



REAL-time monitoring and mitigation of nonlinear effects in optical NETWORKS (REAL-NET)

D5.3 Progress Report 1 submitted to EC

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ACRONYMS

AST: Aston University

CDP: Career Development Plan

CV: *Curriculum Vitae*

EC: European Commission

ESR(s): Early Stage Researcher(s)

GDPR: General Data Protection Regulation

IAB: Industrial Advisory Board

IIPAB: Industrial and IP Advisory Board

INF G: Infinera Germany

INF P: Infinera Portugal

IP: Intellectual Property

IPAB: IP Advisory Board

IPR: Intellectual Property Right

ITN: Innovative Training Network

MSCA: Marie Skłodowska-Curie Action

OTAW: Open To All Workshop

PO: Project Officer

REAL-NET: REAL-time monitoring and mitigation of nonlinear effects in optical NETWORKS

SB: Supervisory Board

TPT: Telecom Paris Tech, TPT is a school within the Institut Mines-Telecom (IMT)

TSW: Transferable Skills Workshop

UPC: Universitat Politècnica de Catalunya

LIST OF FIGURES

Figure 1 Country distribution of REAL-NET applicants.

Figure 2 Percentage of Women and Men who applied for the REAL-NET positions.

1 EXECUTIVE SUMMARY

The present document is a deliverable of the REAL-NET project, funded under the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 813144.

The main objective of REAL-NET is the development of radically different methods for coding, transmission, and (pre & post) processing of information together with the design of practical and implementable disruptive techniques for fibre-optic communications. The goal is a Realistic implementation of DSP algorithm to compensate nonlinear effects in fiber with and without machine-learning-based algorithms. Optical performance monitoring in highly dynamic optical networks.

Following the completion of the first period of activities (January 2018 (M1) to January 2019 (M13)), this deliverables aims to provide an overview of the progress achieved by the consortium so far.

2 GENERAL PROGRESS OF THE ACTION

The REAL-NET training network has started well and overall progressed according to plan in its first year. During the first reporting period the main objective of the Action was the recruitment of 6 Early Stage Researchers (ESRs). To date all ESRs have been recruited. Thus, the pre-finance has been distributed to partners according to the provision agreed upon in the Consortium Agreement.

The kick-off meeting was undertaken in Month 1 (29th January 2019, Munich), which was followed by a management meeting undertaken in Month 9 (24th September 2019, Dublin).

Consortium Agreement has been agreed and signed by all partners on 1st April 2019.

Management tools are implemented, such as REAL-NET website, which is used as major tool of external communication and dissemination of the project.

Despite the delay in the recruitment, most of the ESRs have participated to the REAL-NET induction training event, held in Munich on 18-19th November and other Main Network-Wide Training Events have already been scheduled (more details in section 2.1).

The mid-term check is scheduled for the 13th February 2020 at UKRO, Brussels.

The Supervisory Board (SB) was set-up, composed of representatives from each beneficiary and partner organisations, and had its first assembly during the kick-off meeting and during the management meeting in Dublin. SB was previously described and reported in deliverable D5.13.

An elected (by ESRs) representative from the ESR is going to be present at the SB meetings to allow transparency as well as to raise any issues highlighted by ESRs.

No difficulties or issues concerning the implementation of the Work plan due to specific rules related to the beneficiary's administration/country legislation have been encountered.

2.1 Work progress and achievements during the period (January 2018 to January 2019)

During the first reporting period the main objective of the project, as included in Annex I Grant Agreement, was the recruitment of the 6 ESRs and their initial training. To date, the recruitment has been completed, however due to unforeseen delays in the recruitment of some ESRs, the organization of some training events and the submission of some deliverables have been postponed.

2.1.1 Main network-wide training events

REAL-NET Induction

The ESRs have undergone an introductory meeting with other ESRs and partners during the REAL-NET Induction training on 18-19th November at premises of our industrial partner Infinera in Munich.

This is the first training event out of 14 planned and foreseen network-wide training events in the REAL-NET action. The main goal was to let ESRs to get to know each other, to discuss research topics within the project, exchange ideas on how to achieve the best results and seek for possible simple collaborations. The two days training event was also composed of scientific/training content with the aim of getting ESRs up to speed with technology and specific research tasks within each work package in REAL-NET.

REAL-NET ESRs presented talks about themselves and their scientific background. They all made short statements about their research projects and the main targets they have for the upcoming year.

REAL-NET Coordinators and WP leaders facilitated free discussion and helped ESRs to define and see a clear synergy between individual research projects, Work Packages and scientific deliverable.

The REAL-NET Project Manager Martina Pasini made an overview of the project with emphasis on the compliance with the Grant Agreement, stressing the key elements such as project timeline, schedule of the network-wide training events and reminding the Consortium of its obligation regarding dissemination and outreach activities.

ESRs from the sister project WON joined some of the sessions of the Workshop.

Online material was developed and shared with the ESRs who couldn't manage to be present due to late recruitment and visa issues. The material covers a both general and scientific introduction of the WP leaders present at the training event, and all the slides of the project manager presentation.

1st year REAL-NET workshop

The 1st year REAL-NET workshop has already been scheduled and will be held at Aston University on the 26th of February 2020. The workshop will be attended by the WP leaders of the WP2 and WP3 and by all ESRs. ESRs will be giving technical presentations.

Transferable Skills Workshop (TSW I)

In addition, Transferable Skills Workshop (TSW I) has been scheduled and will be held at Aston University on the 27-28th of February 2020. The workshop will focus on key communication skills, academic writing, open access/research integrity and social/media engagement, all areas that are considered key competencies by the European Commission. An external training provider specialising in working with early stage engineering students will be present.

Furthermore, several scientific training events have been organised for the benefit of the ESRs

2.1.2 REAL-NET scientific work packages (WP1-4)

WP1 (Telecom Paris Tech/TPT). Realistically-implementable nonlinearity mitigation techniques.

In WP1 we will consider nonlinear mitigation of fiber nonlinear impairments with and without the implementation of ML/NN algorithms. This will be carried out by using with coherent dual-polarization systems for example with 16/32/64/128 quadrature amplitude multiplexing (QAM).

The algorithms will be initially tested via numerical simulation (e.g., split-step Fourier method, SSMF), and later validated with data coming from experimental transmission test-beds.

With respect to the ESRs.

ESR 3 and ESR 4 both have started late due to delay in the recruitment process. ESR3 has started in the end of November while ESR 4 has started mid of January.

ESR 3 has been working on nonlinear Schrödinger equation for optical propagation to get familiar with the main fiber propagation impairments that will be part of the PhD work. In particular, ESR 3 was capable of re-obtaining some results already published in literature. Next, he moved to the next task,

where he is aiming at reproducing other results. After this training phase, he will start with the main tasks of his PhD on nonlinear mitigation of nonlinear fiber propagation impairments.

ESR 4 is starting with the initial training.

WP2 (Aston University/AST). Low-complexity machine learning based DSP techniques.

ESR 2 has arrived at Aston in the end of November. At the beginning, most of his time was dedicated to the detailed acquaintance with the position requirements. Later on, ESR2 started to develop his own code for the simulations of light propagation in single-mode fibre: currently, the code has been produced in Python. After the Christmas break, ESR2 started to study the details of the sparse identification method for optical systems and emerging discrete statistical modes: this work will serve as a basis for the Deliverable D2.1.

To date, due to the delay in the recruitment process, ESR2 doesn't obtain any publishable outcomes. However, he has managed to compose the split-step Fourier method for the light propagation simulations using Python. He has done an extensive literature research on digital signal processing algorithms based on machine learning. This resulted in a first proposal of two possible strategies to be followed, both aiming at reducing the complexity of recently published works. The first step now is to proof the working principle on simulation data, and in a second moment we will validate the techniques with experimental data.

ESR 1 hasn't started yet, as he is expected to be at Aston by February the 20th.

The delay in the recruitment of the ESRs is resulting in a delay in the deliverables submission and in possible delays publishing/dissemination research outcomes associated with WP2.

WP3 (Infinera). Optical real-time performance monitoring.

We have been collaborating with UPC on the usage of the Gaussian Noise (GN) model to generate dataset, and from them to estimate key-parameters in the network. This originated a paper to be presented at OFC.

We plan to start analysis on the accuracy required in terms of monitored parameters for the minimizing the OSNR error when using the generalized GN.

WP4 (Universitat Politecnica de Catalunya/UPC). Network application based on the historical monitored data.

In this period, we have focused on:

- ESR6: Implementing models for optical filters. A study is ongoing for the impact of filters on high-order modulation formats for metro applications. We are preparing a paper to be submitted to a mayor conference.
- ESR5: Implementing a framework for distributed learning. Models for OAs, TRX and filters have been implemented in Python to be able to simulate optical nodes. A node controller will be able to program the underlying node simulator, collect measurements and run ML algorithms. An interface with other node controller will enable distribute knowledge. The nodes are controlled by ONOS SDN controller. We are preparing a paper to be submitted to a major conference.

2.2 Deliverables and Milestones

During the initial 12 months, out of 10 deliverables, 3 have been submitted, and out of 12 milestones 5 have been achieved.

As stated before, the delay in the recruitment process caused some delays in the completion of the deliverables and milestone submission. The project officer (PO) has been informed about these delays through the portal and by e-mail. However, these postpone

Secondments will not have a negative impact on the correct implementation of the project.

2.3 Minor changes to training and network meeting schedule

Some changes to the meeting schedule were agreed during the management meeting in Dublin due to the delay in the recruitment process. The changes are related to the timing and location for the events and do not diminish its content.

The 1st year REAL-NET workshop and TSW I, as stated before, have been scheduled on the 26th and 27-28th of February 2020, respectively.

The **REAL-NET Open-to-All Workshop (OTAW II)** on SINO method and applications is planned for May 2020 at Barcelona, together with the first **REAL-NET Mini-symposia** on hardware implementation of DSP algorithms in optical communication. All ESRs have been encouraged to attend.

We are in the early stage of planning the **REAL-NET Open-to-All Workshop (OTAW II)** on machine learning applied to optical communication for the second week of September together with the 2020 **Lake Como** Summer School on Machine Learning Photonics. We plan to co-locate the **REAL-NET Mini-symposia** on the introduction to the machine learning techniques with the OTAWII. All ESRs have been encouraged to attend.

2.4 Deviation from the Grant Agreement.

2.4.1 Changes to secondment schedule

REAL-NET is fully committed to all ESRs spending at least 50% of their time in industry.

During the kick of meeting the REAL-NET Executive discussed that the secondment schedule as per GA was not in the best interest of the ESR-3, ESR-4 and ESR-6. Thus, the executives decided to modify the secondments by remove the 3 months academic secondments for these ESRs.

Following the instructions of the PO two letters from TPT and UPC partners were addressed to the coordinator as responsible of the action, explaining the motivation of the 3-months secondment cancellation. Thus, a third letter from the coordinator was addressed to the PO, explaining these changes and that these changes will not have a negative impact on the correct implementation of the project.

Regarding the ESR-3 and ESR-4 the secondments were originally incorporated to assist in training in the technique called “perturbation theory”. However, as explained in TPT letter, *“the research subject has advanced since the proposal was submitted”* and due to this the consortium agreed *“to update the techniques that are used”* and *“to promote the machine learning approach”* in order to achieve the project objectives. Therefore, the secondments training in perturbation theory is no longer needed, and the host institution of these ESRs is best equipped to provide the adequate preparation in machine learning.

Besides, due to a scientific progress since the submission of the proposal the 3 months secondments at TPT for the ESR-6 is redundant. As detailed in UPC letter *“as a result of an update of the research techniques, SSFM and Volterra series techniques will be substituted and the needed training will be received during ESR’s stay in UPC”*. Therefore, the secondments at TPT becomes deemed irrelevant and the ESR will receive the necessary training during his stay in UPC.

These changes do not adversely affect the overall project implementation and the industrial scheduled number of secondments months remain the same. All other planned secondments will be executed within the duration of the project.

2.4.2 Gender balance

The gender balance has not been achieved in the final cohort of ESR, see section 3.1.3 for details.

3 RECRUITMENT STRATEGY

3.1 Recruitment procedure and guidance to beneficiaries

In terms of recruitment strategy the advertisement of the 6 PhDs positions of REAL-NET project has been made available from the start of the project on websites such as Euraxess, REAL-NET website, and specialised websites. Each beneficiary has driven interviews of selected candidates and recruitment according to the European Commission guidelines for ITN under H2020 MSCA, the procedure described in the proposal and generally the best international hiring. The industrial partner(s) has been involved in the entire process as detailed in section 3.1.2.

During the kick-off meeting, held on the 29th January 2019, partners received a detailed presentation covering recruitment and related obligations in H2020 EIDs, in particular: i) Eligibility and mobility rules; ii) EU-sanctioned countries; iii) mandatory in EID (European Industrial doctorate) 50% stay in industry and iv) joint recruitment between the academic and the industrial partners.

During the kick-off meeting and during the course of the recruitment process the Project Manager was available to discuss and answer queries, check eligibility/mobility compliance of individual candidate and recommend further examination in case of uncertainty. Candidates provide all requested information including a detailed CV and motivation letter. During the selection process in order to prove their eligibility (ESR definition and mobility criteria), candidates were required to provide additional corroborating evidence which could take the form of copies of full transcripts listing years and location of courses studied, all passport pages covering the last 4 years, previous employment contract etc. The Consortium is also been made aware of unconscious bias during the kick-off meeting.

3.1.1 Advertisement for open positions

The 6 ESR positions available were advertised and published internationally and widely as possible.

All ESR positions were advertised in EURAXESS. Additionally each Partner used institutionally available means of advertising the position, using for example findaphd.com, job.ac.uk as well as campaigns at international conferences and workshops.

All together were advertised at:

- Euraxess
- findaphd.com
- jobs.ac.uk
- Aston Website (6 months)
- Webpages of individual partners
- REAL-NET flyers with ESR positions advertised has been distributed to selected universities and leading international conferences (e.g Università Milano Bicocca (Milano, Italy) and Optical Fiber Communication conference (OFC 2019, 3-7 March, San Diego, USA))
- Network of contacts of individual consortium members
- A REAL-NET poster with the ESR positions available at Aston University, has been presented at CLEO/EUROPE 2019, 23-27 June, Munich, Germany

3.1.2 Joint recruitment with the industrial partners

The entire recruitment procedure was a joint-recruitment between the host institution and the industrial partner(s) and it was open, transparent, merit-based, impartial and equitable with no conflict of interest.

The industry was closely involved with the recruitment during the entire process.

The final decision on who to recruit and when to start was taken jointly between the host institution and the industrial partner.

3.1.3 Applications

62 applications were received by beneficiaries, among them 15 candidates were interviewed. As shown in Figure 1, the researchers have been recruited with a good nationality spread, with the majority of the applicant coming from non EU-countries. Some of the candidates apply for the ESR

position at different institution. Among the selected candidates, 5 are from Non-EU countries and only 1 is from EU country, and are all male.

Beneficiaries received 54 male applications and 8 female applications. In a field (i.e. Physic) that is highly dominated by men, it was no surprise that the percentage of women applying was as low as 13% of all applicants (Figure 2). The consortium made offers to two female candidates who, unfortunately, declined resulting in not achieving the gender balance.

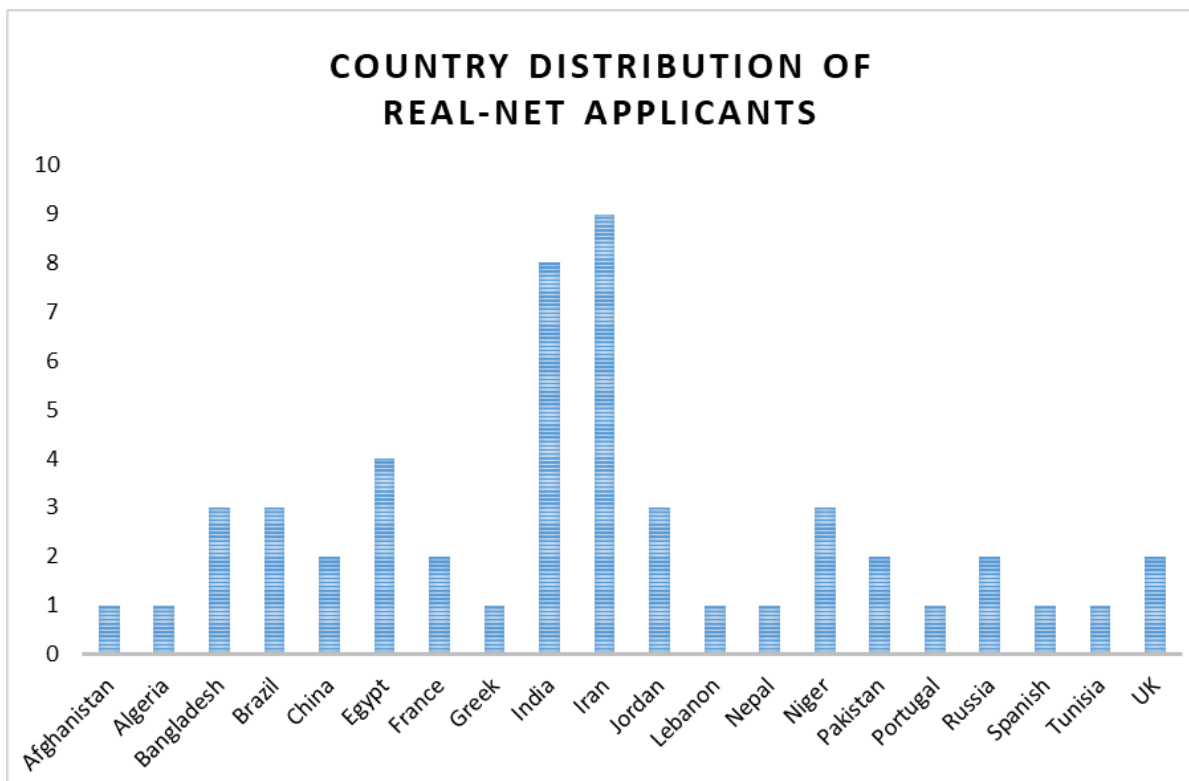


Figure 1 Country distribution of REAL-NET applicants.

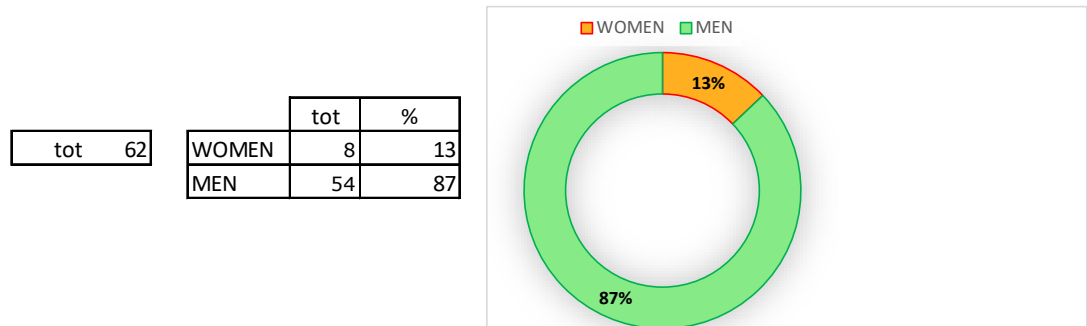


Figure 2 Percentage of Women and Men who applied for the REAL-NET positions.

3.2 Delays in recruitment

As a result of undertaking visa applications for the majority of the ESRs, the consortium experienced delays, sometimes significant, between appointing the selected candidate and their actual recruitment/start date.

To date, all ESRs have been recruited. Unfortunately, due to visa delays not all the ESRs are at the host institution and have started yet. We are expected to receive all the required visas and work permits by the end of January 2020.

This delay in recruitment has no effect on the overall aims of the project, as all ESRs have been recruited within the first year, as planned. The operation of secondments will likely not be delayed as the majority of secondments will not start for another year, which leaves enough time for the ESRs to settle in their host institution, and for the secondments to be planned and put in place appropriately.

3.3 Summary of the recruitment process

ESRs have been selected following institutional selection and interviewing criteria and accordingly to the EC guidelines. All ESRs were selected on high standards and from different backgrounds. The researcher's declaration will be completed once the ESRs will arrive and start at the host institution.

The entire recruitment process was done between April and September for the majority of the ESRs. Only ESR4 was recruited in November.

To date, five out of six ESRs have started their project and are already making good progress. Those ESRs who have already started, have submitted their Personal Career Development Plan (CDP) (available to the EC/REA upon request). The CDP of the students that haven't started working on their project yet will be completed once the ESRs will arrive at the host institution.

After the recruitment process was completed each beneficiary was requested to complete the "Post selection justification template", a REAL-NET internal reporting form, in which we asked partners to list where and how the positions were advertised, number and basic information regarding the applicants and information regarding the shortlisting and selection process. Each beneficiary also declared to the REAL-NET executive that the recruitment procedure was a joint-recruitment between the host institution and industrial partner(s) during the entire process. Besides, through the "Post selection justification template", each beneficiaries confirmed that the recruitment procedure was open, transparent, merit-based, impartial and equitable, and that no conflict of interest existed in or arose from the recruitment procedure. REAL-NET adhere to the principles of Code of Conduct for the Recruitment of Researchers.

4 CAREER DEVELOPMENT PLAN

To date a career development plan (CDP) has been prepared for each recruited researcher. Beneficiaries were provided with a possible template (from CORDIS), but were also free to use their own format.

A list of the short and long-term goals and a planned sequence of experiments have been decided accordingly between the ESR student, the main supervisors from the host beneficiary and the industrial supervisor. The CDP details the plan for the whole project duration, including different types of training activities and secondments.

The supervision by non-academic partner will be in place during the industrial secondments and by continuously advising the ESR and supporting the academic supervisors on the most up-to-date development strategy.

The CDPs will be periodically reviewed and updated.

The CDPs are treated confidentially but are available to the EC/REA upon request.

5 ENROLLMENT OF THE RESEARCH FELLOWS IN A PhD PROGRAMME

Four out of six REAL-NET ESRs have been enrolled into a PhD programme, to date.

ESR	Name	Host Institution	PhD enrolment
ESR1	Mohammad Mohammad Hosseini	AST	He will be enrolled once he will arrive at the host institution
ESR2	Pedro Jorge Freire De Carvalho Souza	AST	Completed
ESR3	Mohannad Abu-Romoh	TPT	Completed
ESR4	Jamal Darweesh	TPT	He is finalizing the registration for a PhD
ESR5	Vishwanath Vijayakumar Pai	UPC	He is finalising the registration for a PhD
ESR6	Diogo Sequeira	UPC	Completed

6 MANAGEMENT OF THE ACTION

6.1 Day-to-day management

Management process is constantly trying to improve its general and individual actions towards the project and the ESRs. Day-to-day management is carried out mainly by e-mail and when necessary by telephone and Skype calls. Documents are shared via e-mails or a repository. The organization of meeting is planned usually by a Doodle Poll in order to scheduling meetings in a simple and quick way.

All data are stored in compliance with GDPR and European Union data protection laws.

Project data is only shared within REAL-NET. Digital datasets will be stored on the responsible partner's local storage systems such as desktop computers, laptops, shared drives. Paperwork containing identifiable personal data will be shredded immediately once it is no longer needed.

6.1.1 Management and Network Meetings

The following Management Meeting took place during the reporting period (January 2019 – January 2020):

- **Kick off meeting** held in Munich the 29th January 2019, was the first REAL-NET meeting and an opportunity for all consortium members to meet and present their role in the project. A large part of the meeting was focused on planning the recruitment of ESRs, fine-tuning the 2019-20 training plan and compliance with the EC MSCA rules.
- The planned **full management meeting** took place in Dublin the 24th September 2019. This second meeting offered the opportunity for the consortium to be updated on the recruitment process and discuss future REAL-NET planning of events and secondments.
- Brief **management meeting** took place in Munich 18-19 November 2019, between Aston, Infinera and UPC, who were present during the REAL-NET Induction training event.

6.1.2 Minor changes in the management structure

Due the considerable overlap in function and members of the Industrial Advisory Board (IAB) and the IP Advisory Board (IPAB), the Consortium decided by unanimous vote during the kick-off meeting, to merge them together resulting in the enlarged **Industrial and IP Advisory Board (IIPAB)**. The IIPAB will be one of the key mechanisms for the exploitation of the REAL-NET results in the

commercial/industrial sector, providing overall advice and support in selecting the most promising ideas for commercialisation, patenting and IPR protection. The IIPAB will meet twice per year.

6.1.3 Change in the name from Coriant to Infinera

Coriant has been acquired by Infinera, provider of Intelligent Transport Networks. The acquisition positions Infinera as one of the largest vertically integrated optical network equipment providers in the world.

INF G and INF P stand for Infinera Germany and Portugal branches, respectively. Before the Infinera acquisition the two subdivisions were known as CORIANT R&D GMBH and CORIANT PORTUGAL UNIPessoal LDA (CORIANT G and CORIANT P, shortly). It is worth to point out that until this moment, the only existing legal entities, for both companies, are the ones present in the initial proposal, CORIANT R&D GMBH and CORIANT PORTUGAL UNIPessoal LDA. As soon as there will be a change in the in the legal entity name, this will be immediately communicated.

6.2 REAL-NET website

REAL-NET website was launched on 30th April 2019, and updated regularly since then. It has been previously described and reported in deliverable D6.1.

It has five main pages: The Home page, Partners, People, Media Center and Contact us. Details of the project with a brief description, a presentation of the partners and the people involved in REAL-NET and the latest news, outreach events and training events, can be found on these pages.

REAL-NET website is used as major tool of external communication for its public part providing events coverage, latest news and communications. The website will be sustained beyond the official close of the project to maintain a record of project outcomes.

7 COMMUNICATION ACTIVITIES

So far, no public engagement and outreach activities has been organised within REAL-NET project. However, all ESRs have been instructed to consider and plan their first outreach activities by the next network meeting.

8 IMPACT OF THE ACTION

8.1 Impact of the Action on the Institution(s) involved

The recruited ESRs are expected to have a positive impact both locally and internationally. At the institutional level the ESRs have engaged positively with local researchers to enhance the capability of each local laboratory, research group and institution.

Additionally, each ESR brings an added value not only in terms of science but also thanks to his/her heterogeneity in terms of background training and country of origin.

8.2 Impact of the Action on the ESRs

Even though ESRs have started only few months ago, the Action has i) already given them the possibility to interact with other members of the consortium and with researchers from other projects; ii) provided them new international networking opportunities; iii) enhanced their technical skills and iv) deepen their scientific knowledge.