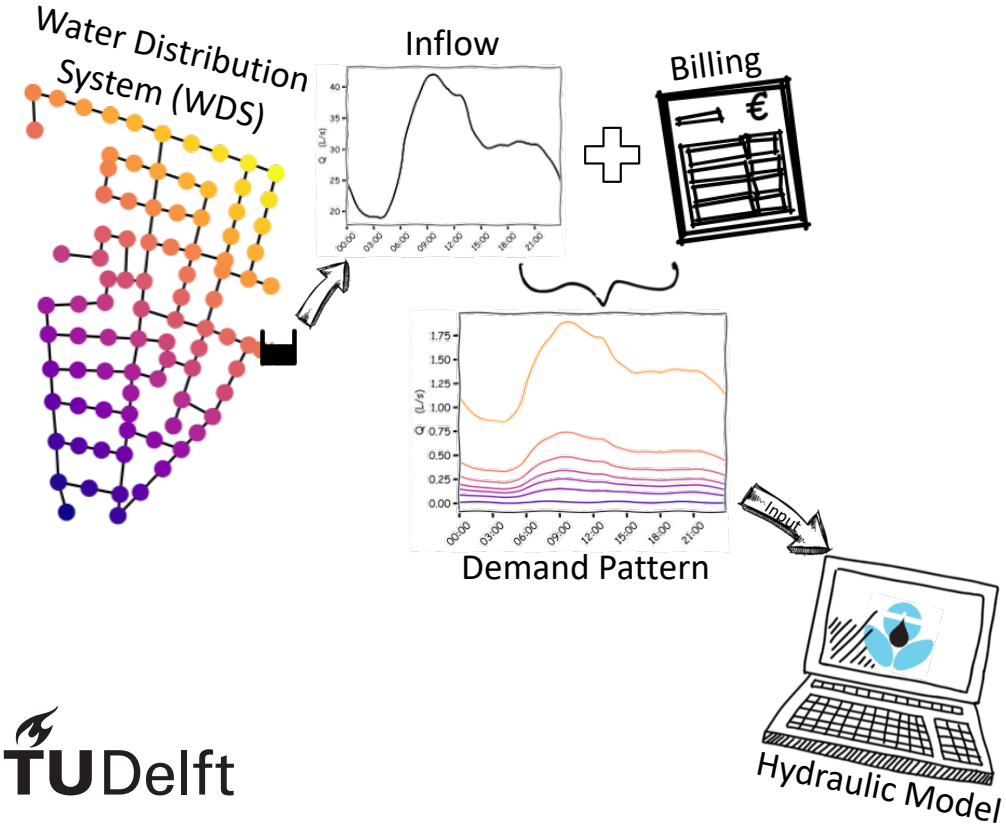
# DASH of Water

## Water Distribution System Modelling in the Age of Smart Water Meters

D.B. Steffelbauer, E.J.M. Blokker, A. Knobbe, E. Abraham

TU Delft

# The “good” old way to model demand

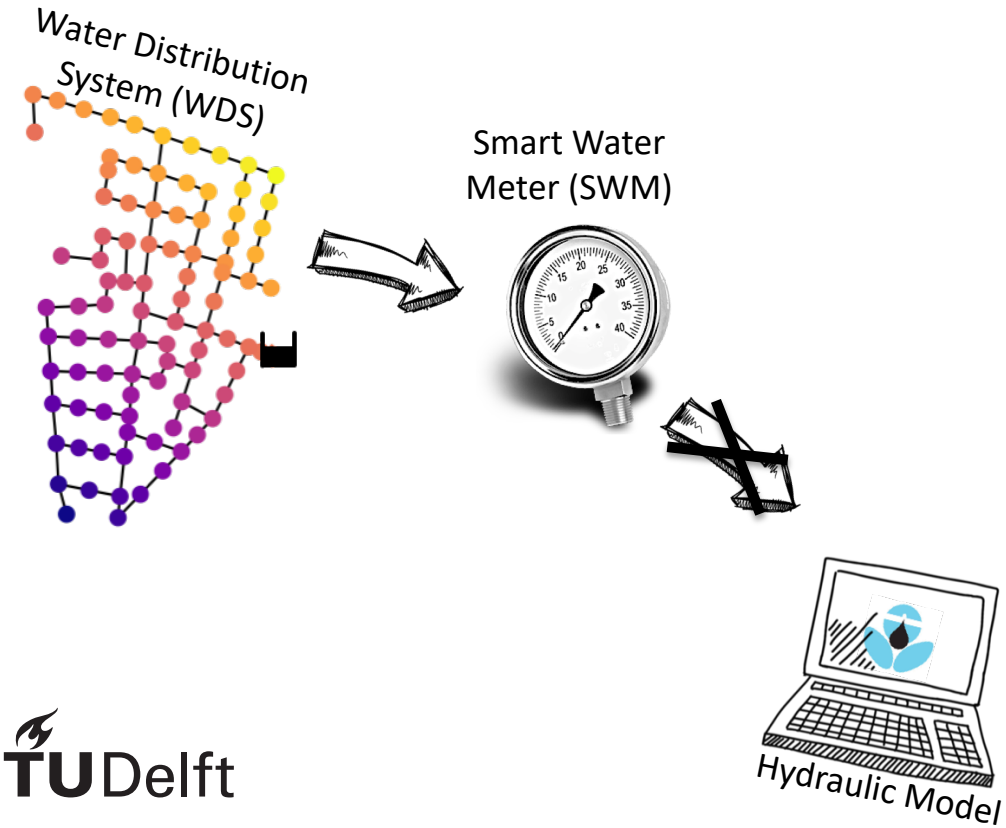



Water demand is one of the uncertain factors in WDS modelling.

The usual approach to model water consumption in hydraulic models is to produce water demand patterns according to inflow measurements and water meter readings from billing information (monthly, yearly).

Consequently, all customers consume water at the same time in hydraulic models, which does not represent the dynamics of those systems in a realistic way.

# The age of smart metering

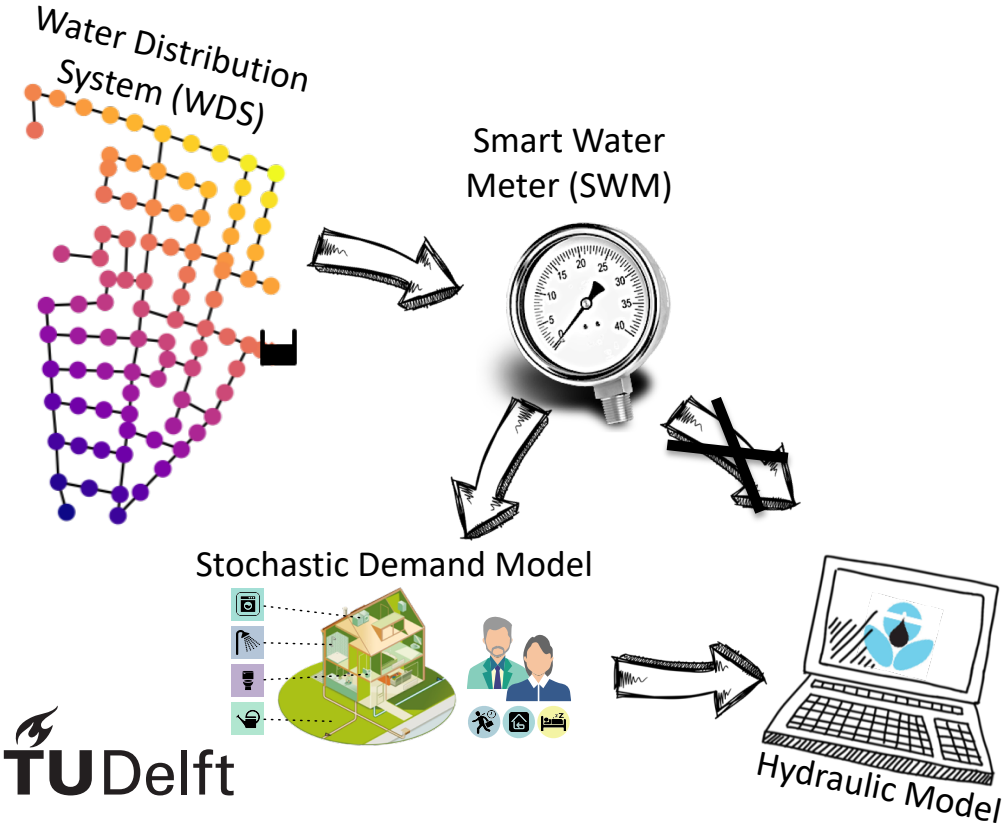



Since more than a decade, SWM meters are available that provide demand information in (near) real-time. However, this information is not used for WDS modelling, since there exist no interfaces between these information and hydraulic models, e.g. EPANET.

Even if we would have those interfaces, a lot of open questions still remain:

- What if not all customers are measured?
- What is the benefit of knowing the current demand load w.r.t. extreme scenarios and faults?
- How useful are SWM for forecasting?
- ….

# The “DASH of Water” approach




DASH of Water uses an alternative approach to link SWM with hydraulic models, through a small detour over stochastic demand models.

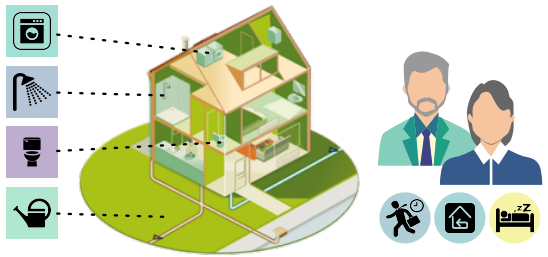
Data science algorithms are used retrieve information of the customers from SWM data.
This information is used afterwards to parametrise and improve stochastic demand models.
Subsequently, stochastic demand models are used as inputs of hydraulic computer models.

Hence, the improved demand models can be used for

- … forecasting future demand loads
- … infer demand to unmeasured locations
- … generating realistical demand for hydraulic simulations (e.g. fault detection,…)
- ….

TU Delft

# Stochastic Demand Model



SIMDEUM® KWR

Blokker, E. J. M., Vreeburg, J. H. G., & van Dijk, J. C. (2010). **Simulating Residential Water Demand with a Stochastic End-Use Model**. *Journal of Water Resources Planning and Management*, *136*(1), 19–26.

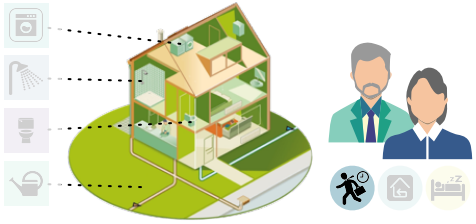
The stochastic demand model SIMDEUM is used within project DASH.

SIMDEUM is a water demand end-use model that is capable of simulating water usage at household level with a time resolution of down to one second SIMDEUM generates randomly water end-use events based on statistical information of users and end-use devices (census data for the number of residents in a household, their age distribution, average number of appliances, daily routines, duration and intensity of different end-uses such as kitchen tap uses, toilet flushes, showers per day ...).

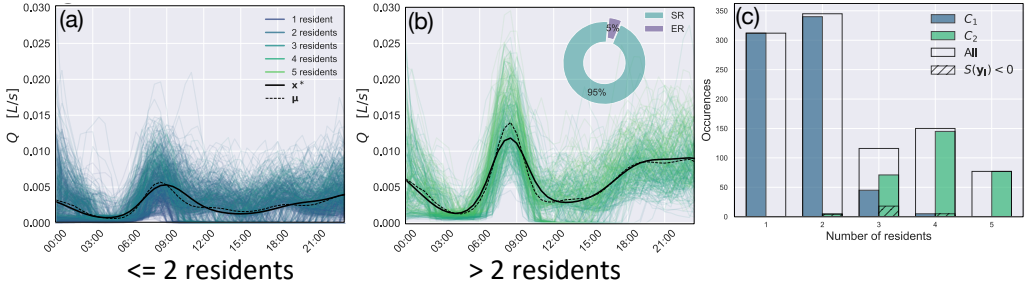
DASH of Water aims to identify those statistical parameters (automatically) from SWM data instead of tediously scanning different data sources for this information.

TU Delft

# Cluster Analysis



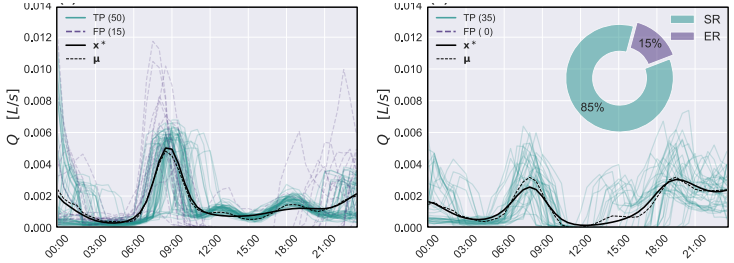
Number of residents




<= 2 residents

> 2 residents

Work schedules




Stay at home

Leave for work

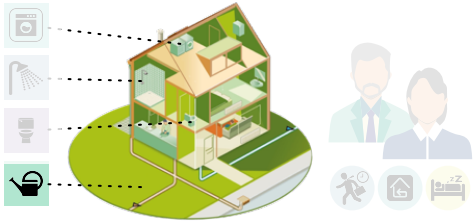
Within project DASH, we investigate the potential of different methods to link SWM data to SIMDEUM parameters.

For example, a novel clustering algorithm using a soft dynamic time warping metric, was applied on daily demand patterns to see, if we can draw conclusions from cluster centres (general pattern shape) to underlying statistical information.

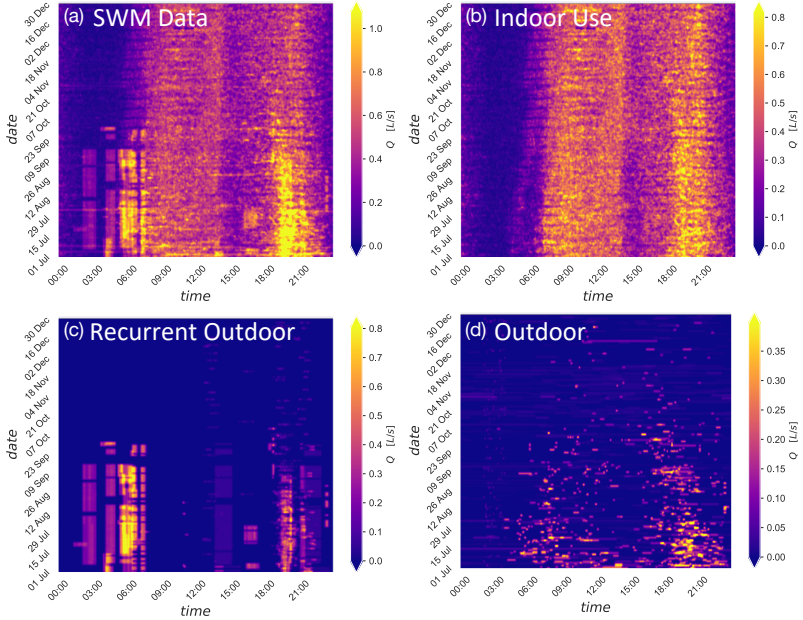
The algorithm showed high success rates (SR) at the task of clustering demand patterns according to their number of residents or their work schedules.

TU Delft

# Indoor-Outdoor Disaggregation



SWM data for 50 households




Furthermore, a simple rule-based method based on boxcar-function transformations has been developed to disaggregate SWM data in indoor water use, outdoor uses and leaks.

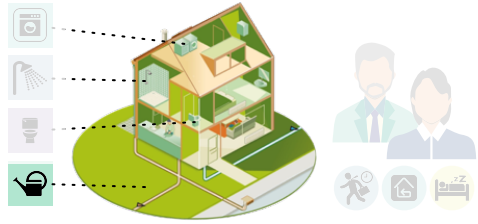
The rules to classify water uses are following:

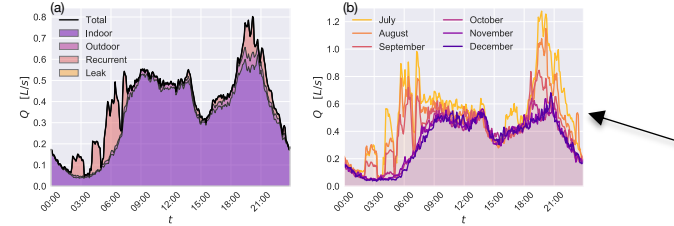
- Leaks have long runtimes
- Outdoor uses have high magnitudes (e.g. garden taps/hoses)
- Recurrent outdoor uses are outdoor uses that have a repeated pattern over time (e.g. automatic garden irrigation systems)

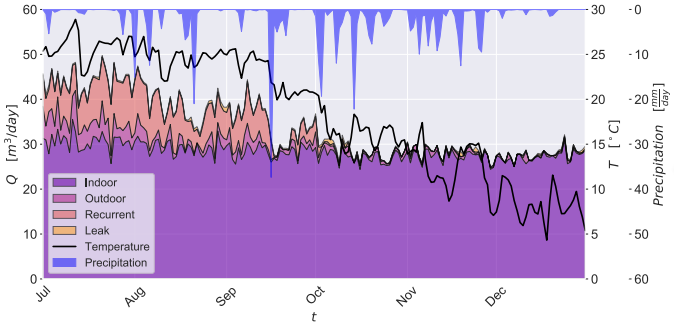
With this method we are able to have a closer look on the variablity of outdoor water use over time.

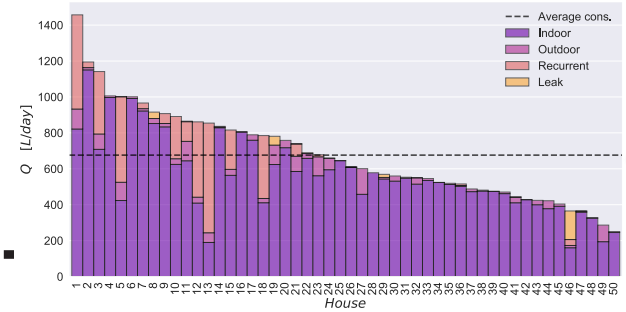
TU Delft

# Indoor-Outdoor Disaggregation





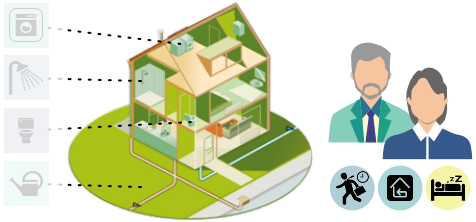



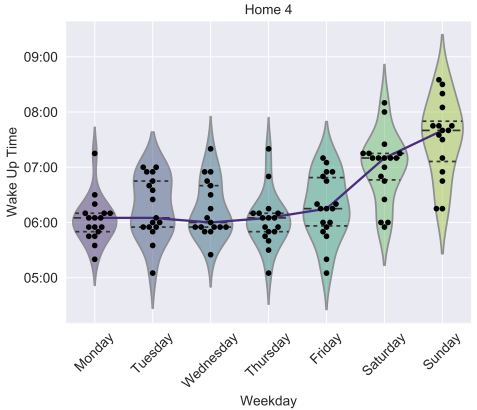

This allows us to investigate the times, when people use water outdoors. For example, automatic irrigation systems are mainly used during the night or in the early morning during the summer months, while the indoor use stays almost constant.

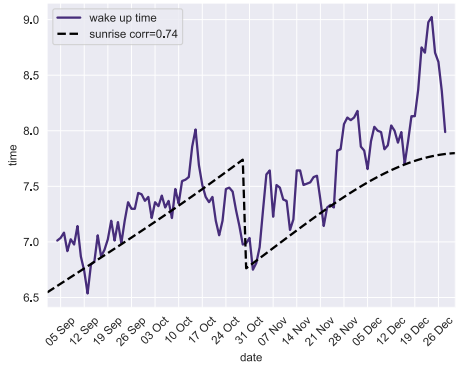
We can link the outdoor water use to climate parameters. The outdoor water use ends apprubtly with a heavy rain event in September, while mean daily temperatures fall below 20 °C.

Additinioally, conclusions can be drawn on the outdoor uses of single households.
This information is highly valuable for user-tailored water saving campaigns.

# Activity Time Identification






Additional algorithms are developed that identify the activity times of users – the times when people are awake, at home and use water.

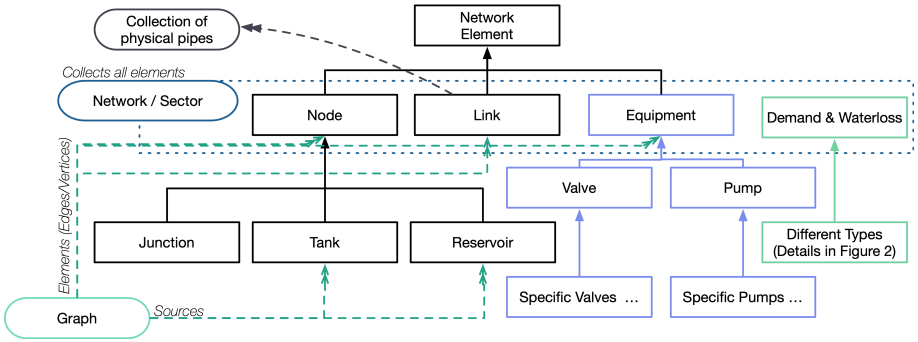
The wake-up times of residents in SIMDEUM are taken from statistical time surveys. We aim to retrieve this information directly from SWM data.

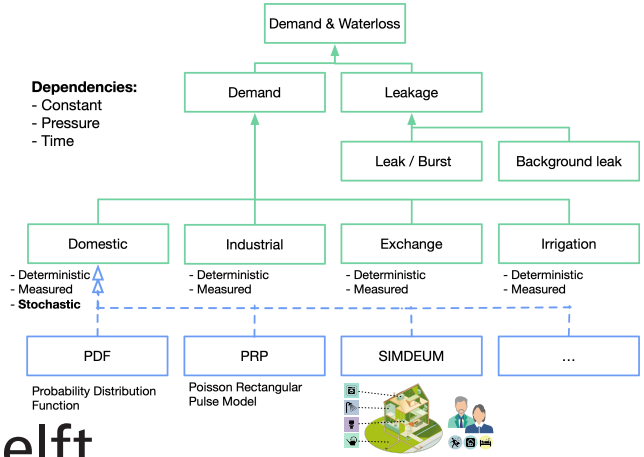
Prelaminary results show that the wake-up times are significantly different between weekdays and weekends.

For some households, the wake-up times are strongly correlated to the sunrise (especially in the data taken from an Italian fisherman village).

TU Delft

# Novel WDS Modelling Tools




At the moment, we are developing a novel object-oriented modelling framework for WDS that is suited for multiple purposes (asset management, hydraulic simulations, demand modelling, etc.).

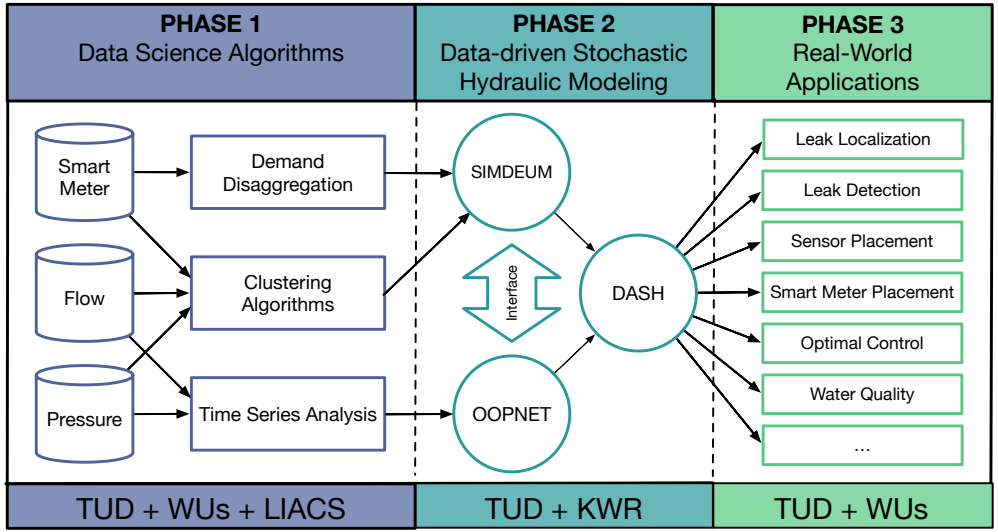
A strong focus of this framework is to incorporate stochastic water demand models for hydraulic simulations.

Additionally, an efficient standard structures for storing WDS data (and metadata) is used.

The whole framework (including the demand models) is written in Python.

TU Delft

# Project DASH overview




The final phase of project DASH consists of applications of the data-driven stochastic hydraulic models (a combination of the parametrised stochastic demand models and hydraulic modelling tools) on different WDS problems.

One application on leak detection and localization was shown earlier in the presentation of Jip van Steen "Fantastic leaks and where to find them".

TU Delft

# Acknowledgements

LEaDing Fellows Postdocs Programme

“This project has received funding from the European Union’s Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 707404. The opinions expressed in this document reflect only the author’s view. The European Commission is not responsible for any use that may be made of the information it contains.”

# Contact Details

David B. Steffelbauer
https://steffelbauer.github.io
d.b.steffelbauer@tudelft.nl

… or just add me on Skype and we can have a short chat

https://join.skype.com/invite/gvDiTKsiuaio

TU Delft