

## OUTPUT FACTSHEET

|                                                                                                |                                                                                                                 |              |                                 |  |          |   |
|------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|--------------|---------------------------------|--|----------|---|
| Project index number                                                                           | CE0100439                                                                                                       | Acronym      | BIM4CE                          |  |          |   |
| Output type<br>("x" to be included)                                                            | Strategy/<br>action plan                                                                                        |              | Pilot action                    |  | Solution | x |
| Output number (O.xx)                                                                           | 2.5                                                                                                             | Output title | Measurement solution (hardware) |  |          |   |
| If the output target is > 1 in the AF, please specify the output(s) described in the factsheet |                                                                                                                 |              |                                 |  |          |   |
| Output delivery date                                                                           | 3/30/2025                                                                                                       |              |                                 |  |          |   |
| Project website                                                                                | <a href="https://www.interreg-central.eu/projects/bim4ce/">https://www.interreg-central.eu/projects/bim4ce/</a> |              |                                 |  |          |   |

### Summary description of the output

Please present the output by addressing the following topics.

#### ***Territorial challenges and needs in the regions specifically addressed by the output***

(max. 700 characters)

In both Slovenia and Germany, bridge infrastructure is highly vulnerable to water ingress, which can cause corrosion, structural deterioration, and costly repairs. Traditional inspection methods often fail to detect leaks at an early stage, particularly under harsh environmental conditions. As part of Output 2.5, pilot actions were carried out on the Tomačev Bridge in Slovenia and the IDA-KI Bridge in Germany to test a flexible leakage sensor foil with high-resolution detection.

At the Tomačev Bridge, the sensor was integrated with Weigh-in-Motion (WIM) sensors, enabling continuous monitoring of both structural moisture infiltration and traffic loading. At the IDA-KI Bridge, the system was tested under challenging weather conditions, demonstrating its ability to detect leaks reliably and at an early stage. Together, the pilots proved that combining leakage detection with structural and traffic monitoring supports more accurate maintenance planning, prevents long-term damage, and extends the service life of bridges across Central Europe.

#### ***Main aim(s) of the output and how it contributes to tackle the identified challenge(s)***

(max. 500 characters)

The aim of Output 2.5 is to deliver a reliable hardware solution for early leakage detection in bridges, using TU Dresden's flexible sensor foil integrated with real-time data acquisition. With a detection resolution of 0.1 ml, the system identifies water ingress at an early stage, even under harsh environmental conditions, enabling timely maintenance and preventing corrosion-related damage.

The solution was demonstrated through pilot actions in both Germany and Slovenia. On the IDA-KI Bridge in Germany, the focus was on validating the sensor's performance under challenging weather conditions and on ageing infrastructure, proving its effectiveness in improving safety and reducing repair costs. On the Tomačev Bridge in Slovenia, Cestel and ZAG installed the leakage sensor foils alongside Weigh-in-Motion (WIM) sensors, creating an integrated setup that monitors both moisture

**Technical description of the output (e.g. scope, main features, innovative elements etc.)**

(max. 1500 characters)

Output 2.5 provides the hardware for the BIM4CE bridge monitoring system, focused on the innovative flexible leakage sensor foil developed by TU Dresden for large-scale water ingress detection. The foil operates between -20 °C and 140 °C, with a thickness of 125 µm, tensile strength of 260 MPa, and 100% elongation at break. It detects leakage through capacitance changes with a resolution of 0.1 ml, ensuring high sensitivity even in harsh environmental conditions such as those on the IDA-KI bridge in Germany.

The foil is connected to a safe low-voltage power supply, eliminating electrical contact risks, and wirelessly transmits data to a bridge-based server. This data, combined with inputs from other sensors, is sent to the BIM4CE cloud platform for integration into the digital twin, enabling continuous monitoring, early leak detection, and informed maintenance planning.

**Involvement of target groups during output development and/or implementation**

(max. 700 characters)

Infrastructure operators, bridge owners, monitoring specialists, and research institutions from Germany, Slovenia, and Italy were actively involved in the development of Output 2.5. Through workshops, pilot testing, and on-site demonstrations, stakeholders such as TU Dresden, ZAG, Cestel, and SPd contributed expertise on sensor design, calibration, and data integration. Their feedback ensured that the leakage sensor foil meets operational requirements, withstands environmental challenges, and remains fully interoperable with existing monitoring systems.

**Cooperation dimension of the output, i.e. joint development within the partnership and, if applicable, joint implementation (see output indicator definitions in chapter I.3.3 and Annex 2 of the programme manual)**

(max. 700 characters)

Output 2.5 was jointly developed through close collaboration between TU Dresden, ZAG, Cestel, SPd, and associated partners Flexora GmbH and Hentschke Bau GmbH. TU Dresden led the design of the flexible leakage sensor foil, while ZAG carried out laboratory testing and calibration. Together with Cestel, ZAG also installed the leakage sensors and Weigh-in-Motion (WIM) sensors on the Tomačev Bridge in Slovenia. Cestel further managed the integration with the bridge server, and SPd connected all data to the BIM4CE cloud platform. This coordinated partnership ensured technical compatibility, scalability, and applicability of the solution across Central Europe.

**Results - expected change and lasting effects in the territories generated specifically by the output, its uptake by relevant organisations and benefits for target groups**

*(max. 1000 characters)*

Output 2.5 delivers an innovative leakage detection hardware solution, enabling early identification of water ingress in bridges with high accuracy (0.1 ml resolution). In Germany, the system demonstrated its ability to shift maintenance from reactive to preventive, reducing corrosion-related damage, extending bridge lifespan, and lowering repair costs. On the Tomačev Bridge in Slovenia, Cestel and ZAG installed flexible leakage sensor foils alongside Weigh-in-Motion (WIM) sensors, creating a combined system that monitors both moisture ingress and traffic loading.

By integrating with the BIM4CE cloud platform and other sensors, the solution enables continuous real-time monitoring and informed decision-making. Its lasting effect will be safer, more resilient infrastructure, transferable to other regions in Central Europe, and a benchmark for incorporating advanced sensing technologies into structural health monitoring frameworks.

**Ownership and durability of the output after the project end, considering financial and institutional support including, if applicable, maintenance**

*(max. 700 characters)*

The technology, materials, and all flexible leakage sensors developed for Output 2.5, together with the associated data acquisition systems, are the property of TU Dresden. This includes the sensor foil design, calibration procedures, and integration components. At the Tomačev Bridge in Slovenia, Cestel and ZAG carried out the installation of the leakage sensors alongside Weight in Motion (WIM) sensors, ensuring full integration with the monitoring system. TU Dresden retains full intellectual property rights, while project partners may request access for future bridge monitoring applications, enabling continued use and replication of the solution across Central Europe.

**Transferability of the output to other territories, sectors or target groups and planned measures for supporting such transfer**

*(max. 700 characters)*

Output 2.5 is fully transferable to other territories and target groups, including local authorities, infrastructure operators, and monitoring specialists across Central Europe. The flexible leakage sensor foil and acquisition system, as well as the combined setup with Weight in Motion (WIM) sensors tested on the Tomačevo Bridge in Slovenia, can be adapted to different bridge types and climatic conditions. Integration with the BIM4CE cloud platform enables straightforward replication, supporting early leakage detection, traffic load monitoring, preventive maintenance, and enhanced safety in diverse regional contexts.

|                                                                                     |                                                                                                                                                             |
|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Related final deliverable(s)<br/>(Number(s) and title(s) to<br/>be included)</b> | Deliverable 2.2.1 Data sheet sensor foils                                                                                                                   |
| <b>Output web link<br/>(if applicable)</b>                                          | <a href="https://www.interreg-central.eu/news/bim4ce-is-implementing-novel-sens">https://www.interreg-central.eu/news/bim4ce-is-implementing-novel-sens</a> |
| <b>GPS coordinates<br/>(if applicable)</b>                                          | 51°12'04.5"N 14°24'23.8"E                                                                                                                                   |