Fostering the Innovation Potential of Research Infrastructures

INFRAINNOV-2-2016: Support to Technological Infrastructures

CLONETS – CLOck NETwork Services
Strategy and innovation for clock services over optical-fibre networks

Grant Agreement Number: 731107

Deliverable D4.5

Documentation on the Pilot Master
Final

Version: 1.0
Author(s): Davide Calonico, INRIM
Date: 23/08/2019

This project receives funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 731107

DOCUMENT INFORMATION

Project and Deliverable Information

Project Acronym:	CLONETS
Project Ref. №:	731107
Project Title:	CLONETS – CLOck NETwork Services: Strategy and innovation for clock services over optical-fibre networks
Project Web Site:	http://www.clonets.eu
Deliverable ID:	D4.5
Deliverable Nature:	Report
Dissemination Level*:	PU
Contractual Date of Delivery:	31/07/2019
Actual Date of Delivery:	23/08/2019
EC Project Officer:	Patricia Postigo-McLaughlin

* The dissemination level is indicated as follows: **PU** – Public, **CO** – Confidential (only for members of the consortium, including the Commission Services), **CL** – Classified (referred to in Commission Decision 2991/844/EC).

Document Control

Document	Title:	Documentation on the Pilot Master
	ID:	D4.5
	Version:	1.0
	Status:	Final
	Available at:	http://www.clonets.eu
	File(s):	CLONETS_Deliverable_D4.5_v1.0.pdf
Authorship	Written by:	Davide Calonico, INRIM
	Contributors:	Filippo Levi, Cecilia Clivati INRIM
	Reviewed by:	Eva Bookjans, OBSPARIS
	Approved by:	Philip Tuckey, OBSPARIS

Document Change History

Version	Date	Status	Comments
1.0	23/08/2019	First published version	

Document citation record

Davide Calonico, Filippo Levi, Cecilia Clivati : Documentation on the Pilot Master. Version 1.0 of D4.5 of the HORIZON 2020 project CLONETS. EU Grant agreement no. 731107.

Keywords: optical fibre, network, clock, time, frequency, international master, training

Disclaimer

This deliverable has been prepared under the responsible Work Package of the CLONETS Project in accordance with the Consortium Agreement and the Grant Agreement n° 731107. It solely reflects the opinion of the parties to these agreements on a collective basis in the context of the Project and to the extent foreseen in these agreements.

Copyright notice

© 2017 CLONETS Consortium Partners. All rights reserved. This document is a project document of the CLONETS project. All contents are reserved by default and may not be disclosed to third parties without the written consent of the CLONETS partners, except as mandated by the European Commission contract 731107 for reviewing and dissemination purposes. All trademarks and other rights on third party products mentioned in this document are acknowledged as owned by the respective holders.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF ACRONYMS AND ABBREVIATIONS

BIPM	International Bureau of Weights and Measures
CLONETS	CLOck NETwork Services: Strategy and innovation for clock services over optical-fibre networks project
DET	Department of Electronics and Telecommunications
DG	Directorate General
ECTS	European Credit Transfer System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
H2020	Horizon 2020
NMI	National Measurement Institute
POLITO	Politechnico of Torino
PPP	Point-to-Point Protocol
REFIMEVE	REseau FIbré MEtrologique à Vocation Européenne
TAI	International Atomic Time
T/F	Time and Frequency
TL	Time Laboratory
TWSTFT	Two-Way Satellite Time and Frequency Transfer
UTC	Universal Time Coordinated
VLBI	Very Long Baseline Interferometry

LIST OF PROJECT PARTNER ACRONYMS

AGH / AGH-UST	Akademia Górniczo-Hutnicza im. Stanisława Staszica w Krakowie, Cracow, Poland
CESNET	CESNET, zájmové sdružení právnických osob, Prague, Czech Republic
CNRS[*]	Centre National de la Recherche Scientifique, Paris, France
INRIM	Istituto Nazionale di Ricerca Metrologica, Turin, Italy
GARR[#]	Gruppo per l'Armonizzazione delle Reti della Ricerca, Rome, Italy
Menlo	Menlo Systems GmbH, Martinsried, Germany
Muquans	Muquans, Talence, France
NPL	National Physical Laboratory, Teddington, United Kingdom
OBSPARIS[¶]	Observatoire de Paris, Paris, France
OPTOKON	OPTOKON a.s., Jihlava, Czech Republic
Piktime Systems	Piktime Systems sp z o.o., Poznan, Poland
PSNC	Instytut Chemii Bioorganicznej Polskiej Akademii Nauk – Poznańskie Centrum Superkomputerowo-Sieciowe, Poznan, Poland
PTB	Physikalsch-Technische Bundesanstalt, Braunschweig, Germany
RENATER	Groupement d'interêt Public pour le Reseau National de Telecommunications pour la Technologie, l'Enseignement et la Recherche, Paris, France
SEVENSOLS	Seven Solutions S.L., Granada, Spain
TOP-IX	Consorzio TOrino Piemonte Internet eXchange, Turin, Italy
UCL	University College London, London, United Kingdom
UP13	Université Paris 13, Villetaneuse, France
UPT AV CR (ISI)	Ustav Pristrojove Techniky AV, v.v.i., Brno, Czech Republic

[*] linked third party to OBSPARIS
[#] third party to INRIM
[¶] coordinator

EXECUTIVE SUMMARY

The CLONETS Consortium recognizes that training is necessary for the establishment of a sustainable time and frequency (T/F) optical fibre network across Europe. One of the project's objectives is to ensure a permanent and effective knowledge transfer to engineers through the implementation of a Master's Programme. This deliverable describes the 2nd level Specializing Master's Programme in "Photonics For Data Networks And Metrology", which was put in place by INRIM in collaboration with the Politecnico of Torino as part of the CLONETS project.

The Pilot Master's Programme was ready to start, but unfortunately was cancelled last minute due to an unusually low enrolment rate combined with the rejection of student visa applications. Nonetheless, the preparation and organization of the Master's Programme has had a significant impact. Firstly, it has produced a Master's Programme appropriate for training professionals in T/F transfer over optical fiber. The content and format of the programme remain relevant and both INRIM and Politecnico of Torino continue to be interested in implementing the Master's Programme in the future. Secondly, it has also raised awareness of the importance of T/F to a wider community outside of the Consortium. The collaboration with the Department of Electronics and Telecommunication of Politecnico of Torino has strengthened the link between T/F metrology over fiber and the large field of optical networking and data traffic providing new opportunities and synergies. Additionally, the Master's Programme has led to the engagement of a new stakeholder Open Fibre, a major Italian telecommunications company, which has expressed its interest in training their employees through the Master's Programme. The value of the Master's Programme as an excellent training opportunity has also been recognized by Compagnia di San Paolo, the main bank foundation in Italy. In support of the Master's Programme, the bank foundation has offered 8 student grants.

1 INTRODUCTION

The CLONETS project firmly believes that training is one of the key points for sustaining the development of time and frequency (T/F) dissemination over optical fibre and the consequent advances in science, metrology and service platforms for Europe. With this objective in mind, CLONETS has prepared a well-structured training opportunity through the establishment of an international, 2nd level Specializing Master's Programme in "Photonics For Data Networks And Metrology". This Pilot Master was prepared by INRIM in close collaboration with the Politecnico of Torino, one of the leading universities in Italy, and in particular with the Department of Electronics and Telecommunications (DET). It has additionally been supported by the TOP-IX Consortium and later also received financial support from Compagnia di San Paolo.

1.1 The Specializing Masters Programmes at Politecnico of Torino

https://didattica.polito.it/master/home/en/the_specializing_masters_programmes

The Specializing Masters Programme (Master universitario) is a high-level scientific qualification. It can be attained after having earned a Bachelor's degree (1st level Specializing Masters Programme) or a Master's degree/laurea specialistica-magistrale (2nd level Specializing Masters Programme). It provides for a minimum of 60 credits (ECTS). Candidates holding a degree belonging to the old university system (vecchio ordinamento), pre-dating Ministerial Decree no. 509/1999, can be admitted to both 1st and 2nd level Specializing Masters Programmes. The Specializing Masters Programme is an academic course aiming at training mid-level professionals (1st level Specializing Masters Programme) or more specialized experts (2nd level Specializing Masters Programme).

In many cases, the Specializing Masters Programme is one of the main tools available to recent graduates to invest in their professional future, since it stems from the close cooperation with the public and private sector or with other Universities, with an eye to facilitating access to the world of work for qualified professionals. In particular, 1st level Specializing Masters Programmes, referred to as "professionalizing" Masters Programmes, aim at training mid-level professionals by enriching their cultural background and laying stress on subjects and sectors that were not examined in depth during undergraduate studies.

These programmes are also a qualified training opportunity for those students who do not enrol in a Master's degree programme. The Specializing Masters Programmes are also offered in accordance with the format of the so called "Advanced Education and Research Apprenticeship" (Apprendistato di Alta Formazione e di Ricerca), in cooperation with one or more private companies.

1.1.1 Structure of the Specializing Masters Programmes

By enrolling in a Specializing Masters Programme, students begin their career: this includes training activities in the classroom and a curricular internship, normally taking place when classes come to an end. As a general rule, the Specializing Masters Programme has a duration of 12 months. Specializing Masters Programmes, offered in accordance with the apprenticeship format, alternate training sessions in the classroom and on-the-job training in a private company, over a period of 24 months. The final qualification is awarded to students provided that they have passed all the exams included in the Curriculum and have completed the internship, earning all the corresponding academic credits (ECTS). The Specializing Master's diploma must be attained within the academic year of enrolment (except for Specializing Masters Programmes following the apprenticeship format, which have a longer duration). In case of failure to complete the programme, students can ask for a certificate of the single exams they have passed.

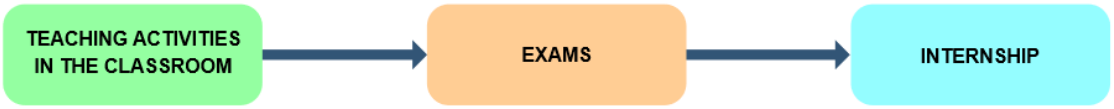

Figure 1. Structure of the Specializing Masters Programmes.

In the CLONETS' case, the internships were planned to take place at the premises of Consortium members.

1.2 Photonics for Data Networks and Metrology

https://didattica.polito.it/master/photonics/2019/glance

Figure 2. Pilot Master "at a Glance": presentation webpage.

Data traffic will experience a dramatic growth over the next years driven by 5G access, high-definition video, virtual and augmented-reality contents, and the considerable growth in cloud services due to Big Data Exchange. Photonic data networks will be required to be more and more pervasive and elastic, to supporting the paradigm of Internet of Thing and to enabling Industry 4.0. Besides data transport, photonic networks will also distribute time and frequency (T/F) standards for research and industry, enabling orders of magnitude performance improvements with respect to satellite systems, over continental geographical areas. The list of institutions supporting the initiative testifies the need for a vertical multidisciplinary knowledge, from the transmission layer up to the IP layer, and training such new professional figures is indeed the mission of the 2nd level Specializing Master's Programme. The Programme is supported by the EU through the project H2020-INFRAINNOV-CLONETS and will offer theoretical and practical lecturing, hand-on experiences and a final internship in European industrial and/or research environments.

2 ORGANIZATION

2.1 INRIM

The Istituto Nazionale di Ricerca Metrologica (INRIM) is the Italian Metrological Institute realizing the SI second in Italy and the Universal Time Coordinated UTC(IT). Over the last decades, INRIM has continuously contributed to the international UTC. INRIM has been operating primary frequency standards since 2003 with IT-CsF1, a laser cooled Caesium fountain. Since 2014, a new cryogenic fountain (IT-CsF2) with a state-of-the-art accuracy of 2e-16 regularly contributes to the evaluation of the BIPM International Atomic Scale (TAI). And since 2017, a Yb lattice optical frequency standard is under operation with an accuracy below 1e-16.

INRIM currently operates all the satellite techniques for T/F transfer, in particular Geodetic GPS, GPS PPP and TWSTFT techniques. Recognising the importance of improving its T/F dissemination capabilities, in order to be able to cope with the requirements of new generation frequency standards, INRIM started in 2009 an activity on frequency dissemination based on optical fibres. Since 2013, INRIM is operating a backbone for frequency dissemination to other relevant national research centres. A 1850-km link connects INRIM to different scientific users, among them the Medicina Radiotelescopes of the Italian National Institute of Astrophysics and the Space Geodesy Center of the Italian Space Agency in Matera (Italy). The link now disseminates primary standards to these laboratories enabling research on VLBI. Its importance is recognised by funding from the Italian government within the Progetti Premiali excellence research programmes. Additionally, INRIM has extended its fibre network to the French border in preparation to connect with the French optical fibre T/F network REFIMEVE. INRIM has been a partner in the European projects EMRP NEAT-FT and EMPIR-OFTEN. Since 2000, INRIM has been participating in the GALILEO project and has formally requested to host an ACES transportable microwave link ground terminal. INRIM is now a partner in the EMRP-ITOC project “International Timescales on Optical Clocks” on remote optical clock comparisons for geodesy applications; the link to the French border was developed within this project. INRIM has also been co-organizing the PhD course in Metrology with Politecnico of Torino. This PhD course specifically addresses the topics of measurement and primary metrology, including T/F dissemination and its dissemination over optical fibres.

2.2 Politecnico of Torino

Politecnico of Torino (POLITO) is a leading public university in technical-scientific teaching and research with over 33.000 students from more than 100 countries. POLITO is strongly committed to collaborating with industry and governmental authorities. In particular, the Politecnico Business Research Centre proves space specifically dedicated to the cooperation with private companies through joint laboratories and research facilities. In November 2013, POLITO was awarded by the European Commission with the label “Human Resource Excellence in Research”, recognizing its commitment to offering researchers from all over the world a positive and challenging environment, where personal development and competences are fostered and strengthened. POLITO is part of many public-private international inter-university networks (CESAER, CLUSTER, EUA, Sefi, T.I.M.E.).

The Department of Electronics and Telecommunications (DET) is the point of reference in Politecnico of Torino for the following areas in the field of Information and Communication Technologies (ICT): telecommunications, electronic devices, circuits, technologies and systems, electronic measurement and characterization techniques, as well as electronic bioengineering. The DET promotes, coordinates and manages basic and applied research, training, technology transfer and services to the local community in the areas of electronics,

electromagnetic fields, telecommunications, electronic bioengineering, electrical and electronic measurement, and circuit theory.

The optical communications group of DET was established in the mid 1990s and is internationally recognized for its excellence in simulating and modelling the physical layer of optical networks. Since 1998, it supports the development of the commercial optical simulation software OptSim, now a Synopsys project. Moreover, recently a GPU-running simulation library has been developed for enabling large bandwidth and mixed service analysis. The optical communications group has been part of several EU (EuroFOS, BONE, COST 291: Towards digital optical networks, ePhoton-ONE+, NOBEL 2, ePhoton-ONE) and national (OSATE, TOSCA, WONDER, ADONIS, RINGO) projects and is currently part of the EU-funded H2020-MSCA-ETN on "Wideband Optical Networks" project investigating and studying multiband transmission, including non-data services. The optical communications group is continuously funded by several companies for specific tasks. These companies are system vendors and operators. The optical communications group is also part of the telecom infraproject.

2.3 Supporting Institutions

https://didattica.polito.it/master/photonics/2019/supporting_institutions

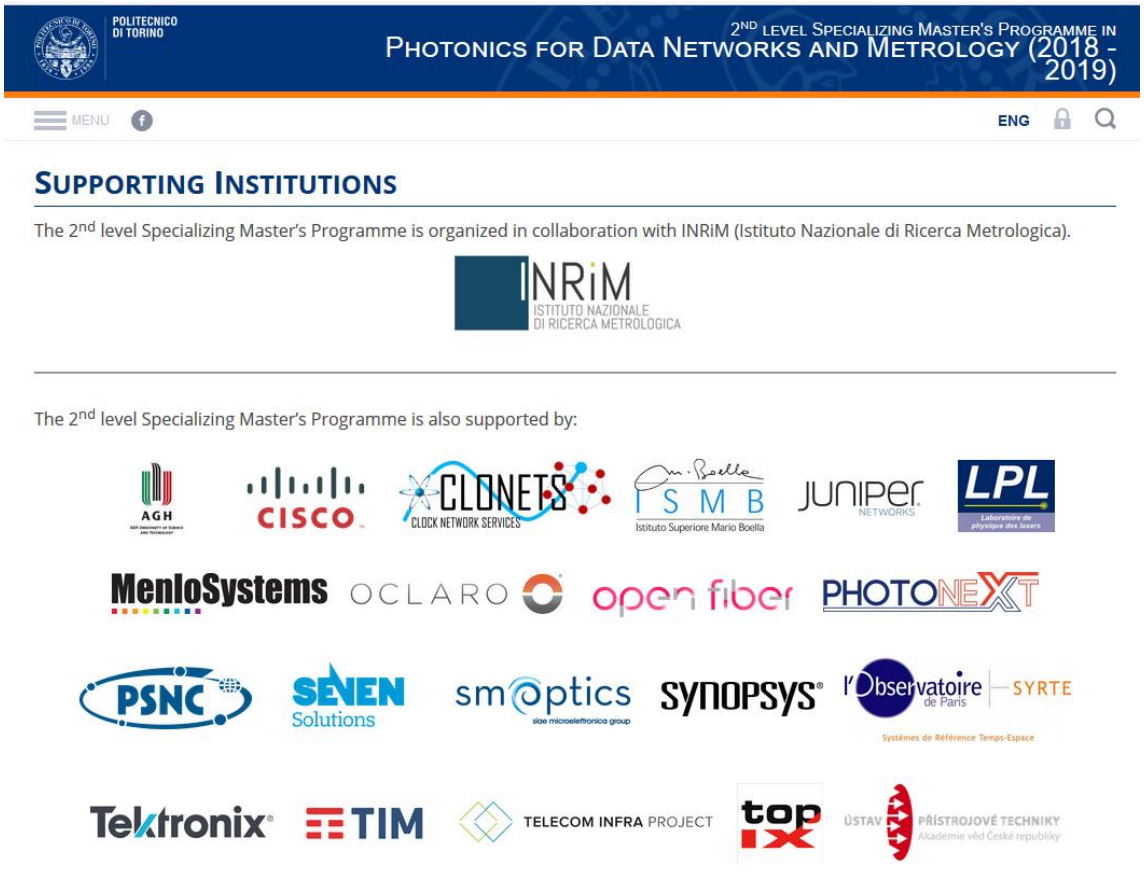

Figure 3. Main supporting institutions and companies of the pilot master programme.

2.4 Financial Support

https://didattica.polito.it/master/photonics/2019/financial_support

2.4.1 Compagnia di San Paolo

Thanks to the support of the Compagnia di San Paolo, the Pilot Master offered a maximum of 9 scholarships to Extra EU and EU participants of the 2nd level Specializing Master's Programme in "Photonics for Data Networks and Metrology" academic year 2018/2019. The gross amount of the scholarship is 4.000,00 Euro (four thousand/00).

The Selection's Commission will assign the scholarships at the end of the lectures period (foreseen for October 2019). In order to be eligible, the students must meet the following requirements:

- To be enrolled in the 2nd Level Specializing Master's programme in "Photonics for Data Networks and Metrology" for the academic year 2018/2019;
- To have attended at least 80% of the total classroom hours;
- To have successfully passed all the exams included in the Study Plan.

The candidates will be evaluated on the basis of the weighted average grade of all their exams and of class attendance. The Selection's Commission will prepare a ranking list of all candidates and will award the 9 scholarships to the top 9 students on the list. The scholarships will be paid in one instalment at the end of lectures period. The scholarship is not compatible with others scholarships offered by Politecnico di Torino for the 2018/19 academic year.

2.4.2 TOP-IX Consortium

Thanks to the support of the TOP-IX Consortium, Politecnico di Torino offered one scholarship to Extra EU and EU applicants of the 2nd level Specializing Master's Programme in "Photonics for Data Networks and Metrology" academic year 2018/2019. The gross amount of the scholarship is 4.000,00 Euro (four thousand/00).

The Selection's Commission will assign the scholarships during the selection process. The scholarship will be paid at the end of the lectures period (foreseen for October 2019). In order to be eligible, the students must meet the following requirements:

- To have applied for the 2nd Level Specializing Master's programme in "Photonics for Data Networks and Metrology" for the academic year 2018/2019;
- To be ranked first in the merit list that will be published on the "Selection outcomes" page of the programme's web site at the end of the selection process

The candidate who fits the above mentioned requirements will be assigned the TOP-IX scholarship. The candidate in order to be eligible for the scholarship will have to accept the internship to be carried out at TOP-IX consortium. The scholarship will be paid in one instalment at the end of lectures period. The scholarship is not compatible with others scholarships offered by Politecnico di Torino for the 2018/19 academic year.

2.5 Internship Programme Supporters

The internship program was planned in collaboration with the CLONETS Consortium Partners, which are listed below and agreed to host an intern.

HOST
1 OBSERVATOIRE DE PARIS France 2 ISTITUTO NAZIONALE DI RICERCA METROLOGICA Italy 3 PHYSIKALISCH-TECHNISCHE BUNDESANSTALT Germany 4 NPL MANAGEMENT LIMITED United Kingdom 5 GROUPEMENT D INTERET PUBLIC POUR LERESEAU NATIONAL DE TELECOMMUNICATIONS POUR LA TECHNOLOGIE L ENSEIGNEMENT ET LA RECHERCHE France 6 CESNET ZAJMOVE SDRUZENI PRAVNICKYCH OSOB Czech Republic 7 INSTYTUT CHEMII BIOORGANICZNEJ POLSKIEJ AKADEMII NAUK Poland 8 UNIVERSITE PARIS 13 France 9 MUQUANS France 10 MENLO SYSTEMS GMBH Germany 11 PIKTIME SYSTEMS SP. Z O.O. Poland 12 USTAV PRISTROJOVE TECHNIKY AV CR, v.v.i. Czech Republic 13 SEVEN SOLUTIONS SL Spain 14 OPTOKON Slovenia 15 AKADEMIA GORNICZO-HUTNICZA IM. STANISLAWA STASZICA W KRAKOWIE Poland 16 UNIVERSITY COLLEGE LONDON UK

3 IMPLEMENTATION

This section describes how the pilot master was implemented with detailed instructions for application, enrolment, and the syllabus.

3.1 Training objectives, learning contents and organization of the activities

https://didattica.polito.it/master/photonics/2019/objective_contents

The purpose of the Programme is to give multidisciplinary knowledge and competence on photonics transmission and networking as well as on fundamentals of metrology and of time reference distribution on telecommunications infrastructure based on optical fiber transmission. The Programme is aimed at students with different backgrounds: graduated in the ICT field and graduated from schools of Physics and Metrology, and will train hybrid professional figures who will be able to design and manage state-of-the-art photonic networks to support the ever-increasing IP traffic demands well as to distribute time references from and among metrology centers.

The 2nd level Specializing Master is a full time Programme of one academic year duration for a total of 69 ECTS; it will start in M1 and will end in M14. Lectures will be held in English at Politecnico di Torino premises – starting in M1 and ending in M10. Lectures include classroom activities with academic and corporate teaching staff. The internship period will start in M11 and will end in M14.

The teaching Programme is organized as follows:

- courses: 32 weeks of full-time classroom activities (M1 – M10)
- internship: 8 weeks (250 hours) of on the job training at companies and/or research institutes in the photonic technologies field (M11 – M14).

n.	SUBJECT	ECTS	HOURS	TEACHER
1	**Digital Communication**	6	60	Bosco Gabriella
2	**Optical Transmission**	5	50	Curri Vittorio
3	**Photonic Devices**	4	40	Guido Perrone
4	**Time and frequency metrology**	5	50	Calonico Davide (INRiM)
5	**Ultrabroadband access networks**	5	50	Gaudino Roberto
6	**Long-haul optical transport**	4	40	Carena Andrea
7	**Photonic Networks**	6	60	Curri Vittorio
8	**Quantum Communications**	4	40	Degiovanni Pietro (INRiM)
9	**Photonics applications in metrology**	4	40	Clivati Cecilia (INRiM)
10	**Time and frequency laboratory**	6	60	Calonico Davide (INRiM)
11	**Security for ICT**	4	40	Degiovanni Pietro (INRiM)
12	**Communications laboratory**	6	60	Ferrero Valter
13	Internship	10	250	
	TOTAL	**69**	**840**	

Figure 4. Overview of the Pilot Master's teaching programme.

3.2 Attendance Requirements

https://didattica.polito.it/master/photonics/2019/who_can_attend

The 2nd level Specializing Master's Programme is intended for Italian and foreign citizens. Applicants must hold a full degree (Master of Science degree/Laurea specialistica/Laurea magistrale) in one of the following fields:

- LM-27 Telecommunication Engineering
- LM-29 Electronic Engineering
- LM-25 Automation Engineering
- LM-32 Computer Engineering
- LM-17 Physics
- LM-18 Computer Science
- LM-44 Physics and mathematics for engineering
- LM-21 Biomedical Engineering
- LM-40 Mathematics

Upon specific and motivated request of the candidate, the Selection Committee will consider for admission also candidates that graduated in a field not listed above, if adequate supporting documentation will be uploaded, including official transcript(s) issued by the University of origin or self-certification, as specified in the page called "Documentation", containing the full list of all the exams, grades and course syllabi. These documents are required to testify that candidates own the scientific and cultural background knowledge requested to successfully attend the Specializing Master's Programme.

The Selection Committee will evaluate candidates who have not graduated yet upon condition that they will obtain the necessary degree within the enrolment deadline. In case they will not obtain the degree within the enrolment deadline, they will not be admitted to the Programme.

English Language

All candidates must prove to have a good knowledge of the English language, which must be certified by a language certificate included in the list of accepted certificates (see Table "English language certificates" in order to know the required level and accepted certificates). Candidates can be exempted from having the IELTS 5.5 certificates by providing a stamped declaration/certificate written on official letter headed paper, which certifies that:

a. They have attended at least one school year at a high school in which the medium of instruction is English. In this case the school must issue a certificate stating that "The medium of instruction is English".

b. They have a foreign high school diploma which is recognized by the Italian Ministry of Education and Research as equivalent to the Italian high school diploma (diploma di maturità), or they have a higher qualification awarded by a higher education institution in which the medium of instruction is English.

In both cases the school must issue a certificate stating that "The medium of instruction is English". With regard to points "a" and "b", please note that diplomas awarded by high schools in the USA, UK , Canada, Ireland, Australia and New Zealand do not need to include the phrase "The medium of instruction is English".

3.3 Participation and enrolment fee

https://didattica.polito.it/master/photonics/2019/fee

The participation fee is 4.000,00 Euro (four thousand/00) + an enrolment fee (enrolment revenue stamp + premium for accident insurance) to be defined within the enrolment deadline; the total amount shall be paid to Politecnico di Torino according to the following installments:

- 1.000,00 Euro within the deadline which will be defined by Politecnico for participants to accept the offer for the Specializing Master's Programme
- 3.000,00 Euro + enrolment fee at the time of enrolment

The participation and the enrolment fee can be paid by wire transfer through the "Apply@Polito" platform. In case of withdrawal or exclusion from the Programme the participation fee and the enrolment fee won't be refunded by Politecnico di Torino under any circumstances. The Programme will start only if the minimum number of 10 participants required is reached.

3.4 Application instructions

https://didattica.polito.it/master/photonics/2019/apply

Applications for the Specializing Master's Programme must be completed on line. Please DO NOT apply by e-mail, fax or mail – those applications will NOT be accepted.

Procedure for candidates holding a bachelor's or master's degree from politecnico di torino (or candidates who already have a "username" provided by the "Apply" service)

- make sure that you meet the admission requirements of the Specializing Master's Programme;
- read the online applicaton form instructions;
- if you are a student (or former student) at Politecnico, log into your personal page of the Teaching Portal (Portale della Didattica), go to "Segreteria online", and click on "Apply@Polito";

  or
- if you already have an Apply username, but you have never been enrolled at Politecnico, in order to log in on "Apply" you shall use the access credentials (username and password) previously assigned to you. In case you forgot your username or password, send a message to: master.universitari@polito.it
- fill in each section of the online Application Form within the relevant deadline, selecting the level (2nd level Specializing Master's Programme) and the programme title;
- attach to your Application Form the required supporting documents (possibly in pdf format). The supporting documents must be written in English or Italian only;

- send your Application Form (save and submit)

If the form is not wholly and correctly filled in your application will not be processed.

Procedure for candidates holding a bachelor's or a master's degree from another (italian or foreign) university (except for Politecnico di Torino)

- make sure that you meet the admission requirements of the Specializing Master's Programme;
- read the online application form instructions;
- fill in each section of the online Application Form within the relevant deadline, after having completed the registration and having provided your personal details. You will receive an e-mail from Politecnico with your username and password: you need to click on the link you find in the body of the e-mail (for your first access only), log in and select the level (2nd level Specializing Master's Programme) and the programme title;
- attach to your Application Form the required supporting documents (possibly in pdf format). The supporting documents must be written in English or Italian only;
- send your Application Form (save and submit)

If the form is not wholly and correctly filled in your application will not be processed.

Visa for study purposes

In order to study at Politecnico, non EU citizens need to get the Italian Visa for Study Purposes from the Italian Embassy of your country of residence. To this end, the Office of Specializing Master's Programmes and Lifelong Learning needs to send a copy of your invitation letter to the Italian Mission (embassy or consulate) that you will contact for visa application. The Office of Specializing Master's Programmes and Lifelong Learning will fornish you with the invitation letter needful to issue your Italian Visa for Study Purposes just in case you will be admitted according to the selection outcomes.

3.5 Application documentation required

https://didattica.polito.it/master/photonics/2019/deadline_documentation

ALL the following supporting documents must be attached to the application form on Politecnico di Torino website (in English or Italian only):

1. valid identification document (passport for extra-EU applicants)
2. curriculum vitae (CV must include the authorization to the processing of personal data – in compliance with Legislative Decree no. 196/2003)
3. list of exams of both Bachelor's and Master's degree programmes:
   - for applicants with degree(s) obtained from a non-Italian University or from a private Italian University: official transcript(s), issued by the University of origin, produced on headed paper, containing the full list of all the exams passed and the grades obtained. The transcript(s) must also include the date of the degree conferral. **or**
   - for applicants with degree(s) obtained from an Italian Public University: self-certification(s) ("dichiarazione sostitutiva di certificazione" - Art. 46 DPR 28 December 2000, n. 445) in which applicants declare to have obtained both Bachelor's and Master's degrees. The self-certification(s) must include: the name of degree, the name of the University, the date of degree conferral and the graduation final grade, the full list of all the exams passed and the grades obtained. In compliance with art. 75 of D.P.R. 445/2000, should the self-certification be found to be false or incorrect, the applicant loses any benefit which he/she might have acquired on the basis of the untruthful declaration.
4. English certificate (see table "English language certificates")

5. Admission Request Form (properly filled-in and signed)
6. Motivation letter which should be no more than 750 characters in total (spaces included).
Failure to attach even one of the above mandatory documents will result in the exclusion from the selection process.

3.6 Selection process

https://didattica.polito.it/master/photonics/2019/selection

To be admitted to this Specializing Master's Programme, applicants must pass the selection procedure as described below; the final decision is taken by the Selection Committee composed of representatives from Politecnico di Torino and INRiM.
After the application deadline the Selection Committee will evaluate all the applications received and the attached documentation. First, the Selection Committee will verify whether the applicants meet the academic requirements, have the necessary qualifications and will select those eligible to attend the Programme. To fairly and properly rank applicants, the documentation attached to the on-line application form will be considered, assigning an overall maximum of 100 points, according to the following criteria.

Selection process - criteria

- Academic background (Master of Science degree final grade - in case of Master's degree conferred without final grade, or Master's degree not yet obtained, the average value of passed exams' grades will be considered-, grades obtained in each examination of the MSc degree, coherence of the MSc curriculum with Specializing Master's topic): maximum 40 points
- Prior experiences (thesis, internship, work, research projects) in the field of digital communications, photonic transmission and networking and time and frequency metrology (specified in the curriculum vitae): maximum 40 points
- Motivation letter: maximum 20 points

Candidates who will not satisfy all of the following items:

- satisfy all the requirements
- attach all the required documents
- reach the minimum score of 50 points

will be considered "not suitable" and they will not be admitted to the Programme.

3.7 Selection Outcomes

https://didattica.polito.it/master/photonics/2019/selection_outcomes

The Selection's Commission was nominated by Politecnico of Torino, and it was composed of Prof. Roberto Gaudino (Full profeesor at Politecnico), Prof. Vittorio Curri (Associated Professor at Politecnico), and Dr. Davide Calonico (Senior Researcher at INRiM).
The Selection's Commission evaluated all the applications received. The following list contains the names (based on their position on the merit list) of the students who are admitted to attend the 2nd level Specializing Master's Programme in Photonics for Data Networks and Metrology:

n.	user apply	surname	name	result
1	F291327	ABDELFATTAH	S.	admitted
2	F181761	MULUGETA	B. A.	admitted
3	F325384	ALAM	S.	admitted
4	F306373	MASOOD	M. U.	admitted
5	F305818	HABIB	M.H.	admitted
6	F157723	KAMRAN	F.	admitted
7	F282383	RASHID	M. M.	admitted
8	F323979	ABDELLATIF	A.	admitted
9	F322030	HOSEK	M.	admitted
10	F309799	MAVLONOV	J.	admitted
11	F322785	KARMAKER	S.	admitted
12	F69883	BASIR	A.	admitted
13	F307105	AHAMED	S.	admitted

In order to be enrolled, the participation fee is 4.000,00 Euro (four thousand/00) + an enrolment fee (19,53 Euro): the total amount shall be paid to Politecnico di Torino according to the following installments:

- 1.000,00 Euro within the first payment deadline
- 3.000,00 Euro + enrolment fee (19,53 Euro) within the second payment deadline

The admitted candidates included in the above mentioned list in order to confirm their participation must take the following steps by the first payment deadline:

1. download the "Participation Acceptance Declaration Form" (click here to download), fill it in, sign it and send it by e-mail to master.universitari@polito.it
2. pay an advance fee of 1.000,00 €. In order to accomplish it, please access to http://apply.polito.it/ with your credentials (username and password), go to the section "enrolment" and follow the instructions. You will have 3 options:
    a. **MAV (Modulo Avviso Pagamento / electronic deposit slip)**. At first you must generate your MAV (please note that you have the possibility to insert a different amount from the one automatically generated by the system). You can pay your MAV at any bank counter or through the online banking service of your own bank. If you wish to pay at a bank counter, you must print your MAV and show it at the bank counter. If you pay through the online banking service of your bank, you must use the code generated by the system, without need to print the MAV. The MAV is a univocal code and can be used only for the credit amount generated at the moment. The MAV will be valid until the payment is done. A bank commission of 0,59 Euro is applied for any MAV transaction. The payment will be automatically recorded within five days of the date of payment (after the bank has sent the data to Politecnico); therefore you do not need to go to the Office of the University Registrar in order to register your payment). Please note that if you pay your MAV after 5.00 p.m., the bank might not record the payment within the same day (you must verify with your bank their recording schedule). This could be a problem if the payment happens on the day of the deadline (extra costs might be applied for late payment).
    b. Credit card (Visa or MasterCard) or debit card; a bank commission of 1% will be applied. At the end of the procedure you will get a payment receipt with all the details.
    c. PagoPa (online electronic payment to the Public Administration). You can choose one of the following payment methods:
        - Avviso di pagamento/ Payment notice: you can generate a payment notice that you can pay at any facility that has a payment agreement with the Public

Administration. When you use this method, your payment will be recorded within 24 hours.

- Credit card: when you use this method, your payment is recorded immediately. By clicking on Details, you can check commissions and payment circuits in order to choose the best service for you.

The 1.000,00 € amount will be deducted from the first installment payment at the moment of your enrolment. This amount will be refunded in case that the programme will not be activated because the minimum number of the students required will not be reached. The amount will be retained by the Politecnico di Torino in all the other cases.

All information about enrollment, VISA, etc. will be sent by e-mail to all admitted candidates. In case that one or more candidates will not confirm their participation within the given deadline, they will not have the possibility to participate in the programme.

3.8 Enrolment

https://didattica.polito.it/master/photonics/2019/enrolment

Admitted candidates who accept the offer to participate in the Programme will have to enrol at Politecnico di Torino by the starting date of the Specializing Master's Programme. Upon enrolment, participants who hold a degree from a non-Italian University must submit the original copy of the "Dichiarazione di Valore"/"Statement of validity" (related to the Master's degree) issued by the Italian Diplomatic Mission in the country where the qualification was awarded.If the Master's degree was awarded by a European University, participants can turn in the "Diploma Supplement" instead of the "Dichiarazione di Valore".

Participants who are non-EU citizens and reside in Italy must submit a valid Italian residence permit. Participants who are non-EU citizens and reside abroad must submit an Italian VISA for study purposes "type – D".

3.9 Diploma

https://didattica.polito.it/master/photonics/2019/diploma

Student obligations

The Specializing Master's Programme requires the participants a full time commitment. Attendance to the activities is mandatory for at least 80% of the Programme. Absences will be allowed up to a maximum of 20% of total classroom hours. Absences for more than 20% of total classroom hours will lead to exclusion from the Specializing Master's Programme.Withdrawal from the Programme must be put in writing. For the purpose of obtaining the Specializing Master's degree, the Scientific Advisory Board will also evaluate the student participation in the activities and the appropriateness of his/her behaviour. Participation will be subject to performance evaluation throughout the Programme. Participants who fail 6 (or more) exams out of 12 will be excluded from the Programme. Detailed rules about the exams will be provided during the opening day. It is not possible to be enrolled in a Specializing Master's Programme and in another University Programme at the same time.

Evaluation method

For each course participants will have to take an exam consisting in a written/oral or both evaluation test. At the end of the Programme the final presentation (dissertation of the project work) will allow to assess the student's skills.

Qualification
After completing the Programme, participants who have regularly attended the activities and reached the total amount of 69 ECTS required for graduation, will be awarded the "Photonics for Data Networks and Metrology" 2nd level Specializing Master's diploma by Politecnico di Torino. The diploma will be issued in Italian.

4 COURSES AND LECTURERS

4.1 Courses

https://didattica.polito.it/master/photonics/2019/objective_contents

n.	SUBJECT	ECTS	HOURS	TEACHER
1	Digital Communication	6	60	Bosco Gabriella
2	Optical Transmission	5	50	Curri Vittorio
3	Photonic Devices	4	40	Guido Perrone
4	Time and frequency metrology	5	50	Calonico Davide (INRiM)
5	Ultrabroadband access networks	5	50	Gaudino Roberto
6	Long-haul optical transport	4	40	Carena Andrea
7	Photonic Networks	6	60	Curri Vittorio
8	Quantum Communications	4	40	Degiovanni Pietro (INRiM)
9	Photonics applications in metrology	4	40	Clivati Cecilia (INRiM)
10	Time and frequency laboratory	6	60	Calonico Davide (INRiM)
11	Security for ICT	4	40	Degiovanni Pietro (INRiM)
12	Communications laboratory	6	60	Ferrero Valter
13	Internship	10	250	
	TOTAL	69	840	

Figure 4. Overview of the courses offered in the pilot master's programme.

Digital Communication
This class will aim at giving the foundations of signal analysis and of digital transmission technology used to transport information in telecommunications infrastructure. Depending on the background of the enrolled students, extra lectures will be organized to fill possible knowledge gaps of students graduated in Physics and/or Metrology.
ECTS:6 Teacher: Bosco Gabriella

Optical Transmission
This class will train students on peculiarity of signal transmission in the single mode optical fiber. The wave equation for modal amplitude – the nonlinear Shroedinger equation – will be derived, introducing the specific effect of the propagation field. A special attention will be spent to properly train students on polarization-related effects that are the main possible source of impairments for metrology signals.
ECTS: 5 Teacher: Curri Vittorio

Photonic Devices
In this class the most relevant active and passive components for photonic networks will be introduced and their system-level behavior will be proposed and analyzed. These components are: optical sources, modulators, amplifiers, detectors, filtering, and passive components in general, reconfigurable optical add/drop multiplexers (ROADMs) and their exploitation in network nodes. As well as in the optical transmission class, a special attention will be spent to properly train students on polarization-related effects that are the main possible source of impairments for metrology signals.
ECTS: 4 Teacher: Guido Perrone

Time and frequency metrology

This class will introduce to the fundamentals of Time and Frequency (T/F) Metrology. The topics will include: the uses of time and frequency references, for science and technology, paying particular attention to telecommunications, smart grids, synchronization and calibrations; the physics and technology of oscillators, atomic clocks and T/F transfer methods (clock comparisons and reference distributions); the fundamental methods for characterization and performance evaluation will be presented, with proper statistical tools.
The main focus will be on optical T/F metrology, including optical clocks, laser for metrology and communication, T/F trasfer over optical fibers.
ECTS: 5 Teacher: Calonico Davide (INRiM)

Ultrabroadband access networks

This class will introduce to the Internet access technologies – including transmission techniques -- exploiting the photonic infrastructure according to the fiber-to-the-home or fiber-to-the-cabinet paradigm. So, the anyzed networks extend are limited to few tens of kilometers. State-of-the-art and near future evolutions will be introduced with special attention to 5G-related technologies. Potentialities and criticalities on possible time distribution to the final user will be addressed.
ECTS: 5 Teacher: Gaudino Roberto

Photonic Networks

This class will introduce back-bone photonic networks – from extended metro up to worldwide submarine networks --, focusing on networking layers up to the IP layer. Protocols will be introduced, and physical-layer-aware networking will be described. Issue related to time and frequency distribution will be addressed. The class will follow a hand-on teaching method structured on developing sw modules.
ECTS: 6 Teacher: Curri Vittorio

Quantum Communications

This class will introduce to the fundamentals of communication using quantum physics. The topics will include: a prime in quantum physics useful to the main concepts analysis; an historical point of view; Experimental fundamentals of QC; the present best techniques; the actual challenges and the perspectives towards a capillary QC; statistical tools, methods in metrology and characterization of QC; fundamental QC protocols over fibre and data networks.
ECTS: 4 Teacher: Degiovanni Pietro (INRiM)

Photonics applications in metrology

This class will introduce to the photonics tools commonly used in optical frequency metrology. There will be a further focus with respect to the T/F class on lasers, fibres, non-linear devices, ultrastable coherent sources, femtosecond laser combs, integrated photonics and photodetectors. The student will have a complete view of the tools used today in the field of applied photonics for metrology.
ECTS: 4 Teacher: Clivati Cecilia (INRiM)

Time and frequency laboratory

This class is devoted to an experimental, hands-on approach to the fundamentals of T/F metrology. The student will have the possibility of working with the up-to-date instrumentation, like atomic clocks, counters, noise analyzers, phasemeters, lasers and optical frequency measurement chains, fibre optics. The instruments and techniques will be explained and the students will receive a practical training in laboratory.
ECTS: 6 Teacher: Calonico Davide (INRiM)

Security for ICT

The class is devoted to the continuously growing challenge of security over data networks and optical communications. The focus will be on fundamentals in threats for networks and basic counteraction; security design for networks; critical infrastructures and their protection; European regulation; blockchain techniques.
ECTS: 4 Teacher: Degiovanni Pietro (INRiM)

Communications laboratory

This class will focus on virtual and lab experiments related to photonic transmission and networking. Fiber propagation analyses will virtually compare simulations with semi-analytical models presented in the preceding classes. Lab experiments will be performed on source characterization, while on networking virtual experiments will be carried on sw modules developed within the "photonic networks" class.
ECTS: 6 Teacher: Ferrero Valter

4.2 Lecturers

Bosco Gabriella
Contact: gabriella.bosco@polito.it

Associated Professor at DET –Electronics and Telecommunication Department.
Member of the Board for Informatics and Meccatronics Engeneering
Member of the Commission for the Coordination of Didactics at Politecnico
Member of the Academic Senatus at Politecnico

Academic Lecturers:
2018/2019 and 2017/2018
Singal theory and Signal processing (437 students)

Recent Publications:

Pilori, Dario; Nespola, Antonino; Forghieri, Fabrizio; Bosco, Gabriella (2019) Non-Linear Phase Noise Mitigation over Systems using Constellation Shaping, In: JOURNAL OF LIGHTWAVE TECHNOLOGY, pagine 3475-3482, ISSN: 0733-8724

Bosco, G. (2019) Advanced Modulation Techniques for Flexible Optical Transceivers: The Rate/Reach Tradeoff, In: JOURNAL OF LIGHTWAVE TECHNOLOGY, pagine 36-49, ISSN: 0733-8724

Ziaie, S.; Guiomar, F. P.; Muga, N. J.; Nespola, A.; Bosco, G.; Carena, A.; Pinto, A. N. (2019) Adaptive Stokes-Based Polarization Demultiplexing for Long-Haul Multi-Subcarrier Systems, In: IEEE PHOTONICS TECHNOLOGY LETTERS, pagine 759-762, ISSN: 1041-1135

Pilori, Dario; Bertignono, Luca; Nespola, Antonino; Forghieri, Fabrizio; Bosco, Gabriella (2018) Comparison of Probabilistically Shaped 64QAM with Lower-Cardinality Uniform Constellations in Long-Haul Optical Systems, In: JOURNAL OF LIGHTWAVE TECHNOLOGY, pagine 501-509, ISSN: 0733-8724

Kashef, Seyed Sadra; Azmi, Paeiz; Bosco, Gabriella; Matinfar, Mehdi D.; Pilori, Dario (2018) Non-Gaussian statistics of CO-OFDM signals after non-linear optical fibre transmission, In: IET OPTOELECTRONICS, pagine 150-155, ISSN: 1751-8768

Research Contracts: Optnext: Delivering the next generation technologies for optical communications (2016-2017)

Calonico Davide (INRiM)
Contact: d.calonico@inrim.it

Senior Researcher (Associated Professor equivalent) at INRIM – Head of the Quantum Metrology and Nanotechnology Division

MS in Physics, (Torino, 1999) and PhD in Metrology (Politecnico di Torino, 2003). Since 2008, Researcher at INRIM. 2010-2019 Responsible of the Calibration Service in Time and Frequency. 2010-2019 Italian representative at the Technical Committee Time and Frequency dell'Organizzazione Metrologica Europea Euramet. Since 2017, chairman of the Working Group on Advanced Time and Frequency Transfer within the Convention of the Meter. Since 2012, Principal Investigator in research projects, national and international (PRIN-MIUR: 2012 e 2015 Acquasim; EMRP: Itoc e Neat-FT; FP7: SOC2; H2020: Demetra e Clonets, H2020 ITN M. Curie: FACT; h2020 MSCA-RISE-2015: Q-Sense), Author of more than 45 peer reviewed international papers (ISI H-index 19, May 2019). Supervisor of MS and PhD thesis.
Main research activities: time and frequency metrology, optical clocks based on ultracold neutral atoms, T/F fiber links and quantum technologies.

Recent Publications:

G. Marra, C. Clivati, C; R. Luckett, R; A. Tampellini, J. Kronjaeger, L. Wright, A. Mura, F. Levi; S. Robinson, A. Xuereb, B. Baptie, D. Calonico, "Ultrastable laser interferometry for earthquake detection with terrestrial and submarine cables", Science 361, 486 (2018)

J. Grotti, S. Koller, S. Vogt, S. Häfner, U. Sterr, C. Lisdat, H. Denker, C. Voigt, L. Timmen, A. Rolland, F. N. Baynes, H. S. Margolis, M. Zampaolo, P. Thoumany, M. Pizzocaro, B. Rauf, F. Bregolin, A. Tampellini, P. Barbieri, M. Zucco, G. A. Costanzo, C. Clivati, F. Levi, and D. Calonico "Geodesy and metrology with a transportable optical clock", Nature Physics 14, 437 (2018)

C. Clivati, R. Ambrosini, T. Artz, A. Bertarini, C. Bortolotti, M. Frittelli, F. Levi, A. Mura, G. Maccaferri, M. Nanni, M. Negusini, F. Perini, M. Roma, M. Stagni, M. Zucco, Massimo; D. Calonico, "A VLBI experiment using a remote atomic clock via a coherent fibre link", Scientific Reports 7, 40992 (2017)

E. Calosso, E. K. Bertacco, D. Calonico, C. Clivati, G. A. Costanzo, M. Frittelli, F. Levi, S. Micalizio, A. Mura, and A. Godone "Doppler-stabilized fiber link with 6 dB noise improvement below the classical limit", Opt. Lett. 40, n. 2, pp. 131-134, (2015)

Calonico, E. K. Bertacco, C. E. Calosso, C. Clivati, G. A. Costanzo, M. Frittelli, A. Godone, A. Mura, N. Poli, D. V. Sutyrin, G. M. Tino, M. E. Zucco, F. Levi "High-accuracy coherent optical frequency transfer over a doubled 642-km fiber link", Appl. Phys. B 117, Issue 3, pp 979-986 (2014)

Carena Andrea
Contact: andrea.carena@polito.it

Associated Professors at DET – Electronics and Telecommunication Department.
Member of the Board of Electronics, Telecommunication and Physics Engineer at Politecnico di Torino.

Academic Lectures:
2018/2019
Computer aided design of communication systems (33 students)
Laboratory on internet and communications (156 students)

Recent Publications:

Ziaie, S.; Guiomar, F. P.; Muga, N. J.; Nespola, A.; Bosco, G.; Carena, A.; Pinto, A. N. (2019) Adaptive Stokes-Based Polarization Demultiplexing for Long-Haul Multi-Subcarrier Systems, In: IEEE PHOTONICS TECHNOLOGY LETTERS, pagine 759-762, ISSN: 1041-1135

Guiomar, F. P.; Bertignono, L.; Nespola, A.; Carena, A. (2018) Frequency-Domain Hybrid Modulation Formats for High Bit-Rate Flexibility and Nonlinear Robustness, In: JOURNAL OF LIGHTWAVE TECHNOLOGY, pagine 4856-4870, ISSN: 0733-8724

Martins, C. S.; Bertignono, L.; Nespola, A.; Carena, A.; Guiomar, F. P.; Pinto, A. N. (2018) Low-Complexity Time-Domain DBP Based on Random Step-Size and Partitioned Quantization, In: JOURNAL OF LIGHTWAVE TECHNOLOGY, pagine 2888-2895, ISSN: 0733-8724

Research Projects:

- SMART LINKS Toward smarter optical communications links (2018-2019)
- EUROFOS-EUROPE'S EXPERTISE ON PHOTONIC SUB SYSTEM (2008-2012)
- FLEX-ON - Flexible Optical Networks - Time Domain Hybrid QAM: DSP and Physical Layer Modelling (2015-2017)

Clivati Cecilia (INRiM)

Contacts: c.clivati@inrim.it

MS in Physics in 2010 at turin University, PhD in Metrology in 2014 at Politecnico di Torino, with a thesis on the realization of a fibre optic infrastructure for the dissemination of frequency standards. Researcher at INRIM Since 2015, her research activity is focused on the use of fibre links for applications in photonics, high accuracy spectroscopy, radio astronomy, high resolution geodesy, (VLBI). CC is responsible of the optical frequency combs at INRIM.
In 2014, she was a lecturer for the 2nd Level Master on Navigation of the Politecnico di Torino.
CC is Principal Investigator in the European Project 15SIB05-OFTEN, (European Metrology Programme for Innovation and Research).

Curri Vittorio

Contact:vittorio.curri@polito.it

Associated Professors at DET –Electronics and Telecommunication Department.
Member of the Board of Electronics, Telecommunication and Physics Engineering and of Informatics Engineering at Politecnico of Torino.
Member of the Commission “Strategies for Information Technologies” and of the Board of the Master School at Politecnico

Academic Lectures:

2018/2019

Digital and Connected World (99 students)

Projects and laboratory on photonic networks (11 students)

Recent Publications:

Virgillito, E.; Ferrari, A.; D'Amico, Andrea; Curri, V. (2019) Statistical assessment of open optical networks, In: PHOTONICS, pagine 64-null, ISSN: 2304-6732

Cantono, M.; Ferrari, A.; Pilori, D.; Virgillito, E.; Augé, J. L.; Curri, V. (2019) Physical Layer Performance of Multi-Band Optical Line Systems Using Raman Amplification, In: JOURNAL OF OPTICAL COMMUNICATIONS AND NETWORKING, pagine A103-A110, ISSN: 1943-0620

Cantono, Mattia; Pilori, Dario; Ferrari, Alessio; Catanese, Clara; Thouras, Jordane; Auge, Jean-Luc; Curri, Vittorio (2018) On the Interplay of Nonlinear Interference Generation with Stimulated Raman Scattering for QoT Estimation, In: JOURNAL OF LIGHTWAVE TECHNOLOGY, pagine 3131-3141, ISSN: 0733-8724

Ahmad, Arsalan; Bianco, Andrea; Chouman, Hussein; De Tommaso, Daniele; Marchetto, Guido; Tahir, Sarosh; Curri, Vittorio (2018) Merit of Raman pumping in fixed-grid all-optical network exploiting multi-rate transponders, In: INTERNATIONAL JOURNAL OF COMMUNICATION SYSTEMS, ISSN: 1099-1131

Ferrari, Alessio; Cantono, Mattia; Ahmad, Arsalan; Curri, Vittorio (2018) Physical Layer Strategies to Save Lightpath Regenerators, In: JOURNAL OF OPTICAL COMMUNICATIONS AND NETWORKING, pagine 703-711, ISSN: 1943-0620

Filer, Mark; Cantono, Mattia; Ferrari, Alessio; Grammel, Gert; Galimberti, Gabriele; Curri, Vittorio (2018) Multi-vendor Experimental Validation of an Open Source QoT Estimator for Optical Networks, In: JOURNAL OF LIGHTWAVE TECHNOLOGY, pagine 3073-3082, ISSN: 0733-8724

Research Projects:
- NGON "Next Generation optical networks" (2016-2017)
- Analytics for Photonic Networks via Streaming Telemetry – ALPINIST (2018-2019)
- "Development and maintenance of software for optical communication system simulation" Rif C61489 (2018-2019)
- OOPT-Raman (2018-2019)
- MIE – Mobilità intelligente ecosostenibile (2014-2017)

Degiovanni Pietro (INRiM)
Contacts: i.degiovanni@inrim.it

IPD is senior researcher at INRIM. His research activity is focused on quantum optics, in particular on quantum information, as demonstrated in more than 80 peer reviewed international papers. He studied the metrological characterization of single photon detectors, and the realization of quantum enhanced measurements. IPD is member of the Industry Specification Group on Quantum Key Distribution of the European Telecommunications Standards Institute (ETSI). IPD coordinates the European project Euramet EMPIR 14IND05 “MIQC2: Optical metrology for quantum-enhanced secure telecommunication”, and he was Principal Investigator in the national FIRB project RBFR10UAUV (MIUR FIRB 2010).

Ferrero Valter
Contact: valter.ferrero@polito.it

Associated Professors at DET –Electronics and Telecommunication Department.
Member of the Board of Electronics, Telecommunication and Physics Engineering at Politecnico of Torino.

Academic Lectures:
2018/2019 and 2017/2018
Theory of Signals and Communications (304 students)
Signal processing and transmission laboratory (88 students)
2017/2018
Teaching Materials

Recent Publications:

TORRES FERRERA, Pablo; Ferrero, Valter; Valvo, Maurizio; Gaudino, Roberto (2018) Impact of the Overall Electrical Filter Shaping in Next-Generation 25 and 50 Gb/s PONs, In: JOURNAL OF OPTICAL COMMUNICATIONS AND NETWORKING, pagine 493-505, ISSN: 1943-0620

Straullu, Stefano; Savio, Paolo; Franco, Giuseppe; Gaudino, Roberto; Ferrero, Valter; Bernabé, Stephane; Fournier, Maryse; Muffato, Viviane; Menezo, Sylvie; Charbonnier, Benoit; Temporiti, Enrico; Baldi, Daniele; Minoia, Gabriele; Repossi, Matteo; Carroll, Lee; Lee, Jun; O'Brien, Peter; Marchetti, Riccardo; Duan, Guang Hua; Saliou, Fabienne; Abrate, Silvio (2017) Demonstration of a Partially Integrated Silicon Photonics ONU in a Self-Coherent Reflective FDMA PON, In: JOURNAL OF LIGHTWAVE TECHNOLOGY, pagine 1307-1312, ISSN: 0733-8724

Straullu, S.; Franco, G.; Abrate, Silvio; Forghieri, Fabrizio; Ferrero, Valter; Gaudino, Roberto (2017) Symmetric 10 Gbps PON operating with a single laser over 31 dB of ODN Loss, In: IEEE PHOTONICS TECHNOLOGY LETTERS, pagine 956-959, ISSN: 1041-1135

Abrate, Silvio; Straullu, Stefano; Nespola, Antonino; Savio, Paolo; Chang, Joana; Ferrero, Valter; Charbonnier, Benoit; Gaudino, Roberto (2016) Overview of the FABULOUS EU Project: Final System Performance Assessment With Discrete Components, In: JOURNAL OF LIGHTWAVE TECHNOLOGY, pagine 798-804, ISSN: 0733-8724

Straullu, Stefano; Savio, Paolo; Nespola, Antonino; Ferrero, Valter; Gaudino, Roberto; Abrate, Silvio (2016) Demonstration of upstream WDM+FDMA reflective PON and real time implementation on an FPGA platform, In: JOURNAL OF LIGHTWAVE TECHNOLOGY, pagine 2020-2026, ISSN: 0733-8724

Bertignono, Luca; Ferrero, Valter; Valvo, Maurizio; Gaudino, Roberto (2016) Photon Ranging for Upstream ONU Activation Signaling in TWDM-PON, In: JOURNAL OF LIGHTWAVE TECHNOLOGY, pagine 2064-2071, ISSN: 0733-8724

Research Projects:

- Project - Beyond NGPON2 Technology for 5G optical access (2017-2017)
- Evolution NGPON2 Technology for 5G optical access (2018-2018)
- National PRIN “Realization of an optical network with wavelength multiplexing and packet commuting” (2003-2005)
- National PRIN “Demonstrator of multilevel optical transmission at 20 Gbit/s, based on coherent detection” (2006-2008)

Gaudino Roberto

Contact: roberto.gaudino@polito.it

Full Professor at DET –Electronics and Telecommunication Department
Member of the Board of Electronics, Telecommunication and Physics Engineering and of Informatics Engineering at Politecnico of Torino.

Academic lectures:

Teaching assignments and number of students:
2018/2019 and 2017/2018

Digital transmission and communication networks (71 students)
Optical communications and Wireless communications (37 students)
Photonext: Hands on course on Photonics for Fiber Transmission (14 students)
Digital transmission and communication networks

Recent Publications:

Nespola, A.; Franco, G.; Forghieri, F.; Traverso, M.; Anderson, S.; Webster, M.; Gaudino, R. (2019) Proof of Concept of Polarization-Multiplexed PAM Using a Compact Si-Ph Device, In: IEEE PHOTONICS TECHNOLOGY LETTERS, pagine 62-65, ISSN: 1041-1135

TORRES FERRERA, Pablo; Ferrero, Valter; Valvo, Maurizio; Gaudino, Roberto (2018) Impact of the Overall Electrical Filter Shaping in Next-Generation 25 and 50 Gb/s PONs, In: JOURNAL OF OPTICAL COMMUNICATIONS AND NETWORKING, pagine 493-505, ISSN: 1943-0620

Pilori, Dario; Bertignono, Luca; Nespola, Antonino; Forghieri, Fabrizio; Mazzini, Marco; Gaudino, Roberto (2018) Bidirectional 4-PAM to Double per-Fiber Capacity in 2-km Intra-Datacenter Links, In: IEEE PHOTONICS JOURNAL, pagine 1-11, ISSN: 1943-0655

Mengesha, Befekadu D.; Torres-Ferrera, Pablo; Gaudino, Roberto (2018) Analysis of 5G new radio uplink signals on an analogue-RoF system based on DSP-assisted channel aggregation, In: APPLIED SCIENCES, pagine 47-60, ISSN: 2076-3417

Mengesha, BEFEKADU DEBEBE; Stefano, Straullu; TORRES FERRERA, Pablo; Gaudino, Roberto (2018) Comparison of DSP-based TDMA and FDMA channel aggregation techniques in mobile fronthauling, In: OPTICAL FIBER TECHNOLOGY, pagine 15-23, ISSN: 1068-5200

Research Projects:

- National PRIN "Realization of high performance, next generation router/switch" (2006-2008)
- ALPHA-ARCHITECTURES FOR FLEXIBLE PHOTONIC HOME AND ACCESS NETWORKS (2008-2011)
- FABULOUS-FDMA ACCESS BY USING LOW-COST OPTICAL NETWORK UNIT IN SILICON PHOTONICS (2012-2015)

Perrone Guido

Contact: guido.perrone@polito.it

Associated Professors at DET –Electronics and Telecommunication Department.
Member of the Board of Electronics, Telecommunication and Physics Engineering at Politecnico of Torino.

Academic Lectures:

2018/2019

Devices for optical and microwave communications (41 Students)
Applied Electromagnetism (152 students)
Photonics: a key enabling technology for engineering applications (14 students)

Recent Pubblications:

Saccomandi, Paola; Quero, Giuseppe; Gassino, Riccardo; Lapergola, Alfonso; Guerriero, Ludovica; Diana, Michele; Vallan, Alberto; Perrone, Guido; Schena, Emiliano; Costamagna, Guido; Marescaux, Jaques; Di Matteo, Francesco M. (2018) Laser ablation of the biliary tree: in vivo proof of concept as potential treatment of unresectable cholangiocarcinoma, In: INTERNATIONAL JOURNAL OF HYPERTHERMIA, ISSN: 0265-6736

Gassino, Riccardo; Pogliano, Jennifer; Perrone, Guido; Vallan, Alberto (2018) Issues and characterization of fiber Bragg grating based temperature sensors in the presence of thermal gradients, In: MEASUREMENT, pagine 15-19, ISSN: 0263-2241

Schena, Emiliano; Davrieux, Federico; Saccomandi, Paola; Tosi, Daniele; Gassino, Riccardo; Massaroni, Carlo; Lo Presti, Daniela; Costamagna, Guido; Perrone, Guido; Vallan, Alberto;

Diana, Michele; Marescaux, Jacques (2018) Solutions to improve the outcomes of thermal treatments in oncology: multi-point temperature monitoring, In: IEEE JOURNAL OF ELECTROMAGNETICS, RF AND MICROWAVES IN MEDICINE AND BIOLOGY., pagine 1-8, ISSN: 2469-7249

Korganbayev, Sanzhar; Orazayev, Yerzhan; Sovetov, Sultan; Bazyl, Ali; Schena, Emiliano; Massaroni, Carlo; Gassino, Riccardo; Vallan, Alberto; Perrone, Guido; Saccomandi, Paola; Arturo Caponero, Michele; Palumbo, Giovanna; Campopiano, Stefania; Iadicicco, Agostino; Tosi, Daniele (2018) Detection of thermal gradients through fiber-optic Chirped Fiber Bragg Grating (CFBG): Medical thermal ablation scenario, In: OPTICAL FIBER TECHNOLOGY, pagine 48-55, ISSN: 1068-5200

Saccomandi, Paola; Varalda, Ambra; Gassino, Riccardo; Tosi, Daniele; Massaroni, Carlo; Caponero, Michele A; Pop, Raoul; Korganbayev, Sanzhar; Perrone, Guido; Diana, Michele; Vallan, Alberto; Costamagna, Guido; Marescaux, Jacques; Schena, Emiliano (2017) Linearly chirped fiber Bragg grating response to thermal gradient: from bench tests to the real-time assessment during in vivo laser ablations of biological tissue, In: JOURNAL OF BIOMEDICAL OPTICS, pagine 1-9, ISSN: 1083-3668

Popescu, V. A; Puscas, N. N.; Perrone, Guido (2017) Simulation of the Sensing Performance of a Plasmonic Biosensor Based on Birefringent Solid-Core Microstructured Optical Fiber, In: PLASMONICS, pagine 905-911, ISSN: 1557-1955

Olivero, Massimo; Vallan, Alberto; Orta, Renato; Perrone, Guido (2017) Single-Mode-Multimode-Single-Mode Optical Fiber Sensing Structure With Quasi-Two-Mode Fibers, In: IEEE TRANSACTIONS ON INSTRUMENTATION AND MEASUREMENT, pagine 1-7, ISSN: 0018-9456

Gassino, Riccardo; Liu, Yu; Konstantaki, Maria; Vallan, Alberto; Pissadakis, Stavros; Perrone, Guido (2017) A Fiber Optic Probe for Tumor Laser Ablation with Integrated Temperature Measurement Capability, In: JOURNAL OF LIGHTWAVE TECHNOLOGY, pagine 3447-3454, ISSN: 0733-8724

5 CONCLUSION

The Pilot Master's Programme has been prepared and organized, but was not completed during the duration of the project. Among the 13 accepted candidates, only 7 enrolled with 2 not receiving the necessary visa from Italian Government. At this point, the Master's Programme was withdrawn. Despite the retraction, the organisation of the CLONETS Pilot Master's Programme has produced and established a Master's Programme, whose format remains relevant for a future implementation. Both Politecnico and INRIM are interested in offering the Master's Programme again in the future. Additionally, the work done towards the Master's Programme as part of the CLONETS project has achieved the following goals in terms of impact and dissemination of the vision of a fibre network for time and frequency services:

- The CLONETS Consortium has collaborated with a new stakeholder, the Politecnico of Turin, and in particular with the Department of Electronics and Telecommunications. This is rather important in view of enlarging the interest in Time and Frequency Metrology over fibre to a wider community, one of CLONETS goals.
- The Master has attracted the interest of Open Fibre (www.openfiber.it), one of the main telecommunication companies in Italy, aiming at cabling at large the country by optical fibres, reducing the Digital divide (within the DG Connect initiatives known as Digital Agenda and relative funding). The interest of Open Fibre is documented by a formal Agreement with Politecnico. While Open Fibre was interested in training their employees through the Master's Programme, they unfortunately were not able to send students to the Master this year. The engagement of a relevant private company is the

direct result of CLONETS activities and demonstrates the extensive impact of the project.

- The Master's Programme has also received the endorsement of Compagnia di San Paolo, the main bank foundation in Italy, which judged this training opportunity as outstanding and consequently offered 8 student grants (see Section 2.4.1). This acknowledgement by the foundation is significant and confirms the value of the programme.

Annex 1. Didattica Privacy statement

https://didattica.polito.it/privacy/index_en.html

PRIVACY STATEMENT

You should receive the following information on the processing of your personal data in accordance with the General Data Protection Regulation (EU Regulation 2016/679).

CONTACTS

The Data Controller is Politecnico di Torino, represented by the Rector, with statutory seat in Corso Duca degli Abruzzi, 24-10129 Torino. You can contact the Data Controller at: politecnicoditorino@pec.polito.it (certified e-mail). For further information and inquiries write to: privacy@polito.it . You can contact the Data Protection Officer (DPO) of Politecnico di Torino for inquiries on the processing of your personal data and your rights at: dpo@polito.it ; dpo@pec.polito.it (certified email).

PURPOSES OF PERSONAL DATA PROCESSING AND LEGAL BASIS

Your personal data shall be processed by Politecnico di Torino (Data Controller) in accordance with:

- the principles of lawfulness, fairness, transparency and data minimization referred to in article 5, paragraph 1 of the GDPR.
- article 6, paragraph 1, letter e) of the GDPR ("processing is necessary for the performance of a task carried out in the public interest or in the exercise of official authority vested in the Controller").
- article 9, paragraph 2, letter g) of the GDPR ("processing is necessary for reasons of substantial public interest, on the basis of Union or Member State law"): the processing of special categories of personal data is carried out for institutional purposes only.

Politecnico di Torino collects your personal data (including your family members' data) when you enrol in a degree programme and during the course of your studies. Here is an example of the personal data, which may be collected and processed by Politecnico in electronic and paper format:

- biographical data
- information related to your school education provided upon enrolment at Politecnico
- information related to your studies and academic progress at Politecnico di Torino (Personal Study Plan, exams, degree, etc.)
- tuition fee payments, late payment penalties, sanctions
- declarations on the financial condition of your family submitted to get tuition fee reduction
- scholarships received from Politecnico di Torino, EDISU (Ente Regionale per il Diritto allo Studio Universitario) or other institutions
- part-time on-campus jobs at Politecnico di Torino
- sanctions imposed on you by Politecnico di Torino, if any
- disability certificates, if submitted

Your data are processed by the Data Controller and by the university bodies authorised by the Data Controller to process your personal data within the scope of their functions and responsibilities. Your data can be disclosed outside the University in the following cases:

- at the request of public authorities when they need your data for institutional purposes (for instance, information is periodically exchanged with the: Ministry of Education, University and Research, National Student Register Office, Ministry of Economy and Finance, Ministry of Foreign Affairs, EDISU – the Regional Agency for the Right to University Education, ISTAT - Italian National Statistical Institute , CNVSU – National

Agency for the Evaluation of the University and Research Systems and Osservatorio Regionale per l'Università e per il diritto allo studio Universitario).

- at the request of judicial authorities.
- when you register for your Final Examination you are asked to give your consent to the transfer of some of your personal data to businesses or institutions which declare to use them for employment purposes or to advertise training and cultural activities.
- when you apply for a Specializing Master's Programme organized in cooperation with external partners (businesses/organizations), you may be asked to give your consent to the transfer of your personal data to these partners who may offer you training opportunities or help you enter the world of work. Any other form of data processing or disclosure is not permitted.
- when you take part in an international mobility project, you may be asked to give your consent to the transfer of your personal data to universities and academic institutions (based also outside the European Union), funding organizations and diplomatic missions.

Personal data are stored in the university servers (located inside Politecnico) and/or in external servers which belong to providers of technical and administrative services. These service providers may have access to your personal data exclusively for the service they render. In this case Politecnico engages them as Processors in accordance with article 28 of the GDPR. Personal data collected for specific institutional purposes (i.e., internships, job placements at companies or institutions located outside the European Union) may be transferred to non-EU countries (third countries). The Data Controller ensures that a transfer of personal data to a third country may take place where the EU Commission has decided that the third country in question ensures an adequate level of protection (art. 45 - GDPR) or has provided appropriate safeguards (art. 46 - GDPR) or the transfer is necessary for important reasons of public interest (art. 49 – GDPR).

PERIOD FOR WHICH PERSONAL DATA ARE STORED

The personal data related to your academic progress at Politecnico di Torino are kept for an unlimited period of time in accordance with the achieving obligations imposed by the law. Other personal data are kept for no longer than is necessary for the purposes for which the personal data are processed (art. 5 - GDPR).

NECESSITY OF PROVIDING PERSONAL DATA

You are required to provide your personal data to Politecnico di Torino. If you refuse to provide your personal data, Politecnico cannot process your requests.

RIGHTS OF THE DATA SUBJECT

You are the Data Subject and you have the right to obtain from the Data Controller (in accordance with articles 15,16,17,18, 18 and 21 of the GDPR):

- access to your personal data and to the information referred to in art. 15 of the GDPR;
- rectification of inaccurate personal data (including the right to have incomplete personal data completed);
- erasure of your personal data (except for data which must be kept by Politecnico di Torino) unless there are overriding legitimate grounds for the processing;
- restriction of processing pursuant to art. 18 of the GDPR.

You also have the right to:

- object to the processing of your personal data, except when the processing is required for your use of university services;
- withdraw your consent given for non-compulsory processing of personal data, without affecting the lawfulness of processing based on consent before its withdrawal;

- data portability.

Please contact the Data Controller if you want to exercise your rights.

COMPLAINT

You have the right to contact the Italian Data Protection Authority (Garante per la protezione dei dati personali) or other public supervisory authorities to lodge a complaint about the processing of your personal data.

The English translation of this document is provided as a support to the student community and has no legal effects. The Italian version shall constitute the sole authentic text and will be referred to for any legal matters.

This privacy statement has been updated on 31.07.2018.

Annex 2. Admitted Students – curricula vitae

The information may be provided in accordance with the terms of the "Didattica Privacy statement" included in Annex 1.