Blueprint report 2.1.6: Dwelling modelling in support of renovation package selection and production

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This work stream aims to establish a digital twin of the dwelling upgrade selection and construction process as a means to support upgrade package efficacy confirmation, constructability assessment and factory machine programming as illustrated in Figure 1.

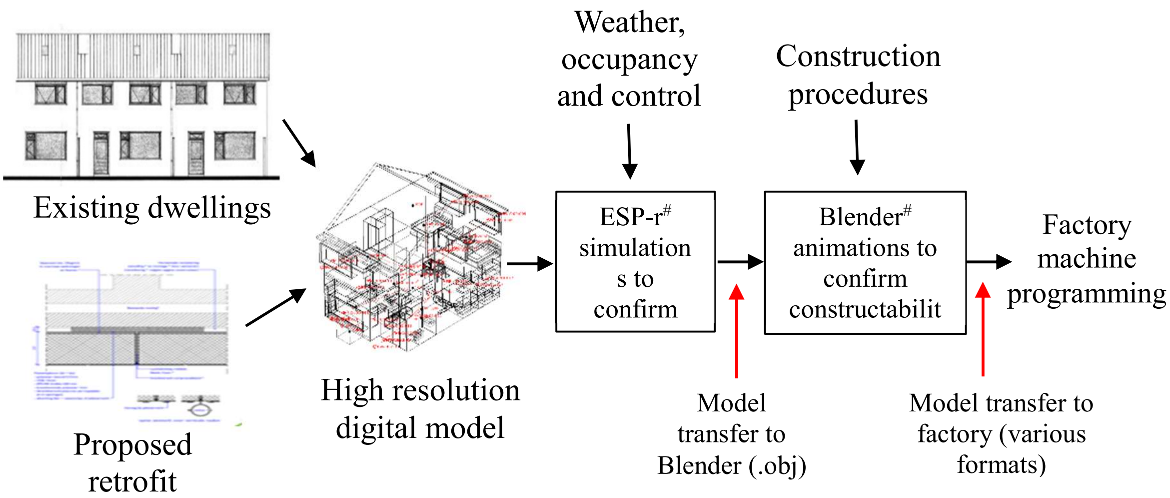

Figure 1: The dwelling upgrade evaluation process.

At the start of the process, information is collected on the dwellings being targeted for upgrade and these data are used to create high resolution digital models of representative cases. This information is collated from sources such as construction drawings, manufacturers' data, site visits and the building standards prevailing at the time of construction. It may be expected that the future evolution of the BIM standard will significantly simplify this activity. It should be noted that the creation of a high resolution digital model of a building requires substantial data: 3D geometry; hygro-thermal properties of construction materials; thermal bridge and air leakage characteristics; internal thermal mass; operational details (occupancy, lighting and small power); heating, ventilation, and domestic hot water systems; control system targets and settings; and embedded renewable energy systems (photovoltaic components, heat recovery *etc*.).

This model is then automatically adapted to include the proposed retrofit package (wall and roof replacement plus heat pump and photovoltaic components for example) and subjected to 'before and after', life-cycle ESP-r simulations as a means to confirm the efficacy of the intended upgrade. Where the predicted improvements in energy use, indoor comfort and emissions are deemed unacceptable, exploratory simulations are undertaken to refine the

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[#] These applications were employed in the project because they are freely available under an open source licence. They can, of course, be replaced by other applications that offer the same functionality.

upgrade specification. Within the project to date, this simulation-based upgrade appraisal capability has been demonstrated for 3 archetype dwellings (terraced, semi-detached and apartment) and for an upgraded showcase house owned by the Domijn Housing Cooperation in Enschede in the Netherlands.

After the efficacy of the proposed upgrade has been confirmed, the construction-related aspects of the ESP-r model are transferred to the Blender application in the form of an open format, Wavefront .obj file* as depicted in the example (here an office) of Figure 2.

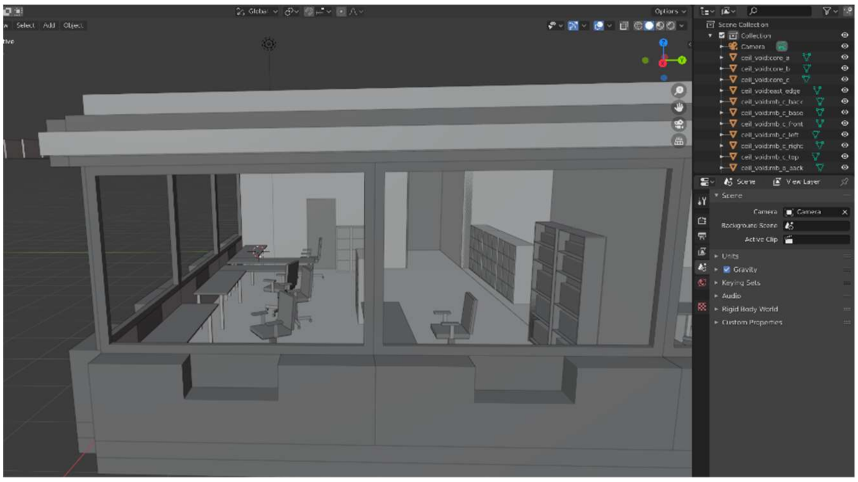

Figure 2: An ESP-r .obj export file displayed in Blender.

Blender's construction animation functionality is then employed to confirm the constructability of the upgrade. Thereafter, the model can be output in a variety of formats to support the establishment of the instruction sets required to control factory-floor robotic production equipment. As an example, Figure 3 shows the PruserSlicer 3D Printing application processing a .stl file delivered from Blender (left) and the subsequent object printing using a Prusa Mini Compact 3D Printer (right)*.

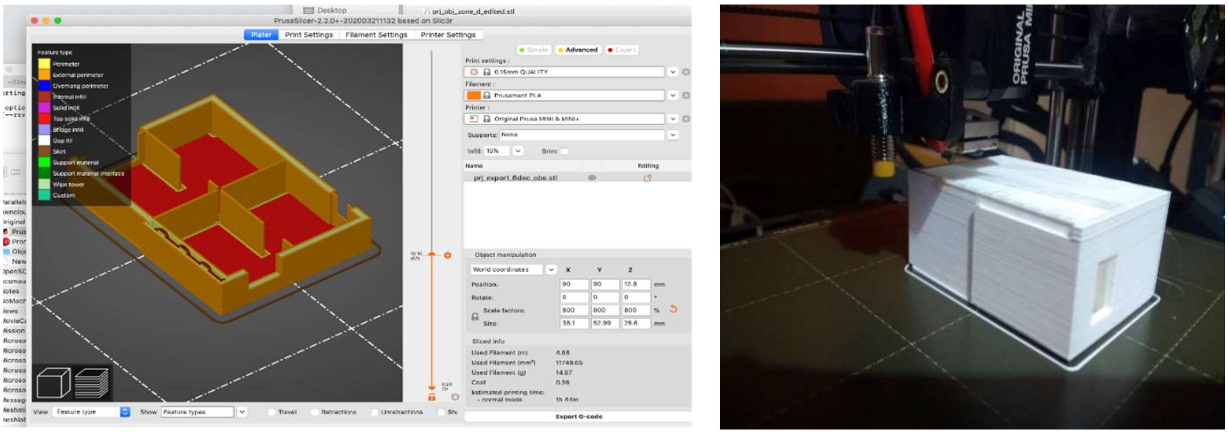

Figure 3: Digital model processing and final 3D printing operation.

The deliverables from the project will include the procedure encapsulated in Figure 1, examples of its applications to typical dwellings, and the results from performance assessments of the project's showcase dwellings.

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* These new capabilities were developed within the project.