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Solving the puzzle of Digital Twins in Urban Drainage in a utility

A.N. Pedersen*, M. Borup, A. Brink-Kjær*, L.E. Christiansen*** & P.S. Mikkelsen****

*VCS Denmark, Vandværksvej 7, 5000 Odense C, Denmark, anp@vandcenter.dk
**DTU Environment, Bygningstorvet, Bygning 115, 2800 Kgs. Lyngby, Denmark, psmi@env.dtu.dk, morb@env.dtu.dk
***DTU Compute, Richard Petersens Plads, bygning 324, 2800 Kgs. Lyngby, Denmark, laec@compute.dtu.dk

Abstract: Digital twins are a fairly new concept in urban drainage, and it is considered in the on-going project if there should be two twins, an identical and a fraternal twin with different objectives. The elements in these twins are mostly the same, however used differently. The preparation of these elements can be time- and resource demanding but is a needed investment in order to secure a high-level digital twin. In the on-going project it is investigated to which degree the digital twins, both the identical and the fraternal twin, is able to replicate the reality with the objective in mind and which elements in the digital twins that should be improved.

Keywords: digital twin; urban drainage; validation

During the last decades hydraulic models of urban drainage systems are built in order to plan and simulate effects of any changes in the system. The objective of these models has undergone changes as the requirements to urban drainage systems are no longer only to secure human health, but also to protect natural values and preserve the natural water cycle at the lowest cost in terms of energy and money.

With a trustworthy hydraulic model, it is possible to develop and compare various solutions against each other. Earlier, it was known that the models were not perfect, but it was the best way to design optimal solutions. There was as expectancy that the more details that were included in the models, the more reliable the model output would be. However, what was experienced was that this does not always follow hand in hand. Something more is needed, and the digital twin terminology is now being considered in the water sector (Sarni et al., 2019). The model is only one element in a digital twin. Other elements could be real-time input, historical data, satellite-data, machine-learning etc. A digital twin can be understood in many ways; however, the basic idea is that the digital twin consists of many elements and it is able to simulate the reality to a certain degree depending on the objective. The objectives of the digital twin can be e.g. documentation of the system performance, understanding the system dynamics, real-time knowledge of the state of the system, real-time control, planning and maintenance of the urban drainage system.

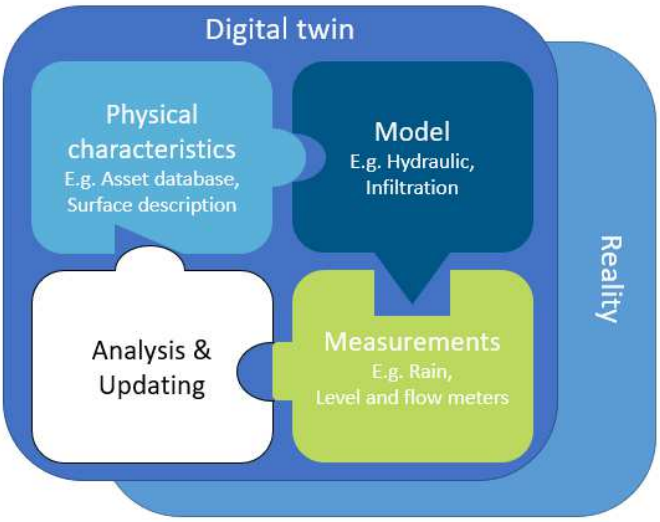

Figure 1 Schematised view of some of the components trying to fit it all to a good digital twin of reality.

As an illustration of a digital twin, a puzzle can be introduced, see Figure 1**Fejl! Henvisningskilde ikke fundet.**. The reality is the total picture, and each puzzle piece is a component of the digital twin, which need to fit to each other in order to make the digital twin work. The puzzle may not be easy to solve, as the output from each component may not match exactly in the other components, which can make the total picture blurred in some corners, whereas other corners are spot-on. The current project will highlight where there is a mismatch between the puzzle pieces, but also to show which data input can be/is needed to make a digital twin from an urban drainage network perspective.

In VCS Denmark the objectives for having a digital twin are primarily to be able to document the system performance and to use the digital twin as a planning tool. For this to happen it is necessary to think in two different twins. They could be called identical and fraternal twins. The identical twins are exactly alike. To make sure that the unknowns are caught, real input as timeseries is inserted e.g. the dynamically boundary condition of inflow to the treatment plant or the actual emptying procedure of the basins. Thereby it is possible to minimize the disturbance from the knowns in order to consider and handle the unknows, which could be e.g. in- and exfiltration. This identical twin can be used for e.g. retrospective documentation of combined sewer overflow volumes or filling degrees of pipes. The fraternal twin, which is not completely identical, can be used for planning where real-time inputs are replaced with e.g. rule-based methods or conceptual models. This could for instance be that a pump is modelled using ideal characteristics instead of the real characteristics, pipes that are expected to be nice and smooth instead of deteriorated and rough as old pipes could be in an identical twin. The reason for doing this is to include the water in downstream structures, as if the pipes where relined, which is highly certain that they would be during a long planning horizon. With a combination of the two twins, it is possible to know the unknowns better, and thereby be able to describe them better in both models, thereby making the planning and design tools stronger.

For VCS Denmark there has been an extensive work during the last decade to ensure that the data in the utility is trustworthy and can be integrated in the digital twins through continuously updating of e.g. the asset database. This database is semi-automatically transferred to a hydraulic model, Mike Urban, through a model-updating software. The runoff is computed using impervious area estimates obtained

from satellite data. To validate the model, and to calculate retro-perspective what happened the day before, VCS Denmark measure the rain at several rain gauges and with radar and measure the depth of water at several locations in the urban drainage system. This input is incorporated in a “day model”, which simulate the previous day and compare output with observations. In order to figure out if some puzzle pieces are missing, the current project looks into a continuous validation of the digital twins comparing them with the reality in order to find the missing pieces of the digital twins. Thereby it can be possible to figure out if the conceptualisation of an element is sufficient to match the digital twin.

An experienced co-benefit of having the building and verification of models, asset data and system observations integrated in a structured way, where different departments in the utility contributes in the process, is that the quality of the data becomes higher as data now serves multi-purposes. This also integrate into the vision of VCS Denmark of digitalisation and usage of the data collected smart and efficiently.

REFERENCES

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