D1.10 FINAL PUBLIC REPORT

Project title	**Photonics technologies for ProgrAmmable transmission and switching modular systems based on Scalable Spectrum/space aggregation for future agIle high capacity metrO Networks**
Project acronym	**PASSION**
Grant number	**780326**
Funding scheme	**Research and Innovation Action - RIA**
Project call	**H2020-ICT-30-2017 Photonics KET 2017 Scope i. Application driven core photonic technology developments**
Work Package	**WP1**
Lead Partner	**POLIMI**
Contributing Partner(s)	**ALL PARTNER**
Nature	**R (Report)**
Dissemination level	**PU (Public)**
Contractual delivery date	**31/05/2021**
Actual delivery date	**30/06/2021**
Version	**1.0**

History of changes

Version	Date	Comments	Main Authors
0.1	03/05/2021	Initial draft	Boffi, Parolari (POLIMI) - Amarilli (FPM)
0.2 - 0.5	25/05/2021	Contributions	ALL
0.6	26/05/2021	Quality Review	Gatto (POLIMI)
1.0	28/06/2021	Final version	Boffi, Parolari (POLIMI), Amarilli (FPM)

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This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No 780326.

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EXECUTIVE SUMMARY

The deliverable D1.10 is PASSION final Public progress report.

It includes the publishable summary evidencing the overall objectives of the project, with attention to the work performed and to results achieved so far. The progress beyond the state of the art, and the expected results and potential impacts, including the socio-economic impact and the wider societal implications, are also described.

The list of achieved deliverables and milestones is reported together with the description of the main achievements obtained in the WPs in the period M25 – M42.

1 SUMMARY FOR PUBLICATION

1.1 SUMMARY OF THE CONTEXT AND OVERALL OBJECTIVES OF THE PROJECT

In the last decade we assisted to a continuous growth of the metro network, but we are now facing a bottleneck in the transmission and routing of the huge amount of data due to the dramatic increase of the number of users, the content size, and to the convergence with mobile and datacom networks. Photonics is a key enabling technology for the evolution of the entire telecommunications infrastructure, supporting increasing bandwidth requirements and quality of service (QoS), but the traditional optical technologies exploited today mainly for long haul transmission are too expensive and power hungry for the future metro network.

The aim of PASSION project is to develop new photonic technologies and devices for supporting sustainable metro networks, capable of enabling target capacities of Tb/s per spatial channel, 100 Tb/s per link and Pb/s per node over a few hundred-kms distances. A new metro network infrastructure is envisioned within the project, fitting the network operator requirements and roadmaps and offering multiple relevant characteristics that include: (i) reduced network cost, energy/power consumption and equipment footprint, that are achieved by the development of compact/cost-effective switching technologies and transmitter (using direct modulated vertical-cavity surface-emitting lasers, VCSELs) and multi-channel coherent receiver modules with dense photonic integration; (ii) increased system flexibility and modularity by the adoption of sliceable bandwidth/bitrate variable transceivers (S-BVTs) with reconfigurable parameters; (iii) increased network and system scalability, programmability and reconfigurability, that are enabled by agile aggregation in the spectrum, polarization and space dimensions and the implementation of a software defined networking (SDN) control platform.

In particular, Figure 1 shows the S-BVT Tx based on the modular approach: the module integrating 40 VCSELs in Silicon photonics capable of enabling up to 2 Tb/s aggregated capacity constitutes the building block of the S-BVT. By combining four of such a module, a full 160-channel Tx supermodule is obtained with 25-GHz granularity over the whole C band and with up to 8 Tb/s capacity. By exploiting also polarization-division multiplexing and spatial multiplexing, coupling two supermodules outputs orthogonal in polarization and exploiting bundles of fibers or multi-core fibers, PASSION Tx is able to reach a capacity per link higher than 100 Tb/s.

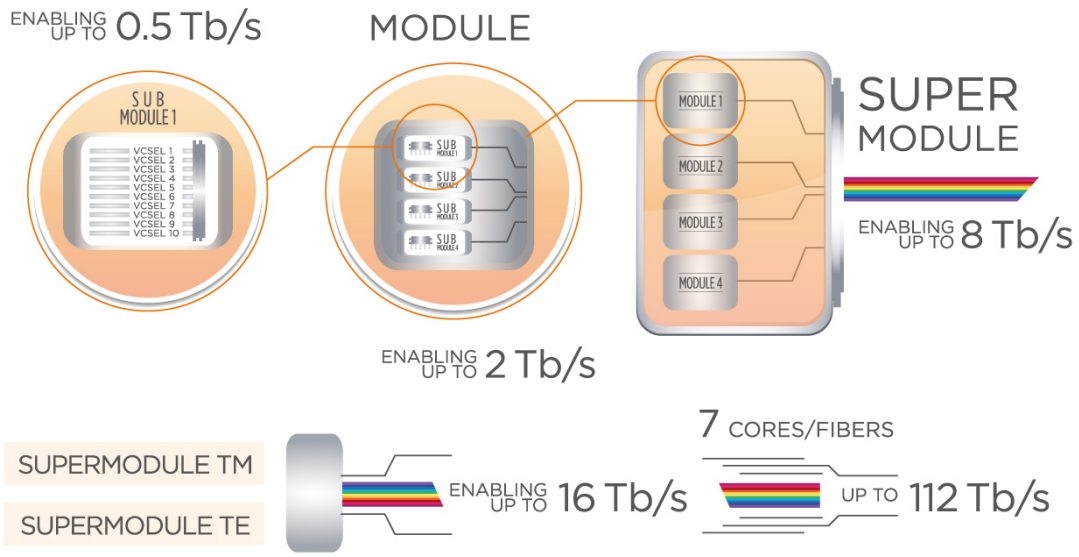

Figure 1. PASSION S-BVT Tx based on the modular approach.

PASSION network platform is also realized by means an innovative energy-efficient and small-footprint node approach, adopting different technologies: flex-grid aggregation/disaggregation/add switches; high-connectivity multicast switches, and large-port photonic polymer PLC-based space switch matrixes. Such a S-BVT based network architecture (Fig. 2) with 25-GHz fine granularity guarantees reconfigurability and flexibility at different levels (in spectrum, polarization and space), and scalability to support a "pay-as-you-grow" scheme. SDN ensures network programmability, fitting network operator requirements and roadmaps.

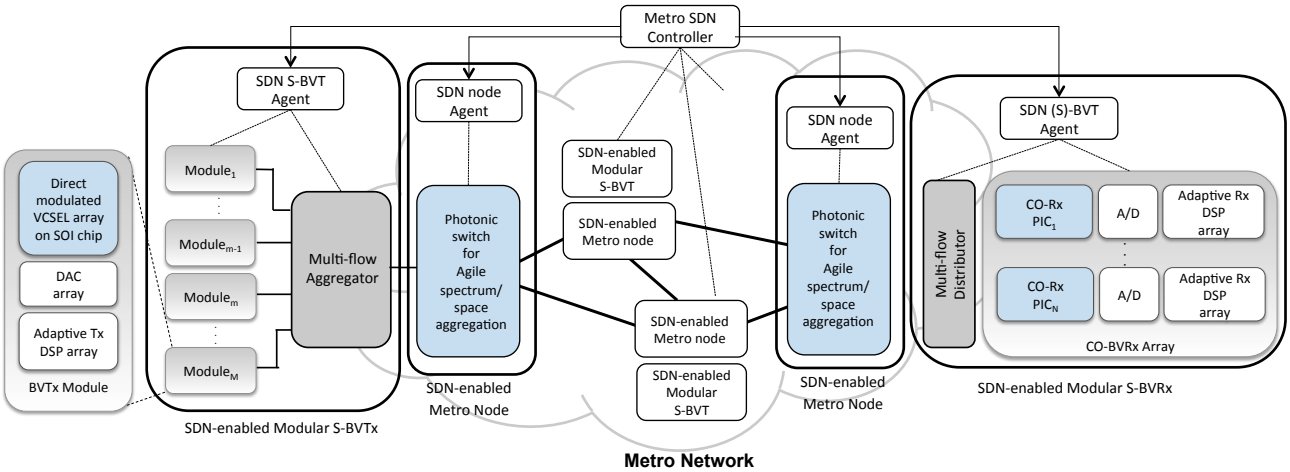

Figure 2. PASSION metro network envisioned infrastructure.

1.2 WORK PERFORMED FROM THE BEGINNING OF THE PROJECT TO THE END OF THE PERIOD COVERED BY THE REPORT AND MAIN RESULTS ACHIEVED SO FAR

After 42 months from the start of the project (December 1st, 2017) all the 42 PASSION deliverables have been completed and 20 milestones have been achieved. In particular, in addition to outcomes related to the project management and dissemination (such as the PASSION website, the

dissemination and data management plans), we achieved important scientific results reported in the following.

- Definition of use cases and requirements for the PASSION network, systems and sub-systems. Considering the targeted use cases, a detailed definition of the metro network architecture divided into a number of hierarchical levels supporting different aggregated data traffic volumes and operating at heterogonous granularities has been provided. Moreover, the node and the transceiver architecture have been defined.
- Detailed design of the VCSEL-based Tx module architecture targeting up to 2 Tb/s aggregated capacity, exploiting high-bandwidth energy-efficient single-mode InP VCSELs assuring beyond 50 Gb/s DMT transmission, optimized for integration in SiPh technology. The SiPh architecture with 40 VCSELs bonded and coupled on a SOI-based Si-PIC embedding wavelength multiplexing capabilities has been developed. According to the chosen assembly strategy, optical and electrical interfaces have been realized, with VCSEL alignment in Si-waveguides by flip-chip systems, and high-performance electric interconnects, favouring industry-standard Land-Grid Array (LGA) package configuration. Modular packaging approach was adopted with small number of components and simple light coupling thanks to the optical WDM VCSEL λs multiplexing SiPh layer. Characterization of the VCSEL sources supported by the selected electrical drivers has been performed. An evaluation board has been realized to host and interconnect the fabricated VCSEL-based Tx module to all needed power supply lines, I2C control interface, RF input connectors and optical output fibre, with the aim to perform initial E/O characterization.
- Definition of the technological circuitry matching the functionalities required by the PASSION optical node. Photonic integrated circuits able to handle the add/drop traffic and traffic aggregation/disaggregation functionalities with a modular approach have been identified and designed with the aim to deliver on-chip switch node functionalities for flexible capacity. In particular, wavelength selective switches (WSSs) and multi-cast switches (MCSs) have been fabricated and characterized both on monolithic InP and hybrid SiPh/InP platforms with promising performance. Specifically, functionality demonstration of an InP 2x4 MCS with lossless performance and of a 1x2 WSS based on a folded single AWG has been completed with reduced footprint. The hybrid assembly of SiPh AWG passives and InP actives has been used to demonstrate a 10-channel wavelength blocker. Moreover, a 16x16 polymer-based space matrix switch was successfully developed with 256 thermo-optic switching elements. The space matrix switch was fully packaged into an integrated module integrated with TEC, making it available to the consortium for the system level experimentation.
- Design and fabrication of a coherent receiver PIC with on-chip polarization handling, together with the development of two tuneable laser concepts for the local oscillator. The PICs have been co-packaged and integrated into multi-channel coherent receivers in various prototyping iteration cycles to realize a multi-channel coherent receiver module focused on the development of the process and the submodule's constituent building blocks, targeting a monolithic approach.
- Design and characterization of the S-BVT architectures targeting a modular and scalable approach, considering up to 50 Gb/s per flow, optimized to support the aggregated capacity targets and envisioned use cases. A pay-as-you-grow model with license-based element activation is envisioned to promote and ease scalability and cost effectiveness. The assessment of the VCSEL-based S-BVT in different experimental setups has been performed, supported by numerical simulations, analysing coherent detection combined with different (double or single sideband multicarrier) modulation schemes to support the target rate over large 5G-supportive MAN. Spectrum and spatial aggregation have been considered and analysed for the scalable and modular design, enabling multiple flows activation and limiting the filtering and crosstalk effects, according to the granularity (also envisioning 25 GHz filtering).

- Integration of the developed PASSION components in a standard industrial telecom node. In particular, a complete transmission board has been developed and integrated in a standard node and a mechanical integration of spatial switch has been demonstrated.
- Completion of the automatic management of end-to-end (bandwidth-demand) connections over the project-adopted hierarchized optical metro network infrastructure. Most target features and functionalities handled by the SDN controller have been developed and validated. Such features and control capabilities include: definition and validation of the APIs for programming PASSION network elements and devices; API for requesting to the SDN controller the dynamic provisioning of connections; on-line routing and spectrum assignment, algorithm accounting with the pool of network and technological constraints, to compute feasible end-to-end connections; dynamic restoration of disrupted optical connections by link failure adopting an autonomous SDN control system exploiting a devised on-line restoration algorithm. Yang models of all PASSION components and related node agent applications have been developed and the test activity validated the SDN SBI interface in a distributed environment.
- Techno-economic analysis of the PASSION metro network architecture, proving that PASSION approach can support pay-as-you-grow strategy and that its single-transceiver-multiple-connection capability (sliceability) can provide very relevant savings w.r.t. traditional fixed transceiver-based solutions, thanks to the support of all optical grooming and edge-to-core (HL4-HL2) connectivity. Moreover, the network software tool for designing and planning networks employing PASSION hardware is provided to help operators evaluate its possible deployment.

1.3 PROGRESS BEYOND THE STATE OF THE ART, OBTAINED RESULTS AND POTENTIAL IMPACTS (INCLUDING THE SOCIO-ECONOMIC IMPACT AND THE WIDER SOCIETAL IMPLICATIONS OF THE PROJECT SO FAR)

PASSION has proposed and demonstrated an application driven photonic platform for the development of a new generation of low-cost, energy-efficient and reduced-footprint devices, modules and sub-systems, for signal generation, detection and switching, driving new technological paths for metro applications devices, with an expected impact in short-medium reach communications applications, where cost reduction and energy sustainability are mandatory. PASSION achievements support a radically new "green" modular and scalable architecture for the metropolitan area networks, based on the superimposition of the spectrum and space aggregation. Scalability arises as a key functionality to consider in the design of the envisioned metro network architecture in order to easily expand/upgrade the network according to the existing and future traffic demand, in a “pay-as-you-grow” scheme. The proposed PASSION programmable and modular approach is crucial to enhance network scalability without requiring significant re-engineering of the existing infrastructure.

In this sense, the photonic technologies developed in PASSION have been tailored in a completely new way with respect to the traditional high-capacity approach exploited for long-haul transport networks, too expensive and power hungry for the future sustainable metro area networks. These targets remain still very relevant after 3 years from the beginning of the project and a technological solution is not yet identified and clear even in the techno-scientific community. As demonstrated in recent literature, completely different approaches are still at a proposal stage.

The innovation potential of the European photonic companies and notably of the SMEs involved in the project has been improved by the cooperation along the value chain in PASSION. In fact,

PASSION is a multi-disciplinary project based on the optical design, integration design, packaging design, system design as well as network design skills. Each Partner has exploited his core competences in terms of his resources and infrastructures, while relying on other Partners, thanks to already-established long-lasting relationships, with a new open access infrastructures and services to design, prototyping manufacturing and testing. Two patents on technological innovations developed in PASSION have been filed. Contacts with standardization bodies, such as IEEE Next Generation Fronthaul Interface (1914) Working Group and Open Networking Foundation (ONF), through the participation to their group meetings, has allowed to promote the PASSION technologies, mapping PASSION network architecture and S-BVT into standards in progress.

The integration of PASSION technology within a standard industrial product gave the opportunity to build an early experience on all the aspects and issues of integrating a new technology. Furthermore, the SW modelling of all PASSION devices gave the opportunity of testing a fully automated integration of new components/feature into the product agent, in coordination with the SDN controller. All these developments have a real value for the industry, bringing new experience and knowledge in the company R&D labs, towards the adoption of new challenging technologies.

Work toward prospecting the medium-term competitiveness of PASSION technology has been carried out, identifying a considerable number of use case driven key-building blocks. An extensive techno-economic analysis has come to the conclusion that the pay-as-you-grow approach and IP-offloading of transit nodes are paramount factors for the commercial future of PASSION technology. Indeed, PASSION has developed a methodology to estimate and compare the costs of different deployment approaches, taking in account optional IP-by-passing and oversubscription, performing an inventory of devices required for a target topology and traffic demand, along with their costs. The tool shows that PASSION technology can compete with WDM FT IP-based aggregation/distribution schemes: the saving for operators can come from the first year if license-based pay-as-you-grow model is in place.

In terms of social implications, PASSION impacts on the development of the future metro communication network, which constitutes the critical infrastructure necessary to provide the citizens a wide range of services and applications in different sectors. PASSION achievements enabling multi-Tb/s capacity allow to facilitate a vast increase in data exchange readily available to all people and thus benefiting society by helping to level the playing field for people of all backgrounds and origins, allowing each to effectively communicate, share knowledge, and reach their individual potentials. The project is also contributing to strength the capability of designing and manufacturing advanced photonics components against the competition of USA and Asia Pacific big players. This in line with EU community strategy underlined also in the upcoming initiatives (e.g. Horizon Europe).

PASSION metro network approach based on the intrinsic flexibility and modularity of the exploited technological solutions is focused on the effective allocation/using of the overall network resources, transforming the operation of today's network infrastructure and reducing over-provisioning and margins. This kind of network concept not only gives benefits for the operators, reducing the apparata costs, but also allows to reduce the overall ICT carbon footprint and to protect the environment. Thanks to the achieved low cost, energy efficient and reduced footprint photonic technologies, PASSION offers a complete change of strategy in the metro transceiver and node development, which represents a unique "green" energy-saving solution. In fact, PASSION deployment based on the exploitation of combined directly-modulated VCSELs and SiPh modules allows a compact design, improving the bandwidth density in bit/cm^2. A reduction factor in power consumption of the optical module in terms of J/bit performance is also achieved, with respect to traditional solutions targeting the same capacity, but based on external modulation.

2 DELIVERABLES (M25 – M42)

Del. No.	Deliverable name	WP No.	Lead benef	Type	Dissle vel	Deliv date	Submis date	Comments
D2.2	Overall network architecture and control aspects definition	WP2	CTTC	R	PU	M26	31/01/2020	Document produced within WP2 "Design of the programmable nodes and modular transceiver architectures" describing mostly the project use cases as well as the design of the SDN control plane functions and APIs to attain the targeted programmability of the underlying network elements and devices.
D4.6	Second generation of hardware efficient modular coherent receivers	WP4	EFP	R	CO	M27	26/02/2020	Document produced within WP4 "Switching, aggregation and Rx photonic technologies", describing measurement results of the second generation PASSION Rx chips. The deliverable has been submitted according the new scheduling shown in the Amendment due to issues with the PCBA supplier feedbacks, out of PASSION control. D4.6 includes in Annex I a summary available for public.
D1.11	Light technical project progress report	WP1	POLIMI	R	CO	M32	31/07/2020	Document produced within WP1 "Project management and coordination" related to the interim light report from M25 to M32, as requested by the P.O. following the Amendment request for the project duration extension.
D2.3	Design of the programmable nodes and modular transceiver architectures	WP2	CTTC	R	PU	M32	27/07/2020	Document produced within WP2 "Design of the programmable nodes and modular transceiver architectures" describing the different node and transceiver architectures defined in T2.3, considering the modularity choice for the proposed photonic technology solutions and

								identifying the programmable parameters of the system. Feasibility studies are also reported.
D4.7	Hybrid integrated low insertion loss Disag/Aggregator	WP4	VTT	R	PU	M32	31/07/2020	Document produced within WP4 "Switching, aggregation and Rx photonic technologies", describing the hybrid integration of SiPh and InP material platform exploited for the first time for switching circuit concepts.
D5.2	Design, specification and initial implementation of the control plane	WP5	CTTC	R	PU	M35	30/10/2020	Document produced within WP5 "Integration and demonstration of photonic devices and technologies". It reports the concept approached for the control and management of the network systems defined in WP2, whose key modules/devices are developed in WP3 and WP4.
D4.8	Optical sub-assemblies with appropriate test boards for evaluation in system experiments	WP4	EFP	R	CO	M36	30/11/2020	Document produced within the WP4 "Switching, aggregation and Rx photonic technologies", including the test report and user manual of the final optical sub-assemblies on a test board ready to be used in the final demonstrator.
D3.6	Test results from the first transmitter submodule with directly modulated VCSELs	WP3	VTT	R	PU	M34	09/06/2021	Document produced within the WP3 "Photonic technologies for Tx", regarding the initial integration results coming from the first prototype combining VCSELs and drivers. Owing the COVID-19 lockdown and access policy to the lab for the researchers affecting the experimental activities (in particular in VTT clean room) the deliverable has been submitted in delay.
D3.7	Test results from the full Tx modules	WP3	TUE	R	PU	M38	09/06/2021	Document produced within the WP3 "Photonic technologies for Tx". It reports the results of the packaged Tx module. Owing the COVID-19 lockdown and access policy

								to the lab for the researchers affecting the experimental activities (in particular in VTT clean room) the deliverable has been submitted in delay.
D4.9	Chip-level characterization for providing performance data to WP5	WP4	TUE	R	PU	M39	31/05/2021	Document produced within WP4 "Switching, aggregation and Rx photonic technologies", describing the realized chips with different functionalities characterized to understand performance and improve subsequent design. Owing to the delays in purchases and components delivery due to COVID-19, the deliverable has been submitted in delay.
D5.3	Integration and preliminary assessment of the PASSION components	WP5	POLIMI	R	PU	M40	31/05/2021	Document produced within WP5 "Integration and demonstration of photonic devices and technologies". Owing to COVID-19 lockdown and access policy to the lab for the researchers, causing the delays in WP3 and WP4 achievements, and to the restrictions limiting the envisioned and joint activities, the deliverable has been submitted in delay.
D2.4	Techno-economic analysis and the PASSION vision on future agile high-capacity optical metro networks	WP2	TID	R	PU	M41	30/04/2021	Document produced within WP2 "Design of the programmable nodes and modular transceiver architectures" summarizing the techno-economic studies and results performed in T2.4, considering the candidate technologies and architectures. It also proposes network architecture refinements.
D1.9	Final project report	WP1	POLIMI	R	CO	M42	30/06/2021	Document produced within WP1 "Project management and coordination" related to the third report (M25-M42), about the full financial, technical and risk management progress.

D1.10	Final public report	WP1	POLIMI	R	PU	M42	30/06/2021	Document produced within WP1 “Project management and coordination” related to the third public progress report (M25-M42).
D5.4	The PASSION metro reconfigurable optical network	WP5	SMO	R	PU	M42	31/05/2021	Document produced within WP5 “Integration and demonstration of photonic devices and technologies" reporting the conducted demos providing the envisioned metro network validation, despite the difficulties to the COVID-19 situation, as well as related delay and issues with components availability and subsystem development.
D6.4	Report on industrial-oriented and scientific-oriented dissemination activities 3	WP6	VLC	R	PU	M42	31/05/2021	Document produced within WP6 “Exploitation plan, dissemination and standardization” related to the third report (M25-M42) about the scientific oriented dissemination activities.
D6.5	Exploitation plan	WP6	EPIC	R	CO	M42	31/05/2021	Document produced within WP6 “Exploitation plan, dissemination and standardization”. It reports the feasibility analyses carried out by the industrial Partners for the PASSION technologies, devices and architectures, as well as the definition of the potential market opportunities.
D6.6	Contribution to standardization	WP6	SMO	R	CO	M42	31/05/2021	D6.6 repot the activity done with respect to Standardisation. We identify the main standard bodies related to PASSION Technologies, proposing a technical analysis to position it with respect to the incoming Standards.
D6.7	Guidelines and software tool for Metro network design based on the PASSION architecture	WP6	TID	R	PU	M42	31/05/2021	Document produced within WP6 “Exploitation plan, dissemination and standardization” related to the software tool developed for the design of the MAN based on PASSION approach.

3 MILESTONES (M25 – M42)

Milestone	Milestone name	WP no	Lead benef	Delivery date	Subm date	Mean of verification	Achieved
MS13	First transmitter subassembly fabricated and tested	WP3	VTT	01/10/20	01/05/2021	Deliverable D3.6 " Test results from the first transmitter submodule with directly modulated VCSELs"	YES
MS14	Realization of a software control board for the InP CO-Rx	WP4	OPSYS	01/01/20	20/12/19	Document PASSION_WP4_MS14_v1.0.pdf uploaded in the PASSION repository on December 20th, 2019.	YES
MS15	First low-loss hybrid integrated Disag/Aggreg switch	WP4	OPSYS	01/06/20	01/06/2020	Deliverable D4.7 "Hybrid integrated low insertion loss Disag/Aggregator"	YES
MS16	Consolidated design of the PASSION control plane	WP5	SMO	01/05/20	30/04/20	Document PASSION_WP5_MS16_v1.0.pdf uploaded in the PASSION repository on April 30th, 2020.	YES
MS17	Full Tx modules fabricated and tested	WP3	VTT	1/2/2021	31/05/2021	Deliverable D3.7 " Test results from the full Tx modules"	YES
MS18	High performance high connectivity add/drop switch	WP4	OPSYS	1/3/2021	01/05/2021	Deliverable D4.9 " Chip-level characterization for providing performance data to WP5"	YES
MS19	Completion of the integration process	WP5	SMO	1/3/2021	01/05/2021	Deliverable D5.3 "Integration and preliminary assessment of the PASSION components"	YES
MS20	Experimental evaluation results	WP5	SMO	1/5/2021	31/05/2021	Deliverable D5.4 "The PASSION metro reconfigurable optical network".	YES

4 WPs ACHIEVEMENTS (M25-M42)

PASSION project is characterized by a very fruitful collaboration among the partners, who periodically meet in WebEx calls and in face-to-face meetings. People can find information about the project development on the PASSION website, where the project achievements and events are continuously promoted to both general public and experts' audience. Moreover, the community is updated by the social media channels, such as Twitter, LinkedIn and Facebook.

From the network point of view, the automatic management of end-to-end (bandwidth-demand) connections over the project-adopted hierarchized optical metro network infrastructure has been complete. In this regard, most target features and functionalities handled by the SDN controller have been developed and validated. Such features and control capabilities include: i) definition and validation of the APIs for programming PASSION network elements and devices; ii) API for requesting to the SDN controller the dynamic provisioning of connections; iii) on-line routing and spectrum assignment (RSA), algorithm accounting with the pool of network and technological constraints, to compute feasible end-to-end connections. iv) dynamic restoration of disrupted optical connections by link failure adopting an autonomous SDN control system exploiting a devised on-line restoration- RSA algorithm. Regarding offline architectural design aspects, the fundamental key building blocks for techno-economic analysis of the proposed metro network architecture were identified and quantified in relative terms. This analysis has proven that PASSION can support pay-as-you-grow and that its single-transceiver-multiple-connection capability (sliceability) can provide very relevant savings w.r.t. traditional FT-based solutions, thanks to the support of all optical grooming and edge-to-core (HL4-HL2) connectivity support. Furthermore, referring to i), Yang model of all PASSION components and related node agent application has been developed. Test activity validate the SDN SBI interface in a distributed environment.

Regarding the development of the photonic technologies for the transmitter, SOI chips integrating 40 InP VCSELs and a new 1x 40ch 100GHz AWG multiplexer have been fabricated in VTT. The 1x40ch 100GHz AWG solution has been tested and found more performant and with consistently lower insertion loss than the previous mux design. Several runs have been completed for optimize the production of VCSELs covering the entire C-band to be modulated up to 50 Gb/s each with DMT. Examples of 2Tb/s Tx modules have been manufactured together with a suitable evaluation board. Regarding the integration of PASSION Tx module in standard industrial telecom nodes, a complete transmission board has been developed and integrated in a standard node in the ETSI 300mm subrack.

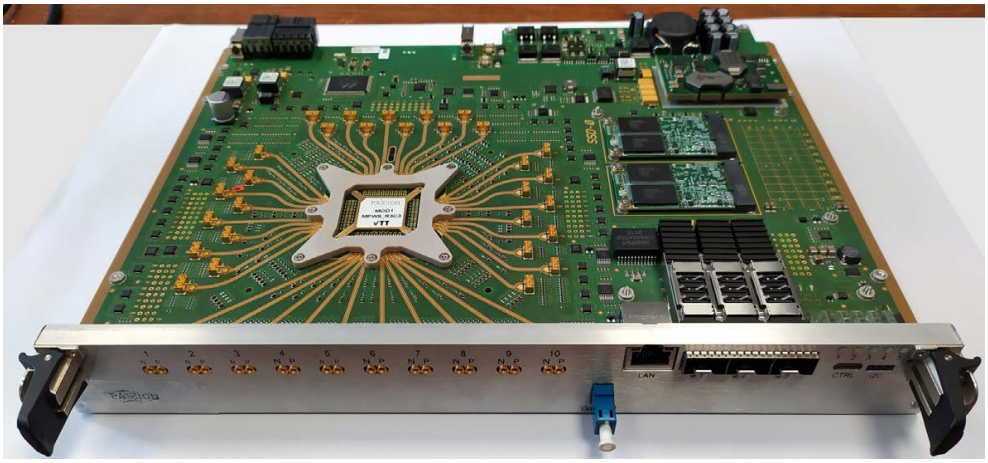

Figure 3. Top view of the developed 2-Tb/s transmitter board

Figure 4 Final 2-Tb/s transmitter board integrated in the ETSI 300mm subrack.

Regarding the node development, design and fabrication of WSSs and MCSs both on monolithic InP and hybrid SiPh/InP platforms have been fabricated and tested. The chosen design allows to reduce the footprint and optimize the losses. A successful data transmission was experimentally achieved. Moreover, a 16x16 polymer-based space matrix switch is successfully developed and fully packaged into a module integrated with a TEC, available for the system level experimentation. Furthermore, the mechanical integration of this spatial switch module in the standard ETSI subrack was achieved.

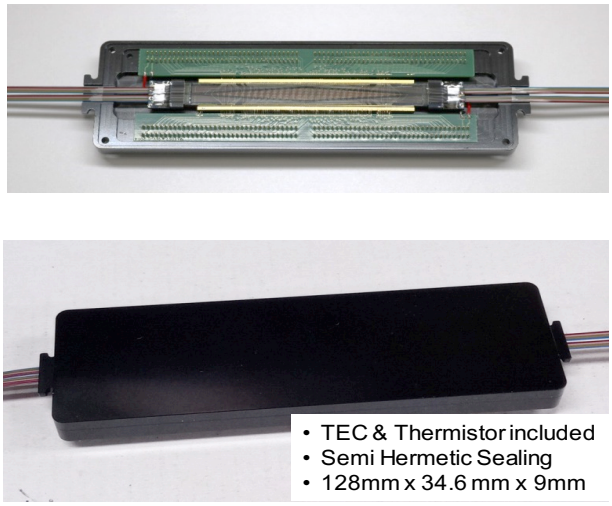

Figure 5 Packaging of 16x16 polymer switch chip

In parallel, a coherent receiver PIC with on-chip polarization handling was developed together with the local oscillator based on two different designs. A multi-channel coherent receiver module targeting a monolithic approach has been realized.

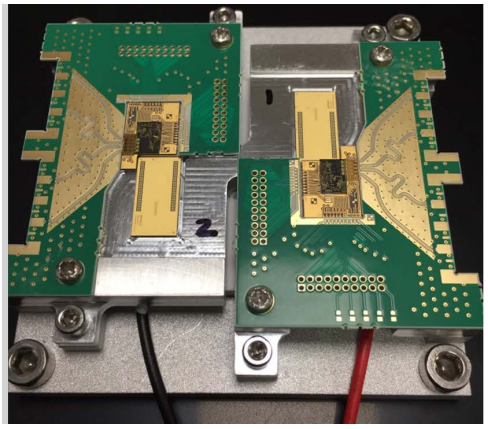

Figure 6 Picture of developed assembled coherent ROSA.

Considering the technologies and devices developed in WP3 and WP4, the modular and scalable S-BVT architecture, based on VCSEL-based fundamental SOI-chip modules and coherent receiver modules, targeting multi-Tb/s capacity (aggregation of multiple data flows at 50 Gb/s) have been analysed and optimized to support the aggregated capacity targets and envisioned use cases. A pay-as-you-grow model with license-based element activation was envisioned to promote and ease scalability and cost effectiveness. The assessment of the VCSEL-based S-BVT in different experimental setups has been performed, supported also by numerical simulations. Spectrum and spatial aggregation have been considered and analysed for the scalable and modular design, enabling multiple flows activation and limiting the filtering and crosstalk effects, according to the granularity (also envisioning 25 GHz filtering).

In these final 18 months (M25-M42), partners participated to 37 plus 14 scientific-oriented and industrial-oriented dissemination events, namely congresses and workshops, and there have been 41 publications in proceedings (28), journals (10) and magazines (3). Moreover, the results achieved in PASSION have been promoted on PASSION social media channels.

The overall number of publications published during the project duration is 72: 56 Conference proceedings and 16 Journals.