CONASENSE: Vision, Motivation and Scope

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Abstract

CONASENSE stands for Communication, Navigation, Sensing and Services and is a new scientific society encouraging cross-cutting research among these four domains. For each domain, the paper shows examples of the interaction with the other domains, highlighting recent advances, trends, and challenges, importance to Future Generation Wireless and other new research areas that arise from taking a top down approach, with the service on the top and the available technology seen as a whole on the bottom.

Keywords: Network convergence, network architectures, navigation systems, networked control, sensor networks, wireless access.

1 Introduction

The Society on Communication, Navigation, Sensing and Services (CONASENSE) is a new scientific society focusing on the provision of new services through the integration of Communication, Navigation and Sensing, 20 to 50 years from now [1].

Convergence of technologies, ultra-high capacity, universal coverage and maximal energy-and cost-efficiency are key characteristics of the Future Generation Wireless (FGW) system concept. The key enabling technologies converging into the FGW system concept are communication, navigation,

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sensing and services (CNSS). Sensing is the main enabling technology for the efficient use of available spectrum. Interoperability of numerous heterogeneous devices, their mobility, and capabilities to provide ubiquitous and secure ultra-fast connectivity without harmful interference relies on novel communication technologies and their convergence with navigation and sensing platforms. With the released large amounts of data information coming from large-scale sensor deployments, as well as with the changing user role from a consumer to a ‘prosumer’, also through the adoption of social networks into the private and business life, more and more data gets generated on a daily basis. Service platforms should be built such that users are guaranteed applications with high QoS and privacy protection but should also abstract the heterogeneity of the communication infrastructure.

In this framework, the CONASENSE society aims to provide a common platform for exchanging ideas among the communities, both academic and industrial, involved in the fields of Communications, Navigation and Sensing, with emphasis on multidisciplinary views and Smart/Intelligent services that require the effective integration of these three fields of research and development.

This paper, which opens the first issue of the CONASENSE journal, aims to explain the main motivation behind this initiative and the research topics that should be promoted within the CONASENSE initiative and through the journal of the Society.

The rest of the paper is organized as follows. Section II aims to give a definition of the CONASENSE concept and a description of the CONASENSE functionalities, i.e. Control (Section III), Sensing (Section IV), Communication (Section V) and Navigation (Section VI). Finally, conclusions are drawn in Section VII.

2 Com/Nav Sensing Interaction for Intelligent Services/Systems

Among various anthropological definitions of “intelligence”, one is the capability to “adapt” in order to survive to dangers and environmental changes. A system with the capability to adapt can work more efficiently with respect to various criteria and can face future technological breakthrough and new user/service requirements. Efficiency is the capability to perform the same task consuming less resources. For instance, an efficient communication system is a system able to transmit at the same bit rate with less bandwidth, power or complexity.

As a matter of fact, this capability to adapt, or in other words, to react to some measured “state”, is a key component of any system/service that aims to provide an answer to some of the current societal challenges [2]. In particular, we need intelligent systems/services for:

- User-centric applications (for instance, patient-centric) where there is the need to adapt to the user requirements in a dynamic environment. In this frame, the user is the entity that is monitored and controlled: an object (e.g. a car in intelligent transportation), a human (e.g. elderly people in assisted living), an animal (e.g. in animal tracking), the environment (e.g. forest fires in environmental monitoring), a process (i.e. industrial automation, smart grid), etc.
- Exploit efficiently current system resources providing the service with the highest quality at the lowest cost, especially when current resources seem to be not sufficient to provide the requested service.

Smart systems are often endowed with some kind of feedback control, as shown in Fig. 1. Usually, there is a centralized or distributed entity able to measure/sense some aspects of the environment/state of the process, process the information and possibly influence the process either directly (with some kind of direct control/actuation) or indirectly by influencing the environment.

Therefore, the provision of smart services and the design of intelligent systems foresee the interaction of communication, navigation and sensing.

Fig. 2 shows the CONASENSE concept of interaction. The provision of enhanced services usually foresees a sensing part, where sensors could be small and distributed in a small or wide area, while in other cases sensors are big Earth Observation satellites. There is also a control part, which contains the intelligence of the system and it is responsible of data fusion and decision making. The nodes of the communication network are sensors, actuators, and the control center besides the various intermediate nodes and gateways of the network. Finally, in all these parts, it is usually crucial to know some “position” or some function of it (“velocity” or “displacement”). For instance, it is important to know the position of sensor nodes to apply energy efficient routing algorithms; it is useful to know the position of communication nodes and eventually optimize their positions according to some criteria; it is for sure important to know the position of the users, for instance, to provide location-based services. Therefore, the position and navigation part (meaning, the part responsible for having awareness on the position of something) is an input to all the other mentioned components.

Figure 1 Scheme of a smart system with feedback control.

Figure 2 CONASENSE Concept

The so-called Cyber-Physical Systems (CPS) [3], which refers to the next generation of embedded ICT systems that are interconnected and collaborating to provide citizens and businesses with a wide range of innovative intelligent services, are examples of systems where communication/sensing and positioning/navigation capabilities are often interconnected as shown in Fig. 2. However, the CONASENSE concept is more general and includes also other systems where the requirement of being embedded is more loose such as surveillance and emergency systems, wide area monitoring, automation etc.

Currently, the typical approach to the integration of communication, navigation and sensing systems follows a bottom-up strategy where different technologies are tied up to provide a single service. The reason is that, commonly, scientists specialized on one field do not have a deep competence on the other field and, hence, cannot manage the CONASENSE concept as a whole. This approach leads to an inefficient integration of communication, navigation and sensing systems which resembles a patchwork where each single piece is still distinguished from each other. We believe that the best strategy for the success of the CONASENSE concept is to follow a top-down approach where new CONASENSE scientists exploit a wider expertise, even if less specialized, which is useful for having a more integrated view of the concept in a first step, and allows to identify problems and develop new solutions in a second step.

The awareness that in any intelligent system/process these three components are interconnected and often in a feedback system, can suggest new approaches to the design of the sensing and control strategy (centralized, distributed, etc.), or of the communication network and on the proper use of positioning. In the next Sections, several examples of the interaction among these three domains are presented with the attempt to suggest also new research areas starting from this novel point of view.

3 Control Part

In traditional control systems, information from the sensors is assumed to be instantaneously available for the controller and the control commands are assumed to be instantaneously delivered to the actuator. Moreover, no losses are usually assumed during the delivery of sensed information and commands. These assumptions do not longer hold in control systems with wireless links, where sometimes even the nodes (sensing nodes or controller nodes etc.) are mobile.

Networked control theory is the control theory that takes into account the fact that the feedback channel can introduce delay or losses in a Networked Control System (NCS) [4–6]. An example of a NCS applied to the CONASENSE concept is shown in Fig. 3. In this example, the user U_1 is monitored through Sensor S_1 and S_2 which are connected to the controller through Network N_1 and N_3 . The controller sends control messages to actuators A_1 and A_2 through network N_2 and N_4 . The sensing signals s_1 and s_2 are digital signals (discrete-time and discrete-valued) generated by the sensors S_1 and S_2 are received by the controller as a delayed and modified version of the sensor signals s'_1 and s'_2 . The same holds for the control signals u_1 and u_2 which are received by the actuators through network N_2 and N_4 . In the ideal case, the received signal s'_1 , s'_2 , u'_1 , u'_2 , are a perfect replica of the signals s_1 , s_2 , u_1 , u_2 , without delay $t_1 = t_2 = t_3 = t_4 = 0$.

The behavior of a NCS is affected by:

- Sampling rate constraints and resulting distortions of signals from the sensors and actuators (quantization etc.)
- Bandwidth for communications
- Disturbances in the communication links
- Time delay in the measurement and control loops
- Data errors or package drop.

Figure 3 Example of a networked control system.

NC theory is a well established research area where communication and control experts need to interact. Several works can be found in literature, where the two main approaches are [6]:

- To build good communication networks in which the above side effects are trivial or can be neglected.
- To design intelligent controller which can tolerate the above side effects to a certain degree

In both cases, useful theoretical tools can be found by the combination of information theory with control theory [7]. Furthermore, the complex decision making process should be assisted by data mining and data fusion techniques which allows to manage a huge amount of heterogeneous measures from sensors with the objective to extract meaningful information [8].

However, not only the interaction between communication and control is important in the general framework shown in Fig. 2. Also the sensing strategies could be crucial in meeting the control requirements. From the control point of view, it would be better to have a centralized sensing, or a distributed sensing? How does the accuracy in the measurements impact the control?

Here a list of some questions that still need to be answered and that need a multidisciplinary approach:

- How to design MAC protocols that finds an appropriate compromise between satisfying control requirements and use the smallest energy?
- Is it possible to enable the existing controller for NCS usage via a minimum communication support?

Or minimum sensing support?

- Is it possible to adapt the control strategy to the communication channel? For instance, the delay is too big? Then, that command is useless and another “sub-optimal” command could be sent.
- What is the best control strategy under the system non idealities: uncertainty of measures, errors on data, delay?
- Complex decision making or artificial intelligence algorithms can run over a smartphone?
- Can control algorithms be used also to manage the sensors with the aim to focus the sensing capabilities to the object/situation that is currently critical?

Moreover, most of the work on NCS that can be found in literature is mainly related to automated control in industrial processes. Much less can be

found on intelligent systems where there is a human being either at the control side or at the user side: often there is a human operator with a HMI; in some other cases, almost real-time automatic commands must be sent to control or change the behavior of a human being (i.e. Ambient Intelligence). The presence of the human being increases the uncertainty on the effectiveness of the output of the control action as the emotional state of the human being for instance might change his reaction, the reaction time or the type of decision. Therefore, the understanding and modeling of the reaction of the human being in a feedback control system is another important area of research which is receiving more and more attention [9].

4 Sensing Part

Sensing can be done by small tiny and low energy sensors, or big sensors (such a ground-based radar or Earth-Observation satellites).

Earth observation data sets are growing in size and variety at an exceptionally fast rate, posing both challenges and opportunities for their access, application and archive. Moreover, wireless sensor networks have changed the paradigm of how sensor data information is made available today. Sensing is not done anymore by few complex sensor devices, wired connected to some control interface, but by a huge number of low-cost, tiny, untethered, battery-powered low-cost MEMS (micro-electro-mechanical systems) devices with limited on-board processing capabilities, storage and short-range wireless communication links based on radio technology, as well as sensing capabilities. Therefore, both data collection and processing are no longer centralized but distributed [10] and the best compromise between local processing and estimation accuracy must be found taking into account the other important metrics such as power consumption and reduction of data transmission. The concept of distributing the “sensing” to different “smaller” sensors, wirelessly connected in an ad hoc manner, is interesting also for space applications. The so-called space-based wireless sensor networks (WSNs) might play an important role in applications such as large-scale space observations, distributed imaging, remote monitoring for deep space exploration, cooperative sensing for high-resolution, synthetic-aperture radar [11].

4.0.1 Sensing and control

More generally, large volumes of data are collected by EO satellites, information-sensing mobile devices, aerial sensory technologies and wireless sensor networks. These data must be organized and delivered to

make use of it, and eventually to use them for some kind of “control”. One of the main current issues is related to the concrete possibility to use it by getting the right and timely information from a huge amount of collected data [12]. Moreover, these data are heterogeneous in nature (images, data, text etc.) or collected by heterogeneous sensors, thus calling for more and more sophisticated and efficient data fusion algorithms. One of the current challenges is related to the possibility to include also information from social networks and more in general, open source data [13].

4.0.2 Sensing and positioning

The knowledge on the position of the nodes is essential to optimize the energy efficiency in WSNs, for instance, through proper routing algorithms [14] or topology-based power management strategies [15] or by optimizing the path of a mobile sink that collects data from a large set of sensors distributed over a wide area (for instance, for environmental monitoring applications) [16].

Moreover, there is a subset of WSN in which the geospatial content of the information collected, aggregated, analyzed, and monitored is of fundamental importance [17]. Those are the so-called geosensor networks (GSN) which are usually used to monitor phenomena in geographic space, and there are a key element of any location-based service.

In these WSNs, the spatial aspect might be dominant at different levels:

- Content level, as it may be the dominant content of the information collected by the sensors (e.g. sensors recording the movement or deformation of objects), or
- Analysis level, as the spatial distribution of sensors may provide the integrative layer to support the analysis of the collected information (e.g. analyzing the spatial distribution of chemical leak feeds to determine the extent and source of a contamination).

GSNs enable the Ambient Spatial Intelligence (AmSI), which is concerned with embedding the intelligence to respond to spatiotemporal queries and monitor geographical events in built and natural environments. In [18] it is argued that decentralized spatial computing, where spatial information is partially or completely filtered, summarized, or analysed in a geosensor network, is a fundamental technique required to support AmSI, in contrast with the centralized approach to computation, where global spatial data is collated and processed, for example in a spatial database or GIS.

4.0.3 Emerging trends

Some of the key requirements of well-designed sensing networks are: minimized number of sensing elements and measurements, reduced complexity of the sensing method, optimized use of the power. To achieve these objectives, recently the use of compressed sensing has been proposed. Compressed sensing is an emerging theory that is based on the fact that a signal can be recovered through a relatively small number of random projections which contain most of its salient information [19].

In this framework, a new element that is emerging is that the user becomes the sensor and the actuator. For instance, the same “personal” device (i.e. smartphone) can be used as sensor (smartphones already includes many types of sensors) and actuator (alarm, vibration). The innovative concept of people as sensors defines a measurement model, in which measurements are not only taken by calibrated hardware sensors, but in which also humans can contribute their individual ‘measurements’ such as their subjective sensations, current perceptions or personal observations [20]. These are shared for instance, through social networks. This novel concept could greatly contribute to overcome the challenge to analyze our surroundings in real-time due to the sparsely available data sources. However, it also poses challenges:

- Sensors (human being) are highly mobile.
- What is the density of people that I need to obtain a certain accuracy?
- What is the balance between sensing accuracy and resource usage (number of people involved, network bandwidth, battery usage)
- What are the incentives for people to collaboratively participate to the sensing?

5 Communication Part

The communication architecture has an important responsibility in fulfilling the requirements of most of the CONASENSE systems, such as very low power consumption, flexibility/adaptability, security and privacy, real-time or almost real-time response to dynamic and complex situations while preserving control, system safety and reliability features. In particular, wireless communication will play a crucial role. In many novel applications, it is getting fundamental the capability of “smart objects” to communicate without the human intervention, which is the so-called Machine-to-Machine (M2M) communication paradigm. M2M applications have their own very unique features [21]: group-based communications, low or no mobility, time-controlled, time-tolerant, small data transmission, secure connection, monitoring, priority

alarm messages. These service requirements dictate the architectural design of the communication network.

In this scenario, satellite communications has the potential to play an important role for different reasons. First of all, the “interconnected devices” are remote in many applications or they are dispersed over a wide geographical area or they are inaccessible. Secondly, satellite could provide an alternative path when redundant communication is required, such as when very high reliability must be provided. As a matter of fact, M2M communication via satellite is a reality and represents a real great opportunity for the satellite market. Nevertheless, interoperability with in-situ sensors/actuators, interoperability with the terrestrial network still poses several challenges.

To enable the dynamic control of wireless network resources, while optimizing spectrum use and energy efficiency, one of the key elements of the communication CONASENSE architecture is the cognitive and learning capability.

The communication architecture has also the challenging task to disseminate in an efficient way (efficient with respect to the energy/bandwidth/processing resources) huge amount of data generated by smart sensing systems, supervisory control and data acquisition systems, wide area monitoring systems, and other sensing/monitoring devices throughout large-scale networks. In this framework, gossiping has been proposed [22]. The goal of gossip protocols is to reduce the number of retransmissions by making some of the nodes discard the message instead of forwarding it.

Moreover, the use of data compression techniques is desirable to help mitigating the burden of the communication among sensors and control systems. The information acquired by the sensors should be compressed at the sending terminals as much as possible, before sending through the wireless communication system. The compression should keep the valuable information contained in the data, and the compressed data, when received at receiving terminals, should be perfectly reconstructed for analysis. In [23], the use of the Wavelet technology for data compression is proposed.

Two increasingly important requirements that must be fulfilled by the communication architecture are related to security and privacy. On one hand, in many applications (for instance, safety critical applications, monitoring of critical infrastructures etc.), sensing data, information on the position, control commands, must be securely transmitted through several communication networks and protected by any attempt to be jammed, blocked or modified. On the other hand, the user must be able to choose what to share and what to keep private. The privacy issue should be tailored and controlled by the user, since

it can change depending on user needs and specific applications/situations. The design of the communication architecture must provide flexible privacy degree controlled by the user.

6 Navigation Part

The capability to know the position is crucial for the sensing nodes, for the communication nodes, for the control nodes.

Position and navigation can be done through radio terrestrial networks (i.e. WiFi/cellular) or through Global Navigation Satellite Systems (GNSS).

In previous Sections, several examples have been presented on how positioning information can be used to optimize the design of the sensing system (definition of the topology, distribution of nodes), control strategy and communication protocols (i.e. location-based routing protocols).

On the other hand, in this Section, we outline how sensing, and communication, usually combined in a feedback control, are needed to face the challenges of navigation/positioning systems that arise in many current applications.

For instance, in order to support ITS road safety applications, such as collision avoidance, lane departure warnings and lane keeping, GNSS based position system must provide lane-level (0.5m-1m) or even in lane-level (0.1–0.3m) lane level accurate and reliable information to users. Current vehicle GNSS receiver (single frequency GPS) can provide road-level accuracy (5–10m). Moreover, in urban areas, the extremely low power of the received GNSS signals and the presence of multipath as a major source of error, makes the GNSS signals not always available and even when available, not reliable.

Regardless those limitations, it would be desirable to use GNSS for those applications thanks to its universal coverage and low equipment cost.

As a matter of fact, accuracy and reliability of GNSS systems can be improved in different ways:

- by combining the signals from GNSS satellites with other information gathered by other types of sensors. It is well known that the combination of sensors such as inertial sensors that measure the motion of the platform to which they are attached without reference to an external system, can improve the availability of the positioning service. By accumulating the measurements from these sensors relative to a known initialization point it is possible to “bridge” the periods when GNSS-derived positions are unavailable, or to improve the confidence in the position estimate when GNSS is available. However, the use of other sensors (baro-altimeters,

active RFID tags, cameras) and combination with other information (i.e., maps) has been proposed to improve indoor positioning.

- by combining the signals from GNSS satellites with other RF signals. There is a class of RF signals that are specifically designed for this purpose, and they are the pseudolites and beacons [24]. However, recently is getting more and more attention the use of the so-called signals of opportunity. These are signals not designed for navigation purposes, but that can be used for that purpose. Examples are digital/analog TV, AM radio or nowadays great interest is in the use of WiFi signal [25]. To enable the use of these signals of opportunity, recent advances in wireless communication technologies are crucial. As a matter of fact, a receiver able to use these signals of opportunity must process simultaneously different signals and the capabilities of a software defined cognitive radios to switch quickly frequencies would be important for a practical receiver for positioning purposes.
- broadcasting GNSS corrections generated from a local or regional or global network of ground stations to the user via various data links, mostly 3G networks or communication satellites (i.e. EGNOS). Two example of this approach are represented by the Real Time Kinetic (RTK) or Precise Point Positioning (PPP).

About the latter point, what is the impact of the performance of the communication network used for the broadcast on the GNSS augmented performance? For instance, also GEO satellites such as EGNOS, encounters limitations in urban and rural canyons, accentuated at high latitudes where the EGNOS GEO satellites are seen with low elevation angles. Studies have been done to assess the performance of EGNOS augmented GNSS for road applications [26].

Moreover, what is the impact on the communication network of the added load due to the need to transmit those corrections? This question could be important in future wide-area ITS services. Some studies have been done recently to reduce this load by using proper communication protocols and message format or by assuming less-frequent update of this broadcast information [27].

A communication infrastructure is needed also for broadcasting information for integrity support. Integrity is the measure of trust that can be placed in the correctness of the information supplied by the navigation system. Integrity Support Message (ISM), an integral part of the advanced integrity architectures [28], carries integrity information to the user receiver. The ISM architecture involves:

- Ground monitoring network in charge of collecting the observables to compute the ISM content. We refer to the entity mainly responsible for the computation of the ISM as the Integrity Processing Facility (IPF).
- Broadcast network in charge of delivering the ISM to the final user. The choice of broadcast network will have an impact on the ISM design parameters such as ISM content, ISM update rate, and ISM dissemination latency.

In this context, it is important to assess the impact of the dissemination network performance on the ISM architecture design parameters. By taking into account the performance of the broadcast network, it will be possible to better decide the role of ground station in the provision of integrity monitoring. Moreover, such a study on the communication architecture will also provide guidelines, in terms of ISM contents, ISM packet size, data rate requirements, and ISM update interval. With the objective to provide integrity support via ARAIM to avionic Galileo PRS (Public Regulated Service) users, in [29] a study on the use of TETRA in the ISM dissemination network is performed.

In case of urban road users, multipath is a major source of errors. As another example of research area that calls for a multidisciplinary approach, we wonder if some more local capability to detect the level of multipath, with sensors, cooperation among different users and sensors, could be effectively used to provide either more accuracy or at least a quality measurement of the reliability of the positioning system.

7 Conclusion

The need to carry out cross-cutting research across the Communication/Navigation and Sensing domains has strongly emerged in the last decades. Their interaction is the enabler of FGW systems and key component of most of the intelligent services aimed to improve the Quality of Life.

This paper presented an overview of the already existing interactions in terms of trends and challenges, but also provide examples highlighting the importance of taking a top-down approach where the more and more challenging service requirements are met by a joint design of the communication network, sensing, positioning and control strategy.

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Biographies

Ernestina Cianca received the Laurea degree in Electronic Engineering “cum laude” at the University of L’Aquila in 1997. She got the Ph.D. degree at the University of Rome Tor Vergata in 2001. She concluded her Ph.D. at Aalborg University where she has been employed in the Wireless Networking Groups (WING), as Research engineer (2000–2001) and as Assistant Professor (2001–2003). Since Nov. 2003 she is Assistant Professor in Telecommunications at the URTV (Dpt. of Electronics Engineering), teaching DSP, Information and Coding Theory and Advanced Transmission Techniques. She is the co-director of a II level Master in Advanced Satellite Communication and Navigation Systems. She has been the principal investigator of the WAVE-A2 mission, funded by the Italian Space Agency and aiming to design payloads in W-band for scientific experimental studies of the W-Band channel propagation phenomena and channel quality. She has been coordinator of the scientific

activities of the Electronic Engineering Department on the following projects: ESA project European Data Relay System (EDRS); feasibility study for the scientific small mission FLORAD (Micro-satellite FLOWer Constellation of millimeter-wave RADiometers for the Earth and space Observation at regional scale); TRANSPONDER2, funded by ASI, about the design of a payload in Q-band for communications; educational project funded by ASI EduSAT on pico-satellites. She has worked on several European and National projects. Her research mainly concerns wireless access technologies (CDMA and MIMO-OFDM-based systems), integration of terrestrial and satellite systems, short-range communications in biomedical applications. She has been General Chair of the conference ISABEL2010 (Third Symposium on Applied Sciences in Biomedical and Telecommunication Engineering), she has been TPC Co-Chair of the conference European Wireless Technology 2009 (EuWIT2009); TPC Co-Chair in the conference Wireless Vitae 2009. She is Guests Editors of some Special Issues in journals such as *Wireless Personal Communications* (Wiley) and *Journal of Communications* (JCM, ISSN 1796–2021). She is author of about 70 papers, on international journals/transactions and proceedings of international conferences.

Mauro De Sanctis received the “Laurea” degree in Telecommunications Engineering in 2002 and the Ph.D. degree in Telecommunications and Micro-electronics Engineering in 2006 from the University of Roma “Tor Vergata” (Italy).

In autumn of 2004, he joined the CTIF (Center for TeleInFrastruktur), a research center focusing on modern telecommunications technologies located at the University of Aalborg (Denmark).

He was with the Italian Space Agency (ASI) as holder of a two-years research fellowship on the study of Q/V band satellite communication links for a technology demonstration payload, concluded in 2008; during this period

he participated to the opening and to the first trials of the ASI Concurrent Engineering Facility (ASI-CEF).

From the end of 2008 he is Assistant Professor at the Department of Electronics Engineering, University of Roma “Tor Vergata” (Italy), teaching “Information and Coding Theory”.

From January 2004 to December 2005 he has been involved in the MAGNET (My personal Adaptive Global NET) European FP6 integrated project and in the SatNEx European network of excellence. From January 2006 to June 2008 he has been involved in the MAGNET Beyond European FP6 integrated project as scientific responsible of WP3/Task3.

In 2006 he was a post-doctoral research fellow for the European Space Agency (ESA) ARIADNA extended study named “The Flower Constellation Set and its Possible Applications”.

He has been involved in research activities for several projects funded by the Italian Space Agency (ASI): DAVID satellite mission (DAta and Video Interactive Distribution) during the year 2003; WAVE satellite mission (W-band Analysis and VERification) during the year 2004; FLORAD (Micro-satellite FLOWer Constellation of millimeter-wave RADiometers for the Earth and space Observation at regional scale) during the year 2008; CRUSOE (CRUising in Space with Out-of- body Experiences) during the years 2011/2012.

He has been involved in several Italian Research Programs of Relevant National Interest (PRIN): SALICE (Satellite-Assisted Localization and Communication systems for Emergency services), from October 2008 to September 2010; ICONA (Integration of Communication and Navigation services) from January 2006 to December 2007, SHINES (Satellite and HAP Integrated Networks and Services) from January 2003 to December 2004, CABIS (CDMA for Broadband mobile terrestrial-satellite Integrated Systems) from January 2001 to December 2002. In 2007 he has been involved in the Internationalization Program funded by the Italian Ministry of University and Research (MIUR), concerning the academic research collaboration of the Texas A&M University (USA) and the University of Rome “Tor Vergata” (Italy).

He is currently involved in the coordination of scientific activities of the experiments for broadband satellite communications in Q/V band (Alphasat Technology Demonstration Payload 5 - TDP5) funded jointly by ASI and ESA.

He is serving as Associate Editor for the Space Systems area of the IEEE Aerospace and Electronic Systems Magazine. His main areas of interest are: wireless terrestrial and satellite communication networks, satellite constellations (in particular Flower Constellations), resource management of short

range wireless systems. He co-authored more than 60 papers published on journals and conference proceedings. He was co-recipient of the best paper award from the 2009 International Conference on Advances in Satellite and Space Communications (SPACOMM 2009).

Dr Alben Mihovska obtained the PhD from Aalborg University, Denmark, where she is currently an Associate Professor at the Center for TeleInfrastruktur (CTIF). She has more than 14 year experience as a researcher in the area of mobile telecommunication systems. She was deeply involved in the design of a next generation radio communication system through her work as the AAU research team leader in the FP6 European funded project WINNER and WINNER II, and later continuing under the CELTIC framework programme as WINNER+, with the related research laying most of the foundations for the current Long-Term Evolution (LTE) and LTE-Advanced, the latter recently approved as an IMT-Advanced standard in ITU-R. She has conducted research activities within the area of advanced radio resource management, cross-layer optimisation, and spectrum aggregation, the results of which were put forward as IMT-A standardisation proposals to the Radio Communication Study Groups of the ITU by the WINNER+ Evaluation Group. She has more than 90 publications including 4 books published by Artech House in 2009 in the next generation mobile communication systems track and 4 book chapters. Further, one of her papers on the topic of next generation communication systems was voted at number 51 of the top 100 IEEE papers for July 2009. She is actively involved in ITU-T Standardization activities within SG13, and Focus Groups Cloud Computing, Smart Grids. She is also actively involved within IEEE Smart Grid Activities. She is a Steering Committee Member of IEEE WCNC, Special Session Chair of GWS2014, and Program Committee Co-Chair for the Wireless Telecommunication Symposium (WTS) 2015. She was Publicity Chair for WPMC2002, Treasurer of IEEE WCNC2006, Secretary of IEEE ComSoc WiMAX 2009 and on the TPC of many highly renowned

international conferences, such as IEEE ICC, IEEE VTC, and so forth. She is an Associate Editor of the InderScience International Journal of Mobile Network Design and Innovation (IJMNDI).

Ramjee Prasad is currently the Director of the Center for TeleInfrastruktur (CTIF) at Aalborg University, Denmark and Professor, Wireless Information Multimedia Communication Chair.

Ramjee Prasad is the Founding Chairman of the Global ICT Standardisation Forum for India (GISFI: www.gisfi.org) established in 2009. GISFI has the purpose of increasing of the collaboration between European, Indian, Japanese, North-American and other worldwide standardization activities in the area of Information and Communication Technology (ICT) and related application areas. He was the Founding Chairman of the HERMES Partnership – a network of leading independent European research centres established in 1997, of which he is now the Honorary Chair.

He is the founding editor-in-chief of the Springer International Journal on Wireless Personal Communications. He is a member of the editorial board of other renowned international journals including those of River Publishers. Ramjee Prasad is a member of the Steering, Advisory, and Technical Program committees of many renowned annual international conferences including Wireless Personal Multimedia Communications Symposium (WPMC) and Wireless VITAE. He is a Fellow of the Institute of Electrical and Electronic Engineers (IEEE), USA, the Institution of Electronics and Telecommunications Engineers (IETE), India, the Institution of Engineering and Technology (IET), UK, and a member of the Netherlands Electronics and Radio Society (NERG), and the Danish Engineering Society (IDA). He is a Knight (“Ridder”) of the Order of Dannebrog (2010), a distinguished award by the Queen of Denmark.