operative operation of heterogeneous access networks, including broadcast/multicast (terrestrial and satellite based) and supporting SDN and virtualization
- Multi-tenancy for Radio Access Network (RAN) sharing
- Integration of Satellite Networks to support ubiquitous coverage, resilience, specific markets

High capacity elastic - optical networks

- Support very high traffic and capacity increase originating from an (5G) heterogeneous access networks with matching capabilities from the core and metro environments, at ever increasing speeds and in more flexible and adaptive form
- New spectrally efficient, adaptive transmission, networking, control and management approaches to increase network capacity by a factor of >100 while at the same time providing high service granularity, guarantees for end-to-end optimization and QoS - reducing power consumption, footprint and cost per bit and maintaining reach
- Integration of new optical transport and transmission designs with novel network control and management paradigms (e.g., SDN) are expected to enable programmability

Software Networks

- Software network architecture to support access agnostic converged core network and control framework enabling next generation services
- Architecture leverages SDN/NFV paradigm to integrate/manage next generation transport and optical technologies
- Unified management of connectivity, with end to end security mobility and routing for flexible introduction of new services
- Scalability and efficiency related to increasing deployment of software-based network equipment and functions as well as corresponding more diverse services and usages
- Ease of deployment of multitenant networks, cost and energy efficiency, "five 9" reliability, flexibility and perceived "zero latency" where relevant
- Target is for a Network Operating System (NOS) with hardware and user interfaces to manage and orchestrate unified access to computing, storage, memory and networking resources
- Management and security for virtualised networks and services
- Network analytics tools, knowledge reasoning and cognition, may be extended towards network operations
- Management of security across multiple virtualised domains

Ubiquitous 5G access leveraging optical technologies

- 5G access networks have to dramatically grow in user capacity, quality of service, responsiveness, energy efficiency and number of connected devices while keeping a sustainable cost
- To develop and assess new optical access network solutions based on integrated optical device prototypes
- Co-operative radio-optical approaches are seen as very promising, also to cover intelligent interference cancellation
- Techniques to map 5G channels to optical transport and a co-design of the optical and wireless interfaces and protocols
- Scalable demonstrators validated through typical usage scenario

Flexible network applications

- Leveraging current intense research activities in relation to Virtualised Network Functions (VNF) and targeting development of a multiplicity of VNF's useful to operators, service providers and users
- Service providers or third party providers should be able to assemble virtualised 5G functions as "network apps" from NFV hosting infrastructure, to deploy them in the relevant network nodes, to orchestrate and customise resources to provision user services
- Target is for a cloud like 5G infrastructures, supporting network services, resource and service orchestration
- This environment also provides an open source development framework for control functionalities and application developments
- It also provides the link between the network –terminal functions and the app/content providers towards standards developments

H2020 5G Infrastructure PPP

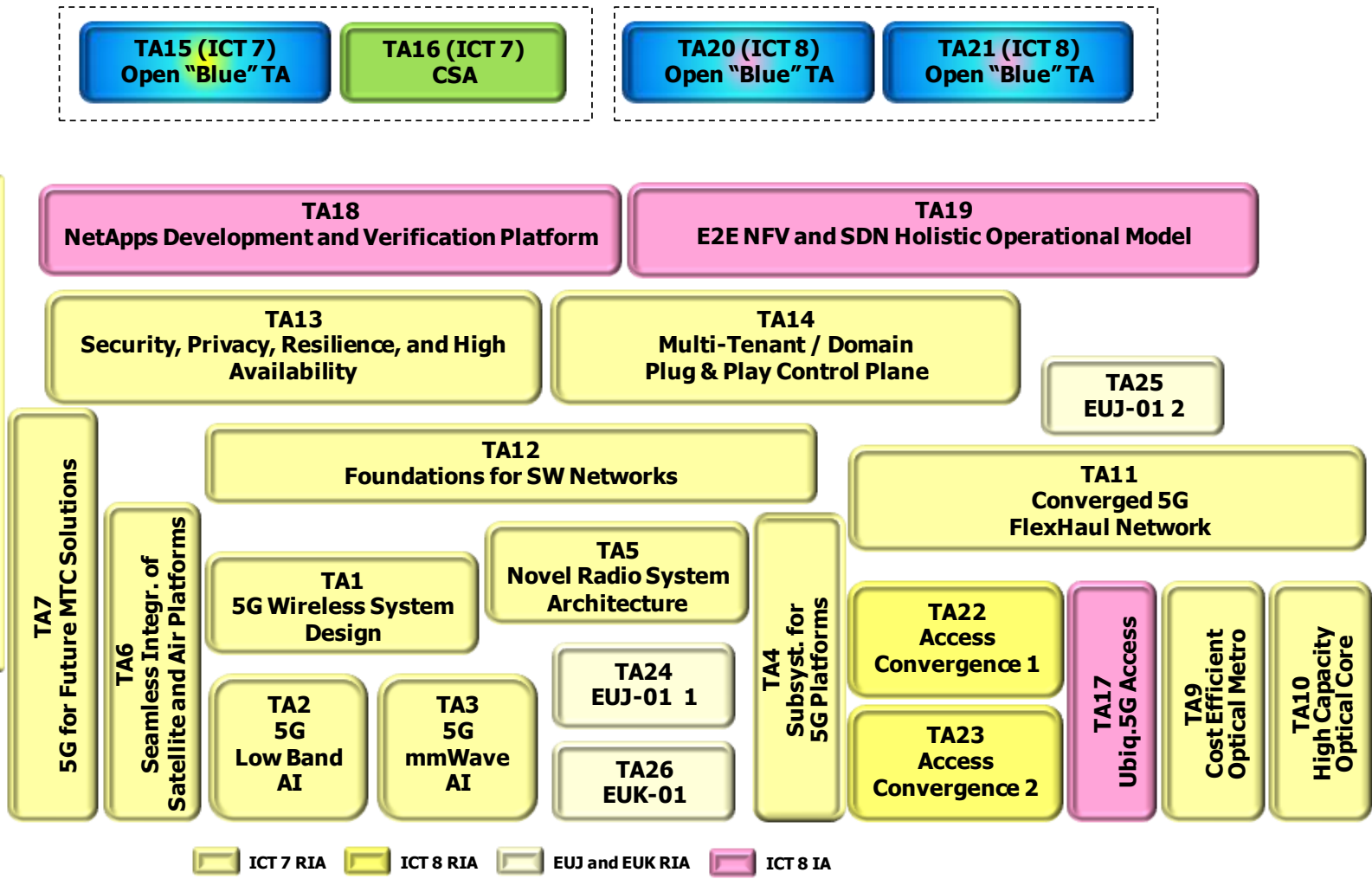
Phase 2 Pre-structuring Model – TAs Portfolio

5G Infrastructure PPP
The European path towards global next generation communication networks

Application Layers

Physical Layer

TAS
Cognitive Network Mngt



Note: The size and the orientation of the TAs boxes do not indicate the potential size or manpower of future Projects

ICT-07-2017: 5G PPP Research and Validation of critical technologies and systems

- Specific Challenge:
 - 5G PPP initiative phase 2 implemented under this LEIT-ICT Work Program
 - Challenge to eliminate current and anticipated limitations of network infrastructures
 - Supporting a much wider array of requirement than is the case today and with capability of flexibly adapting to different "vertical" application requirements
 - Vision: In ten years from now, telecom and IT will be integrated in a common very high capacity and flexible 5G ubiquitous infrastructure, with seamless integration of heterogeneous wired and wireless capabilities
 - 5G Networks have to cover a wide range of services from different use case and application areas/verticals, for increasingly capable user terminals, and for an extremely diverse set of connected machines and things

Source: EU Commission: HORIZON 2020 - Work Programme 2016 - 2017 Information and Communication Technologies.

23/09/2016

ICT-07-2017: 5G PPP Research and Validation of critical technologies and systems

- Specific Challenge:
 - Increasingly cloud-based service access; to support a shift from the “Client-Server” model to “Anything” as a Service (XaaS); interfaces and functions based on virtualisation technologies
 - To leverage work and results of phase 1 (WP 2014-15) and to accelerate on proof of concepts and demonstrators
 - Where technological maturity permits, validation of research results will be supported by experimental testing conducted in the context of use cases in active cooperation with the various potential "vertical" sectors
 - This validation activity to be leveraged in the context of the important standardisation (3G PP) and spectrum (WRC 19) milestones

Scope: a. Research and Innovation Actions

- Strand 1
 - Wireless access and radio network architecture/technologies
- Strand 2
 - High capacity elastic - optical networks
- Strand 3
 - "Software Network"

Scope: a. Research and Innovation Actions

Strand 1: Wireless access and radio network architecture/technologies

- **Novel air interface technologies**
 - i) supporting efficiently a heterogeneous set of requirements from low rate sensors including mission critical M2M communications to very high rate HD/3D TV and immersive services;
 - ii) supporting local and wide area systems, heterogeneous multi-layer deployments, assuring uniform performance coverage, capacity, e.g. through advanced Multi Antenna Transceiver Techniques, including 3D and massive MIMO beam-forming;
 - iii) enabling usage of frequency bands above 6GHz, for ultra-high speed access, backhaul and fronthaul, based on fully characterised channel models.
- **Hardware architectures technologies and building blocks for 5G low cost low-within relevant spectrum range**

Scope: a. Research and Innovation Actions

Strand 1: Wireless access and radio network architecture/technologies

- **(Radio) Network functional architectures and interfaces** leading to a stable vision / reference architecture for 5G in support of standardisation work
 - Provides a platform for technical coordination with other 5G initiatives
 - Architecture efficiently supports different deployment topologies ranging from fully distributed to fully centralised, with reduced management complexity and minimised signalling overhead
 - Technologies like WiFi covered
 - Supports the “5G services and verticals” framework embracing the machine-type of communication services, the Internet of Things
 - Solutions that unify connection, security, mobility, multicast/broadcast and routing/forwarding management capable of instantiating any type of virtual network architecture
- **Co-operative operation of heterogeneous access networks** integrating virtual radio functions into service delivery networks, including broadcast/multicast technologies (terrestrial and satellite based) and supporting Software Defined Networking (SDN) and virtualisation techniques of RAN functions

Scope: a. Research and Innovation Actions

Strand 1: Wireless access and radio network architecture/technologies

- **Support of numerous devices with different capabilities**, with unified connectivity management capabilities, in terms of security, mobility and routing including cloud and edge computing for low latency requirements and carrier grade communications for MTC
- Coordination and optimization of **user access to heterogeneous radio accesses** including ultra-dense networks
- **Multi-tenancy** for Radio Access Network (RAN) sharing, covering ultra-dense network deployments with the ability to allocate traffic to shared MNOs infrastructure while satisfying their SLAs
- **Integration of Satellite Networks** to support ubiquitous coverage, resilience, specific markets, and where appropriate further complement terrestrial technologies (e.g. in traffic off loading, backhaul, or content delivery)

Scope: a. Research and Innovation Actions

Strand 2 High capacity elastic - optical networks

- Support very high traffic and capacity increase
 - originating from an (5G) heterogeneous access networks with matching capabilities from the core and metro environments,
 - at ever increasing speeds and in more flexible and adaptive form.
 - Covers new spectrally efficient, adaptive transmission, networking, control and management approaches to increase network capacity by a factor of >100 while at the same time providing high service granularity, guarantees for end-to-end optimization and QoS - reducing power consumption, footprint and cost per bit and maintaining reach.
 - Integration of such new optical transport and transmission designs with novel network control and management paradigms (e.g., SDN) are expected to enable programmability.
- Disruptive approaches for massive capacity scaling may impact network infrastructure, and system architectures which need to be assessed for integration and migration aspects.

Scope: a. Research and Innovation Actions

Strand 3 "Software Network"

- **Software network architecture** to support an access agnostic converged core network and control framework enabling next generation services (including services for vertical sectors) and integrating next generation access and devices. The architecture leverages the SDN/NFV paradigm and is able to integrate/manage next generation transport and optical technologies, both for backhaul and fronthaul, to flexibly meet increasing system capacity requirements;
- A **unified management of connectivity**, with end to end security mobility and routing (including multicast/broadcast) beyond current concepts (e.g. tunnelling) for flexible introduction of new services. This aims at a unified physical infrastructure and includes corresponding abstractions – (virtual) resources, functions, hardware etc. – for control and orchestration. Solutions to provision SDN networks across administrative boundaries (e.g. multiple operators, customer networks, datacentres) and interoperability issues between multiple SDN control domains are in scope;

Source: EU Commission: HORIZON 2020 - Work Programme 2016 - 2017 Information and Communication Technologies.

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Scope: a. Research and Innovation Actions

Strand 3 "Software Network"

- **Solutions** (e.g. API's and corresponding abstractions) that **allow re-location or anycast search of services and their components**, as a function of the context. This includes problems involved in portability of virtual network functions and naming of deployed functions and services. It supports co-existence of multiple network domains and easy migration;
- **Scalability and efficiency** related to increasing deployment of **software-based network equipment and functions** as well as corresponding more diverse services and usages. These include ease of deployment of multitenant networks, cost and energy efficiency, "five 9" reliability, flexibility and perceived "zero latency" where relevant;

Scope: a. Research and Innovation Actions

Strand 3 "Software Network"

- Realisation of the "**plug and play vision**" for **computing, storage and network resources** through appropriate abstraction, interfaces, and layering. It covers the full network infrastructure from core network to heterogeneous access, also with integration of the 5G architecture with legacy infrastructure. The target is for a Network Operating System (NOS) with hardware and user interfaces to manage and orchestrate unified access to computing, storage, memory and networking resources. The approach towards a NOS may also be considered in the context of experimental facilities, in view of integrating multiple heterogeneous European experimental facilities. The goal is to allow proper testing and comparison of the different 5G technological components. OSS solutions are preferred;

Scope: a. Research and Innovation Actions

Strand 3 "Software Network"

- **Management and security for virtualised networks and services** to support service deployment decisions related with location and lifecycle management of network functions, and flexible configuration of network nodes. Network analytics tools, knowledge reasoning and cognition, may be extended towards network operations to cope with complex, heterogeneous, and dynamic networks featuring large numbers of nodes, and to correlate all monitoring sources in order to create a real-time supervision of Quality of Service and Quality of Experience. Management of security (privacy where appropriate) across multiple virtualised domains is a key aspect to be covered by this call.

Scope: a. Research and Innovation Actions Funding

- The Commission considers that proposals requesting a **contribution from the EU of between EUR 5 and 8 million** would allow this area to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts, in particular for proposals targeting significant experiment/demonstrations activities in relation to well identified use cases justifying higher amounts.

Scope: a. Research and Innovation Actions

Expected impact

- Overarching impact: 40% of the world communication infrastructure market for EU headquartered companies;
- Demonstrated progress towards core 5G PPP KPI's: 1000x capacity, 1ms latency, 90% energy savings, 10x battery lifetime, service creation in minutes, better/increased/ubiquitous coverage, 10 times to 100 times higher typical user data rate, 10 times lower energy consumption for low power Machine type communication, Lowered EMF levels compared to LTE solutions;
- Novel business models through innovative sharing of network resources across multiple actors;
- Finer grained management of optical metro and core capacity and capacity increase by a factor of 100 (only for Strand 2);
- Optimised optical backhaul architectures and technologies (only for Strand 2);
- Ubiquitous 5G access including in low density areas (only for Strand 1 and 2);

Source: EU Commission: HORIZON 2020 - Work Programme 2016 - 2017 Information and Communication Technologies.

23/09/2016



Scope: a. Research and Innovation Actions

Expected impact

- Definition of 5G network architecture and of core technological components (only for Strand 1 and 3);
- Proactive contribution to the 3G PP standardisation activity on 5G, and to other standardisation activities, e.g. ONF, ETSI-NFV, IEEE; proactive contribution to the WRC 19 preparation for 5G spectrum.
- Proof-of-concept and demonstrators beyond phase one and validating core functionalities and KPI's in the context of specific use cases with verticals closely associated to the demonstrations and validation. Indicative sectors include: automotive, connected cars; eHealth; video/TV broadcast; Energy management; very high density locations and events (only for Strand 1 and 3);
- Novel connectivity paradigms, beyond the Client server model and enabling massive edge network deployments (only for Strand 1 and 3);

Scope: a. Research and Innovation Actions

Expected impact

- Network function implementation through generic IT servers (target) rather than on non-programmable specific firmware (today) (only for Strand 3);
- OS like capabilities to orchestrate network resources (only for Strand 3);
- Trustworthy interoperability across multiple virtualised operational domains, networks and data centres;
- Solutions for the management of multi domain virtualised networks with coverage of security architectures based on industry characterised threat models.

Scope: b. Coordination and Support Actions

Objectives

- 5G PPP projects will be implemented as a program through the use of complementary grants and the respective options of Article 2, Article 31.6 and Article 41.4 of the Model Grant Agreement will be applied. This calls for activities to ensure a sound programmatic view of the implemented 5G Research and Innovation Actions (RIA) and Innovation Actions (IA) results. The proposed support actions shall liaise with the 5G RIA and IA actions to exploit synergies in the implementation of the activities that include:
 - Program level integration through management and orchestration of 5G PPP project cooperation for horizontal issues of common interests (security, energy efficiency, spectrum, standardisation, societal impact of 5G...) in support of the commitments of the 5G PPP contractual arrangement and mapping the strategic program of the 5G industrial Association;
 - Portfolio analysis, coverage, mapping and gap analysis, roadmaps for key PPP technologies and for experimental requirements and facilities, also taking into account national developments;

Scope: b. Coordination and Support Actions

Objectives

- Proactive support to the emergence of a 5G PPP "5G vision", to key international co-operation activities. A clear proactive strategy is expected to channel relevant 5G PPP project outcomes towards key SDO's like 3GPP (standardisation work expected to start in 2016) and to valorise relevant spectrum work in the context of future WRC's;
- Organisation of stakeholder events, including reaching out to users and key verticals;
- Monitoring of the openness, fairness and transparency of the PPP process, including sector commitments and leveraging factor;
- Maintenance of the "5G web site".

Scope: b. Coordination and Support Actions Funding

- The Commission considers that proposals requesting a **contribution from the EU up to EUR 3 million** would allow this area to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Scope: b. Coordination and Support Actions

Expected impact

- Maximised output and exploitation of 5G PPP project results in key domains (standardisation, spectrum) through managed projects cooperation on horizontal issues;
- Constituency building, stakeholder support, support to key international cooperation events; dissemination, support to core international cooperation activities, to relevant stakeholder events;
- Definition of future R&I actions through roadmapping.

- Specific Challenge:
 - Network and service providers are faced with increasing challenges to manage convergence technologies
 - On the one hand, technological versatility increases service provision capabilities, with ever raising possibilities to dimension service offer to context and user specific SLA's
 - On the other hand, convergence technologies are getting increasingly complex, with ever larger integration of multiple technological heterogeneous hardware and software components, and more difficult properties to characterise at scale
 - The challenge thus tackles scalability and usability of mixed network technological approaches that can benefit from previous research, towards validation of deployment at scale

Scope: a. Innovation actions

- Strand 1
 - Ubiquitous 5G access leveraging optical technologies
- Strand 2
 - Flexible network applications

Scope: a. Innovation Actions

Strand 1: Ubiquitous 5G access leveraging optical technologies

- 5G access networks have to dramatically grow in user capacity, quality of service, responsiveness, energy efficiency and number of connected devices while keeping a sustainable cost.
 - The objective is to **develop and assess new optical access network solutions** based on integrated optical device prototypes.
 - Novel integrated devices and subsystems may cover **new optical transmission, switching and information processing techniques** to support key access functionalities such as beam forming, high accuracy cm/mmWave generation and massive MIMO deployments.
 - They may also be based on **new network concepts and control architectures**.
 - **Co-operative radio-optical approaches** are seen as very promising, also to cover intelligent interference cancellation.
 - Techniques to map **5G channels to optical transport** and a co-design of the **optical and wireless interfaces and protocols** are also targeted, to increase capacity and reduce latency, especially in highly dense 5G scenarios.
 - The work draws on existing scientific and research results in the field and includes scalable demonstrators validated through typical usage scenario.

Scope: a. Innovation Actions

Strand 2 Flexible network applications

- The work leverages the current intense research activities in relation to **Virtualised Network Functions (NFV)** and targets development of a multiplicity of VNF's useful to operators, service providers and users.
 - Service providers or third party providers should be able to assemble these virtualised 5G functions as "**network apps**" from an NFV hosting infrastructure, to deploy them in the relevant network nodes, to orchestrate and customise resources to provision user services.
 - The target is for a **cloud like 5G infrastructures**, supporting network services, resource and service orchestration.
 - This environment also provides an **open source development framework** for control functionalities and application developments.
 - It also provides the link between the network –terminal functions and the app/content providers towards standards developments.
 - The platform will be opened to third party developers to demonstrate network "apps".

Scope: a. Innovation Actions Funding

- The Commission considers that proposals requesting a **contribution from the EU of between EUR 5 and 8 million** would allow this area to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts. Minimum one action per strand will be selected.

Scope: a. Innovation Actions

Expected impact

- Validated access network architecture with integrated optical technologies for the realisation of critical access and transport control function (only for Strand 1);
- Demonstration of technological applicability to dense access scenarios supporting the 1000 capacity increase objective (only for Strand 1);
- Demonstrated scalability, close to operational context, of the proposed technological approach (only for Strand 1);
- Contribution to standards, notably 5G and optical access (only for Strand 1);
- Optical access interface with 10 times lower energy consumption (only for Strand 1);
- Open environments for creation of network apps (only for Strand 2);
- Open repository of network apps that may be validated and leveraged by third party developers (only for Strand 2);
- Validation at scale of the VNF aggregation capability of the proposed environment (only for Strand 2).

Source: EU Commission: HORIZON 2020 - Work Programme 2016 - 2017 Information and Communication Technologies.

Scope: b. Research and Innovation Actions – Cooperation in access convergence, Objectives

- This activity takes advantage of the **supporting 5G research and demonstration facilities offered by Taiwan** towards collaborative 5G research with the EU, and aims at developing and demonstrating an integrated convergent access across different air interface technologies and the fronthaul/backhaul/core network.
- Test beds making use of facilities offered by Taiwanese partners are targeted. It demonstrates the capabilities of **new spectrum access schemes**, including for co-working with the network. A system demonstrator showing applications potential is thus favoured, e.g. for high speed moving vehicles.

Scope: b. Research and Innovation Actions – Cooperation in access convergence, Funding

- The Commission considers that proposals requesting a **contribution from the EU of EUR 2.5 million** would allow this area to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Scope: b. Research and Innovation Actions – Cooperation in access convergence, Expected Impact

- Contribution to the ITU-R objectives for the next generation mobile network including requirements on data rates, mobility, connection density, latency, energy efficiency, spectrum efficiency, and traffic volume density
- Contribution to the 1000 fold mobile traffic increase per area, in the context of the target application
- Contribution to the 1ms latency objective in the context of the target application
- Results exploitation in the context of standardization and spectrum requirements

Program approach and international cooperation

- For both objectives
 - ICT-07-2017
 - ICT-08-2017projects will be implemented as a program and be expected to actively contribute key horizontal results to the integration process led by the program level CSA
- Therefore all grants awarded will be complementary to each other and to the grant agreement(s)
- The respective options of Article 2, Article 31.6 and Article 41.4 of the Model Grant Agreement will be applied
- International cooperation with clear EU industrial benefits may be considered, preferably with nations having launched strategic 5G initiatives (e.g. China, Japan, South Korea, Taiwan, **USA**)

Horizon 2020 Call 2 funding budget and time plan

- Call 2 for proposals published: May 10, 2016
- Call 2 closed: November 8, 2016

Objective	Funding budget [Mio €]
ICT-07-2017 (RIA)	100
ICT-07-2017 (CSA)	3
ICT-08-2017 (IA)	40
ICT-08-2017 (RIA)	5
Sum	148

- In addition, there are related 5G specific objectives like
 - EU-Japan
 - EU-Korea calls

Discussion

