



ICON

HORIZON-HADEA

WP6 Demonstrations

Deliverable 6.1 Use cases definition for the demonstrator

Main Author(s):

Tomas Horvath, BUT

Petr Münster, BUT

Marco Ruffini, TCD

Aleksandra Kaszubowska, TCD

Due date of deliverable: 31st of March 2026
Actual submission date: 31st of March 2026
Deliverable type: R — Document, report
Dissemination level: PU - Public

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. The European Union cannot be held responsible for them. The project is supported by the SNS-JU.



Funded by
the European Union

Project information

Project Name:	Intent and Context-Aware Optical Networks
Grant Agreement:	101189703
Project Duration:	1 January 2025 – 31 December 2027

List of Contributors

Partner number	Partner acronym	Partner name	Name of contact
5	BUT	Brno University of Technology	Jan Bukovsky
5	BUT	Brno University of Technology	Tomáš Horváth
5	BUT	Brno University of Technology	Petr Münster
2	ADTN	Adtran	André Sandmann
7	TalTech	Tallinn University of Technology	Kaida Kaeval
8	FAU	Friedrich-Alexander-Universität Erlangen-Nürnberg	Lukas Bernhardt

Document control

Document version	Date	Author / Organisation	Change
V1.0	03/03/2026	Tomáš Horváth/BUT	First draft
V2.0	23/03/26	Marco Ruffini/TCD	Second draft
V3.0	26/03/26	Kaida Kaeval/TalTech	Third draft
V4.0	31/03/26	Aleksandra Kaszubowska/TCD	Final draft

Table of contents

Project information	2
List of Contributors	2
Executive Summary	4
Introduction.....	5
1. Infrastructures	6
1.1. BUT Infrastructure	6
1.2. Adtran Infrastructure	7
1.3. DTU Infrastructure	8
1.4. FAU Infrastructure	9
1.5. TalTech Infrastructure.....	9
1.6. Tampnet Infrastructure	12
1.7. TCD Infrastructure	12
2. Demonstrations	13
2.1. Use Cases Selected for Demonstration	13
2.1.1. Optical Network Infrastructure Protection	13
2.1.2. Availability Map.....	14
2.2. Demonstration of Network Infrastructure Protection Use Case.....	14
2.3. Demonstration of the Integrated Communication and Sensing	15
2.4. Demonstration of the Intent- and Context-Aware Optical Network and the Final Demonstrator	16
3. External Support Systems.....	18
3.1. Fibre Bragg Grating	18
3.2. Weather Station	18
3.3. Camera	18
3.4. Automatic Identification System (AIS)	18
Conclusions.....	19

Executive Summary

This deliverable defines the plan for the implementation of the ICON project's demonstration activities. It specifies the network configuration, including fibre deployment type (indoor/outdoor) and fibre length, and identifies the sensing techniques to be applied. The plan is based on an assessment of the available infrastructures of the project partners, both laboratory-based and field-deployed.

Furthermore, the deliverable provides an overview of external support systems available to the project partners, including camera systems, AIS information, and other complementary technologies, which are considered as sources of reference data for the validation and interpretation of detected events.

The presented plan provides a basis for the execution of the demonstration activities and the subsequent validation and evaluation of the results.

Introduction

Deliverable 6.1 on the “Use cases definition for the demonstrator” is an outcome of Task 6.1 “Definition of testing activities, including final demonstrators”.

The main objective of this deliverable is to define a comprehensive plan for the demonstration activities to be carried out, including the selection of the network type and the sensing techniques to be applied. The available infrastructures of the project partners, both laboratory-based and field-deployed, are analysed in order to assess the feasibility of deploying suitable sensor systems and to propose appropriate deployment strategies.

The plan serves as a guide for subsequent deployment and verification activities. An essential component of this work is an overview of external support systems that may support the validation and interpretation of detected events, such as camera systems, AIS information, and other complementary technologies.

This deliverable is structured in the following way:

- Section 1 provides a description of the infrastructures of individual partners.
- Section 2 describes the demonstration activities to be carried out, including the selection of network types and the sensing techniques to be applied.
- Section 3 outlines the external support systems available to partners.

1. Infrastructures

Section 1 presents the infrastructures brought into the ICON consortium for the test and validation of the joint communication and sensing concepts. This includes the laboratory, campus, terrestrial and subsea fibre infrastructures operated by the different project partners. They are described in terms of their main technical properties, sensing and transmission equipment, external infrastructures and example use cases. This section provides the respective experimental basis, helping to determine a suitable infrastructure for the planned validation experiments and final demonstrations.

1.1. BUT Infrastructure

Brno University of Technology (BUT) has two fibre testbed setups. The outdoor setup has an optical path up to 8.1 km long. It consists of five spans, each about 1.5 km in length, with 24 G.652 fibres. These fibres are buried and end with SC/APC connectors. Certain fibres are terminated with Faraday rotating mirrors (FRMs). Selected fibres are spliced to couplers and terminated with FRMs, thus forming a Michelson interferometer. In other selected fibres, a pair of fibres is spliced via couplers to form a Mach–Zehnder interferometer. This setup is located next to a street to enable real-world testing. Camera-based monitoring and weather stations can serve as an external support system. This setup is designed for advanced experiments, including distributed acoustic sensing (DAS), distributed strain and temperature sensing (DSTS), interferometric measurements, and polarisation analysis. Various test scenarios can be performed along the route, for example, road traffic and activities involving cable manholes, including simultaneous sensing and data transmission.

Table 1: BUT outdoor setup

Topic	Description
Type	Buried
Maximum length (km)	8.1
Number of fibres	24
Fibre type	G.652
Connector type	SC/APC
External support systems	Video camera and weather station
Possible test scenarios	Various test scenarios can be performed along the route, for example, road traffic and activities involving cable manholes, including simultaneous sensing and data transmission.
Note	

The indoor setup has up to 2.0 km long optical path split into 20 short sections, each about 0.1 km, with 20 G.657 fibres ending with LC/APC connectors. The installation is implemented within suspended ceiling structures. Fibre Bragg gratings (FBGs) and cameras used for corridor monitoring can serve as external support systems. The setup is designed for advanced experiments, including DAS, DSTS, interferometric measurements, and polarisation analysis. Various test scenarios can be performed along the path, such as controlled temperature variations, induced vibrations, and direct fibre manipulation, including simultaneous sensing and data transmission.

Table 2: BUT indoor setup

Topic	Description
Type	Inside
Maximum length (km)	2.0
Number of fibres	20
Fibre type	G.657
Connector type	LC/APC
External support systems	Video camera and FBG
Possible test scenarios	Various test scenarios can be performed along the path, such as controlled temperature variations, induced vibrations, and direct fibre manipulation, including simultaneous sensing and data transmission.
Note	

1.2. Adtran Infrastructure

Adtran has several devices with a focus on DWDM data transmission, coherent 100G, 400G and soon an 800G system (M-Flex800) that will be used for ICON in the lab in Meiningen, Germany. Furthermore, several network elements, such as Erbium-doped fibre amplifiers (EDFAs), as well as DWDM and CWDM wavelength multiplexers, are available.

In addition, ALM (standard OTDR) and Distrasense devices are available. The consortium can also avail of a correlation-aided coherent OTDR demonstrator, which enables combined time- and frequency domain interrogation, allowing standard fibre as well as fibre Bragg grating (FBG) array interrogation, developed within the SoFiN EU-project.

Our test fibre infrastructure includes several 100 km of standard single-mode fibre spools, Bragg gratings and other types of speciality fibre.

Moreover, we have access to an ~8 km deployed underground fibre link with a loopback. Finally, an outdoor testbed with ~150-meter deployed underground cable with standard as well as speciality temperature and strain sensing fibres is available.

Table 3: Adtran's indoor and outdoor setup

Topic	Description
Type	Indoor and Outdoor
Maximum length (km)	Indoor: several hundred kilometres Outdoor: ~8 km

Number of fibres	Indoor: >10 Outdoor: >8
Fibre type	G.652, other speciality fibres
Connector type	LC/APC, LC/PC
External support systems	Weather station, thermal imaging camera
Possible test scenarios	Joint DWDM communication and sensing experiments, transceiver telemetry sensing, vibration simulation with piezo fibre stretcher, acoustic signal detection in an isolated chamber, temperature-controlled cabinet for temperature sensing
Note	-

1.3. DTU Infrastructure

The Technical University of Denmark (DTU) is currently developing an indoor experimental testbed based on a C-OTDR interrogator. The system employs a narrow-linewidth laser that generates continuous-wave (CW) light, which is modulated by an acousto-optic modulator (AOM) driven by a pulse generator. The resulting optical pulses are amplified using a pulsed EDFA and injected into the fibre under test through a circulator. As the pulses propagate along the fibre, Rayleigh backscattering is generated at numerous points due to intrinsic refractive index inhomogeneities. This backscattered light is collected by the circulator and routed to the detection stage. Because the intensity of the backscattered signal is significantly weaker than that of the launched pulses, a second amplification stage is required. For this purpose, a continuous-wave EDFA (CW-EDFA) is spliced directly to the output of the circulator to amplify the incoming signals. However, EDFAs inherently introduce amplified spontaneous emission (ASE) noise into the amplified signal. To mitigate this effect, a narrow optical bandpass filter is employed to suppress unwanted spectral components across the optical spectrum. The filtered signal is then mixed with a local oscillator derived from 10% of the optical power of the same narrow-linewidth laser. The resulting beat signal exhibits fluctuations in both intensity and phase in response to physical perturbations—such as strain or temperature variations—occurring along the fibre. The primary objective of this testbed is to provide a platform for experimentally evaluating advanced signal processing techniques, as well as hardware and software enhancements, aimed at improving the performance of conventional fibre-optic sensing systems beyond their current capabilities.

Table 4: DTU setup

Topic	Description
Type	Indoor
Maximum length (km)	To be defined
Number of fibres	1
Fibre type	Single Mode Fibre
Connector type	FC/APC

External support systems	
Possible test scenarios	Induced acoustic vibrations and controlled temperature variations.
Note	

1.4. FAU Infrastructure

Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU) currently only conducts indoor fibre sensing tests. The setup is designed for controlled laboratory experiments, with a particular focus on Raman-based DTS. The centrepiece of the setup is a Raman-IOFDR temperature measurement prototype. A climate chamber allows fibre spools to be brought to defined temperatures and, if necessary, controlled humidity. A large inventory of fibre spools is available, spanning a wide range of lengths and fibre types, with a combined length of approximately 300 km. This inventory enables the flexible assembly and reconfiguration and can be integrated into existing testbed infrastructures if necessary. In addition, a wide collection of optical components is available, allowing a variety of measurement systems and sensing modalities to be incorporated.

Table 5: FAU setup

Topic	Description
Type	Indoor
Maximum length (km)	300 (spooled)
Number of fibres	>10
Fibre type	100km G.654 (TeraWaveSCUBA150), 24km G.655, 250km G.652, 2km HI1060FLEX (backscatter enhanced fibre)
Connector type	LC/PC, FC/APC
External support systems	Commercial OTDR for Fibre Length and Health Testing
Possible test scenarios	
Note	

1.5. TalTech Infrastructure

The fibre optical assets in the Optical Communication and Sensing Lab in Tallinn University of Technology (TalTech) include seven 15 km, four 25 km and four 50 km fibre spools of G. 652G-compatible fibres. The lab also has access to a small campus fibre infrastructure, consisting of 12 fibres installed under the corridor ceilings. The campus infrastructure is interconnected to Tele2 Estonia metro network, where four fibres with a 3.4-km length are connected to Elering premises, from where the fibres can be further interconnected to various other data centres in Tallinn, Estonia.

However, the initial test infrastructure dedicated to testing activities within the ICON project was located between the remote Lihula and Keila substations in Western Estonia. The dedicated 101.7-km long Optical Power Ground Wire (OPGW)-based segment included four G. 652G-compatible fibres and had one glass-through site in the middle. The test equipment, including C-OTDR, DD-OTDR, and TeraFlex transceiver from Adtran, State of Polarisation analysers from Tampnet and Brno University were installed in Lihula and Keila site was used for amplification and SoP transmitter housing. The primary objective of this testbed was to provide a platform for correlating signals from various sensing and telemetry devices, as well as external data sources such as room temperature sensors and data from a nearby weather station. Furthermore, the setup is used as the primary data input for evaluating the requirements of the Telemetry/Sensing as a Service platform, implemented in the TalTech Optical Communication and Sensing lab, and interconnected to the high-capacity storage available at TalTech's High Power Computing Centre. Detailed information about the infrastructure and equipment tested on the segment is explained in Figure 1. The measurement period for this setup was from the 27th of October 2025 until the 10th of March 2026.

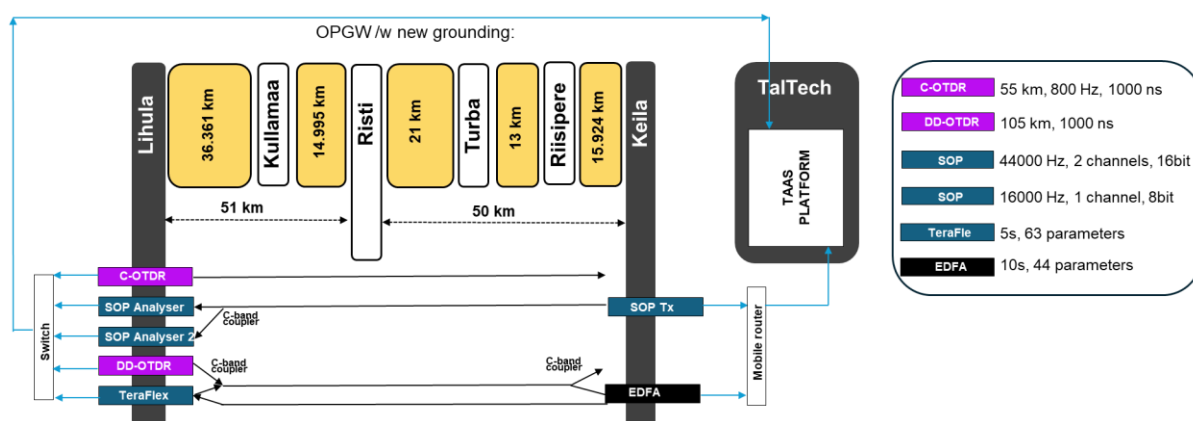


Figure 1: Lihula-Keila measurement set-up.

The second test scenario to be demonstrated involves a segment from TalTech Optical Communication and Sensing Lab to Elering Veskimetsa Substation, and from there to Järve and Ülemiste Substations. The segment details are under negotiation at the time of the submission of this deliverable, but the desired segments between Veskimetsa and the mentioned substations are around 5 km per segment, with the first segment being a direct buried fibre and the second one an OPGW-based segment. Testing on this segment is planned to take place between the 10th of April and the 20th of May. The primary objective of the testing on the metro segment is monitoring the direct disturbances on the infrastructure, which can be introduced by the fibre manipulations in TalTech's premises, and observations of known impacts from nearby train stations, as well as recording a baseline for various infrastructure types, which can then be used in the availability assistant developments. Figure 2 explains the planned test setup.

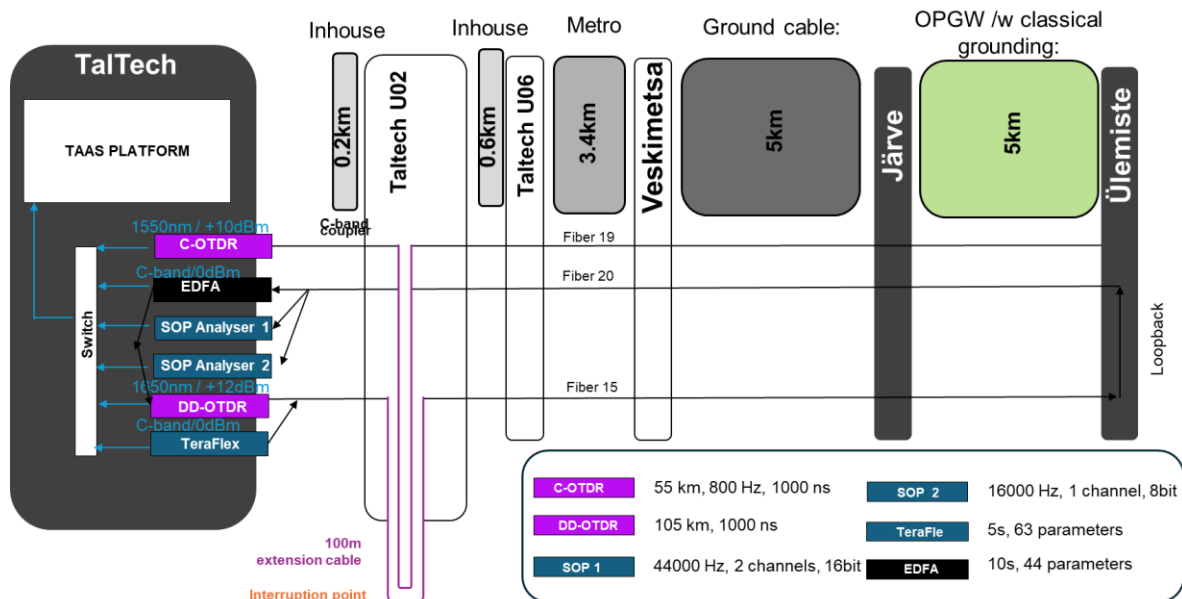


Figure 2: Planned measurement set-up between TalTech and Elering substations in Tallinn, using a mix of optical infrastructure from TalTech, Tele2 Estonia, and Elering.

Table 6: TalTech setup

Topic	Description
Type	In-house, buried (loose tube), Optical Power Ground Wire. TalTech has no equipment. All active equipment for testing is sent to Tallinn by the project partners.
Maximum length (km)	Fibre lengths for the production fibres vary. The longest measured span is 101.7km of OPGW from Elering, and the shortest metro segments are between 0.2 and 5 km. In addition, TalTech Lab provides about 400 km of spooled fibres
Number of fibres	Varies per segment. Mostly 4 fibres, except between Veskimetsa and Keila.
Fibre type	G.652G
Connector type	LC/UPC and SC/UPC, depending on the infrastructure installation year
External support systems	N/A
Possible test scenarios	Correlations, single fibre, etc
Note	Primary testing for the T/SaaS platform took place between the 27th of October 2025 and the 10th of March 2026. Planned testing for the metro segments is scheduled to take place between the 10th of April and the 20th of May.

1.6. Tampnet Infrastructure

Tampnet has a vast network of subsea cables in the North Sea. The recently laid NORFEST cable that runs along the southern Norwegian coast from Stavanger to Oslo, with several branches along the path, has several available fibre pairs. In addition, selected cables in the North Sea have available capacity that can be used as scientific test beds.

Table 7: Tampnet setup

Topic	Description
Type	Subsea and laboratory
Maximum length (km)	~700 km (end-to-end through patches in landings) (shorter looped subsea fibre sections available) Laboratories with several fibre-spools and fibre-types, as well as a piece of subsea cable for i.e. sensing sensitivity testing.
Number of fibres	~5 cables in a festoon configuration with several fibres
Fibre type	G.652
Connector type	LC connectors
External support systems	OTDRs, information on as-laid distances, weather data, and communication channel telemetry.
Possible test scenarios	Test to observe marine events, vessel crossings, or trawler events. Test for long-haul performance of sensing instruments in the field. Earthquake observations.
Note	

1.7. TCD Infrastructure

TCD has classical networking lab infrastructure from the OpenIreland research testbed. It also has field fibres, some of which are directly connected to the lab. There is access to undersea fibres, but it is in a remote location and not always allowed. The lab has metro transmission equipment, with 1,700km of fibre spools. The lab has two DAS systems and polarisation analysers.

Table 8: TCD setup

Topic	Description
Type	Subsea, terrestrial and laboratory. 2 DAS systems and equipment for measurement of Polarisation
Maximum length (km)	200km outside, 1,700km in the lab

Number of fibres	2 subsea (although with limited availability), 4 terrestrials, several spools in the lab
Fibre type	Single mode, multiple types, the field fibre is not known
Connector type	Mostly LC
External support systems	OTDR, AIS data, weather data, telemetry measure of power in the network and BER at the transceivers
Possible test scenarios	In the lab: effect of coexistence with other telco equipment, simulation of wind, temperature and noise in different parts of a lab metro network. Outdoor: street and other noise from the people, the effect of wind and temperature.
Note	

2. Demonstrations

Section 2 describes the planned demonstration activities were/to be carried out in ICON, the use cases that were/will be validated, the main demonstration targets, the protection of the optical network infrastructures, the availability map and the implementation in the selected infrastructures of the project partners. This section describes the plans for the demonstration and, in particular, the sensing systems, the test conditions, and expected outcomes, and how the ICON technologies will be validated experimentally.

2.1. Use Cases Selected for Demonstration

Three primary use cases have been identified, each addressing distinct operational needs and leveraging advanced fibre sensing technologies: environmental sensing & infrastructure monitoring, optical network infrastructure protection, and the availability map. Within ICON, two use cases will be demonstrated: optical network infrastructure protection and the availability map.

2.1.1. Optical Network Infrastructure Protection

This use case focuses on the early detection and prevention of fibre issues, such as potential harmful impacts, degradation and impending faults, through continuous, real-time monitoring. By integrating, e.g. DAS and SoP monitoring, operators can detect and localise events like trawling, digging, anchor drags, and environmental loads (e.g., currents, ice, earthquakes) before they escalate into service-impacting incidents. An automatic proactive service rerouting based on the combined information from transceivers and sensing interrogators will be considered.

This proactive approach is essential for minimising downtime, reducing repair costs, and safeguarding critical services across both terrestrial and subsea infrastructures

Simultaneous sensing and data transmission on the same fibre requires seamless interoperability between the sensing and data transmission signals and systems. Different integration variants will be considered in the demonstration, where the probe signal and data signals propagate in the same and opposite directions in the fibre, i.e. co-directional and counter-directional propagation. In addition, the type of probe signal and its wavelength separation from the data channels play a role. Overall, the focus is on seamless integration of sensing signals with negligible impact on transmission and sensing performance and minimal fibre channel capacity loss.

2.1.2. Availability Map

The availability map use case supports network operators in identifying stable versus risk-prone routes, planning maintenance, and reacting to emerging risks. Unlike real-time protection, this use case emphasises long-term data collection and analysis, combining sensing data, telemetry, and data-lake resources with visual interfaces to display availability assessments for specific network segments, derived from sensing data such as phase changes or state of polarisation changes.

The development of the Availability Map relies on reliable and systematic data collection from various synchronised telemetry and sensing data sources, which are then stored in a data lake (Telemetry/Sensing as a Service platform) for multi-tenant access, studied in Task 2.3. The primary objective of the Availability Assistant use-case in the ICON project is to derive reliability estimations for the monitored infrastructure segments. This means identifying the infrastructure segments with higher variations from the sensing activity with the ones with steady baselines, in order to give operators a tool to visualise network segments prone to human error, disturbances from heavy winds or lightning storms, subsea trailing, or other. This gives operators clear insights into redundancy calculations or future network infrastructure planning.

The infrastructure and test-setup for data collection for Availability Assistant are provided by TalTech and include production fibres from Tele2 Estonia and Elering, passing through Tallinn city from TalTech premises to Ülemiste substation, with a total length of 15 km. The primary sensing sources utilised for deriving reliability estimates for Availability Assistant are the C-OTDR from Adtran, and the State of Polarisation analysers from Tampnet and BUT. The timeline for the initial data collection is between the 10th of April and the 22nd of May 2026.

The work to determine the standard method of presenting and sharing of the sensing data for use in telecommunication and non-telecommunication related applications, such as the Availability Map, is still underway, and will be finished in M18. The data processing from the first measurement period from Elering infrastructure between Lihula and Keila is still in progress, and at this stage, no final correlations between the data sources can be established.

2.2. Demonstration of Network Infrastructure Protection Use Case

BUT will conduct a demonstration using the indoor and outdoor fibre setups within the use case of optical network infrastructure protection. The experiment will deploy conventional optical performance monitoring (OPM) data reported to the network management system (NMS) by two ADVA FSP 3000 C systems equipped with coherent transceivers operating at 200 Gb/s as indicators of physical perturbations along the optical fibre. Two coherent transceivers will be deployed as the primary transmission units on channels CH32 and CH35.

To emulate realistic metropolitan-scale network conditions, the fibre setup will be extended using additional fibre spools and auxiliary fibre sections, resulting in a total optical path of approximately 18 km. The extended optical path will comprise a launch fibre, fibre spools placed before and after the perturbation stage, and the corresponding fibre sections within the indoor and outdoor setups. Dense wavelength division multiplexing (DWDM) modules will be installed at both link ends to multiplex and demultiplex the transmission channels. The OPM data collected by the transceivers will include carrier frequency offset, differential group delay, chromatic dispersion, polarisation-dependent loss, forward error correction bit error rate, received power, signal-to-noise ratio, optical signal-to-noise ratio, and Q-factor. The minimum, maximum, and average values of these parameters will be periodically reported to the NMS via consecutive remote procedure calls (RPCs).

Controlled perturbations will be introduced using dedicated actuation equipment. A thermal chamber will be used to introduce controlled temperature variations, and a robotic arm will apply a defined force at an intermediate section of the link. To provide independent reference measurements, external support systems will be employed. The applied force will be verified using a load cell, while temperature variations will be independently validated using FBG.

The demonstration will include controlled temperature steps (e.g., 25 °C as baseline, followed by elevated temperature levels up to 75 °C), with each temperature level maintained for a defined duration during which OPM samples will be continuously collected. Mechanical perturbations will be introduced at predefined force levels (e.g., 5–20 N), with multiple repetitions.

The objective of the demonstration will be to show that standard OPM parameters obtained from coherent transceivers can serve as indicators of environmental perturbations such as temperature variations and strain, without requiring dedicated sensing hardware. A deep learning framework will be developed to analyse OPM data and detect and classify anomalies caused by these perturbations. The demonstration will validate the feasibility of using conventional transmission infrastructure as a sensing platform under realistic network operating conditions within the optical network infrastructure protection use case.

Table 9: Overview of the first planned demonstration of the network infrastructure protection

Topic	Description
Infrastructure	Extended indoor and outdoor fibre setups at BUT, incorporating additional fibre spools and auxiliary fibre sections
Range	Approximately 18 km
Sensing systems	Two ADVA FSP 3000 C systems equipped with coherent transceivers operating at 200 Gb/s
External support systems	FBG and load cell
Objective	Show that standard OPM parameters obtained from coherent transceivers can serve as indicators of environmental perturbations such as temperature variations and strain, without requiring dedicated sensing hardware
Use case	Optical network infrastructure protection
Note	

2.3. Demonstration of the Integrated Communication and Sensing

In addition to the previous experiment, an ICAS concept will be tested and demonstrated using the indoor and outdoor fibre setup within the use case of optical network infrastructure protection, focusing on simultaneous communication and distributed acoustic sensing (DAS) over the same optical fibre. The experiment will deploy a DAS system operating on a dedicated DWDM channel within a 100 GHz ITU grid, alongside coherent communication channels.

Two configurations will be tested: the first one is to use adjacent DWDM channels (e. g., 100 GHz spacing), the DAS and the data channel, with optionally an additional CW SoP signal in the other adjacent channel, to achieve a worst-case scenario for cross-phase modulation. Specifically, the DAS will occupy CH34, while two ADVA FSP 3000 C systems equipped with 200 Gb/s coherent transceivers will be deployed on adjacent channels CH33 and CH35. To emulate realistic network loading conditions, shaped amplified spontaneous emission (ASE) noise will be introduced to represent additional channels (CH29–CH32 and CH36–CH39), corresponding to four channels on each side of the coherent transmission channels. Overall, an optical bandwidth of approximately 1 THz will be loaded into the transmission fibre, including both communication and sensing channels.

The second one is to use the maximum wavelength range allowed in the C-band, e. g., 1530 nm for the data channel and 1565 nm (or even in the L-band, for instance, replacing the laser of the demonstrator with the available 1590 nm source) for the DAS. In this case, the Raman transfer will dominate.

The optical link will consist of the indoor fibre setup combined with an outdoor fibre segment and a laboratory fibre spool extending the total length to approximately 6.7 km. A perturbation section will be implemented on a section of the laboratory fibre spool. DWDM modules will be installed at both link

ends to multiplex and demultiplex the transmission channels. The communication performance will be evaluated primarily through the Q-factor metric reported by the coherent transceivers. In addition, selected OPM parameters will be collected and reported to the NMS to support the analysis. In parallel, the DAS system will generate optical pulses with defined duration and repetition rate, enabling distributed sensing along the fibre.

Controlled perturbations will be introduced using dedicated actuation equipment. A robotic arm will be used to apply a defined force at the perturbation section. The applied force will be independently verified using a load cell.

The demonstration will include two operational modes: communication-only and simultaneous communication and sensing. The impact of the DAS on communication performance will be evaluated by comparing the Q-factor in communication-only and simultaneous communication and sensing modes. Additionally, controlled mechanical perturbations will be introduced using predefined force levels (e.g., 0–20 N), with multiple repetitions, while monitoring both the sensing data and communication performance.

The objective of the demonstration will be to show that DAS and high-capacity coherent transmission can coexist within the same optical fibre. The experiment will validate that, despite external perturbations, the communication channels maintain error-free operation after FEC decoding.

Table 10: Overview of the second planned demonstration of ISAC

Topic	Description
Infrastructure	Extended indoor and outdoor fibre setups at BUT, incorporating additional fibre spool
Range	Approximately 6.7 km
Sensing systems	Two ADVA FSP 3000 C systems equipped with coherent transceivers operating at 200 Gb/s and OptaSense ODH-F
External support systems	A load cell to determine the exact pressure of the fibre
Objective	Show that DAS and high-capacity coherent transmission can coexist within the same optical fibre
Use case	Optical network infrastructure protection
Note	

2.4. Demonstration of the Intent- and Context-Aware Optical Network and the Final Demonstrator

The OpenIreland testbed will be used to carry out a lab demonstration of the intent-driven and context-aware control plane for optical fibre sensing. The demonstration showcases the capability of an intelligent control plane to autonomously configure and orchestrate sensing operations based on high-level operator intent, without requiring detailed technical specification of the underlying sensing parameters.

The control plane accepts sensing requests expressed at an abstract level, specifying only the event type of interest and the target location, and autonomously determines the appropriate sensing modality (e.g., DAS vs. Polarisation), the optimal sensing route through the network, and the number and placement of sensing probes required to fulfil the request.

A set of representative use cases will be defined, covering diverse event types and deployment conditions. Simulated disturbance events will include vibration signatures representative of real-world threats and activities, such as mechanical excavation and vehicle passage, as well as physical perturbations of aerial fibre infrastructure, including fibre sagging and objects impacting the cable.

The demonstration will systematically vary key parameters across use cases, including event location along the fibre within a metro network topology, distance of the disturbance source from the fibre (or equivalently, disturbance intensity), and background noise conditions. The latter will encompass both external environmental noise and optical noise contributions from co-propagating sources within the same fibre, including ASE noise and DWDM data channels (both coherent and direct detection).

The demonstration will be conducted within a laboratory-based metro network topology comprising multiple ROADMs, representative of a realistic Optical Spectrum as a Service (OSaaS) operational environment. The sensing control plane will operate alongside live DWDM traffic, reflecting the constraints and co-existence requirements of a production optical network.

The primary objective is to validate the ability of the intelligent control plane to autonomously derive an optimal probing configuration from minimal information by an operator. Performance will be assessed in terms of the classification and detection accuracy of the underlying machine learning algorithms, evaluated across the range of event types, locations, intensities, and noise conditions defined in the use case suite. The demonstration will thus provide evidence of the system's capacity to deliver reliable, intent-driven sensing as an automated network service.

As the work across all WPs of the ICON project progresses, their outcomes will be integrated with the TCD demonstrator, leading to the creation of the final demonstrator of the technology developed within ICON. This demonstrator will showcase the interoperability of the sensing solutions (SoP and DAS), the event classification algorithms, the ICON intelligent controller and the network controller. It will be based on the detection of threats to the network infrastructure and proactive switching of the traffic from the affected links.

The final ICON demonstrator will present an integrated demonstration of the project's optical sensing and control concept, combining relevant sensing technologies, analysis components, and control functions in a representative networking environment. It will be used to illustrate the overall approach to intent- and context-aware operation, including selected aspects of sensing, event interpretation, and interaction with network control mechanisms. The demonstration is expected to cover the project's main application directions, including the Availability Assistant and network intrusion-related scenarios, and to make use of the OpenIreland network/testbed as one of the representative environments considered for validation.

Table 11: Overview of the demonstration plan using the OpenIreland testbed

Topic	Description
Infrastructure	Indoor laboratory setup with fibre spools, ROADMs, coherent and direct detection transceivers and optical amplifiers.
Range	Approximately 100km
Sensing systems	OptoDAS, Adtran DistranSense and polarimeters
External support systems	Speaker and other mechanisms to create vibration and other events
Objective	Demonstrate autonomous decision-making in sensing probe selection and routing to satisfy a given sensing requirement, over shared fibre.
Use case	Environmental sensing
Note	

3. External Support Systems

This section presents the external support systems used in the demonstrations to provide independent reference data and assist in the validation and interpretation of detected events.

3.1. Fibre Bragg Grating

FBGs are millimetre-scale reflective microstructures inscribed in the core of an optical fibre. They reflect only a specific (Bragg) wavelength, while transmitting the remaining spectrum. The reflected wavelength shifts in response to temperature changes and strain, enabling precise measurement of these quantities. In the demonstrations, the FBG will serve as an external reference sensor providing independent validation of temperature variations and mechanical perturbations applied to the optical fibre.

3.2. Weather Station

The weather station is an external monitoring system used to record environmental parameters such as ambient temperature, humidity, atmospheric pressure, wind speed, and precipitation. These measurements provide independent reference data describing external environmental conditions affecting the outdoor fibre route. Within the demonstrations, the weather station will support the validation of detected events by enabling correlation between measurements and actual atmospheric conditions.

3.3. Camera

In the demonstrations, cameras will serve as external monitoring systems providing visual verification of experimental conditions and detected events.

3.4. Automatic Identification System (AIS)

For undersea infrastructure, the AIS ship-tracking system will serve as an external reference source, providing independent verification of vessel identity, position, speed, and course along the test corridor. The initial work here involves integrating the AIS data into the digital twin (DT) of the optical network. Within ICON, a DT for different sensor system layers, from the individual sensor elements to additional network components and sensor systems, is implemented. Digital twins provide a virtual representation and description of physical systems; however, they can also be used to include externally sourced information regarding those systems to provide a better understanding of measured events to the user. This is the goal for the digital twin of ICON: to be able to support the use case scenarios with meaningful external data for each sensor system. This includes the storage of weather data for both terrestrial and undersea fibre infrastructure and the tracking of ships by storing the information provided by AIS for undersea cables. Both applications are currently being implemented in the DT of ICON as external sensors. Within the DT, the measured data will be correlated with the relevant data from external sensors. This will enhance the understanding of the measured data and enable data assessment in a bigger picture. Relevant external sensors will be chosen and implemented by the partners depending on the application and use case to ensure optimised, sustainable data handling and storage. Thus, the DT will serve as the integration layer, combining information from support systems (i.e., external sensor data) and organising and distributing the relevant information to each sensor element and system.

In addition, the AIS data will be used to correlate and validate DAS observations (e.g., ship passages and blade-passing tones) and to label events in the dataset.

Conclusions

This deliverable has defined a comprehensive plan for the implementation of the demonstration activities, including the specification of the network configuration (i.e., fibre deployment type, indoor/outdoor, and fibre length) and the selection of appropriate sensing techniques. The assessment of the available partner infrastructures, both laboratory-based and field-deployed, has supported the design of the demonstration activities and deployment strategies.

In addition, an overview of external support systems available to the project partners has been provided, highlighting their role in supporting the validation and interpretation of detected events.

The presented plan establishes a solid basis for the subsequent deployment and validation activities and supports a consistent approach across the project partners.

The next steps involve the implementation of the planned demonstration activities, followed by the validation and evaluation of the results obtained.