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INBRIDGE4EU PROJECT FOR BRIDGE DYNAMICS: TOWARDS INTEROPERABILITY IN THE EUROPEAN RAILWAY NETWORK

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Abstract. *In this contribution the objectives and initial activities from the InBridge4EU project are presented. InBridge4EU was awarded to a consortium of 11 members, including two infrastructure managers, DB Netz AG and ADIF, and four Spanish universities: Universidad Politécnica de Madrid, Universidad Politécnica de Valencia, Universidad de Sevilla and Universitat Jaume I de Castellón. The project's proposal is aligned with the European's Rail Joint Undertaking overall targets in the following domains: (i) contribute towards the achievement of the Single European Railway Area by defining Europe-wide harmonized standards and interoperability criteria; (ii) improving bridges' structural analysis to optimise the railway capacity meeting user demand; (iii) establishing criteria for bridges' structural performance, increasing the quality and consistency of the service; and (iv) contributing to reduce the design and maintenance cost of bridges stock, improving the competitiveness of the European rail system overall. Detailed analysis is being carried out for 9 railway lines belonging to 5 different countries in the European Union covering a wide range of structural types and maximum speeds. The overall objective of InBridge4EU project is to develop a dynamic interface between railway bridges and rolling stock, proposing new methods compatible with existing regulations, and approaching the analysis of existing infrastructures, which role is critical for the sustainability of the European rail system. The project is organized in seven work packages that aim to address the 11 different Work Streams stipulated in the call topic and in the ERA Technical Note [1].*

1 INBRIDGE4EU PROJECT: MAIN OBJECTIVES AND PARTICIPANTS

InBridge4EU project started on September 1st 2023. The project is funded by Europe's Rail Joint Undertaking under Horizon Europe research and innovation program. The overall objective of InBridge4EU is to develop a dynamic interface between railway bridges and rolling stock, proposing new methods compatible with existing regulations, namely INF TSI [2], LOC&PAS TSI [3], EN 15528 [4], EN 1990-Annex A2 [5] and EN 1991-2 [6], and approaching the analysis of existing infrastructures, which role is critical for the sustainability of the European rail system. 11 entities including two Infrastructure Managers and four Spanish universities (see Fig. 1 left) participate in the consortium, led by Universidade do Porto. The project is articulated in seven work packages with the following objectives:

- WP1: Definition of Dynamic Line Categories for ensuring compatibility of the interface between trains and bridges. Objective: to improve the practical methods available for determining the train-bridge interface for dynamic loading effects, based on the use of spectral methods and transient dynamic analysis.
- WP2: Identification of critical bridge parameters for the assessment of the economic impact of the new DTCs. Objective: to estimate the time and cost of physical works required for implementing each proposed DTC in average on a line.
- WP3: Revision of the dynamic factors Φ' and Φ''. Objective: to propose revised formulae for the dynamic factors Φ' and Φ'' stipulated in the Annex C of EN 1991-2 [6].
- WP4: Revision of damping in railway bridges. Objective: estimating damping in different bridge types based on experimental data and identifying the main parameters that most influence the damping values of existing railway bridges and the main reasons for the wide range of damping values observed in similar structures.
- WP5: Revision of bridge deck acceleration limit. Objective: to provide additional background to a revised limit criteria for vertical bridge deck acceleration.
- WP6: Recommendations for dynamic compatibility checks. Objective: proposing recommendations to the regulatory bodies, namely the European Union Agency for Railways (ERA) and the European Committee for Standardization (CEN), for reviewing or implementing updates in the current Eurocodes and Technical Specifications for Interoperability (TSI) based on the research carried out in WP1 to WP5.
- WP7: Project coordination, scientific quality assurance and dissemination, exploitation and communication.

2 WP2: IMPLEMENTATION OF BRIDGE DATA BASE

The coauthors of this contribution participate actively in WP2 tasks. In WP2, during the first year of the project, an extensive and representative set of European railway bridges needs to be selected, and relevant data needed to evaluate their dynamic performance retrieved and stored in a database. Starting from the beginning of the second year, time-step calculation (TSC) transient dynamic analyses will be performed over the complete database under real train models / MU classes and under the new DTCs proposed in WP1. From the analysis of the database realistic worst-case combinations of critical parameters for use in parametric studies will be identified. From the detection and evaluation of the bridges that do not meet the economic technical acceptance criteria an estimation of the resources required for implementing each DTC on a particular line will be presented. Relevant output will also be provided in relation to the appropriateness of different model updates and of the use of the classical beam line model for the analysis of certain bridge configurations.

So far, 10 railway lines from 5 EU countries have been selected covering different maximum design speeds (see Figure 1 right). Relevant information from about 50 bridges per line has been retrieved with the intensive participation of the corresponding Infrastructure Managers, including technical drawings and experimental data (Figure 2 left). In parallel, a cloud database has been designed and made accessible to all the partners in the consortium (Figure 2 right). The data base will accommodate the bridges data and the results of posterior analyses.

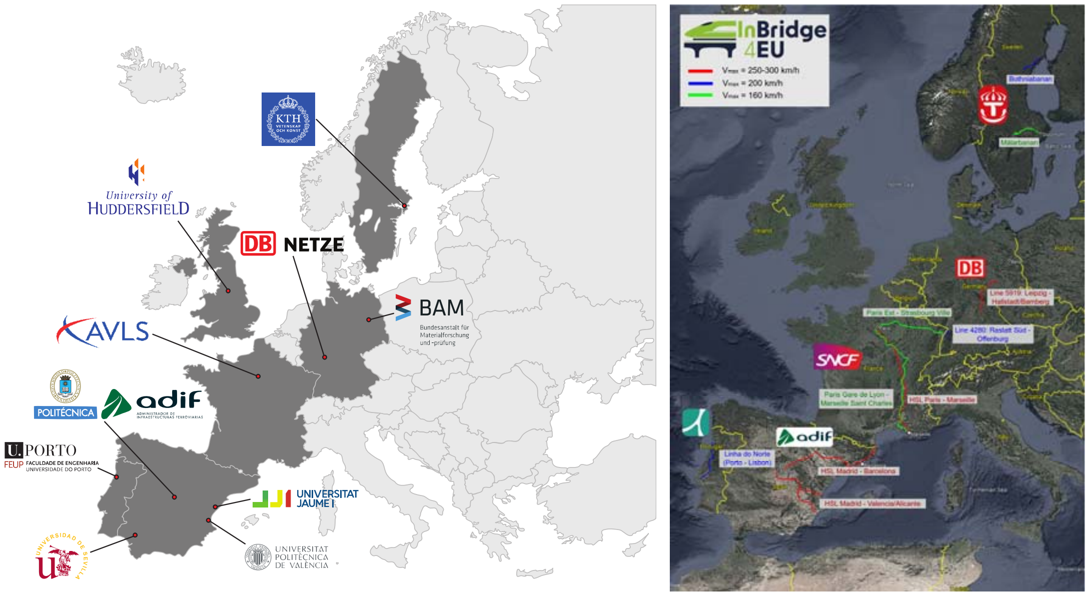

Figure 1: InBridge4EU consortium (left) and selected railway lines (right).

3 WP2: FUTURE TASKS

In the upcoming months, time step calculations will be performed with different complexity models for the bridges, depending on the configuration. Interaction phenomena will be disregarded (i.e., vehicle-bridge, soil-bridge) and modal superposition will be admitted, limiting the computation costs. Detailed 3D numerical models will be used for the bridges requiring further investigation to confirm if they meet the technical bridge acceptance criteria. For those failing this last check, the nature of the likely physical works most appropriate in each situation (e.g. strengthening, stiffening, deck substitution, complete substitution) will be identified and economically appraised. From the statistical analysis of the database, realistic bridge parameter combinations, the distribution of most critical parameters and most critical parameter combinations considering parameter interrelations will be identified. Existing bridge configurations that cannot be adequately represented by simple line beam models in dynamic analyses will be identified and the limitations of the beam-type analysis will be evaluated and compared to alternative models.

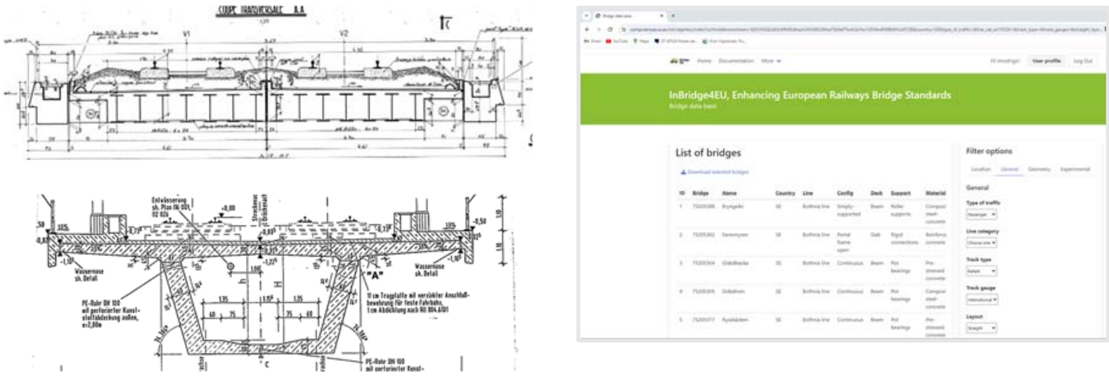

Figure 2: Example of bridge deck typologies (left) and cloud data base interface (right).

4 CONCLUSIONS

The outcomes of the project will have a clear impact on the current European normative documents related with bridge dynamics and on the harmonisation of working methods across European countries. The outcomes will consequently influence the design of new railway bridges and the evaluation/monitoring of existing ones. In addition, InBridge4EU results will influence over time several critical aspects related to railway bridges and respective interaction with rolling stock.

5 ACKNOWLEDGEMENTS

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