PhD in Information Technology and Electrical Engineering

Università degli Studi di Napoli Federico II

PhD Student: Ivan Iudice

XXIX Cycle

Training and Research Activities Report – First Year

Tutor: Prof. Giacinto Gelli

1. Information

My name is Ivan Iudice, I was born in Livorno, Italy, in 1986. I received the B.S. degree, in 2008, and the M.S. degree, in 2010, from Università degli Studi di Napoli Federico II, both in Communications Engineering. Since November 2011 I have been working as part of the Communication Systems and Signal Processing group at Italian Aerospace Research Center (CIRA) in Capua, Caserta, Italy. Since March 2014 I have been following the PhD course in Information Technology and Electrical Engineering (ITEE), XXIX cycle, at Università degli Studi di Napoli Federico II, with Prof. Giacinto Gelli as tutor.

2. Study and training activities

During my first PhD year, I attended the following "ad hoc" courses organized by Dipartimento di Ingegneria Elettrica e delle Tecnologie dell'Informazione (DIETI):

- "Aspetti elettromagnetici nella progettazione di reti wireless", taught by Prof. Antonio Iodice, focused on the main electromagnetic phenomena to be taken into account when designing wireless networks;
- "Elettromagnetismo e relatività", taught by Prof. Amedeo Capozzoli, focused on the fundamentals of restricted relativity by Albert Einstein and its effects on electrodynamics.

Moreover, I attended the following "modules for improvement of research skills":

- "EuroProgettazione", by Gianpaolo Varchetta, containing general information on the organization and planning of European Community funds focusing on the program "2007-2013" and "Europe 2020" (in particular "Horizon 2020");
- "The Entrepreneurial Analysis of Engineering Research Projects", by Prof. Luca Iandoli, providing an overview of the process of creation of a new venture, with focus on academic spin-offs and other forms of market valorization of academic research in engineering;
- "Project Management per la Ricerca", by Prof. Guido Capaldo, providing an overview of the elements that identify a project, an introduction to planning, the concept of risk analysis, and the monitoring and control of various project work packages.

Finally I attended a five-day external course on "Antenna Synthesis", by European School of Antennas (ESoA), focused on the efficient synthesis of complex antenna systems.

During my first PhD year, I had the opportunity to attend many multidisciplinary seminars:

- "Fractal programming for Energy Efficiency in Wireless Networks", Dr. Alessio Zappone, September 2014;
- "Towards agile flight of vision-controlled micro flying robots: from frame-based to event-based vision", Prof. Davide Scaramuzza, September 2014;
- "Nano-carbon based components and materials for high frequency electronics", Prof. Sergey Maksime, Prof. Gregory Slepya, Prof. Pavel Dyachko, and Prof. Alexander Lobk, October 2014;

- "Reliability and Availability Modeling in Practice", Prof. Kishor S. Trivedi, November 2014;
- "Capacity Planning for infrastructure-as-a-Service Cloud", Prof. Kishor S. Trivedi, November 2014;
- "Quantum Teleportation", Prof. Giovanni Miano, October 2014;
- "Developmental Robotics: From Babies to Robots", Prof. Angelo Cangelosi, October 2014;
- "Methods and tools for smart device integration and simulation", Prof. Franco Fummi, November 2014;
- "Heterogeneities in temporal networks emerging from adaptive social interactions", Prof. Takaaki Aoki, November 2014;
- "UML Profiles for the specification of non-functional properties of software system", Prof. Simona Bernardi, December 2014;
- "Site Reliability Engineering at Google", Marco Papa Manzillo, PhD, November 2014;
- "Verification of Mobile Agents in Partially Known Environment", Dr. Sasha Rubin, November 2014.

3. Research activities

The main goal of my research activities is to study and implement advanced technologies for communication systems to be used in aeronautical environment, specifically for Unmanned Aircraft (UA) applications, and test them on specific test-bed or flight laboratories available at CIRA. To obtain the objectives of my research, I'm currently collaborating, under the supervision of my tutor Prof. Giacinto Gelli, with Prof. Francesco Verde, from DIETI, and Prof. Donatella Darsena, from Dipartimento di Ingegneria of Università Parthenope di Napoli, Italy.

I started to study the main issues about communication systems used in UA applications, in order to extract the critical requirements. UAs need communication data-links with specific requirements about data-rate, reliability and security: some key challenges should be the large distances involved, the high-speed of aircrafts, and hostile interferences/hijacking. A classical aeronautical communication system typically encompasses multiple data-links: a *payload data-link*, which requires high data-rates but does not have strong constrains on latency and reliability, and a *telemetry data-link*, used to transmit in downlink the parameters representing the health of the avionic system, which requires high reliability and low latency, with a relatively low data-rate; both data-links require moderate-to-high security characteristics. The UA scenario has significantly changed these requirements: consider, for example, an UA flying in remote piloting vehicle (RPV) mode, wherein the pilot, located in the ground control station, needs to see, with low latency, the images coming from a camera installed on the vehicle to correctly pilot it; in this case, to include the video stream, the telemetry channel has to satisfy much higher data-rate requirements.

Modulation and coding techniques traditionally used for telemetry are not suitable to transmit at very high data-rates: thus, the adoption of orthogonal frequency-division multiplexing (OFDM), possibly coupled with multiple-input multiple-output (MIMO) antenna configurations, is a viable alternative. In particular, I started formalizing a MIMO-OFDM model that should involve all issues relevant to the UA context, aimed at analytical evaluation of the expected performance, as well as at simulating a possible implementation.

In order to correctly implement MIMO-OFDM technologies and design robust modulation and coding schemes for achieving high reliability, it is first necessary to accurately model the wireless channel. To this aim, I investigated the most important models used to represent the aeronautical channel: in this regard, my literature scan shows in particular that the UA MIMO channel has to include strong line-of-sight (LOS) and specular (SPE) components, as well as some diffuse (DIF) component, and the aircraft and environment mobility must be considered for many applications. Usually, the LOS component is deterministically evaluated, whereas statistical models are used for SPE and DIF components. Statistical modeling is well motivated when time varying path delays arise due to a large number of scatterers (e.g., in over-the-horizon communications).

Alternative deterministic basis expansion models (BEMs) have gained popularity in some mobility applications, especially when the multipath is caused by a few strong reflectors and path delays exhibit variations due to the kinematics of the mobiles. BEMs consist in representing each time-varying tap as a superposition of time-varying base functions (e.g., complex exponentials when modeling Doppler effects) with time-invariant coefficients. The next step in my research will consist in verifying whether BEMs are suitable for aeronautical environments, specifically in UA applications; this analysis can be based both on data collected from literature or on direct measurements.

4. Products

I spent most of the time of this first year to improve my background on the state-of-art in communication systems for UA applications. As a first step in my research, I submitted the following paper regarding BEM applications in UA scenarios:

- D. Darsena, G. Gelli, F. Verde, and I. Iudice “Blind LTV shortening of doubly selective OFDM channels for UAS applications,” submitted to 2nd IEEE International Workshop on Metrology for Aerospace, Benevento, Italy, 2015.

5. Conferences and seminars

None.

6. Activities abroad

None.

7. Tutorship

None.

8. Credits summary

	Credits year 1								2	3	
		1	2	3	4	5	6				
	Estimated	bimonth	bimonth	bimonth	bimonth	bimonth	bimonth	Summary	Estimated	Estimated	Check
Modules	20				6		13	**19**	15	6	30-70
Seminars	5				2,2	3		**5,2**	5	0	10-30
Research	35	8	8	8	2	6	4	**36**	40	54	80-140
	60	8	8	8	10,2	9	17	**60,2**	60	60	180