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Applying urban-scale 3D subsurface modeling to sustainably manage the underground assets of Rotterdam (NL)

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The greater City of Rotterdam has c. one million inhabitants and is hosting one of the busiest shipping ports in the world. Yet, the coastal-deltaic plain the city is situated on poses specific problems regarding its long-term sustainability. For example, building on soft soil combined with artificial lowering of the groundwater level has led to persisting subsidence and high maintenance costs for houses, public space and utilities. Better knowledge of the ground beneath our feet could have prevented or mitigated such unfavorable subsurface-related processes and events. Combining functions (e.g. subsurface infrastructure and stormwater storage) could have minimized pressure on scarce open areas. The Dutch government has recently introduced 3D spatial planning as a tool for integral planning of the above-surface and subsurface space.

To optimize the use of the subsurface in city development and thus increase the resilience of the city, the Municipality of Rotterdam and the Geological Survey of the Netherlands (TNO-GSN) collectively develop methods to increase the understanding of the subsurface geometry and properties. This information is subsequently coupled to 3D spatial claims to assist in 3D city planning and ultimately to sustain the welfare of the citizens of Rotterdam.

Figure 1: Geological voxel model of Rotterdam

Current nation- to region-wide 3D subsurface models are not particularly suited to be used in 3D urban planning processes. The most enhanced model in use in the Netherlands is GeoTOP, schematizing the subsurface up to a depth of 50 m in voxels of 100 by 100 by 0.5 m. For each voxel the model provides estimates of the geological unit and lithological class, including uncertainties. GeoTOP can also be populated with an expanding range of derived parameters, for example hydraulic conductivity and geochemical reaction capacity. To improve the applicability of GeoTOP in urbanized regions focus has been particularly on:

1. Improving model resolution by increasing the amount and diversity of input data. Apart from traditional borehole data, historic maps have been used, as well as abundantly available geotechnical measurements, for example cone penetration test data.
2. Improving mapping and characterization of man-made deposits. This is being achieved by using for example archaeological research results.

3. Integrating 3D models of geology, man-made deposits and subsurface infrastructure, and visually combining these with above-ground information.

In this presentation, we show that the resulting 3D subsurface model for the city center provides the detail necessary to make the right decisions on 3D spatial planning issues. As such, the urban-scale model assists the Municipality of Rotterdam in assessing current and future subsurface-related risks, as well as taking full benefit of the opportunities the subsurface provides.