# Pre-conference workshops. 29th June 2025

## WS1: 09:00.13:00. Future of ICA in the water sector.
Gustaf Olsson, Michela Mulas, Pernille Ingildsen, Leiv Rieger, Oliver Grievson.

What do we learn from earlier progress and mistakes? New demand pull and technology push. What kind of instrumentation is needed and what is possible to measure? Have we forgotten 'classic' operation and control? How can AI, data mining, and massive computational tools improve ICA operations? Can we handle new risks and cyber security? Are we developing ICA tools for operators so that they trust the system? Will we see a better coupling between design and operation? How can ICA provide better balance between technology and people (operators, customers)? How do we handle the gap between what is theoretically possible and what is practically possible in the 'real reality'?

## WS2: 09:00-13:00 Data about data – when, why and how metadata can support the digital plant.
**Janelcy Alferes,** Janelcy Alferes, Prabhushankar Chandrasekeran, Gabriel Fierro, Hanna Molin, Daniel Aguado García, Maria Victoria Ruano García, Queralt Plana Puig, Spencer Snowling, Oscar Samuelsson, Jean-David Therrien, Kris Villez.

A structured approach for recording data quality and contextual information about how and why a signal exists – i.e. metadata – is central to interpret and use sensor data correctly. This is becoming increasingly important with the global trend with data-driven applications such as digital twins and AI-models. But a structured metadata collection and organization of sensor data is not routine in most plants, which can result in lost information and missed opportunities to make use of the investments made in the data collection. The aim with this workshop is to both disseminate and to extend the MetaCO task group work on metadata. The workshop targets water professionals that are using data, including utility practitioners, consultants, and academics.

## WS3: 13:00-16:00: Potential and Challenges of Hybrid Modelling for Soft-Sensor Development, Control and Automation.
Sina Borzooei, Saba Daneshgar, Cristian C. Gómez Cortéz, Andreas Froemelt, Mariane Y. Schneider, Marcello Serrao, Alireza Dehghani Tafti, Elena Torfs, Kris Villez, Jun-Jie Zhu, Xu Zou

Hybrid modelling (HM) combines mechanistic and data-driven approaches and is a transformative step in advancing mathematical models to address today's complex water-related challenges. By integrating mechanistic components into data-driven frameworks, hybrid models enhance resilience to out-of-scope (training) data, making them particularly suitable for control, automation, and decision-making applications. These models are also inherently adaptable, allowing for real-time updates with new data, which adds practical value for digital twin applications. This workshop will explore the potential applications of hybrid modelling for control and automation while addressing these challenges. Participants will learn about ongoing activities within the IWA Working Group on Hybrid Modelling, such as compiling open-access examples and guidelines to support researchers and practitioners in building their models. Discussions will cover practical case studies, good modelling practices, and strategies to overcome current barriers.

## WS4: 13:00-16:00 How can ML/DL and GAI contribute to urban water management
Zhiguo Yuan, Wenchong Tian, How Yong Ng, Peter Vanrolleghem

With the breakthrough advancements in artificial intelligence technologies, an increasing number of research initiatives and practical engineering projects have integrated machine learning (ML), deep learning (DL), and generative artificial intelligence (GAI) into the management and operation of urban water systems, driving the intelligent transformation of the water industry. However, due to the complexities of urban water systems, numerous challenges persist in practical implementation. Thus, how to apply these technologies appropriately remains worthy of in-depth discussion. Join us in this discourse to illuminate potential pathways for addressing these questions and co-create innovative perspectives for the intelligent transformation of urban water management.

# Workshop: *Future of ICA in the water sector*

Gustaf Olsson[1*], Michela Mulas[2], Pernille Ingildsen[3], Leiv Rieger[4], Oliver Grievson[5]

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**Abstract**: What do we learn from earlier progress and mistakes? New demand pull and technology push. What kind of instrumentation is needed and what is possible to measure? Have we forgotten 'classic' operation and control? How can AI, data mining, and massive computational tools improve ICA operations? Can we handle new risks and cyber security? Are we developing ICA tools for operators so that they trust the system? Will we see a better coupling between design and operation? How can ICA provide better balance between technology and people (operators, customers)? How do we handle the gap between what is theoretically possible and what is practically possible in the 'real reality'?

**Join us to share your experiences and express your visions of the ICA future. We expect heated discussions!**

**Keywords**: Instrumentation, operation, control, AI, cyber security, people aspects

| Workshop Time | Activity | Speakers |
|---|---|---|
| 09:00-09:15 | Welcome and introduction. Workshop format. | Gustaf Olsson |
| 09:15-09:45 | Possible vs. desirable ICA futures. Short introductions and perspectives. *Instrumentation*: measuring out there in the messy world and our efforts at getting the data right. *Control*: why it still requires highly skilled people to make control work. Why and how it can go wrong. *ICA*: our struggle to achieve a holistic approach and plant wide control. | *Speakers:* Michela Mulas with Pernille Ingildsen: what do we wish the system to achieve? Oliver Grievson: why is sensing still not perfect? Leiv Rieger: why is control still not perfect? |
| 09:45-10:30 | Interactive group discussions on each of the topics. Reviews, feedback and new ideas. | *Group leaders:* Gustaf, Michela, Leiv, Oliver |
| 10:30-11:00 | Short summary of the reviews. Responses from the speakers. In-depth discussion | Gustaf, moderator The speakers |
| 11:00-11:30 | Coffee break | |
| 11:30-12:30 | Opportunities and bottlenecks for<br>• water utilities and operation<br>• research<br>• academic education<br>• customers<br>Take home task: my own (=participant) priorities and to-do list after the ICA 2025 | Gustaf, moderator All participants |

# Data about data – when, why and how metadata can support the digital plant

Janelcy Alferes[1], Prabhushankar Chandrasekeran[2], Gabriel Fierro[3], Hanna Molin[4], Daniel Aguado García[5], Maria Victoria Ruano García[6], Queralt Plana Puig[7], Spencer Snowling[8], Oscar Samuelsson[4], Jean-David Therrien[9,10], Kris Villez[11]

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## BACKGROUND

A structured approach for recording data quality and contextual information about how and why a signal exists – *i.e. metadata* – is central to interpret and use sensor data correctly. This is becoming increasingly important with the global trend with data-driven applications such as digital twins and AI-models. But a structured metadata collection and organization of sensor data is not routine in most plants, which can result in lost information and missed opportunities to make use of the investments made in the data collection. Therefore, the IWA task group on Metadata Collection and Organization in wastewater resource recovery systems (MetaCO) was initiated in 2020 and recently delivered the IWA scientific and technical report number 31. The report gives and in-depth description about metadata in water resources recovery facilities (WRRFs) and is available as open access at IWA publishing. The report is the outcome of the collaboration between more than 80 water professionals with the intention to serve WRRF data users with a guide on how to structure and make use of metadata throughout the data pipeline in order to maximize the value of sensor data.

## GOAL

The aim with this workshop is to both disseminate and to extend the MetaCO task group work on metadata. The workshop targets water professionals that are using data, including utility practitioners, consultants, and academics. In specific, the workshop goals are to:

- Define metadata basics and establish a common language for the workshop attendees
- Understand and identify when and how metadata creates value for utilities
- Make academics appreciate metadata-related challenges in practice

The anticipated workshop outcome is a call to action, and to answer the question:

- What is the next step to facilitate metadata usage and create value for water data users?

## WORKSHOP FORMAT

The workshop will mix presentations, interactive polls and discussions to both educate and debate about metadata usage in the water sector. The workshop is planned for 3 h between 09:00–12:00. Coffee break is between 09:50–10:20.

| Time | | | Speaker/moderator |
|---|---|---|---|
| **09:00** | **What are metadata?** | | |
| | | An introduction to metadata | Kris Villez/Janelcy Alferes, Jean-David Therrien, Gabriel Fierro, Oscar Samuelsson |
| **09:50-10:20** | | Coffee break | |
| **10:20-11:00** | **Metadata – Digital pleasure or frustration?** | | |
| | | An exercise in prioritizing and valuing metadata | Oscar Samuelsson, Victoria Ruano |
| | | Leg stretch | |
| **11:00-12:00** | **Taking metadata to the next level** | | |
| | | Identify key challenges and what actions that are needed to bring out the value in data | Victoria Ruano, Jean-David Therrien, Janelcy Alferes |

# Workshop: Potential and Challenges of Hybrid Modelling for Soft-Sensor Development, Control and Automation

Sina Borzooei[3]**, Saba Daneshgar[1], Cristian C. Gómez Cortéz[1], Andreas Froemelt[4], Mariane Y. Schneider[1]*, Marcello Serrao[9], Alireza Dehghani Tafti[8], Elena Torfs[6], Kris Villez[5], Jun-Jie Zhu[2], Xu Zou[7]

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**Abstract**: Hybrid modelling (HM) combines mechanistic and data-driven approaches and is a transformative step in advancing mathematical models to address today's complex water-related challenges. By integrating mechanistic components into data-driven frameworks, hybrid models enhance resilience to out-of-scope (training) data, making them particularly suitable for control, automation, and decision-making applications. These models are also inherently adaptable, allowing for real-time updates with new data, which adds practical value for digital twin applications. The momentum of HM in research continues to grow, as highlighted by Schneider et al. (2022). This modelling paradigm uniquely balances theoretical precision and real-world adaptability, bridging gaps that neither mechanistic nor data-driven models can address alone. However, challenges such as integration complexity, computational demands, and the need for standardized modelling practices remain critical barriers to widespread adoption.

This workshop will explore the potential applications of hybrid modelling for control and automation while addressing these challenges. Participants will learn about ongoing activities within the IWA Working Group on Hybrid Modelling, such as compiling open-access examples and guidelines to support researchers and practitioners in building their models. Discussions will cover practical case studies, good modelling practices, and strategies to overcome current barriers.

Join us to explore how HM can bridge the gaps in control and automation, contribute to advancing the field, and collaborate with experts to shape its future.

**Keywords**: hybrid modelling, data-driven modelling, mechanistic modelling, soft sensors, good modelling practice

| Workshop Time | Activity | Speakers |
|---|---|---|
| 13:00 – 13:15 | Welcome | M.Y. Schneider |
| 13:15 – 13:30 | Introduction to hybrid modelling for soft sensor development, control, and automation | *K. Villez* (Replacement E. Torfs) |
| 13:30-14:10 | Examples of (hybrid models for) soft-sensor development and control | Research: K. Solon<br>*TBD* |
| 14:10 – 15:00 | What are the challenges in control and automation? Can hybrid modelling fill these gaps for the current challenges? | Intro by G. Olsson. L. Rieger, G. Herold. All workshop participants |
| 15:00 – 15:20 | Coffee break | |
| 15:20 – 16:00 | Panel discussion: Quo vadis hybrid modelling for soft-sensor development control and automation? | Panel: L. Rieger, G. Olsson, O. Samuelsson, E. Torfs<br>*TBD*<br>Moderation: S. Borzooei |

## REFERENCES

Schneider, M.Y., Quaghebeur, W., Borzooei, S., Froemelt, A., Li, F., Saagi, R., Wade, M.J., Zhu, J.-J., Torfs, E., 2022. Hybrid modelling of water resource recovery facilities: status and opportunities. Water Sci. Technol. 85, 2503–2524. https://doi.org/10.2166/wst.2022.115

# Sunday June 29, 13:00 – 16:00
# How can ML/DL and GAI contribute to urban water management?

Zhiguo Yuan and Wenchong Tian

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Abstract: With the breakthrough advancements in artificial intelligence technologies, an increasing number of research initiatives and practical engineering projects have integrated machine learning (ML), deep learning (DL), and generative artificial intelligence (GAI) into the management and operation of urban water systems, driving the intelligent transformation of the water industry. However, due to the complexities of urban water systems, numerous challenges persist in practical implementation. Thus, how to apply these technologies appropriately remains worthy of in-depth discussion.

Join us in this discourse to illuminate potential pathways for addressing these questions, and co-create innovative perspectives for the intelligent transformation of urban water management.

**Key words:** Machine learning, deep learning, generative artificial intelligence, urban water management.

| Workshop Time | Activity | Speakers |
|---|---|---|
| 13:00-13:05 | Welcome and introduction. | Zhiguo Yuan |
| 13:05-13:20 | Achieving a shared understanding of terminologies | Wenchong Tian |
| 13:20-13:55 | Topic 1: How can ML/DL contribute to wastewater treatment? | Zhiguo Yuan |
| 13:55-14:30 | Topic 2: How to use ML/DL in the operation and optimisation of urban drainage systems (UDS)? | Wenchong Tian |
| 14:30-14:45 | Coffee break | |
| 14:45-15:20 | Topic 3: How can GAI (including LLM) contribute to urban water management? | How Yong Ng |
| 15:20-15:55 | Topic 4: How can we deal with the situation of insufficient data? | Peter Vanrolleghem |