2019 8th REGIONAL african water LEAKAGE SUMMIT

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gls

Reducing water losses in a Smart City

Presented by:
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Participating and supporting organisations :

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Smart City and reducing water losses:

SWAN THE SMART WATER NETWORKS FORUM

- A city where at least Advanced Metering Infrastructure (AMI) is implemented that
  - Supports strategies to address water scarcity/conservation
  - Reduces non-revenue water by detecting water losses
  - Incorporates more accurate billing and efficient administration
  - Understands water consumption and demand patterns better
  - Improves management of water production, storage & distribution
  - Provides enhanced customer service.

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Smart City: Implementation

- Developments towards a Water Digital Twin where
  - Digital models are truly representative of the real world
  - Models can be updated and maintained continuously
  - Extensive monitored network data available for calibration & validation
  - High quality information available, e.g. customer demands & weather forecasts
  - Can give best picture of what
    - Has happened
    - Is happening now
    - Will happen in the future

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Smart City: Types of models

- **Static infrastructure** ► Asset register ► Steady State Model
- **Dynamic network** ►Time Simulation Model
- **Real-time performance** ►
  - Dynamic model of performance - now
  - Validated against real-time monitoring
  - Can be used for prediction of near-future
  - Gives warnings of potential failures
  - Used to optimize actions, costs etc

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Smart City: Disruptive technologies

- AMR (Automated Meter Reading) ► Smart Meters (Two way) ► AMI (Advanced Metering Infrastructure)
- IoT (Internet of Things)
- Cloud computing (e.g. Web Services, Edge computing)
- Real-time hydraulic modelling
- Artificial intelligence / Machine Learning / Big data analytics
- All connected by fast internet (5G etc)
- Moving towards 4th Industrial Revolution

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Diverse systems integrated on GLS 4.0 pilot

- Time series data via web services
  - *Zednet* (WRP)
  - *MyCity* (Flowtron)
  - *Adroit* (implemented by SSE)
  - Temperature & Solar Power (University of Stellenbosch)
- Extended Period Hydraulic Models
  - *Wadiso®* (GLS)

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Base functionality

- Highlight and summarize key information
  - Highlight sensors that have stale information
  - Show critical meter status and historic graphs
- Link data
  - From hydraulic model or system schematic based on GIS
- Perform advanced post-processing
  - Using Smart Points™
- Provide results to other online reporting systems

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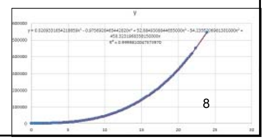
Additional functionality - Smart Points™

- Wide range of post processing functions
  - Sensor data integrity
    - Sensor data age
  - Accurate calculation of dam storage volumes from levels
    - Using polynomial regression function
  - Multiple aggregation of sensors from different vendors
    - Near real-time water balance for zones or whole city taking average over a period (e.g. 1 week)
  - Interaction with Hydraulic model
    - Calculation of remaining number of days of water storage



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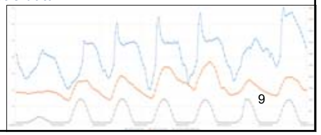
Moving towards a digital twin (1)

- Simulate model with near real-time data
  - Cleaning of demand data
    - Correct errors, fill missing gaps, ignore datasets if unreliable
  - Resampling and smoothing of data
    - Extracting a usable 168 hour demand pattern
  - Loading time simulation patterns
    - Data not everywhere available, so missing data must be patched correctly
  - Calibrating
    - For example highest demand week against theoretical/synthetic data
  - Incorporating other time series
    - For example temperature, solar power or rainfall



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Moving towards a digital twin (2)

- Analysing the past
  - Critical incidents such as
    - Pump station outage
    - Pipe bursts
- Confirming the present
  - Showing alarms as reservoir level is dropping too fast and identifying the reason
- Predicting the future
  - The next week, based on latest weather prediction
  - A large event, e.g. start of university one week earlier in summer

- Reducing water losses
  - Identifying slow leaks through routine data analysis and machine learning
  - Instant location of large leaks as they happen through pressure sensors and smart algorithms

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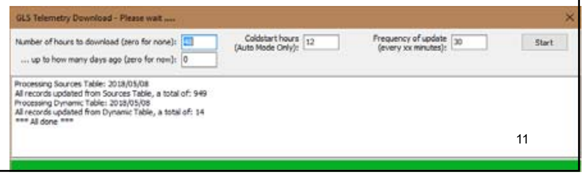
Pilot implementation

- *GLS Telemetry* Module
  - Pilot implementation
  - Developed in *Wadiso* on top of *Albion* CAD/GIS engine
- First component:
  - Scheduled downloader



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GLS Telemetry in Wadiso®

- Data from many different service providers combined:

System	BaseURL	Method	ParamName0
MyCity	http://www.mycity.co.za/cities/stellenb...	POST	chart_1.logger:records
MyCity	http://www.mycity.co.za/cities/stellenb...	POST	chart_1.logger:records
MyCity	http://www.mycity.co.za/cities/stellenb...	POST	chart_1.logger:records
ZedNet	https://live.zednet.co.za/index.php/api...	GET	channels
ZedNet	https://live.zednet.co.za/index.php/api...	GET	channels
MyCity	http://www.mycity.co.za/cities/stellenb...	POST	chart_1.logger:records
MyCity	http://www.mycity.co.za/cities/stellenb...	POST	chart_1.logger:records
MyCity	http://www.mycity.co.za/cities/stellenb...	POST	chart_1.logger:records
MyCity	http://www.mycity.co.za/cities/stellenb...	POST	chart_1.logger:records
MyCity	http://www.mycity.co.za/cities/stellenb...	POST	chart_1.logger:records
MyCity	http://www.mycity.co.za/cities/stellenb...	POST	chart_1.logger:records
IMQSAdroid	http://imqs8-sw1.gls.co.za:3000/Scada...	GET	Tag

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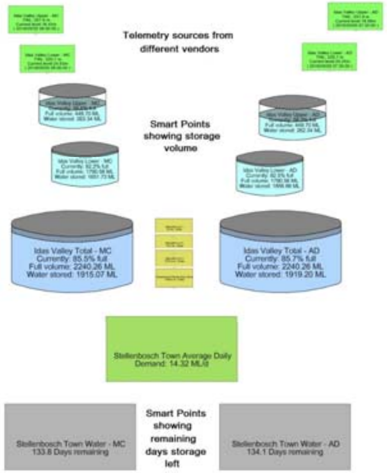

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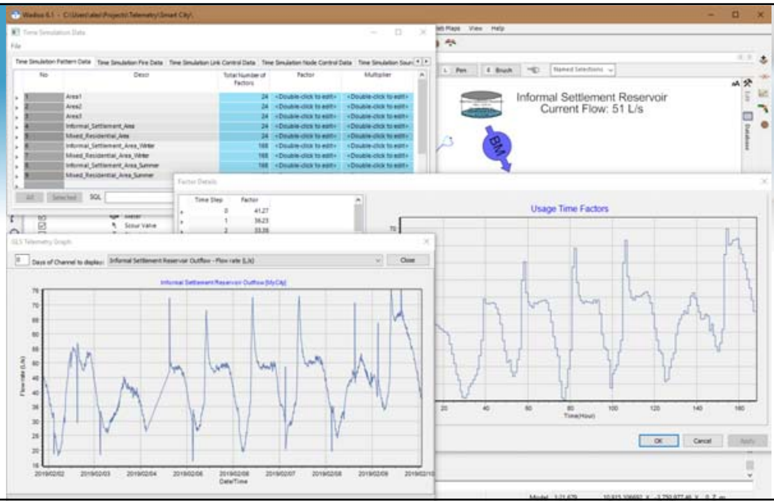

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Case study: Smart City

- Conception Western Cape town with existing time simulation model but real telemetry data sourced from neighbouring towns
  - actual telemetry data not extensive enough
  - obfuscate sensitive data
- First focus on calibration of synthetic model using demand scenarios from different seasons
- Then perform analysis of existing event
- Finally perform prediction of future event

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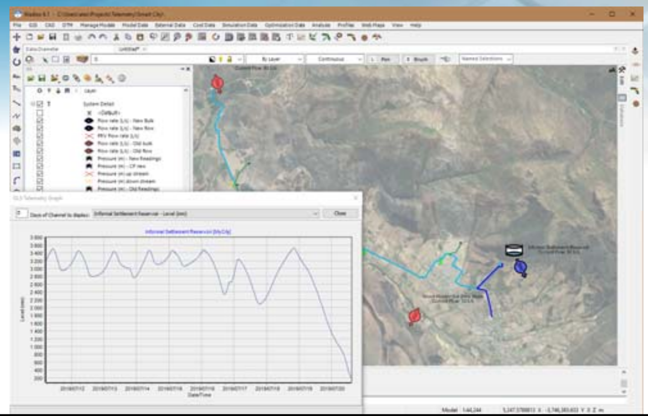
Model layout: Smart City



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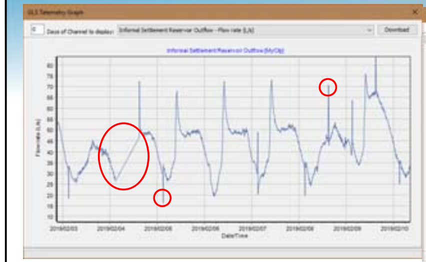
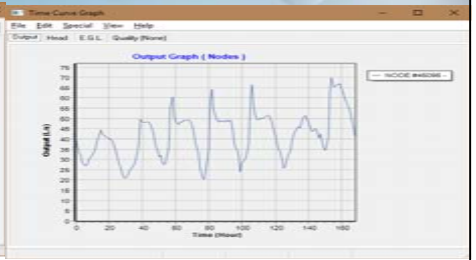
Calibration: Data clean-up and analysis





Raw telemetry outflow data for Informal Settlement (IS) Reservoir in critical summer week. Showing strange spikes at 03h00/15h00 and has a gap in measurement on the 2019/02/04.

Cleaned and extracted time simulation demand pattern for Informal Settlement Reservoir in critical summer week. Typical informal land use daily pattern, with odd weekday morning demand.

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Calibration: Confirmation

Telemetry reservoir water level data for Informal Settlement Reservoir in critical summer week.

Simulated water level fluctuation for Informal Settlement Reservoir in critical summer week.

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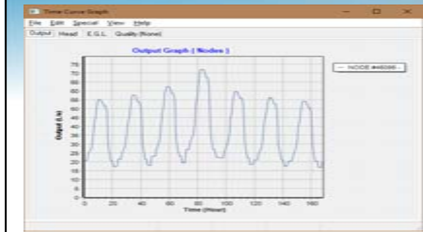
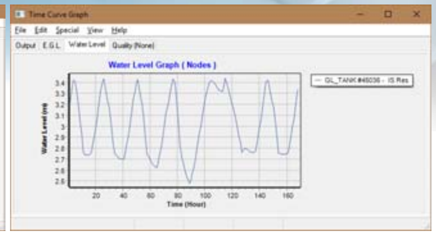
Calibration: Fall-back





Synthetic demand pattern used for critical week, based on land use data, average annual demand, and expected peak factors for land use and zone size.

Simulated water level fluctuation for Informal Settlement Reservoir in critical summer week, using synthetic demand pattern and expected pump operational rules. This is used as fall-back where no telemetry data is available.

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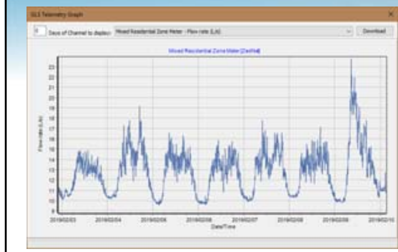
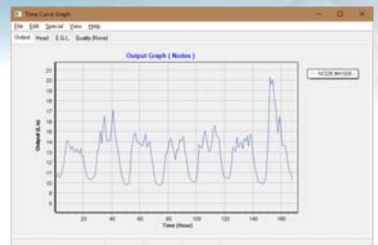
Calibration: Mixed (formal & informal) demand area





Here the source data has a higher resolution and needs to be resampled and filtered for errors

The resulting time simulation demand pattern shows a typical morning and evening peak matching an expected more formal demand pattern

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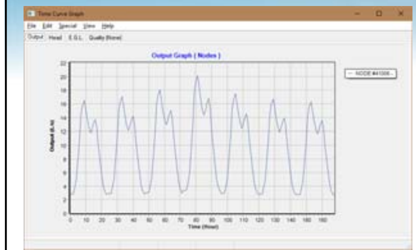
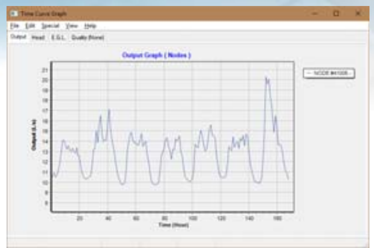
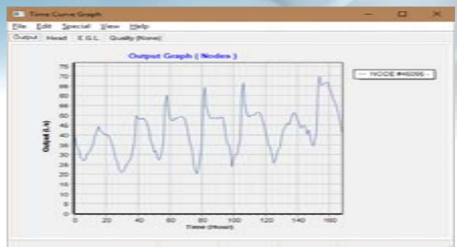
Calibration: Mixed (formal & informal) demand area





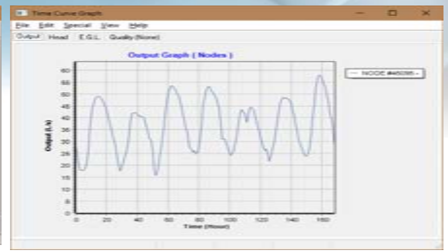
Synthetic pattern for peak demand week matches telemetry data, but base flow is quite different and requires correction.

Looking at weather (hottest summer week)



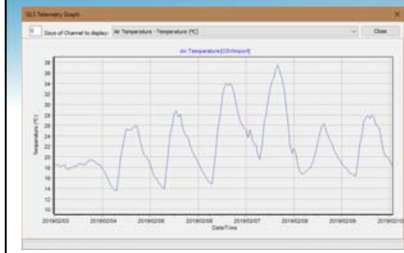
For some demand patterns such as this informal area, air temperature can be a very good indication of predicted demand. However weekly patterns, such as the last day being a Saturday, result in exceptions.

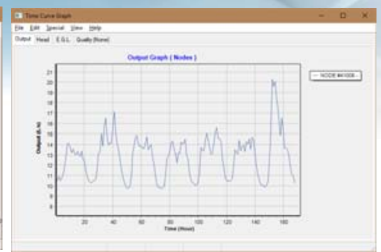
Looking at weather (recent winter week)



Here the water demand follows the air temperature closely, and can be used as proxy for predicting near future demand, e.g. the week ahead.

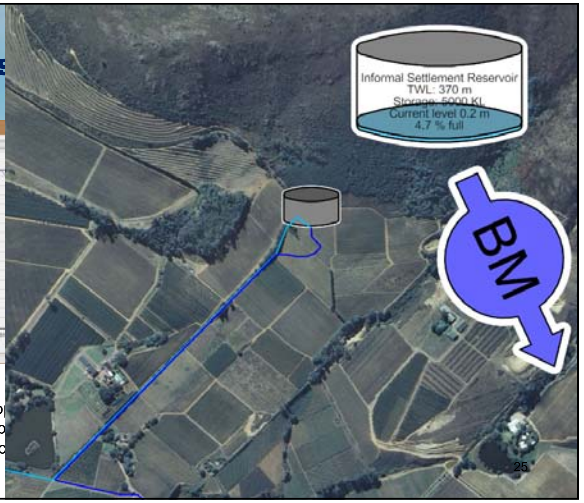
Looking at weather (mixed demand area)





For other demand patterns such as this mixed demand area, air temperature is not a good prediction of demand. However weekly patterns, such as a warm or sunny Saturday could be predicted, but more data requires to be analysed to confirm this.

Analysing events

In preparation for this paper, a catastro
This could be simulated by two interrup
reservoir filling however has not been c
predicted.

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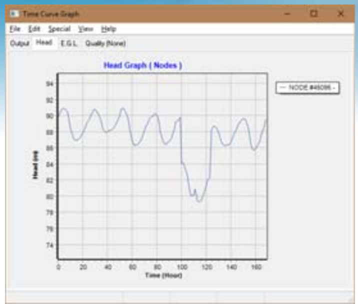
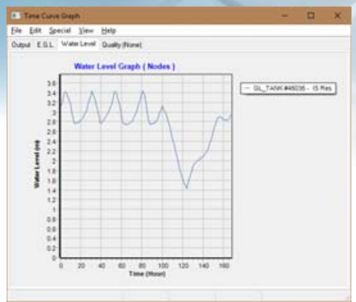
Simulating effect of major leakage





A leak in the major distribution pipe from the IS Reservoir that is temporary repaired with the main still live, is simulated by an emitter node modelled for 24 hours, 100 hours into the simulation. The reservoir level is able to recover before the end of the week. This theoretical event is not yet supported by telemetry data.

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Future work

- Other analyses can be performed, e.g. how has demand usage patterns changed after droughts
- Integrate more telemetry source, e.g. for ground water, large-users
- Get utilities to install more bulk and zone meters
- Roll-out affordable IoT meters to even include end-user monitoring
- Host Smart Points™ as web service, so results also accessible to other software, e.g. web clients
- Include concepts of Machine Learning to analyse patterns
- Model the future by understanding the history better

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