NextVIS Visibility Prediction Framework –

a next-generation model for visibility in smoke in the built environment

The ITB research project, financed under the "OPUS 20" competition by the National Science Center in Kraków, under contract No. **UMO-2020/39/I/ST8/03159,** implemented on the basis of the Lead Agency Procedure

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Project implementation period: 18. 01. 2022 – 17. 01. 2025

Total budget of the project: PLN 1 059 814

The following activities have been planned as part of the project:

1. Preparation of next-generation visibility in smoke experiments
2. Visibility Prediction Framework (VPF) model development
3. Experiments on the visibility in smoke in compartments
4. Model evaluation and validation
5. Use of VPF for computing visibility in a built environment

Strategic goal of the project: The main goal of the project is to develop a new model of visibility in smoke. The model will be made available in the form of the **Visibility Prediction Framework platform**, which will allow for processing numerical modelling results in context of visibility, and thus will be used in determining the **fire safety of buildings**.

Project results: As part of the research, a **physical model of the interaction of light with smoke particles** will be used in place of the existing simple relation linking the smoke concentration with visibility. This will allow to precisely define what the tested object will look like (evacuation sign, exit, obstacle) in the eyes of the evacuating person. Thanks to this simulation, **"visibility maps"** will be obtained in many places in the building, in which areas where visibility is good or bad will be marked. It will be possible to find **solutions tailored to each building**, such as the use of larger escape signs or a change in the emergency lighting strategy. **A modern tool** will be created that will enable the design of fire-safe buildings and will contribute to the development of fire science.

NARODOWE CENTRUM NAUKI

Popular science summary

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Smoke is the greatest threat in building fires. The smoke and its constituents – the toxic products of combustion, may lead to poisoning, incapacitation or even death. The first effect that smoke has on humans is the reduction of visibility – the smoke conceals evacuation signs and exits, and makes the orientation in space a very difficult task. The loss of visibility happens at a very low concentration of smoke. In fact, this concentration is so low, that if the visibility through smoke is not significantly reduced, it also means the smoke is not a direct threat to life in a short exposure. This concept is profound to the design of **safety systems in buildings**, and it is the part of determining the Available and Required Safe Evacuation Time.

Assessment of visibility is fundamental to building safety. Yet, we do not have adequate tools to do this. The existing model of T. Jin was created in Japan in the 1970s and has not been significantly modified since then. The tools at our disposal have certainly evolved for the last 50 years, but in the field of visibility in smoke, we can still only 'appraise' it, rather than 'model'.

The **NextVIS** project is our response to this dire need. In place of the existing relationship between the concentration of smoke and visibility (at a smoke concentration of … the visibility is …), we intend to implement a physical model of photon and smoke particle interaction. This will enable us to precisely model the appearance of a target (evacuation sign, exit, obstacle) through a layer of smoke, as in the eye of the observer. If we use this tool to assess the visibility in multiple locations in a building, we will be able to map the areas with good and poor visibility. In contrast to the existing simple model, our tool will allow evaluating the impact of the characteristics of an evacuation sign (size, colour, light intensity) or the architectural context of the building. This will enable safety solutions tailor-fit for the building, e.g. use of larger evacuation signage or change in the emergency lighting strategies. The existing model of Jin does not allow for that.

Our next-generation model for visibility in smoke will have a considerable impact on fire science. The scientists do base their conclusions related to safety on parameters that can be measured. Visibility in smoke is one of such parameters; arguably, the most popular one. Many recent research projects on innovative measures to provide safety in fires is, in fact, the research on how to improve visibility in smoke in the most efficient way. Our model will be built into a software package – the **Visibility Prediction Framework**. This package will be open-source and available to everyone. This model will be directly useful to the researchers in the most innovative research fields in fire science, such as the use of Virtual Reality to investigate human behaviour in fires.

The project is designed for three years, in which two research teams will conduct their tasks in cooperation. In Poland, the **Building Research Institute (ITB)** team will perform novel experiments on the visibility in smoke conditions, which should reveal the smoke obscuration effects with the highest precision, so far. Observers will participate in these experiments, to help us determine at what distortion conditions the evacuation sign stops being visible. This data will be used by the German team of the **University of Wuppertal (BUW).** The German team will be building the heart of the project – the VPF framework. This will be the tool, that will allow modelling the visibility in smoke. After two years in development, we will use the VPF in the built environment. We will carry further experiments, this time in real buildings. We will start fires, and try to model them. By comparing the predicted and observed results, we will be able to improve our model and verify its capabilities in assessing the safety of buildings. We hope that our next-generation model will become a part of this toolbox, and will help design new buildings that provide better safety to their occupants.