EC H2020 5G Infrastructure PPP
Pre-structuring Model
RTD & INNO Strands

(Version 2.0)

Recommendation by 5G Infrastructure Association

H2020 5G Infrastructure PPP
PPP Pre-structuring Model Approach (1/5)

- PPP is an ambitious Programme with ambitious KPIs
- More than a group of standalone projects working together through Concertation & Clusters meetings and activities
- Pre-structuring Model
  - Ensuring that the right set of projects will work together
  - Model focused on projects portfolio and related projects, not proposals as such
  - Possible set of projects objectives, scopes and expected impacts
  - Projects interfaces and possible cross-issues to be defined to reach the PPP KPIs
    - Example of Energy Efficiency to be seen as "by design"
  - Model focused on PPP Phase 1 as described in EC LEIT Work Programme 2014-2015 (ICT 14 – 2014: Advanced 5G Network Infrastructure for the Future Internet - http://ec.europa.eu/information_society/newsroom/cf/dae/document.cfm?doc_id=3958)
- Possibility to have proposals submitted according to the model ("guideline")?
- Possibility to then have EC reviewers making their best selection to fill one project with the best corresponding proposal ("guideline")?
- Avoiding duplication ("hype") and gaps issues?

H2020 5G Infrastructure PPP
PPP Pre-structuring Model Approach (2/5)

- Model defined, communicated, enriched, endorsed before end of April 14
  - Approach initiated in 2013 (http://5g-ppp.eu/coverage-plans)
  - Pre-structuring Model Version 1.0 released publicly on 19.03.14 (http://5g-ppp.eu/wp-content/uploads/2014/03/March-2014-_5G-Infra-PPP_Pre-structuringModel_v1-0.pdf)
  - Open Consultation launched on 19.03.14 with deadline for contributions on 17.04.14 (http://5g-ppp.eu/consultation/)
  - 5G Infrastructure PPP session during FIA 2014 on 20.03.14 in Athens
  - More than 20 contributions received and processed to enrich the Model from Version 1.0 to Version 2.0
    - Note that the Model does not exclude particular technologies
  - Info Day on 28.04.14 in Issy Les Moulineaux (Orange)
  - Pre-structuring Model version 2.0 is the final version
- Additional documents from the 5G Infrastructure Association to contribute to the further definition of the PPP preparation will be communicated in the coming months
  - More details on last slide
- Next 5G Infrastructure PPP workshop during EuCNC 2014 (26.06.14 in Bologna)

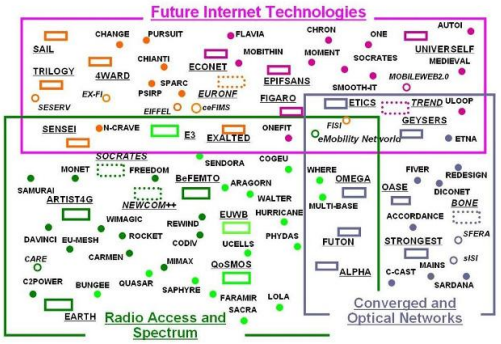
H2020 5G Infrastructure PPP
PPP Pre-structuring Model Approach (3/5)

Projects Pre-definition & Specification

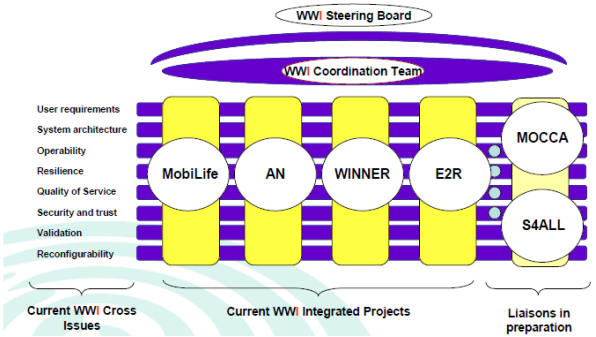
- Standalone Projects
- Potential connections between Proposals
- Clusters and Concertation
- Loose Coupling

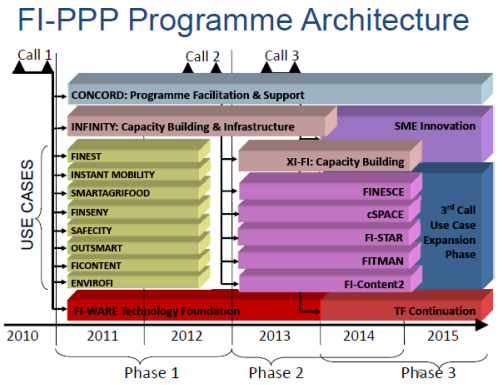
- Coordination of set of proposals
- Tight connections between proposals
- Clusters and Concertation for projects outside of the initiative
- Joint events / meetings based on WWI momentum
- No joint technical KPI

- Very tight pre-definition and integration



http://cordis.europa.eu/fp7/ict/future-networks/projects_en.html





FP6-like
FP7-like

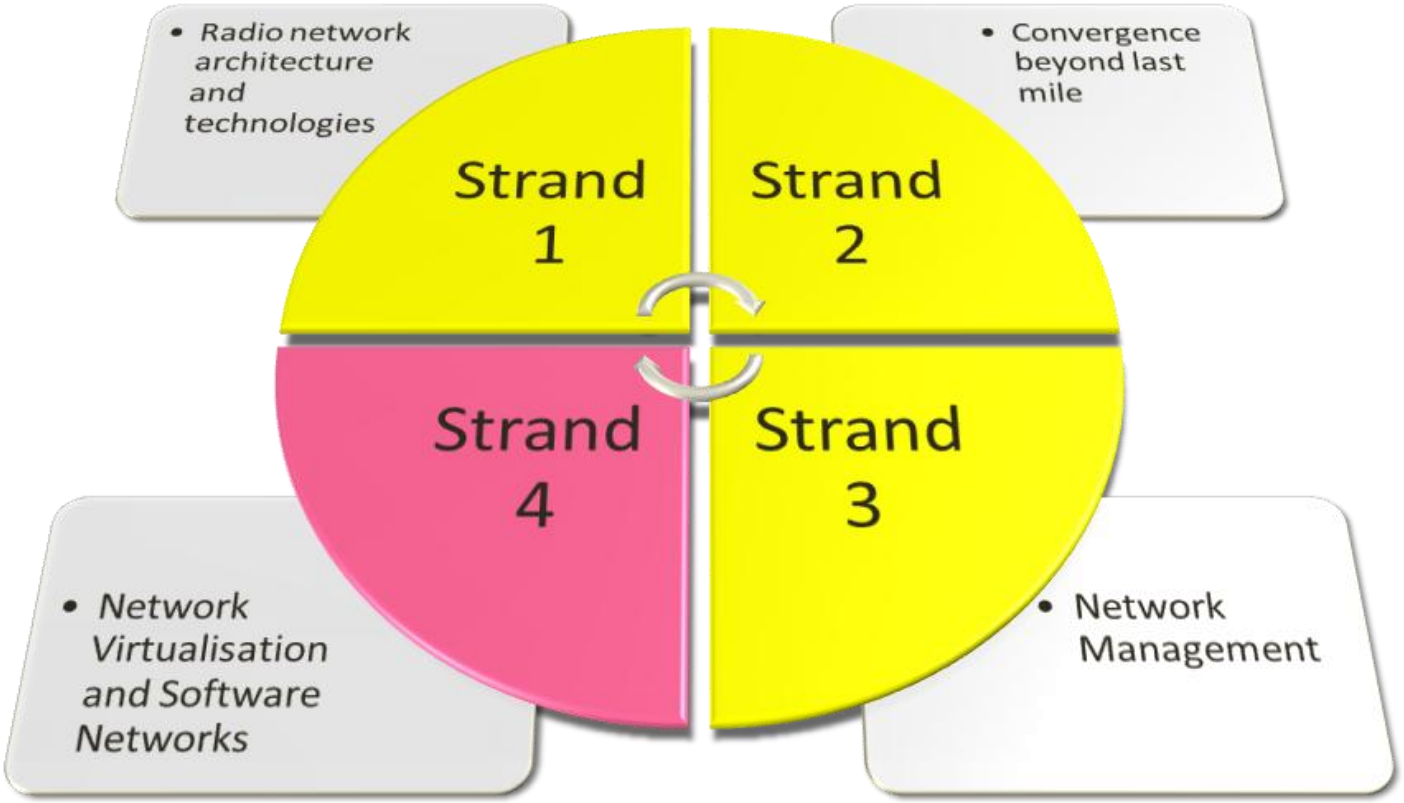
FP6 WWI

FI PPP

H2020 5G Infrastructure PPP
PPP Pre-structuring Model Approach (4/5)

5G PPP

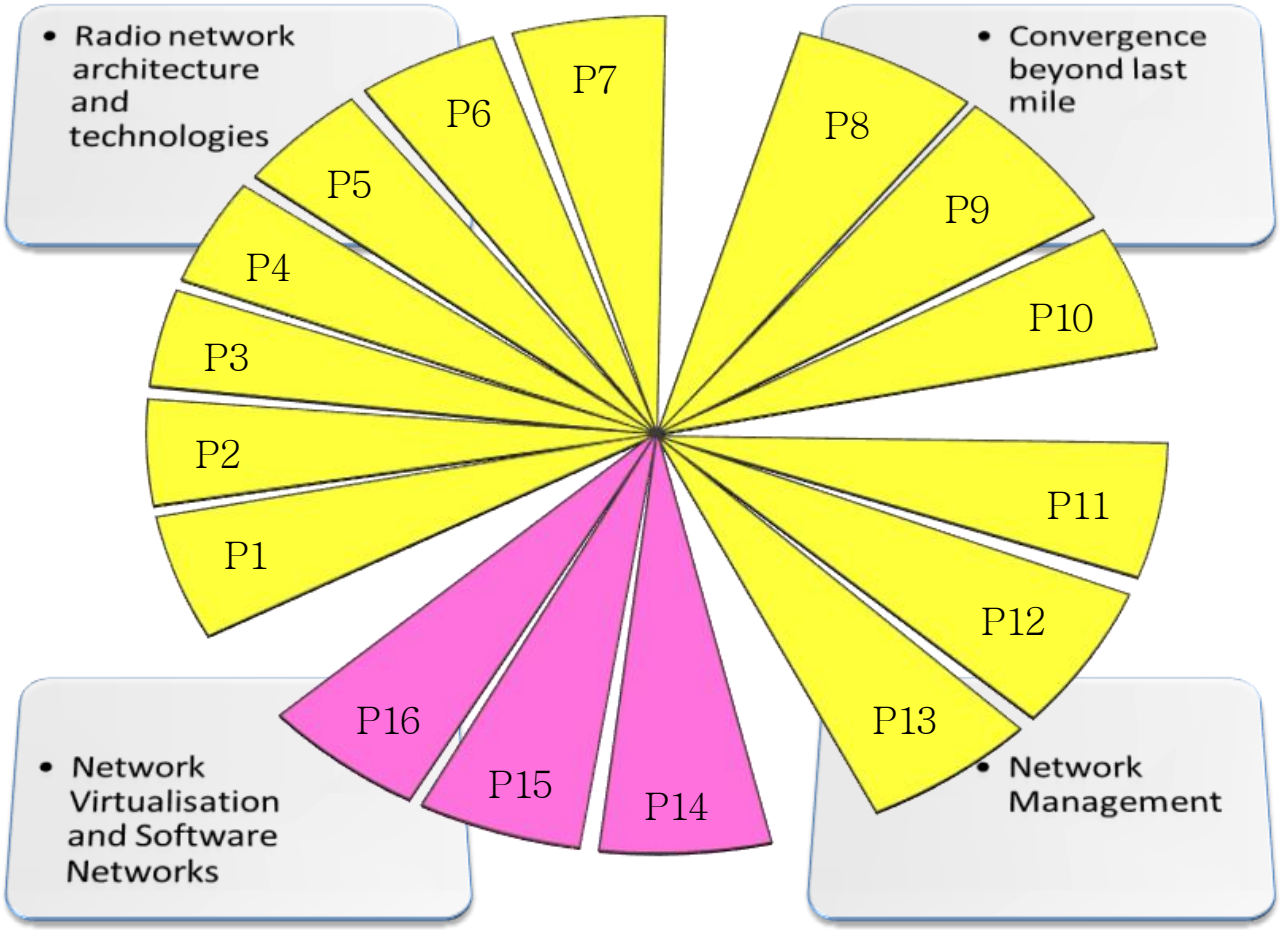
Pulling Strands Together



H2020 5G Infrastructure PPP
PPP Pre-structuring Model Approach (5/5)

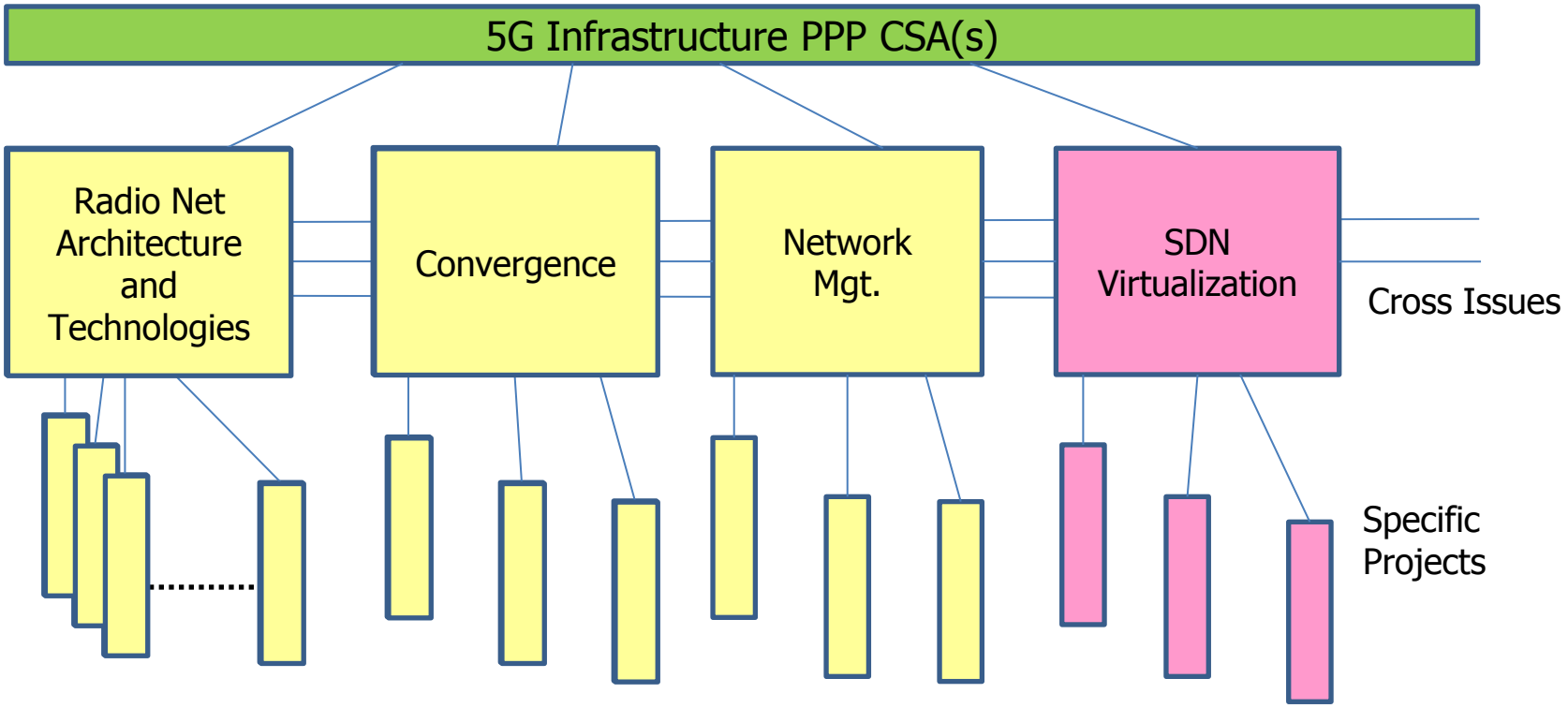
5G PPP

A coordinated set of R&I and I Projects



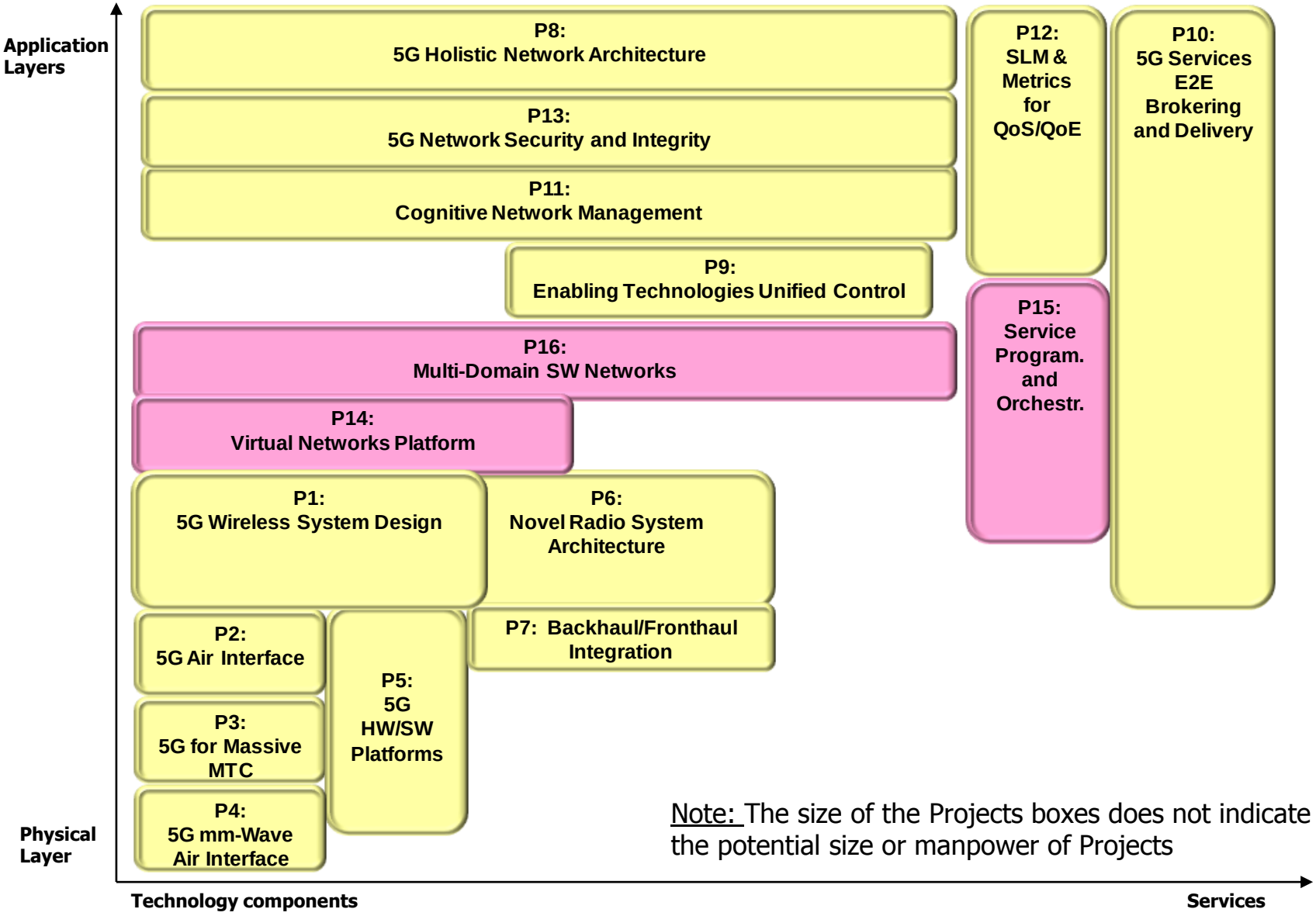
H2020 5G Infrastructure PPP
PPP Pre-structuring Model – System Perspective (1/2)

- 3 RTD Strands / 1 INNO Strand / CSAs



Note: The CSA(s) (definition and operation) is not described in the Pre-structuring Model

H2020 5G Infrastructure PPP
PPP Pre-structuring Model – System Perspective (2/2)



Note: The size of the Projects boxes does not indicate the potential size or manpower of Projects

P1: 5G Wireless System Design

Objective

- Design the 5G wireless system that
  - efficiently meets the large variety of use cases and application requirements beyond 2020
  - builds upon a smooth migration from current technology
  - also considers satellite and broadcast potential

Scope

- Identify and evolve key 5G scenarios and consolidate the requirements for 5G within the 5G-PPP and with external stakeholders
- Design a Multi-RAT system that efficiently integrates legacy and 5G air interfaces
  - Integration of new radio access concepts especially from other 5G PPP project, and exploiting radio access capabilities to address the service requirements
  - Interference, mobility and spectrum management
  - Control- and user-plane design for novel 5G components
  - Moderation of service requirements versus radio access capabilities
  - Integration of innovative spectrum usage concepts (e.g. sharing, pooling…)
- Define an architecture that supports the 5G system concept whilst also making it as RAT agnostic as possible to anticipate future RATs integration
- Ensure overall KPI evaluation by providing an evaluation framework and performing an overall assessment in close collaboration with other 5G-PPP projects
- Tight cooperation with most related/relevant 5G-PPP projects

Expected Impact

- A 5G wireless system that meets the requirements for integrated wireless communications well beyond 2020
- Industrial and global alignments: Preparation of WRC 18 and contribution to the ITU-R 5D evaluation work, preparation of a European headstart in standardization of 5G in e.g. 3GPP
- Demonstrate the key 5G system components

P2: Air Interface and Multi-Antenna, Multi-Service Air Interface below xx GHz

Objective

- To design a highly flexible and adaptable air interface being able to support efficiently
  - the multitude of service classes (from continuous high rate to sporadic low rate and with an option for very low latency) and service types (bi-directional unicast, uni-directional broadcast / multicast)
  - and device types (from high-end tablet to low-end device, incl. Body Area Devices)
  - and MIMO capabilities (in both UE and eNB)
  - in various areal settings (from heterogeneous ultra dense urban setting with cooperation to macro cell dominated rural/remote –land, sea and air areas)
  - with flexible spectrum usage

Scope

- **Scalability, adaptability, flexibility** - to meet temporal and areal fluctuations of active service and device class mixes and to support massive simultaneous network access
- **Energy efficiency** - both for the radio access network and devices
- **Uniform coverage, high capacity** – interference-robustness, adaptability to a wide range of spectrum allocations, high spectral efficiency at minimal control overhead
- **Unified multi-antenna support** - support localized, distributed and co-ordinated multi-antenna systems as an embedded feature in a natural way, and channel models
- **Robustness** – to support very high velocity (high-speed trains and other environments, access and backhaul) and relaxed synchronisation (low-end devices)

Expected Impact

- Enable 5G to support both broadband and machine type transmissions within the same band with high efficiency and at similar costs (devices and energy) compared to dedicated solutions
- Expand the business model and broaden the market of providing wireless services
- Easy implementation under various settings (deployment, carrier frequency …)
- Increased and uniform quality of experience
- Contribution to standardisation bodies

P3: 5G-MTC for Consumers and Professional Communications

Objective

- Research, develop and prototype systems for massive machine type communications addressing consumers and professional users in vertical industry like vehicles, energy, public safety, disaster recovery, wireless production, precision agriculture, etc.

Scope

- Capillary and wide area networks support
- Cellular assisted and non-assisted MTC methods
- Realtime multilink design
- Navigation support for mobile devices
- Lower layer security support
- Concepts for high reliability and availability

Expected Impact

- Enabler for new MTC applications (e.g. autonomous driving,…) for end users
- Enhanced safety, operational efficiency and serviceability for consumers and professional users
- Cost reductions for vertical industry communications due to common system approach
- Avoidance of fragmentation for communications in vertical industry
- Ensure rapid deployment of 5G public safety communication network
- Contribution to standardisation bodies

P4: New Spectrum and mm-Wave Air Interface for Access, Backhaul and Fronthaul

Objective

- To research and design mm-wave air interface, its key technology components , and system architecture as an integral component of 5G, enabling
  - Superior user experience of UHD/3D TV, immersive and cloud –based services on future generation mobile devices
  - Flexible and dynamic utilization of wide bands of contiguous spectrum in mmWave region to support economically viable access, backhaul and front haul solutions for ultra-dense deployment

Scope

- Analysis of mm-wave spectrum for 5G systems, investigations of sharing and coexistence mechanisms with other services, and development of recommendations for spectrum regulatory bodies
- Measurements, characterization and modeling of mm-wave channels for 5G applications, considering a wide range of scenarios and environments
- Research and development of multi-antenna technologies to enable coverage, mobility and multi-user support in mmWave frequencies
- Design of integrated and dynamic mm-wave based access, backhaul and fronthaul solutions for 5G RANs
- Design of technology components that enable support a smart co-existence and interworking between a mm-wave RAT and cm-wave RATs (5G or legacy)
- Close research collaboration with relevant 5G PPP projects

Expected Impact

- Seamless integration of mmWave technology and systems as an integral component of 5G architecture
- Proof of concepts and validation of mm-wave 5G technology, supporting immersive services for mobile users
- Recommendations for 5G mmWave standardization, spectrum regulatory bodies and industry consensus

P5: Efficient Hardware/Software and Platforms for 5G Network Elements and Devices

Objective

- Research and evaluation of efficient hardware/software and platforms for 5G: Hardware/software complexity, the viability of novel network elements, radio technology, and multi-RAT implementations for different kinds of platforms

Scope

- Efficient, reconfigurable, modular and highly scalable platform for RAN processing, depending on different architecture solutions
- Flexible platform concepts for network elements and mobile platform transceivers
- Multi-RAT aspects
- Function split aspects
- Study platforms in the light of
  - Complexity
  - Storage and computing requirements
  - Energy consumption
  - Hardware and Software aspects
  - Flexibility/scalability/modularity/reconfigurability/latency

Expected Impact

- Demonstration of architectures and platform implementations featuring flexibility, reconfigurability, modularity, scalability, multi-RAT capacity and/or improved energy-efficiency

P6: Novel Radio System Architecture

Objective

- Design Novel Multi-service 5G Radio System Architecture which efficiently support a multitude of diverse services. The architecture is to be highly flexible for supporting known and diverse Use Cases as well as easy integration of future unknowns

Scope

- Design signaling, protocols and mobility management across multi-point, multi-band, multi layer network
- Split of functionality across different network elements/locations
- RAN virtualization and cloudification
- Flexible networking to meet the requirements of 5G services
- Introduce methods making the network application-service aware
- Integration of RAN and CN functions/ cloud
- Excellent security design for the 5G integrated network and its applications, tailored to the future applications needs

Expected Impact

- Architecture able to efficiently support new 5G services as well as 'traditional' ones
- Flexible, simple, cost effective architecture
- Contribution to standardisation bodies

P7: Backhaul and Fronthaul Integration

Objective

- This project focuses on the analysis and design of heterogeneous backhaul and fronthaul technologies for 5G and their joint optimization with the access, aiming at an energy-efficient, scalable, highly modular, flexible, reconfigurable and with reduced cost 5G design

Scope

- Convergence of heterogeneous technologies for access, backhaul and fronthaul
  - Seamless integration of heterogeneous wireless, wireline optical and satellite transport technologies
  - Ultra-broadband backhaul network modeling, smart resource control algorithms and innovative planning
- Joint access, backhaul and fronthaul management
  - Design of techniques such as handover management considering jointly the RAN and backhaul conditions or holistic routing considering jointly RAN status and backhaul load, among others
  - Combined monitoring and management of RAN and transport
  - Enable low latency for inter-site communications and machine-type and device-to-device fixed and mobile services
  - Distributed security for low-latency services
- Energy-efficient and scalable designs
  - Adaptability of the RAN, fronthaul and backhaul to substantially reduce the energy consumption while keeping the overall QoE
- Reconfigurable integrated backhaul design
  - Adjustable to varying load distributions, dealing with per-flow requirements and with traffic aggregates simultaneously
- Design of Backhaul and fronthaul for novel network architectures
  - Backhaul and fronthaul for Cloud-based network architectures (e.g., traffic engineering techniques to provide the required connectivity with the cloud)
  - Support for centralized and distributed/flat architecture (including local-breakout support at RAN, fronthaul and backhaul level)
- Backhaul/fronthaul design for very dense small cell deployments
  - Solutions for very dense deployments, both indoors and outdoors
  - Advanced low-cost wireless solutions for small-cell backhaul

Expected Impact

- Change of the paradigm in the backhaul/fronthaul design with joint access optimization
- Increased flexibility and simplicity for operators in the configuration and operation of the backhaul
- Contribution to standardisation bodies
- Early proof of concept of the proposed solutions

P8: Holistic 5G Network Architecture

Objective

- Define and design an overall system concept (functions, interfaces and characteristics of protocols) which covers different fixed-mobile-convergence scenarios and considering broadcast and multicast services. The system concept for 5G will describe a converged control plane taking into consideration different user/data plane concepts and the management of next generation devices and the support of current and future services

Scope

- Define a converged and flexible control plane for a heterogeneous access network environment based on defined requirements from the 5G community showing the needed characteristics of the functions in a 5G system
- Define a context information driven control plane for optimisation of data and service delivery with interface towards traffic engineering
  - Define the necessary functions for optimal resource allocation (network slices, compute slices)
- Define access agnostic user services (for the wide variety of devices) covering the three basic building blocks:
  - Mobility, addressing, homing, session management
  - Quality of Service/assurance, service differentiation (control and monitoring part of the core, implementation in the access)
  - Security, privacy, ID management including role management (maybe including business models), AAA, Charging
- Define a modular framework to enforce scenario driven orchestration in a fixed and mobile infrastructure based on the following principles:
  - Flat
  - Building block oriented
  - Distributed (moving the service execution point close to the service consuming point, local break-out, etc.)
- Definition of open interfaces towards third party providers/developers
- Concepts based on implementation principles following SDN and NFV methodology

Expected Impact

- Software based architecture for flexible orchestration of control plane functions to support user services and efficient data paths
- Basis for standardisation of converged network control functions and interfaces for current and future access network technologies (potentially including mobile, wireless, wireline and satellite)
- Functions defined for enabling orchestration of various network operator scenarios and virtual operators

P9: Enabling Technologies for Unified Control of Converged 5G System

Objective

- Conceive and design novel enabling technology elements for a unified control and data plane infrastructure of the future fixed-mobile and satellite software-hardware, composed of heterogeneous devices, etc. 5G System, fulfilling the new requirements of scale (a large number of devices per human user), latency (for delay-critical applications), energy efficiency, ultra reliability, security, dependability and distributed mobility

Scope

- Access agnostic (*) control, policy and charging mechanisms and protocols for dynamic establishment, configuration, reconfiguration and release of any type of resource (Bandwidth, Computation, Memory, Storage) in software defined networks, for any type of devices (e.g. terminal, car, robot, drone, etc.) and services (e.g. Network, Security, Data, Knowledge, Machine, and Thing as a Service), including in E2E fashion when necessary
- Leveraging SDN technologies for
    - New control mechanisms and protocols for relocating functions, protocol entities and corresponding states fulfilling the new requirements as per above objective, also E2E
    - Functional migration management and notification when Network Functions are not bound to dedicated Network Elements
    - Configurable and access agnostic mobility functions depending on use case, including ephemeral networks, with reduced utilization of tunneling protocols and anchoring functions
- Identity extension to any type of device (terminal, car, robot, drone, etc.)
- Access agnostic authentication mechanisms extended to any type of device (terminal, car, robot, drone, etc.), device to device and network to device
- Charging and billing mechanisms related to the new services and SLAs
- Satisfy heterogeneous requirements (e.g. Coverage, QoS, Availability, Resilience, Reliability and Security) of Control Applications
- Full "mutualization" of fixed, mobile and satellite infrastructures, equipment and pipes and beyond (structural convergence)
- Unified access / aggregation network (transport aspects) for network infrastructure simplification
- Harmonization of protocol stacks between fixed and mobile (data and control planes)
- Novel technological means for unified control and data planes beyond the ones identified above

(*) cellular wireless, license-free wireless, fixed, satellites, etc.

Expected Impact

- Technological foundations for the establishment, modification, release and relocation of any type of resources across software defined networks and services in the 5G system
- Deliver novel technologies and solutions fulfilling 5G Converged System requirements
- Contribution to standardisation bodies

P10: 5G Services E2E Brokering and Delivery

Objective

- Define and study 5G innovative services and related mechanisms squeezing the most out of the converged 5G architecture

Scope

- **Service Delivery workflows and control**
  - Exchange models as per business models and type of traffic
    - Service delivery life cycle (Request, negotiation, purchasing, provisioning, reporting,…)
    - Delivery of services up to end user devices (at home, smart terminals,…), via unicast, broadcast and multicast, with service termination point capabilities
  - Performance issues of service delivery, sustainability, resilience
    - Response time, interruptions optimization under mobility constraints
    - Dynamic service re-allocation for network resource optimization
  - Service reporting and assurance
    - Self-managed and/or "as-a-service" service assessment

- **5G services Brokering and composition**
  - Holistic support of business models (B2B, B2C, C2C, D2D)
  - Enabled Advanced 5G services over terrestrial and satellite domains
  - Multi-tenant, multi-party End-to-End service component composition
    - Including advanced multi-broker extensions
  - 5G services
    - Network Resource transparency to the user
    - Multi-criteria (re-)optimization in composition (policy-based filtering, selection,…)
    - Reputation and performance-based feedback loops for service selection

- **Flow and Content mapping to Services**
  - Flow identification for E2E service association (including stitching for multi-domain)
    - Authentication mechanisms for secured service usage
    - Localization-based service mapping
    - Content-based mapping to service
  - Traffic offloading
  - Local vs. distributed policy-based decisions considering scalability issues

Expected Impact

- Foster benefits of the 5G converged architecture and resources through service-oriented common easy-to-use approaches. Universal applicability to any network type in either terrestrial or satellite domains

P11: Cognitive Network Management

Objective

- The Cognitive Network Management project will develop a **new management paradigm** and investigate, develop and verify processes, algorithms and solutions that enable future 5G networks to be self-managed

Scope

- **Novel processes, architecture and functions** for managing 5G systems at both network and services level, considering different options of (function) distribution
- **Cognitive Functions** for provisioning, optimization and troubleshooting
- **Cognitive Network Operations** including cognitive function orchestration and coordination, and system verification
- **Management unification** towards management of a convergent network
- **Contribution of SDN** to management solutions

Expected Impact

- **Decrease OPEX** by means of novel processes, architecture and functions
- **Improved quality of service, user experience, dependability and security**
- Build a **consensus on future network management architecture** to create a basis for standardization

P12: Service Level Management & Metrics for QoS & QoE

Objective

- To develop the E2E service level management for 5G based on metrics and techniques that map the state of the underlying network infrastructure and the terminal capabilities to the user perceived quality of services

Scope

- Build an effective QoE-aware **QoS model for 5G environments** for the end to end optimization of user-perceived service quality
- Develop **novel QoE estimation and prediction methods** to enable monitoring and processing of a very large proportion of OTT services
- Develop methods for defining **QoE for different traffic types**: M2M and sensor communication, future mobile media, augmented reality applications, etc
- Study QoE/QoS **correlation models** and **mapping functions** minimising the "disturbance zone"
- QoE-driven **adaptive Service Level Management**
- **Service Level Agreement** metrics, lifecycle, attribute model and composition in 5G inter-domains.
- QoE/QoS enforcement using policies and SLAs
- Analysis **of impact of network virtualisation** (SDN/NFV) on perceived QoE and how this can be controlled by SLA

Expected Impact

- To increase **the experience and service quality** (including dependability), as perceived by the users **enabling user/service driven network management**
- To enable **network-aware services and QoE-based management**, contributing to novel scalable management frameworks to efficient operate future 5G services

P13: 5G Network Security and Integrity

Objective

- To investigate the 5G network specific vulnerabilities and develop solutions to overcome the security and vulnerability threats

Scope

- Holistic view for 5G network to guarantee the data, service and communication reliability, trust and integrity, taking into account both the "physical" and information security
- Short and mid-term security and privacy strategy in 5G integrated systems with a clear, solid understanding of the security needs of now and in the future
- Network security, dependability and privacy across multiple virtualized/SDN domains as well as heterogeneous networks
- Intelligence driven security mechanisms and big data analytics to harden the 5G network

Expected Impact

- Security and reliability for core technology solutions in 5G system
- Privacy, trust and security for end-users and services in 5G system
- Authentication, authorization and accounting solutions to enable and manage service provisioning for different business areas and models
- Contribution to standardisation bodies

P14: Virtual Network Platform

Objective

- Develop a new generation of control and management solutions supported by innovative network technologies such as SDN and NFV
  - Operation platforms
  - Related business solutions
  - Advanced virtualized networking models
- Enable smart software-based innovations in future carrier-grade networks

Scope

- Intra-domain oriented, while also providing enablers for inter-domain
- Analysing business drivers, economic and industry challenges and opportunities
- Architectural and functional solutions for virtualising network services
  - Reference implementation of Network OS
  - Abstraction & information modelling of network functions and services
- Enablers and solutions for
  - Efficient and flexible provisioning of end-to-end differentiated services
  - Innovative and smart network control and management
  - Open Interfaces / APIs
  - Security, Robustness and Energy efficiency
- Experimentation and analysis of relevant use cases
- Migration strategies and legacy integration
- Field-trials, demonstrations and feasibility experimentations

Expected Impact

- Standards contribution and lead role in selected areas
- Significantly improved operations and network efficiencies
- Rich world of applications
- Better exploitation of 5G capabilities

P15: Service Programming and Orchestration

Objective

- A programming interface to services for fast and flexible service development and deployment
- Orchestration of services and service composition

Scope

- Abstractions, languages, and mechanism for service programmability
- Functional service descriptions, service graphs
- Modularity and composability of service function blocks
- Environment and Toolbox (SDK) for service development and deployment
  - Rule sets for automatic composition
  - Component dependency resolution
  - Automatic deployment and configuration of services and its components
- Orchestration functions, tools, APIs
  - Composition of complex services from virtualized building blocks
  - Isolation and policing between different virtual services and virtual service providers
  - Integration with OSS (real-time aspects)
  - Interfacing to hybrid (SDN & non-SDN) networks
- Value chains (operator, SP, vendor, NF developer, etc.) and business models
- Experimentations, usability tests

Expected Impact

- Standards contributions
- Vivid ecosystem of service developers and providers
- Rich world of applications
- Better exploitation of 5G capabilities

P16: Multi-Domain SW Networks

Objectives

- Enable e2e network orchestration over multiple administrations
- Solve network scaling
- Enable orchestration over heterogeneous technological layers (multi-layer)

Scope

- Architecture: control plane organization (mesh, hierarchical, hybrid)
- Performance: optimal layering and clustering for different metrics
- Resiliency: fate sharing between layers, domains and clusters
- Security: CP transactions, flexible authentication
- Scalability: splitting into layers or domains for scaling, dynamic sizing and re-configuration
- Dynamism and flexibility through the domains: coordination of end-to-end control planes
- Protocol aspects: East/West, Northbound APIs, end-to-end service programmability
- Multi-provider issues: information sharing/hiding, shared economy, revenue sharing
- Abstractions and information hiding across/over domains
- Early proof of concept of the proposed solutions, experimentations

Expected Impact

- Standards contributions
- Dynamic and flexible SDN based end-to-end solutions across multi-domain network segments
- Interworking of heterogeneous control planes , providing interoperability, increased flexibility and simplicity

H2020 5G Infrastructure PPP
PPP Pre-structuring Model – Next Steps

- Pre-structuring Model version 2.0 will be the final version
- Additional documents from the 5G Infrastructure Association to contribute to the further definition of the PPP preparation will be communicated in the coming months
  - Definition of potential Projects cooperation (e.g. Projects interfaces and Cross Issues)
  - Further definition of PPP KPIs
  - Definition of possible CSA(s) organization and operation to support the PPP
  - Definition of possible common scenarios and use-cases to be considered by the PPP Projects (in connection with the ETP White Papers and forthcoming ETPs and Association Workshops)
  - Further definition of Association milestones and priorities for Phase 1
- Next 5G Infrastructure PPP workshop during EuCNC 2014 (26.06.14 in Bologna)

➡ Stay tuned and join us in implementing a very successful PPP with impact!