



ceit

Add Control: plant virtualization for control solutions in WWTP

M. Maiza, A. Bengoechea, P. Grau, W. De Keyser, I. Nopens, D. Brockmann,
J.P. Steyer, F. Claeys, G. Urchegui, O. Fernández, E. Ayesa

ABOUT MY TALK

Automatic Control for WWTPs



International
Water Association

IWA World Water Congress & Exhibition
16-21 September 2012, Busan - Korea

M. Maiza, A. Behgoechea, P. Grau, W. De Keyser, I. Nopens, D. Brockmann, J. P. Steyer, F. Claeys, G. Urchegui and E. Ayesa (2012). Add Control: plant virtualization for control solutions in WWTP. *IWA World Water Congress and Exhibition*, 16 – 22 September, Busan, South Korea.

ceit

ABOUT MY TALK

Is a **rapid transition** from the simulation based design of controllers to their implementation in a real plant **possible**?

The answer is...

Let's discover it...



International
Water Association

IWA World Water Congress & Exhibition
16-21 September 2012, Busan - Korea

M. Maiza, A. Behgochea, P. Grau, W. De Keyser, I. Nopens, D. Brockmann, J. P. Steyer, F. Claeys, G. Urchegui and E. Ayesa (2012). Add Control: plant virtualization for control solutions in WWTP. *IWA World Water Congress and Exhibition*, 16 – 22 September, Busan, South Korea.

ceit

ABOUT MY TALK

- European project Add Control
- FP7 “Research for SMEs”
- Duration: 2 years (2009-2011)
- 9 partners - 4 European countries



International
Water Association

IWA World Water Congress & Exhibition
16-21 September 2012, Busan - Korea

ABOUT ME

- Mikel Maiza
- PhD in Electronics
- Researcher at the Environmental Engineering Department of CEIT



International
Water Association

IWA World Water Congress & Exhibition
16-21 September 2012, Busan - Korea

ABOUT CEIT

- Non profit Research Centre
- Founded in 1982
- 270 researchers in 6 areas:
 - Materials
 - Applied Mechanics
 - Electronics and Communications
 - **Environmental Engineering**
 - Microelectronics and Microsystems
 - Biomedical Engineering



International
Water Association

IWA World Water Congress & Exhibition
16-21 September 2012, Busan - Korea

ABOUT CEIT

□ Located in San Sebastian (Spain)



International
Water Association

IWA World Water Congress & Exhibition
16-21 September 2012, Busan - Korea

M. Maiza, A. Behgoechea, P. Grau, W. De Keyser, I. Nopens, D. Brockmann, J. P. Steyer, F. Claeys, G. Urchegui and E. Ayesa (2012). Add Control: plant virtualization for control solutions in WWTP. *IWA World Water Congress and Exhibition*, 16 – 22 September, Busan, South Korea.

ceit

MOTIVATION

❑ Is technology transfer of control solutions good enough?

- Many CONTROL approaches tested and verified at the simulation level, but...
- Are many of them implemented in real plant?
- ...NOT as many as we wanted...



International
Water Association

IWA World Water Congress & Exhibition
16-21 September 2012, Busan - Korea

MOTIVATION

□ What does that mean?

Transition from...

Simulation-based controllers



Full-scale plant implementation

is NOT straightforward



International
Water Association

IWA World Water Congress & Exhibition
16-21 September 2012, Busan - Korea

MOTIVATION

□ Why?

- WWTP-specific simulation tools traditionally not intended for automatic control purposes...
- Models traditionally do not include all elements of a plant...



International
Water Association

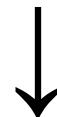
IWA World Water Congress & Exhibition
16-21 September 2012, Busan - Korea

OBJECTIVE

□ Propose a new “concept” for designing controllers to make...

Transition from...

Simulation-based controllers



Full-scale plant implementation...

straightforward



International
Water Association

IWA World Water Congress & Exhibition
16-21 September 2012, Busan - Korea

CONCEPT

□ Definition

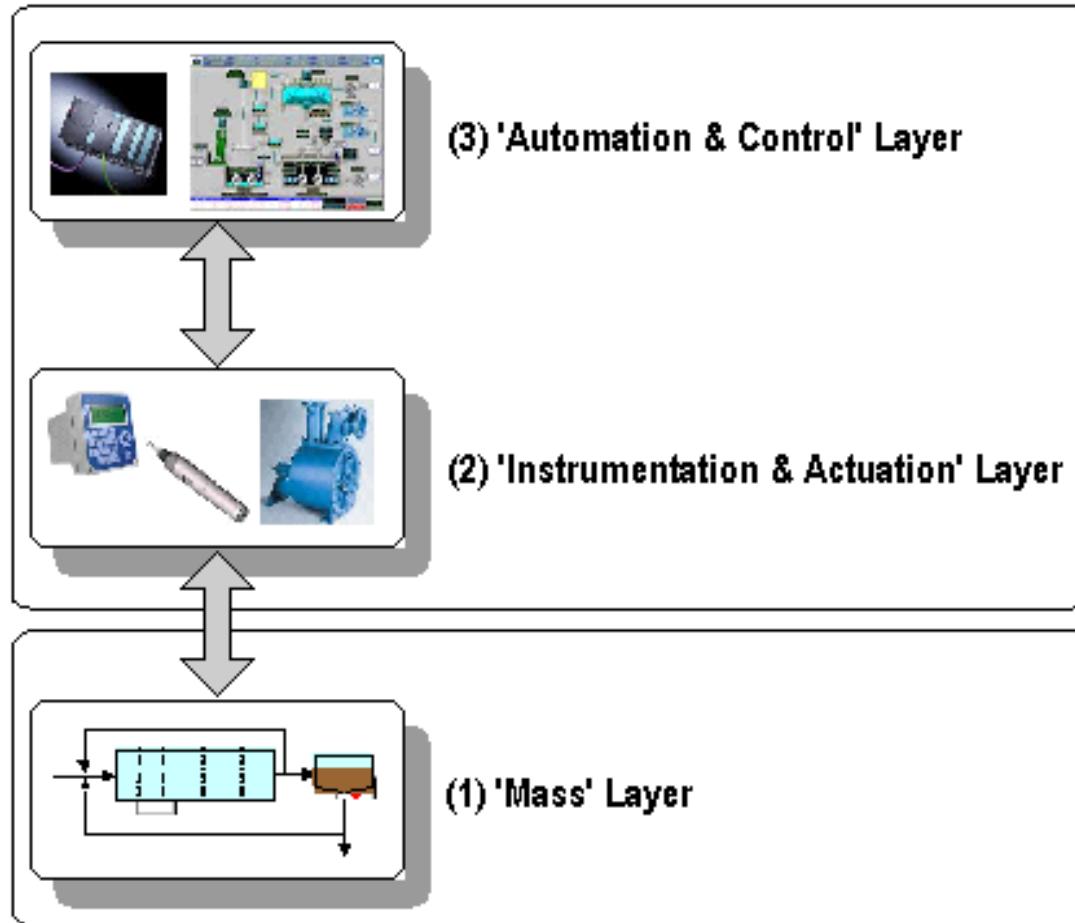
- Model the entire plant...
- Separate the plant in 2 main layers...
 - “Mass” layer: process elements
 - “Signals” layer:
 - Sensors
 - Actuators
 - Controllers
 - DSS



International
Water Association

IWA World Water Congress & Exhibition
16-21 September 2012, Busan - Korea

CONCEPT



“Signals”
Layer

“Mass”
Layer



International
Water Association

IWA World Water Congress & Exhibition
16-21 September 2012, Busan - Korea

CONCEPT

□Advantages

- Separation allows...
 - A new working method
 - Different teams with different expertise work together... but separately...
 - More flexibility
 - Different simulation platforms...
 - Different modelling approaches...
 - Different control solutions...
 - ...even different Solvers...
 - ...without modifying the “other layer”



International
Water Association

IWA World Water Congress & Exhibition
16-21 September 2012, Busan - Korea

CONCEPT

□ More advantages

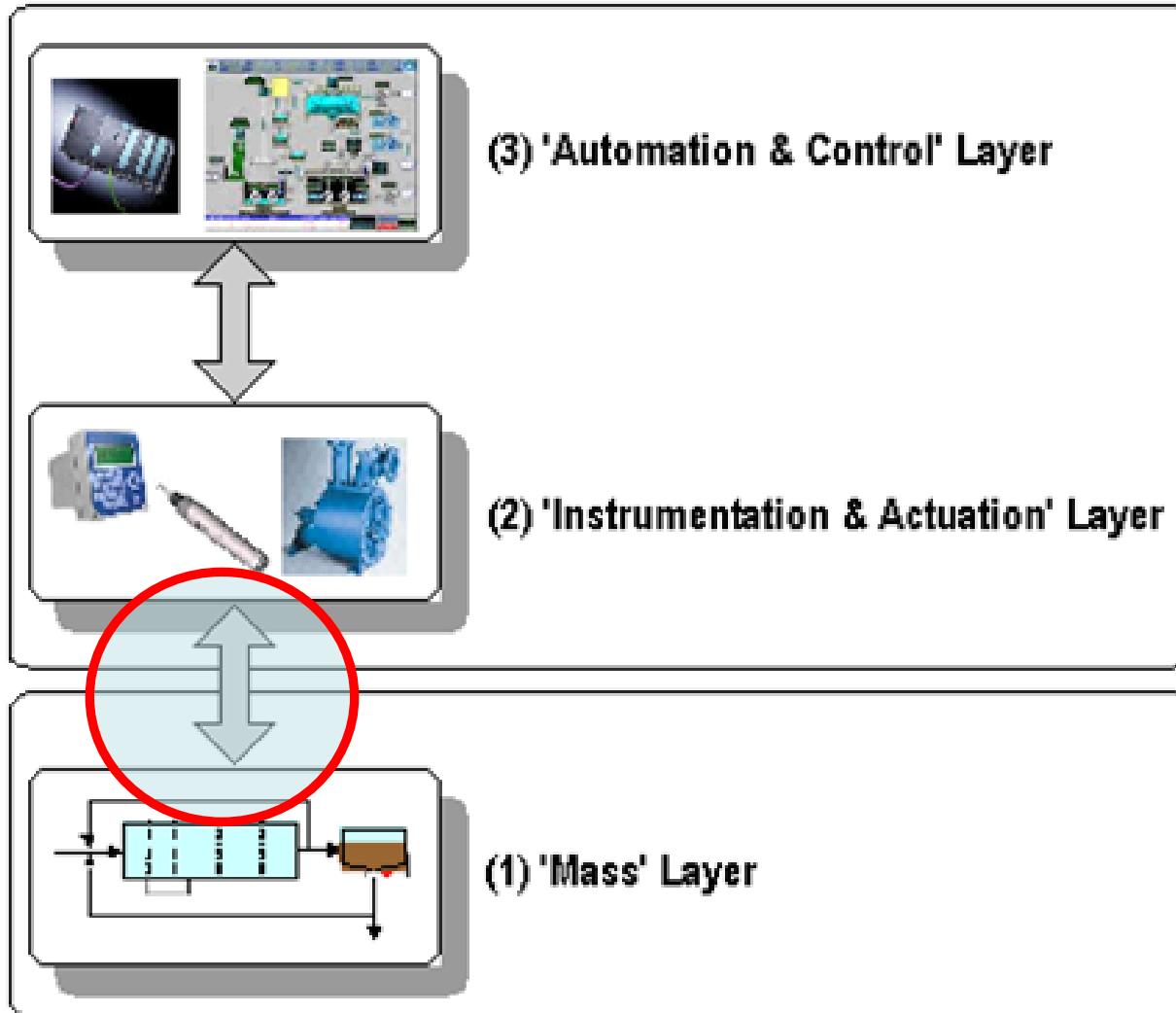
- Modelling the entire plant allows...
 - A new controller design approach
 - Not only water quality objectives...
 - Also sensors performance...
 - Also energy consumption...



International
Water Association

IWA World Water Congress & Exhibition
16-21 September 2012, Busan - Korea

CONCEPT



“Signals”
Layer

“Mass”
Layer

DEVELOPMENT

□ Design of controllers

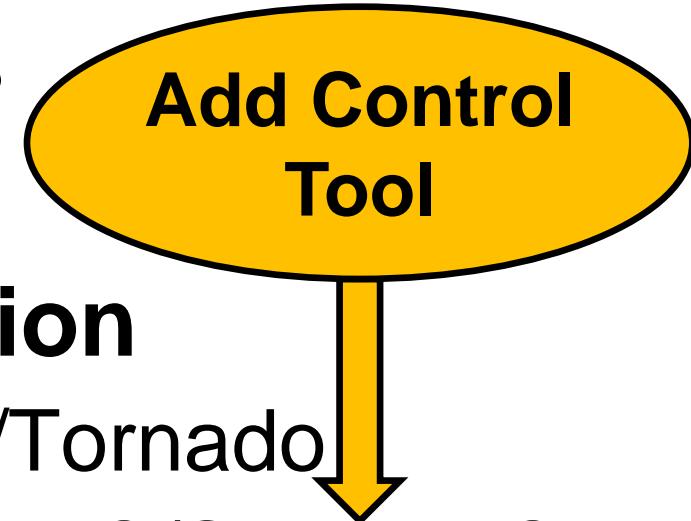
- Artica controllers

□ Model-based simulation

- “Mass” layer: WEST®/Tornado
- “Signals” layer: MATLAB®/Simulink®
- Interface: standard “wrapper”

□ Full-scale Implementation

- Mekolalde WWTP (Spain)



International
Water Association

IWA World Water Congress & Exhibition
16-21 September 2012, Busan - Korea

DEVELOPMENT



- 40,000 e.i.
- 3 lines
- 1 active



International
Water Association

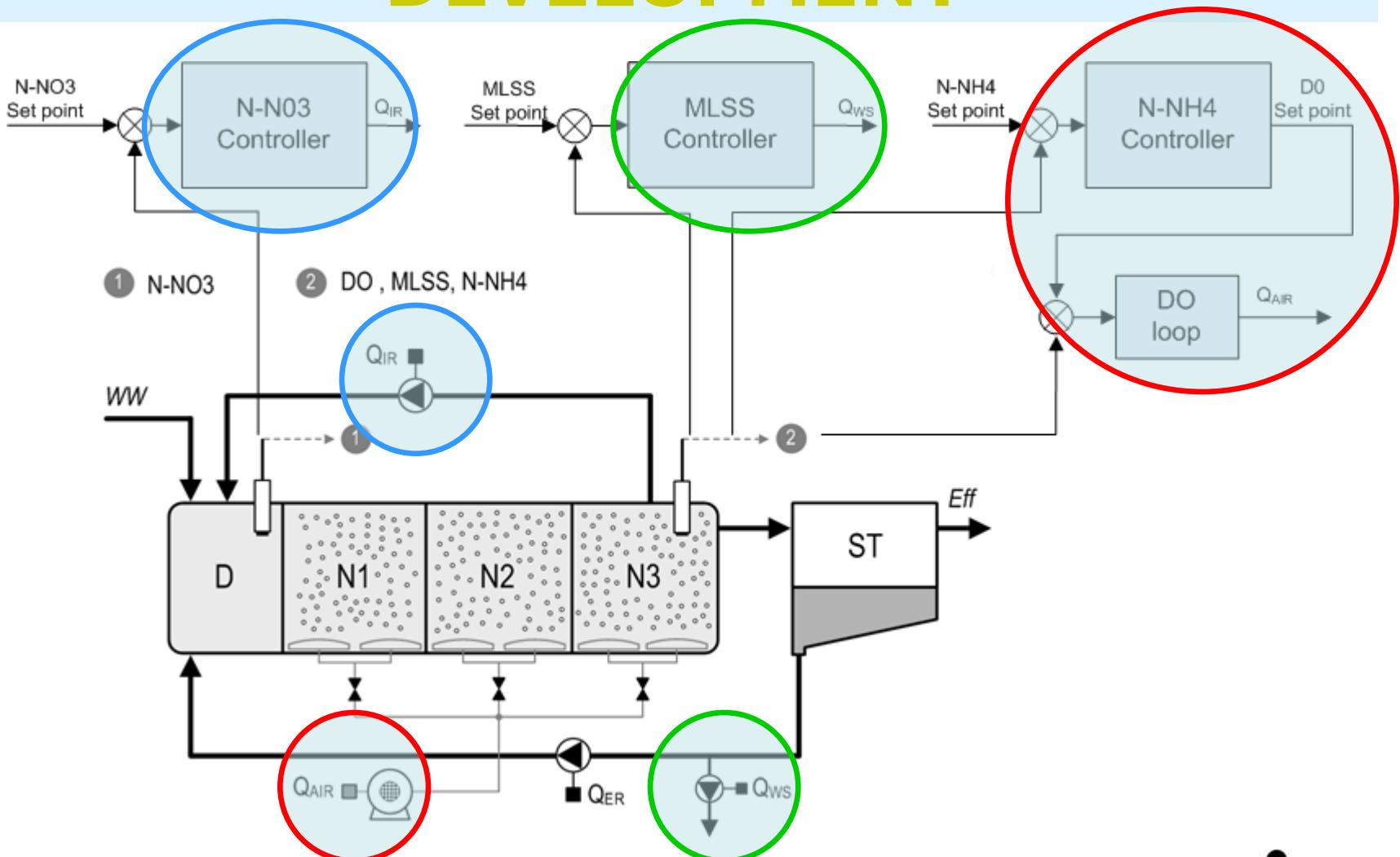
IWA World Water Congress & Exhibition
16-21 September 2012, Busan - Korea

M. Maiza, A. Behgochea, P. Grau, W. De Keyser, I. Nopens, D. Brockmann, J. P. Steyer, F. Claeys, G. Urchegui and E. Ayesa (2012). Add Control: plant virtualization for control solutions in WWTP. *IWA World Water Congress and Exhibition*, 16 – 22 September, Busan, South Korea.



Add Control: plant virtualization for control solutions in WWTP

DEVELOPMENT



International
Water Association

IWA World Water Congress & Exhibition
16-21 September 2012, Busan - Korea

M. Maiza, A. Behgochea, P. Grau, W. De Keyser, I. Nopens, D. Brockmann, J. P. Steyer, F. Claeys, G. Urchegui and E. Ayesa (2012). Add Control: plant virtualization for control solutions in WWTP. *IWA World Water Congress and Exhibition*, 16 – 22 September, Busan, South Korea.

ceit

RESULTS

□ Design of controllers: successful

- Different experts work together...
 - Experts in process:
 - “Mass” layer
 - Experts in sensors & actuators:
 - “Instrumentation & Actuation” layer
 - Experts in control:
 - “Automation & Control” layer
- Integration: “wrapper”



International
Water Association

IWA World Water Congress & Exhibition
16-21 September 2012, Busan - Korea

RESULTS

- Model-based simulation: successful
 - Benefits of combining “Mass” layer and “Signals” layer:
 - Estimation of better energy performance
 - Maintaining water quality performance



International
Water Association

IWA World Water Congress & Exhibition
16-21 September 2012, Busan - Korea

Add Control: plant virtualization for control solutions in WWTP

RESULTS

Energy – general results

	Q _{AIR} Cost MWh	Q _{IR} Cost MWh	Total Costs MWh	Savings (%) (reference point)
Open Loop	266	33	299	
Close Loop	255	22	277	7.4

Water Quality – general results

	Effluent NH4-N mg N/L	Effluent NO3-N mg N/L	TN mg N/L	Reduction (%) (reference point)	MLSS mg/L
Open Loop	0.64	9.41	10.05		3172
Close Loop	0.94	7.79	8.73	13.3	3004



International
Water Association

IWA World Water Congress & Exhibition
16-21 September 2012, Busan - Korea

RESULTS

□ Full-scale implement.: successful

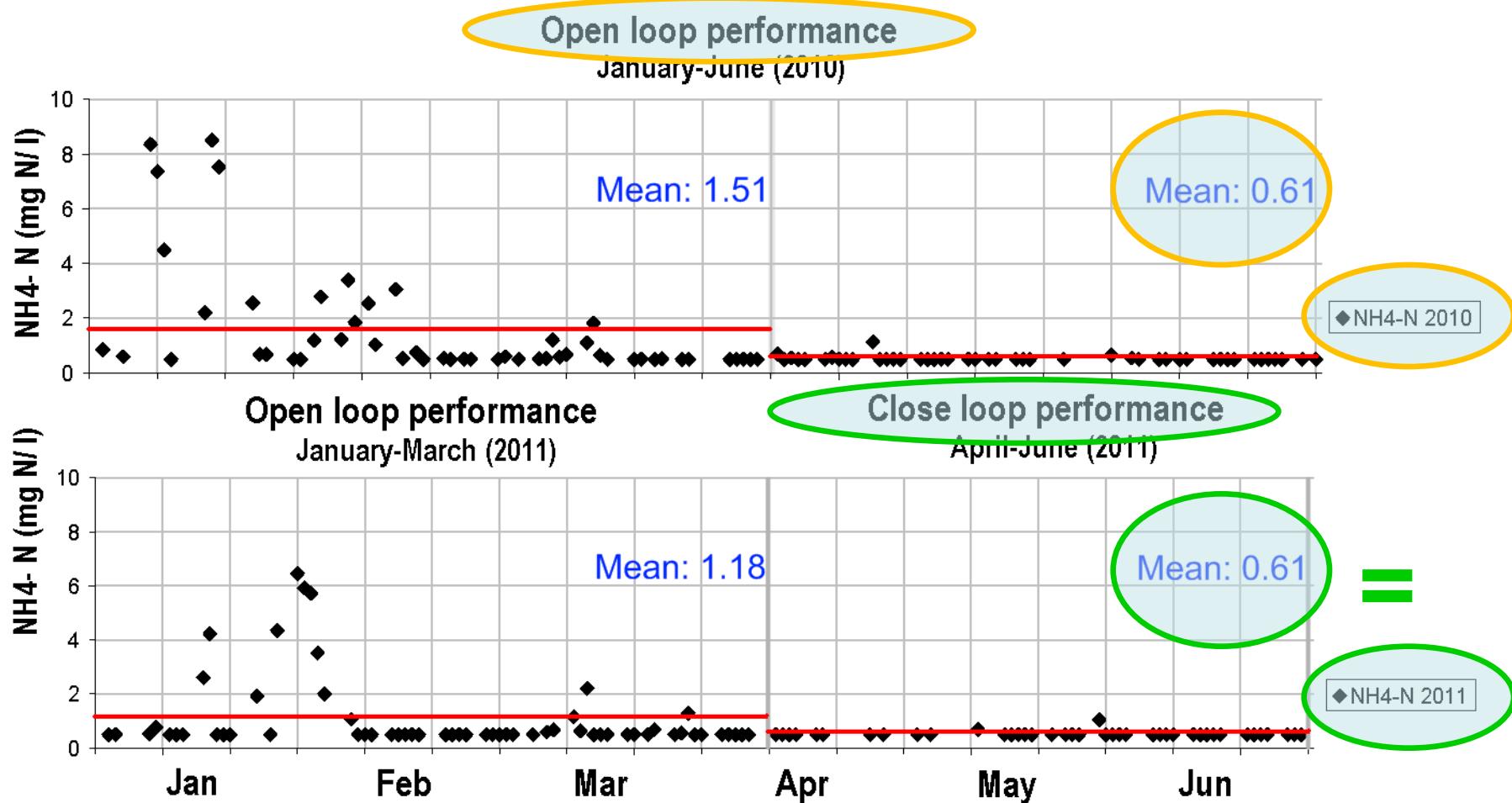
- Experimental validation of simulation-based design of controllers for WWTPs
- Successful implementation and validation of Artica controllers



International
Water Association

IWA World Water Congress & Exhibition
16-21 September 2012, Busan - Korea

RESULTS

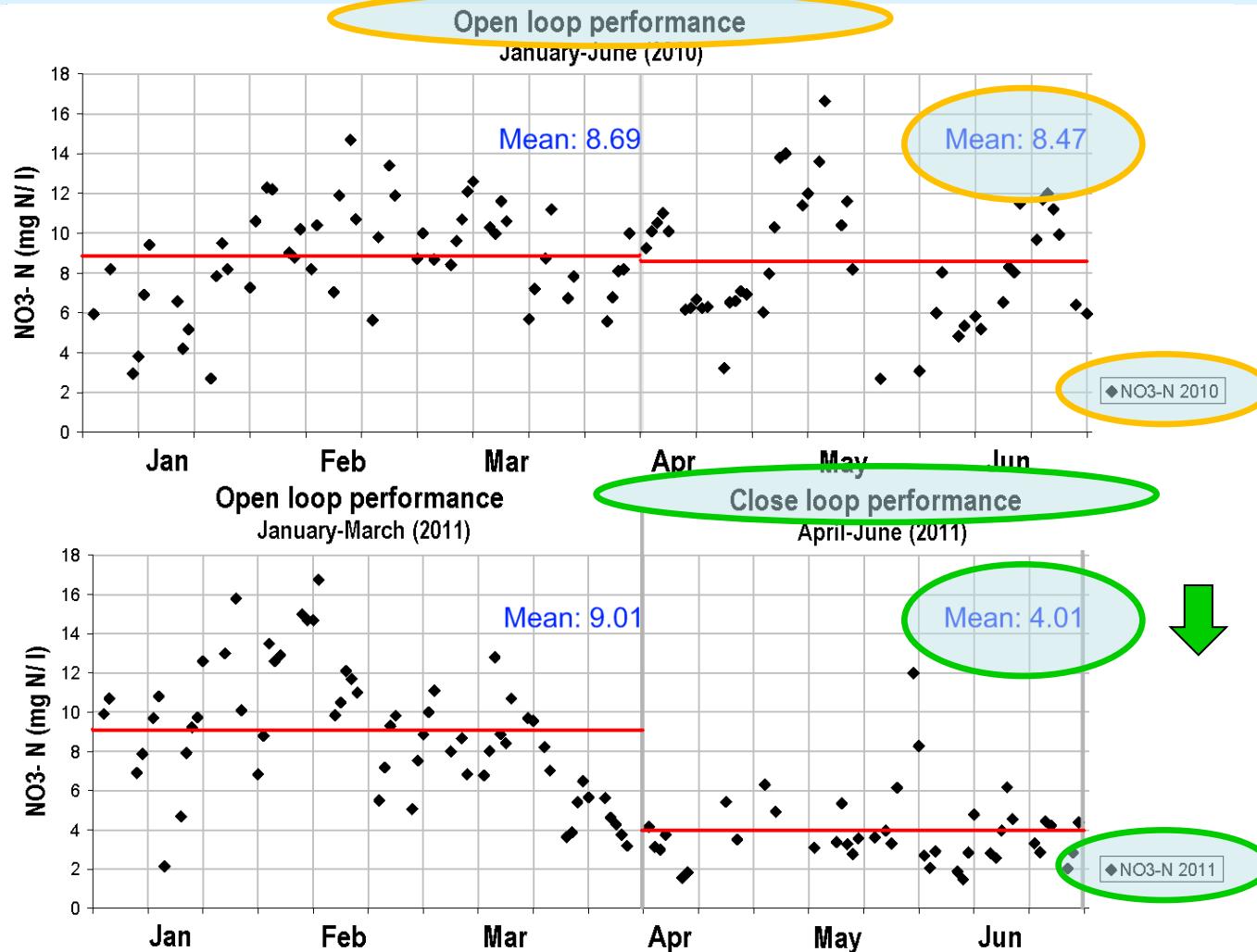


International
Water Association

IWA World Water Congress & Exhibition
16-21 September 2012, Busan - Korea

Add Control: plant virtualization for control solutions in WWTP

RESULTS



International
Water Association

IWA World Water Congress & Exhibition
16-21 September 2012, Busan - Korea

RESULTS

□ Full-scale implement.: successful

- Transition from the design phase to the implementation phase is of **3 months**

Task	2012											
	January				February				March			
	1	2	3	4	1	2	3	4	1	2	3	4
Modeling & Design of Controller	3 weeks											
Simulations					3 weeks							
Full-scale implementation									6 weeks			



International
Water Association

IWA World Water Congress & Exhibition
16-21 September 2012, Busan - Korea

CONCLUSIONS

□ Previous results **confirm** that...

- Simulation platforms are valid tools for designing controllers
- **Artica** controllers work well

□ And **discover** that...

- The proposed “**concept**” for designing controllers is **valid**, as...
 - Allows a **rapid** industrialization of controllers
 - Even **improving** controllers’ performance



International
Water Association

IWA World Water Congress & Exhibition
16-21 September 2012, Busan - Korea



... getting back to The QUESTION...

Is a **rapid transition** from the simulation based design of controllers to their implementation in a real plant **possible**?

The answer is...

YES it is!



International
Water Association

**IWA World Water Congress & Exhibition
16-21 September 2012, Busan - Korea**

M. Maiza, A. Behgochea, P. Grau, W. De Keyser, I. Nopens, D. Brockmann, J. P. Steyer, F. Claeys, G. Urchegui and E. Ayesa (2012). Add Control: plant virtualization for control solutions in WWTP. *IWA World Water Congress and Exhibition*, 16 – 22 September, Busan, South Korea.

ceit

ACKNOWLEDGEMENTS

□ Add Control partners

- MSI-Spain
- CEIT-Spain
- CAG-Spain
- UGENT-Belgium
- MOSTforWATER-Belgium
- INRA-France
- NASKEO-France
- SCAD-France
- AQUA-CONTACT-Czech Republic



Gipuzkoako Ur Kontsortzioa
Gipuzkoako Urak



International
Water Association

IWA World Water Congress & Exhibition
16-21 September 2012, Busan - Korea

ACKNOWLEDGEMENTS



European
Commission





Add Control: plant virtualization for control solutions in WWTP

M. Maiza, A. Bengoechea, P. Grau, W. De Keyser, I. Nopens, D. Brockmann,
J.P. Steyer, F. Claeys, G. Urchegui, O. Fernández, E. Ayesa