

**SMART SENSORS FOR THE WATER SECTOR:  
ROCKING THE BOAT OR MISSING IT?**

THURSDAY, OCTOBER 23, 2014 | 11:00AM - 12:30PM EDT | 4:00PM - 5:30PM BST

**Moderator**

**Dr. Corina Carpentier,**  
*Water quality monitoring expert*  
**O<sub>2</sub> Environmental Technology Assessment Group (TAG)**

**Panelists**

**Dr. Ana Soares,**  
*Lecturer, Biological Processes, Cranfield University*

**Tom Bolling,**  
*Global Business Unit Director, Hach-Lange/Danaher Corporation*

**Jos-Willem Verhoef,**  
*Managing Director, Optiqua Technologies*

**Sam Saintonge,**  
*Principal, XPV Capital*



**Dr. Corina Carpentier**

Water quality monitoring expert

**O<sub>2</sub> Environmental TAG**

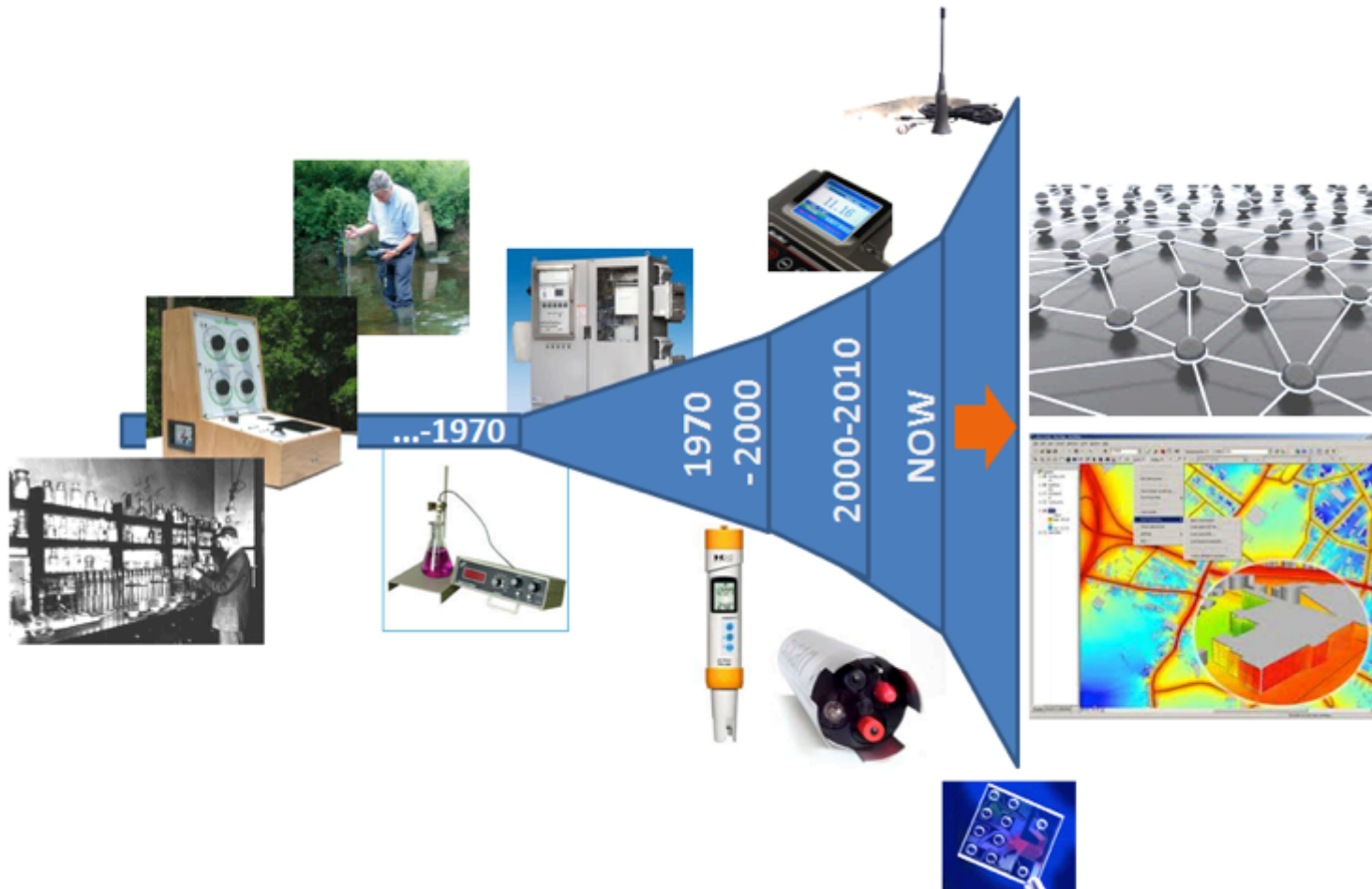
# About BlueTech® Research

BlueTech Research is an independent market intelligence and advisory firm, focused exclusively on the water technology industry.



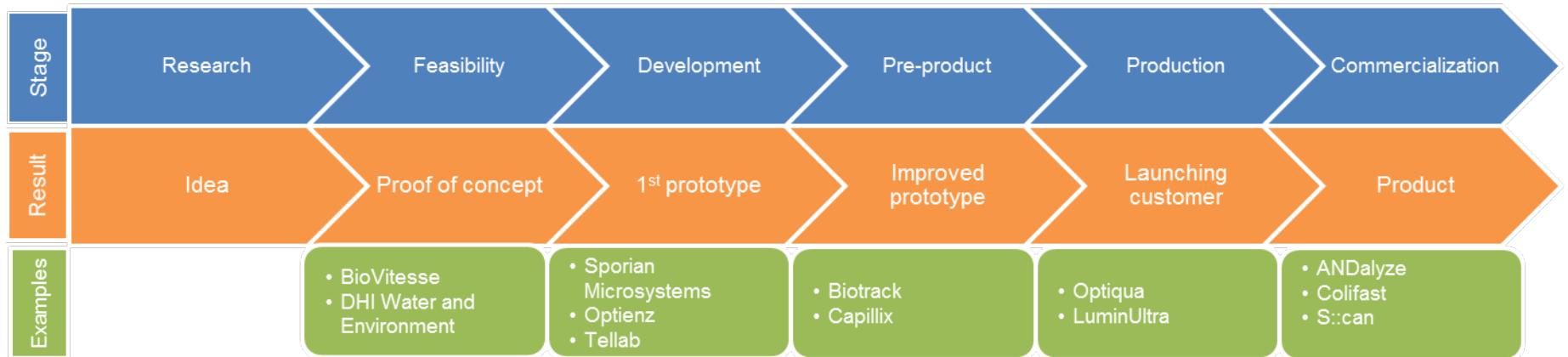
***The leading source of actionable  
water-technology market intelligence***

# Evolution of online sensors



# Today's discussion

- Water utilities:
  - very interested in new sensor developments
  - benefit from new sensors meeting their needs
  - mostly not the main source of funding



# Meet the Panelists

Dr. Ana Soares,  
*Lecturer, Biological Processes*  
**Cranfield University**



Tom Bolling,  
*Global Business Unit Director*  
**Hach-Lange/Danaher Corporation**



Jos-Willem Verhoef,  
*Managing Director,*  
**Optiqua Technologies**



Samuel Saintonge  
*Principal,*  
**XPV Capital**



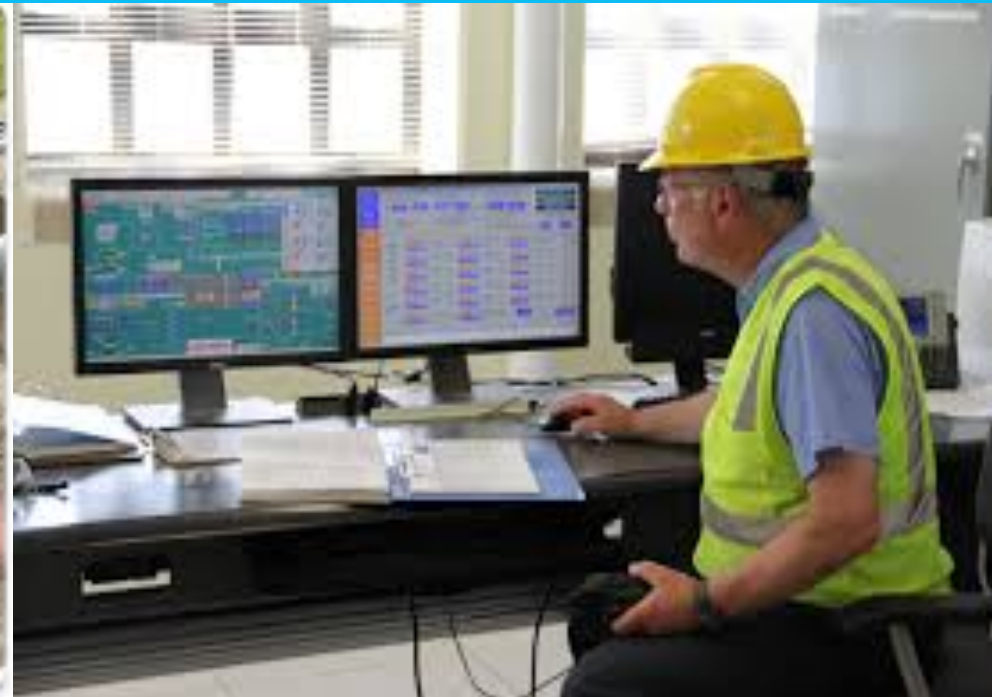


# Dr. Ana Soares

Lecturer, Biological Processes, Environmental  
Science and Technology Department

**Cranfield University**

# Sensors for wastewater monitoring: where are we and where we want to be

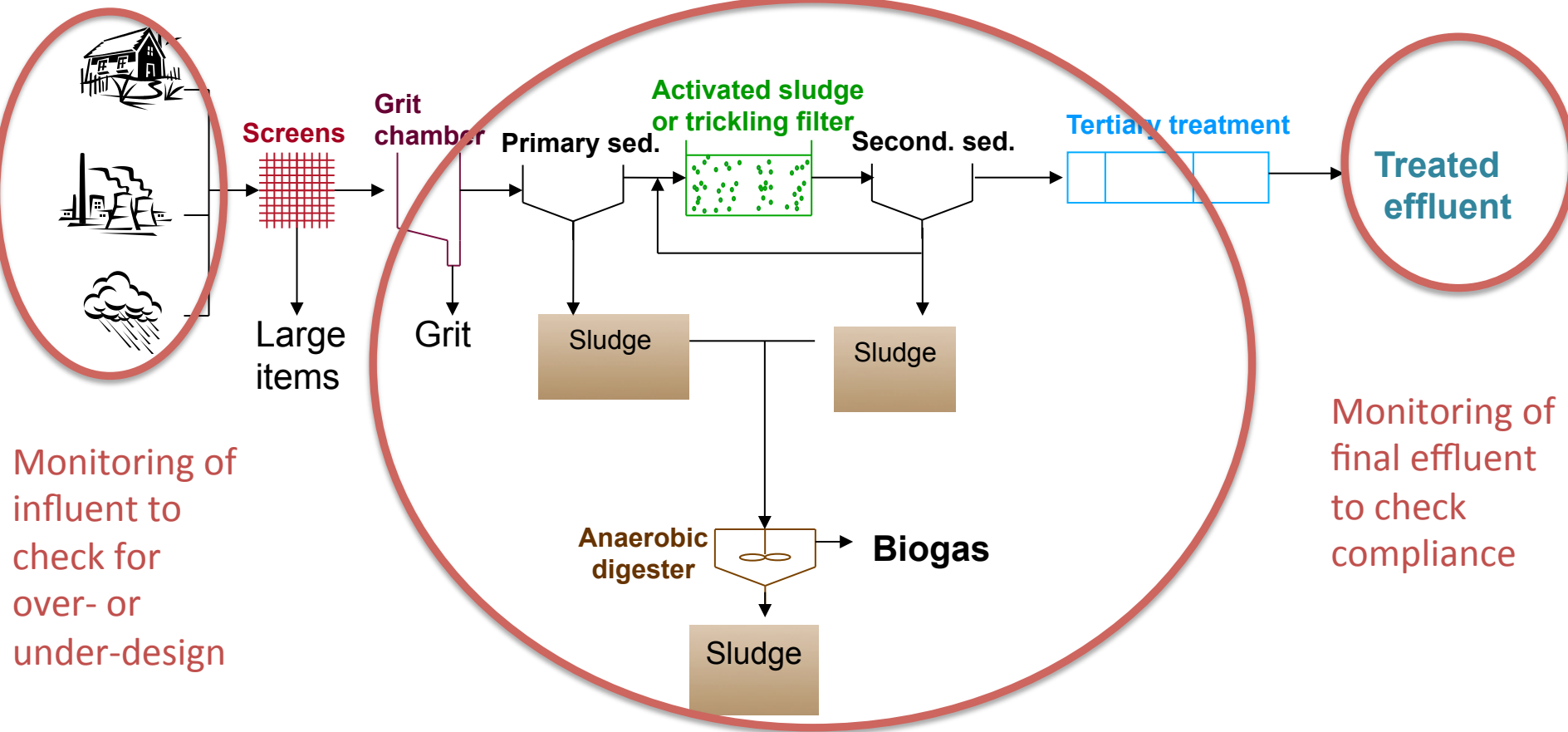


Dr Ana Soares, Cranfield University

23 Oct 2014

# A generic wastewater treatment plant

Monitoring of intermediary processes for optimization



# What can we measure? (commercially available)

Flow (liquid and gases)

pH

Temperature

Total suspended solids (TSS)

Dissolved oxygen

Ammonia ( $\text{NH}_4^+$ )

Nitrate ( $\text{NO}_3^-$ )

Nitrate ( $\text{NO}_2^-$ )

Phosphorus

Chemical oxygen demand (COD)

Biochemical oxygen demand (BOD)

# Measurement principles

## Ammonia ( $\text{NH}_4\text{-N}$ )

- Colourimetric
- ISE
- GSE
- UV

## DO

- Electrochemical
- Luminescence (optical)

## Nitrate ( $\text{NO}_3\text{-N}$ )

- ISE
- UV/Vis

## Solids

- scattered light

## Phosphorus (P)

- Colourimetric

# Wider range of parameters can now be measured or under development

## Heavy metals

Anal Bioanal Chem (2014) 406:3957–3975  
DOI 10.1007/s00216-014-7804-x

REVIEW

### Graphene-based sensors for detection of heavy metals in water: a review

Jingbo Chang · Guihua Zhou · Erik R. Christensen · Robert Heideman · Junhong Chen

## Hazardous priority substances

Analytical  
Methods



PAPER

View Article Online  
View Journal Online



Cite this Anal. Methods 2014, 6, 8624

**Electrochemical sensor for endocrine disruptor bisphenol A based on a glassy carbon electrode modified with silica and nanocomposite prepared from reduced graphene oxide and gold nanoparticles†**

Enli Liu and Xiaoli Zhang\*

## New sensors to overcome limitations



### Conductance based sensing and analysis of soluble phosphates in wastewater

Christopher Warwick<sup>a</sup>, Antonio Guerreiro<sup>b</sup>, Alberto Gomez-Caballero<sup>c</sup>, Elizabeth Wood<sup>d</sup>, James Kitson<sup>d</sup>, James Robinson<sup>d</sup>, Ana Soares<sup>a</sup>

[Show more](#)

## Pathogens and key organism



Available online at [www.sciencedirect.com](http://www.sciencedirect.com)

SCIENCE @ DIRECT®

Enzyme and Microbial Technology 32 (2003) 3–13

ENZYME and  
MICROBIAL  
TECHNOLOGY

[www.elsevier.com/locate/enmictec](http://www.elsevier.com/locate/enmictec)

Review

### Advances in biosensors for detection of pathogens in food and water

Paul Leonard<sup>a</sup>, Stephen Hearty<sup>a</sup>, Joanne Brennan<sup>a</sup>, Lynsey Dunne<sup>a</sup>, John Quinn<sup>a,b</sup>,  
Trinad Chakraborty<sup>c</sup>, Richard O'Kennedy<sup>a,\*</sup>

## BOD/ COD/ TOC

Search by brand

Choose manufacturer

Product range

- Automatic Samplers
- Algae Control
- Ammonia analysers

### COD, BOD & TOC

The new generation from WTW: CarboVIS®, NitraVis® and NiCaVis®

The new optical system design ensures the highest measurement accuracy, repeatability and stability. The drift-free sensor guarantees reliable data over extended periods of time, without the need for routine maintenance.

Using the full UV-VIS spectral wave length range from 200 to 720 nm provides the best measurement results and optimum compensation of interferences like turbidity.



## Virtual sensors



Environmental Modelling & Software 47 (2013) 88–107

Contents lists available at [SciVerse ScienceDirect](http://SciVerse.ScienceDirect)

Environmental Modelling & Software

Journal homepage: [www.elsevier.com/locate/envsoft](http://www.elsevier.com/locate/envsoft)



Review

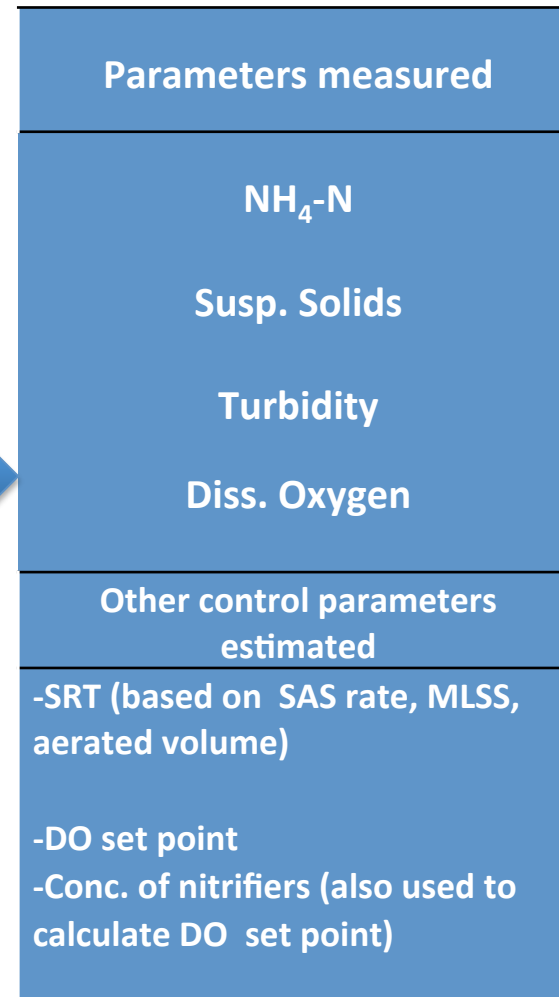
### Data-derived soft-sensors for biological wastewater treatment plants: An overview

Henri Haimi<sup>a,\*</sup>, Michela Mulas<sup>a</sup>, Francesco Corona<sup>b</sup>, Riku Vahala<sup>a</sup>



# The future of sensors – multisensory platforms integrated into control systems

ASM1 model parameters		
Symbol	Value	Explanation
$Y_A$	0.24	Autotrophic biomass yield
$Y_H$	0.67	Heterotrophic biomass yield
$i_{NB}$	0.086	Nitrogen mass per mass of COD in biomass
$\mu_A$	0.8	Maximum specific growth rate of autotrophic biomass
$\mu_H$	6	Maximum specific growth rate of heterotrophic biomass
$K_S$	20	Half-saturation coefficient for heterotrophic biomass
$K_{OH}$	0.2	Oxygen half-saturation coefficient for heterotrophic biomass
$K_{NO}$	0.5	Nitrate for denitrifying heterotrophs
$K_{NH}$	1.0	Ammonium half-saturation coefficient for autotrophic biomass
$K_{OA}$	0.4	Oxygen half-saturation coefficient for autotrophic biomass
$\eta_g$	0.8	Correction factor for $\mu_H$ under anoxic conditions
$\eta_h$	0.4	Correction factor for hydrolysis under anoxic conditions
$k_b$	3	Maximum hydrolysis rate
$K_X$	0.03	Half-saturation coefficient for hydrolysis of slowly-biodegradable substrate



Process optimization:

Reduced aeration (energy saving)

100% effluent compliance

# Existing sensors have limitations

Optical (DO)	Electrochemical (DO)	ISE	Colourimetric (NH <sub>4</sub> , NO <sub>3</sub> , PO <sub>4</sub> )
<ul style="list-style-type: none"> <li>• Susceptible to errors</li> <li>• Membrane fouling</li> <li>• Membrane fragile, sensitive</li> <li>• Electrodes and electrolytes consumed</li> <li>• Needs re-calibration if temp &amp; pressure significantly fluctuates</li> <li>• Often drifts from calibration</li> <li>• Very long start up time (as much as 6 hrs)</li> <li>• Maintenance &amp; downtime</li> </ul>	<ul style="list-style-type: none"> <li>• Response time is slower for decreasing concentration than for increasing concentration</li> </ul>	<ul style="list-style-type: none"> <li>• Precision rarely better than 1%</li> <li>• Electrodes easily fouled by proteins and organic solutes</li> <li>• Interference by presence of other ions</li> <li>• Electrodes fragile, have limited shelf life (requires replacement &gt; thrice a year)</li> <li>• Electrodes respond to activity of uncomplexed ions (ligands must be masked)</li> <li>• Often drifts from calibration</li> <li>• Long start up times</li> </ul>	<ul style="list-style-type: none"> <li>• Sample filtration/preparation</li> <li>• Need specialist on site to carry maintenance</li> <li>• Uses chemicals</li> <li>• Chemical disposal required</li> <li>• Frequent clogging of narrow tubings</li> </ul>

# Use of a wider range of receptors: e.g.: Molecularly Imprinted Polymers (MIPs)

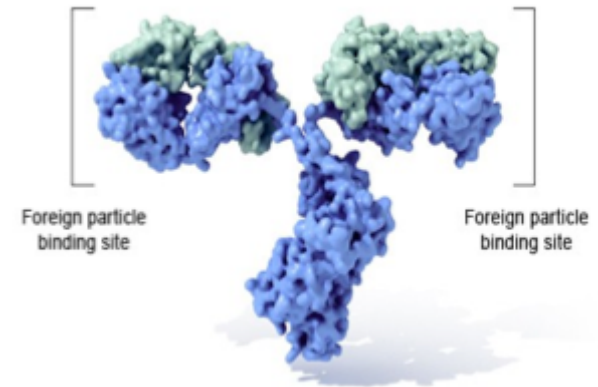
Similar affinity and specificity as natural receptors

Stability in extremes of pH, pressure and temperature

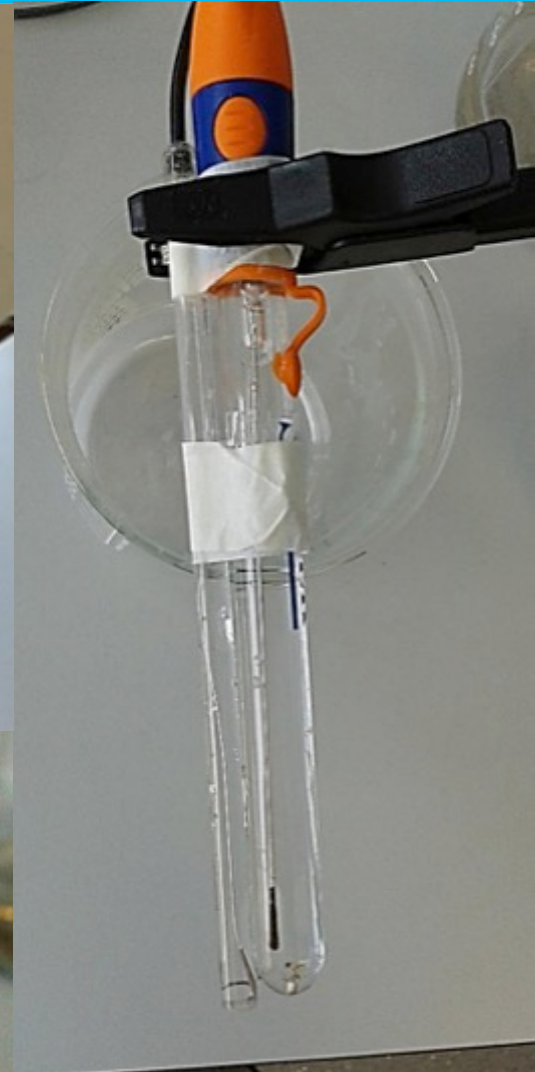
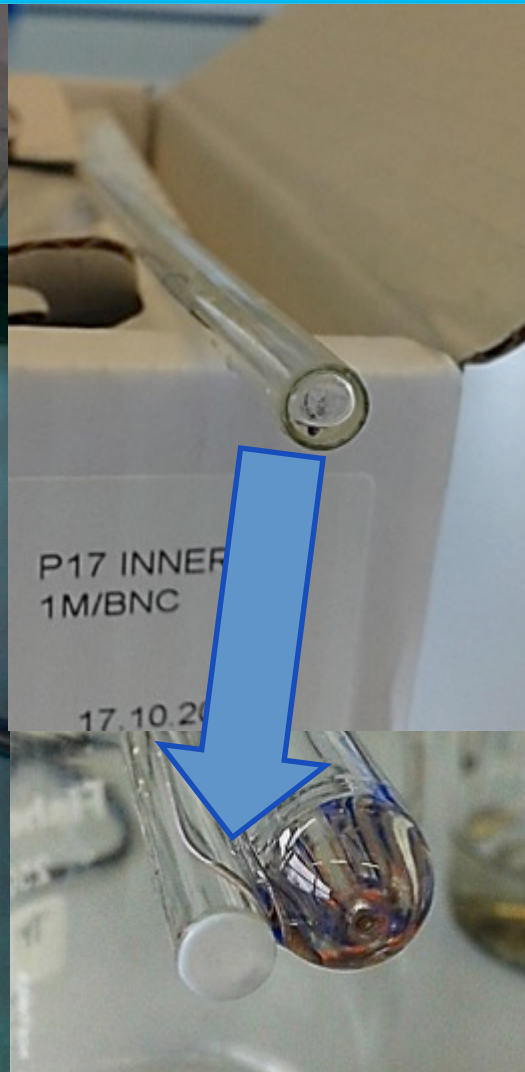
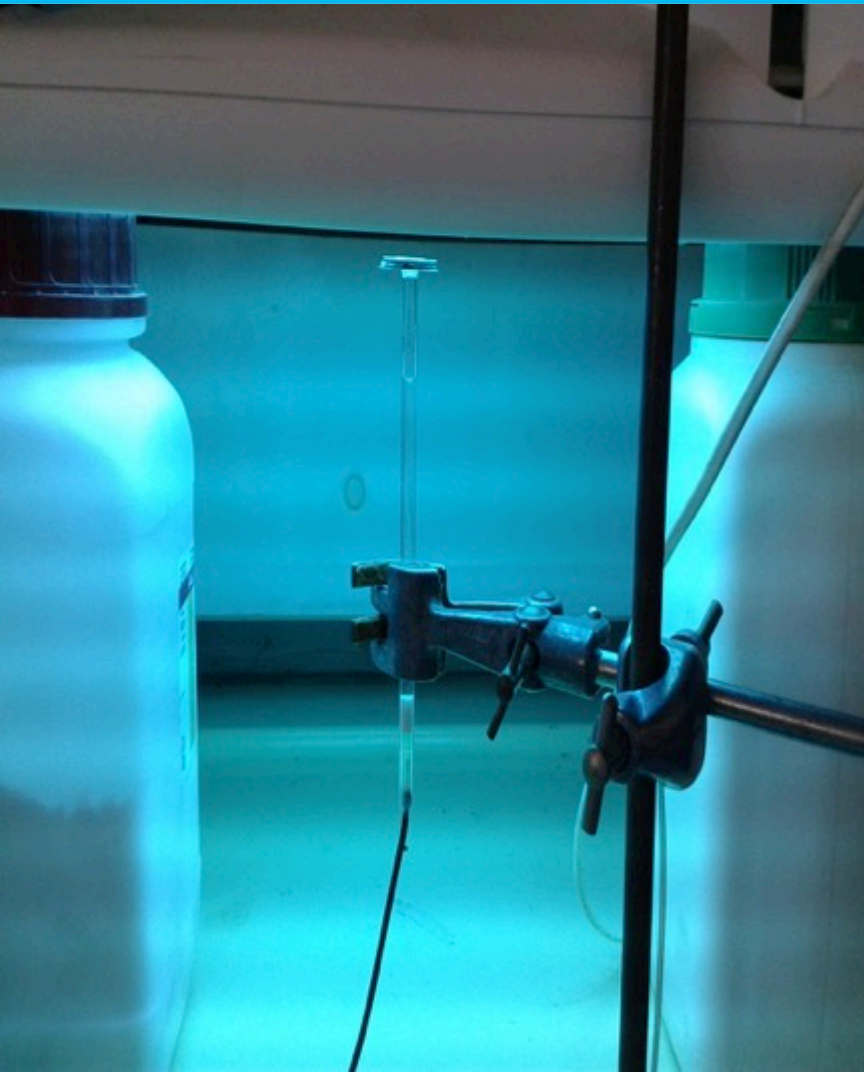
Imprinting theoretically possible for any compound

Can be used both in organic and aqueous environments

Price



# New phosphate sensor with MIP receptors



# The instruments on site



# The sensors currently within the unit

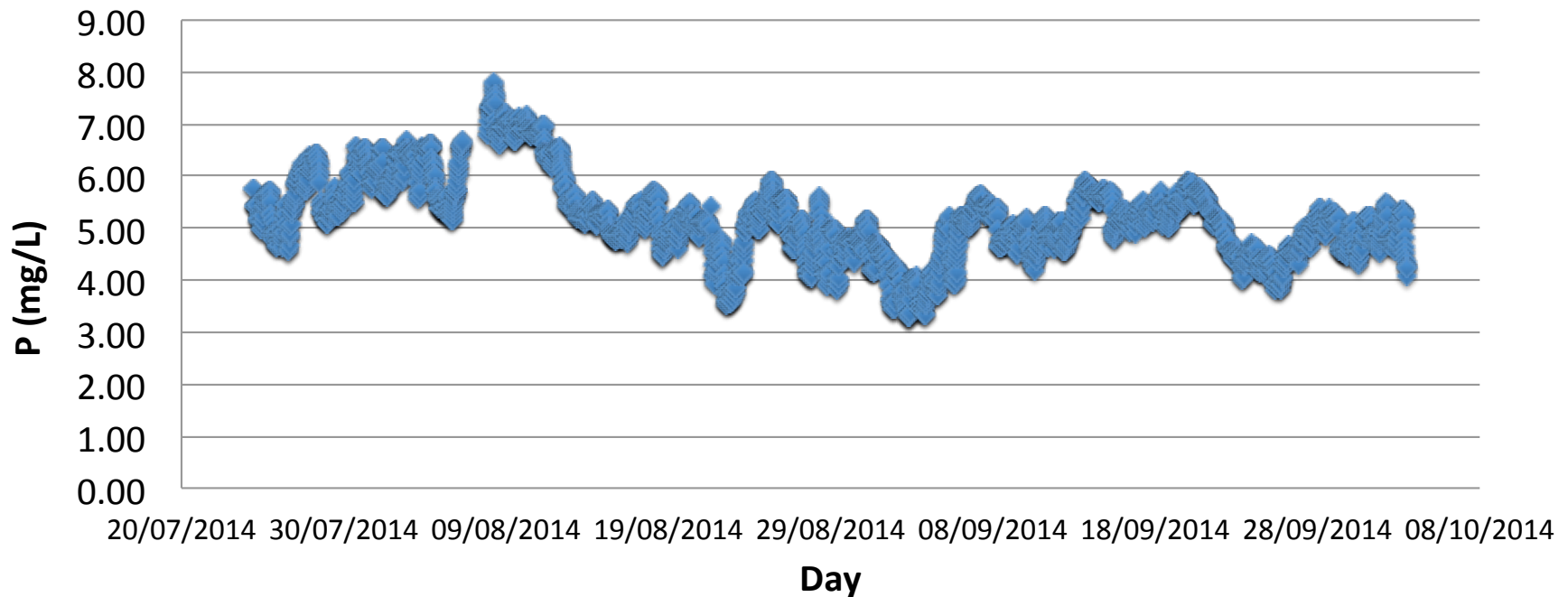
- Temperature, pH
  - P sensor
  - Electrical conductivity
  - Dissolved oxygen
  - Turbidity
- 
- Measurements currently taken every 30 minutes
  - Rinse cycle with tap water between measurements
  - Results logged on site & remotely



# The instruments on site



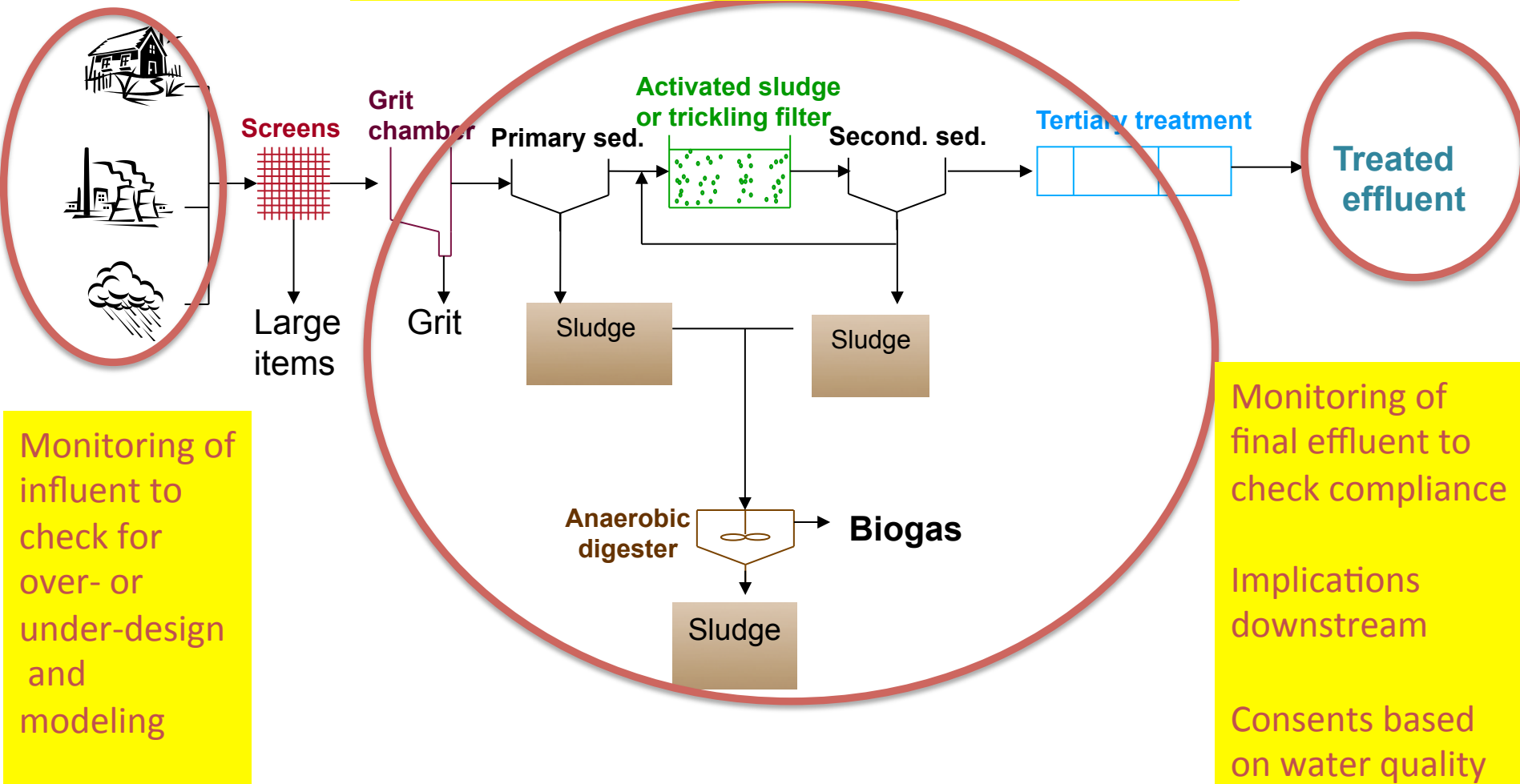
# On-line instrument: Operation over three months



- No maintenance to investigate sensor longevity
- 3 months and 10 days of operation
- 102 days X 48 readings/day = 4896 measurements

# A generic wastewater treatment plant – the future

Monitoring of intermediary processes for optimization



# Thank you for your attention

## Contacts:

- Ana Soares: [a.soares@cranfield.ac.uk](mailto:a.soares@cranfield.ac.uk)
- Iva Chianella: [i.chianella.1998@cranfield.ac.uk](mailto:i.chianella.1998@cranfield.ac.uk)



**Tom Bolling**

Global Business Unit Director

**Hach-Lange/Danaher Corporation**

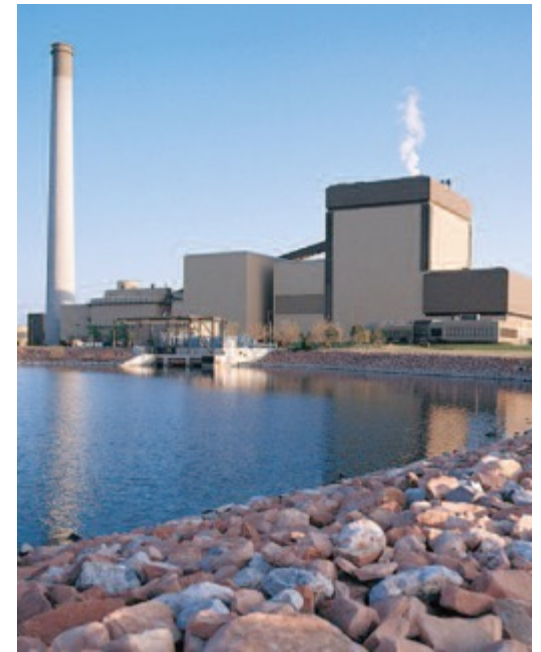
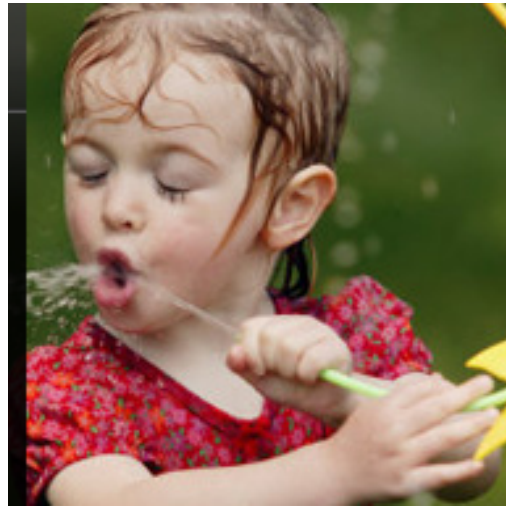


**LANGE**



UNITED FOR WATER QUALITY

**BlueTech**  
RESEARCH  
AN O<sub>2</sub> ENVIRONMENTAL COMPANY



# SMART SENSORS FOR THE WATER INDUSTRY

Tom Bolling

Global Business Unit Director – Process Solutions

Hach Lange

# DANAHER CORPORATION

## Environmental

### Water Quality



### Gilbarco Veeder-Root



## Test & Measurement

### Communications



### Instruments



## Dental

### Dental



## Life Sciences & Diagnostics

### Diagnostics



### Life Sciences



## Industrial Technologies

### Product ID



### Motion



# HACH LANGE

## Mission

Ensure water quality for people around the world.

## Vision

We make water analysis better – faster, simpler, greener and more informative – via unsurpassed customer partnerships, the most knowledgeable experts, and reliable, easy-to-use products.

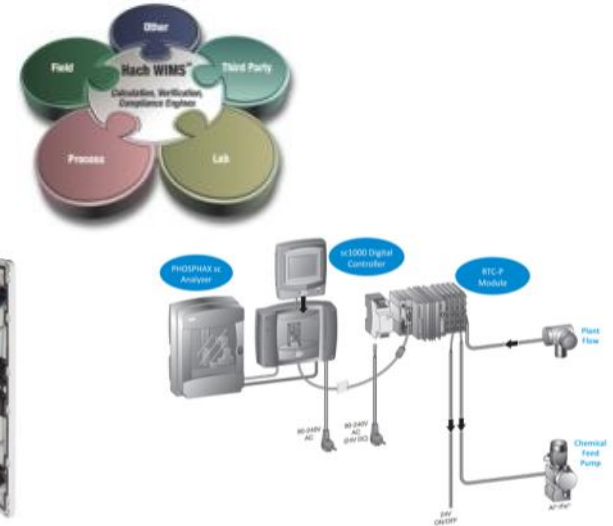
### Lab Grab Samples



### Process Monitoring



### Software / Solutions



# SOURCES OF INNOVATION FOR LARGE INCUMBENTS



## Internal R&D



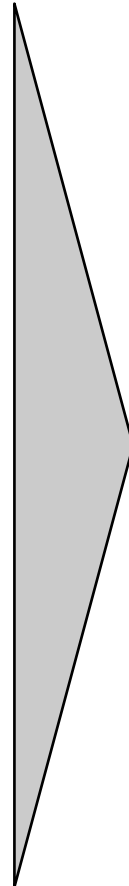
## Other Incumbents



## Universities



## Start-Up/Small Players



## Decision Framework Example

### Importance

NOT HIGH

HIGH

YES

(II)

**How big  
could it be?**

(I)

**When can  
we meet?**

NO

(III)

**No thanks.**

(IV)

**Is it a break-  
through?**

**Gap**

# EXAMPLES OF EXTERNAL INNOVATIONS

Importance	
II	I
III	IV

Gap



**BiTector**



## Sensors on sc Platform

- Fill gaps in offering
- Commercial partnerships

## Best-in-Class TOC Analyzer

- Breakthrough capabilities
- Began with partnership
- Resulted in acquisition

## Software / Solutions

- Strategic focus
- Began with acquisition
- Integration with portfolio



**Jos-Willem Verhoef**

Managing Director

**Opitqua Technologies**

**optiqua**

**BlueTech**  
RESEARCH  
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# Smart Sensors for the Water Sector: Rocking the Boat or Missing It?

## Optical sensor technology for water quality monitoring “From science to paying customers”



**Jos-Willem Verhoef**  
Managing director Optiqua Technologies

**optiqua**

October 23th, 2014

# Optiqua: provider of innovative sensor technology and monitoring solutions for the water industry

**Based in  
The Netherlands & Singapore**

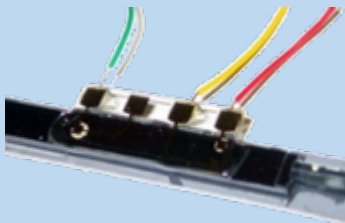


**EventLab**  
Generic online water quality monitoring in  
the distribution network

**Real-time**  
Refractive Index as generic parameter  
Monitors full spectrum of contaminants  
No calibration, low maintenance  
Advanced data algorithms  
Enables network wide quality monitoring in  
the distribution network



**Optical sensor platform**  
Patented and awarded technology



Asian  
Innovation  
Awards  
2011



**MiniLab**  
System for on site target sensing

**Identifies specific compounds**  
Interface coating with target receptors  
On site detection at ppb to ppt levels  
Re-usable test cartridge  
Easy to use, low costs per test



**optiqua**

# Water Quality Monitoring in the Distribution Network too little, too late

**Water quality monitoring: a crucial element in ensuring water safety and optimizing the water distribution process**

**Current approach is based on traditional sensor technologies and grab sampling ....**

**..... and is incapable of effectively monitoring water quality and its dynamics**

**Increasing market demand for innovative and effective “smart” water quality monitoring solutions**

**Key component in a smart water grid and smart city concept (safety and efficiency)**

**Traditional technologies and grab sample analysis fall short**



**optiqua**

# Optiqua walked a long way from science to paying customers

Expertise in design,  
manufacturing, data  
processing & biochemistry

17 staff led by experienced  
management team

Products developed in  
partnership with leading  
utilities



Rapidly-growing  
international customer  
base



State-of-the-art facilities in  
Netherlands & Singapore

IP comprising patents &  
know-how

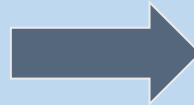


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# Creating a company is like diamond cutting

**Diamond cutting is the practice of changing a diamond from a rough stone into a faceted gem**

**Wikipedia**



# Creating a company is like diamond cutting

Robust, optical chip,  
produced by  
own staff and  
patented worldwide

Co-funded by grants

Application for the water market  
Subsidiary in Singapore  
Partner network & External  
shareholders

Secure  
core  
technology

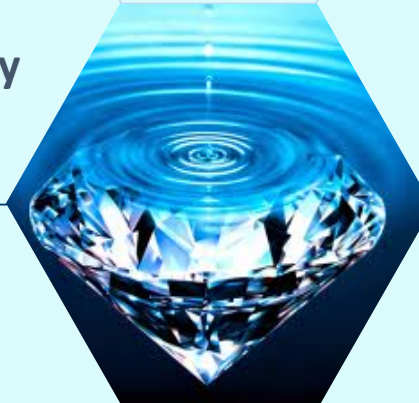
Market  
focus

Launching  
customers

Early  
adopters

Access to  
world  
markets

Science



UNIVERSITY OF TWENTE.

Proof of principle  
of integrated optical  
sensor  
technology



optiqua

# Challenge 1: Enter the market even if your product is not perfect, ...yet

Find the urgent need that you can meet

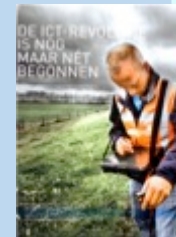
Challenge yourself to get paid for your innovations

Create presence at international forums

Promote your company by building a brand/image and showing concepts



"The Optiqua EventLab works and is reliable. Vitens is now determining its roll-out plan."



In H2O vol 7/8, 2014 the Dutch magazine for water professionals



optiqua

## Challenge 2: Create time to mature - €€ and €€ €€ €€

Grants are very welcome,  
provided they support main stream  
developments

Long-term growth requires the availability of  
stable equity capital

Understand the sets of things investors look  
for in a start-up

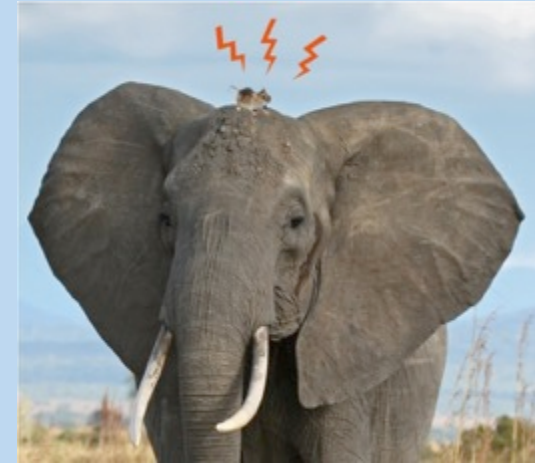


# Challenge 3: The mouse and the elephant: ( invest in partner network)

For understanding of crucial market challenges

Helps to create awareness and credibility

Use joint national/ EU funded projects as marketing tool



optiqua

## Challenge 4: To outsource or not to outsource To patent or not to

Partnering is great but make sure core technology is protected



Chip development, chip production , data algorithms & bio-chemistry are the key areas of expertise which are distinctive to our company



Difficult to balance between short term cash-flow and long term shareholder value



## Challenge 5: Form a multidisciplinary team and keep your eyes on the ball

Create hands on mentality

Establish a setting in which a team with a background in international marketing, finance, research and product development, can flourish

A new product is never finished, force your team to focus on bare essentials for chosen application

A product is never perfect, but might be a gift from heaven for those looking for a solution to their problems



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# From Science to paying customers

**Create time to mature**

**Go to market even if your product is not perfect, ...yet**

**Invest in smart partnerships and networks**

**Protect core technology**

**Form a multidisciplinary team**



**optiqua**

# Thank you for your attention

For more information

## **Optiqua Technologies**

82 WaterHub  
Toh Guan Road East #C2-11/1  
Singapore 608576

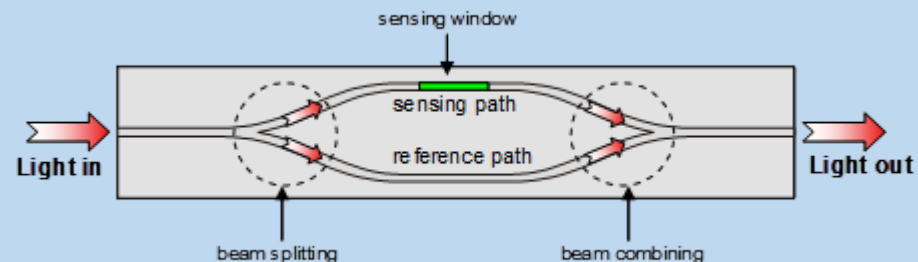
**info@optiqua.com**

Hengelosestraat 705  
7521 PA Enschede  
The Netherlands

**www.optiqua.com**

**optiqua**

# Highly sensitive patented optical chip technology is the basis for Optiqua's monitoring products

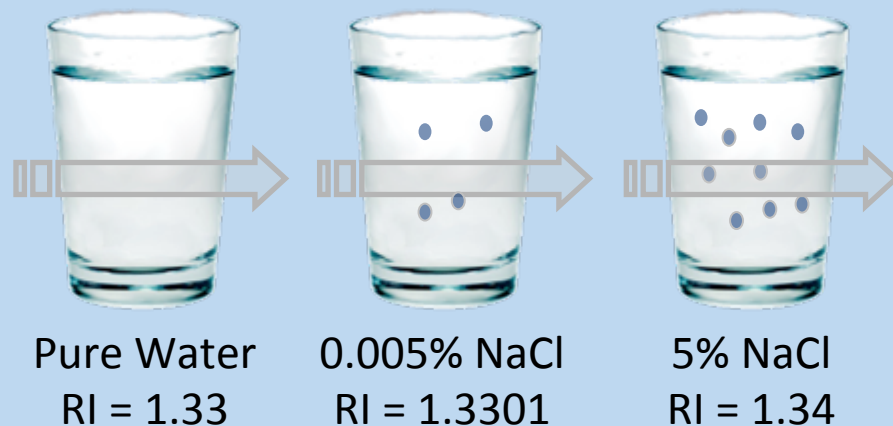


Optiqua's optical sensor detects minute changes in the **refractive index (RI)** in water

Any contaminant dissolved in water, changes the RI of the water.



Single sensor for real-time detection of full spectrum of chemical contaminants



optiqua

# Optiqua EventLab: complete solution for real time continuous water quality monitoring throughout the network

1

EventLab

Optical

No calibration

Minimal  
maintenance

Full spectrum  
detection

No consumables

ppm sensitivity



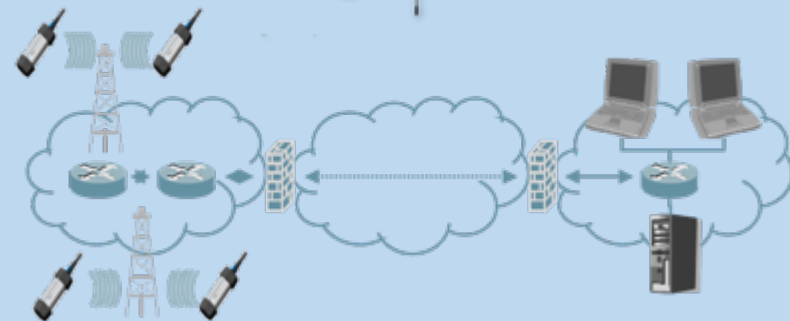
2

Control unit collects sensor readings and transmits to SCADA and through wireless protocol (GPRS)

3

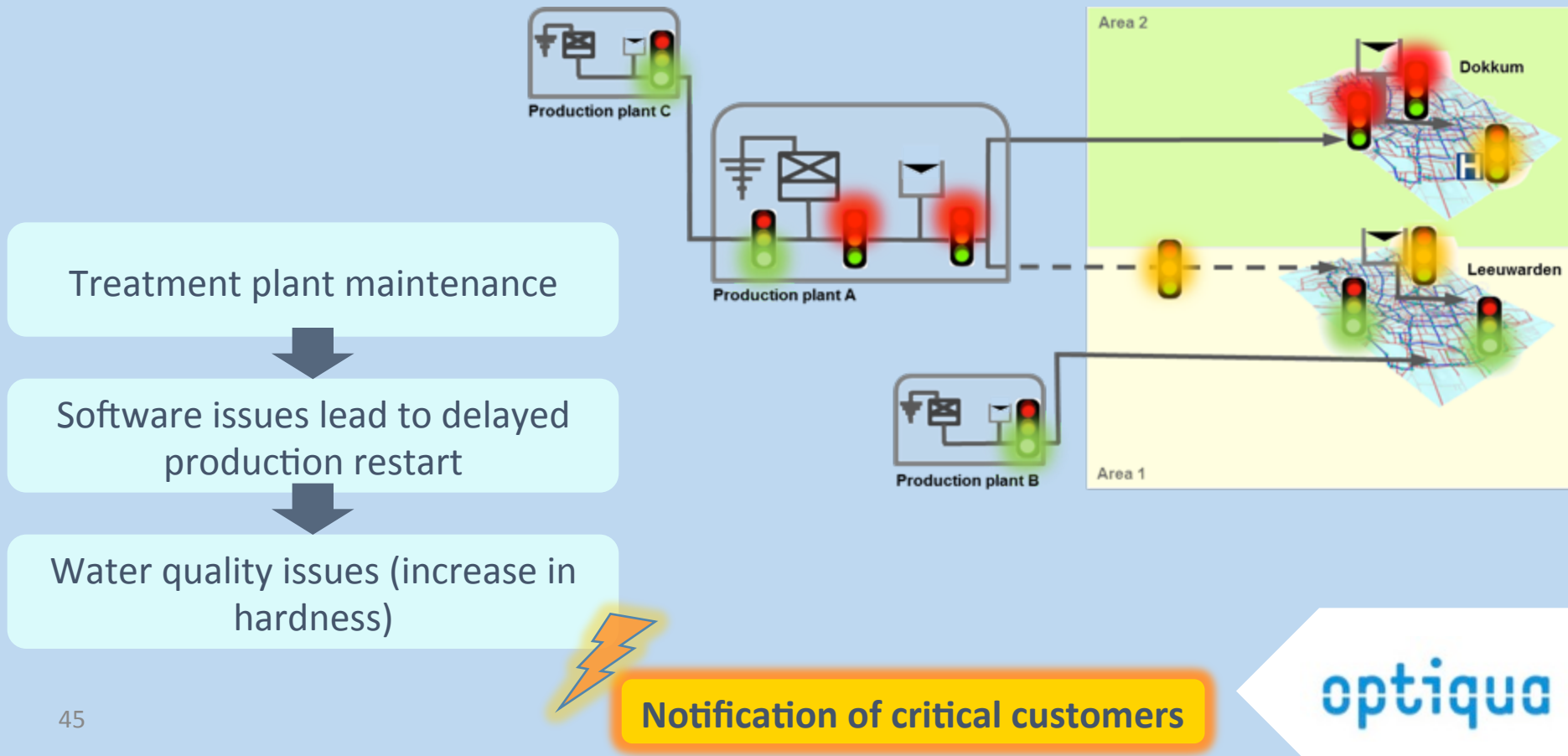
Sensor network information processed at central data server  
Software algorithms determine natural variations and flag water quality incidents

Easily accessible network overview via web based user interface



# EventLab Tracks Water Quality Event through Distribution Network

Sequence of events that led to disruption of water production for 36 hours and water quality incident



# Optiqua MiniLab: detection of specific contaminants

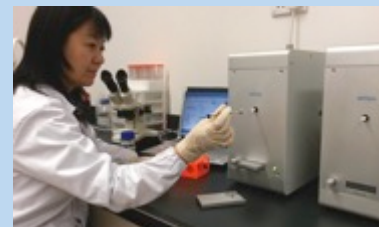
## MiniLab complements EventLab concept in water sector.

Interface coating with specific target receptors

- Selective detection of analytes
- Detection at ppb to ppt levels
- Re-usable disposable test cartridge
- Use in Lab and in the field

### Applications:

- Rapid detection of high priority substances (e.g. for water security)
- Monitoring of source water for suspect compounds.
- Routine monitoring of specific compounds in treatment plants or distribution network



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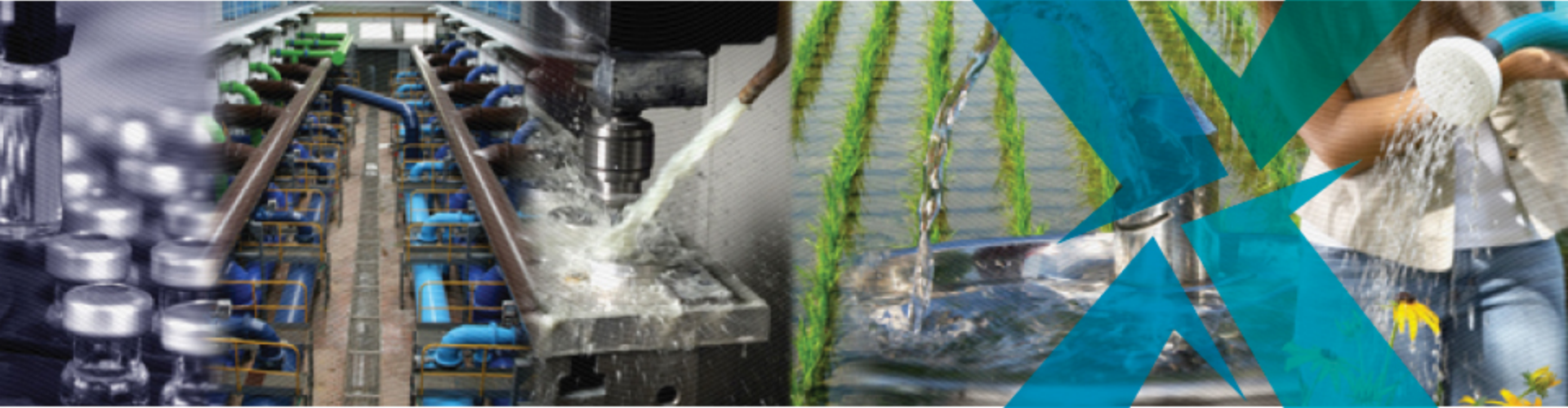
**Samuel Saintonge**

Principal

**XPV Capital**



# MAKING A DIFFERENCE IN WATER



## Smart Sensors for the Water Industry

Sam Saintonge, Principal, XPV Capital

# XPV IN PERSPECTIVE

Toronto-based growth equity investor

Exclusively focused on the water sector

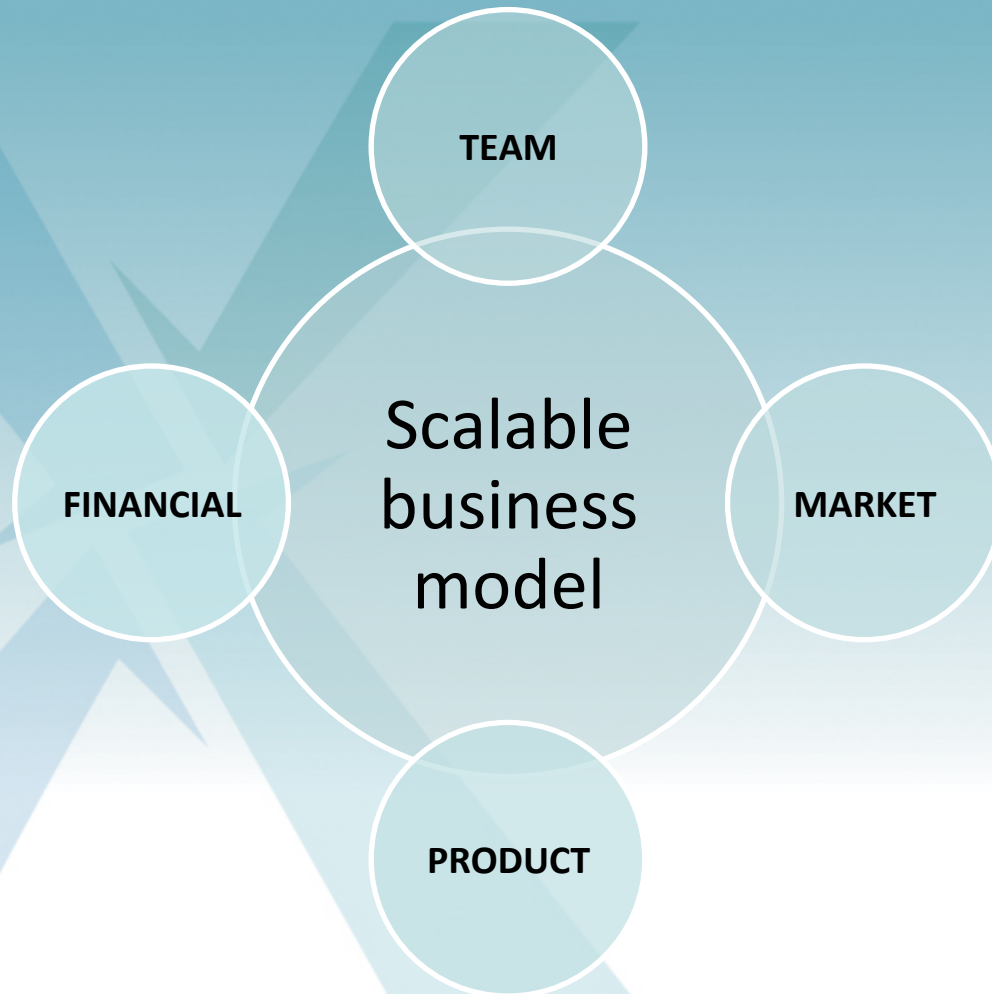
Team experience spans water sector and growth equity investment

Database of 2,400+ water opportunities reviewed

Synergistic portfolio of high growth companies

MAKING A DIFFERENCE IN WATER

# AN INVESTOR'S VIEW

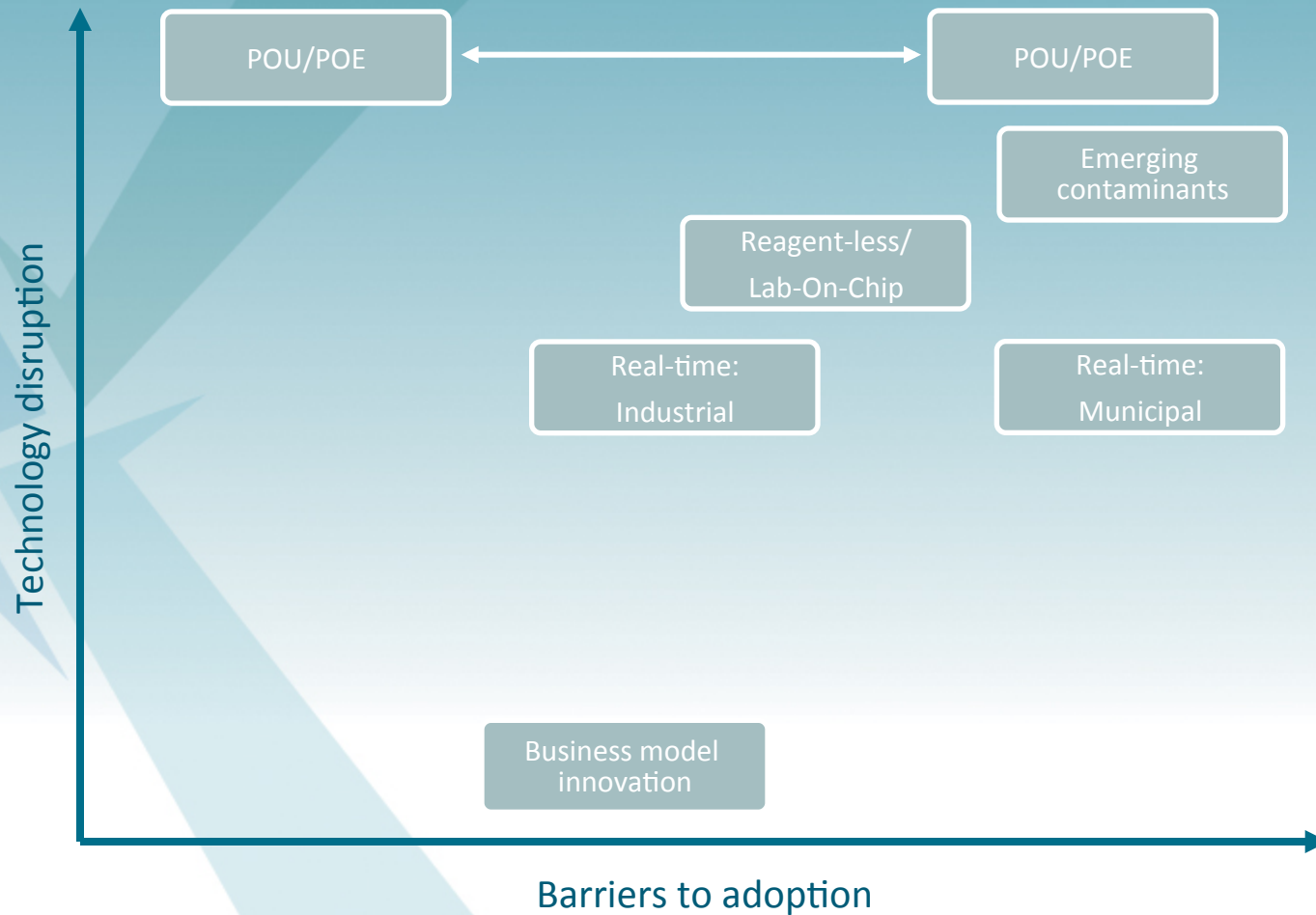


## Sample other considerations:

Exit ecosystem  
Co-investor syndicate  
Track-record of similar businesses

Historically, sensors/analytics companies in the water sector have been challenged to address all areas

# POCKETS OF INNOVATION



MAKING A DIFFERENCE IN WATER

# WHAT CAN EARLY STAGE COMPANIES DO

Build a team that reflects  
market realities

Picks applications  
that matter

FOCUS!

Leverage  
strategic  
accounts

Don't wait  
for  
regulations

Shareholder  
alignment

# Panel Discussion



**Dr. Ana  
Soares**



**Tom  
Bolling**



**Jos-Willem  
Verhoef**



**Samuel  
Saintonge**

# Question

- (Waste)water utilities are the main target-group for (new) WQ sensor technologies, but not main investors
  - Investors ultimately aim for return on investment
- Do we run the risk that:
- only sensors with a sufficiently high market potential will be developed?
  - specific niche-sensors will not reach the market?

# Upcoming BlueTech Events:

## **Next BlueTech Series Webinar**

### **Energy Optimization in Reverse Osmosis Desalination**

**November 13, 2014**

#### **Moderator:**

- James Fotouhi, Technology Research Analyst, **BlueTech Research**

#### **Panelists:**

- Mark Wilf, Membrane Technology Expert,  
**O2 Environmental Technology Assessment Group (TAG)**
- Rick Stover, Executive Vice President, **Desalitech**
- Rodney Clemente, VP Technical Service & Aftermarket,  
**Energy Recovery Inc.**